

Kenilworth Public Schools

Curriculum Guide

Content Area: AP Biology
Grade: 11-12
BOE Approved: 3/13/2017

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AP Biology – Grades 11 & 12 Scope and Sequence

Unit 1- Chemistry of Life	Unit 2- Cell Structure & Function	Unit 3- Cellular Energetics	Unit 4- Cell Communication & Cell Cycle	Unit 5- Heredity
Weeks 1-4	Weeks 5-8	Weeks 9-13	Weeks 14-17	Weeks 18-21
<p><i>Unit Description:</i> Introduction to the AP course as well as a review of statistics needed for the course. Chemistry content is focused on this unit including elements needed for life, water and hydrogen bonding, and the exploration of the structure and function of biological macromolecules.</p>	<p><i>Unit Description:</i> This unit focuses on the structures and functions related to the cell. This includes the subcellular components of a cell and cell size and its effect on cell function and its environment. The middle of this unit focuses on the plasma membrane and the movement of molecules in and out of the cell to achieve homeostasis (via passive and active transport). The last part of this unit emphasizes the differences between eukaryotic and prokaryotic cell structure and the evolutionary connection between them.</p>	<p><i>Unit Description:</i> The beginning of this unit focuses on enzymes. The structure, function and environmental impacts upon enzymes will be explored. The second half of this unit focuses on how energy is obtained and used in organisms via biological systems to achieve maximum fitness in their environments. Photosynthesis and cellular respiration will be discussed in detail.</p>	<p><i>Unit Description:</i> This unit explores how cells communicate with each other through signaling pathways. The specific pathways, the effects of changing any part of the pathways, and the concept of feedback will be demonstrated. The end of this unit will focus on how cells reproduce identical copies of themselves, and the regulation required to correctly make copies (and consequences from lack of regulation).</p>	<p><i>Unit Description:</i> The focus of this unit is how genetic information is stored and transmitted from one generation to the next. Patterns of inheritance via Mendel and non-Mendelian genetics will be used to show heredity.</p>
<p><i>Unit Targets:</i></p> <ul style="list-style-type: none"> • Explain how the properties of water that result from its 	<p><i>Unit Targets:</i></p> <ul style="list-style-type: none"> • Describe the structure and/or function of 	<p><i>Unit Targets:</i></p> <ul style="list-style-type: none"> • Describe the properties of enzymes. 	<p><i>Unit Targets:</i></p> <ul style="list-style-type: none"> • Describe ways that cells can communicate with one 	<p><i>Unit Targets:</i></p> <ul style="list-style-type: none"> • Explain how meiosis results in the transmission

<p>polarity and hydrogen bonding affect its biological function.</p> <ul style="list-style-type: none"> • Describe the composition of macromolecules required by living organisms. • Describe the properties of monomers and types of bonds that connect monomers in biological macromolecules. • Explain how a change in the subunits of a polymer may lead to changes in structure or function of the macromolecule. • Compare and contrast DNA and RNA 	<p>subcellular components and organelles.</p> <ul style="list-style-type: none"> • Explain how subcellular components and organelles contribute to the function of a cell. • Describe the structural features of a cell that allow organisms to capture, store and use energy. • Explain the effect of surface area-to-volume ratios on the exchange of materials between cell or organisms and the environment. • Explain how specialized structures and strategies are used for the efficient exchange of molecules to the environment. • Describe the roles of each of the components in maintaining the internal environment of the cell. • Explain how the structure of biological membranes influences selective permeability. • Describe the mechanisms that organisms use to maintain solute and water balance. • Describe the mechanisms organisms use to transport 	<ul style="list-style-type: none"> • Explain how enzymes affect the rate of biological reactions. • Explain how changes to the structure of an enzyme may affect its function. • Explain how the cellular environment affects enzyme activity. • Describe the role of energy in living organisms. • Describe the photosynthetic processes that allow organisms to capture and store energy. • Explain how cells capture energy from light and transfer it to biological molecules for storage and use. • Describe the processes that allow organisms to use energy stored in biological macromolecules. • Explain how cells obtain energy from biological macromolecules to power cell functions. • Explain the connection between variation in the number and types of molecules within cells to the ability of the organism to survive and/or reproduce 	<p>another.</p> <ul style="list-style-type: none"> • Describe the components of a signal transduction pathway. • Describe the role of components of a signal transduction pathway in producing a cellular response. • Describe the role of the environment in eliciting a cell response. • Describe the different types of cell responses elicited by a signal transduction pathway. • Explain how a change in the structure of any signaling molecule affects the activity of the signaling pathway. • Describe positive and/or negative feedback. • Explain how negative feedback helps to maintain homeostasis. • Explain how positive feedback affects homeostasis. • Describe the events that occur in the cell cycle. • Explain how mitosis results in the transmission of chromosomes from one 	<p>of chromosomes from one generation to the next.</p> <ul style="list-style-type: none"> • Compare and contrast the phases and outcomes of mitosis and meiosis. • Explain how the process of meiosis generates genetic diversity. • Explain how shared, conserved, fundamental processes and features support the concept of common ancestry. • Explain the inheritance of genes and traits as described by Mendel's laws. • Explain deviations from Mendel's model of the inheritance of traits. • Explain how the same genotype can result in multiple phenotypes under different environmental conditions. • Explain how chromosomal inheritance generates genetic variation in sexual reproduction.
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	<p>large molecules across the plasma membrane.</p> <ul style="list-style-type: none"> • Explain how the structure of a molecule affects its ability to pass through the plasma membrane. • Explain how concentration gradients affect the movement of molecules across membranes. • Explain how osmoregulatory mechanisms contribute to the health and survival of organisms. • Describe the processes that allow ions and other molecules to move across membranes. • Explain how internal membranes and membrane-bound organelles contribute to compartmentalization of eukaryotic cell functions. • Compare and contrast compartmentalization in prokaryotic and eukaryotic cells. • Describe the relationship between the functions of endosymbiotic organelles and their free-living ancestral counterparts. 	<p>in different environments.</p>	<p>generation to the next.</p> <ul style="list-style-type: none"> • Describe the role of checkpoints in regulating the cell cycle. • Describe the effects of disruptions to the cell cycle on the cell or organism. 	
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AP Biology – Grades 11 & 12 Scope and Sequence

