Curricular Requirements	**Page(s)**
CR1 Students and teachers use a recently published (within the last 10 years) college-level biology textbook.	3
CR2 The course is structured around the enduring understandings within the big ideas as described in the AP® Biology Curriculum Framework.	3, 5, 6, 7, 10, 12, 14, 16, 17,19, 21, 23, 24
CR3a Students connect the enduring understandings within Big Idea 1 (the process of evolution drives the diversity and unity of life) to at least one other big idea.	3
CR3b Students connect the enduring understandings within Big Idea 2(biological systems utilize free energy and molecular building blocks to grow, to reproduce, and to maintain dynamic homeostasis) to at least one other big idea.	7, 12
CR3c Students connect the enduring understandings within Big Idea 3(living systems store, retrieve, transmit, and respond to information essential to life processes) to at least one other big idea.	17
CR3d Students connect the enduring understandings within Big Idea 4 (biological systems interact and these systems and their interactions possess complex properties) to at least one other big idea.	24
CR4a The course provides students with opportunities outside of thelaboratory investigations to meet the learning objectives within Big Idea 1.	4
CR4b The course provides students with opportunities outside of thelaboratory investigations to meet the learning objectives within Big Idea 2.	9
CR4c The course provides students with opportunities outside of thelaboratory investigations to meet the learning objectives within Big Idea 3.	17
CR4d The course provides students with opportunities outside of thelaboratory investigations to meet the learning objectives within Big Idea 4.	24
CR5 The course provides students with opportunities to connect their biological and scientific knowledge to major social issues (e.g., concerns, technological advances, innovations) to help them become scientifically literate citizens.	15
CR6 The student-directed laboratory investigations used throughout the course allow students to apply the seven science practices defined in the AP Biology Curriculum Framework and include at least two lab experiences in each of the four big ideas.	2, 7, 14
CR7 Students are provided the opportunity to engage in investigative laboratory work integrated throughout the course for a minimum of 25 percent of instructional time.	2
CR8 The course provides opportunities for students to develop and record evidence of their verbal, written and graphic communication skills through laboratory reports, summaries of literature or scientific investigations, and oral, written, or graphic presentations.	7

Course Overview:

This accelerated course exposes students to a college level course in both the amount and depth of material covered. It is designed to offer students a solid foundation in introductory college-level biology. The core focus of the course is to prepare the student to be successful on the AP exam given by the CollegeBoard in May. This course is designed around the AP Biology Curriculum Framework that focuses on the major concepts in biology and their connections. At least one of the four Big Ideas will be incorporated in every lesson throughout the course. The Essential Knowledge statements are utilized as lessons in the course. Key topics of each lesson include the same illustrative examples provided in Curriculum Framework, while the activities are based on learning objectives and science practices.

The four Big Ideas are as follows:

Big Idea 1: The process of evolution drives the diversity and unity of life.
Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce, and to maintain dynamic homeostasis.
Big Idea 3: Living systems store, retrieve, transmit, and respond to information essential to life processes.
Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties. **[CR2]**

The course of study includes 8 laboratory investigations, derived from the CollegeBoard lab manual of which there are 2 from each big idea. Students will practice lab techniques that will aid them later in college lab situations, they will keep a lab notebook, develop and test hypothesis, collect data, analyze data, discuss results and present findings. Students will maintain a laboratory notebook throughout the course that documents all of their laboratory investigations. The Science Practice skills will be worked on throughout the entire course and reinforced through opportunities to make observations, ask questions based on those observations and investigate their own questions both in and out of the designated lab times. The student directed and inquiry based laboratory investigations used throughout the course enable students to apply the seven science practices as defined in the Curriculum Framework. They will communicate lab results, using written, verbal and graphic skills. This communication may take place in group presentations, PowerPoint presentations, poster presentations, modeling and written reports. The total lab time will be a minimum of 25% of total instructional time, with investigations distributed throughout the course. **[CR6] [CR7] [CR8]**

Application of Science Practices in the Laboratory Investigations: **[CR6]**

Lab	SP 1	SP 2	SP 3	SP 4	SP 5	SP 6	SP 7
Lab 1: Artificial Selection	X	X			X		
Lab 2: Hardy-Weinberg	X	X			X		
Lab 4: Diffusion and Osmosis		X		X	X		
Lab 6: Cellular Respiration	X	X	X			X	X
Lab 8: Biotechnology: Bacterial Transformation	X		X		X	X	X
Lab 9: Biotechnology: Restriction Enzyme Analysis of DNA			X			X	
Lab 11: Transpiration	X	X		X		X	X
Lab 13: Enzyme Activity					X	X	X

Instructional Resources:

Campbell, Neil and Reece, Jane B. *AP Edition Biology,* Seventh Edition, Pearson Education, Inc. 2005 **[CR1]**

www.campbellbiology.com - the website to accompany the main text provides animations, investigations, other audio-visual resources to enhance instruction

Taylor, Martha. *Student Study Guide for Biology*, 7th edition, 2005 - accompanies text

AP Biology Investigative Labs: An Inquiry-Based Approach, New York: The CollegeBoard, 2012

AP Biology Lab Manual. New York: The College Board, 2001.

Anestis, Mark. *5 Steps to a 5 AP Biology* 2nd edition, 2007

Skloot, Rebecca. *The Immortal Life of Henrietta Lacks,* Random House, Inc. 2010

Unit 1: Evolution timing: 20-25 days

Big Idea 1: The process of evolution drives the diversity and unity of life. [CR2]

Unit 1 Laboratory Investigations:

- Lab 1: Artificial Selection (Wisconsin fast-plants) – Students will grow Fast Plants and select for specific traits over several generations.
- Lab 2: Mathematical Modeling: Hardy-Weinberg (former lab8) – Spreadsheet development to investigate factors affecting the Hardy-Weinberg equilibrium. **[CR3a]**

Chapters utilized in Unit 1:

From Campbell/Reece: 4, 22, 23, 24, 25, 26

Section 1: Enduring understanding 1.A: Change in the genetic makeup of a population over time is evolution. [CR2]

Lesson 1: Essential knowledge 1.A.1: Natural selection is a major mechanism of evolution.

Ch 22.2, 23.1

Topics:

Darwin's theory of natural selection, competition, favorable phenotypes survive and reproduce, evolutionary fitness, genetic variation, mutation, diverse gene pool, environmental role in evolutionary rate and direction, adaptation, advantage, chance and random events, small populations, Hardy-Weinberg equilibrium, large population, migration, net mutations, random mating, selection

Key Topics: (Illustrative examples)

Graphical analysis of allele frequencies in a population
Application of the Hardy-Weinberg equilibrium equation

Activities:

Students will be able to convert a data set from a table of numbers that reflect a change in the genetic makeup of a population over time and apply mathematical methods and conceptual understandings to investigate the cause(s) and effect(s) of this change. (Learning Objective 1.1 – Science Practice 1.5, 2.2)
Students will be able to evaluate evidence provided by data to qualitatively and quantitatively investigate the role of natural selection in evolution. (LO 1.2 - SP 2.2, 5.3)
Students will be able to apply mathematical methods to data from a real or simulated population to predict what will happen to the population in the future. (LO 1.3 - SP 2.2)

Lesson 2: Essential knowledge 1.A.2: Natural selection acts on phenotypic variations in populations.

