Subject	AP Biology
Unit	Big Idea 1: Evolution
Est. Length	21 lessons (Aug - Oct)
Big Idea	The process of evolution drives the diversity and unity of life.
Essential Questions	1. Why are some adaptations favored by natural selection in changing environments? 2. How are characteristics placed on phylogenetic trees to determine the evolutionary history of different species? 3. What factors lead to speciation?
Advanced Placement Standards (AP) *Power standards in bold	1.A: Change in the genetic makeup of a population over time is evolution. ● 1.A.1: Natural selection is a major mechanism of evolution. ● 1.A.2: Natural selection acts on phenotypic variations in populations. ● 1.A.3: Evolutionary change is also driven by random processes. ● 1.A.4: Biological evolution is supported by scientific evidence from many disciplines, including mathematics. 1.B: Organisms are linked by lines of descent from common ancestry. ● 1.B.1: Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today.

	● 1.B.2: Phylogenetic trees & cladograms are graphical representations (models) of evolutionary history that can be tested. 1.C: Life continues to evolve within a changing environment. ● 1.C.1: Speciation & extinction have occurred throughout Earth's history. ● 1.C.2: Speciation may occur when two populations become reproductively isolated from each other. ● 1.C.3: Populations of organisms continue to evolve. 1.D: The origin of living systems is explained by natural processes. ● 1.D.1: There are several hypotheses about the natural origin of life on Earth, each with supporting scientific evidence. ● 1.D.2: Scientific evidence from many different disciplines supports models of the origin of life.
Common Core State Standards (CCSS)	Reading ● RST11-12.1: Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. ● RST11-12.7: Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g. quantitative data, video, multimedia) in order to address a question or solve a problem. ● RST11-12.8: Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. ● RST11-12:9: Synthesize information from a range of sources (e.g. texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept resolving conflicting information when possible. Writing ● WHST9-12.1: Write arguments focused on discipline-specific content. ● WHST9-12.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. ● WHST9-12.5: Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. ● WHST9-12.7: Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. ● WHST9-12.9: Draw evidence from informational texts to support analysis, reflection, and research. ● WHST11-12.8: Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
Science	**1. Asking scientific questions & defining engineering problems**

Practices (SP)	2. Developing & using models 3. Planning & carrying out investigations **4. Analyzing & interpreting data** 5. Using mathematics & computational thinking 6. Constructing scientific explanations & designing engineering solutions **7. Engaging in argument from evidence** 8. Obtaining, evaluating, and communicating information
Assessment Alignment	Minor assessments ● MC quiz (E1 - E7) ● OR quiz (E8 - ES2) Major assessments ● Hardy-Weinberg lab report ● BLAST lab report ● Evolution unit exam
Honors Assignments	Not required for AP courses
20 Key Vocabulary Words	Allele frequency, allopatric speciation, common ancestor, derived trait, gene flow, genetic drift, genotype frequency, homologous DNA sequence, Hardy-Weinberg equilibrium, homeotic gene, morphology, natural selection, nonrandom mating, phenotype, phenotypic variation, phylogenetic tree, prezygotic barrier, species, speciation, sympatric speciation

Prior knowledge that students have entering this unit
1. Students learned the Hardy-Weinberg equation and how to solve for allele and genotype frequencies 2. Students learned the definitions of genetic drift and gene flow 3. Students performed BLAST searches using the NCBI website 4. Students learned the flow of information in the central dogma 5. Students have seen basic concepts of natural selection and explored topics in sexual selection 6. Students have been introduced to the basic concept of speciation 7. The summer reading assignment of “Endless Forms Most Beautiful” introduced students to evo-devo topics

Where this knowledge goes next
1. Students will next study biochemistry 2. The emphasis on molecular evidence for evolution and core processes will be revisited as students learn mechanisms of energy capture and storage 3. Evolution is a major theme of genetics and systems biology to compare phenotypes between organisms and examine why some genotypes have survived over time.

Descriptive outline narrative of unit
Students begin the year with a reintroduction to evolution beginning with the origin of life and shared molecular characteristics through common ancestry. Students will then explore how natural selection acts on the genetic makeup of organisms, leading to adaptations. Students will also study graphs to draw conclusions about how natural selection impacts the evolution of an organism or population. Next, students will explore speciation, beginning with the science practice of designing an experiment. Students will then examine how isolation leads to speciation and how speciation can be modeled within a population. Students will then use simulations to make predictions about how speciation may occur within a population. Students move into learning about Hardy-Weinberg equilibrium, first by solving word problems and learning how to use a grid-in answer format and then by completing their first lab investigation. The lab will be assessed in a formal lab report. Students will then learn about cladograms and phylogenetic trees with an emphasis on how to draw a cladogram or phylogenetic tree based on data from a table of shared traits in animals. Finally, students will use BLAST searches to place a fossil on a cladogram and write a formal lab report about this placement. The unit will conclude with a comprehensive exam.

Day	Lesson #/name	AP	CCSS	Content Objective	Language Objective	Science practice(s)
1	E0	N/A	RST.11-12.1	SWBAT explain the expectations for success in AP Biology.	(S): Explain to a partner how to study in AP Biology.	SP8: Obtain, evaluate, & communicate information

2	E1	1.D.1	RST.11-12.7	SWBAT evaluate scientific questions based on hypotheses about the origin of life on Earth (LO1.28, SP 3.3).	(R): Read a question about the origin of life and classify the question as valid or invalid.	SP1: Asking questions
3	E2	1.B.1	RST.11-12.9	SWBAT justify the claim that organisms share ancient conserved DNA sequences and features (LO1.16, SP 6.1).	(W): Identify evidence from a figure and write a 3 - 5 sentence justification.	SP7: Arguments from evidence
4	E3	1.A.2	RST.11-12.8	SWBAT evaluate evidence that describes evolutionary change in the genetic makeup of a population (LO1.4, SP5.3).	(S): Explain to a partner why evidence from a figure can be used to show that evolutionary change is occurring.	SP7: Arguments from evidence
5	E4	1.A.1	RST.11-12.8	SWBAT evaluate data to investigate the role of natural selection in evolution (LO1.2, SP 2.2, 5.3).	(R): Read a data table or figure and identify the best evidence for the process of natural selection.	SP4: Analyzing & interpreting data
6	E5	SP 5.3	RST.11-12.7	SWBAT examine a graph to justify ongoing natural selection and predict how genotypes may change over time (SP5.3).	(R): Read a graph and identify data that can be used to support ongoing natural selection.	SP4: Analyzing & interpreting data
7	E6	1.C.1	WHST.9-12.7	SWBAT design a plan to collect data to investigate the scientific claim that speciation & extinction have occurred throughout Earth's history (LO1.21, SP 4.2).	(L): Identify through discussion at least five valid scientific steps that can be used to investigate the claim about speciation.	SP3: Designing investigations
8	E7	1.C.2	RST.11-12.8	SWBAT describe speciation in an isolated population and identify the mechanism that led to the speciation event (LO1.24, SP 7.2).	(W): Write a 3 - 5 sentence paragraph that explains how two new species formed in an isolated population.	SP6: Constructing explanations
9	E8	1.C.3	WSHT.9-12.1	SWBAT describe a model that represents evolution within a population (LO1.25, SP 1.2).	(S): Explain to a partner how a data can be used from a figure as evidence to support the	SP2: Developing & using models