Unit 6- Gene Expression & Regulation	Unit 7- Natural Selection	Unit 8- Ecology
Weeks 22-27	Weeks 28-33	Weeks 34-38
<p><i>Unit Description:</i> This unit will explore how an individual's genotype is shown through its phenotype. The difference between DNA & RNA will be reviewed as well as how DNA replicates itself. Protein synthesis is one of the main methods of gene expression, and the regulation of this process and the mutation that can arise will be explained. New biotechnological advances will be addressed.</p>	<p><i>Unit Description:</i> Natural selection drives evolution and diversity and unity of life. This unit will discuss the scientific evidence to show how it supports models about the origin of life on Earth and biological evolution. This will include mathematical calculations, population genetics, phylogeny and other types of evidence.</p>	<p><i>Unit Description:</i> This unit focuses on the interactions within a ecosystem are directly related to the amount of energy available and how it is able to evolve and respond to changes in its environment. The topics examined will include energy flow in ecosystems, interactions between and within populations, how organisms respond to their environment, biodiversity, and how humans and other organisms have disrupted ecosystems.</p>
<p><i>Unit Targets:</i></p> <ul style="list-style-type: none"> • Describe the structures involved in passing hereditary information from 1 generation to the next. • Describe the characteristics of DNA that allow it to be used as hereditary material. • Describe the mechanisms by which genetic information is copied. • 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 	<p><i>Unit Targets:</i></p> <ul style="list-style-type: none"> • 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. • Explain how random occurrences affect the genetic makeup of a population. • 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. 	<p><i>Unit Targets:</i></p> <ul style="list-style-type: none"> • 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

<p>genotype.</p> <ul style="list-style-type: none"> • Describe the types of interactions that regulate gene expression. • Explain how the location of regulatory sequences relates to their function. • Explain how the binding of transcription factors to promoter regions affects gene expression and/or the phenotype of the organism. • Explain the connection between the regulation of gene expression and phenotypic differences in cell and organisms. • 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. 	<ul style="list-style-type: none"> • Explain the impacts on the population if any of the conditions of Hardy-Weinberg 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 the factors that lead to the extinction of a population. • 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. 	<p>and heterotrophs enable the flow of energy within an ecosystem.</p> <ul style="list-style-type: none"> • 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. • 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.
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SAMPLE SYLLABUS #1

AP[®] Biology**Curricular Requirements**

CR1	The teacher and students have access to college-level resources including a recently published (within the last 10 years) college-level textbook and reference materials in print or electronic format.	<i>See page:</i> 2
CR2	The course provides opportunities to develop student understanding of the required content outlined in each of the units described in the AP Course and Exam Description (CED).	<i>See pages:</i> 2, 5, 6, 7, 9, 10, 11, 12, 14
CR3	The course provides opportunities to develop student understanding of the big ideas.	<i>See pages:</i> 8, 9, 12, 13, 15
CR4	The course provides opportunities for students to develop the skills related to Science Practice 1: Concept Explanation.	<i>See pages:</i> 5, 9, 10
CR5	The course provides opportunities for students to develop the skills related to Science Practice 2: Visual Representations.	<i>See pages:</i> 5, 7, 8, 10, 11, 13
CR6	The course provides opportunities for students to develop the skills related to Science Practice 3: Questions and Methods.	<i>See pages:</i> 10, 15
CR7	The course provides opportunities for students to develop the skills related to Science Practice 4: Representing and Describing Data.	<i>See pages:</i> 5, 9, 13, 15
CR8	The course provides opportunities for students to develop the skills related to Science Practice 5: Statistical Tests and Data Analysis.	<i>See pages:</i> 5, 10, 14, 15
CR9	The course provides opportunities for students to develop the skills related to Science Practice 6: Argumentation.	<i>See pages:</i> 5, 7, 9, 10, 13, 15
CR10	The course provides students with opportunities to apply their knowledge of AP Biology concepts to real-world questions or scenarios (including societal issues or technological innovations) to help them become scientifically literate citizens.	<i>See pages:</i> 11, 12
CR11	Students spend a minimum of 25% of instructional time engaged in a wide range of hands-on, inquiry-based laboratory investigations to support the learning of required content and development of science practice skills throughout the course. Students must conduct a minimum of two labs per big idea.	<i>See pages:</i> 3, 4, 7, 8, 11, 12, 13, 15
CR12	The course provides opportunities for students to record and present evidence of their laboratory investigations.	<i>See pages:</i> 3, 4

Advanced Placement Biology Sample Syllabus #1

Philosophy

This AP[®] Biology course is designed to offer students a solid curriculum in introductory college-level biology, and the course focuses on enduring conceptual understandings and the biological content that supports them. Science practices are employed to help students utilize inquiry-based learning that maximizes depth of learning. Therefore, the course is structured around big idea statements, enduring understandings, and science practices that allow students opportunities to develop an appreciation for the science of biology and to identify and understand unifying principles within a diversified biological world. The process of inquiry and the development of critical thinking skills are important components of my AP Biology course.

