The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*.
## New York State P-12 Science Learning Standards

<table>
<thead>
<tr>
<th>HS. Matter and Energy in Organisms and Ecosystems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students who demonstrate understanding can:</td>
</tr>
<tr>
<td><strong>HS-LS1-5.</strong> Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.**</td>
</tr>
<tr>
<td>[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.]</td>
</tr>
<tr>
<td><strong>HS-LS1-6.</strong> Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements such as nitrogen, sulfur, and phosphorus to form amino acids and other carbon-based molecules.**</td>
</tr>
<tr>
<td>[Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations for the synthesis of lipids, starches, proteins, and nucleic acids.] [Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of structural and molecular formulas for macromolecules.]</td>
</tr>
<tr>
<td><strong>HS-LS1-7.</strong> 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 the bonds in new compounds are formed resulting in a net transfer of energy.**</td>
</tr>
<tr>
<td>[Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of aerobic cellular respiration.] [Assessment Boundary: Assessment should not include identification of the steps or specific processes involved in aerobic respiration.]</td>
</tr>
<tr>
<td><strong>HS-LS2-3.</strong> Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in ecosystems.**</td>
</tr>
<tr>
<td>[Clarification Statement: Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration and photosynthesis within ecosystems.] [Assessment Boundary: Assessment does not include the specific chemical processes of aerobic respiration, anaerobic respiration, and photosynthesis.]</td>
</tr>
<tr>
<td><strong>HS-LS2-4.</strong> Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.**</td>
</tr>
<tr>
<td>[Clarification Statement: Emphasis is on using a mathematical model such as a pyramid of biomass/energy 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.]</td>
</tr>
<tr>
<td><strong>HS-LS2-5.</strong> Develop a model to illustrate the role of various processes in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.**</td>
</tr>
<tr>
<td>[Clarification Statement: Examples of models include simulations, diagrams, and mathematical models of the carbon cycle (photosynthesis, respiration, decomposition, and combustion.)] [Assessment Boundary: Assessment does not include the specific chemical steps of photosynthesis and respiration.]</td>
</tr>
</tbody>
</table>

The performance expectations above were developed using the following elements from the NRC document, *A Framework for K-12 Science Education.*

### Science and Engineering Practices

**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. (HS-LS1-5),(HS-LS1-7)
  - Develop a model based on evidence to illustrate the relationships between systems or components of a system. (HS-LS2-5)

**Using Mathematics and Computational Thinking**
- Mathematical and computational thinking 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.
  - Use mathematical representations of phenomena or design solutions to support claims. (HS-LS2-4)

**Constructing Explanations and Designing Solutions**
- 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. (HS-LS2-3)

### Disciplinary Core Ideas

- The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (HS-LS1-5)
- As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. (HS-LS1-6),(HS-LS1-7)
- (NYSED) Sugar molecules contain carbon, hydrogen, and oxygen. Their hydrocarbon backbones combine with other elements to make amino acids and other carbon-based molecules that can be assembled into larger molecules, such as proteins or DNA. (HS-LS1-6)
- (NYSED) Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed. In this process ATP is produced, which is used to carry out life processes. (HS-LS1-7)

#### 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. (HS-LS2-3)
- 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. 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)
- (NYSED) When matter is cycled through organisms and ecosystems, some of the matter reacts to release energy for life functions, some is stored in newly made structures, and some is eliminated as waste. (HS-LS2-4)

### Crosscutting Concepts

#### 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. (HS-LS2-5)

#### 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. (HS-LS1-5), (HS-LS1-6)
- Energy can be transferred between one place and another place, between objects and/or fields, or between systems. (HS-LS1-7),(HS-LS2-4)
- Energy drives the cycling of matter within and between systems. (HS-LS2-3)

*Note: The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.*

The text in the “Disciplinary Core Ideas” section is reproduced verbatim from *A Framework for K-12 Science Education: Practices, Cross-Cutting Concepts, and Core Ideas* unless it is preceded by (NYSED).
New York State P-12 Science Learning Standards

