STATE OF SOUTH CAROLINA
DEPARTMENT OF EDUCATION

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Biology 2 Performance Targets

for the

South Carolina College- and Career-Ready Science Standards 2021

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Contents

Purpose and Use

Science is a way of understanding the physical universe using observation and experimentation to explain natural phenomena. Science also refers to an organized body of knowledge that includes core ideas to the disciplines and common themes that bridge the disciplines. As science educators we must take a 3-dimensional approach in facilitating student learning. By addressing content, science and engineering practices and crosscutting concepts, students can have relevant and evidence-based instruction that can help solve current and future problems.

This document is intended as a guide for discerning and describing features of students and their work who have met the stated Performance Expectation (PE). This is not a curriculum or a means to limit instruction in the classroom. Although each PE states a dedicated Science and Engineering Practice (SEP) and Crosscutting Concept (CCC), students will need to use the whole range of SEPs and CCCs to achieve success by the end of instruction.

The PEs aligned to the course Biology 2 include four repeated from Biology 1. The expectation is that, through their Biology 2 coursework, students build upon the foundational knowledge developed in Biology 1 to deepen their understanding of the content. Thus, the Performance Target description of student performance may extend beyond the State Assessment Boundary for the four repeated PEs. Teachers have the flexibility to enrich students learning as best fits the needs and interests of their student population. Biology 2 is not assessed by the End of Course Examination Program. The PEs aligned to Biology 2 are:

- B-LS1-1 (repeat)
- B-LS2-2
- B-LS2-3
- B-LS2-4
- B-LS2-6
- B-LS2-8
- B-LS3-1
- B-LS3-2 (repeat)
- B-LS3-3 (repeat)
- B-LS4-1 (repeat)
- B-LS4-3
- B-LS4-6

Three-dimensional science learning requires discipline specific communication skills. This means that effective science learning occurs when students are expected to speak, listen, read, and write in ways that are appropriate to science. With each Performance Target, there are question/sentence stems and terminology to support student discourse about phenomena to help teachers facilitate the acquisition of science discourse. Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding. The terms and stems in this section are intended to provide a baseline for teachers, neither list is exhaustive nor complete.

In addition to the doing (SEP), thinking (CCC), and learning of science knowledge (Disciplinary Core Ideas) outlined here, students will also require a working knowledge of grade-level appropriate tools and techniques of science. Students should know and recognize how scientists and engineers use these tools and techniques, not just identify them. Students should be able to use these tools to gather data, describe how these tools gather data, and/or interpret data sampled from them.

Acknowledgement

The office of Assessment and Standards science team greatly appreciates the input received from the committee members of the High School Off-tested Performance Target Review Committee.

Document Updates

June 2024

- Updated watermark to 2024-2025.
- Adjusted formatting and grammar.

LS1 – From Molecules to Organisms: Structures and Processes

B-LS1-1. 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.

State 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.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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 [models, peer review, simulations, theories, students' own investigations]) 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.	**LS1.A: Structure and Function** Systems of specialized cells within organisms help them perform the essential functions of life. All cells contain genetic information, in the form of DNA. Genes are specific regions within the extremely large DNA molecules that form the chromosomes. Genes contain the instructions that code for the formation of molecules called proteins, which carry out most of the work of cells to perform the essential functions of life. Proteins provide structural components, serve as signaling devices, regulate cell activities, and determine the performance of cells through their enzymatic actions **LS3.A: Inheritance of Traits** The sequence of nucleotides spells out the information in a gene. DNA controls the expression of proteins by being transcribed into a "messenger" RNA, which is translated in turn by the cellular machinery into a protein.	**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.

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Observable features of student performance by the end of the course:

1. **Articulating the explanations of phenomena**
    a. Students articulate a statement describing/explaining relationships between the structure of DNA and the structure and function of resulting molecules, including:
        i. regions of DNA determine the structure of proteins or functional RNA molecules and
        ii. proteins carry out the essential functions of life.
2. **Evidence**
    a. Students identify and describe the evidence to construct the explanation, including:
        i. all cells contain DNA,
        ii. DNA contains regions called genes,
        iii. a single gene codes for a protein or functional RNA molecules,
        iv. through the biochemical process of transcription (initiation, elongation, termination), a DNA sequence is transcribed into a mRNA sequence,
        v. through the biochemical process of translation (initiation, elongation, termination), a mRNA sequence is translated into an amino acid sequence at the ribosome,
        vi. the sequence of genes contains instructions that code for proteins or functional RNA molecules,
        vii. proteins carry out the essential functions of life, and
        viii. in complex organisms, groups of specialized cells use proteins to carry out functions that are essential to the organism.
3. **Reasoning**
    a. Students use the following chain of reasoning to connect the evidence and support, refute, or revise an explanation, including:
        i. because all cells contain DNA, all cells contain genes that can code for the formation of proteins and functional RNA molecules,
        ii. gene sequence, including mutations, affects product function,
        iii. proper functioning of many gene products is necessary for the proper functioning of cells,
        iv. as a result of differentiation, different genes are activated in different cells that share the same genetic code in complex organisms, and
        v. systems of specialized cells share similar structures and functions; these are carried out by proteins and functional RNA molecules.

B-LS1-1 Academic Language

Question/Sentence Stems

- The _______ structures help _______to function because _______.
- The _______ structures are present in _______ and are related to the function _______.
- If ___ structure is altered, what results?
- What are some similarities and differences between ___ and ___?

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- adenine
- amino acid
- anticodon
- base
- cell
- chromosome
- codon
- cytoplasm
- cytosine
- deoxyribose
- differentiation
- DNA
- double helix
- elongation
- endoplasmic reticulum
(smooth and rough)
- enzyme
- functional RNA
- gene
- Golgi apparatus
- guanine
- hydrogen bond
- initiation
- mRNA
- mutagen
- mutation
- nuclear membrane
- nucleic acid
- nucleotide
- nucleus
- peptide bond
- phosphate
- polypeptide
- protein synthesis
- ribose
- ribosome
- RNA
- rRNA
- start codon
- stop codon
- termination
- thymine
- transcription
- translation
- tRNA
- uracil
- vesicle

LS2 – Ecosystems: Interactions, Energy, and Dynamics

B-LS2-2. 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.
State Assessment Boundary: Assessment is limited to provided data.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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 representations of phenomena or design solutions to support and revise explanations.	**LS2.A: Interdependent Relationships in Ecosystems** 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. **LS2.C: Ecosystem Dynamics, Functioning, and Resilience** 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.	**Scale, Proportion, and Quantity** Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.

Observable features of student performance by the end of the course:

1. **Representation**
   a. Students develop/use mathematical models (for example: trends, averages, graphs of the number of organisms per unit area in a stable system, etc.) to identify and describe the components that are relevant to support, revise, or refute an explanation about factors affecting biodiversity and ecosystems, including:
      i. data on numbers and types of organisms are represented and/or
      ii. interactions between ecosystems at different scales (for example: micro, messo, biome) are represented.
   b. Students support, revise, or refute an explanation of factors affecting biodiversity and population levels, including:
      i. The populations and number of organisms in ecosystems vary as a function of the physical and biological dynamics of the ecosystem.
      ii. The response of an ecosystem to a small change might not significantly affect populations, whereas the response to a large change can have a large effect on populations and then feeds back to the ecosystem at a range of scales.
      iii. Ecosystems can exist in the same location on a variety of scales (for example: plants and animals vs. microbes), and these populations can interact in ways that significantly change these ecosystems (for example: interactions among microbes, plants, and animals can be an important factor in the resources available to both a microscopic and macroscopic ecosystem).
2. **Mathematical modeling**
   a. Students develop/use a mathematical model (for example: trends, averages, graphs, etc.) of factors affecting biodiversity and ecosystems to identify changes over time in the numbers and types of organisms in ecosystems of different scales.

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3. **Analysis**
   a. Students develop/use and analyze a mathematical model of factors affecting biodiversity and ecosystems:
      i. to identify the most important factors that determine biodiversity and population numbers of an ecosystem,
      ii. as evidence to support, revise, or refute explanations for the effects of both abiotic and biotic factors on biodiversity and population size,
      iii. as evidence to support, revise, or refute explanations for the interactions of ecosystems on different scales, and/or
      iv. to describe how factors affecting ecosystems at one scale can cause observable changes in ecosystems at a different scale.
   b. Students develop/use a mathematical model to support, revise, or refute explanations for the effects of modest to extreme disturbances on an ecosystem's capacity to return to its original status or become a different ecosystem.
   c. Students develop/use a mathematical model to support, revise, or refute explanations based on new evidence about any factors that affect biodiversity and populations for example: data illustrating the effect of a disturbance within the ecosystem).