					evolution of a population.	
10	E9	1.C.2	RST.11-12.9	SWBAT use simulated population data to predict what will happen to the population in the future (LO1.22, SP 6.4).	(R): Examine a model of a population to identify data that can be used to predict future outcomes.	SP5: Using mathematics
11	E10	1.A.1	WSHT.9-12.1	SWBAT convert a data set from a table of numbers to show changes in genotype frequency over time (LO1.1, SP 1.5, 2.2).	(W): Identify from a word problem the recessive gene and translate the recessive allele frequency from a percentage to a decimal value..	SP5: Using mathematics
12	E11	1.A.3	WHST.9-12.1	SWBAT use data from mathematical models to solve Hardy-Weinberg problems (LO1.6, SP 1.4, 2.1)	(R): Read a word problem and identify whether the solution requires a calculation of p, q, p^2, q^2, or 2pq.	SP5: Using mathematics
13	EL1	1.A.3	RST.11-12.1	SWBAT justify the selection of data from a spreadsheet to analyze genetic drift in a population (LO1.7, SP 2.1, 4.1).	(S): Working with a partner, agree on the data in a spreadsheet that demonstrates genetic drift in a population.	SP4: Analyzing & interpreting data
14	EL2	1.A.3	RST.11-12.9	SWBAT make predictions about the effects of genetic drift on a population (LO1.8, SP 6.4).	(W): Write a prediction about how genetic drift may affect a virtual population of organisms.	SP7: Arguments from evidence
15	EL3	1.A.3	WSHT.9-12.7	SWBAT write a lab report about genetic drift in a population (SP 7.1).	(W): Write an abstract that summarizes background information, the experiment, results, and conclusions in 7 sentences.	SP8: Communicating information
16	E12	1.B.2	RST.11-12.8	SWBAT evaluate evidence provided by fossils and phylogenetic trees to determine a species evolutionary history (LO1.18, SP 5.3).	(R): Read a phylogenetic tree to determine where a trait or species should be added.	SP4: Analyzing & interpreting data

17	E13	1.B.2	RST.11-12.8	SWBAT create a cladogram that correctly represents evolutionary history from a data set (LO1.19, SP 1.1).	(W): Draw a cladogram based on evidence provided in a data table.	SP2: Developing & using models
18	EL4	1.B.2	WSHT.9-12.1	SWBAT BLAST the DNA sequence from an extinct species to identify the most closely related living species (SP 4.3).	(R): Read a set of BLAST results to identify which species is most closely related to the search DNA sequence.	SP3: Designing investigations
19	EL5	1.B.2	RST.11-12.9	SWBAT use evidence from BLAST searches to place an unknown fossil on a phylogenetic tree (SP 4.3).	(W): Use evidence from BLAST searches to place the unknown fossil on a cladogram.	SP4: Analyzing & interpreting data
20	EL6	1.B.2	WHST.9-12.7	SWBAT write a lab report about speciation and phylogenetic trees (SP 7.1).	(W): Write a scientifically valid questions and hypotheses.	SP8: Communicating information
21	Exam	N/A	N/A	SWBAT rock the evolution exam!	(R): Extract information to answer evolution questions	SP8: Communicating information

Subject	AP Biology
Unit	Big Idea 2: Biochemistry
Est. Length	15 lessons (Oct - Nov)
Big Idea	Biological systems utilize free energy and molecular building blocks to grow, to reproduce, and to maintain dynamic homeostasis.
Essential Questions	1. How do cell membranes regulate the transport of cellular materials? 2. How is free energy captured and stored in living organisms? 3. What feedback mechanisms allow organisms to maintain dynamic homeostasis?
Advanced Placement Standards (AP) *Power standards in bold	2.A: Growth, reproduction, and maintenance of the organization of living systems require free energy and matter. ● 2.A.1: All living systems require constant input of free energy. ● 2.A.2: Organisms capture & store free energy for use in biological processes. ● 2.A.3: Organisms must exchange matter with the environment to grow, reproduce, and maintain organization. 2.B: Growth, reproduction, and dynamic homeostasis require that cells create & maintain internal environments that are different from their external environments. ● 2.B.1: Cell membranes are selectively permeable due to their structure. ● 2.B.2: Growth & dynamic homeostasis are maintained by the constant movement of molecules across membranes. ● 2.B.3: Eukaryotic cells maintain internal membranes that partition the cell into specialized regions. 2.C: Organisms use feedback mechanisms to regulate growth and reproduction, and to maintain dynamic homeostasis. ● 2.C.1: Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental changes. ● 2.C.2: Organisms respond to changes in their external environment. 2.D: Growth and dynamic homeostasis of a biological system are influenced by changes in the system's environment. ● 2.D.1: All biological systems from cells to organisms to populations, communities, and ecosystems are affected by complex biotic & abiotic interactions involving exchange of matter & free energy. ● 2.D.2: Homeostatic mechanisms reflect both common ancestry and divergence due to adaptation in different environments.

	● 2.D.3: Biological systems are affected by disruptions to their dynamic homeostasis. ● 2.D.4: Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis. 2.E: Many biological processes involved in growth, reproduction, and dynamic homeostasis include temporal regulation and coordination. ● 2.E.1: Timing and coordination of specific events are necessary for the normal development of an organism, and these events are regulated by a variety of mechanisms. ● 2.E.2: Timing and coordination of physiological events are regulated by multiple mechanisms. ● 2.E.3: Timing and coordination of behavior are regulated by various mechanisms and are important in natural selection.
Common Core State Standards (CCSS)	Reading ● RST11-12.1: Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. ● RST11-12.7: Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g. quantitative data, video, multimedia) in order to address a question or solve a problem. ● RST11-12.8: Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. ● RST11-12:9: Synthesize information from a range of sources (e.g. texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept resolving conflicting information when possible. Writing ● WHST9-12.1: Write arguments focused on discipline-specific content. ● WHST9-12.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. ● WHST9-12.5: Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. ● WHST9-12.7: Conduct short as well as more sustained research projects to ansewr a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. ● WHST9-12.9: Draw evidence from informational texts to support analysis, reflection, and research. ● WHST11-12.8: Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
Science	**1. Asking scientific questions & defining engineering problems**

Practices (SP)	2. Developing & using models 3. Planning & carrying out investigations **4. Analyzing & interpreting data** 5. Using mathematics & computational thinking 6. Constructing scientific explanations & designing engineering solutions **7. Engaging in argument from evidence** 8. Obtaining, evaluating, and communicating information
Assessment Alignment	Minor assessments ● MC/OR Quiz (B1 - B9) Major assessments ● Enzyme Activity Lab ● Biochemistry Exam
Honors Assignments	Not required for AP Courses
20 Key Vocabulary Words	Abiotic, active transport, adaptive immunity, biotic, Calvin cycle, dynamic homeostasis, endergonic reaction, exergonic reaction, innate immunity, lactic acid fermentation, light reactions, negative feedback, osmosis, oxidative phosphorylation, passive transport, positive feedback, surface area:volume, transcription factor

