MA Draft Revised MS-HS *Lij*

Based on *A Framework for K-12 Science Education* (NRC, 20
Please direct comments, suggested edits, an
The standards and strand maps are avai
(*) denotes integration of technology

Grade 6

Grade 7

MS-LS1-1. Provide evidence that organisms (unicellular and multicellular) are made of cells. [Clarification Statement: Evidence can be drawn from multiple types of organisms, such as plants, animals and bacteria.]

4-LS1-1

MS-LS1-2. Develop and use a model to describe the ways parts of cells contribute to key cellular functions of obtaining nutrients and water from its environment, disposing of waste, and producing energy: a. the nucleus contains genetic information (DNA) which regulates a cell's activities; b. chloroplasts are the site of photosynthesis which produces necessary glucose and oxygen; c. mitochondria facilitate cellular respiration (energy production); d. vacuoles store materials, including water, nutrients and waste; e. the cell membrane is a protective barrier that enables nutrients to enter the cell and wastes to be expelled; and f. the cell wall provides structural support to some types of cells

MS-LS1-3. Develop an argument supported by evidence that the body systems interact to carry out key body functions, including providing nutrients and oxygen to cells, removing carbon dioxide and waste from cells and the body, controlling body motion/activity and coordination, and protecting the body. [Clarification Statement: Body systems to be included are the circulatory, excretory, digestive, respiratory, muscular/skeletal and nervous systems. Emphasis is on the function and interactions of the body systems, not specific body parts or organs.] [Assessment Boundary: Assessment does not include the mechanism of one body system independent of others.]

fe Science Strand Map (12/20/13)

)12) and adapted from the *Next Generation Science Standards* (2013)
ıd questions to: mathsciencetech@doe.mass.edu.
lable at: www.doe.mass.edu/stem/review.html
/engineering through a practice or core idea.

Grade 8

Biology (Grade 9-10)

HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within animals. Use the model to illustrate that: a. different types of cells contain different sets of proteins which enables the cells to perform specific functions; b. specialized cells work together to form specialized tissues, which in turn join to form specialized organs; and c. specialized organs work together to form the body systems that coordinate to carry out the essential functions of life. [Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to neural stimuli. Animal body systems include circulatory, excretory, digestive, respiratory, muscular/skeletal, endocrine and nervous systems. Examples of interacting systems could include an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system.] [Assessment Boundary: Assessment does not include interactions and functions at the molecular or chemical reaction level. Assessment does not include the identification of specific proteins in cells. Assessment is limited to include major organs, such a lungs, stomach, small intestine, liver, heart and kidneys.]

HS-LS1-3. Provide evidence that feedback mechanisms promote (through positive feedback) or inhibit (through negative feedback) activities within an organism to maintain homeostasis. [Clarification Statement: Examples could include heart rate response to exercise and recovery, insulin production and inhibition in response to blood sugar levels, stomate response to moisture and temperature, and root development in response to water levels.] [Assessment Boundary: Assessment does not include sub-cellular processes involved in the feedback mechanism nor interactions at the molecular level.]

HS-LS1-4. Explain why the cell cycle is necessary for the growth, maintenance, and repair of multicellular organisms. Model the major events of the cell cycle, include cell growth, DNA replication, preparation for division, separation of chromosomes, and separation of cell contents. [Assessment Boundary: Assessment does not include specific gene control mechanisms or rote memorization of the steps of mitosis.]