B-LS2-2 Academic Language

Question/Sentence Stems

- The quantity of _______ and _______ can be compared.
- The proportion of _______ is _______because _______.
- The scale of the model of _______ is _______ compared to the actual population.
- To understand the phenomenon of _______, I/we can use a scale of _______ in my/our model.
- How do the quantity of __ and __ compare?
- The effect of __ is ___ because ____.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- abiotic
- abundance
- biodiversity
- biotic
- carrying capacity
- climate change
- commensalism
- competition
- deforestation
- density
- disturbance
- equilibrium
- extinction
- feedback
- fluctuation
- generation
- limiting factor
- limiting resource
- mutualism
- parasitism
- pollution
- population
- population control
- predation
- stability
- sustainable
- symbiosis
- trend

B-LS2-3. 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 the conservation of matter and flow of energy into, out of, and within various ecosystems.
State Assessment Boundary: Assessment focuses on the conceptual understanding and does not include the specific chemical processes of either aerobic or anaerobic respiration.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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 [models, peer review, simulations, theories, students' own investigations]) 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.	**LS2.B: Cycles of Matter and Energy** Transfer in Ecosystems Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.	**Energy and Matter** Energy drives the cycling of matter within and between systems.

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Observable features of student performance by the end of the course:

1. **Articulating the explanation of phenomena**
    a. Students articulate a statement that describes/explains that:
        i. life depends on biogeochemical cycles (for example: carbon, nitrogen, water) and
        ii. biogeochemical cycling is driven by aerobic and anaerobic cellular processes.
2. **Evidence**
    a. Students identify and describe evidence necessary to construct an explanation, including:
        i. all organisms take in matter and rearrange the atoms in chemical reactions:
            1. photosynthesis captures light energy to create chemical products (limited to glucose) that can be used in cellular respiration and
            2. cellular respiration is the process by which glucose reacts chemically with other compounds (limited to glycolysis, Kreb's cycle, electron transport chain, fermentation), rearranging the matter to release stored chemical energy that is used for essential life processes,
        ii. biological availability and reservoirs, and
        iii. key processes of:
            1. Carbon cycle:
                a. photosynthesis,
                b. cellular respiration, and
                c. burning of fossil fuels,
            2. Water cycle:
                a. condensation,
                b. evaporation,
                c. precipitation, and
                d. transpiration,
            3. Nitrogen cycle:
                a. nitrogen fixation,
                b. lightening,
                c. volcanic activity, and
                d. agricultural production.

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3. **Reasoning**
    a. Students use the following chain of reasoning to connect the evidence and support, refute, or revise an explanation:
        i. Energy inputs into cells occur either by photosynthesis or taking in matter.
        ii. All cells engage in cellular respiration (aerobic or anaerobic) and produce products of respiration.
        iii. The cycling of matter into and out of cells/organisms is driven by the energy captured by photosynthesis and released by respiration.
        iv. The cycling of matter and transfer of energy must occur whether respiration is aerobic or anaerobic.
        v. The transfer of energy through respiration also drives the cycling of nutrients between organisms and the environment (for example: nitrogen and water cycles).
    b. Given new data or information, students review the explanation and justify the revision (for example: recent discoveries of life surrounding deep sea ocean vents have shown that photosynthesis is not the only driver for the cycling of matter and transfer of energy in ecosystems).

B-LS2-3 Academic Language

Question/Sentence Stems

- _______ happens to matter as it moves within the system.
- In this system, energy is entering by _______, doing _______ in the system, and leaving the system by _______.
- The energy for _______ is from _______.
- The flow of energy causes _______ to occur in the system.
- The energy is entering the system by _______.
- In the system, the cycling of matter _______.
- The matter in the system enters from _______.
- When the matter leaves the system, it goes _______.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- aerobic
- agricultural production
- anaerobic
- autotroph
- biomass
- carbon
- condensation
- consumer
- cycling of matter
- decomposer
- energy flow
- energy pyramid
- evaporation
- fermentation
- food chain
- food web
- fossil fuel
- glucose
- heterotroph
- lightening
- microbe
- nitrogen
- nitrogen fixation
- photosynthesis
- precipitation
- predator-prey relationship
- producer
- pyramid of biomass
- reservoir/sink
- respiration
- solar energy
- transpiration
- trophic level
- volcanic activity
- water

B-LS2-4. 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 conservation of carbon, oxygen, hydrogen, and nitrogen as they move through an ecosystem.
> ***State Assessment Boundary:*** Assessment is limited to proportional reasoning to describe the cycling of matter and flow of energy.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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 representations of phenomena or design solutions to support claims.	**LS2.B: Cycles of Matter and Energy Transfer in Ecosystems** 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.	**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.

