AP Biology Guide

The AP biology program is organized into four underlying big ideas. The guide below lists the enduring understandings for each big idea, and identifies where the material is located in **AP Biology 1** (blue) or **AP Biology 2** (black).

Big Idea 1: The process of evolution drives the diversity and unity of life		
1A: Change in the genetic makeup of a population over time is evolution		
1.A.1	Natural selection is a major mechanism of evolution	Genetic Change in Populations
1.A.2	Natural selection acts on phenotypic variations in populations	
1.A.3	Evolutionary change is also driven by random processes	
1.A.4	Biological evolution is supported by scientific evidence from many disciplines	Evidence for Biological Evolution
1B: Organisms are linked by lines of descent from common ancestry		
1.B.1	Organisms share many conserved core processes and features that have evolved	The Relatedness of Organisms
1.B.2	Phylogenetic trees and cladograms are graphical models of evolutionary history	
1C: Life continues to evolve within a changing environment		
1.C.1	Speciation and extinction have occurred throughout the Earth's history	Speciation and Extinction
1.C.2	Speciation may occur when populations become reproductively isolated	
1.C.3	Populations continue to evolve	
1D: The origin of living systems is explained by natural processes		
1.D.1	Hypotheses about the natural origin of life	The Origin of Living Systems
1.D.2	Scientific evidence from different disciplines supports models of life's origin	
Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis		
2A: Growth, reproduction and maintenance of the organization of living systems require free energy and matter		
2.A.1	All living systems require energy	Energy in Living Systems, Homeostasis & Energy Allocation
2.A.2	Organisms capture and store free energy for use in biological processes	Energy in Living Systems, Energy Flow & Nutrient Cycles
2.A.3	Energy exchange maintains life processes	The Biochemistry of Life
2B: Growth, reproduction and dynamic homeostasis require that cells create and maintain internal environments that are different from their external environments		
2.B.1	Cell membranes are selectively permeable	Cell Structure and Processes
2.B.2	Movement of molecules across membranes maintains growth and homeostasis	
2.B.3	Internal membranes in eukaryotic cells partition the cell into specialized regions	
2C: Organisms use feedback mechanisms to regulate growth and reproduction, and to maintain dynamic homeostasis		
2.C.1	Organisms used feedback mechanisms to maintain internal environments	Homeostasis & Energy Allocation
2.C.2	Organisms respond to change in their external environments	Homeostasis & Energy Allocation, Timing & Coordination
2D: Growth & dynamic homeostasis are influenced by changes in the environment		
2.D.1	Biotic and abiotic factors affect biological systems	Populations & Communities
2.D.2	Homeostatic mechanisms reflect both common ancestry and divergence due to adaptation in different environments	Homeostasis & Energy Allocation, Plant Structure & Adaptation, Comparing Animal Systems, Interactions in Physiological Systems, The Diversity & Stability of Ecosystems (2.D.3 only)
2.D.3	Biological systems are affected by disruptions to their dynamic homeostasis*	
2.D.4	Plants and animals have chemical defenses against infections	Internal Defense, Plant Structure & Adaptation
2E: Many biological processes involved in growth, reproduction & dynamic homeostasis include temporal regulation & coordination		
2.E.1	Timing and coordination of events are regulated and necessary for development	Regulation of Gene Expression
2.E.2	Multiple mechanisms regulate timing & coordination of physiological events	Timing & Coordination
2.E.3	Timing and coordination are regulated and are important in natural selection	

Big Idea 3: Living systems store, retrieve, transmit & respond to information essential to life processes		
3A: Heritable information provides for continuity of life		
3.A.1	DNA, and in some cases RNA, is the primary source of heritable information	DNA and RNA
3.A.2	In eukaryotes, heritable information is passed on via the cell cycle and mitosis or meiosis plus fertilization	Chromosomes & Cell Division
3.A.3	The chromosomal basis of inheritance gives an understanding of transmission of genes from parent to offspring	Chromosomes & Cell Division, The Chromosomal Basis of Inheritance
3.A.4	The inheritance pattern of many traits is not explained by Mendelian genetics	The Chromosomal Basis of Inheritance
3B: Expression of genetic information involves cellular and molecular mechanisms		
3.B.1 3.B.2	Gene regulation results in differential gene expression and cell specialization Signals mediate gene expression	Regulation of Gene Expression
3C: Processing of genetic information is imperfect and a source of genetic variation		
3.C.1 3.C.2 3.C.3	Genotype changes can alter phenotype Processes that increase genetic variation Viral replication and genetic variation	Sources of Variation
3D: Cells communicate by generating, transmitting and receiving chemical signals		
3.D.1 3.D.2 3.D.3 3.D.4	Commonalities in cell communication Signaling by direct contact or chemicals Signal transduction pathways Changes to signal transduction pathways	Cellular Communication
3E: Transmission of information results in changes within and between systems		
3.E.1	Communicating information with others	Communicating & Responding
3.E.2	Nervous systems and responses	
Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties		
4A: Interactions within biological systems lead to complex properties		
4.A.1	Properties of a molecule are determined by its molecular construction	The Biochemistry of Life, DNA and RNA
4.A.2	The structure and function of subcellular components, and their interactions, provide essential cellular processes	Cell Structure and Processes Energy in Living Systems
4.A.3	Gene expression results in specialization of cells, tissues and organs	Regulation of Gene Expression
4.A.4	Organisms exhibit complex properties due to interactions between their parts	Plant Structure & Adaptation, Comparing Animal Systems, Interactions in Physiological Systems
4.A.5	Communities are composed of populations that interact in complex ways	Populations and Communities
4.A.6	Movement of matter and energy	Populations & Communities, Energy Flow & Nutrient Cycles, The Diversity and Stability of Ecosystems
4B: Competition and cooperation are important aspects of biological systems		
4.B.1	Interactions between molecules affect their structure and function	Enzymes & Metabolism
4.B.2	Cooperative interactions within organisms promote efficiency	Plant Structure & Adaptation, Comparing Animal Systems, Interactions in Physiological Systems
4.B.3	Population interactions influence species distribution and abundance	Populations & Communities, The Diversity & Stability of Ecosystems
4.B.4	Ecosystem distribution changes over time	The Diversity & Stability of Ecosystems
4C: Naturally occurring diversity among and between components within biological systems affects interactions with the environment		
4.C.1*	Variation in molecular units provides cells with a wider range of functions	Internal Defense
4.C.2*	Environmental factors influence the expression of the genotype	The Chromosomal Basis of Inheritance
4.C.3 4.C.4	Variation in populations affects dynamics Diversity may influence ecosystem stability	Populations & Communities, The Diversity & Stability of Ecosystems

