Biology

Curriculum/Content Area: Science	**Course Length:** 2 Terms
Course Title: Biology	**Date last reviewed:** September 2017
Prerequisites: None	**Board approval date:** December 5, 2017
Primary Resource:	

Desired Results

Course description and purpose: Biology is a laboratory science course that investigates the relationship between structure and function from molecules to organisms and systems, the interdependence and interactions of biotic and abiotic components of the environment, and mechanisms that maintain continuity and lead to changes in populations over time. Students explore biological concepts through an inquiry approach.

Enduring Understandings:	**Essential Questions**:
1. **Patterns:** Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them. 2. **Cause and Effect:** Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering. 3. **Scale, Proportion, and Quantity:** In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change. 4. **Systems and System Models:** A system is an organized group of related objects or components;	1. How can structure affect functions of living and nonliving organisms? 2. What are the varying processes in living organisms? 3. How do living organisms interact with one another and their environment? 4. How can an organism's environment affect them? 5. How can the scientific method be used to investigate questions and how can those findings be communicated? 6. How can technology and scientific research impact society? 7. How can a scientist clearly and effectively write to share scientific information and knowledge? 8. How are scientific facts and evidence used to influence and persuade

models can be used for understanding and predicting the behavior of systems. 5. **Energy and Matter:** Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior. 6. **Structure and Function:** The way an object is shaped or structured determines many of its properties and functions. 7. **Stability and Change:** For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.	others?

Unit 1: Nature of Science
Essential Questions: 1. How do scientists study the world? 2. What is biology? 3. What is life? 4. What is homeostasis? 5. How do scientists run valid experiments, interpret data and communicate results?
Standards:
<u>Cross-Cutting Concepts:</u> **1. Stability and Change -** Feedback (negative or positive) can stabilize or destabilize a system. **<u>Science and Engineering Practices</u>** 1. **Planning and Carrying Out Investigations** - Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. ○ Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials,

cost, risk, time), and refine the design accordingly.

2. **Scientific Investigations Use a Variety of Methods -** Connections to Nature of Science Scientific Investigations Use a Variety of Methods Scientific inquiry is characterized by a common set of values that include: logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings.

Disciplinary Core Ideas

1. **LS1.A: Structure and Function**
   a. Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.

WI Standards for Literacy in All Subjects:

1. **RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-LS1-1),(HS-LS1-6)
2. **WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-LS1-1),(HS-LS1-6)
3. **WHST.9-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-LS1-6)
4. **WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-LS1-3)
5. **WHST.11-12.8** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. *(HS-LS1-3)*
6. **WHST.9-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-LS1-1),(HS-LS1-6)
7. **SL.11-12.5** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Learning Targets:

1. I can plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. (DCI LS1.A; S&EP -Planning & Carrying Out

Investigations; CCC - S&C)

Assessment Evidence:

Performance Assessment Options *May include, but are not limited to the following:* 1. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. [Clarification Statement: Examples of investigations could include heart rate response to exercise, stomate response to moisture and temperature, and root development in response to water levels.] [*Assessment Boundary: Assessment does not include the cellular processes involved in the feedback mechanism.*]	**Other assessment options** May include, but are not limited to the following:

Digital Tools & Supplementary Resources:

Simulations

Unit 2: Molecular

Unit Essential Questions:

1. What atoms and molecules are used by organisms?
2. How do living things use chemical reactions to sustain life?
3. Why is water important to living things?
4. What is pH and how does it affect organisms?
5. How do organisms take advantage of enzymes to sustain life?
6. Why do we study cells?
7. What is the difference between prokaryotic and eukaryotic cells?
8. How do organelles contribute to the survival of a cell?
9. How does a cell obtain nutrients and dispose of metabolic waste?
10. How do cells facilitate the transfer of energy within the environment?
11. How does the structure of chloroplasts allow it to efficiently produce oxygen and carbohydrates?
12. Describe how plants transform CO_2 into $C_6H_{12}O_6$ while producing O_2 from H_2O?
13. Why is it important for the inner membrane of the mitochondria is highly folded?
14. Explain how photosynthesis and respiration are mirror processes?
15. What are the phases of the cell cycle?
16. What are the stages of mitosis?

Standards:

Cross-Cutting Concepts

1. **Systems and System Models -** Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions — including energy, matter, and information flows — within and between systems at different scales.
2. **Energy and Matter** - Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. Energy cannot be created or destroyed; it only moves between one place and another place, between objects and/or fields, or between systems.