Instructional Context

AP Biology is offered to juniors and seniors at a high school that employs a typical 50-minute period daily schedule. Most students have taken and were successful in first-year biology and chemistry courses prior to enrolling in AP Biology. A summer assignment is used to review basic principles of biology and chemistry. This strategy also enables me to quickly engage students in activities that explore topics in biochemistry.

Instructional Resources

Urry, Lisa A., et al. *Campbell Biology*. Pearson Higher Education, Inc., 2018. **CR1**

Heitz, Jean, et al. *Practicing Biology: a Student Workbook*. Pearson Education, 2014.

AP Biology Investigative Labs: An Inquiry Approach. College Board.

Advanced Placement Biology Content

The AP course is structured around four big ideas, enduring understandings within the big ideas, and essential knowledge within the enduring understandings. Students are given opportunities to develop skills utilized by biologists as they employ the science practices throughout the course. The course is organized into eight units of instruction.

Units of Instruction **CR2**

Unit 1: Chemistry of Life

Unit 2: Cell Structure and Function

Unit 3: Cellular Energetics

Unit 4: Cell Communication and Cell Cycle

CR1

The syllabus must cite the title, author, and publication date of a college-level textbook. The primary course textbook must be published within the last 10 years.

CR2

The syllabus must include an outline of course content by unit title or topic using any organizational approach to demonstrate the inclusion of required course content.

Unit 5: Heredity

Unit 6: Gene Expression and Regulation

Unit 7: Natural Selection

Unit 8: Ecology

The Big Ideas (and how they are spiraled through the units)

Big Idea 1: Evolution (EVO) (Units 2, 5, 7, 8)

The process of evolution drives the diversity and unity of life.

Big Idea 2: Energetics (ENE) (Units 1, 2, 3, 4, 8)

Biological systems use energy and molecular building blocks to grow, reproduce, and maintain dynamic homeostasis.

Big Idea 3: Information Storage and Transmission (IST) (Units 1, 4, 5, 6, 8)

Living systems store, receive, transmit, and respond to information essential to life processes.

Big Idea 4: Systems Interactions (SYI) (Units 1, 2, 3, 5, 7, 8)

Biological systems interact, and these systems and their interactions exhibit complex properties.

Science Practices

1. Concept Explanation: Explain biological concepts, processes, and models presented in written format.
2. Visual Representations: Analyze visual representations of biological concepts and processes.
3. Questions and Methods: Determine scientific questions and methods.
4. Representing and Describing Data: Represent and describe data.
5. Statistical Tests and Data Analysis: Perform statistical tests and mathematical calculations to analyze and interpret data.
6. Argumentation: Develop and justify scientific arguments using evidence.

The Investigative Laboratory Component

This AP Biology course is structured around inquiry in the lab and in the use of the six science practices throughout the course.

Students are given the opportunity to engage in hands-on, inquiry-based investigations throughout the course for a minimum of 25% of the instructional time. **CR11**

Students will conduct a minimum of eight inquiry-based investigations (two per big idea throughout the course). The course will provide opportunities for students to develop, record, and communicate the results of their laboratory investigations. Students will be required to maintain a laboratory portfolio that includes lab reports of their investigative work. **CR12**

CR11

The syllabus must include an explicit statement that at least 25% of instructional time is spent engaged in hands-on, inquiry-based laboratory experiences.

CR12

The syllabus must include an explicit statement that students are required to maintain a lab notebook or portfolio (hard-copy or electronic).

The laboratory portfolio will contain varied methods of written student presentation of their investigative work, either original work, copy, or picture of the work (formal report, mini-poster, PowerPoint presentation, poster). Each method will require students to communicate and reflect on their investigative work through the following components:

- Testable question for the investigation
- Hypothesis or prediction of the results of experimentation
- Detailed methods (experimental variables, controls, constant variables)
- Description of data as shown in properly labeled tables and graphs
- Statistical analyses as appropriate
- Discussion and conclusions using evidence from the investigation. **CR12**

Big Ideas and Science Practices in the Investigative Labs **CR11**

(Descriptions of labs are listed within the units)

Investigative Lab	Big Idea	Science Practices	Unit	Lab Portfolio Entry
BLAST Lab	EVO	1, 2, 3, 4, 6	7	√
Natural Selection with Brine Shrimp	EVO	1, 2, 3, 4, 5, 6	7	√
Diffusion and Osmosis	ENE	1, 3, 4, 5, 6	2	√
Enzyme Catalysis	ENE	1, 3, 4, 5, 6	3	√
Photosynthesis and Cellular Respiration	ENE	1, 3, 4, 5, 6	3	√
Environmental Effects on Mitosis	IST	1, 2, 3, 4, 5, 6	4	√
Transformation	IST	1, 3, 4, 5, 6	6	√
Electrophoresis	IST	1, 4, 6	6	√
Isopod Behavior	SYI	1, 3, 4, 5, 6	8	√
Transpiration	SYI	1, 3, 4, 5, 6	8	√
Science Project	(open)	1, 3, 4, 5, 6	(open)	√

TOPICS AND TIMELINES (Units, Chapters, Topics)

Throughout each unit, **Topic Questions** will be provided to help students check their understanding. The Topic Questions are especially useful for confirming understanding of difficult or foundational topics before moving on to new content or skills that build upon prior topics. Topic Questions can be assigned before, during, or after a lesson, and as in-class work or homework. Students will get rationales for each **Topic Question** that will help them understand why an answer is correct or incorrect, and their results will reveal misunderstandings to help them target the content and skills needed for additional practice.

At the end of each unit or at key points within a unit, **Personal Progress Checks** will be provided in class or as homework assignments in AP Classroom. Students will get a personal report with feedback on every topic, skill, and question that they can use to chart their progress, and their results will come with rationales that explain every question's answer. One to two class periods are set aside to re-teach skills based on the results of the Personal Progress Checks.