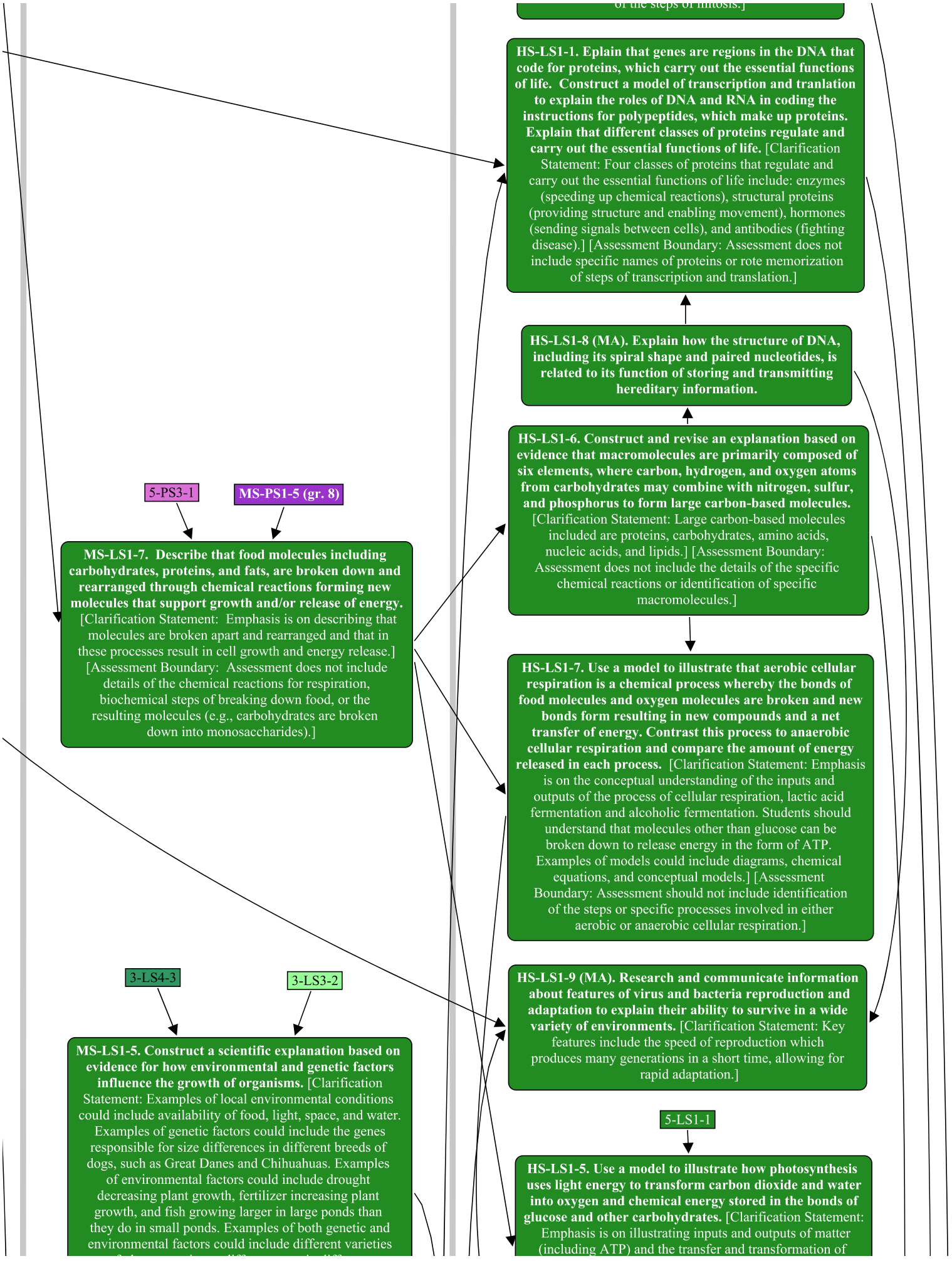
1. From Molecules to Organisms: Structures and Processes

wall provides structural support to some types of cells. [Clarification Statement: Functions should focus on basic survival needs.] [Assessment Boundary: Assessment does not include specific biochemical steps or chemical processes, ATP, or active transport through the cell membrane.]