Science and Engineering Practices

1. **Developing and Using Models -** Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.
    - Use a model based on evidence to illustrate the relationships between systems or between components of a system.
2. **Constructing Explanations and Designing Solutions -** Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.
    - Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Disciplinary Core Ideas

1. **LS1.B: Growth and Development of Organisms**
    a. In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism.
2. **LS1.C: Organization for Matter and Energy Flow in Organisms**
    a. The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.
    b. The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells.
    c. As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.

WI Standards for Literacy in All Subjects:

1. **RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-LS1-1),(HS-LS1-6)
2. **WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-LS1-1),(HS-LS1-6)
3. **WHST.9-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-LS1-6)
4. **WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-LS1-3)
5. **WHST.11-12.8** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. *(HS-LS1-3)*
6. **WHST.9-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-LS1-1),(HS-LS1-6)
7. **SL.11-12.5** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Learning Targets:

1. I can use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. (DCI LS1.B; S&EP -Develop and Using Models; CCC - Systems and System Models)
2. I can use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. (DCI LS1.C; S&EP -Develop and Using Models; CCC -Energy & Matter)
3. I can construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. (DCI LS1.C; S&EP -Explanations & Solutions; CCC - Energy & Matter)
4. I can use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. (DCI LS1.C; S&EP -Develop and Using Models; CCC - Energy & Matter)

Assessment Evidence:

Performance Assessment Options *May include, but are not limited to the following:*	**Other assessment options**

1. Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. [*Assessment Boundary: Assessment does not include specific gene control mechanisms or rote memorization of the steps of mitosis.*] (HS-LS1-4) 2. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] [*Assessment Boundary: Assessment does not include specific biochemical steps.*] (HS-LS1-5) 3. Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. [Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.] [*Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules.*] (HS-LS1-6) 4. Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed, resulting in a net transfer of energy. [Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.] [*Assessment Boundary: Assessment should not include identification of the steps or specific processes involved in cellular respiration.*] (HS-LS1-7)	May include, but are not limited to the following:
Digital Tools & Supplementary Resources:	
Simulations	

Unit 3: Genetics
Essential Questions: 1. What is the difference between a gene, a DNA molecule, and a chromosome? 2. What is the basic building block of DNA? 3. How does DNA replicate? 4. How do haploid and diploid cells differ? 5. What role did Mendel play in in the evolution of modern genetics? 6. Why is a garden pea a good subject for genetic study?

7. What factors influence the patterns of heredity?
8. Why do mutations cause genetic disorders?
9. What are some examples of genetic disorders?

Standards:

Cross-Cutting Concepts

1. **Structure and Function -** Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.
2. **Scale, Proportion, and Quantity -** Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).
3. **Science is a Human Endeavor**
    - Technological advances have influenced the progress of science and science has influenced advances in technology.
    - Science and engineering are influenced by society and society is influenced by science and engineering.

- **Cause and Effect -** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Science and Engineering Practices

1. **Constructing Explanations and Designing Solutions -** Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.
    - Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
2. **Asking Questions and Defining Problems -** Asking questions and defining problems in 9-12 builds on K-8 experiences and progresses to formulating, refining and evaluating empirically testable questions and design problems using models and simulations.
    - Ask questions that arise from examining models or a theory to clarify relationships.
3. **Engaging in Argument from Evidence -** Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.
    - Make and defend a claim based on evidence about the natural world that reflects scientific knowledge and student-generated evidence.
4. **Analyzing and Interpreting Data -** Analyzing data in 9-12 builds on K-8

experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

- Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.

Disciplinary Core Ideas:

1. **LS1.A: Structure and Function**
   - **a.** Systems of specialized cells within organisms help them perform the essential functions of life.
   - **b.** All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (Note: This Disciplinary Core Idea is also addressed by HS-LS3-1.)
2. **LS3.A: Inheritance of Traits**
   - **a.** Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function.
3. **LS3.B: Variation of Traits**
   - **a.** In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited.
   - **b.** Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors.

WI Standards for Literacy in All Subjects:

1. **RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-LS1-1),(HS-LS1-6)
2. **RST.11-12.9** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. *(HS-LS3-1)*
3. **WHST.9-12.1** Write arguments focused on *discipline-specific content.* (HS-LS3-2)

Learning Targets:

1. I can construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. (DCI LS1.A; S&EP -Develop and Using Models; CCC - Systems & System Models)
2. I can ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. (DCI LS1.A, LS3.A; S&EP -Asking Questions; CCC - Cause & Effect)
3. I can make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. (DCI LS3.B; S&EP -Engaging in Argument; CCC - Cause & Effect)
4. I can apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. (DCI LS3.B; S&EP -Engaging in Argument; CCC - Cause & Effect)

Assessment Evidence:

Performance Assessment Options
May include, but are not limited to the following:

1. Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells. [*Assessment Boundary: Assessment does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis.*] (HS-LS1-2)
2. Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. [*Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.*] (HS-LS3-1)
3. Make and defend a claim based on evidence that inheritable genetic variations may result from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. [Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs.] [Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.] (HS-LS3-2)
4. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.[Clarification Statement: Emphasis is on the use of mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.]