* 4.C.1 and 4.C.2 also see Sources of Variation

Addressing the Science Practices

The AP Biology Science Practices are addressed in context throughout AP Biology 1 & 2. As students progress through their program of work, they can identify the Science Practices associated with each activity by the picture tab system at the bottom of the activity page. Activities relating to the specific Science Practices are identified in the tables on the following pages.

PRACTICES

SCIENCE PRACTICE 1

Use representations and models to communicate scientific phenomena and solve scientific problems. Includes creating, describing, refining, and using representations and models of natural or man-made phenomena and systems.

Practice number	Practice description	Activity number in AP1	Activity number in AP2
1.1	The student can *create representations* and models of natural or man-made phenomena and systems in the domain.	66, 77, 100, 138, 145, 174, 189, 240, 256	125, 126, 132, 178, 180-181, 210, 212, 226
1.2	The student can *describe representations* and models of natural or man-made phenomena and systems in the domain.	2, 28, 40, 51, 52, 54, 77,100, 104, 106, 129, 154, 179, 264, 277, 278	21, 125, 126, 132, 166 (bonus content), 178, 185-186, 205, 208, 210, 212, 226, 259
1.3	The student can *refine representations* and models of natural or man-made phenomena and systems in the domain.	66, 210	21, 23, 104, 190, 210, 226, 241, 259-260
1.4	The student can *use representations and models* to analyze situations or solve problems qualitatively and quantitatively.	51, 52, 54, 66, 72, 77, 100, 134, 138, 169, 172, 176, 179, 197, 210, 248	5, 6, 107, 205, 208, 210, 212, 226, 241, 259-260
1.5	The student can *reexpress key elements* of natural phenomena across multiple representations in the domain.	77, 106, 179, 213	93, 135, 157, 213, 236, 237, 248, 249, 266, 274

PRACTICES

SCIENCE PRACTICE 2

Use mathematics appropriately, including justifying the use of mathematical routines, applying mathematical routines, and making numerical estimates.

Practice number	Practice description	Activity number in AP1	Activity number in AP2
2.1	The student can *justify the selection* of a mathematical routine to solve problems.	8, 16, 20, 49, 211-213, 223	11, 18, 26, 197, 203
2.2	The student can *apply mathematical routines* to quantities that describe natural phenomena.	3, 6-10,16-19, 42-43, 48-49, 67, 69, 156-157, 184-185, 211-213, 215, 221, 223, 235	9, 11, 23, 32-33, 64, 105, 114, 194, 197-198, 200-203, 205, 207-208, 212-213, 226, 229, 239, 241, 243, 256-257, 271
2.3	The student can *estimate numerically quantities* that describe natural phenomena.	6	23, 208

PRACTICES

SCIENCE PRACTICE 3

Engage in scientific questioning to extend thinking or to guide investigations, including posing, refining, and evaluating scientific questions.

Practice number	Practice description	Activity number in AP1	Activity number in AP2
3.1	The student can *pose scientific questions.*	1, 43, 63, 79, 122, 135, 138, 162, 185, 250, 254	18, 64, 153
3.2	The student can *refine scientific questions.*	38, 115,135, 185, 229	26,153, 225, 229, 259
3.3	The student can *evaluate scientific questions.*	38, 43, 63, 65, 100, 115, 119, 122-125, 131, 135, 138, 185, 229, 276, 278	18, 26, 64, 153, 201, 241, 243, 258-260

PRACTICES

SCIENCE PRACTICE 4

Plan and implement data collection strategies appropriate to a particular scientific question. Includes posing, refining, and evaluating scientific questions as well as drawing conclusions from the experimental results of other scientists.

Practice number	Practice description	Activity number in AP1	Activity number in AP2
4.1	The student can *justify the selection of the kind of data* needed to answer a particular scientific question.	4, 45, 47, 96-97, 115, 126, 229, 278	139, 140, 201
4.2	The student can *design a plan* for collecting data to answer a particular scientific question.	4, 11, 38, 43, 46, 63, 115, 126, 229	26, 139, 153, 201
4.3	The student can *collect data* to answer a particular scientific question.	43, 63, 118, 229	153
4.4	The student can *evaluate sources of data* to answer a particular scientific question.	5, 38, 60, 63, 65, 68-69, 96-97,103, 115, 119, 135, 229, 276-278	8, 18, 26, 65, 139-140, 153, 201, 225, 229, 243

PRACTICES

SCIENCE PRACTICE 5

Perform data analysis and evaluation of evidence, including analyzing data to identify patterns or relationships and evaluating evidence provided by data in relation to a particular question.

