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

Enduring understanding 1.A: Change in the genetic makeup of a population over time is evolution.	**Essential knowledge 1.A.1**: Natural selection is a major mechanism of evolution.	**LO 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. [See **SP 1.5, 2.2**] **LO 1.2** The student is able to evaluate evidence provided by data to qualitatively and quantitatively investigate the role of natural selection in evolution. [See **SP 2.2, 5.3**] **LO 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. [See **SP 2.2**]
	Essential knowledge 1.A.2: Natural selection acts on phenotypic variations in populations.	**LO 1.4** The student is able to evaluate data-based evidence that describes evolutionary changes in the genetic makeup of a population over time. [See **SP 5.3**] **LO 1.5** The student is able to connect evolutionary changes in a population over time to a change in the environment. [See **SP 7.1**]
	Essential knowledge 1.A.3: Evolutionary change is also driven by random processes.	**LO 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 specific populations. [See **SP 1.4, 2.1**] **LO 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. [See **SP 2.1**] **LO 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.
	Essential knowledge 1.A.4: Biological evolution is supported by scientific evidence from many disciplines, including mathematics.	**LO 1.9** The student is able to evaluate evidence provided by data from many scientific disciplines that support biological evolution. [See **SP 5.3**] **LO 1.10** The student is able to refine evidence based on data from many scientific disciplines that support biological evolution. [See **SP 5.2**] **LO 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. [See **SP 4.2**] **LO 1.12** The student is able to connect scientific evidence from many scientific disciplines to support the modern concept of evolution. [See **SP 7.1**] **LO 1.13** The student is able to construct and/or justify mathematical models, diagrams or simulations that represent processes of biological evolution. [See **SP 1.1, 2.1**
Enduring understanding 1.B: Organisms are linked by lines of descent from common ancestry.	**Essential knowledge 1.B.1**: Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today.	**LO 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. [See **SP 3.1**] **LO 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. [See **SP 7.2**] **LO 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. [See **SP 6.1**]
	Essential knowledge 1.B.2: Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested.	**LO 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 characteristics, (2) make inferences about the evolutionary history of the group, and (3) identify character data that could extend or improve the phylogenetic tree. [See **SP 3.1**] **LO 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. [See **SP 5.3**] **LO 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. [See **SP 1.1**]
Enduring understanding 1.C: Life continues to evolve within a changing environment.	**Essential knowledge 1.C.1**: Speciation and extinction have occurred throughout the Earth's history.	**LO 1.20** The student is able to analyze data related to questions of speciation and extinction throughout the Earth's history. [See **SP 5.1**] **LO 1.21** 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. [See **SP 4.2**]
	Essential knowledge 1.C.2: Speciation may occur when two populations become reproductively isolated from each other.	**LO 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. [See **SP 6.4**] **LO 1.23** The student is able to justify the selection of data that address questions related to reproductive isolation and speciation. [See **SP 4.1**] **LO 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. [See **SP 7.2**]
	Essential knowledge 1.C.3: Populations of organisms continue to evolve.	**LO 1.25** The student is able to describe a model that represents evolution within a population. [See **SP 1.2**] **LO 1.26** The student is able to evaluate given data sets that illustrate evolution as an ongoing process. [See **SP 5.3**]
Enduring understanding 1.D: The origin of living systems is explained by natural processes.	**Essential knowledge 1.D.1**: There are several hypotheses about the natural origin of life on Earth, each with supporting scientific evidence.	**LO 1.27** The student is able to describe a scientific hypothesis about the origin of life on Earth. [See **SP 1.2**] **LO 1.28** The student is able to evaluate scientific questions based on hypotheses about the origin of life on Earth. [See **SP 3.3**] **LO 1.29** The student is able to describe the reasons for revisions of scientific hypotheses of the origin of life on Earth. [See **SP 6.3**] **LO 1.30** The student is able to evaluate scientific hypotheses about the origin of life on Earth. [See **SP 6.5**] **LO 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. [See **SP 4.4**]
	Essential knowledge 1.D.2: Scientific evidence from many different disciplines supports models of the origin of life.	**LO 1.32** The student is able to justify the selection of geological, physical, and chemical data that reveal early Earth conditions. [See **SP 4.1**]