Other assessment options
May include, but are not limited to the following:

[*Assessment Boundary: Assessment does not include Hardy-Weinberg calculations.*] (HS-LS3-2)	
Digital Tools & Supplementary Resources:	
Simulations:	

Unit 4: Evolution
Essential Questions: 1. What evidence of evolution did Darwin present? 2. What pattern did Darwin observe among organisms of the Galapagos Islands? 3. How is natural variation used in artificial selection and species fitness? 4. What are the main sources of inheritable variation in a population? 5. What determines the number of phenotypes for a given trait? 6. What conditions are needed to maintain genetic equilibrium? 7. What factors are involved in the formation of a new species?
Standards:
Cross-Cutting Concepts 1. Patterns - Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. 2. Cause and Effect - Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. 3. Scientific Knowledge Assumes an Order and Consistency in Natural Systems - Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. **Science and Engineering Practices** 1. Analyzing and Interpreting Data - Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. ○ Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. 2. Using Mathematics and Computational Thinking - Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. ○ Create or revise a simulation of a phenomenon, designed device, process, or

system.

3. Constructing Explanations and Designing Solutions - Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.
    - Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
4. **Engaging in Argument from Evidence -** Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current or historical episodes in science.
    - Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments.
5. Obtaining, Evaluating, and Communicating Information - Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.
    - Communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).
6. **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena -** A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.

Disciplinary Core Ideas:

1. LS4.A: Evidence of Common Ancestry and Diversity
    a. Genetic information, like the fossil record, provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence. (HS-LS4-1)
2. LS4.B: Natural Selection
    a. Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. (HS-LS4-2),(HS-LS4-3)

b. The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. (HS-LS4-3)

3. LS4.C: Adaptation
    a. Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. (HS-LS4-2)
    b. Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. (HS-LS4-3),(HS-LS4-4)
    c. Adaptation also means that the distribution of traits in a population can change when conditions change. (HS-LS4-3)
    d. Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species. (HS-LS4-5),(HS-LS4-6)
    e. Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost. (HS-LS4-5)
4. LS4.D: Biodiversity and Humans
    a. Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. (HS-LS4-6) *(Note: This Disciplinary Core Idea is also addressed by HS-LS2-7.)*
5. ETS1.B: Developing Possible Solutions
    a. When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. *(secondary to HS-LS4-6)*
    b. Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive

presentation to a client about how a given design will meet his or her needs. *(secondary to HS-LS4-6)*

WI Standards for Literacy in All Subjects:

1. **RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-LS1-1),(HS-LS1-6)
2. **RST.11-12.8** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-LS4-5)
3. **WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-LS1-1),(HS-LS1-6)
4. **WHST.9-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-LS1-6)
5. **WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-LS1-3)
6. **WHST.9-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-LS1-1),(HS-LS1-6)
7. **SL.11-12.4** Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. (HS-LS4-1),(HS-LS4-2)

Learning Targets:

1. I can communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. (DCI LS4.A; S&EP -Obtaining, Evaluating, & Communicating Information; Science Models, Laws, & Mechanisms; CCC - Patterns; Order and Consistency in Natural Systems)
2. I can construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. (DCI LS4.B, LS4.C; S&EP -Constructing Explanations & Designing Solutions; CCC - Cause & Effect)
3. I can apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait. (DCI LS4.B, LS4.C; S&EP -Analyzing & Interpreting Data; CCC - Patterns)
4. I can construct an explanation based on evidence for how natural selection leads to adaptation of populations. (DCI LS4.C; S&EP -Constructing Explanations and Designing Solutions; CCC - Cause & Effect; Order and Consistency in Natural

Systems)

5. I can evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. (DCI LS4.C; S&EP -Engaging in Argument; CCC - Cause & Effect)
6. HS-LS4-6. I can create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity. (DCI LS4.C, LS4.D, ETS1.B; S&EP -Using Math; CCC - Cause & Effect)

Assessment Evidence:

Performance Assessment Options

May include, but are not limited to the following:

1. Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. [Clarification Statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.] (HS-LS4-1)
2. Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. [Clarification Statement: Emphasis is on using evidence to explain the influence each of the four factors has on number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.] [*Assessment Boundary: Assessment does not include other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution.*] (HS-LS4-2)
3. Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait. [Clarification Statement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.] [*Assessment Boundary: Assessment is limited to basic statistical and graphical analysis. Assessment does not include allele frequency calculations.*] (HS-LS4-3)
4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations. [Clarification