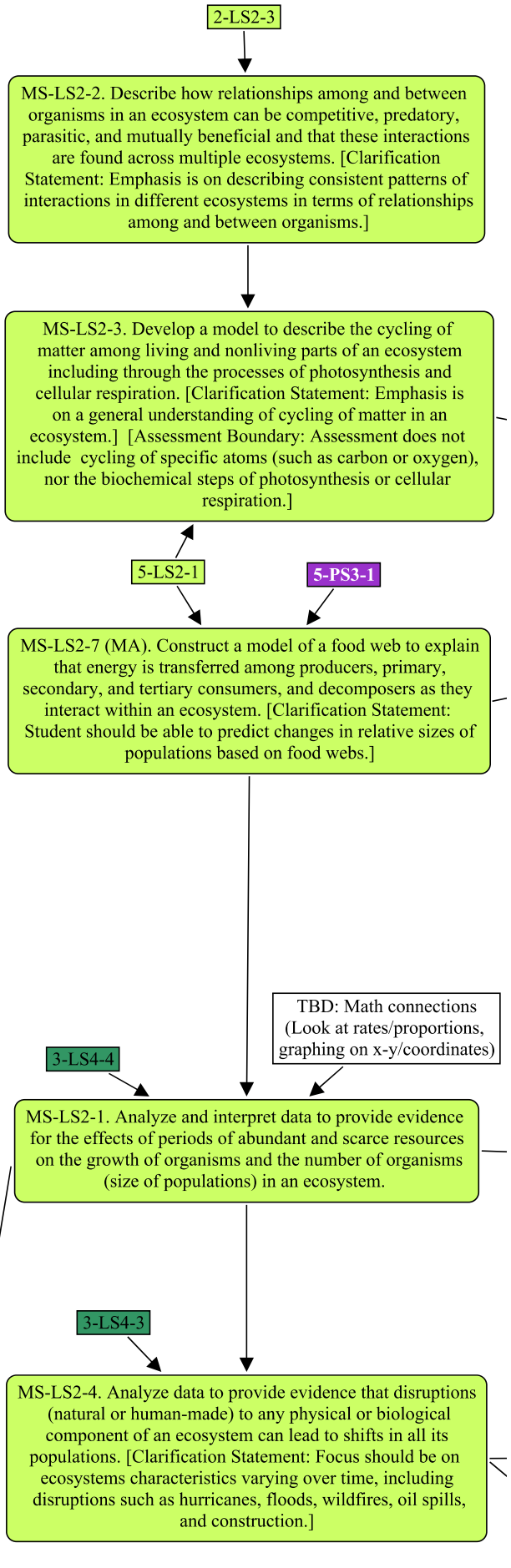
3-LS4-2

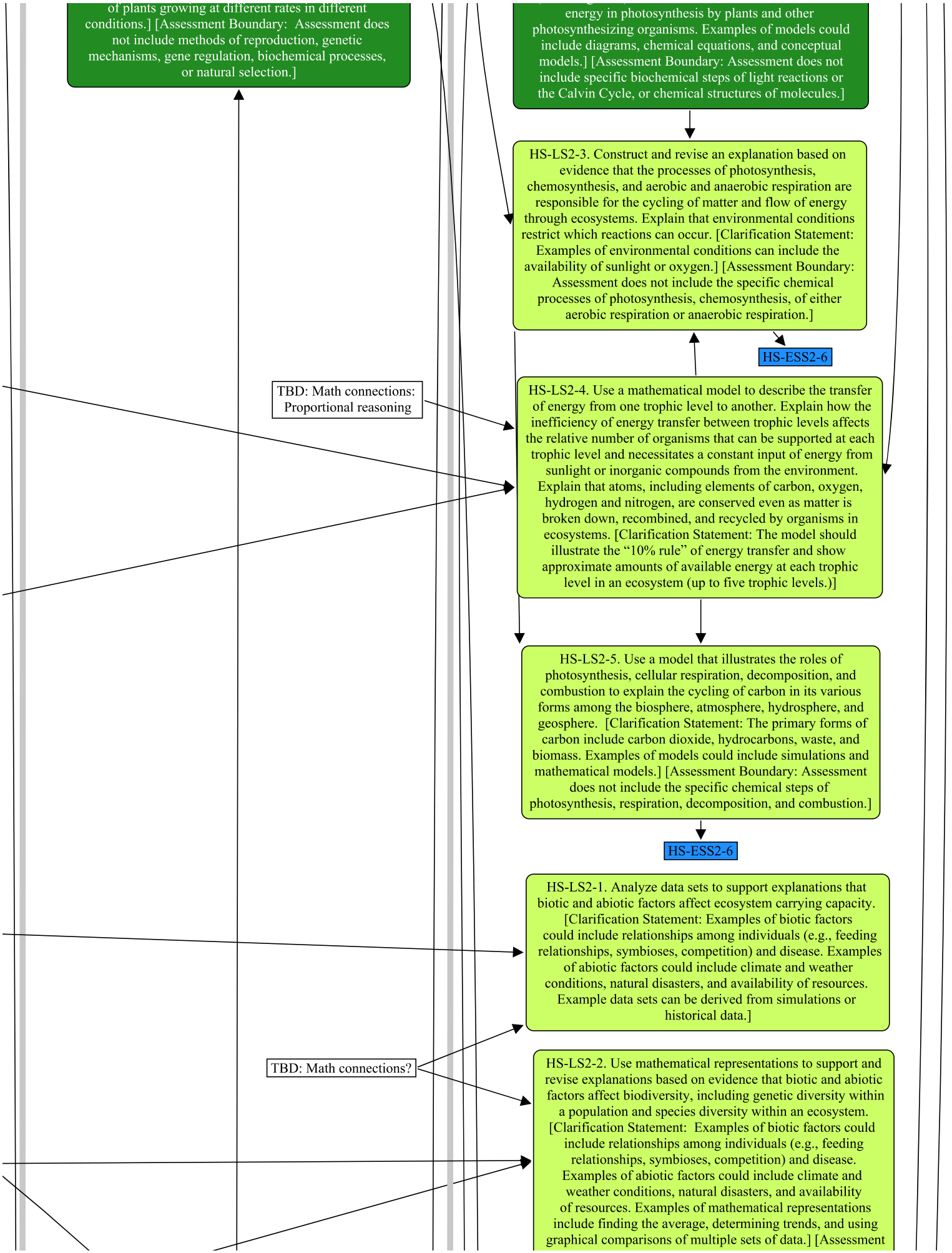
4-LS1-1

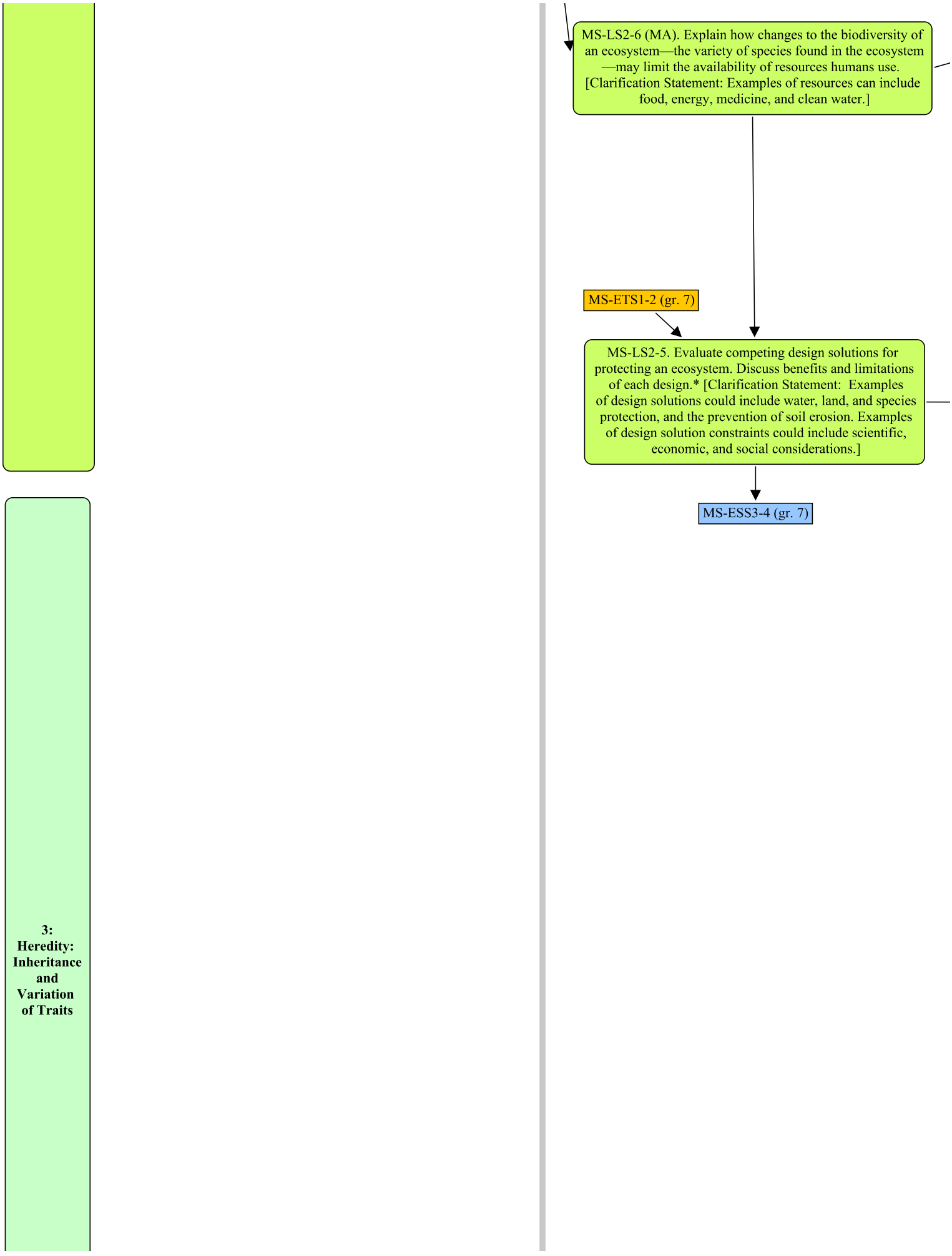
MS-LS1-4. Explain, based on evidence, how characteristic animal behaviors as well as specialized plant structures increase the probability of successful reproduction of animals and plants respectively. [Clarification Statement: Examples of animal behaviors that affect the probability of animal reproduction could include nest building to protect young from cold, herding of animals to protect young from predators, and vocalization of animals and colorful plumage to attract mates for breeding. Examples of animal behaviors that affect the probability of plant reproduction could include transferring pollen or seeds; and, creating conditions for seed germination and growth. Examples of plant structures that affect the probability of plant reproduction could include bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract insects that transfer pollen, and hard shells on nuts that squirrels bury.] [Assessment Boundary: Assessment does not include natural selection.]