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

Enduring understanding 2.A: Growth, reproduction and maintenance of the organization of living systems require free energy and matter.	**Essential knowledge 2.A.1:** All living systems require constant input of free energy.	**LO 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. [See **SP 6.2**] **LO 2.2** 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. [See **SP 6.1**] **LO 2.3** The student is able to predict how changes in free energy availability affect organisms, populations and ecosystems. [See **SP 6.4**]
	Essential knowledge 2.A.2: Organisms capture and store free energy for use in biological processes.	**LO 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. [See **SP 1.4, 3.1**] **LO 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. [See **SP 6.2**]
	Essential knowledge 2.A.3: Organisms must exchange matter with the environment to grow, reproduce and maintain organization.	**LO 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. [See **SP 2.2**] **LO 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. [See **SP 6.2**] **LO 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. [See **SP 4.1**] **LO 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. [See **SP 1.1, 1.4**]
Enduring understanding 2.B: Growth, reproduction and dynamic homeostasis require that cells create and maintain internal environments that are different from their external environments.	**Essential knowledge 2.B.1**: Cell membranes are selectively permeable due to their structure.	**LO 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. [See **SP 1.4, 3.1**] **LO 2.11** The student is able to construct models that connect the movement of molecules across membranes with membrane structure and function. [See **SP 1.1, 7.1, 7.2**]
	Essential knowledge 2.B.2: Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes.	**LO 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. [See **SP 1.4**]
	Essential knowledge 2.B.3: Eukaryotic cells maintain internal membranes that partition the cell into	**LO 2.13** The student is able to explain how internal membranes and organelles contribute to cell functions. [See **SP 6.2**] **LO 2.14** The student is able to use representations and models to describe differences in prokaryotic and eukaryotic cells. [See **SP**

	specialized regions.	1.4]
Enduring understanding 2.C: Organisms use feedback mechanisms to regulate growth and reproduction, and to maintain dynamic homeostasis.	**Essential knowledge 2.C.1**: Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental changes.	**LO 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. [See **SP 6.1**] **LO 2.16** The student is able to connect how organisms use negative feedback to maintain their internal environments. [See **SP 7.2**] **LO 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. [See **SP 5.3**] **LO 2.18** The student can make predictions about how organisms use negative feedback mechanisms to maintain their internal environments. [See **SP 6.4**] **LO 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. [See **SP 6.4**] **LO 2.20** The student is able to justify that positive feedback mechanisms amplify responses in organisms. [See **SP 6.1**]
	Essential knowledge 2.C.2: Organisms respond to changes in their external environments.	**LO 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. [See **SP 4.1**]
Enduring understanding 2.D: Growth and dynamic homeostasis of a biological system are influenced by changes in the system's environment.	**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.	**LO 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. [See **SP 1.3, 3.2**] **LO 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. [See **SP 4.2, 7.2**] **LO 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). [See **SP 5.1**]
	Essential knowledge 2.D.2: Homeostatic mechanisms reflect both common ancestry and divergence due to adaptation in different environments.	**LO 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. [See **SP 6.2**] **LO 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. [See **SP 5.1**] **LO 2.27** The student is able to connect differences in the environment with the evolution of homeostatic mechanisms. [See **SP 7.1**]
	Essential knowledge 2.D.3: Biological systems are affected by disruptions to their dynamic homeostasis.	**LO 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. [See **SP 1.4**]
	Essential knowledge 2.D.4: Plants and animals have a variety of chemical defenses	**LO 2.29** The student can create representations and models to describe immune responses. [See **SP 1.1, 1.2**] **LO 2.30** The student can create representations or models to describe