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Observable features of student performance by the end of the course:

1. **Representation**
    a. Students develop/use a mathematical model to identify and describe the components that are relevant to support, revise, or refute a claim, including relative quantities related to:
        i. organisms,
        ii. matter,
        iii. energy, and
        iv. food webs in an ecosystem.
2. **Mathematical modeling**
    a. Students develop/use a mathematical model to describe how a claim can be expressed as a mathematical relationship.
    b. Students develop/use mathematical models of the food web to:
        i. explain the transfer of matter (as atoms and molecules) and energy upward between organisms and their environment,
        ii. identify the transfer of energy and matter between trophic levels, and/or
        iii. identify the relative proportion of organisms at each trophic level by correctly identifying:
            1. producers as the lowest trophic level and having the greatest biomass and energy and
            2. consumers decreasing in numbers at higher trophic levels.
3. **Analysis**
    a. Students develop/use mathematical models to support, revise, or refute claims including:
        i. matter cycles between organisms and their environment and
        ii. energy transfers from one trophic level to another and through the environment.
    b. Students develop/use and analyze a mathematical model to account for:
        i. energy not transferred to higher trophic levels, but which is instead used for growth, maintenance, or repair and/or transferred to the environment and/or
        ii. inefficiencies in transfer of matter and energy.

B-LS2-4 Academic Language

Question/Sentence Stems

- _______ happens to matter as it moves within the system.
- In this system, energy is entering by _______, doing _______ in the system, and leaving the system by _______.
- The energy for _______ is from _______.
- The flow of energy causes _______ to occur in the system.
- The energy is entering the system by _______.
- In the system, the cycling of matter _______.
- The matter in the system enters from _______.
- When the matter leaves the system, it goes _______.
- According to the data, _______ leads to a change in __________.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- aerobic
- anaerobic
- autotroph
- biomass
- carbon
- consumer
- cycling of matter
- decomposer
- energy flow
- energy pyramid
- food chain
- food web
- fossil fuel
- glucose
- heterotroph
- microbe
- photosynthesis
- predator-prey relationship
- producer
- pyramid of biomass
- reservoir/sink
- respiration
- solar energy
- trophic level
- water

B-LS2-6. 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.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** 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.	**Stability and Change** Much of science deals with constructing explanations of how things change and how they remain stable.

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Observable features of student performance by the end of the course:

1. **Identifying the supporting claims, evidence, and reasoning**
    a. Students identify the explanation that complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem that is supported by the claims, evidence, and reasoning, including:
        i. the claims to be evaluated,
        ii. the evidence to be evaluated, and
        iii. the reasoning to be evaluated.
2. **Identifying any additional evidence relevant to the evaluation**
    a. Students identify and describe additional evidence (for example: data, information, etc.) that was not provided but is relevant to the explanation and its evaluation, including:
        i. factors that affect biodiversity,
        ii. relationships between species and the physical environment in an ecosystem, and/or
        iii. changes in the numbers of species and organisms in an ecosystem that has been subjected to a modest or extreme change in ecosystem conditions.
3. **Evaluating and critiquing**
    a. Students identify and describe the strengths and weaknesses of the explanation by accurately describing a particular response of biodiversity to a changing condition, based on an understanding of the factors that affect biodiversity and the relationships between species and the physical environment in an ecosystem.
    b. Students use the additional evidence to assess the validity and reliability of the explanation's evidence and its ability to support the argument that resiliency of an ecosystem is subject to the degree of change in the biological and physical environment.
    c. Students assess the logic of the reasoning, including the relationship between degree of change and stability in ecosystems, and the utility of the reasoning in supporting the explanation of how:
        i. Modest biological or physical disturbances in an ecosystem result in maintenance of relatively consistent numbers and types of organisms.
        ii. Extreme fluctuations in conditions of the size of any population can challenge the functioning of ecosystems in terms of resources and habitat availability and can even result in a new ecosystem.