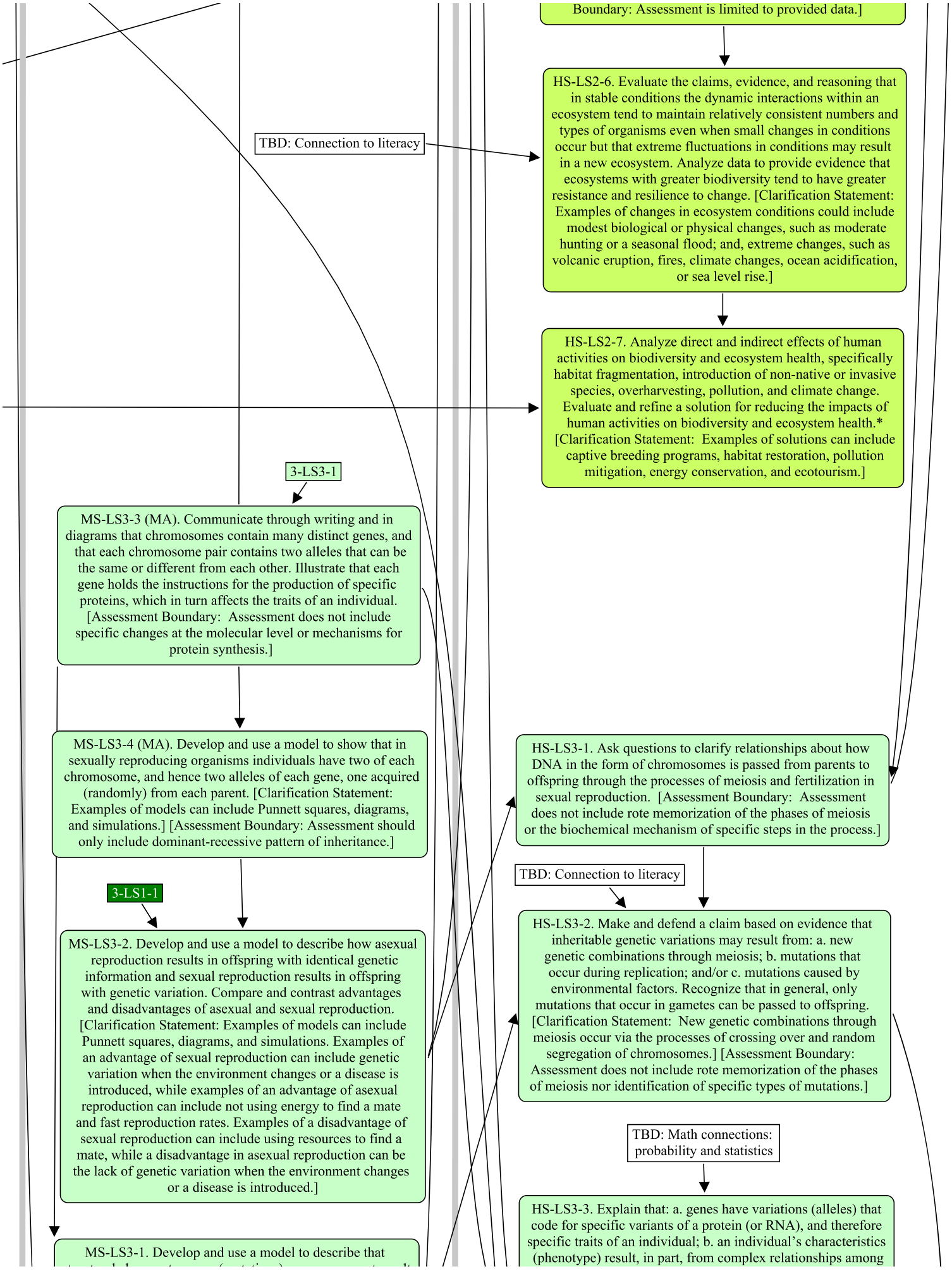

of the steps of mitosis.]
HS-LS1-1. Eplain that genes are regions in the DNA that code for proteins, which carry out the essential functions of life. Construct a model of transcription and tranlation to explain the roles of DNA and RNA in coding the instructions for polypeptides, which make up proteins. Explain that different classes of proteins regulate and carry out the essential functions of life. [Clarification Statement: Four classes of proteins that regulate and carry out the essential functions of life include: enzymes (speeding up chemical reactions), structural proteins (providing structure and enabling movement), hormones (sending signals between cells), and antibodies (fighting disease).] [Assessment Boundary: Assessment does not include specific names of proteins or rote memorization of steps of transcription and translation.]
HS-LS1-8 (MA). Explain how the structure of DNA, including its spiral shape and paired nucleotides, is related to its function of storing and transmitting hereditary information.
HS-LS1-6. Construct and revise an explanation based on evidence that macromolecules are primarily composed of six elements, where carbon, hydrogen, and oxygen atoms from carbohydrates may combine with nitrogen, sulfur, and phosphorus to form large carbon-based molecules. [Clarification Statement: Large carbon-based molecules included are proteins, carbohydrates, amino acids, nucleic acids, and lipids.] [Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of specific macromolecules.]
5-PS3-1
MS-PS1-5 (gr. 8)
MS-LS1-7. Describe that food molecules including carbohydrates, proteins, and fats, are broken down and rearranged through chemical reactions forming new molecules that support growth and/or release of energy. [Clarification Statement: Emphasis is on describing that molecules are broken apart and rearranged and that in these processes result in cell growth and energy release.] [Assessment Boundary: Assessment does not include details of the chemical reactions for respiration, biochemical steps of breaking down food, or the resulting molecules (e.g., carbohydrates are broken down into monosaccharides).]
HS-LS1-7. Use a model to illustrate that aerobic cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and new bonds form resulting in new compounds and a net transfer of energy. Contrast this process to anaerobic cellular respiration and compare the amount of energy released in each process. [Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration, lactic acid fermentation and alcoholic fermentation. Students should understand that molecules other than glucose can be broken down to release energy in the form of ATP. Examples of models could include diagrams, chemical equations, and conceptual models.] [Assessment Boundary: Assessment should not include identification of the steps or specific processes involved in either aerobic or anaerobic cellular respiration.]
3-LS4-3
3-LS3-2
HS-LS1-9 (MA). Research and communicate information about features of virus and bacteria reproduction and adaptation to explain their ability to survive in a wide variety of environments. [Clarification Statement: Key features include the speed of reproduction which produces many generations in a short time, allowing for rapid adaptation.]
MS-LS1-5. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. [Clarification Statement: Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include the genes responsible for size differences in different breeds of dogs, such as Great Danes and Chihuahuas. Examples of environmental factors could include drought decreasing plant growth, fertilizer increasing plant growth, and fish growing larger in large ponds than they do in small ponds. Examples of both genetic and environmental factors could include different varieties
5-LS1-1
HS-LS1-5. Use a model to illustrate how photosynthesis uses light energy to transform carbon dioxide and water into oxygen and chemical energy stored in the bonds of glucose and other carbohydrates. [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter (including ATP) and the transfer and transformation of