Prior knowledge that students have entering this unit
1. General understanding of ATP as the source of energy in the cell 2. Basic knowledge about cellular respiration and photosynthesis, mainly focused on reactants and products over the various processes involved in each 3. General knowledge about cell membrane structure 4. Background on homeostasis comes from tracking physical exercise in Biology lab 5. Students have little knowledge of positive and negative feedback loops but have seen aspects of these systems studying anatomy in Biology 6. The first Big Idea will help students connect dynamic homeostasis to mechanisms of common ancestry 7. Students have little knowledge of gene regulation and how the timing of development is coordinated

Where this knowledge goes next
1. Students will next explore genetics and the basic mechanisms of energy production will be connected to how genes are expressed in cells 2. The systems biology unit will cover organelle structure, spiraling back to the structure of membranes that promote energy generation and transport in cells 3. Homeostasis will be linked to gene regulation as well as to organismal and ecological homeostasis in the systems biology unit 4. Other aspects of gene regulation, including epigenetic inheritance, will be covered in the genetics unit

Descriptive outline narrative of unit
This unit will start with an overview of membrane structure and function that emphasizes understanding the difference between osmosis, passive transport of solutes, and active transport. Students will then spend one class making surface area and volume calculations to generate SA:V ratios that can be used to compare rates of nutrient and waste transport in cells. Students will then transition to five lessons on photosynthesis and cellular respiration. The first two lessons will be focused on the light reactions and then the dark reactions of photosynthesis. Next, cellular respiration will be studied, first focusing on glycolysis and the Krebs cycle followed by a lesson on the electron transport chain. Finally, a single lesson will try to link the process of photosynthesis and cellular respiration to each other. The next three lessons will focus on dynamic homeostasis. The first lesson in this series will be about negative feedback loops followed by a lesson on positive feedback loops. Dynamic homeostasis in the immune system will finish this set of lessons with a focus on adaptive immunity. The unit will conclude with the enzyme activity lab. Students will first perform a baseline experiment with turnip peroxidase enzyme and develop a color scale of enzyme activity. In the next lesson, students will investigate how an abiotic factor affects turnip peroxidase enzyme activity. Students will conclude this lab by writing a formal lab report that synthesizes how enzyme activity is affected by abiotic factors. The unit will finish with the biochemistry exam.

Day	Lesson #/name	AP	CCSS	Content Objective	Language Objective	Science practice(s)
1	B1	2.B.1	RST.11-12.1	SWBAT use models to pose questions about cell membranes and selective permeability (LO2.10, SP 1.4, 3.1).	(R): Identify information in a picture to ask a questions about how substances cross the cell membrane.	SP2: Developing & using models
2	B2	2.B.2	RST.11-12.1	SWBAT use models to investigate whether dynamic homeostasis is maintained by actively moving molecules across membranes (LO2.12, SP 1.4).	(S): Explain to a partner in at least three steps how molecules move against concentration gradients in cells.	SP2: Developing & using models
3	B3	2.A.3	WHST.9-12.1	SWBAT use calculated SA:V ratios to predict the rate at which molecules diffuse within cells (LO2.6, SP 2.2).	(W): Calculate the surface area and volumes of spheres and cubes using the AP Bio formula sheet.	SP5: Using mathematics
4	B4	2.A.2	WHST.9-12.1	SWBAT describe the structural features that chloroplasts use to capture light energy (LO2.5, SP 6.2).	(W): Summarize in 3- 5 sentences from pictures how light energy is captured by chloroplasts.	SP6: Constructing explanations
5	B5	2.A.2	WHST.9-12.9	SWBAT describe the mechanical features of the Calvin cycle that produce glucose (LO2.5, SP 6.2).	(S): Explain to a partner how carbon dioxide and NADPH are used to produce glucose in the Calvin cycle.	SP6: Constructing explanations
6	B6	2.A.2	WHST.9-12.9	SWBAT describe the structural features that cells use to convert glucose into NADH and $FADH_2$ (LO2.5, SP 6.2).	(R): Identify evidence from figures of glycolysis and the Krebs cycle to show that sugar is broken down into high energy molecules.	SP6: Constructing explanations
7	B7	2.A.2	WHST.9-12.9	SWBAT describe the mechanical features of the mitochondria that result in the production of ATP (LO2.5, SP	(W): Explain in 3 - 5 sentences how proton gradients are used to make ATP.	SP6: Constructing explanations

				6.2).		
8	B8	2.A.2	WHST.9-12.9	SWBAT evaluate data to show how free energy flows between the photosynthesis and cellular respiration processes (LO2.41, SP 5.3, 7.1).	(S): Debate with a partner how the energy in glucose produced during photosynthesis is converted into ATP during cellular respiration.	SP4: Analyzing & interpreting data
9	B9	2.C.1	RST.11-12.9	SWBAT make predictions about how organisms use negative feedback to maintain their internal environment (LO2.18, SP 6.4).	(W): Explain in 3 - 5 sentences how insulin release is an example of negative feedback.	SP7: Arguments from evidence
10	B10	2.C.1	RST.11.12.8	SWBAT justify that positive feedback mechanisms amplify responses in organisms (LO2.20, SP 6.1).	(W): Explain in 3 - 5 sentences how the release of oxytocin is an example of positive feedback.	SP7: Arguments from evidence
11	B11	2.D.4	WHST.9-12.1	SWBAT create a model that describes the animal immune response system (LO2.29, SP 1.1).	(W): Draw a picture that shows how B cells and T cells respond to infections in the human body.	SP2: Developing & using models
12	BL1	2.D.1	RST.11-12.7	SWBAT analyze data to identify a relationship between a biotic factor and enzyme activity (LO2.24, SP 5.1).	(S): Explain to a partner how increasing substrate concentration affects enzyme activity.	SP4: Analyzing & interpreting data
13	BL2	2.D.1	RST.11-12.7	SWBAT design a plan to collect data about how an abiotic factor affects enzyme activity (LO2.23, SP 4.2, 7.2).	(W): Write out 5 - 7 steps of a procedure to test the role of an abiotic factor on enzyme activity.	SP3: Planning investigations
14	BL3	2.D.1	WHST.9-12.7	SWBAT write a lab report about how biotic and abiotic factors affect enzyme activity (SP 7.1).	(W): Create a data table and choose the appropriate bar graph to display the data in the table.	SP8: Communicating information
15	Exam	N/A	N/A	SWBAT rock the biochemistry exam!	(R): Extract information to answer biochemistry questions	SP8: Communicating information