B-LS2-6 Academic Language

Question/Sentence Stems

- The key components of the system are_______.
- In the system, ____________ and ____________ are shown in the model.
- In the system, __________ and _________ work together to________.
- In the system, ____________ and _____________ interact in ________________ way.
- In this system, if ___ disturbance occurs, _____ results.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- anthropogenic
- biodiversity
- biosphere
- carbon cycle
- climate change
- climax community
- consumer
- decomposer
- disturbance
- ecosystem
- environment
- equilibrium
- extinction
- fluctuation
- habitat
- human impact
- intermediate species
- niche
- nitrogen cycle
- organism
- pioneer species
- primary succession
- producer
- resources
- secondary succession
- species
- stability
- succession
- water cycle

B-LS2-8. 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, or herding, and cooperative behaviors such as hunting, migrating, or swarming.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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 evidence behind currently accepted explanations to determine the merits of arguments.	**LS2.D: Social Interactions and Group Behavior** Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives.	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

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Observable features of student performance by the end of the course:

1. **Identifying the given explanation and the supporting evidence**
    a. Students identify an explanation that group behavior can increase the chances for an individual and species to survive and reproduce that is supported by the evidence to be evaluated.
2. **Identifying additional evidence relevant to the evaluation**
    a. Students identify and describe additional evidence (for example: data, information, etc.) that was not provided but is relevant to the explanation and its evaluation including:
        i. relationships between specific group behaviors (for example: flocking, schooling, herding, cooperative hunting, migrating, swarming) and individual fitness.
3. **Evaluating and critiquing**
    a. Students use additional evidence to assess the validity, reliability, strengths, and weaknesses of the given evidence and evaluate its ability to support logical and reasonable arguments about the outcomes of group behavior.
    b. Students evaluate the given evidence for the degree to which it supports an explanation that group behavior can have a survival advantage for some species including:
        i. how it supports cause and effect relationships between various kinds of group behavior and individual survival rates.

B-LS2-8 Academic Language

Question/Sentence Stems

- By looking at patterns in the data, I/we determined that _______ caused _______.
- _______ caused the patterns I am observing. I know this because _______.
- If _______ happens, I/we predict that _______ will occur.
- Even though I/we cannot see _______, it explains why _______ is happening.
- When I/we change _______ in the system, _______ is affected.
- The probability that _______ caused _______ is _______. I/We know this because _______.
- The evidence _______ presented in the scenario supports the claim that _______ causes _______.
- To conclude that _______ caused _______, the following evidence is needed _______.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- altruism
- behavior
- beneficial
- competition
- cooperative hunting
- evolution
- fitness
- flocking
- herding
- limited resource
- migration
- natural selection
- predator
- prey
- proliferation
- schooling
- selective pressure
- sexual reproduction
- social interaction
- species
- swarming

LS3 – Heredity: Inheritance and Variation of Traits

B-LS3-1. Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

State Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process (including gene regulation).

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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.	**LS1.A: Structure and Function** 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. (*secondary*) **LS3.A: Inheritance of Traits** 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.	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

*Students will need to examine and interpret a variety of models (for example: pedigree, Punnett Square, karyotype, etc.).

Observable features of student performance by the end of the course:

1. **Addressing phenomena of the natural world**
    a. Students develop/use models of DNA to formulate questions to clarify:
        i. the cause-and-effect relationships between DNA, the proteins it codes for, phenotypic expression,
        ii. that DNA and chromosomes can be regulated in multiple ways (for example: differentiation), and/or
        iii. the relationship between the non-protein coding sections of DNA and their functions (for example: regulatory functions) in organisms.
2. **Evaluating empirical testability**
    a. Student questions are empirically testable.