	against infections that affect dynamic homeostasis.	nonspecific immune defenses in plants and animals. [See **SP 1.1, 1.2**]
Enduring understanding 2.E: Many biological processes involved in growth, reproduction and dynamic homeostasis include temporal regulation and coordination.	**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.	**LO 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. [See **SP 7.2**] **LO 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. [See **SP 1.4**] **LO 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 [See **SP 6.1**] **LO 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. [See **SP 7.1**]
	Essential knowledge 2.E.2: Timing and coordination of physiological events are regulated by multiple mechanisms.	**LO 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. [See **SP 4.2**] **LO 2.36** The student is able to justify scientific claims with evidence to show how timing and coordination of physiological events involve regulation. [See **SP 6.1**] **LO 2.37** The student is able to connect concepts that describe mechanisms that regulate the timing and coordination of physiological events. [See **SP 7.2**]
	Essential knowledge 2.E.3: Timing and coordination of behavior are regulated by various mechanisms and are important in natural selection.	**LO 2.38** The student is able to analyze data to support the claim that responses to information and communication of information affect natural selection. [See **SP 5.1**] **LO 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. [See **SP 6.1**] **LO 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. [See **SP 7.2**]

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

Enduring understanding 3.A: Heritable information provides for continuity of life.	**Essential knowledge 3.A.1:** DNA, and in some cases RNA, is the primary source of heritable information.	**LO 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. [See **SP 6.5**] **LO 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. [See **SP 4.1**] **LO 3.3** The student is able to describe representations and models that illustrate how genetic information is copied for transmission between generations. [See **SP 1.2**] **LO 3.4** The student is able to describe representations and models illustrating how genetic information is translated into polypeptides. [See **SP 1.2**] **LO 3.5** The student can justify the claim that humans can manipulate heritable information by identifying *at least two* commonly used technologies. [See **SP 6.4**] **LO 3.6** The student can predict how a change in a specific DNA or RNA sequence can result in changes in gene expression. [See **SP 6.4**]

	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.	**LO 3.7** The student can make predictions about natural phenomena occurring during the cell cycle. [See **SP 6.4**] **LO 3.8** The student can describe the events that occur in the cell cycle. [See **SP 1.2**] **LO 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. [See **SP 6.2**] **LO 3.10** The student is able to represent the connection between meiosis and increased genetic diversity necessary for evolution. [See **SP 7.1**] **LO 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. [See **SP 5.3**]
	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.	**LO 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. [See **SP 1.1, 7.2**] **LO 3.13** The student is able to pose questions about ethical, social or medical issues surrounding human genetic disorders. [See **SP 3.1**] **LO 3.14** The student is able to apply mathematical routines to determine Mendelian patterns of inheritance provided by data sets. [See **SP 2.2**]
	Essential knowledge 3.A.4: The inheritance pattern of many traits cannot be explained by simple Mendelian genetics.	**LO 3.15** The student is able to explain deviations from Mendel's model of the inheritance of traits. [See **SP 6.5**] **LO 3.16** The student is able to explain how the inheritance patterns of many traits cannot be accounted for by Mendelian genetics. [See **SP 6.3**] **LO 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. [See **SP 1.2**]
Enduring understanding 3.B: Expression of genetic information involves cellular and molecular mechanisms.	**Essential knowledge 3.B.1**: Gene regulation results in differential gene expression, leading to cell specialization.	**LO 3.18** The student is able to describe the connection between the regulation of gene expression and observed differences between different kinds of organisms. [See **SP 7.1**] **LO 3.19** The student is able to describe the connection between the regulation of gene expression and observed differences between individuals in a population. [See **SP 7.1**] **LO 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. [See **SP 6.2**] **LO 3.21** The student can use representations to describe how gene regulation influences cell products and function. [See **SP 1.4**]
	Essential knowledge 3.B.2: A variety of intercellular and intracellular signal transmissions mediate gene expression.	**LO 3.22** The student is able to explain how signal pathways mediate gene expression, including how this process can affect protein production. [See **SP 6.2**] **LO 3.23** The student can use representations to describe mechanisms of the regulation of gene expression. [See **SP 1.4**]
Enduring understanding 3.C: The processing of genetic information is	**Essential knowledge 3.C.1**: Changes in genotype can result in changes in phenotype.	**LO 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. [See **SP 6.4, 7.2**] **LO 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