CR12

The syllabus must describe how students will record and present evidence of their investigative work, including elements typically required in lab reporting.

CR11

The syllabus must list lab titles and brief descriptions including at least two labs from each big idea and must indicate how the lab experiences, collectively, provide students opportunities to apply all six science practices.

Unit 1: Chemistry of Life (5–7 Class Periods) **CR2**

Big Ideas: 2, 3, 4

Enduring Understandings:

- SYI-1. Living systems are organized in a hierarchy of structural levels that interact.
- ENE-1. The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.
- IST-1. Heritable information provides for continuity of life.

Textbook Chapter Resource:

1. Introduction: Themes in the Study of Life
2. The Chemical Context of Life
3. Water and Life
4. Carbon and the Molecular Diversity of Life
5. The Structure and Function of Large Biological Molecules

Unit 1 Topics:

- 1.1 Structure of Water and Hydrogen Bonding (Skill 2.A)
- 1.2 Elements of Life (Skill 2.A)
- 1.3 Introduction to Biological Macromolecules (Skill 2.A)
- 1.4 Properties of Biological Macromolecules (Skill 1.A)
- 1.5 Structure and Function of Biological Macromolecules (Skill 6.E.b)
- 1.6 Nucleic Acids (Skill 2.A)

Examples of Activities:

1. Students use construction paper to make models of atoms and molecules with magnetic backs in order to facilitate discussion, using a magnetic whiteboard, of basic chemistry concepts, including essential elements of life, bonding, ions, properties of water due to hydrogen bonding, and how these properties impact living systems. (Science Practice 2) **CR5**
2. Outside of lab activity: Exploring the Properties of Water. Students choose various water solutions and various coins to explore the question “How many drops can you get on the coin?” Students predict, experiment, graph data, and describe data. Five trials of each test will be used to calculate mean, standard deviation, and standard error of the mean to determine if there are statistical differences in means at the 95% confidence interval. (Science Practices 1, 4, 5) **CR7 CR8**
3. Students are provided with a visual of the tertiary structure of a protein showing positions of aspartic acid and lysine. Students predict how replacing lysine with another amino acid will affect the shape and function of the protein and then justify their prediction. (Science Practices 1, 2, 6) **CR5 CR9**
4. Students read an annotated paper, “Plastic for Dinner,” (original title: “A bacterium that degrades and assimilates polyethylene terephthalate”). Students are asked to rewrite the abstract in their own words to show understanding of concepts from this unit. (Science Practice 1) **CR4**

CR5

The syllabus must include a description of an instructional approach outside of labs (e.g., assignment or activity) in which students analyze visual representations of biological concepts and processes. The instructional approach must be labeled with the relevant science practice(s).

CR7

The syllabus must include a description of an instructional approach outside of labs (e.g., assignment or activity) in which students represent and describe data. The instructional approach must be labeled with the relevant science practice(s).

CR8

The syllabus must include a description of an instructional approach outside of labs (e.g., assignment or activity) in which students perform statistical tests and mathematical calculations to analyze and interpret data. The instructional approach must be labeled with the relevant science practice(s).

CR9

The syllabus must include a description of an instructional approach outside of labs (e.g., assignment or activity) in which students develop and justify scientific arguments using evidence. The instructional approach must be labeled with the relevant science practice(s).

5. The science project assignment is a long-term assignment where students engage in a study of a biological concept. The general plan for the activity due at the end of first semester is:

- Research topic to formulate a question
- Hypothesize
- Design a method with variable(s), control(s), and constant conditions to test the hypothesis (at least five trials)
- Analyze data and make conclusions, applying statistical analysis when appropriate
- Prepare a folder of the scientific work and prepare a visual (the idea is to prepare for the school science fair) (Science Practices 1, 3, 4, 5, 6)

CR4

The syllabus must include a description of an instructional approach outside of labs (e.g., assignment or activity) in which students explain biological concepts, processes, and models presented in written format. The instructional approach must be labeled with the relevant science practice(s).

Assessments:

Formative Assessment (for practice):

- Personal Progress Check Multiple Choice Questions (MCQ) for Unit 1
- Personal Progress Check Free Response Questions (FRQ) for Unit 1

Summative Assessment (for grade):

- Teacher Created Unit Test for Unit 1

Unit 2: Cell Structure and Function (11–13 Class Periods) CR2

Big Ideas: 1, 2, 4

Enduring Understandings:

- SYI-1. Living systems are organized in a hierarchy of structural levels that interact.
- ENE-1. The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.
- ENE-2. Cells have membranes that allow them to establish and maintain internal environments that are different from their external environments.
- EVO-1. Evolution is characterized by a change in the genetic makeup of a population over time and is supported by multiple lines of evidence.

Textbook Chapter Resource:

6. A Tour of the Cell
7. Membrane Structure and Function

Unit 2 Topics:

- 2.1 Cell Structure: Subcellular Components (Skill 1.A)
- 2.2 Cell Structure and Function (Skill 6.A)
- 2.3 Cell Size (Skill 2.D.a, Skill 5.A.d)
- 2.4 Plasma Membranes (Skill 2.A)
- 2.5 Membrane Permeability (Skill 3.D, 5.D.b)
- 2.6 Membrane Transport (Skill 3.E.b)
- 2.7 Facilitated Diffusion (Skill 6.E.b)
- 2.8 Tonicity and Osmoregulation (Skill 4.A)
- 2.9 Mechanisms of Transport (1.B)
- 2.10 Cell Compartmentalization (Skill 6.E.a)
- 2.11 Origins of Cell Compartmentalization (Skill 6.B)

Examples of Activities:

1. Students use common classroom items (paper clips, pens, coins, etc.) to create models of cells. As they explain their models and the structures they have included, one of the structures is removed and students are asked to make a claim about the impact of removal of that cellular structure from the cell. They then must justify their claim. (Science Practices 2, 6) **CR5 CR9**
2. Diffusion and Osmosis Investigative Lab: Students use agar cubes to explore surface-area-to-volume ratios. They explore diffusion rates of three sizes and calculate surface-area-to-volume ratios to explore the reason cells are small. A demonstration of glucose-starch solution in dialysis tubing submerged in iodine solution allows students to observe diffusion and osmosis and use evidence to support predictions about the movement of molecules. Students design an experiment using the dialysis tubing model to determine water potential of various plant tissues. The experiment involves graphically determining the molar concentration of solution in plant cells and the calculation of water potential. Descriptive statistics will also be applied to determine significant differences in data points. (Big Idea 2, Science Practices 1, 3, 4, 5, 6) **CR11**
3. Students are shown a diagram of an artificial cell containing sucrose solutions submerged in a beaker of a different solution. Students have to draw arrows to indicate molecule movement; identify solutions as hypertonic, isotonic, or hypotonic; draw arrows to indicate net osmosis; and predict and explain outcomes of the artificial cell emerged in the solution in the beaker. (Science Practices 2, 6) **CR5 CR9**
4. Students were given the homework assignment of viewing the video “Compartmentalization.” In this video, the author addresses differences in prokaryotic and eukaryotic cells, surface-area-to-volume relationships, impact of compartmentalization seen in eukaryotic cells, and the endosymbiont hypothesis. Students defend the claims presented in this video in a student-directed, teacher-facilitated, whole-class discussion. (Science Practices 1, 6) **CR9**

CR9

The syllabus must include a description of an instructional approach outside of labs (e.g., assignment or activity) in which students develop and justify scientific arguments using evidence. The instructional approach must be labeled with the relevant science practice(s).

Assessment:

Formative Assessment (for practice):

- Personal Progress Check MCQ for Unit 2
- Personal Progress Check FRQ for Unit 2

Summative Assessment (for grade):

- Unit Test for Unit 2

Unit 3: Cellular Energetics (14–17 Class Periods) **CR2**

Big Ideas: 2, 4

Enduring Understandings:

- ENE-1. The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.
- SYI-3. Naturally occurring diversity among and between components within biological systems affects interactions with the environment.

Textbook Chapter Resource:

8. An Introduction to Metabolism
9. Cellular Respiration and Fermentation
10. Photosynthesis

Unit 3 Topics:

- 3.1 Enzyme Structure (Skill 1.B)
- 3.2 Enzyme Catalysis (Skill 3.C.b, Skill 3.C.c)
- 3.3 Environmental Impacts on Enzyme Function (Skill 6.E.c)
- 3.4 Cellular Energy (Skill 6.C)
- 3.5 Photosynthesis (Skill 6.B)
- 3.6 Cellular Respiration (Skill 4.A)
- 3.7 Fitness (Skill 6.C)

Examples of Activities:

1. Using manipulatives provided by the teacher, students will model both fermentation and cellular respiration as they occur in a eukaryotic and prokaryotic cell. Students will describe differences in fermentation and respiration using their models. (Science Practices 1, 2) **CR5**
2. Enzyme Catalysis Investigative Lab: Students use a baseline activity to determine the effect of three different concentrations of turnip peroxidase on the catalysis of a hydrogen peroxide decomposition reaction. A colorimeter is used. Students use graphical analysis of absorbance versus time to give the rate of reaction. Using this guided activity, students explore enzyme catalysis by asking their own questions and designing an experiment to evaluate hypotheses. (Big Idea 2, Science Practices 1, 3, 4, 5, 6) **CR11**
3. Photosynthesis and Cellular Respiration Investigative Lab: Students will encapsulate *Chlorella* algae in alginate spheres. By placing the algae spheres in a carbon dioxide indicator, students will conduct a laboratory investigation to determine how light impacts photosynthesis (indicator turns purple if spheres are in bright light) and respiration (indicator turns yellow if spheres are kept in darkness). Students will be shown how to use a colorimeter to collect data from the experiment. Students then will design their own investigation using the algae spheres, including making hypotheses. Students will be required to discuss the quality of the data collected and how a follow-up experiment might be planned to improve the quality of data. (Big Idea 2, Science Practices 1, 3, 4, 5, 6) **CR11**
4. Students will complete a case study that focuses on five herbicides with different effects on photosynthesis. Students play the role of lab interns and explore photosynthesis and the herbicide effects by engaging in concept mapping, experimental design, data manipulation, and data analysis. The goal is to use the experimental data to predict the steps in photosynthesis that are inhibited by each herbicide. (Big Idea 2, Science Practices 1, 2, 4, 6) **CR3**

Assessment:

Formative Assessment (for practice):

- Personal Progress Check MCQ for Unit 3
- Personal Progress Check FRQ for Unit 3

Summative Assessment (for grade):

- Unit Test for Unit 3

CR3

The syllabus must include four student activities, one for each big idea, in which students engage with the big ideas outside of laboratory investigations. Each activity must be labeled on the syllabus with the related big idea(s).

Unit 4: Cell Communication and Cell Cycle (9–11 Class Periods) **CR2**

Big Ideas: 2, 3

Enduring Understandings:

- 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.