B-LS3-1 Academic Language

Question/Sentence Stems

- By looking at patterns in the data, I/we determined that _______ caused _______.
- _______ caused the patterns I am observing. I know this because _______.
- If _______ happens, I/we predict that _______ will occur.
- Even though I/we cannot see _______, it explains why _______ is happening.
- When I/we change _______ in the system, _______ is affected.
- The probability that _______ caused _______ is _______. I/We know this because _______.
- The evidence _______ presented in the scenario supports the claim that _______ causes _______.
- To conclude that _______ caused _______, the following evidence is needed _______.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- allele
- chromosomes
- codominant
- dominant
- epigenetics
- exon
- gene expression
- genes
- genotype
- heredity
- heterozygous
- homozygous
- incomplete dominance
- inheritance
- intron
- Karyotype
- methylation
- offspring
- parent
- pattern
- pedigree
- phenotype
- probability
- Punnett square
- recessive
- sex-linked
- trait

B-LS3-2. 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 genetic variation occurs.
State Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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.	**LS3.B: Variation of Traits** 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. 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.	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

*References to "viable errors occurring during replication" are operationally defined as errors that bypass DNA proofreading (the cell cycle successfully moves past G_2).

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Observable features of student performance by the end of the course:

1. **Developing a claim**
    a. Students make a claim that inheritable genetic variations may result from:
        i. new genetic combinations through meiosis,
        ii. viable errors occurring during replication, and/or
        iii. mutation caused by environmental factors (mutagen).
2. **Identifying scientific evidence**
    a. Students identify and describe the evidence that supports the claim, including:
        i. Variation in genetic material naturally results during meiosis from
            1. crossing over and
            2. independent assortment.
        ii. Genetic mutations can occur due to
            1. replication errors and
            2. environmental factors (mutagen).
        iii. Genetic material is inheritable.
3. **Evaluating and critiquing evidence**
    a. Students identify strengths and weaknesses of the evidence used to support the claim, including:
        i. types of sources,
        ii. sufficiency, including validity and reliability, of the evidence to make and defend the claim, and/or
        iii. any alternative interpretations of the evidence and why the evidence supports or does not support the student's claim, as opposed to any other claims.
4. **Reasoning and synthesis**
    a. Students use the following chain of reasoning to connect the evidence:
        i. Genetic mutations produce genetic variation between cells or organisms.
        ii. Genetic variations produced by mutation and meiosis can be inherited.
    b. Students use reasoning and evidence to explain that new combinations of DNA can arise from several sources, including:
        i. meiosis,
        ii. replication error, and/or
        iii. mutations caused by mutagens.
    c. Students defend a claim against counterclaims by evaluating counterclaims and by describing the connections between the relevant and appropriate evidence to the strongest claim.

B-LS3-2 Academic Language

Question/Sentence Stems

- By looking at patterns in the data, I/we determined that _______ caused _______.
- _______ caused the patterns I am observing. I know this because _______.
- If _______ happens, I/we predict that _______ will occur.
- Even though I/we cannot see _______, it explains why _______ is happening.
- When I/we change _______ in the system, _______ is affected.
- The probability that _______ caused _______ is _______. I/We know this because _______.
- The evidence _______ presented in the scenario supports the claim that _______ causes _______.
- To conclude that _______ caused _______, the following evidence is needed _______.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- allele
- cellular division
- centromere
- chromatid
- chromosome
- codon (chart)
- crossing over
- daughter cell
- deletion
- diploid
- DNA
- egg cell
- epigenetic
- fertilization
- frameshift
- gamete
- gene
- gene expression
- gene mutation
- genetic code
- genetic variation
- genome
- haploid
- homologous chromosome
- independent assortment
- inherited
- insertion
- meiosis
- meiosis I
- meiosis II
- monosomy
- multicellular
- mutagen
- mutation
- nondisjunction
- offspring
- parent cell
- point mutation
- replication
- sexual reproduction
- somatic cell
- sperm cell
- substitution
- trait
- trisomy

B-LS3-3. 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.
State Assessment Boundary: Assessment does not include Hardy-Weinberg or Chi-square analysis.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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.	**LS3.B: Variation of Traits** 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.	**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).

(Continued on next page.)

Observable features of student performance by the end of the course:

1. **Organizing data**
    a. Students organize data for expressed traits in the population by:
        i. distribution,
        ii. frequency, and/or
        iii. variation.
2. **Identifying relationships**
    a. Students analyze data (for example: probability measures, Hardy-Weinberg Conditions) to determine the relationship between a trait's occurrence within a population and environmental factors.
3. **Interpreting data**
    a. Students analyze and interpret data to explain the distribution of expressed traits, including:
        i. Recognition and use of patterns in statistical analysis to predict changes in trait distribution within a population if environmental variables change.
        ii. Description of the expression of a chosen trait and its relationship to some environmental factors based on reliable evidence.