Ch 23.2, 23.4

Topics:
Environmental changes, selective mechanisms, phenotypic variation control, new gene combinations, increases/decreases in fitness, human impact in other species

Key Topics: (Illustrative examples)
Flowering time in relation to global climate change
Peppered moth
Sickle cell anemia
Peppered moth
DDT resistance in insects
Artificial selection
Loss of genetic diversity within a crop species
Overuse of antibiotics

Activities:
Students will be able to evaluate data-based evidence that describes evolutionary changes in the genetic makeup of a population over time. [LO 1.4 - SP 5.3]
Students will be able to connect evolutionary changes in a population over time to a change in the environment. [LO 1.5 - SP 7.1]
Students analyze news articles about new cases of antibiotic resistance. **[CR4a]**

Lesson 3: Essential knowledge 1.A.3: Evolutionary change is also driven by random processes.
Ch 23. 3

Topics:
Genetic drift, nonselective processes, evolution in small populations, reducing variation, creating differences among members of same species

Key Topics: (Illustrative examples)
None in this lesson

Activities:
The student is able to use data from mathematical models based on the Hardy-Weinberg equilibrium to analyze genetic drift and effects of selection in the evolution of specific populations. [LO 1.6 - SP 1.4, 2.1]
The student is able to justify data from mathematical models based on the Hardy-Weinberg equilibrium to analyze genetic drift and the effects of selection in the evolution of specific populations. [LO 1.7 - SP 2.1]
The student is able to make predictions about the effects of genetic drift, migration and artificial selection on the genetic makeup of a population. [LO 1.8 - SP 6.4]

Lesson 4: Essential knowledge 1.A.4: Biological evolution is supported by scientific evidence from many disciplines, including mathematics.
Ch 22.3, 26.2

Topics:
Geographical evidence, geological evidence, physical evidence, chemical evidence, mathematical applications, molecular evidence, morphological evidence, genetic evidence, extinct organisms, fossils, dating, isotopes, phylogenetic trees, morphological homologies, vestigial structures, biochemical and genetic similarities

Key Topics: (Illustrative examples)
Graphical analyses of allele frequencies in a population
Analysis of sequence data sets
Analysis of phylogenetic trees
Construction of phylogenetic trees based on sequence data

Activities:
The student is able to evaluate evidence provided by data from many scientific disciplines that support biological evolution. [LO 1.9 - SP 5.3]
The student is able to refine evidence based on data from many scientific disciplines that support biological evolution. [LO 1.10 - SP 5.2]

The student is able to design a plan to answer scientific questions regarding how organisms have changed over time using information from morphology, biochemistry and geology. [LO 1.11 - SP 4.2]
The student is able to connect scientific evidence from many scientific disciplines to support the modern concept of evolution. [LO 1.12 - SP 7.1]
The student is able to construct and/or justify mathematical models, diagrams or simulations that represent processes of biological evolution. [LO 1.13 - SP 1.1, 2.1]

Section 2: Enduring understanding 1.B: Organisms are linked by lines of descent from common ancestry. [CR2]

Lesson 5: Essential knowledge 1.B.1: Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today.

Ch 26.1, 26.3, 26.4, 26.5

Topics:
Structural evidence, functional evidence, relatedness, domains, eukaryotes, DNA, RNA, transcription, translation, replication, shared genetic code, conserved metabolic pathways

Key Topics: (Illustrative examples)
Cytoskeleton (a network of structural proteins that facilitate cell movement, morphological integrity and organelle transport)
Membrane-bound organelles (mitochondria and/or chloroplasts)
Linear chromosomes
Endomembrane systems, including the nuclear envelope

Activities:
The student is able to pose scientific questions that correctly identify essential properties of shared, core life processes that provide insights into the history of life on Earth. [LO 1.14 - SP 3.1]
The student is able to describe specific examples of conserved core biological processes and features shared by all domains or within one domain of life, and how these shared, conserved core processes and features support the concept of common ancestry for all organisms. [LO 1.15 - SP 7.2]
The student is able to justify the scientific claim that organisms share many conserved core processes and features that evolved and are widely distributed among organisms today. [LO 1.16 - SP 6.1]

Lesson 6: Essential knowledge 1.B.2: Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested.

Ch 25.1, 25.2, 25.3

Topics:
Phylogenetic trees, cladograms, speciation, common ancestor, morphological similarities, DNA similarities, protein sequence similarities, relatedness, dynamic

Key Topics: (Illustrative examples)
Number of heart chambers in animals
Opposable thumbs
Absence of legs in some sea mammals

Activities:
The student is able to pose scientific questions abouta group of organisms whose relatedness is described by a phylogenetic tree or cladogram in order to (1) identify shared characteristics, (2) make inferences about the evolutionary history of the group, and (3) identify character data that could extend or improve the phylogenetic tree. [LO 1.17 - SP 3.1]
The student is able to evaluate evidence provided by a data set in conjunction with a phylogenetic tree or a simple cladogram to determine evolutionary history and speciation. [LO 1.18 - SP 5.3]
The student is able create a phylogenetic tree or simple cladogram that correctly represents evolutionary history and speciation from a provided data set. [LO 1.19 - SP 1.1]

Section 3: Enduring understanding 1.C: Life continues to evolve within a changing environment. [CR2]

Lesson 7: Essential knowledge 1.C.1: Speciation and extinction have occurred throughout the Earth's history.

Ch 24.2, 24.3, 26.2

Topics:

Speciation rates, adaptive radiation, new habitats, extinction, ecological stress

Key Topics: (Illustrative examples)
Five major extinctions
Human impact on ecosystems and species extinction rates

Activities:
The student is able to analyze data related to questions of speciation and extinction throughout the Earth's history. [LO 1.20 - SP 5.1]
The student is able to design a plan for collecting data to investigate the scientific claim that speciation and extinction have occurred throughout the Earth's history. [LO 1.21 - SP 4.2]

Lesson 8: Essential knowledge 1.C.2: Speciation may occur when two populations become reproductively isolated from each other.
Ch 24.1

Topics:
Speciation, diversity, geographic barriers, pre-zygotic mechanisms, post-zygotic mechanisms, reproductive isolation, gene flow, polyploidy in plants

Key Topics: (Illustrative examples)
None utilized in this lesson

Activities:
The student is able to use data from a real or simulated population(s), based on graphs or models of types of selection, to predict what will happen to the population in the future. [LO 1.22 - SP 6.4]
The student is able to justify the selection of data that address questions related to reproductive isolation and speciation. [LO 1.23 - SP 4.1]
The student is able to describe speciation in an isolated population and connect it to change in gene frequency, change in environment, natural selection and/or genetic drift. [LO 1.24 - SP 7.2)

Lesson 9: Essential knowledge 1.C.3: Populations of organisms continue to evolve.
Ch 24.2

Topics:
Evidence for evolution in all species, continuing

Key Topics: (Illustrative examples)
Chemical resistance (mutations for resistance to antibiotics, pesticides, herbicides or chemotherapy drugs occur in the absence of the chemical)
Emergent diseases
Observed directional phenotypic change in a population (Grants' observations of Darwin's finches in the Galapagos)
A eukaryotic example that describes evolution of a structure or process such as heart chambers, limbs, the brain and the immune system

Activities:
The student is able to describe a model that represents evolution within a population. [LO 1.25 - SP 1.2]
The student is able to evaluate given data sets that illustrate evolution as an ongoing process. [LO 1.26 - SP 5.3]

Section 4: Enduring understanding 1.D: The origin of living systems is explained by natural processes. [CR2]

Lesson 10: Essential knowledge 1.D.1: There are several hypotheses about the natural origin of life on Earth, each with supporting scientific evidence.
Ch 4.1, 26.1, 26.3, 26.4, 26.5

Topics:
Scientific evidence, primitive Earth, inorganic precursors, organic molecules, synthesized, available free energy, absence of oxygen, monomers, amino acids, nucleotides, polymers, organic soup model, RNA

Key Topics: (Illustrative examples)
None utilized in this lesson
Activities:
The student is able to describe a scientific hypothesis about the origin of life on Earth. [LO 1.27 - SP 1.2]
The student is able to evaluate scientific questions based on hypotheses about the origin of life on Earth. [LO 1.28 - SP 3.3]
The student is able to describe the reasons for revisions of scientific hypotheses of the origin of life on Earth. [LO 1.29 - SP 6.3]
The student is able to evaluate scientific hypotheses about the origin of life on Earth. [LO 1.30 - SP 6.5]
The student is able to evaluate the accuracy and legitimacy of data to answer scientific questions about the origin of life on Earth. [LO 1.31 - SP 4.4]

Lesson 11: Essential knowledge 1.D.2: Scientific evidence from many different disciplines supports models of the origin of life.
Ch 26.6

Topics:
Geological evidence, origin of life, 4.6 bya, fossil evidence, 3.5 bya, organic from inorganic, common ancestral origin, common molecular building blocks, common genetic code

Key Topics: (Illustrative examples)
None

Activities:
The student is able to justify the selection of geological, physical and chemical data that reveal early Earth conditions. (LO 1.2 - SP 2.2, 5.3)

Unit 2: Energy Processes timing: 60-70 days

Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis. [CR2]

Unit 2 Laboratory investigations:

Lab 4: Diffusion and Osmosis – A demonstration using dialysis tubing (model) will allow students to make observations and to provide evidence for the diffusion of molecules; students set up an experiment regarding osmosis and concentration gradients after hypothesizing the outcome; data collection, calculations of percent change in mass, graphing percent change in mass and analysis of the data will follow. All work will be kept in the laboratory research notebook. **[CR3b] [CR6] [CR8]**

Lab 6: Cellular Respiration (old lab 5 revision) – Students will engage in the process of inquiry as they conduct an experiment to measure the rate of cell respiration in germinating peas at room temperature. Next, students will design a controlled experiment to answer a question of their choice that they asked while conducting the experiment at room temperature. Students will collect and determine cellular respiration rates and demonstrate an understanding of concepts involved by preparing a report in their laboratory research. **[CR6] [CR8]**

Chapters utilized in Unit 2:

From Campbell/Reece: 3, 4, 6, 7, 8, 9, 10, 11, 19, 21, 24, 38, 39, 40, 43, 50, 51, 52, 53, 54, 55

Section 1: Enduring understanding 2:A: Growth, reproduction and maintenance of the organization of living systems require free energy and matter. [CR2]

Lesson 1: Essential knowledge 2.A.1: All living systems require constant input of free energy.
Ch 8.1, 8.2, 8.3, 9.1, 9.2, 9.3, 9.4, 9.5, 10.1, 10.2, 10.3, 40.1, 40.2, 40.3, 40.4, 40.5, 51.3, 52.3, 52.4, 53.2, 54.1, 54.3

Topics:
Highly ordered systems, constant free energy input, loss of order, entropy, 2nd law of thermodynamics, entropy, coupling cellular processes, free energy, ATP, ADP, energy related pathways, organization, growth, reproduction, body temperature, metabolism, reproductive strategies, metabolic rate per unit body mass/size of organism, energy storage, population size, disruptions or ecosystems

Key Topics: (Illustrative examples)

Krebs cycle, Glycolysis, Calvin cycle, Fermentation, Endothermy, Ectothermy, Elevated floral temperatures in some plant species, Seasonal reproduction in animals and plants, Life-history strategy, producer level changes, energy resource changes affects on other trophic levels

Activities:
The student is able to explain how biological systems use free energy based on empirical data that all organisms require constant energy input to maintain organization, to grow and to reproduce. [LO 2.1 - SP 6.2]
The student is able to justify a scientific claim that free energy is required for living systems to maintain organization, to grow or to reproduce, but that multiple strategies exist in different living systems. [LO 2.2 - SP 6.1]
The student is able to predict how changes in free energy availability affect organisms, populations and ecosystems. [LO 2.3 - SP 6.4]

Lesson 2: Essential knowledge 2.A.2: Organisms capture and store free energy for use in biological processes.
Ch 9.1, 9.2, 9.3, 9.4, 9.5, 10.1, 10.2, 10.3'

Topics:
Autotrophs, photosynthetic, chemosynthetic, oxygen, heterotrophs, carbon compounds, hydrolysis, alcohol fermentation, lactic acid fermentation, electron acceptors, NADP+, cellular respiration, light-dependent reactions, ATP and NADPH, chlorophylls, energy level, Photosystems I and II, thylakoids, electron transport chain, electrochemical gradient, proton gradient, ATP synthase, Calvin cycle, stroma, oxygenated atmosphere, glycolysis, pyruvate, mitochondria, Krebs cycle, substrate level phosphorylation, coenzymes, FADH2, coupled reactions, terminal electron acceptor, oxygen, NADP+, inner mitochondrial membrane, oxidative phosphorylation, thermoregulation

Activities:
Students will use representations to pose scientific questions about what mechanisms and structural features allow organisms to capture, store and use free energy. [LO 2.4 - SP 1.4, 3.1]
The student is able to construct explanations of the mechanisms and structural features of cells that allow organisms to capture, store or use free energy. [LO 2.5 - SP 6.2]

Lesson 3: Essential knowledge 2.A.3: Organisms must exchange matter with the environment to grow, reproduce and maintain organization.
Ch 3.1, 3.2, 3.3, 4.1, 4.2, 6.2

Topics:
Carbon, nitrogen, phosphorus from environment, builds carbohydrates, proteins, lipids and nucleic acids, storage, cell formation, water properties, polarity and hydrogen bonding, surface area-to-volume ratios, resources, waste, cell size

Key Topics: (Illustrative examples)
Cohesion
Adhesion
High specific heat capacity
Universal solvent supports reactions
Heat of vaporization
Heat of fusion
Water's thermal conductivity
Root hairs
Cells of the alveoli
Cells of the villi
Microvilli

Activities:
The student is able to use calculated surface area-to-volume ratios to predict which cell(s) might eliminate wastes or procure nutrients faster by diffusion. [LO 2.6 - SP 2.2]
Students will be able to explain how cell size and shape affect the overall rate of nutrient intake and the rate of waste elimination. [LO 2.7 - SP 6.2]
The student is able to justify the selection of data regarding the types of molecules that an animal, plant or bacterium will take up as necessary building blocks and excrete as waste products. [LO 2.8 - SP 4.1]
The student is able to represent graphically or model quantitatively the exchange of molecules between an organism and its environment, and the subsequent use of these molecules to build new molecules that facilitate dynamic homeostasis, growth and reproduction. [LO 2.9 - SP 1.1, 1.4]

Section 2: Enduring understanding 2.B: Growth, reproduction and dynamic homeostasis require that cells create and maintain internal environments that are different from their external environments. [CR2]

Lesson 4: Essential knowledge 2.B.1: Cell membranes are selectively permeable due to their structure.

Ch 7.1, 7.2

Topics:

Membranes separate internal from external, selective permeability, fluid mosaic model, phospholipid molecules, embedded proteins, cholesterol, glycoproteins and glycolipids, hydrophilic, hydrophobic, aqueous, uncharged polar molecules, small nonpolar molecules, channel and transport proteins, aquaporins, plant cell walls, cellulose, prokaryotes and fungi

Key Topics: (Illustrative examples)

None

Activities:

The student is able to use representations and models to pose scientific questions about the properties of cell membranes and selective permeability based on molecular structure. [LO 2.10 - SP 1.4, 3.1]

The student is able to construct models that connect the movement of molecules across membranes with membrane structure and function. [LO 2.11 - SP 1.1, 7.1, 7.2]

The student is able to construct models connecting the movement of molecules across membranes with membrane structure and function. Students will include mechanisms of membrane transport. **[CR4b]**

Lesson 5: Essential knowledge 2.B.2: Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes.

Ch 7.3, 7.4, 7.5

Topics:

Passive transport, input of metabolic energy, net movement of molecules, high concentration to low concentration, membrane proteins, facilitated diffusion, hypotonic, hypertonic or isotonic, active transport, concentration gradients, endocytosis and exocytosis, vesicles

Key Topics: (Illustrative examples)

Glucose transport

Na+/K+ transport

Activities:

The student is able to use representations and models to analyze situations or solve problems qualitatively and quantitatively to investigate whether dynamic homeostasisis maintained by the active movement of molecules across membranes. [LO 2.12 - SP 1.4]

Lesson 6: Essential knowledge 2.B.3: Eukaryotic cells maintain internal membranes that partition the cell into specialized regions.

Ch 6.2, 6.3, 6.4, 6.5

Topics:

Internal membranes, minimize interactions, increasing surface area, membrane-bound organelles, compartmentalize, enzymatic reactions, Archaea and Bacteria,

Key Topics: (Illustrative examples)

Endoplasmic reticulum

Mitochondria

Chloroplasts

Golgi

Nuclear envelope

Activities:

The student is able to explain how internal membranes and organelles contribute to cell functions. [LO 2.13 - SP 6.2]

The student is able to use representations and models to describe differences in prokaryotic and eukaryotic cells. [LO 2.14 - SP 1.4]

Section 3: Enduring understanding 2.C: Organisms use feedback mechanisms to regulate growth and reproduction, and to maintain dynamic homeostasis. [CR2]

Lesson 7: Essential knowledge 2.C.1: Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental changes.