- **(NYSED)** Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, hydrosphere, and geosphere through chemical, physical, geological, and biological processes. (HS-LS2-5)

**PS3.D: Energy in Chemical Processes**
- 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)

**Connections to other DCIs in this grade-band:**
- **HS.PS1.B** (HS-LS1-5),(HS-LS1-6),(HS-LS1-7),(HS-LS2-3),(HS-LS2-5); **HS.PS2.B** (HS-LS1-7); **HS.PS3.B** (HS-LS1-5),(HS-LS1-7),(HS-LS2-3),(HS-LS2-4); **HS.PS3.D** (HS-LS2-3),(HS-LS2-4); **HS.ESS2.A** (HS-LS2-3); **HS.ESS2.D** (HS-LS2-5)

**Articulation of DCIs across grade-bands:**
- **MS.PS1.A** (HS-LS1-6); **MS.PS1.B** (HS-LS1-5),(HS-LS1-6),(HS-LS1-7),(HS-LS2-3); **MS.PS3.D** (HS-LS1-5),(HS-LS1-6),(HS-LS1-7),(HS-LS2-3),(HS-LS2-4),(HS-LS2-5); **MS.LS1.C** (HS-LS1-5),(HS-LS1-6),(HS-LS1-7),(HS-LS2-3),(HS-LS2-4),(HS-LS2-5); **MS.LS2.B** (HS-LS1-5),(HS-LS1-7),(HS-LS2-3),(HS-LS2-4),(HS-LS2-5); **MS.ESS2.A** (HS-LS2-5); **MS.ESS2.E** (HS-LS1-6)

New York State Next Generation Learning Standards:

**ELA/Literacy –**
- **11-12.RST.1** Cite specific evidence to support analysis of scientific and technical texts, charts, diagrams, etc., attending to the precise details of the source, and attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-LS1-6),(HS-LS2-3)
- **9-10.WHST.2** Write explanatory text focused on discipline-specific content. (HS-LS1-6),(HS-LS2-3)
- **11-12.WHST.2** Write explanatory and analytical text focused on discipline-specific content and which uses strategies for conveying information like those used in the respective discipline. (HS-LS1-6),(HS-LS2-3)
- **9-12.WHST.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-LS1-6)
- **11-12.SL.5** Make strategic use of digital media and/or visual displays in presentations to enhance understanding of findings, reasoning, and evidence, and to add elements of interest to engage the audience. (HS-LS1-5),(HS-LS1-7)

**Mathematics –**
- **MP.2** Reason abstractly and quantitatively. (HS-LS2-4)
- **MP.4** Model with Mathematics. (HS-LS2-4)
- **AI-N.Q.1** Select quantities and use units as a way to: i) interpret and guide the solution of multi-step problems; ii) choose and interpret units consistently in formulas; and iii) choose and interpret the scale and the origin in graphs and data displays. (HS-LS2-4)
- **AI-N.Q.3** Choose a level of accuracy appropriate to limitations on measurement and context when reporting quantities. (HS-LS2-4)

*Connection boxes updated as of September 2018*

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New York State P-12 Science Learning Standards

**HS. Interdependent Relationships in Ecosystems**

Students who demonstrate understanding can:

**HS-LS2-1. Use mathematical and/or computational representations to support explanations of biotic and abiotic 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-LS2-2. 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 could include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [Assessment Boundary: Assessment is limited to provided data.]

**HS-LS2-6. 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.** [Clarification Statement: Examples of changes in ecosystem conditions include ecological succession, modest biological or physical changes, such as moderate hunting or seasonal floods; and extreme changes, such as volcanic eruption or sea level rise.]

**HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.** [Clarification Statement: Examples of human activities could include urbanization, building dams, and dissemination of invasive species. Examples of solutions could include simulations, product development, technological innovations, and/or legislation.]