Subject	AP Biology
Unit	Big Idea 3: Genetics
Est. Length	31 lessons (Nov - Feb)
Big Idea	Living systems store, retrieve, transmit, and respond to information essential to life processes.
Essential Questions	1. How is essential information passed to daughter cells via mitosis and meiosis? 2. How does gene regulation lead to cell specialization? 3. How do cells communicate over short and long distances?
Advanced Placement Standards (AP) *Power standards in bold	3.A: Heritable information provides for continuity of life. ● 3.A.1: DNA, and in some cases RNA, is the primary source of heritable information. ● 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. ● 3.A.3: The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring. ● 3.A.4: The inheritance pattern of many traits cannot be explained by simple Mendelian genetics. 3.B: Expression of genetic information involves cellular & molecular mechanisms. ● 3.B.1: Gene regulation results in differential gene expression, leading to cell specialization. ● 3.B.2: A variety of intercellular and intracellular signal transmissions mediate gene expression. 3.C: The processing of genetic information is imperfect & is a source of genetic variation. ● 3.C.1: Changes in genotype can result in changes in phenotype. ● 3.C.2: Biological systems have multiple processes that increase genetic variation. ● 3.C.3: Viral replication results in genetic variation, and viral infection can introduce genetic variation into the hosts. 3.D: Cells communicate by generating, transmitting, and receiving chemical signals. ● 3.D.1: Cell communication processes share common features that reflect a shared evolutionary history. ● 3.D.2: Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling. ● 3.D.3: Signal transduction pathways link signal reception with cellular response. ● 3.D.4: Changes in signal transduction pathways can alter cellular response. 3.E: Transmission of information results in changes within and between biological systems. ● 3.E.1: Individuals can act on information and communicate it to others. ● 3.E.2: Animals have nervous systems that detect external and internal signals, transmit and integrate

	information, and produce responses.
Common Core State Standards (CCSS)	Reading ● RST11-12.1: Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. ● RST11-12.7: Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g. quantitative data, video, multimedia) in order to address a question or solve a problem. ● RST11-12.8: Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. ● RST11-12:9: Synthesize information from a range of sources (e.g. texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept resolving conflicting information when possible. Writing ● WHST9-12.1: Write arguments focused on discipline-specific content. ● WHST9-12.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. ● WHST9-12.5: Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. ● WHST9-12.7: Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. ● WHST9-12.9: Draw evidence from informational texts to support analysis, reflection, and research. ● WHST11-12.8: Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
Science Practices (SP)	**1. Asking scientific questions & defining engineering problems** 2. Developing & using models 3. Planning & carrying out investigations **4. Analyzing & interpreting data** 5. Using mathematics & computational thinking 6. Constructing scientific explanations & designing engineering solutions **7. Engaging in argument from evidence** 8. Obtaining, evaluating, and communicating information
Assessment	Minor assessments

Alignment	• MC Quiz (G1 - G7) • OR Quiz (G8 - G11) • MC Quiz (G12 - G19) • OR quiz (G20 - G24) Major assessments • Mitosis Lab Report • Biotech Lab Report • Genetics Exam
Honors Assignments	Not required for AP Courses
20 Key Vocabulary Words	Action potential, allele, antiparallel, cell cycle, genotype, hormone, hydrophilic, ligand, meiosis, mitosis, mutation, neuron, neurotransmitter, non-Mendelian, nucleotide, phenotype, receptor, regulatory gene, restriction enzyme, second messenger, transcription, translation, virus

Prior knowledge that students have entering this unit

1. Students learned basic vocabulary about genotypes and phenotypes in 8th grade science
2. Students have solved one-factor cross Punnett square problems
3. Students began reviewing the terms allele, genotype, and phenotype during the evolution unit and when completing Hardy-Weinberg calculations
4. Students learned the basic stages of the cell cycle and mitosis in BIO
5. Students also learned about hormones and neuronal structure in BIO

Where this knowledge goes next

1. Students will attempt to synthesize their knowledge of genetics along with evolution and biochemistry to explore interactions within and between organisms in the systems biology unit
2. Systems biology begins with examining polymers and the knowledge of DNA and protein structure from the genetics unit will set the stage for understanding polymerization

3. By this point in the year, students should have a decent grasp on experimental design and should be comfortable writing lab reports that make specific reference to data from their investigation about plant growth in Big Idea 4

Descriptive outline narrative of unit

The genetics unit will begin with an overview of historical experiments that demonstrated DNA is the heritable material in cells followed by an introduction to DNA structure. Lessons on transcription, translation, and the effects of mutation on protein synthesis will follow. Next, students will explore how transcription factors regulate gene expression.

Chromosome segregation will be introduced with two lessons on mitosis and two lessons on meiosis, followed by the mitosis and meiosis lab where students attempt to understand how environmental factors affect chromosome segregation. These lessons will be followed by an overview of the cell cycle. The students will then focus on Mendelian vs. non-Mendelian patterns of inheritance to complete their learning about chromosome segregation.

Cell communication will begin the next area of study. Students will explore how receptor-ligand pairs activate signaling cascades within cells to trigger transcriptional responses. Then students will study how chemical messengers like plant and animal hormones, act as long-range signals to activate cellular responses.

The nervous system will be explored beginning with two lessons on the structure and function of neurons followed by an overview of the central nervous system in vertebrates with a particular emphasis on the vertebrate brain.

The genetics unit will conclude core content lessons with an exploration of the lytic and lysogenic cycles of viruses and how bioethics impacts the field of biology. Students will then explore concepts in biotechnology by transforming bacteria with plasmids and selection to identify cells that have become resistant to antibiotics. The unit will end with a comprehensive exam.

Day	Lesson #/name	AP	CCSS	Content Objective	Language Objective	Science practice(s)
1	G1	3.A.1	RST11-12.1	SWBAT justify the selection of data from experimental evidence that shows DNA is inherited by offspring (LO3.2,	(R): Examine a figure and identify how DNA is transferred	SP4: Analyzing & interpreting data

				SP 4.1).	from the environment or a virus into a cell.	
2	G2	3.A.1	RST11-12.8	SWBAT explain based on the structure of nucleic acids that DNA or RNA is the heritable material (LO3.1, SP 6.2, 6.5).	(S): Explain to a partner two pieces of evidence that show DNA is inherited by daughter cells.	SP7: Arguments from evidence
3	G3	3.A.1	WHST9-12.1	SWBAT describe models that illustrate how DNA is transcribed into RNA (LO3.3, SP 1.2).	(W): Explain in 3 - 5 sentences at least 3 specific steps in the process of transcription.	SP2: Developing & using models
4	G4	3.A.1	WHST9-12.1	SWBAT describe models that illustrate how mRNA is translated into polypeptides (LO3.3, SP 1.2).	(W): Explain in 3 - 5 sentences at least 3 specific steps in the process of translation.	SP2: Developing & using models
5	G5	3.A.1	RST11-12.7	SWBAT predict how a change in a DNA sequence can change gene expression (LO3.6, SP 6.4).	(S): Persuade a partner using evidence from a data table or figure that mutations can affect gene expression.	SP7: Arguments from evidence
6	G6	2.E.1	WHST9-12.1	SWBAT justify that the induction of transcription during development results in sequential gene expression (LO2.33, SP 6.1).	(W): Explain in 5 - 7 sentences how the *lac* operon involves sequential steps for gene expression.	SP7: Arguments from evidence
7	G7	3.B.1	RST11-12.8	SWBAT explain how the regulation of gene expression is essential for cell function (LO3.20, SP 6.2).	(S): Describe to a partner how turning genes on and off is required for fruit fly development.	SP8: Communicating information
8	G8	3.A.2	WHST9-12.1	SWBAT describe the events that occur in the cell cycle (LO3.8, SP 1.2).	(S): Summarize with a partner the four steps of the cell cycle.	SP6: Constructing explanations
9	G9	3.A.2	RST11-12.8	SWBAT construct an explanation using models about how DNA in chromosomes are transmitted to the next generation (LO3.9, SP 6.2).	(W): Explain in 3 - 5 sentences the four steps of mitosis and how mitosis segregates DNA to offspring.	SP4: Analyzing & interpreting data