Ch 40.2, 40.4, 40.5

Topics:
Negative feedback, dynamic homeostasis, target set point, positive feedback, amplify responses, amplification, deleterious consequences

Key Topics: (Illustrative examples)
Operons in gene regulation
Temperature regulation in animals
Plant responses to water limitations
Lactation in mammals
Onset of labor in childbirth
Ripening of fruit
Diabetes mellitus in response to decreased insulin
Dehydration in response to decreased antidiuretic hormone (ADH)
Graves' disease (hyperthyroidism)
Blood clotting

Activities:
The student can justify a claim made about the effect(s) on a biological system at the molecular, physiological or organismal level when given a scenario in which one or more components within a negative regulatory system is altered.
[LO 2.15 - SP 6.1]
The student is able to connect how organisms use negative feedback to maintain their internal environments. [LO 2.16 - SP 7.2]
The student is able to evaluate data that show the effect(s) of changes in concentrations of key molecules on negative feedback mechanisms. [LO 2.17 - SP 5.3]
The student can make predictions about how organisms use negative feedback mechanisms to maintain their internal environments. [LO 2.18 - SP 6.4]
The student is able to make predictions about how positive feedback mechanisms amplify activities and processes in organisms based on scientific theories and models. [LO 2.19 - SP 6.4]
The student is able to justify that positive feedback mechanisms amplify responses in organisms. [LO 2.20 - SP 6.1]

Lesson 8: Essential knowledge 2.C.2: Organisms respond to changes in their external environments.

Ch 40.5

Topics:
Response, behavioral, physiological

Key Topics: (Illustrative examples)
Photoperiodism and phototropism in plants
Hibernation and migration in animals
Taxis and kinesis in animals
Chemotaxis in bacteria, sexual reproduction in fungi
Nocturnal and diurnal activity: circadian rhythms
Shivering and sweating in humans

Activities:
The student is able to justify the selection of the kind of data needed to answer scientific questions about the relevant mechanism that organisms use to respond to changes in their external environment. [LO 2.21 - SP 4.1]

Section 4: Enduring understanding 2.D: Growth and dynamic homeostasis of a biological system are influenced by changes in the system's environment. [CR2]

Lesson 9: Essential knowledge 2.D.1: All biological systems from cells and organisms to populations, communities and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy.

Ch 50.2, 52.1, 52.2, 52.3, 53.1, 53.2, 53.3, 53.4, 53.5, 54.1, 54.2, 54.3, 54.4

Topics:
Biotic factors, and abiotic factors, interactions, stability of populations, communities, ecosystems

Key Topics: (Illustrative examples)
Cell density
Biofilms
Temperature
Water availability
Sunlight
Symbiosis (mutualism, commensalism, parasitism)
Predator–prey relationships
Water and nutrient availability, temperature, salinity, pH
Availability of nesting materials and sites
Food chains and food webs
Species diversity
Population density
Algal blooms

Activities:
The student is able to refine scientific models and questions about the effect of complex biotic and abiotic interactions on all biological systems, from cells and organisms to populations, communities and ecosystems. [LO 2.22 - SP 1.3, 3.2]
The student is able to design a plan for collecting data to show that all biological systems (cells, organisms, populations, communities and ecosystems) are affected by complex biotic and abiotic interactions. [LO 2.23 - SP 4.2, 7.2]
The student is able to analyze data to identify possible patterns and relationships between a biotic or abiotic factor and a biological system (cells, organisms, populations, communities or ecosystems). [LO 2.24 - SP 5.1]

Lesson 10: Essential knowledge 2.D.2: Homeostatic mechanisms reflect both common ancestry and divergence due to adaptation in different environments.
Ch 40.4, 40.5, 55.1

Topics:
Common ancestry, mechanisms for obtaining nutrients, eliminating wastes, microbes, plants and animals

Key Topics: (Illustrative examples)
Gas exchange in aquatic and terrestrial plants
Digestive mechanisms in animals such as food vacuoles, gastrovascular cavities, one-way digestive systems
Respiratory systems of aquatic and terrestrial animals
Nitrogenous waste production and elimination in aquatic and terrestrial animals
Excretory systems in flatworms, earthworms and vertebrates
Osmoregulation in bacteria, fish and protists
Osmoregulation in aquatic and terrestrial plants
Circulatory systems in fish, amphibians and mammals
Thermoregulation in aquatic and terrestrial animals (countercurrent exchange mechanisms)

Activities:
The student can construct explanations based on scientific evidence that homeostatic mechanisms reflect continuity due to common ancestry and/or divergence due to adaptation in different environments. [LO 2.25 - SP 6.2]
The student is able to analyze data to identify phylogenetic patterns or relationships, showing that homeostatic mechanisms reflect both continuity due to common ancestry and change due to evolution in different environments. [LO 2.26 - SP 5.1]
The student is able to connect differences in the environment with the evolution of homeostatic mechanisms. [LO 2.27 - SP 7.1]

Lesson 11: Essential knowledge 2.D.3: Biological systems are affected by disruptions to their dynamic homeostasis.
Ch 40.4, 40.5, 55.1

Topics:
Molecular and cellular disruptions, ecosystems, dynamic homeostasis, ecosystem balance

Key Topics: (Illustrative examples)

Physiological responses to toxic substances
Dehydration
Immunological responses to pathogens, toxins and allergens
Invasive and/or eruptive species
Human impact
Hurricanes, floods, earthquakes, volcanoes, fires
Water limitation
Salination

Activities:
The student is able to use representations or models to analyze quantitatively and qualitatively the effects of disruptions to dynamic homeostasis in biological systems. [LO 2.28 - SP 1.4]

Lesson 12: Essential knowledge 2.D.4: Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis.
Ch 39.5, 43.1, 43.2, 43.3, 43.4, 43.5

Topics:
Nonspecific immune responses, specific immune response, cell mediated and humoral response, cytotoxic T cells, lymphocytic white blood, pathogens, antigens, antibodies, B cells, second exposure

Key Topics: (Illustrative examples)
Invertebrate immune systems have nonspecific response mechanisms, but they lack pathogen-specific defense responses.
Plant defenses against pathogens include molecular recognition systems with systemic responses; infection triggers chemical responses that destroy infected and adjacent cells, thus localizing the effects.
Vertebrate immune systems have nonspecific and nonheritable defense mechanisms against pathogens.

Activities:
The student can create representations and models to describe immune responses. [LO 2.29 - SP 1.1, 1.2]
The student can create representations or models to describe nonspecific immune defenses in plants and animals. [LO 2.30 - SP 1.1, 1.2]

Section 5: Enduring understanding 2.E: Many biological processes involved in growth, reproduction and dynamic homeostasis include temporal regulation and coordination. [CR2]

Lesson 13: Essential knowledge 2.E.1: Timing and coordination of specific events are necessary for the normal development of an organism, and these events are regulated by a variety of mechanisms.
Ch 19.2, 21.2, 38.1, 38.2

Topics:
Differentiation, gene expression, tissue-specific proteins, induction, transcription factors, sequential gene expression, homeotic genes, developmental patterns, embryonic induction, event timing, plant germination, genetic mutations, transplantation, microRNAs, apoptosis

Key Topics: (Illustrative examples)
Morphogenesis of fingers and toes
Immune function
C. elegans development
Flower development

Activities:
The student can connect concepts in and across domains to show that timing and coordination of specific events are necessary for normal development in an organism and that these events are regulated by multiple mechanisms. [LO 2.31 - SP 7.2]
Students will read and discuss Rachel Carson's Silent Spring, then research and report on the effects of thalidomide on human development. **[CR3b]**
The student is able to use a graph or diagram to analyze situations or solve problems (quantitatively or qualitatively) that involve timing and coordination of events necessary for normal development in an organism. [LO 2.32 - SP 1.4]

The student is able to justify scientific claims with scientific evidence to show that timing and coordination of several events are necessary for normal development in an organism and that these events are regulated by multiple mechanisms. [LO 2.33 - SP 6.1]
The student is able to describe the role of programmed cell death in development and differentiation, the reuse of molecules, and the maintenance of dynamic homeostasis. [LO 2.34 - SP 7.1]

Lesson 14: Essential knowledge 2.E.2: Timing and coordination of physiological events are regulated by multiple mechanisms.
Ch 11.1, 24.1, 38.1, 38.2, 39.2, 39.3

Topics:
Environmental stimuli, internal molecular signals, phototropism, photoperiodism, synchronize, environmental cycles and cues, fungi, protists and bacteria

Key Topics: (Illustrative examples)
Circadian rhythms, or the physiological cycle of about 24 hours that is present in all eukaryotes and persists even in the absence of external cues
Diurnal/nocturnal and sleep/awake cycles
Jet lag in humans
Seasonal responses, such as hibernation, estivation and migration
Release and reaction to pheromones
Visual displays in the reproductive cycle
Fruiting body formation in fungi, slime molds and certain types of bacteria
Quorum sensing in bacteria