2: Ecosystems: Interactions, Energy, and Dynamics

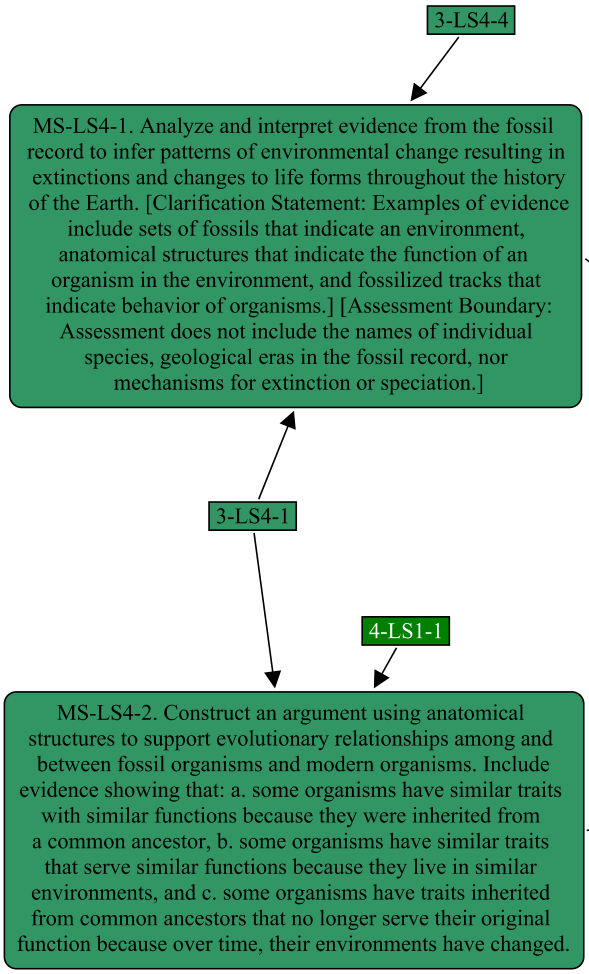


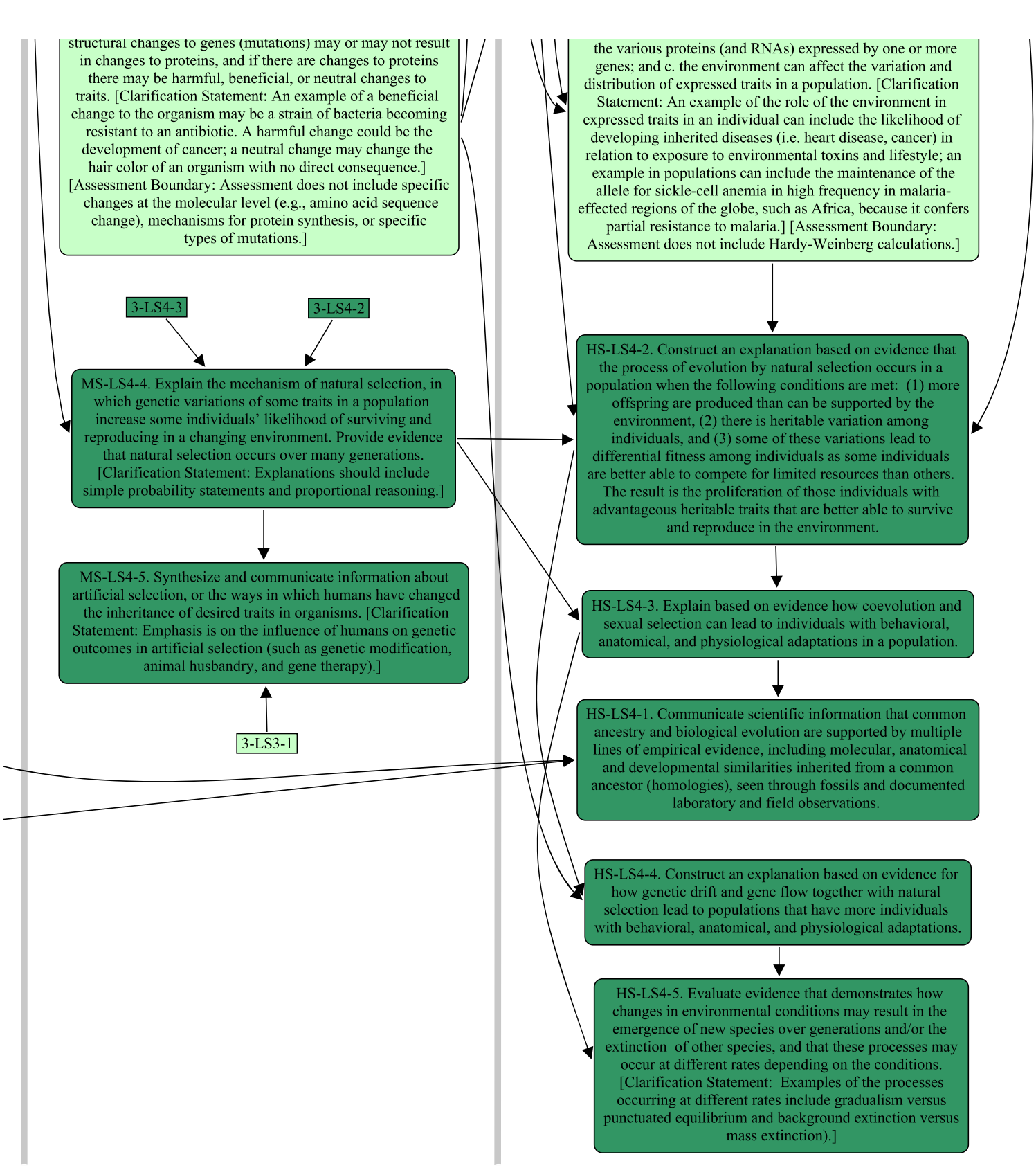

of plants growing at different rates in different conditions.] [Assessment Boundary: Assessment does not include methods of reproduction, genetic mechanisms, gene regulation, biochemical processes, or natural selection.]
energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] [Assessment Boundary: Assessment does not include specific biochemical steps of light reactions or the Calvin Cycle, or chemical structures of molecules.]
HS-LS2-3. Construct and revise an explanation based on evidence that the processes of photosynthesis, chemosynthesis, and aerobic and anaerobic respiration are responsible for the cycling of matter and flow of energy through ecosystems. Explain that environmental conditions restrict which reactions can occur. [Clarification Statement: Examples of environmental conditions can include the availability of sunlight or oxygen.] [Assessment Boundary: Assessment does not include the specific chemical processes of photosynthesis, chemosynthesis, of either aerobic respiration or anaerobic respiration.]
HS-ESS2-6
TBD: Math connections: Proportional reasoning
HS-LS2-4. Use a mathematical model to describe the transfer of energy from one trophic level to another. Explain how the inefficiency of energy transfer between trophic levels affects the relative number of organisms that can be supported at each trophic level and necessitates a constant input of energy from sunlight or inorganic compounds from the environment. Explain that atoms, including elements of carbon, oxygen, hydrogen and nitrogen, are conserved even as matter is broken down, recombined, and recycled by organisms in ecosystems. [Clarification Statement: The model should illustrate the “10% rule” of energy transfer and show approximate amounts of available energy at each trophic level in an ecosystem (up to five trophic levels.)]