Textbook Chapter Resource:

11. Cell Communication
12. The Cell Cycle

Unit 4 Topics:

- 4.1 Cell Communication (Skill 1.B)
- 4.2 Introduction to Signal Transduction (Skill 1.A)
- 4.3 Signal Transduction (Skill 6.C)
- 4.4 Changes in Signal Transduction Pathways (Skill 6.E.b)
- 4.5 Feedback (Skill 6.E.b)
- 4.6 Cell Cycle (Skill 4.B.b, Skill 5.A.e)
- 4.7 Regulation of Cell Cycle (6.E.a)

Examples of Activities:

1. Students will be allowed to explore the meanings of reception, transduction, and cellular response by engaging in a strategy used to develop academic vocabulary. The meanings of the terms will be provided. Students will then write the meanings of the terms in their own words. They will then provide illustrations that depict the meanings. They will engage in group discussions using these terms as they explore cell communication concepts. (Science Practice 1) **CR4**
2. Students explore the meanings of reception, transduction, and cellular response in a live case study. Students learn about cell signaling through the work of a veterinarian who is treating a dog that has tremors and trouble standing up. They will analyze graphical data, make claims, and provide reasoning to determine what part of the signaling pathway may have a flaw that is causing the tremors that the dog is experiencing. (Science Practices 1, 4, 6) **CR7 CR9**
3. Students will utilize pop-beads to model the process of mitosis. (Science Practice 2) **CR3**
4. Environmental Effects on Mitosis Investigative Laboratory: Students model mitosis with pop beads. In a guided investigation, students explore the effects of the environment on mitosis by investigating if onion roots that are treated with bean lectin have an increased mitotic rate in cells. Students then design their own investigations to test the effect of various chemicals on mitotic process in onion cells. Students count the cells that are in interphase and mitosis and use the chi square test to analyze data. Students must make a claim about the impact of the chemical on mitosis in onion root cells and then justify their claim using evidence. (Big Idea 3, Science Practices 1, 2, 3, 4, 5, 6) **CR11**

Assessment:

Formative Assessment (for practice):

- Personal Progress Check MCQ for Unit 4
- Personal Progress Check FRQ for Unit 4

Summative Assessment (for grade):

- Unit Test for Unit 4

Unit 5: Heredity (9–11 Class Periods) **CR2**

Big Ideas: 1, 3, 4

Enduring Understandings:

- IST-1. Heritable information provides for continuity of life.
- EVO-2. Organisms are linked by lines of descent from common ancestry.
- SYI-3. Naturally occurring diversity among and between components within biological systems affects interactions with the environment.

Textbook Chapter Resource:

13. Meiosis and Sexual Life Cycles
14. Mendel and the Gene Idea
15. The Chromosomal Basis of Inheritance

Unit 5 Topics:

- 5.1 Meiosis (Skill 1.B)
- 5.2 Meiosis and Genetic Diversity (Skill 3.A)
- 5.3 Mendelian Genetics (Skill 5.C, Skill 6.E.c)
- 5.4 Non-Mendelian Genetics (Skill 5.A.b, Skill 5.C)
- 5.5 Environmental Effects on Phenotype (Skill 1.C)
- 5.6 Chromosomal Inheritance (Skill 6.E.b)

Examples of Activities:

1. Students will be given data collected from F1 and F2 generations of two fruit fly genetic crosses. Students will use the results to predict the mode of inheritance of the crosses. They will use the data to calculate chi square values and use the statistic to reject or fail to reject a null hypothesis that has been made for each cross. (Science Practices 1, 5) **CR4 CR8**
2. Students analyze outcomes of *Sordaria* crosses using chi square statistics, determine phenotypes due to crossover or noncrossover, and determine percent recombination and map units. They will compare their observations with the known map distance from gene to centromere. (Science Practices 1, 5) **CR4 CR8**
3. Students will use a chromosome bead kit to simulate the process of meiosis and explain when haploidy occurs. (Science Practice 2) **CR5**
4. “Roses are red, violets are blue, why are my hydrangeas red or blue?” In a think-pair-share activity, students make a prediction about how the environment (soil pH) will affect the phenotype of hydrangea blossoms, and they develop and describe an experiment to test their prediction. Students then explain, with justification, the expected outcomes. This is a student-directed, teacher-facilitated activity. (Science Practice 3, 6) **CR6 CR9**

CR6

The syllabus must include a description of an instructional approach outside of labs (e.g., assignment or activity) in which students determine scientific questions and methods. The instructional approach must be labeled with the relevant science practice(s).

5. Students complete the real-world activity *Cancer and the Loss of the Cell Cycle Control*. In pairs, one student is assigned a normal karyotype and the other student is assigned a karyotype with chromosomal mutations. Students utilize information in the activity to determine whether their karyotype is normal or cancerous. Students engage in a whole-class discussion to explore how the cell cycle is impacted by UV radiation and/or viruses. The discussion will include HPV vaccines and whether scientific research can be independent of social and ethical values. (Science Practices 1, 2, 6) **CR10**

Assessment:

Formative Assessment (for practice):

- Personal Progress Check MCQ for Unit 5
- Personal Progress Check FRQ for Unit 5

Summative Assessment (for grade):

- Unit Test for Unit 5

Unit 6: Gene Expression and Gene Regulation (18–21 Class Periods) **CR2**

Big Idea: 3

Enduring Understandings:

- IST-1. Heritable information provides for continuity of life.
- IST-2. Differences in the expression of genes account for some of the phenotypic differences between organisms.
- IST-4. The processing of genetic information is imperfect and is a source of genetic variation.