Activities:
The student is able to design a plan for collecting data to support the scientific claim that the timing and coordination of physiological events involve regulation. [LO 2.35 - SP 4.2]
The student is able to justify scientific claims with evidence to show how timing and coordination of physiological events involve regulation. [LO 2.36 - SP 6.1]
The student is able to connect concepts that describe mechanisms that regulate the timing and coordination of physiological events. [LO 2.37 - SP 7.2]

Lesson 15: ***Essential knowledge 2.E.3: Timing and coordination of behavior are regulated by various mechanisms and are important in natural selection.***
Ch 39.2, 39.3, 51.1, 51.2, 53.1

Topics:
Actions, communication, innate behaviors, learning, interactions, responses, phototropism, photoperiodism, cooperative behavior, survival of populations

Key Topics: (Illustrative examples)
Hibernation
Estivation
Migration
Courtship
Availability of resources leading to fruiting body formation in fungi and certain types of bacteria
Niche and resource partitioning
Mutualistic relationships (lichens; bacteria in digestive tracts of animals; mycorrhizae)
Biology of pollination

Activities:
The student is able to analyze data to support the claim that responses to information and communication of information affect natural selection. [LO 2.38 - SP 5.1]
The student is able to justify scientific claims, using evidence, to describe how timing and coordination of behavioral events in organisms are regulated by several mechanisms. [LO 2.39 - SP 6.1]
The student is able to connect concepts in and across domain(s) to predict how environmental factors affect responses to information and change behavior. [LO 2.40 - SP 7.2]

Unit 3: Information/DNA timing: 60-70 days

Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes. [CR2]

Unit 3 Laboratory Investigations:

Lab 8: Biotechnology: Bacterial Transformation (old lab 6A revision) – Students transform a bacterial cell to uptake a plasmid containing a gene product that will make the cell appear to glow. Students will then study the structure of the plasmid and make predictions regarding growth on various agar plates. They will then examine the bacterial growth afterwards and collect quantitative data. They will calculate transformation efficiency. They will then plan a controlled experiment they think will improve the transformation efficiency. **[CR6]**

Lab 9: Biotechnology: Restriction Enzyme Analysis of DNA (old lab 6B revision) – Students will understand the principles of gel electrophoresis. They will collect quantitative data by using marker DNA results to graph data. They will utilize ban migration distances and extrapolate band sizes from their graphs.

Chapters utilized in Unit 3:

From Campbell/Reece: 5, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23, 27, 48, 51

Section 1: Enduring understanding 3.A: Heritable information provides for continuity of life. [CR2]

Lesson 1: Essential knowledge 3.A.1: DNA, and in some cases RNA, is the primary source of heritable information.

Ch 5.5, 27.1, 16.1, 16.2, 17.1, 17.2, 17.3, 17.4, 18.1, 20.1, 20.2, 20.3

Topics:

Genetic information, DNA, RNA, circular chromosomes, linear chromosomes, plasmids, Watson, Crick, Wilkins, and Franklin, Avery-MacLeod-McCarty experiment, Hershey-Chase experiment, DNA replication, semiconservative, template, complementary, DNA polymerase, leading and lagging strands, retroviruses, reverse transcriptase, transcription, translation, ligase, RNA polymerase, helicase, topoisomerase, components, sugar, phosphate, nitrogen base, 3' and 5' ends, sugar-phosphate backbone, antiparallel, single stranded, double stranded, purines, pyrimidines, conserved through evolution, A-T or A-U and C-G, ring structures, mRNA, tRNA, rRNA, RNAi, amino acids, phenotypes, initiation, elongation, termination, ribosome, codon, order of amino acids, polypeptide, genetic engineering techniques

Key Topics: (illustrative examples)

Addition of a poly-A tail
Addition of a GTP cap
Excision of introns
Enzymatic reactions
Transport by proteins
Synthesis
Degradation
Electrophoresis
Plasmid-based transformation
Restriction enzyme analysis of DNA
Polymerase Chain Reaction (PCR)
Genetically modified foods
Transgenic animals
Cloned animals
Pharmaceuticals, such as human insulin or factor X

Activities:

The student is able to construct scientific explanations that use the structures and mechanisms of DNA and RNA to support the claim that DNA and, in some cases, that RNA are the primary sources of heritable information. [LO 3.1 - SP 6.5]
The student is able to justify the selection of data from historical investigations that support the claim that DNA is the source of heritable information. [LO 3.2 - SP 4.1]
The student is able to describe representations and models that illustrate how genetic information is copied for transmission between generations. [LO 3.3 - SP 1.2]

The student is able to describe representations and models illustrating how genetic information is translated into polypeptides. [LO 3.4 - SP 1.2]
The student can justify the claim that humans can manipulate heritable information by identifying *at least two* commonly used technologies. [LO 3.5 - SP 6.4]
The student can predict how a change in a specific DNA or RNA sequence can result in changes in gene expression. [LO 3.6 - SP 6.4]

Lesson 2: Essential knowledge 3.A.2: In eukaryotes, heritable information is passed to the next generation via processes that include the cell cycle and mitosis or meiosis plus fertilization.
Ch 12.1, 12.2, 12.3, 13.1, 13.2, 13.3

Topics:
Cell cycle, checkpoints, interphase, growth, synthesis, cyclins, cyclin-dependent kinases, mitosis, cytokinesis, growth, repair, asexual reproduction, replication, alignment, separation, meiosis, fertilization, genetic diversity, haploid, 1N, homologous chromosomes, homologue, crossing over, genetic variation, gametes, zygote, diploid

Key Topics: (illustrative examples)
Mitosis-promoting factor (MPF)
Action of platelet-derived growth factor (PDGF)
Cancer results from disruptions in cell cycle control

Activities:
The student can make predictions about natural phenomena occurring during the cell cycle. [LO 3.7 - SP 6.4]
The student can describe the events that occur in the cell cycle. [LO 3.8 - SP 1.2]
The student is able to construct an explanation, using visual representations or narratives, as to how DNA in chromosomesis transmitted to the next generation via mitosis, or meiosis followed by fertilization. [LO 3.9 - SP 6.2]
The student is able to represent the connection between meiosis and increased genetic diversity necessary for evolution. [LO 3.10 - SP 7.1]
The student is able to evaluate evidence provided by data sets to support the claim that heritable information is passed from one generation to another generation through mitosis, or meiosis followed by fertilization. [LO 3.11 - SP 5.3]
Students read, discuss and report on *The Immortal Life of Henrietta Lacks,* focusing on the ethics and benefits of using human tissue in cancer and other biological research. Students report on at least one of the following: bioethics, cancer cells and cell cycle control, use of HeLa cells in scientific research. **[CR5]**

Lesson 3: Essential knowledge 3.A.3: The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring.
Ch 14.1, 14.2, 14.3, 14.4

Topics:
Probability, traits, segregation, independent assortment, genetic variation, adjacent gene movement, distance, pattern of inheritance, monohybrid, dihybrid, sex-linked, genotype, phenotype, human genetic disorders, nondisjunction

Key Topics: (illustrative examples)
Sickle cell anemia
Tay-Sachs disease
Huntington's disease
X-linked color blindness
Trisomy 21/Down syndrome
Klinefelter's syndrome
Reproduction issues
Civic issues such as ownership of genetic information, privacy, historical contexts, etc.

Activities:
The student is able to construct a representation that connects the process of meiosis to the passage of traits from parent to offspring. [LO 3.12 - SP 1.1, 7.2]
The student is able to pose questions about ethical, social or medical issues surrounding human genetic disorders. [LO 3.13 - SP 3.1]
The student is able to apply mathematical routines to determine Mendelian patterns of inheritance provided by data sets. [LO 3.14 - SP 2.2]

Lesson 4: Essential knowledge 3.A.4: The inheritance pattern of many traits cannot be explained by simple Mendelian genetics.

Ch 15.1, 15.2, 15.3, 15.5

Topics:
Multiple genes, multiple physiological processes, quantitative analysis, ratios statistically differ from predicted ratios, genes on sex chromosomes

Key Topics: (illustrative examples)
Sex-linked genes reside on sex chromosomes (X in humans).
In mammals and flies, the Y chromosome is very small and carries few genes.
In mammals and flies, females are XX and males are XY; as such, X-linked recessive traits are always expressed in males.
Some traits are sex limited, and expression depends on the sex of the individual, such as milk production in female mammals and pattern baldness in males.