HS-LS2-5. Use a model that illustrates the roles of photosynthesis, cellular respiration, decomposition, and combustion to explain the cycling of carbon in its various forms among the biosphere, atmosphere, hydrosphere, and geosphere. [Clarification Statement: The primary forms of carbon include carbon dioxide, hydrocarbons, waste, and biomass. Examples of models could include simulations and mathematical models.] [Assessment Boundary: Assessment does not include the specific chemical steps of photosynthesis, respiration, decomposition, and combustion.]
HS-ESS2-6
HS-LS2-1. Analyze data sets to support explanations that biotic and abiotic factors affect ecosystem carrying capacity. [Clarification Statement: Examples of biotic factors could include relationships among individuals (e.g., feeding relationships, symbioses, competition) and disease. Examples of abiotic factors could include climate and weather conditions, natural disasters, and availability of resources. Example data sets can be derived from simulations or historical data.]
TBD: Math connections?
HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence that biotic and abiotic factors affect biodiversity, including genetic diversity within a population and species diversity within an ecosystem. [Clarification Statement: Examples of biotic factors could include relationships among individuals (e.g., feeding relationships, symbioses, competition) and disease. Examples of abiotic factors could include climate and weather conditions, natural disasters, and availability of resources. Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [Assessment


MS-LS2-6 (MA). Explain how changes to the biodiversity of an ecosystem—the variety of species found in the ecosystem—may limit the availability of resources humans use. [Clarification Statement: Examples of resources can include food, energy, medicine, and clean water.]
MS-ETS1-2 (gr. 7)
MS-LS2-5. Evaluate competing design solutions for protecting an ecosystem. Discuss benefits and limitations of each design.* [Clarification Statement: Examples of design solutions could include water, land, and species protection, and the prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.]
MS-ESS3-4 (gr. 7)
3: Heredity: Inheritance and Variation of Traits