B-LS3-3 Academic Language

Question/Sentence Stems

- How can the quantity of _______ and _______ can be compared?
- The proportion of _______ is _______because _______.
- The scale of the model of _______ is _______ compared to the actual population.
- To understand the phenomenon of _______, I/we can use a scale of _______ in my/our model.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- allele
- autosomal
- codominance
- complete dominance
- dihybrid cross
- distribution
- dominant
- environmental
- F_1 (first filial)
- F_2 (second filial)
- gamete
- gene expression
- genetic variability
- genotype
- genotypic ratio
- Hardy-Weinberg Conditions
- Hardy-Weinberg Equilibrium
- heredity
- heterozygous
- homozygous
- incomplete dominance
- karyotype
- monohybrid cross
- P (parental)
- pedigree
- phenotype
- phenotypic ratio
- polygenic inheritance
- population
- probability
- Punnett square
- ratio
- recessive
- sex linked
- trait
- variation

LS4 – Biological Evolution: Unity and Diversity

B-LS4-1. Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.

Clarification Statement: Emphasis is on students' 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.
State Assessment Boundary: Assessment is limited to conceptual explanations of the evidence for biological evolution and is not extended to the lines of evidence for specific species. Assessment does not include classification of organisms.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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).	**LS4.A: Evidence of Common Ancestry and Diversity** Genetic information, like the fossil record, provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; notably, 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. **ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World** The understanding of evolutionary relationships has recently been greatly accelerated by using new molecular tools to study biology.	**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.

(Continued on next page.)

Observable features of student performance by the end of the course:

1. **Communication**
    a. Students use and cite at least two different formats (for example: oral, graphical, textual, mathematical, etc.) to communicate scientific information about how common ancestry and biological evolution are supported by multiple lines of empirical evidence.
2. **Connections**
    a. Students identify and communicate evidence for common ancestry and biological evolution, including:
        i. Information derived from DNA sequences, which vary among species but have many similarities between species.
        ii. Similarities of the patterns or amino acid sequences, even when DNA sequences are slightly different, including that multiple patterns of DNA sequences can code for the same amino acids.
        iii. The triplet codon pattern (for example: codon chart) that is used to decode sequences of mRNA for protein construction is universal amongst known species.
        iv. Patterns in the fossil record (for example: presence, location, and possible inferences in lines of evolutionary descent for multiple specimen [biogeography]).
        v. Patterns of anatomical and embryological similarities.
    b. Students identify and communicate connections between the lines of evidence and the claim of common ancestry and biological evolution.
    c. Students communicate that together, the patterns observed at multiple spatial and temporal scales (for example: DNA sequences, embryological development, fossil record) provide evidence for relationships relating biological evolution and common ancestry.

B-LS4-1 Academic Language

Question/Sentence Stems

- I/We can observe (notice) the pattern of _______ presented in the data collected.
- I/We can observe (notice) the pattern of _______in the data presented.
- The pattern seen in the collected data allows me/us to conclude (know) that _______.
- The observed pattern supports the conclusion that _______ is caused by _______, because _______.
- The pattern of _______ is changing over time.
- The following predictions can be made about _______ when using the pattern of _______ found in the data.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- adaptation
- amino acid sequencing
- analogous structure
- anatomy
- biochemical evidence
- biogeography
- cladogram
- common ancestry
- comparative anatomy
- descent with modification
- DNA sequencing
- electrophoresis
- embryo
- embryology
- evolution
- evolutionary tree
- fossil record
- heritable trait
- homologous structure
- homology
- natural selection
- paleontology
- phenotypic similarity
- phylogenetic tree
- phylogeny
- sedimentary layers
- species
- vestigial structure

B-LS4-3. 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.
State Assessment Boundary: Assessment is limited to basic statistical and graphical analysis. Assessment does not include allele frequency calculations.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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.	**LS4.B: Natural Selection** 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. The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. **LS4.C: Adaptation** 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. Adaptation also means that the distribution of traits in a population can change when conditions change.	**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.

(Continued on next page.)