Activities:
The student is able to explain deviations from Mendel's model of the inheritance of traits. [LO 3.15 - SP 6.5]
The student is able to explain how the inheritance patterns of many traits cannot be accounted for by Mendelian genetics. [LO 3.16 - SP 6.3]
The student is able to describe representations of an appropriate example of inheritance patterns that cannot be explained by Mendel's model of the inheritance of traits. [LO 3.17 - SP 1.2]

Section 2: Enduring understanding 3.B: Expression of genetic information involves cellular and molecular mechanisms. [CR2]

Lesson 5: Essential knowledge 3.B.1: Gene regulation results in differential gene expression, leading to cell specialization.
Ch 18.4, 19.2

Topics:
Gene expression, regulatory sequences, regulatory genes, small regulatory RNAs, regulatory proteins, control transcription, positive and negative control mechanisms, inducer, repressor, inhibit gene expression, inactivate repressor function, always turned "on", ribosomal genes, regulatory elements, transcription factors, activators, repressors, gene regulation

Key Topics: (illustrative examples)
Promoters
Terminators
Enhancers

Activities:
The student is able to describe the connection between the regulation of gene expression and observed differences between different kinds of organisms. [LO 3.18 - SP 7.1]
The student is able to describe the connection between the regulation of gene expression and observed differences between individuals in a population. [LO 3.19 - SP 7.1]
The student is able to explain how the regulation of gene expression is essential for the processes and structures that support efficient cell function. [LO 3.20 - SP 6.2]
The student can use representations to describe how gene regulation influences cell products and function.[LO 3.21 - SP 1.4]

Lesson 6: Essential knowledge 3.B.2: A variety of intercellular and intracellular signal transmissions mediate gene expression.
Ch 11.1, 11.4, 18.4, 19.2, 21.2

Topics:
Signal transmission, within and between cells, gene expression, cell function

Key Topics: (illustrative examples)
Cytokines regulate gene expression to allow for cell replication and division.
Mating pheromones in yeast trigger mating gene expression.
Levels of cAMP regulate metabolic gene expression in bacteria.
Expression of the SRY gene triggers the male sexual development pathway in animals.
Ethylene levels cause changes in the production of different enzymes, allowing fruits to ripen.
Seed germination and gibberellin.
Mating pheromones in yeast trigger mating genes expression and sexual reproduction.
Morphogens stimulate cell differentiation and development.

Changes in p53 activity can result in cancer.
HOX genes and their role in development.

Activities:
Students explain how DNA is the genetic material for all living organisms on Earth though citing how the presence or absence of different hormones affect plant development, or how pheromones in yeast trigger gene expression. **[CR3c]**
The student is able to explain how signal pathways mediate gene expression, including how this process can affect protein production. [LO 3.22 - SP 6.2]
The student can use representations to describe mechanisms of the regulation of gene expression. [LO 3.23 - SP 1.4]

Section 3: Enduring understanding 3.C: The processing of genetic information is imperfect and is a source of genetic variation. [CR2]

Lesson 7: Essential knowledge 3.C.1: Changes in genotype can result in changes in phenotype.
Ch 15.4, 16.2, 17.7, 23.4

Topics:
Alterations in a DNA sequence, protein production, phenotype, mutations, positive, negative, neutral, DNA repair mechanisms, radiation, reactive chemicals, random changes, environmental context, genetic variation, errors in meiosis, trisomy 21, XO, natural selection, enhance survival and reproduction, selected by environmental conditions

Key Topics: (illustrative examples)
Antibiotic resistance mutations
Pesticide resistance mutations
Sickle cell disorder and heterozygote advantage

Activities:
The student is able to predict how a change in genotype, when expressed as a phenotype, provides a variation that can be subject to natural selection. [LO 3.24 - SP 6.4, 7.2]
The student can create a visual representation to illustrate how changes in a DNA nucleotide sequence can result in a change in the polypeptide produced. [LO 3.25 - SP 1.1]
The student is able to explain the connection between genetic variations in organisms and phenotypic variations in populations. [LO 3.26 - SP 7.2]
The student is able to explain the connection between genetic variations in organism and phenotypic variations in populations. Students will provide written comparison between artificial and natural selection using an organism of their choice. **[CR4c]**

Lesson 8: Essential knowledge 3.C.2: Biological systems have multiple processes that increase genetic variation.
Ch 13.4, 18.3

Topics:
Increases variation, replication and repair, uptake of naked DNA, transformation, transduction, conjugation, transposition, sexual reproduction, crossing-over, random assortment, fertilization

Key Topics: (illustrative examples)
Processes that provide for genetic variation

Activities:
The student is able to compare and contrast processes by which genetic variation is produced and maintained in organisms from multiple domains. [LO 3.27 - SP 7.2]
The student is able to construct an explanation of the multiple processes that increase variation within a population. [LO 3.28 - SP 6.2]

Lesson 9: Essential knowledge 3.C.3: Viral replication results in genetic variation, and viral infection can introduce genetic variation into the hosts.
Ch 18.1

Topics:
Viral replication, efficient, rapid evolution, component assembly model, lytic cycle, lack of replication error-checking mechanisms, RNA viruses, HIV, pathogenicity of viral infection

Key Topics: (illustrative examples)
Transduction in bacteria
Transposons present in incoming DNA

Activities:
The student is able to construct an explanation of how viruses introduce genetic variation in host organisms. [LO 3.29 - SP 6.2]
The student is able to use representations and appropriate models to describe how viral replication introduces genetic variation in the viral population. [LO 3.30 - SP 1.4]

Section 4: Enduring understanding 3.D: Cells communicate by generating, transmitting and receiving chemical signals. [CR2]

Lesson 10: Essential knowledge 3.D.1: Cell communication processes share common features that reflect a shared evolutionary history.
Ch 11.1, 11.2

Topics:
Cell communication, transduction of signals, organisms or environment, selective pressure

Key Topics: (illustrative examples)
Use of chemical messengers by microbes to communicate with other nearby cells and to regulate specific pathways in response to population density (quorum sensing)
Use of pheromones to trigger reproduction and developmental pathways
Response to external signals by bacteria that influences cell movement
Epinephrine stimulation of glycogen breakdown in mammals
Temperature determination of sex in some vertebrate organisms
DNA repair mechanisms

Activities:
The student is able to describe basic chemical processes for cell communication shared across evolutionary lines of descent. [LO 3.31 - SP 7.2]
The student is able to generate scientific questions involving cell communication as it relates to the process of evolution. [LO 3.32 - SP 3.1]
The student is able to use representation(s) and appropriate models to describe features of a cell-signaling pathway. [LO 3.33 - SP 1.4]

Lesson 11: Essential knowledge 3.D.2: Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling.
Ch 11.1, 11.2

Topics:
Cell-to-cell contact, local regulators, endocrine signals, signal molecules

Key Topics: (illustrative examples)
Immune cells interact by cell-cell contact, antigen-presenting cells (APCs), helper T-cells and killer T-cells. [See also 2.D.4]
Plasmodesmata between plant cells that allow material to be transported from cell to cell.
Neurotransmitters
Plant immune response
Quorum sensing in bacteria
Morphogens in embryonic development
Insulin
Human growth hormone
Thyroid hormones
Testosterone
Estrogen

Activities:

The student is able to construct explanations of cell communication through cell-to-cell direct contact or through chemical signaling. [LO 3.34 - SP 6.2]
The student is able to create representation(s) that depict how cell-to-cell communication occurs by direct contact or from a distance through chemical signaling. [LO 3.35 - SP 1.1]

Lesson 12: Essential knowledge 3.D.3: Signal transduction pathways link signal reception with cellular response.
Ch 11.3

Topics:
Signal recognition, chemical messenger, ligand, receptor protein, chemical messengers, peptides, small chemicals, specific one-to-one relationship, shape change, response, cascades, amplification, second messengers

Key Topics: (illustrative examples)
G-protein linked receptors
Ligand-gated ion channels
Receptor tyrosine kinases
Ligand-gated ion channels
Second messengers, such as cyclic GMP, cyclic AMP calcium ions (Ca2+), and inositol triphosphate (IP3)