Practice number	Practice description	Activity number in AP1	Activity number in AP2
5.1	The student can *analyze data* to identify patterns and relationships.	12-20, 63-65, 69, 97, 119, 135, 143, 184-185, 213, 215, 217, 229, 234, 236-237, 240, 242-244, 256-257, 263	9, 11, 25, 26, 32-34, 39-40, 64, 101, 105, 146-147, 151, 153, 160, 171, 177, 188, 203-205, 208, 210-213, 216, 224, 226-227, 229-230, 243, 250, 258, 264-266, 268, 271-272
5.2	The student can *refine observations and measurements* based on data analysis.	38, 60, 97, 229	9, 26, 153, 210, 226, 229
5.3	The student can evaluate the *evidence provided by data sets* in relation to a particular scientific question.	18-19, 60, 63-65, 69, 97, 103, 119, 130-131,135,143, 184-185, 213, 215, 217, 229, 234, 240, 242-248, 255-257, 263, 267	9, 26, 40, 45, 64, 139-140, 153, 156, 210, 216, 224, 226, 229, 243, 258, 268

PRACTICES

SCIENCE PRACTICE 6

Work with scientific explanations and theories, including justifying claims with evidence, constructing explanations and making claims and predictions about natural phenomena.

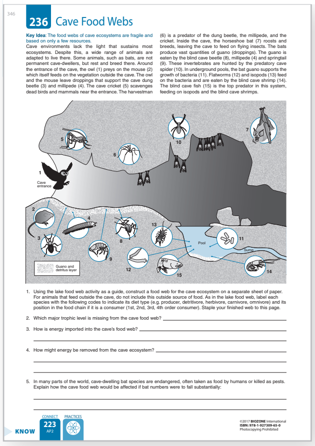
Practice number	Practice description	Activity number in AP1	Activity number in AP2
6.1	The student can *justify claims with evidence.*	32, 60, 89, 103, 171, 184, 185, 217, 221, 250-251, 277-278	13, 64, 139-140, 188, 229
6.2	The student can *construct explanations of phenomena based on evidence* produced through scientific practices.	41-43, 60-61, 64, 79, 97, 103, 111, 112, 129, 135, 144, 173, 183, 190, 191, 193, 197, 199, 201, 203, 217, 278	2, 5, 6, 8, 14, 32, 63, 105, 117, 139-141, 178-183, 188, 229, 258, 260
6.3	The student can *articulate the reasons that scientific explanations and theories are refined or replaced.*	60, 97, 103, 205, 216, 250, 278	140, 229, 259-260, 262, 268
6.4	The student can *make claims and predictions about natural phenomena* based on scientific theories and models.	28, 40, 64, 73, 97, 103, 110, 129, 236, 144, 183, 193, 206, 214, 216, 217, 221-223, 250, 251, 265-267, 272, 277	8, 13, 42-43, 45, 60, 64, 139-141, 180, 182, 188, 229, 250, 252, 254, 257-259
6.5	The student can *evaluate alternative scientific explanations.*	62, 63, 97, 103, 147-150, 153-155, 159-160, 164, 166, 167, 216, 276	229, 260

SCIENCE PRACTICE 7

Connect and relate knowledge across various scales, concepts, and representations in and across domains. Includes connecting phenomena and models across scales such as time, size, and complexity, and describing how enduring understandings and/or big ideas are connected.

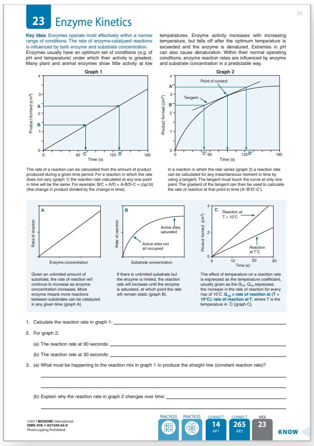
Practice number	Practice description	Activity number in AP1	Activity number in AP2
7.1	The student can *connect phenomena and models* across spatial and temporal scales.	22, 28, 40, 42, 73-74, 78-80, 92, 94, 110, 137, 142, 162, 167, 169-172, 174, 176-177, 182, 187, 196-197, 202, 207-208, 217, 220-223, 228, 236, 238, 242-245, 251, 256-257, 262, 267, 270-272	13, 28, 30, 41-42, 63, 79, 83-84, 89, 94, 96, 100-101, 115, 120, 122, 136, 161-162, 168, 169, 174, 175, 178, 180, 183, 206, 216, 218-223, 226, 229, 245-247, 253, 261
7.2	The student can *connect concepts* in and across domain(s) to generalize or extrapolate in and/or across enduring understandings and/or big ideas.	21-23, 27-28, 31-32, 34-35, 39-40, 42, 59, 62, 66-67, 73-74, 78-87, 92-95, 110, 130-131, 142, 144, 162, 167, 169-178, 182, 187, 189, 196-197, 202, 207-208, 217, 220-223, 228, 236, 238, 242-245, 251, 256-257, 262-263, 267, 270-272, 274	3-4, 8, 13, 28-30, 41-42, 61, 63, 67, 76-77, 79, 83-84, 87-89, 94, 96, 100-101, 115, 118, 120, 122, 126, 131, 136, 161-162, 169, 180, 182, 201, 206, 216, 218-223, 226, 229, 245-247, 253, 261