Other assessment options

May include, but are not limited to the following:

Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.] (HS-LS4-4)

5. Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. [Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.] (HS-LS4-5)
6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.* [Clarification Statement: Emphasis is on testing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.] (HS-LS4-6)

Digital Tools & Supplementary Resources:

Simulations

Unit 5: Ecology

Essential Questions

1. How do ecologists organize their study of the environment?
2. How does the flow of energy compare to the cycling of matter in the biosphere?
3. How do organisms within a community affect each other?
4. How do populations fluctuate depending on outside factors?
5. How do ecosystems recover from disruption?
6. How do human populations differ from other species?
7. What impact do humans have on the biosphere?

Standards:

Cross-Cutting Concepts

1. Cause and Effect - Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
2. Scale, Proportion, and Quantity - The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. Using the concept of orders of

magnitude allows one to understand how a model at one scale relates to a model at another scale.

3. Systems and System Models - Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.
4. Energy and Matter - Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. Energy drives the cycling of matter within and between systems.
5. Stability and Change - Much of science deals with constructing explanations of how things change and how they remain stable.

Science and Engineering Practices

1. Developing and Using Models - Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show how relationships among variables between systems and their components in the natural and designed worlds.
    - Develop a model based on evidence to illustrate the relationships between systems or components of a system.
2. Using Mathematics and Computational Thinking - Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.
    - Use mathematical and/or computational representations of phenomena or design solutions to support explanations.
    - Use mathematical representations of phenomena or design solutions to support and revise explanations.
    - Use mathematical representations of phenomena or design solutions to support claims.
3. Constructing Explanations and Designing Solutions - Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.
    - Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
    - Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
4. Engaging in Argument from Evidence - Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations

about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.
    - Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.
    - Evaluate the evidence behind currently accepted explanations to determine the merits of arguments.
5. Scientific Knowledge is Open to Revision in Light of New Evidence
    - Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence.
    - Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.

Disciplinary Core Ideas:

1. LS2.A: Interdependent Relationships in Ecosystems
    a. Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. (HS-LS2-1),(HS-LS2-2)
2. LS2.B: Cycles of Matter and Energy Transfer in Ecosystems
    a. Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. (HS-LS2-3)
    b. Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved. (HS-LS2-4)
    c. Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. (HS-LS2-5)
3. LS2.C: Ecosystem Dynamics, Functioning, and Resilience
    a. A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is

resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. (HS-LS2-2),(HS-LS2-6)

b. Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (HS-LS2-7)

4. LS2.D: Social Interactions and Group Behavior
    a. Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives. (HS-LS2-8)
5. LS4.D: Biodiversity and Humans
    a. Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). *(secondary to HS-LS2-7)*
    b. Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. *(secondary to HS-LS2-7) (Note: This Disciplinary Core Idea is also addressed by HS-LS4-6.)*
6. PS3.D: Energy in Chemical Processes
7. The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. *(secondary to HS-LS2-5)*
8. ETS1.B: Developing Possible Solutions
9. When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. *(secondary to HS-LS2-7)*

Learning Targets:

1. I can use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. (DCI LS2.A; S&EP -Using Math; CCC - Scale, Proportion, & Quantity)
2. I can use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. (DCI LS2.A, LS2.C; S&EP -Using Math; Open Revision; CCC - Scale, Proportion, & Quantity)
3. I can construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.
4. I can use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.

5. I can develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.
6. I can evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
7. . I can design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*
8. I can evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.

Assessment Evidence:

Performance Assessment Options *May include, but are not limited to the following:*	**Other assessment options** *May include, but are not limited to the following:*
1. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. [Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.] [*Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.*] (HS-LS2-1) 2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. [Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [*Assessment Boundary: Assessment is limited to provided data.*] (HS-LS2-2) 3. Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions. [Clarification Statement: Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments.] [*Assessment Boundary: Assessment does not include the specific chemical processes of either aerobic or anaerobic respiration.*] (HS-LS2-3) 4. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. [Clarification Statement: Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and	

that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem.] [*Assessment Boundary: Assessment is limited to proportional reasoning to describe the cycling of matter and flow of energy.*] (HS-LS2-4)

5. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. [Clarification Statement: Examples of models could include simulations and mathematical models.] [*Assessment Boundary: Assessment does not include the specific chemical steps of photosynthesis and respiration.*] (HS-LS2-5)
6. Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.[Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.] (HS-LS2-6)
7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*[Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.] (HS-LS2-7)
8. Evaluate evidence for the role of group behavior on individual and species' chances to survive and reproduce. [Clarification Statement: Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.] (HS-LS2-8)

Digital Tools & Supplementary Resources:

Simulations