Activities:
The student is able to describe a model that expresses the key elements of signal transduction pathways by which a signal is converted to a cellular response. [LO 3.36 - SP 1.5]

Lesson 13: Essential knowledge 3.D.4: Changes in signal transduction pathways can alter cellular response.
Ch 11.4

Topics:
Blocked or defective signal transduction, deleterious, preventative or prophylactic

Key Topics: (illustrative examples)
Diabetes, heart disease, neurological disease, autoimmune disease, cancer, cholera
Effects of neurotoxins, poisons, pesticides
Drugs (Hypertensives, Anesthetics, Antihistamines and Birth Control Drugs)

Activities:
The student is able to justify claims based on scientific evidence that changes in signal transduction pathways can alter cellular response. [LO 3.37 - SP 6.1]
The student is able to describe a model that expresses key elements to show how change in signal transduction can alter cellular response. [LO 3.38 - SP 1.5]
The student is able to construct an explanation of how certain drugs affect signal reception and, consequently, signal transduction pathways. [LO 3.39 - SP 6.2]

Section 5: Enduring understanding 3.E: Transmission of information results in changes within and between biological systems. [CR2]

Lesson 14: Essential knowledge 3.E.1: Individuals can act on information and communicate it to others.
Ch 51.2, 51.3

Topics:
Organisms exchange information, internal changes, external cues, behavior, communication, reproductive success, visual, audible, tactile, electrical, chemical, dominance, territory, natural selection, cooperation, fitness

Key Topics: (illustrative examples)
Fight or flight response
Predator warnings
Protection of young
Plant-plant interactions due to herbivory
Avoidance responses
Herbivory responses
Territorial marking in mammals

Coloration in flowers
Bee dances
Bird's songs
Territorial marking in mammals
Pack behavior in animals
Herd, flock, and schooling behavior in animals
Predator warning
Colony and swarming behavior in insects
Coloration
Parent and offspring interactions
Migration patterns
Courtship and mating behaviors
Foraging in bees and other animals
Avoidance behavior to electric fences, poisons, or traps

Activities:
The student is able to analyze data that indicate how organisms exchange information in response to internal changes and external cues, and which can change behavior. [LO 3.40 - SP 5.1]
The student is able to create a representation that describes how organisms exchange information in response to internal changes and external cues, and which can result in changes in behavior. [LO 3.41 - SP 1.1]
The student is able to describe how organisms exchange information in response to internal changes or environmental cues. [LO 3.42 - SP 7.1]

Lesson 15: Essential knowledge 3.E.2: Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses.
Ch 48.1, 48.2, 48.3, 48.4, 48.5

Topics:
Neuron, cell body, axon and dendrites, myelin sheath, electrical insulator, detection, generation, transmission and integration, Schwann cells, impulse, polarized, electrical potentials, Na+ and K+ gated channels, ATP, membrane potential, synapses, chemical messengers, neurotransmitters

Key Topics: (illustrative examples)
Acetylcholine
Epinephrine
Norepinephrine
Dopamine
Serotonin
GABA
Vision
Hearing
Muscle movement
Abstract thought and emotions
Neuro-hormone production
Forebrain (cerebrum), midbrain (brainstem) and hindbrain (cerebellum)
Right and left cerebral hemispheres in humans

Activities:
The student is able to construct an explanation, based on scientific theories and models, about how nervous systems detect external and internal signals, transmit and integrate information, and produce responses. [LO 3.43 - SP 6.2, 7.1]
The student is able to describe how nervous systems detect external and internal signals. [LO 3.44 - SP 1.2]
The student is able to describe how nervous systems transmit information. [LO 3.45 - SP 1.2]
The student is able to describe how the vertebrate brain integrates information to produce a response. [LO 3.46 - SP 1.2]
The student is able to create a visual representation of complex nervous systems to describe/explain how these systems detect external and internal signals, transmit and integrate information, and produce responses. [LO 3.47 - SP 1.1]
The student is able to create a visual representation to describe how nervous systems detect external and internal signals. [LO 3.48 - SP 1.1]
The student is able to create a visual representation to describe how nervous systems transmit information. [LO 3.49 - SP 1.1]
The student is able to create a visual representation to describe how the vertebrate brain integrates information to produce a response. [LO 3.50 - SP 1.1]

Unit 4: Interactions/Ecology timing: 20-25 days

Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties. **[CR2]**

Unit 4 Laboratory Investigations:

Lab 11: Transpiration (old lab 9 revision) – Students investigate the movement of water through plants in a model system.
Lab 13: Enzyme Activity (old lab 2 revision) – An open inquiry lab where students investigate and quantify factors that affect enzyme action.

Chapters utilized in Unit 4:

From Campbell/Reece: 5, 6, 8, 14, 19, 21, 23, 25, 40, 48, 52, 53, 54, 55

Section 1: Enduring understanding 4.A: Interactions within biological systems lead to complex properties. **[CR2]**

Lesson 1: Essential knowledge 4.A.1: The subcomponents of biological molecules and their sequence determine the properties of that molecule.

Ch 5.1, 5.2, 5.3, 5.4, 5.5

Topics:
Polymer structure, polymer function, monomer assembly, structure/function, nucleic acids, nucleotides, nucleotide components, DNA and RNA structural differences, 3' and 5' carbons, 3' and 5' ends, complementary nucleotides, synthesis, transcription, proteins, amino acids, primary structure, secondary structure, tertiary structure, quaternary structure, R groups, amino and carboxyl ends, peptide bonds, lipids, nonpolar, polar, phospholipids, saturation, carbohydrates, dehydration synthesis, directionality

Key Topics: (illustrative examples)
Cellulose vs. starch

Activities:
The student is able to explain the connection between the sequence and the subcomponents of a biological polymer and its properties. [LO 4.1 - SP 7.1]
The student is able to refine representations and models to explain how the subcomponents of a biological polymer and their sequence determine the properties of that polymer. [LO 4.2 - SP 1.3]
The student is able to use models to predict and justify that changes in the subcomponents of a biological polymer affect the functionality of the molecule. [LO 4.3 - SP 6.1, 6.4]

Lesson 2: Essential knowledge 4.A.2: The structure and function of subcellular components, and their interactions, provide essential cellular processes.

Ch 6.2, 6.3, 6.4, 6.5

Topics:
Ribosomes, ribosomal RNA, protein, interaction, protein synthesis, translation, polypeptides, smooth endoplasmic reticulum, rough endoplasmic reticulum, compartmentalize, mechanical support, bound ribosomes, transport, synthesize lipids, Golgi complex, cisternae, synthesis, packaging, transport, lysosomes, mitochondria, energy, convoluted, cristae, enzymes ATP, hydrolytic enzymes, digestion, apoptosis, vacuole, waste, pigments, surface to volume ratio, chloroplasts, sunlight, conversion, photosynthesis, pigment, chlorophyll a, thylakoids, grana, ATP, $NADPH_2$, Calvin-Benson cycle, stroma, carbon fixation

Key Topics: (illustrative examples)
None in this lesson

Activities:
The student is able to make a prediction about the interactions of subcellular organelles. [LO 4.4 - SP 6.4]
The student is able to construct explanations based on scientific evidence as to how interactions of subcellular structures provide essential functions. [LO 4.5 - SP 6.2]
The student is able to use representations and models to analyze situations qualitatively to describe how interactions of subcellular structures, which possess specialized functions, provide essential functions. [LO 4.6 - SP 1.4]

Lesson 3: Essential knowledge 4.A.3: Interactions between external stimuli and regulated gene expression result in specialization of cells, tissuesand organs.

Ch 21.2

Topics:

Differentiation, external cues, internal cues, gene regulation, divergence of cells, environmental stimuli

Key Topics: (illustrative examples)

None in this lesson

Activities:

The student is able to refine representations to illustrate how interactions between external stimuli and gene expression result in specialization of cells, tissues and organs. [LO 4.7 - SP 1.3]

Lesson 4: Essential knowledge 4.A.4: Organisms exhibit complex properties due to interactions between their constituent parts.

Ch 48.4

Topics:

Interactions and coordination, organs and systems

Key Topics: (illustrative examples)

Stomach and small intestines
Kidney and bladder
Root, stem and leaf
Respiratory and circulatory
Nervous and muscular
Plant vascular and leaf

Activities:

The student is able to evaluate scientific questions concerning organisms that exhibit complex properties due to the interaction of their constituent parts. [LO 4.8 - SP 3.3]
The student is able to predict the effects of a change in a component(s) of a biological system on the functionality of an organism(s). [LO 4.9 - SP 6.4]
The student is able to refine representations and models to illustrate biocomplexity due to interactions of the constituent parts. [LO 4.10 - SP 1.3]

Lesson 5: Essential knowledge 4.A.5: Communities are composed of populations of organisms that interact in complex ways.