10	G10	3.A.2	RST11-12.9	SWBAT describe the connection between meiosis and the increased genetic diversity needed for evolution (LO3.10, SP 7.1).	(S): Explain to a partner how meiosis results in greater genetic diversity in offspring.	SP7: Arguments from evidence
11	G11	3.A.2	WHST9-12.1	SWBAT construct an explanation using models about how DNA in chromosomes are segregated into sex cells (LO3.9, SP 6.2).	(W): Draw the process of crossing over in prophase I and chromosome segregation in anaphase I and II.	SP7: Arguments from evidence
12	GL1	3.A.2	WHST9-12.7	SWBAT construct a data table that summarizes cell counts from treated and control onion root tip cells (LO3.9, SP 6.2).	(W): Make a data table in Google Docs that has control and experimental cell counts from the mitosis lab.	SP3: Planning investigations
13	GL2	3.A.2	RST11-12.1	SWBAT determine whether a control and treated data set are significantly different using a Chi square test (LO3.9, SP 2.2).	(R): Extract information from model tables to determine if two data sets are statistically different.	SP5: Using mathematics
14	GL3	3.A.2	WHST9-12.5	SWBAT write a lab report that evaluates whether a chemical can increase the rate of mitosis in onion root tip cells (LO3.9, SP 5.1).	(W): Explain in 3 - 5 sentences one source of error in this lab and speculate on the consequences of this error.	SP8: Communicating information
15	G12	3.A.2	RST11-12.1	SWBAT evaluate evidence to show that heritable information is passed from parents to offspring in mitosis and meiosis (LO3.11, SP 5.3).	(R): Read a data table and highlight evidence that shows DNA is passed from mother to daughter cells.	SP6: Constructing explanations
16	G13	3.A.3	RST11-12.8	SWBAT apply mathematical routines to determine Mendelian patterns of inheritance (LO3.14, SP 2.2).	(S): Explain to a partner how a data table or Punnett square supports that genes are inherited following Mendelian patterns.	SP5: Using mathematics
17	G14	3.A.4	WHST9-12.1	SWBAT describe a representation of inheritance patterns that cannot be explained by Mendel's model of	(W): Explain in 3 - 5 sentences why a data table or Punnett	SP5: Using mathematics

				inheritance (LO3.17, SP 1.2).	square does not support Mendelian inheritance.	
18	G15	3.D.1	RST11-12.1	SWBAT describe basic chemical processes for cell communication shared across evolution (LO3.31, SP 7.2).	(S): Explain to a partner how receptors and ligands interact to trigger a signaling cascade.	SP2: Developing & using models
19	G16	3.D.3	RST11-12.7	SWBAT describe the model of G protein signaling in which a signal is converted into a response (LO3.36, SP 1.5).	(R): Read a figure of G protein signaling and identify how the ligand stimulates a response in the cell.	SP2: Developing & using models
20	G17	3.D.4	WHST9-12.1	SWBAT describe a model that shows how changes in signal transduction affect cellular responses (LO3.38, SP 1.5).	(W): Explain in 3 - 5 sentences how cells signaling can activate transcription.	SP2: Developing & using models
21	G18	3.D.2	WHST9-12.2	SWBAT draw how cell-to-cell communication occurs in plants (LO3.35, SP 1.1).	(W): Draw how plasmodesmata allow neighboring plant cells to communicate.	SP6: Constructing explanations
22	G19	3.E.1	RST11-12.1	SWBAT describe how animals exchange information in response to chemical and visual cues (LO3.42, SP 7.1).	(S): Explain to a partner how pheromones stimulate mating in bees.	SP6: Constructing explanations
23	G20	3.E.2	WHST9-12.1	SWBAT create a visual representation to describe how neurons detect and transmit signals (LO3.48, SP 1.1).	(W): Draw a neuron and label the axon, dendrite, cell body, synapse, and myelin sheath.	SP2: Developing & using models
24	G21	3.E.2	RST11-12.1	SWBAT describe how neurons transmit information (LO3.45, SP 1.2).	(R): Examine an action potential figure and identify evidence of the key steps that cause axons to fire.	SP4: Analyzing & interpreting data
25	G22	3.E.2	RST11-12.7	SWBAT describe how the vertebrate brain integrates information to create a response (LO3.46, SP 1.2).	(S): Describe to a partner how visual and olfactory information is processed in the brain.	SP6: Constructing explanations

26	G23	3.C.3	RST11-12.1	SWBAT construct an explanation of how viruses introduce genetic variation into host organisms (LO3.29, SP 6.2).	(R): Read a figure to compare and contrast the lytic and lysogenic cycle.	SP6: Constructing explanations
27	G24	3.A.3	RST11-12.8	SWBAT pose questions about ethical or social issues surrounding human genetic disorders (LO3.13, SP 3.1).	(S): Debate with a partner about whether CRISPR-Cas9 research is ethical.	SP7: Arguments from evidence
28	GL4	3.A.1	WHST9-12.1	SWBAT transform a plasmid into a bacterial cell (LO3.5, SP 6.2, 6.4).	(W): Record observations of the procedure and data during the experiment.	SP3: Planning investigations
29	GL5	3.A.1	WHST9-12.5	SWBAT analyze selective conditions to determine the frequency in which bacterial cells survived a transformation experiment (LO3.5, SP 6.2, 6.4).	(S): Working with a partner, discuss which selective conditions promote bacterial survival after transformation.	SP4: Analyzing & interpreting data
30	GL6	3.A.1	WHST9-12.5	SWBAT write a lab report that evaluates how cells can take up foreign DNA and acquire new traits (LO3.5, SP 6.2, 6.4).	(W): Justify the claim that bacteria can take up DNA from their surroundings to acquire new traits.	SP8: Communicating information
31	Exam	N/A	N/A	SWBAT rock the genetics exam!	(R): Extract information to answer genetics questions	SP8: Communicating information

Subject	AP Biology
Unit	Big Idea 4: Systems Biology
Est. Length	16 lessons (Feb - April)
Big Idea	Biological systems interact and these systems and their interactions possess complex properties.
Essential Questions	1. Why does function follow form in cells? 2. How are complex interactions regulated within and between organisms? 3. Are the interactions between living systems and the environment positive or negative?
Advanced Placement Standards (AP) *Power standards in bold	4.A: Interactions within biological systems lead to complex properties. ● 4.A.1: The subcomponents of biological molecules and their sequence determine the properties of that molecule. ● 4.A.2: The structure & function of subcellular components, and their interactions, provide essential cellular processes. ● 4.A.3: Interactions between external stimuli and regulated gene expression result in specialization of cells, tissues, and organs. ● 4.A.4: Organisms exhibit complex properties due to interactions between their constituent parts. ● 4.A.5: Communities are composed of populations of organisms that interact in complex ways. ● 4.A.6: Interactions among living systems and with their environment result in the movement of matter and energy. 4.B: Competition & cooperation are important aspects of biological systems. ● 4.B.1: Interaction between molecules affect their structure & function. ● 4.B.2: Cooperative interactions within organisms promote efficiency in the use of energy and matter. ● 4.B.3: Interactions between & within populations influence patterns of species distribution & abundance. ● 4.B.4: Distribution of local and global ecosystems changes over time. 4.C: Naturally occurring diversity among and between components within biological systems affects interactions with the environment. ● 4.C.1: Variation in molecular units provides cells with a wider range of functions. ● 4.C.2: Environmental factors influence the expression of the genotype in an organism. ● 4.C.3: The level of variation in a population affects population dynamics. ● 4.C.4: The diversity of species within an ecosystem may influence the stability of the ecosystem.