PRACTICES



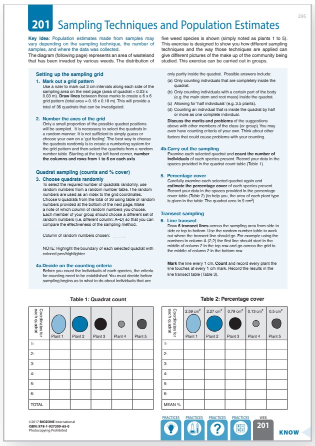
Reexpress the information provided as a diagram.

PRACTICES



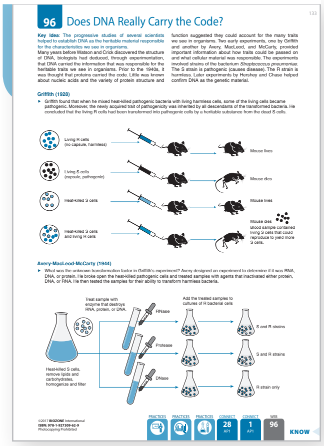
Apply a mathematical routine to determine reaction rate and Q_{10}.

PRACTICES



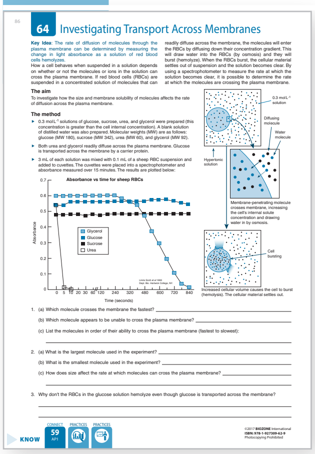
Evaluate scientific questions about sampling techniques.

PRACTICES



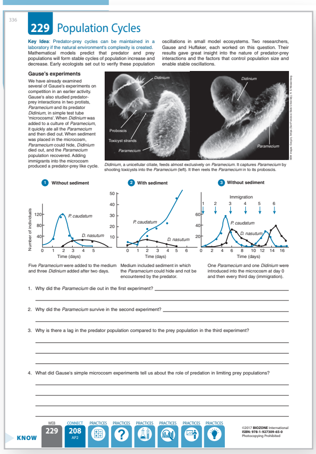
Evaluate data from experiments investigating scientific questions.

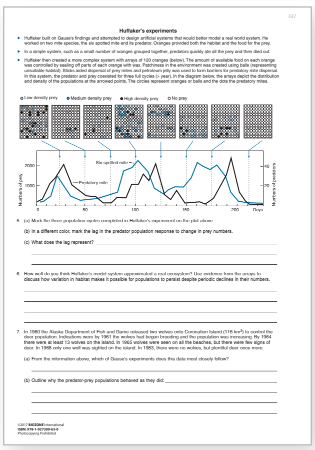
PRACTICES



Evaluate the results of an investigation of cellular transport.

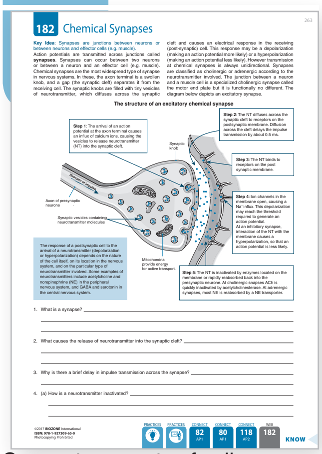
PRACTICES





Using the presented results of several key historical investigations to explain phenomena and understand how explanations are refined.

PRACTICES



Connect concepts of cell signaling across domains.

Addressing Student Learning Objectives

The Learning Objectives for AP Biology are summarized below together with the activities through which they can be wholly or partly met. In some cases, Learning Objectives are met though an instructional sequence of several related activities. The activities identified support the student's achievement of the learning objective directly (e.g. require the student to evaluate evidence provided by data) or sometimes indirectly (e.g. by providing the background to enable the student to pose a scientific question or design a plan to collect data, which may not be required of them in the activity *per se*.). It is BIOZONE's plan to extend this support of Learning Objectives further in our print and online resources.