Ch 52.1, 52.3, 52.4, 52.5, 52.6, 53.1, 53.2

Topics:

Community, species, diversity, population interaction, math and computer models, growth patterns, interactions

Key Topics: (illustrative examples)

Predator/prey relationships spreadsheet model
Symbiotic relationship
Graphical representation of field data
Introduction of species
Global climate change models

Activities:

The student is able to justify the selection of the kind of data needed to answer scientific questions about the interaction of populations within communities. [LO 4.11 - SP 1.4, 4.1]
The student is able to apply mathematical routines to quantities that describe communities composed of populations of organisms that interact in complex ways. [LO 4.12 - SP 2.2]
The student is able to predict the effects of a change in the community's populations on the community. [LO 4.13 - SP 6.4]

Lesson 6: Essential knowledge 4.A.6: Interactions among living systems and with their environment result in the movement of matter and energy.

Ch 53.2, 54.1, 54.2, 54.3, 54.4, 55.4

Topics:
Energy, matter, primary productivity, food webs, food chains, models predict changes, biotic, abiotic, competition, growth, logistic model, territoriality, predation, wastes, density-dependent population, human activities, habitat, population size, habitat destruction, extinction, adaptations

Key Topics: (illustrative examples)
None in this lesson

Activities:
The student is able to apply mathematical routines to quantities that describe interactions among living systems and their environment, which result in the movement of matter and energy. [LO 4.14 - SP 2.2]
The student is able to use visual representations to analyze situations or solve problems qualitatively to illustrate how interactions among living systems and with their environment result in the movement of matter and energy. [LO 4.15 - SP 1.4]
The student is able to predict the effects of a change of matter or energy availability on communities.[LO 4.16 - SP 6.4]

Section 2: Enduring understanding 4.B: Competition and cooperation are important aspects of biological systems. **[CR2]**

Lesson 7: Essential knowledge 4.B.1: Interactions between molecules affect their structure and function.
Ch 5.4, 8.4, 8.5

Topics:
Structure/function, shape, active sites, substrate, complementary, cofactors, coenzyme, rate, environment, allosteric site, interference, product, competitive inhibitor

Key Topics: (illustrative examples)
None in this lesson

Activities:
The student is able to analyze data to identify how molecular interactions affect structure and function. [LO 4.17 - SP 5.1]

Lesson 8: Essential knowledge 4.B.2: Cooperative interactions within organisms promote efficiency in the use of energy and matter.
Ch 6.4, 40.1, 40.2

Topics:
Cooperation among components, plasma membrane, cytoplasm organelles, specialization, organs, populations

Key Topics: (illustrative examples)
Exchange of gases
Circulation of fluids
Digestion of food
Excretion of wastes
Bacterial community in the rumen of animals
Bacterial community in and around deep sea vents

Activities:
The student is able to use representations and models to analyze how cooperative interactions within organisms promote efficiency in the use of energy and matter. [LO 4.18 - SP 1.4]

Lesson 9: Essential knowledge 4.B.3: Interactions between and within populations influence patterns of species distribution and abundance.
Ch 53.1

Topics:
Interactions between populations, distribution, abundance, dynamics, competition, parasitism, predation, mutualism, commensalism, predator/prey, epidemiological models, invasive species, symbiotic relationships, feedback control, cooperation, competition, species-specific, environmental catastrophes, geological events, influx/depletion of abiotic resources, increased human activities, distribution and abundance

Key Topics: (illustrative examples)
Loss of keystone species
Kudzu
Dutch elm disease

Activities:
The student identifies emerging diseases and compares the effects of the interactions of pathogens and hosts. **[CR3d]**
The student is able to use data analysis to refine observations and measurements regarding the effect of population interactions on patterns of species distribution and abundance. [LO 4.19 - SP 5.2]
The student is able to use data analysis to refine observations and measurements regarding the effect of population interactions on patterns of species distribution and abundance. The students will be able to identify an invasive species in their community and design a plan to investigate its impact on the community. **[CR4d]**

Lesson 10: Essential knowledge 4.B.4: Distribution of local and global ecosystems changes over time.
Ch 25.4, 54.5, 55.1

Topics:
Human impact, geological and meteorological events

Key Topics: (illustrative examples)
Logging, slash and burn agriculture, urbanization, monocropping, infrastructure development (dams, transmission lines, roads), and global climate change threaten ecosystems and life on Earth.
An introduced species can exploit a new niche free of predators or competitors, thus exploiting new resources.
Introduction of new diseases can devastate native species, example: Dutch elm disease, Potato blight, Small pox
El Niño
Continental drift
Meteor impact on dinosaurs

Activities:
The student is able to explain how the distribution of ecosystems changes over time by identifying large-scale events that have resulted in these changes in the past. [LO 4.20 - SP 6.3]
The student is able to predict consequences of human actions on both local and global ecosystems. [LO 4.21 - SP 6.4]

Section 3: Enduring understanding 4.C: Naturally occurring diversity among and between components within biological systems affects interactions with the environment. **[CR2]**

Lesson 11: Essential knowledge 4.C.1: Variation in molecular units provides cells with a wider range of functions.
Ch 5.1, 5.2, 5.3, 5.4, 5.5, 19.5

Topics:
Variation within molecules, greater functionality, multiple copies of alleles, phenotypes, heterozygote advantage

Key Topics: (illustrative examples)
Different types of phospholipids in cell membranes
Different types of hemoglobin
MHC proteins
Chlorophylls
Molecular diversity of antibodies in response to an antigen
The antifreeze gene in fish

Activities:
The student is able to construct explanations based on evidence of how variation in molecular units provides cells with a wider range of functions. [LO 4.22 - SP 6.2]

Lesson 12: Essential knowledge 4.C.2: Environmental factors influence the expression of the genotype in an organism.
Ch 14.3

Topics:
Environmental factors, adaptation, flexible response

Key Topics: (illustrative examples)
Height and weight in humans
Flower color based on soil pH
Seasonal fur color in arctic animals
Sex determination in reptiles
Density of plant hairs as a function of herbivory
Effect of adding lactose to a Lac + bacterial culture
Effect of increased UV on melanin production in animals
Presence of the opposite mating type on pheromones production in yeast and other fungi
Darker fur in cooler regions of the body in certain mammal species
Alterations in timing of flowering due to climate changes

Activities:
The student is able to construct explanations of the influence of environmental factors on the phenotype of an organism. [LO 4.23 - SP 6.2]
The student is able to predict the effects of a change in an environmental factor on the genotypic expression of the phenotype. [LO 4.24 - SP 6.4]

Lesson 13: Essential knowledge 4.C.3: The level of variation in a population affects population dynamics.
Ch 23.1, 23.2, 23.3

Topics:
Population response, genetic diversity, extinction, different response to same changes, allelic variation, Hardy-Weinberg equation

Key Topics: (illustrative examples)
California condors
Black-footed ferrets
Prairie chickens
Potato blight causing the potato famine
Corn rust affects on agricultural crops
Tasmanian devils and infectious cancer
Not all animals in a population stampede.
Not all individuals in a population in a disease outbreak are equally affected; some may not show symptoms, some may have mild symptoms, or some may be naturally immune and resistant to the disease.

Activities:
The student is able to use evidence to justify a claim that a variety of phenotypic responses to a single environmental factor can result from different genotypes within the population.[LO 4.25 - SP 6.1]
The student is able to use theories and models to make scientific claims and/or predictions about the effects of variation within populations on survival and fitness. [LO 4.26 - SP 6.4]

Lesson 14: Essential knowledge 4.C.4: The diversity of species within an ecosystem may influence the stability of the ecosystem.
Ch 14.3, 23.1, 53.2, 55.1

Topics:
Ecosystems, components, diversity, keystone species, producers, abiotic and biotic factors, disproportionate effects, ecosystem collapse

Key Topics: (illustrative examples)
None in this lesson

Activities:
The student is able to make scientific claims and predictions about how species diversity within an ecosystem influences ecosystem stability. [LO 4.27 - SP 6.4]