Common Core State Standards (CCSS)	Reading ● RST11-12.1: Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. ● RST11-12.7: Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g. quantitative data, video, multimedia) in order to address a question or solve a problem. ● RST11-12.8: Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. ● RST11-12:9: Synthesize information from a range of sources (e.g. texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept resolving conflicting information when possible. Writing ● WHST9-12.1: Write arguments focused on discipline-specific content. ● WHST9-12.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. ● WHST9-12.5: Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. ● WHST9-12.7: Conduct short as well as more sustained research projects to ansewr a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. ● WHST9-12.9: Draw evidence from informational texts to support analysis, reflection, and research. ● WHST11-12.8: Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
Science Practices (SP)	**1. Asking scientific questions & defining engineering problems** 2. Developing & using models 3. Planning & carrying out investigations **4. Analyzing & interpreting data** 5. Using mathematics & computational thinking 6. Constructing scientific explanations & designing engineering solutions **7. Engaging in argument from evidence** 8. Obtaining, evaluating, and communicating information
Assessment Alignment	Minor assessments ● MC Quiz (S1 - S5) ● OR Quiz (S6 - S10)

	Major assessments ● Energy Dynamics Lab Report ● Systems Biology Exam
Honors Assignments	Not required for AP Courses
20 Key Vocabulary Words	Carbohydrate, community, differentiation, dispersal, ecological succession, energetic hypothesis, exponential population growth, keystone species, logistic population growth, net primary production, nucleotide, organelle, peptide bond, polymer, polypeptide, population, primary productivity, species diversity, symbiotic relationships, trophic efficiency

Prior knowledge that students have entering this unit

1. Biology: Students learned last year about the four types of biomolecules and protein synthesis during biochemistry and aspects of ecology, including symbiotic relationships and trophic efficiency, during the ecology unit.
2. Evolution: Students learned the definition of a species and touched on the meaning of populations and communities.
3. Biochemistry: Students learned about the four types of biomolecules, with an emphasis on carbohydrates that arise during photosynthesis and are metabolized during cellular respiration. Students also explored how proteins function within a cell membrane during transport.
4. Genetics: Students learned about the role of transcription and translation in polypeptide synthesis and about intercellular communication.

Where this knowledge goes next

1. Systems biology synthesizes knowledge from the other three units to show how interaction occur at the subcellular, cellular, tissue, organ, organ system, and organism levels.
2. Following this unit, students will review for the AP Biology exam.
3. Content from this unit will also be used to help students complete their senior project in collaboration with the Novartis CELL lab.

Descriptive outline narrative of unit
The systems biology unit attempts to look at interactions from the molecular to the ecosystem level. Students will begin with a lesson on free energy followed by looking at reaction coupling as an example of using energy efficiently in biological systems. Students will then begin planning a lab to track how biomass is gained by wheat bran plants and by mealworms. This lab will take about two weeks where students will periodically check the mass of the wheat bran and the worms to accumulate data from the investigation before writing a formal lab report about energy transfer. The next content lesson will examine enzyme activity and how structural changes that arise from enzyme-substrate binding affect the function of enzymes in cells. Students will then explore polymers with an emphasis on the four levels of protein structure followed by examining how changing a monomer can affect the function of a polymer. Organelles will be explored first by looking at how subcellular organelles in the secretory pathway interact followed by an exploration of the essential features provided by organelles to the cell. The next shift will be to population dynamics as students will examine how the interaction between populations affects species distribution. Students will then study communities and population dynamics within communities, including how mathematical models can be used to examine population dynamics. The unit will conclude by examining ecosystem stability and the impact of human actions on the ecosystem.

Day	Lesson #/name	AP	CCSS	Content Objective	Language Objective	Science practice(s)
1	S1	2.A.1	WHST9-12.1	SWBAT explain how biological systems use free energy to organize, grow, and reproduce (LO2.1, SP 6.2).	(W): Describe in 3 - 5 sentences how ATP can be used to organize and grow cells.	SP6: Constructing explanations
2	S2	4.B.2	RST11-12.1	SWBAT use models to analyze how cooperative interactions promote efficiency in the use of energy and matter (LO4.18, SP 1.4).	(R): Examine an image and identify examples of coupling ATP hydrolysis with endergonic reactions.	SP2: Developing & using models
3	SL1	4.A.6	WHST9-12.2	SWBAT prepare an experiment to determine how energy is transferred	(S): Explain to a partner how to either begin growing wheat bran	SP3: Planning investigations

				from wheat bran to mealworms (LO4.16, SP 6.4).	or how to measure the initial mass of mealworms.	
4	S3	4.B.1	RST11-12.1	SWBAT analyze data to identify how molecular interactions affect structure & function (LO4.17, SP 5.1).	(S): Explain to a partner how substrate binding causes enzyme activity to change.	SP4: Analyzing & interpreting data
5	S4	4.A.1	RST11-12.9	SWBAT refine a model to explain how the sequence of a protein determines the properties of a polypeptide (LO4.2, SP 1.3).	(W): Explain in 2 - 4 sentences how a mutation would affect protein folding in a polypeptide.	SP2: Developing & using models
6	SL2	4.A.6	WHST9-12.1	SWBAT collect and analyze data to predict how changing matter can affect a community (LO4.16, SP 6.4).	(S): Explain to a partner how biomass has been increased as wheat bran has converted light energy into matter.	SP4: Analyzing & interpreting data
7	S5	4.A.1	RST11-12.8	SWBAT use models to predict how changing the sequence of a polymer will affect the function of a polymer (LO4.3, SP 6.1, 6.4).	(W): Explain in 3 - 5 sentences why changing a monomer can affect a polymer and predict how a polymer is affected by changing a monomer.	SP2: Developing & using models
8	SL3	4.A.6	WHST9-12.5	SWBAT write a lab report that demonstrates how changing matter affects a community (LO4.16, SP 6.4).	(W): Justify a claim with three pieces of evidence from wheat bran or mealworm growth.	SP8: Communicating information
9	S6	4.A.2	RST11-12.8	SWBAT make predictions about the interactions of subcellular organelles (LO4.4, SP 6.4).	(S): List the organelles of the secretory pathway and describe the pathway that transports proteins to the plasma membrane.	SP4: Analyzing & interpreting data
10	S7	4.A.2	RST11-12.9	SWBAT construct explanations based on scientific evidence about how subcellular structures provide essential functions (LO4.5, SP 6.2).	(S): Justify to a partner how changing the function of an organelle will affect other organelles in the cell.	SP6: Constructing explanations