BIG IDEA 1: The process of evolution drives the diversity and unity of life				
Enduring Understanding 1A: Change in the genetic makeup of a population over time is evolution				
	Learning Objectives	**SP**	**EK**	**Activities**
1.1	The student is able to convert a data set from a table of numbers that reflect a change in the genetic makeup of a population over time and to apply mathematical methods and conceptual understandings to investigate the cause(s) and effect(s) of this change.	1.5 2.2	1A1	213, 215, 229
1.2	The student is able to evaluate evidence provided by data to qualitatively and quantitatively investigate the role of natural selection in evolution.	2.2 5.3	1A1	213-220
1.3	The student is able to apply mathematical methods to data from a real or simulated population to predict what will happen to the population in the future.	2.2	1A1	211, 213, 216, 219-223
1.4	The student is able to evaluate data-based evidence that describes evolutionary changes in the genetic makeup of a population over time.	5.3	1A2	213, 215, 218, 226, 229
1.5	The student is able to connect evolutionary changes in a population over time to a change in the environment.	7.1	1A2	217, 220, 236, 238, 244-247
1.6	The student is able to use data from mathematical models based on the Hardy-Weinberg equilibrium to analyze genetic drift and effects of selection in the evolution of populations.	1.4 2.1	1A3	212-213, 223
1.7	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.	2.1	1A3	212-213, 223
1.8	The student is able to make predictions about the effects of genetic drift, migration and artificial selection on the genetic makeup of a population.	6.4	1A3	221-224, 226-229
1.9	The student is able to evaluate evidence provided by data from many scientific disciplines that support biological evolution.	5.3	1A4	234, 240-248
1.10	The student is able to refine evidence based on data from many scientific disciplines that support biological evolution.	5.2	1A4	231-249
1.11	The student is able to design a plan to answer scientific questions regarding how organisms have changed over time using information from morphology, biochemistry and geology.	4.2	1A4	247, 248
1.12	The student is able to connect scientific evidence from many scientific disciplines to support the modern concept of evolution.	7.1	1A4	231-249
1.13	The student is able to construct and/or justify mathematical models, diagrams or simulations that represent processes of biological evolution.	1.1 2.1	1A4	240
Enduring Understanding 1B: Organisms are linked by lines of descent from common ancestry				
1.14	The student is able to pose scientific questions that correctly identify essential properties of shared, core life processes that provide insights into the history of life on Earth.	3.1	1B1	250
1.15	The student is able to describe specific examples of conserved core biological processes and features shared by all domains or within one domain of life, and how these shared, conserved core processes and features support the concept of common ancestry for all organisms.	7.2	1B1	251
1.16	The student is able to justify the scientific claim that organisms share many conserved core processes and features that evolved and are widely distributed among organisms today.	6.1	1B1	250-251
1.17	The student is able to pose scientific questions about a group of organisms whose relatedness is described by a phylogenetic tree or cladogram in order to (1) identify shared (derived) characteristics, (2) make inferences about the evolutionary history of the group, and (3) identify character data that could extend or improve the phylogenetic tree.	3.1	1B2	252-256
1.18	The student is able to evaluate evidence provided by a data set in conjunction with a phylogenetic tree or a simple cladogram to determine evolutionary history and speciation.	5.3	1B2	254-256
1.19	The student is able create a phylogenetic tree or simple cladogram that correctly represents evolutionary history and speciation from a provided data set.	1.1	1B2	256
Enduring Understanding 1C: Life continues to evolve within a changing environment				
1.20	The student is able to analyze data related to questions of speciation and extinction throughout the Earth's history.	5.1	1C1	257
1.21	The student is able to analyze data related to questions of speciation and extinction throughout the Earth's history.	4.2	1C1	257, 263, 265-272, 274

1.22	The student is able to use data from a real or simulated population(s), based on graphs or models of types of selection, to predict what will happen to the population in the future.	6.4	1C2	265-267
1.23	The student is able to justify the selection of data that address questions related to reproductive isolation and speciation.	4.1	1C2	258-263
1.24	The student is able to describe speciation in an isolated population and connect it to change in gene frequency, change in environment, natural selection and/or genetic drift.	7.2	1C2	263
1.25	The student is able to describe a model that represents evolution within a population.	1.2	1C3	244, 263-264
1.26	The student is able to evaluate given data sets that illustrate evolution as an ongoing process.	5.3	1C3	244, 263, 265-267
Enduring Understanding 1D: The origin of living systems is explained by natural processes				
1.27	The student is able to describe a scientific hypothesis about the origin of life on Earth.	1.2	1D1	276-278
1.28	The student is able to evaluate scientific questions based on hypotheses about the origin of life on Earth	3.3	1D1	276-278
1.29	The student is able to describe the reasons for revisions of scientific hypotheses of the origin of life on Earth.	6.3	1D1	276-278
1.30	The student is able to evaluate scientific hypotheses about the origin of life on Earth.	6.5	1D1	276
1.31	The student is able to evaluate the accuracy and legitimacy of data to answer scientific questions about the origin of life on Earth.	4.4	1D1	276-278
1.32	The student is able to justify the selection of geological, physical, and chemical data that reveal early Earth conditions.	4.1	1D2	278
BIG IDEA 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce, and to maintain dynamic homeostasis				
Enduring Understanding 2A: Growth, reproduction and maintenance of the organization of living systems require free energy and matter				
2.1	The student is able to explain how biological systems use free energy based on empirical data that all organisms require constant energy input to maintain organization, to grow and to reproduce.	6.2	2A1	1-2, 32
2.2	The student can 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.	6.1	2A1	1-2, 32, 34-36
2.3	The student is able to predict how changes in free energy availability affect organisms, populations and ecosystems.	6.4	2A1	2, 32, 34-39
2.4	The student is able to use representations to pose scientific questions about what mechanisms and structural features allow organisms to capture, store, and use free energy.	1.4 3.1	2A2	2, 5, 10, 14, 32-39
2.5	The student is able to construct explanations of the mechanisms and structural features of cells that allow organisms to capture, store or use free energy.	6.2	2A2	2, 5, 8, 10, 14
2.41	The student is able to evaluate data to show the relationship between photosynthesis and respiration in the flow of free energy through a system.	5.3 7.1	2A2	2, 5
2.6	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.	2.2	2A3	41-43
2.7	Students will be able to explain how cell size and shape affect the overall rate of nutrient intake and the rate of waste elimination.	6.2	2A3	41-43
2.8	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.	4.1	2A3	21, 24, 25
2.9	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.	1.1 1.4	2A3	25
Enduring Understanding 2B: Growth, reproduction and dynamic homeostasis require that cells create and maintain internal environments that are different from their external environments.				
2.10	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.	1.4 3.1	2B1	59-60, 63-66
2.11	The student is able to construct models that connect the movement of molecules across membranes with membrane structure and function.	1.1 7.1 7.2	2B1	63-66
2.12	The student is able to use representations and models to analyze situations or solve problems qualitatively and quantitatively to investigate whether dynamic homeostasis is maintained by the active movement of molecules across membranes.	1.4	2B2	63-66, 71-74
2.13	The student is able to explain how internal membranes and organelles contribute to cell functions.	6.2	2B3	51-58, 61
2.14	The student is able to use representations and models to describe differences in prokaryotic and eukaryotic cells.	1.2 1.4	2B3	51, 52, 54
Enduring Understanding 2C: Organisms use feedback mechanisms to regulate growth and reproduction, and maintain dynamic homeostasis				
2.15	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.	6.1	2C1	41, 43-49