imperfect and is a source of genetic variation.		polypeptide produced. [See **SP 1.1**] **LO 3.26** The student is able to explain the connection between genetic variations in organisms and phenotypic variations in populations. [See **SP 7.2**]
	Essential knowledge 3.C.2: Biological systems have multiple processes that increase genetic variation.	**LO 3.27** The student is able to compare and contrast processes by which genetic variation is produced and maintained in organisms from multiple domains. [See **SP 7.2**] **LO 3.28** The student is able to construct an explanation of the multiple processes that increase variation within a population. [See **SP 6.2**]
	Essential knowledge 3.C.3: Viral replication results in genetic variation, and viral infection can introduce genetic variation into the hosts.	**LO 3.29** The student is able to construct an explanation of how viruses introduce genetic variation in host organisms. [See **SP 6.2**] **LO 3.30** The student is able to use representations and appropriate models to describe how viral replication introduces genetic variation in the viral population. [See **SP 1.4**]
Enduring understanding 3.D: Cells communicate by generating, transmitting and receiving chemical signals.	**Essential knowledge 3.D.1**: Cell communication processes share common features that reflect a shared evolutionary history.	**LO 3.31** The student is able to describe basic chemical processes for cell communication shared across evolutionary lines of descent. [See **SP 7.2**] **LO 3.32** The student is able to generate scientific questions involving cell communication as it relates to the process of evolution. [See **SP 3.1**] **LO 3.33** The student is able to use representation(s) and appropriate models to describe features of a cell signaling pathway. [See **SP 1.4**]
	Essential knowledge 3.D.2: Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling.	**LO 3.34** The student is able to construct explanations of cell communication through cell-to-cell direct contact or through chemical signaling. [See **SP 6.2**] **LO 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. [See **SP 1.1**]
	Essential knowledge 3.D.3: Signal transduction pathways link signal reception with cellular response.	**LO 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. [See **SP 1.5**]
	Essential knowledge 3.D.4: Changes in signal transduction pathways can alter cellular response.	**LO 3.37** The student is able to justify claims based on scientific evidence that changes in signal transduction pathways can alter cellular response. [See **SP 6.1**] **LO 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. [See **SP 1.5**] **LO 3.39** The student is able to construct an explanation of how certain drugs affect signal reception and, consequently, signal transduction pathways. [See **SP 6.2**]
Enduring understanding 3.E: Transmission of information results in changes within and between biological systems.	**Essential knowledge 3.E.1**: Individuals can act on information and communicate it to others.	**LO 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. [See **SP 5.1**] **LO 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. [See **SP 1.1**] **LO 3.42** The student is able to describe how organisms exchange information in response to internal changes or environmental cues. [See **SP 7.1**]

	Essential knowledge 3.E.2: Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses.	**LO 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. [See **SP 6.2, 7.1**] **LO 3.44** The student is able to describe how nervous systems detect external and internal signals. [See **SP 1.2**] **LO 3.45** The student is able to describe how nervous systems transmit information. [See **SP 1.2**] **LO 3.46** The student is able to describe how the vertebrate brain integrates information to produce a response. [See **SP 1.2**] **LO 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. [See **SP 1.1**] **LO 3.48** The student is able to create a visual representation to describe how nervous systems detect external and internal signals . [See **SP 1.1**] **LO 3.49** The student is able to create a visual representation to describe how nervous systems transmit information. [See **SP 1.1**] **LO 3.50** The student is able to create a visual representation to describe how the vertebrate brain integrates information to produce a response. [See **SP 1.1**]