Boundary: Assessment is limited to provided data.]
HS-LS2-6. Evaluate the claims, evidence, and reasoning that in stable conditions the dynamic interactions within an ecosystem tend to maintain relatively consistent numbers and types of organisms even when small changes in conditions occur but that extreme fluctuations in conditions may result in a new ecosystem. Analyze data to provide evidence that ecosystems with greater biodiversity tend to have greater resistance and resilience to change. [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, fires, climate changes, ocean acidification, or sea level rise.]
TBD: Connection to literacy
HS-LS2-7. Analyze direct and indirect effects of human activities on biodiversity and ecosystem health, specifically habitat fragmentation, introduction of non-native or invasive species, overharvesting, pollution, and climate change. Evaluate and refine a solution for reducing the impacts of human activities on biodiversity and ecosystem health.* [Clarification Statement: Examples of solutions can include captive breeding programs, habitat restoration, pollution mitigation, energy conservation, and ecotourism.]
3-LS3-1
MS-LS3-3 (MA). Communicate through writing and in diagrams that chromosomes contain many distinct genes, and that each chromosome pair contains two alleles that can be the same or different from each other. Illustrate that each gene holds the instructions for the production of specific proteins, which in turn affects the traits of an individual. [Assessment Boundary: Assessment does not include specific changes at the molecular level or mechanisms for protein synthesis.]
MS-LS3-4 (MA). Develop and use a model to show that in sexually reproducing organisms individuals have two of each chromosome, and hence two alleles of each gene, one acquired (randomly) from each parent. [Clarification Statement: Examples of models can include Punnett squares, diagrams, and simulations.] [Assessment Boundary: Assessment should only include dominant-recessive pattern of inheritance.]
3-LS1-1
MS-LS3-2. Develop and use a model to describe how asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. Compare and contrast advantages and disadvantages of asexual and sexual reproduction. [Clarification Statement: Examples of models can include Punnett squares, diagrams, and simulations. Examples of an advantage of sexual reproduction can include genetic variation when the environment changes or a disease is introduced, while examples of an advantage of asexual reproduction can include not using energy to find a mate and fast reproduction rates. Examples of a disadvantage of sexual reproduction can include using resources to find a mate, while a disadvantage in asexual reproduction can be the lack of genetic variation when the environment changes or a disease is introduced.]
MS-LS3-1. Develop and use a model to describe that
HS-LS3-1. Ask questions to clarify relationships about how DNA in the form of chromosomes is passed from parents to offspring through the processes of meiosis and fertilization in sexual reproduction. [Assessment Boundary: Assessment does not include rote memorization of the phases of meiosis or the biochemical mechanism of specific steps in the process.]
TBD: Connection to literacy
HS-LS3-2. Make and defend a claim based on evidence that inheritable genetic variations may result from: a. new genetic combinations through meiosis; b. mutations that occur during replication; and/or c. mutations caused by environmental factors. Recognize that in general, only mutations that occur in gametes can be passed to offspring. [Clarification Statement: New genetic combinations through meiosis occur via the processes of crossing over and random segregation of chromosomes.] [Assessment Boundary: Assessment does not include rote memorization of the phases of meiosis nor identification of specific types of mutations.]
TBD: Math connections: probability and statistics
HS-LS3-3. Explain that: a. genes have variations (alleles) that code for specific variants of a protein (or RNA), and therefore specific traits of an individual; b. an individual's characteristics (phenotype) result, in part, from complex relationships among

4: Biological Evolution: Unity and Diversity




structural changes to genes (mutations) may or may not result in changes to proteins, and if there are changes to proteins there may be harmful, beneficial, or neutral changes to traits. [Clarification Statement: An example of a beneficial change to the organism may be a strain of bacteria becoming resistant to an antibiotic. A harmful change could be the development of cancer; a neutral change may change the hair color of an organism with no direct consequence.] [Assessment Boundary: Assessment does not include specific changes at the molecular level (e.g., amino acid sequence change), mechanisms for protein synthesis, or specific types of mutations.]
the various proteins (and RNAs) expressed by one or more genes; and c. the environment can affect the variation and distribution of expressed traits in a population. [Clarification Statement: An example of the role of the environment in expressed traits in an individual can include the likelihood of developing inherited diseases (i.e. heart disease, cancer) in relation to exposure to environmental toxins and lifestyle; an example in populations can include the maintenance of the allele for sickle-cell anemia in high frequency in malaria-effected regions of the globe, such as Africa, because it confers partial resistance to malaria.] [Assessment Boundary: Assessment does not include Hardy-Weinberg calculations.]
3-LS4-3
3-LS4-2
MS-LS4-4. Explain the mechanism of natural selection, in which genetic variations of some traits in a population increase some individuals' likelihood of surviving and reproducing in a changing environment. Provide evidence that natural selection occurs over many generations. [Clarification Statement: Explanations should include simple probability statements and proportional reasoning.]
HS-LS4-2. Construct an explanation based on evidence that the process of evolution by natural selection occurs in a population when the following conditions are met: (1) more offspring are produced than can be supported by the environment, (2) there is heritable variation among individuals, and (3) some of these variations lead to differential fitness among individuals as some individuals are better able to compete for limited resources than others. The result is the proliferation of those individuals with advantageous heritable traits that are better able to survive and reproduce in the environment.
MS-LS4-5. Synthesize and communicate information about artificial selection, or the ways in which humans have changed the inheritance of desired traits in organisms. [Clarification Statement: Emphasis is on the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, and gene therapy).]
HS-LS4-3. Explain based on evidence how coevolution and sexual selection can lead to individuals with behavioral, anatomical, and physiological adaptations in a population.
3-LS3-1
HS-LS4-1. Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence, including molecular, anatomical and developmental similarities inherited from a common ancestor (homologies), seen through fossils and documented laboratory and field observations.
HS-LS4-4. Construct an explanation based on evidence for how genetic drift and gene flow together with natural selection lead to populations that have more individuals with behavioral, anatomical, and physiological adaptations.
HS-LS4-5. Evaluate evidence that demonstrates how changes in environmental conditions may result in the emergence of new species over generations and/or the extinction of other species, and that these processes may occur at different rates depending on the conditions. [Clarification Statement: Examples of the processes occurring at different rates include gradualism versus punctuated equilibrium and background extinction versus mass extinction).]