2.16	The student is able to connect how organisms use negative feedback to maintain their internal environments.	7.2	2C1	41, 43-45, 47-49
2.17	The student is able to evaluate data that show the effect(s) of changes in concentrations of key molecules on negative feedback mechanisms.	5.3	2C1	45
2.18	The student can make predictions about how organisms use negative feedback mechanisms to maintain their internal environments.	6.4	2C1	41, 43-45, 47-49
2.19	The student is able to make predictions about how positive feedback mechanisms amplify activities and processes in organisms based on scientific theories and models.	6.4	2C1	42-43, 50
2.20	The student is able to justify that positive feedback mechanisms amplify responses in organisms.	6.1	2C1	42-43, 50
2.21	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.	4.1	2C2	44-45, 136-148
2.42	The student is able to pose a scientific question concerning the behavioral or physiological response of an organism to a change in its environment.	3.1	2C2	151-153
Enduring Understanding 2D: Growth and dynamic homeostasis of a biological system are influenced by changes in the system's environment				
2.22	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	1.3 3.2	2D1	18, 23, 193, 217, 220-225, 227, 229
2.23	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.	4.2 7.2	2D1	197-203
2.24	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).	5.1	2D1	203
2.25	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.	6.2	2D2	59-63, 68-93, 98, 101-105, 117
2.26	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.	5.1	2D2	61, 68, 70-72, 75-92, 95, 101
2.27	The student is able to connect differences in the environment with the evolution of homeostatic mechanisms.	7.1	2D2	61, 68-92, 101
2.28	The student is able to use representations or models to analyze quantitatively and qualitatively the effects of disruptions to dynamic homeostasis in biological systems.	1.4	2D3	47, 48, 106, 120, 133-134
2.29	The student can create representations and models to describe immune responses.	1.1 1.2	2D4	128, 130-132
2.30	The student can create representations or models to describe nonspecific immune defenses in plants and animals.	1.1 1.2	2D4	124-126
2.43	The student is able to connect the concept of cell communication to the functioning of the immune system.	7.2	2D4	126, 130, 133 also 80-81
Enduring Understanding 2E: Many biological processes involved in growth, reproduction, and dynamic homeostasis include temporal regulation and coordination				
2.31	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.	7.2	2E1	169-177
2.32	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.	1.4	2E1	170-173, 175-176
2.33	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.	6.1	2E1	170-176
2.34	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.	7.1	2E1	130-131, 177
2.35	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.	4.2	2E2	140, also 173
2.36	The student is able to justify scientific claims with evidence to show how timing and coordination of physiological events involve regulation.	6.1	2E2	136, 139-141, 144-147
2.37	The student is able to connect concepts that describe mechanisms that regulate the timing and coordination of physiological events.	7.2	2E2	136-149, 170-176
2.38	The student is able to analyze data to support the claim that responses to information and communication of information affect natural selection.	5.1	2E3	137, 141, 144, 147-152, 156-164 also 170, 173-177