11	S8	4.B.3	RST11-12.1	SWBAT use data to refine observations about how population interactions affect species distribution (LO4.19, SP 2.2, 5.2).	(R): Look at a data table or simulation of a population to identify evidence about how species distribution is changed following a disturbance.	SP4: Analyzing & interpreting data
12	S9	4.A.5	RST11-12.9	SWBAT justify the selection of data to answer scientific questions about how populations interact within communities (LO4.11, SP 1.4, 4.1).	(S): Justify to a partner the data from a figure or table that answers how population interactions change a community.	SP1: Asking questions
13	S10	4.A.5	RST11-12.1	SWBAT apply mathematical routines to quantities that describe populations that interact in complex ways (LO4.12, SP 2.2).	(R): Examine graphs of population density to determine how factors increase or decrease organisms in a population.	SP5: Using mathematics
14	S11	4.C.4	RST11-12.7	SWBAT make a claim about how species diversity influences ecosystem stability (LO4.27 & 4.26, SP 6.4).	(S): Evaluate the claim your partner makes about how species diversity influences ecosystem stability.	SP6: Constructing explanations
15	S12	4.C.2	WHST9-12.1	SWBAT explain how the environment influences the phenotype of an organism (LO4.23, SP 6.2).	(W): Explain in 3 - 5 sentences how the environment can select for specific genotypes in a population.	SP6: Constructing explanations
16	S13	4.B.4	RST11-12.9	SWBAT predict the consequences of human actions on local and global ecosystems (LO4.20 & 4.21, SP 6.4).	(S): Justify to a partner how human actions are harming species in Massachusetts.	SP4: Analyzing & interpreting data
17	Exam	N/A	N/A	SWBAT rock the systems biology exam!	(R): Extract information to answer systems biology questions.	SP8: Communicating information
18	SL4	2.B.1	WHST9-12.2	SWBAT use models to pose questions about the properties of selectively	(R): Examine a detailed procedure to set up and perform	SP6: Constructing explanations

				permeable membranes (LO2.10, SP 1.4).	an experiment with a selectively permeable membrane.	
19	SL5	2.B.1	WHST9-12.1	SWBAT construct models that connect the movement of molecules across a selectively permeable membrane with membrane function (LO2.11, SP 7.1).	(W): Draw a model of how different solutions move across a selectively permeable membrane.	SP4: Analyzing & interpreting data
20	SL6	2.B.1	WHST9-12.5	SWBAT write a lab report that demonstrates how selective permeability affects molecular movement (LO2.10, SP 6.2).	(W): Construct a 5 - 7 sentence response to analysis questions that explain how materials move across selectively permeable membranes.	SP8: Communicating information

Subject	AP Biology
Unit	Unit 5: AP Bio Exam Review
Est. Length	8 lessons (Apr - May)
Big Idea	Students must master content knowledge to answer multiple-choice, grid-in, and free response questions.
Essential Questions	1. How can reading comprehension strategies be used to answer multiple-choice questions? 2. How can figures be used to predict answers on free response questions? 3. What mathematical routines are useful on the AP Biology exam?
Advanced Placement Standards (AP) *Power standards in bold	1.A: Change in the genetic makeup of a population over time is evolution. ● 1.A.2: Natural selection acts on phenotypic variations in populations. 2.A: Growth, reproduction, and maintenance of the organization of living systems require free energy and matter. ● 2.A.2: Organisms capture & store free energy for use in biological processes. ● 2.A.3: Organisms must exchange matter with the environment to grow, reproduce, and maintain organization. 2.B: Growth, reproduction, and dynamic homeostasis require that cells create & maintain internal environments that are different from their external environments. ● 2.B.1: Cell membranes are selectively permeable due to their structure. 2.C: Organisms use feedback mechanisms to regulate growth and reproduction, and to maintain dynamic homeostasis. ● 2.C.1: Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental changes. 3.A: Heritable information provides for continuity of life. ● 3.A.1: DNA, and in some cases RNA, is the primary source of heritable information. 3.D: Cells communicate by generating, transmitting, and receiving chemical signals. ● 3.D.2: Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling. 3.E: Transmission of information results in changes within and between biological systems. ● 3.E.2: Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses.
Common Core	Reading

State Standards (CCSS)	● RST11-12.1: Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. ● RST11-12.7: Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g. quantitative data, video, multimedia) in order to address a question or solve a problem. ● RST11-12.8: Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. ● RST11-12:9: Synthesize information from a range of sources (e.g. texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept resolving conflicting information when possible. Writing ● WHST9-12.1: Write arguments focused on discipline-specific content. ● WHST9-12.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. ● WHST9-12.5: Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. ● WHST9-12.7: Conduct short as well as more sustained research projects to ansewr a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. ● WHST9-12.9: Draw evidence from informational texts to support analysis, reflection, and research. ● WHST11-12.8: Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
Science Practices (SP)	**1. Asking scientific questions & defining engineering problems** 2. Developing & using models 3. Planning & carrying out investigations **4. Analyzing & interpreting data** 5. Using mathematics & computational thinking 6. Constructing scientific explanations & designing engineering solutions **7. Engaging in argument from evidence** 8. Obtaining, evaluating, and communicating information
Assessment Alignment	None

Honors Assignments	Not required for AP Courses
20 Key Vocabulary Words	Cellular respiration, central dogma, communication, feedback, free energy, membranes, natural selection, neurons, photosynthesis

Prior knowledge that students have entering this unit

1. Students have taken the entire AP Biology course and are preparing for the AP exam

Where this knowledge goes next

1. Students will apply this knowledge on the AP Biology exam and in college biology courses.

Descriptive outline narrative of unit

This unit reviews for the AP Biology exam by placing students into groups and working through POGIL worksheets. The homework for this unit is a practice AP Biology exam; students will complete about 10 multiple-choice or 4 free response questions per night for homework. The class will start with 15 minutes reviewing the homework answers followed by 50 minutes working through POGIL worksheets. The flow of content review is: Free energy, membranes, cellular respiration + photosynthesis, communication, central dogma, natural selection, neurons, and feedback mechanisms.