Textbook Chapter Resource:

16. The Molecular Basis of Inheritance
17. Gene Expression: From Gene to Protein
18. Regulation of Gene Expression
19. DNA Tools and Biotechnology

Unit 6 Topics:

- 6.1 DNA and RNA Structure (Skill 1.C)
- 6.2 Replication (Skill 2.B.b)
- 6.3 Transcription and RNA Processing (Skill 2.B.b)
- 6.4 Translation (Skill 2.D.b, Skill 6.E.a)
- 6.5 Regulation of Gene Expression (Skill 6.A)
- 6.6 Gene Expression and Cell Specialization (Skill 6.B)
- 6.7 Mutations (Skill 2.C, Skill 3.D)
- 6.8 Biotechnology (Skill 6.D)

Examples of Activities:

1. Students will be given a DNA sequence (template and nontemplate strand). Using manipulatives for molecules, ribosomes, and other components, students will build a dynamic model of the processes of transcription and translation. They will then use the model to explain the two processes to other students. (Science Practice 1, 2) **CR5**
2. Transformation Investigative Laboratory: Students will perform a transformation experiment in which they transform a bacterial cell to contain a plasmid with a gene that can be expressed to produce protein products that make the cell glow. Students

CR10

The syllabus must label and provide a description of at least one activity requiring students to apply their knowledge of AP Biology concepts to understand real-world questions or scenarios.

will then study the structure of the plasmid and make predictions regarding growth on various agar plates (LB plates, plates with ampicillin and arabinose added). Students will investigate with procedures they think will improve the transformation efficiency on “investigative” plates. They will then examine the bacterial growth afterwards and collect quantitative data. They will calculate transformation efficiency. (Big Idea 3, Science Practices 1, 3, 4, 5, 6) **CR11**

3. Electrophoresis Investigative Laboratory: Students will use microtechniques to restrict DNA and, using a marker DNA along with “crime scene” and “suspect” DNA, predict which suspect matches the crime scene using the principles of gel electrophoresis. Students will collect quantitative data by using the marker DNA results to graph data on semilog (Log Y) graph paper. They will use band migration distances and predict band sizes by extrapolating from their graphs. Students will make claims and justify those claims using evidence from the investigative lab work. (Big Idea 3, Science Practices 1, 4, 6) **CR11**
4. Real-World Activity: Students will be allowed to collect and orally present evidence supporting the affirmative and negative arguments of using CRISPR-Cas9. Students will be expected to show biological understanding of how this biotechnological tool works and the impacts of its use on society. (Science Practices 1, 6) **CR10**
5. Students will complete the activity Modeling the Regulatory Switches of the *PITX1* Gene in Stickleback Fish. This hands-on activity supports the short film *The Making of the Fittest: Evolving Switches, Evolving Bodies*, and aims to help students understand eukaryotic gene regulation and its role in body development using the example of a well-studied gene called *PITX1*. Students will interpret molecular diagrams of eukaryotic gene transcription to familiarize themselves with the molecular components and mechanisms responsible for regulating gene transcription. They will then create models showing how *PITX1* gene transcription is regulated in two morphologically different populations of stickleback fish. (Big Idea 3, Science Practices 1, 2, 6) **CR3**

Assessment:

Formative Assessment (for practice):

- Personal Progress Check MCQ for Unit 6
- Personal Progress Check FRQ for Unit 6

Summative Assessment (for grade):

- Unit Test for Unit 6

Unit 7: Natural Selection (20–23 Class Periods) **CR2**

Big Ideas: 1,4

Enduring Understandings:

- EVO-1. Evolution is characterized by a change in the genetic makeup of a population over time and is supported by multiple lines of evidence.
- EVO-2. Organisms are linked by lines of descent from common ancestry.
- EVO-3. Life continues to evolve within a changing environment.
- SYI-3. Natural occurring diversity among and between components within biological systems affects interactions with the environment.

Textbook Chapter Resource:

22. Descent with Modification: A Darwinian View of Life
23. The Evolution of Populations
24. The Origin of Species
25. The History of Life on Earth
26. Phylogeny and the Tree of Life

Unit 7 Topics:

- 7.1 Introduction to Natural Selection (Skill 2.A)
- 7.2 Natural Selection (Skill 1.B)
- 7.3 Artificial Selection (Skill 4.B.c)
- 7.4 Population Genetics (Skill 3.B)
- 7.5 Hardy-Weinberg Equilibrium (Skill 5.A.a, Skill 1.C)
- 7.6 Evidence of Evolution (Skill 4.B.a)
- 7.7 Common Ancestry (Skill 6.E.b)
- 7.8 Continuing Evolution (Skill 3.E.a)
- 7.9 Phylogeny (Skill 2.D.c)
- 7.10 Speciation (Skill 6.E.a, Skill 2.B.a)
- 7.11 Extinction (Skill 3.B)
- 7.12 Variations in Populations (Skill 6.C)
- 7.13 Origin of Life on Earth (Skill 3.B)

Examples of Activities:

1. Students will complete a modeling activity titled Investigating Common Descent. They will first hypothesize a morphological tree of interrelatedness of a gorilla, chimpanzee, and human. Using colored paper clips, students will work in groups of four to “synthesize” strands of DNA of all three organisms, including a “common ancestor.” They will use their models to test hypotheses and, using graphs, determine which one is best supported by data. In addition, students will explore the impact of a nucleotide substitution mutation on the outcome of the relatedness of the organisms. (Science Practices 2, 4, 6) **CR5 CR7 CR9**
2. During a student-directed, teacher-facilitated activity, Phylogenetic Trees, students explore how changes in gene sequences allow biologists to reconstruct the evolutionary relationships between related species. Students explore a phylogenetic tree of bears. They then explore how DNA sequence diversion can help biologists analyze relatedness of organisms. Finally, students compare cytochrome c amino acid sequence data and propose a phylogenetic tree based on this data. The activity allows students opportunities to evaluate data and make and justify claims. (Big Idea 1, Science Practices 2, 4, 6) **CR3**
3. BLAST Investigative Laboratory: Students will learn how to analyze cladograms and understand evolutionary relationships using the Basic Local Alignment Sequencing Tool. Students will analyze morphological details about a newly discovered fossil, hypothesize as to the position of the fossil in a preconstructed cladogram, then test the hypothesis using BLAST. Once students become comfortable with BLAST, they will use the tool to answer questions of their choice regarding gene sequences. Since students have already investigated the action of the enzyme catalase, they might explore the relatedness of organisms with respect to catalase. (Big Idea 1, Science Practices 1, 2, 3, 4, 6) **CR11**
4. Natural Selection with Brine Shrimp Investigative Laboratory: Students will use brine shrimp to explore principles of natural selection. Students first review a cladogram showing physical adaptations and possible evolutionary relationships of the branchiopods, the class of arthropods that includes brine shrimp. In a guided activity, students explore brine shrimp adaptations by studying brine shrimp egg-hatching rate in salt solutions of varying concentrations. They then design their own investigation to explore natural selection using brine shrimp eggs. The investigation will require the development of questions and methods and the representation and analysis of data. In addition, appropriate statistical analysis will be required. (Big Idea 1, Science Practices 1, 2, 3, 4, 5, 6) **CR11**