2.39	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.	6.1	2E3	139-144, 147, 148, 156-159
2.40	The student is able to connect concepts in and across domain(s) to predict how environmental factors affect responses to information and change behavior.	7.2	2E3	151-153, 156-157
BIG IDEA 3: Living systems store, retrieve, transmit, and respond to information essential to life processes				
Enduring Understanding 3A: Heritable information provides for continuity of life				
3.1	The student is able to construct scientific explanations that use the structures and mechanisms of DNA and RNA to support the claim that DNA and, in some cases, that RNA are the primary sources of heritable information.	6.2 6.5	3A1	96-98, 100, 103
3.2	The student is able to justify the selection of data from historical investigations that support the claim that DNA is the source of heritable information.	4.1	3A1	96-97
3.3	The student is able to describe representations and models that illustrate how genetic information is copied for transmission between generations.	1.2	3A1	100-103
3.4	The student is able to describe representations and models illustrating how genetic information is translated into polypeptides	1.2	3A1	104-109
3.5	The student can justify the claim that humans can manipulate heritable information by identifying at least two commonly used technologies	6.2 6.4	3A1	111-126
3.6	The student can predict how a change in a specific DNA or RNA sequence can result in changes in gene expression.	6.4	3A1	105, 110
3.7	The student can make predictions about natural phenomena occurring during the cell cycle	6.2 6.5	3A2	129
3.8	The student can describe the events that occur in the cell cycle.	1.2	3A2	129
3.9	The student is able to construct an explanation, using visual representations or narratives, as to how DNA in chromosomes is transmitted to the next generation via mitosis, or meiosis followed by fertilization.	6.2	3A2	132-139
3.10	The student is able to represent the connection between meiosis and increased genetic diversity necessary for evolution	7.1	3A2	137
3.11	The student is able to evaluate evidence provided by data sets to support the claim that heritable information is passed from one generation to another generation through mitosis, or meiosis followed by fertilization.	5.3	3A2	143
3.12	The student is able to construct a representation that connects the process of meiosis to the passage of traits from parent to offspring.	1.1 7.2	3A3	144-145
3.13	The student is able to pose questions about ethical, social or medical issues surrounding human genetic disorders.	3.1	3A3	162-163
3.14	The student is able to apply mathematical routines to determine Mendelian patterns of inheritance provided by data sets.	2.2	3A3	156-158
3.15	The student is able to explain deviations from Mendel's model of the inheritance of traits.	6.2 6.5	3A4	147-150, 153-155, 159-160, 164, 166-167
3.16	The student is able to explain how the inheritance patterns of many traits cannot be accounted for by Mendelian genetics.	6.3	3A4	147-150, 153-155, 159-160, 164, 166-167
3.17	The student is able to describe representations of an appropriate example of inheritance patterns that cannot be explained by Mendel's model of the inheritance of traits.	1.2	3A4	153-155, 166-167
Enduring Understanding 3B: Expression of genetic information involves cellular and molecular mechanisms				
3.18	The student is able to describe the connection between the regulation of gene expression and observed differences between different kinds of organisms	7.1	3B1	171-176, also 243
3.19	The student is able to describe the connection between the regulation of gene expression and observed differences between individuals in a population.	7.1	3B1	171-176, also 243
3.20	The student is able to explain how the regulation of gene expression is essential for the processes and structures that support efficient cell function.	6.2	3B1	173
3.21	The student can use representations to describe how gene regulation influences cell products and function.	1.4	3B1	169-173
3.22	The student is able to explain how signal pathways mediate gene expression, including how this process can affect protein production.	6.2	3B2	169, 172-173 also 77, 79, 82-83
3.23	The student can use representations to describe mechanisms of the regulation of gene expression.	1.4	3B2	172-173, 178-180
Enduring Understanding 3C: The processing of genetic information is imperfect and is a source of genetic variation				
3.24	The student is able to predict how a change in genotype, when expressed as a phenotype, provides a variation that can be subject to natural selection.	6.4 7.2	3C1	182-183
3.25	The student can create a visual representation to illustrate how changes in a DNA nucleotide sequence can result in a change in the polypeptide produced.	1.1	3C1	187, 189

3.26	The student is able to explain the connection between genetic variations in organisms and phenotypic variations in populations.	7.2	3C1	187-197
3.27	The student is able to compare and contrast processes by which genetic variation is produced and maintained in organisms from multiple domains.	6.2	3C2	182-183, 187-197, also 242
3.28	The student is able to construct an explanation of the multiple processes that increase variation within a population.	1.4	3C2	182-183, 187-197, also 242
3.29	The student is able to construct an explanation of how viruses introduce genetic variation in host organisms.	6.2	3C3	197-202
3.30	The student is able to use representations and appropriate models to describe how viral replication introduces genetic variation in the viral population	1.4	3C3	197-198, 200-202
Enduring Understanding 3D: Cells communicate by generating, transmitting, and receiving chemical signals				
3.31	The student is able to describe basic chemical processes for cell communication shared across evolutionary lines of descent.	7.2	3D1	77-79
3.32	The student is able to generate scientific questions involving cell communication as it relates to the process of evolution.	3.1	3D1	78-82
3.33	The student is able to use representation(s) and appropriate models to describe features of a cell signaling pathway.	1.4	3D1	77, 85
3.34	The student is able to construct explanations of cell communication through cell-to-cell direct contact or through chemical signaling.	6.2	3D2	77, 79-82, 172
3.35	The student is able to create representation(s) that depict how cell-to-cell communication occurs by direct contact or from a distance through chemical signaling.	1.1	3D2	77
3.36	The student is able to describe a model that expresses the key elements of signal transduction pathways by which a signal is converted to a cellular response.	1.5	3D3	77, 85-87
3.37	The student is able to justify claims based on scientific evidence that changes in signal transduction pathways can alter cellular response.	6.1	3D4	89
3.38	The student is able to describe a model that expresses key elements to show how change in signal transduction can alter cellular response.	1.5	3D4	88, 89
3.39	The student is able to construct an explanation of how certain drugs affect signal reception and, consequently, signal transduction pathways.	6.2	3D4	89
Enduring Understanding 3E: Transmission of information results in changes within and between biological systems				
3.40	The student is able to analyze data that indicate how organisms exchange information in response to internal changes and external cues, and which can change behavior.	5.1	3E1	167, 171, 174-177
3.41	The student is able to create a representation that describes how organisms exchange information in response to internal changes and external cues, and which can result in changes in behavior.	1.1	3E1	167, 171, 174-177
3.42	The student is able to describe how organisms exchange information in response to internal changes or environmental cues.	7.1	3E1	168, 174-175
3.43	The student is able to construct an explanation, based on scientific theories and models, about how nervous systems detect external and internal signals, transmit and integrate information, and produce responses.	6.2 7.1	3E2	178-183
3.44	The student is able to describe how nervous systems detect external and internal signals.	1.2	3E2	166, 178
3.45	The student is able to describe how nervous systems transmit information.	1.2	3E2	178-182
3.46	The student is able to describe how the vertebrate brain integrates information to produce a response.	1.2	3E2	181, 185-186
3.47	The student is able to create a visual representation of complex nervous systems to describe/explain how these systems detect external and internal signals, transmit and integrate information, and produce responses.	1.1	3E2	178
3.48	The student is able to create a visual representation to describe how nervous systems detect external and internal signals.	1.1	3E2	166, 178
3.49	The student is able to create a visual representation to describe how nervous systems transmit information.	1.1	3E2	180-181
3.50	The student is able to create a visual representation to describe how the vertebrate brain integrates information to produce a response.	1.1	3E2	185-186
BIG IDEA 4: Biological systems interact, and these systems and their interactions possess complex properties				
Enduring Understanding 4A: Interactions within biological systems lead to complex properties				
4.1	The student is able to explain the connection between the sequence and the subcomponents of a biological polymer and its properties.	7.1	4A1	27-32, 34-36, 39-40, 91
4.2	The student is able to refine representations and models to explain how the subcomponents of a biological polymer and their sequence determine the properties of that polymer.	1.2	4A1	27-32, 34-36, 39-40, 91, 100
4.3	The student is able to use models to predict and justify that changes in the subcomponents of a biological polymer affect the functionality of the molecule.	6.1 6.4	4A1	31-35, 39-40, 100