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

Enduring understanding 4.A: Interactions within biological systems lead to complex properties.	**Essential knowledge 4.A.1:** The subcomponents of biological molecules and their sequence determine the properties of that molecule.	**LO 4.1** The student is able to explain the connection between the sequence and the subcomponents of a biological polymer and its properties. [See **SP 7.1**] **LO 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. [See **SP 1.3**] **LO 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. [See **SP 6.1, 6.4**]
	Essential knowledge 4.A.2: The structure and function of subcellular components, and their interactions, provide essential cellular processes.	**LO 4.4** The student is able to make a prediction about the interactions of subcellular organelles. [See **SP 6.4**] **LO 4.5** The student is able to construct explanations based on scientific evidence as to how interactions of subcellular structures provide essential functions. [See **SP 6.2**] **LO 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. [See **SP 1.4**]
	Essential knowledge 4.A.3: Interactions between external stimuli and regulated gene expression result in specialization of cells, tissues and organs.	**LO 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. [See **SP 1.3**]
	Essential knowledge 4.A.4: Organisms exhibit complex properties due to interactions between	**LO 4.8** The student is able to evaluate scientific questions concerning organisms that exhibit complex properties due to the interaction of their constituent parts. [See **SP 3.3**] **LO 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).

	their constituent parts.	[See **SP 6.4**] **LO 4.10** The student is able to refine representations and models to illustrate biocomplexity due to interactions of the constituent parts. [See **SP 1.3**]
	Essential knowledge 4.A.5: Communities are composed of populations of organisms that interact in complex ways.	**LO 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. [See **SP 1.4, 4.1**] **LO 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. [See **SP 2.2**] **LO 4.13** The student is able to predict the effects of a change in the community's populations on the community. [See **SP 6.4**]
	Essential knowledge 4.A.6: Interactions among living systems and with their environment result in the movement of matter and energy.	**LO 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. [See **SP 2.2**] **LO 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. [See **SP 1.4**] **LO 4.16** The student is able to predict the effects of a change of matter or energy availability on communities. [See **SP 6.4**]
Enduring understanding 4.B: Competition and cooperation are important aspects of biological systems.	**Essential knowledge 4.B.1**: Interactions between molecules affect their structure and function.	**LO 4.17** The student is able to analyze data to identify how molecular interactions affect structure and function. [See **SP 5.1**]
	Essential knowledge 4.B.2: Cooperative interactions within organisms promote efficiency in the use of energy and matter.	**LO 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. [See **SP 1.4**]
	Essential knowledge 4.B.3: Interactions between and within populations influence patterns of species distribution and abundance.	**LO 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. [See **SP 5.2**]
	Essential knowledge 4.B.4: Distribution of local and global ecosystems changes over time.	**LO 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. [See **SP 6.3**] **LO 4.21** The student is able to predict consequences of human actions on both local and global ecosystems. [See **SP 6.4**]
Enduring understanding 4.C: Naturally occurring diversity among and between components within biological systems affects interactions with the environment.	**Essential knowledge 4.C.1**: Variation in molecular units provides cells with a wider range of functions.	**LO 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. [See **SP 6.2**]

	Essential knowledge 4.C.2: Environmental factors influence the expression of the genotype in an organism.	**LO 4.23** The student is able to construct explanations of the influence of environmental factors on the phenotype of an organism. [See **SP 6.2**] **LO 4.24** The student is able to predict the effects of a change in an environmental factor on the genotypic expression of the phenotype. [See **SP 6.4**]
	Essential knowledge 4.C.3: The level of variation in a population affects population dynamics.	**LO 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. [See **SP 6.1**] **LO 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. [See **SP 6.4**]
	Essential knowledge 4.C.4: The diversity of species within an ecosystem may influence the stability of the ecosystem.	**LO 4.27** The student is able to make scientific claims and predictions about how species diversity within an ecosystem influences ecosystem stability. [See **SP 6.4**]