5. From the College Board's AP Biology Lab Manual for students, copyright 2001: Lab # 8, Population Genetics and Evolution. This is a simulation (model) studying Hardy-Weinberg equilibrium in populations. Multiple case studies allow students to analyze the impact of selection and genetic drift on allele frequencies. Allele frequencies are calculated by analyzing data at the end of five generations of mating and the chi square statistic is used. In addition, students work several HW problems using the HW equation. (Big Idea 1, Science Practices 2, 5) **CR8**

Assessment:

Formative Assessment (for practice):

- Personal Progress Check MCQ for Unit 7
- Personal Progress Check FRQ for Unit 7

Summative Assessment (for grade):

- Unit Test for Unit 7

Unit 8: Ecology (18–21 Class Periods) **CR2**

Big Ideas: 1, 2, 4

Enduring Understandings:

- ENE-3. Timing and coordination of biological mechanisms involved in growth, reproduction, and homeostasis depend on organisms responding to environmental cues.
- IST-5. Transmission of information results in changes within and between biological systems.
- ENE-1. The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.
- SYI-1. Living systems are organized in a hierarchy of structural levels that interact.
- ENE-4. Communities and ecosystems change on the basis of interactions among populations and disruptions to the environment.
- SYI-3. Naturally occurring diversity among and between components within biological systems affects interactions with the environment.
- EVO-1. Evolution is characterized by change in the genetic makeup of a population over time and is supported by multiple lines of evidence.
- SYI-2. Competition and cooperation are important aspects of biological systems.

Textbook Chapter Resource:

51. Animal Behavior
52. An Introduction to Ecology and the Biosphere
53. Population Ecology
54. Community Ecology
55. Ecosystems and Restoration Ecology

Unit 8 Topics:

- 8.1 Responses to the Environment (Skill 3.C.a)
- 8.2 Energy Flow Through Ecosystems (Skill 6.D)
- 8.3 Population Ecology (Skill 4.A)
- 8.4 Effect of Density of Populations (Skill 5.A.c)
- 8.5 Community Ecology (Skill 5.B)
- 8.6 Biodiversity (Skill 6.E.c)
- 8.7 Disruptions to Ecosystems (Skill 5.D.a, Skill 5.D.b)

Examples of Activities:

1. Isopod Behavior Investigative Laboratory: Students design their own experiments to investigate a question they have about animal behavior (kinesis and taxis in isopods). Students will perform chi square hypothesis testing on their results. They will be required to make claims and justify their claims based on experimental outcomes. The entire investigative laboratory and experimental design and analysis will be displayed on a poster, and students will be allowed to verbally share the outcomes of their results to peers. (Big Idea 4, Science Practices 1, 3, 4, 5, 6). **CR11**
2. Transpiration Investigative Laboratory: Students will design their own experiments to investigate a variable that might impact transpiration rate. First, students explore stomatal density by calculating average density of stomata on plants (top vs. bottom of leaves of same species, bottoms of leaves of different species, etc.). They then use descriptive statistics to determine whether means are statistically different. Students then design their own investigation of transpiration using the whole plant method and at least three plants in order to get means. Students must graph the percent change in mass of the plants per mm^2 over three days in order to calculate and discuss rates of transpiration. They use error bars at the 95% confidence interval to determine whether sample means are statistically different. (Big Idea 4, Science Practices 1, 3, 4, 5, 6) **CR11**
3. Students read an overview of a scientist's research. In the overview, students are given background information on a field experiment conducted by a group of scientists who were investigating whether climate change would benefit spotted knapweed, an invasive species in Michigan. Students identify the hypothesis, identify independent and dependent variables, construct a graph of data, and make a claim regarding this invasive species. They support their claim with evidence and use biological reasoning to connect the evidence to the claim. (Big Idea 4, Science Practices 1, 3, 4, 6) **CR3 CR6**
4. Students explore the question "What models can you use to calculate how quickly a population can grow?" Students utilize the appropriate equations on the AP Biology Equations and Formulas sheet to make and use calculations to analyze various population growth scenarios. They make predictions and use reasoning based on calculations and statistics. (Science Practices 2, 5, 6) **CR8 CR9**
5. Students read a scenario about a foraging model of Northwestern crows. A graph is provided that summarizes the results of an experiment conducted to measure the height necessary to dropping sea snails in order to break the shell of the snail. Students interpret the data from the graph. (Science Practices 1, 4) **CR7**

Assessment:

Formative Assessment (for practice):

- Personal Progress Check MCQ for Unit 8
- Personal Progress Check FRQ for Unit 8

Summative Assessment (for grade):

- Unit Test for Unit 8