Observable features of student performance by the end of the course:

1. **Organizing data**
    a. Students organize data (for example: tables, charts, graphs, etc.) by the distribution of genetic traits over time.
2. **Identifying relationships**
    a. Students analyze data (for example: probability measures) to determine patterns of change in numerical distributions of traits over various time and population scales.
3. **Interpreting data**
    a. Students use the analyzed data as evidence to support explanations about:
        i. Positive or negative effects on fitness of individuals as relating to their expression of a variable trait in a population.
        ii. Natural selection as the cause of increases and decreases in heritable traits over time in a population, but only if it affects reproductive success.
        iii. The changes in distribution of adaptations of anatomical, behavioral, and physiological traits in a population.

B-LS4-3 Academic Language

Question/Sentence Stems

- I/We can observe (notice) the pattern of _______ presented in the data collected.
- I/We can observe (notice) the pattern of _______in the data presented.
- The pattern seen in the collected data allows me/us to conclude (know) that _______.
- The observed pattern supports the conclusion that _______ is caused by _______, because _______.
- The pattern of _______ is changing over time.
- The observed trait ___ is changing in the population by a noticed _____ in the model.
- The following predictions can be made about _______ when using the pattern of _______ found in the data.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- adaptation
- advantageous
- allele
- distribution
- fitness
- gene
- heritable trait
- increase
- natural selection
- proportion
- significance
- variation

B-LS4-6. 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.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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. Create or revise a simulation of a phenomenon, designed device, process, or system.	**LS4.C: Adaptation** 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. **LS4.D: Biodiversity and Humans** 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. **ETS1.B: Developing Possible Solutions** 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*) 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*) **ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World** Modern civilization depends on major technological systems, including those related to agriculture, health, water, energy, transportation (e.g., wildlife corridors), manufacturing, construction, and communications. (*secondary*) Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (*secondary*)	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Observable features of student performance by the end of the course:

1. **Representation**
    a. Students create or revise a simulation that:
        i. Models effects of human activity on threatened or endangered species or to the genetic variation within a species. Examples of human activity include:
            1. adverse habitat alterations,
            2. climate change,
            3. invasive species,
            4. overexploitation,
            5. overpopulation, and/or
            6. pollution.
        ii. Provides quantitative information about the effect of a solution on threatened or endangered species.
    b. Students describe the components that are modeled by the simulation, including human activity and the factors that affect biodiversity.
    c. Students describe the variables that can be changed by the user to evaluate the proposed solutions, tradeoffs, or other decisions.
2. **Computational Modeling**
    a. Students use logical and realistic inputs for the simulation that show an understanding of the reliance of ecosystem function and productivity on biodiversity, and that consider the following restraints:
        i. Cost,
        ii. cultural and environmental impacts,
        iii. reliability, and/or
        iv. safety.
    b. Students use the simulation to identify possible negative consequences of solutions that would outweigh their benefits.
3. **Analysis**
    a. Students compare the simulation results to expected results.
    b. Students analyze the simulation results to determine whether the simulation provides sufficient information to evaluate the solution.
    c. Students identify the limits of the simulation.
    d. Students interpret simulation results and predict the effects of the specific design solutions on biodiversity based on that interpretation.
4. **Revision**
    a. Students revise the simulation to provide sufficient information to evaluate the simulation.

B-LS4-6 Academic Language

Question/Sentence Stems

- By looking at patterns in the data, I/we determined that _______ caused _______.
- _______ caused the patterns I am observing. I know this because _______.
- If _______ happens, I/we predict that _______ will occur.
- Even though I/we cannot see _______, it explains why _______ is happening.
- The probability that _______ caused _______ is _______. I/We know this because _______.
- The evidence _______ presented in the scenario supports the claim that _______ causes _______.
- To conclude that _______ caused _______, the following evidence is needed _______.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- abiotic
- anthropogenic
- biodiversity
- biotic
- captive breeding
- carrying capacity
- climate
- climate change
- conservation
- constraints
- criteria
- deforestation
- ecological restoration
- ecosystem
- ecosystem diversity
- ecotourism
- endangered species
- environment
- extinction
- genetic diversity
- habitat
- habitat destruction
- habitat fragmentation
- habitat restoration
- human impact
- human population growth
- invasive species
- iterative
- mitigation
- optimize
- overharvesting
- pollution
- solution
- species diversity
- sustainable development

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