Day	Lesson #/name	AP	CCSS	Content Objective	Language Objective	Science practice(s)
1	R1	2.A.2	WHST9-12.1	SWBAT explain in writing how temperature, entropy, and enthalpy can be used to calculate Gibbs Free Energy (POGIL 2 & 7).	(W): Describe the role of entropy and enthalpy in Gibbs free energy.	S6: Constructing explanations

2	R2	2.B.1	WHST9-12.1	SWBAT describe in writing how membrane structure dictates membrane function (POGIL 4 & 5).	(W): Explain in 3 - 5 sentences how selective permeability leads to the passive and active transport of substances across membranes.	S6: Constructing explanations
3	R3	2.A.3	WHST9-12.1	SWBAT explain in writing how light energy is converted into chemical energy (POGIL 8 & 11).	(W): Identify the equation for cellular respiration and explain the four major processes that create ATP.	S6: Constructing explanations
4	R4	3.D.2	WHST9-12.1	SWBAT describe in writing how external signals are converted into cellular responses (POGIL 12 & 13).	(W): Describe how receptor-ligand interactions initiate signal transduction pathways.	S6: Constructing explanations
5	R5	3.A.1	WHST9-12.1	SWBAT explain in writing how genetic information encoded in DNA is translated into proteins (POGIL 14 & 15).	(W): Transcribe and translate a DNA sequence.	S6: Constructing explanations
6	R6	1.A.2	WHST9-12.1	SWBAT describe in writing how adaptations are selected in nature (POGIL 21 & 22).	(W): Describe in 3 - 5 sentences how cladograms can be used to trace evolutionary history.	S6: Constructing explanations
7	R7	3.E.2	WHST9-12.1	SWBAT describe in writing the structure and function of a neuron (POGIL 29 & 30).	(W): Draw a neuron and identify the axon, dendrite, cell body, synapse, and myelin sheath.	S6: Constructing explanations
8	R8	2.C.1	WHST9-12.1	SWBAT explain in writing how feedback mechanisms regulate cellular function (POGIL 27 & 28).	(W): Describe in 2 - 4 sentences an example of negative feedback.	S6: Constructing explanations

Subject	AP Biology
Unit	Unit 6: Novartis SCD Expedition
Est. Length	13 lessons (May - June)
Big Idea	Targeted therapy be used to treat sickle cell disease (SCD)
Essential Questions	1. What are the molecular causes of SCD? 2. How can molecular biology be used to identify SCD patients? 3. What treatments are available for SCD?
Advanced Placement Standards (AP) *Power standards in bold	1.A: Change in the genetic makeup of a population over time is evolution. ● 1.A.2: Natural selection acts on phenotypic variations in populations. 3.A: Heritable information provides for continuity of life. ● 3.A.1: DNA, and in some cases RNA, is the primary source of heritable information. 3.C: The processing of genetic information is imperfect & is a source of genetic variation. ● 3.C.1: Changes in genotype can result in changes in phenotype. 4.A: Interactions within biological systems lead to complex properties. ● 4.A.1: The subcomponents of biological molecules and their sequence determine the properties of that molecule.
Common Core State Standards (CCSS)	Reading ● RST11-12.1: Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. ● RST11-12.7: Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g. quantitative data, video, multimedia) in order to address a question or solve a problem. ● RST11-12.8: Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. ● RST11-12:9: Synthesize information from a range of sources (e.g. texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept resolving conflicting information when possible. Writing ● WHST9-12.1: Write arguments focused on discipline-specific content.

	● WHST9-12.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. ● WHST9-12.5: Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. ● WHST9-12.7: Conduct short as well as more sustained research projects to ansewr a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. ● WHST9-12.9: Draw evidence from informational texts to support analysis, reflection, and research. ● WHST11-12.8: Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
Science Practices (SP)	**1. Asking scientific questions & defining engineering problems** 2. Developing & using models 3. Planning & carrying out investigations **4. Analyzing & interpreting data** 5. Using mathematics & computational thinking 6. Constructing scientific explanations & designing engineering solutions **7. Engaging in argument from evidence** 8. Obtaining, evaluating, and communicating information
Assessment Alignment	Major assessments ● Summary Graphic (BA4) ● Group Presentation (MAJ)
Honors Assignments	Not required for AP Courses
20 Key Vocabulary Words	HbA, HbS, hemoglobin, point mutation, polymerase chain reaction, sickle cell disease (SCD)

Prior knowledge that students have entering this unit

1. Students have learned about how genetic variation can affect phenotypes in specific environments.
2. Students have some knowledge of biotechnology techniques.
3. Students have an understanding of evolution, genetics, and systems biology.

Where this knowledge goes next

1. Students will apply this knowledge in college biology courses.

Descriptive outline narrative of unit

In collaboration with the Community Exploration & Learning Lab (CELL), students will take four trips Novartis to examine the molecular biology of sickle cell disease (SCD), including using PCR to examine the genotypes of different SCD samples. Students will also collaborate with Novartis scientists to learn about SCD and refine their understanding of SCD.

In classes at CCSC, students will be separated into four groups to address one of the following questions:

- What is known about the history of SCD?
- What is the molecular biology of SCD?
- What symptoms do patients with SCD experience?
- What current treatments and future cures are possible for SCD patients?

Students will work in groups to produce two deliverables. The first will be a graphic, produced individually, that summarizes one aspect of the SCD exploration. Second, students will work to produce a group presentation for Novartis scientists that will address one of the above questions about SCD.

Day	Lesson #/name	AP	CCSS	Content Objective	Language Objective	Science practice(s)
1	N1	1.A.2	RST11-12.1	SWBAT summarize in writing how sickle cell disease (SCD) arises from genetic variation in humans.	(W): Explain in 3 - 5 sentences how SCD arises from point mutations in DNA.	SP1: Asking questions

2	N2	4.A.1	RST11-12.1	SWBAT build a model of normal and mutant hemoglobin.	(S): Explain to a partner how point mutations affect protein folding.	SP2: Develop & use models
3	N3	3.A.1	RST11-12.7	SWBAT complete part 1 of the Novartis expedition.	(R): Read a protocol and identify the equipment necessary to complete step of the procedure.	SP3: Planning investigations
4	N4	3.A.1	RST11-12.7	SWBAT complete part 2 of the Novartis expedition.	(R): Read a protocol and identify the equipment necessary to complete step of the procedure.	SP3: Planning investigations
5	N5	3.C.1	RST11-12.7	SWBAT complete part 3 of the Novartis expedition.	(R): Read a protocol and identify the equipment necessary to complete step of the procedure.	SP3: Planning investigations
6	N6	3.C.1	RST11-12.7	SWBAT complete part 4 of the Novartis expedition.	(R): Read a protocol and identify the equipment necessary to complete step of the procedure.	SP3: Planning investigations
7	N7	4.A.1	WHST9-12.2	SWBAT prepare a rough draft of their graphic summary of SCD.	(W): Make a concept map with at least six different nodes.	SP8: Communicating information
8	N8	4.A.1	WHST9-12.2	SWBAT prepare a final draft of their graphic summary of SCD.	(W): Revise a concept map by adding new nodes to the graphic.	SP8: Communicating information
9	N9	3.C.1	RST11-12.8	SWBAT analyze molecular data from SCD experiments with Novartis scientists.	(S): Explain to a partner or a Novartis scientist how electrophoresis gels can be used to analyze SCD.	SP5: Analyzing & interpreting data
10	N10	4.A.1	RST11-12.7	SWBAT identify three valid resources to answer their question about SCD.	(R): Use an Internet search to identify valid sources to learn about SCD.	SP8: Communicating information
11	N11	4.A.1	RST11-12.7	SWBAT identify new information to add to their PPT presentation.	(S): Discuss with a partner how new sources can be integrated	SP8: Communicating information

					into the SCD presentation.	
12	N12	4.A.1	RST11-12.7	SWBAT complete and practice their PPT presentation.	(S): Read text from slides to the group and listen to feedback on the presentation.	SP8: Communicating information
13	N13	4.A.1	N/A	SWBAT present an answer to their SCD question to Novartis scientists.	(S): Read and explain text from slides to Novartis scientists to answer a question about SCD.	SP8: Communicating information