4.4	The student is able to make a prediction about the interactions of subcellular organelles.	6.4	4A2	73
4.5	The student is able to construct explanations based on scientific evidence as to how interactions of subcellular structures provide essential functions.	6.2	4A2	61,73 6-7
4.6	The student is able to use representations and models to analyze situations qualitatively to describe how interactions of subcellular structures, which possess specialized functions, provide essential functions.	1.4	4A2	61,72-73 6-7
4.7	The student is able to refine representations to illustrate how interactions between external stimuli and gene expression result in specialization of cells, tissues and organs.	1.3	4A3	169-170, 173
4.8	The student is able to evaluate scientific questions concerning organisms that exhibit complex properties due to the interaction of their constituent parts.	3.3	4A4	53-63, 64, 65, 72-74, 82, 85, 88, 118, 94, 96-97, 107-118
4.9	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).	6.4	4A4	59-61, 64, 66,73-74, 76,101,104-105, 118
4.10	The student is able to refine representations and models to illustrate biocomplexity due to interactions of the constituent parts.	1.3	4A4	64, 98, 104-105,190
4.11	The student is able to justify the selection of the kind of data needed to answer scientific questions about the interaction of populations within communities.	1.4 4.1	4A5	193-194, 197-203, 226, 231
4.12	The student is able to apply mathematical routines to quantities that describe communities composed of populations of organisms that interact in complex ways.	2.2	4A5	194, 197-198, 201-203, 226
4.13	The student is able to predict the effects of a change in the community's populations on the community.	6.4	4A5	207, 210-213, 250-252,
4.14	The student is able to apply mathematical routines to quantities that describe interactions among living systems and their environment, which result in the movement of matter and energy.	2.2	4A6	239, 241, 243, 257, 274
4.15	The student is able to use visual representations to analyze situations or solve problems qualitatively to illustrate how interactions among living systems and with their environment result in the movement of matter and energy.	1.4	4A6	234-237, 240-244, 246-248
4.16	The student is able to predict the effects of a change of matter or energy availability on communities.	6.4	4A6	235, 241, 243, 254, 257
Enduring Understanding 4B: Competition and cooperation are important aspects of biological systems.				
4.17	The student is able to analyze data to identify how molecular interactions affect structure and function.	5.1	4B1	25
4.18	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.	1.4	4B2	59, 83-84, 107
4.19	The student is able to use data analysis to refine observations and measurements regarding the effect of population interactions on patterns of species distribution and abundance.	2.2 5.2	4B3	226, 229
4.20	The student is able to explain how the distribution of ecosystems changes over time by identifying large-scale events that have resulted in these changes in the past.	6.2 6.3	4B4	262, 268
4.21	The student is able to predict consequences of human actions on both local and global ecosystems.	6.4	4B4	254-267
Enduring Understanding 4C: Naturally occurring diversity among and between components within biological systems affects interaction with the environment.				
4.22	The student is able to construct explanations based on evidence of how variation in molecular units provides cells with a wider range of functions.	6.2	4C1	189, 191-193
4.23	The student is able to construct explanations of the influence of environmental factors on the phenotype of an organism.	6.2	4C2	179, 182-183
4.24	The student is able to predict the effects of a change in an environmental factor on the genotypic expression of the phenotype.	6.4	4C2	179, 182-185
4.25	The student is able to use evidence to justify a claim that a variety of phenotypic responses to a single environmental factor can result from different genotypes within the population.	6.1	4C3	182-183, 188-193
4.26	The student is able to use theories and models to make scientific claims and/ or predictions about the effects of variation within populations on survival and fitness.	6.4	4C3	188-193, also 206-207
4.27	The student is able to make scientific claims and predictions about how species diversity within an ecosystem influences ecosystem stability.	6.4	4C4	249, 253, 263, 270-272