**HS-LS2-8. Evaluate the 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, herding, and cooperative behaviors such as hunting, migrating, and swarming.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

### Science and Engineering Practices

**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. (HS-LS2-1)
- Use mathematical representations of phenomena or design solutions to support and revise explanations. (HS-LS2-2)
- Create or revise a simulation of a phenomenon, designed device, process, or system. (HS-LS2-7)

**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.

- 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. (HS-LS2-7)

**Engaging in Argument from Evidence**
Engaging in argument from evidence in 9–12 builds from 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. (HS-LS2-6)
- Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments. (HS-LS2-8)

### Disciplinary Core Ideas

**LS2.A: Interdependent Relationships in Ecosystems**
- Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. 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)
- Carrying capacity results from the availability of biotic and abiotic factors and from challenges such as predation, competition, and disease. (HS-LS2-1), (HS-LS2-2)

**LS2.B: 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. (HS-LS2-2), (HS-LS2-6)
- 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)

**LS2.C: Social Interactions and Group Behavior**
- Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives. (HS-LS2-8)

**LS4.D: Biodiversity and Humans**
- Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction), (secondary to HS-LS2-7)
- Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activities are also having diverse 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)

### Crosscutting Concepts

**Cause and Effect**
- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS2-7), (HS-LS2-8)

**Scale, Proportion, and Quantity**
- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-LS2-1)
- Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. (HS-LS2-2)

**Stability and Change**
- Much of science deals with constructing explanations of how things change and how they remain stable. (HS-LS2-6), (HS-LS2-7)

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New York State P-12 Science Learning Standards

Connections to other DCIs in this grade-band: HS.ESS2.D (HS-LS2-7),(HS-LS4-6); HS.ESS2.E (HS-LS2-2),(HS-LS2-6),(HS-LS2-7),(HS-LS4-6); HS.ESS3.A (HS-LS2-2),(HS-LS2-7),(HS-LS4-6); HS.ESS3.D (HS-LS2-2),(HS-LS4-6)

Articulation of DCIs across grade-bands: MS.LS1.B (HS-LS2-8); MS.LS2.A (HS-LS2-1),(HS-LS2-2),(HS-LS2-6); MS.LS2.C (HS-LS2-1),(HS-LS2-2),(HS-LS2-6),(HS-LS2-7),(HS-LS4-6); MS.ESS2.E (HS-LS2-6); MS.ESS3.A (HS-LS2-1); MS.ESS3.C (HS-LS2-1),(HS-LS2-2),(HS-LS2-6),(HS-LS2-7),(HS-LS4-6); MS.ESS3.D (HS-LS2-7)

New York State Next Generation Learning Standards:

ELA/Literacy –

9-10.RST.8 Assess the extent to which the reasoning and evidence in a source support the author’s claim or a recommendation for solving a scientific or technical problem. (HS-LS2-6),(HS-LS2-7),(HS-LS2-8)

11-12.RST.1 Cite specific evidence to support analysis of scientific and technical texts, charts, diagrams, etc., attending to the precise details of the source, and attending to important distinctions the author makes and how any gaps or inconsistencies in the account. (HS-LS2-1),(HS-LS2-2),(HS-LS2-6),(HS-LS2-8)

11-12.RST.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-LS2-6),(HS-LS2-7),(HS-LS2-8)

11-12.RST.8 Evaluate the 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-LS2-6),(HS-LS2-7),(HS-LS2-8)

9-10.WHST.2 Write informative/explanatory text focused on discipline-specific content. (HS-LS2-1),(HS-LS2-2)

11-12.WHST.2 Write explanatory and analytical text focused on discipline-specific content and which uses strategies for conveying information like those used in the respective discipline. (HS-LS2-1),(HS-LS2-2)

11-12.WHST.5 Conduct short as well as more sustained research projects to answer a question (including a self-generated question), analyze a topic, 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-LS2-7),(HS-LS4-6)

Mathematics –

MP.2 Reason abstractly and quantitatively. (HS-LS2-1),(HS-LS2-2),(HS-LS2-6),(HS-LS2-7)

MP.4 Model with Mathematics. (HS-LS2-1),(HS-LS2-2)

AI-N.Q.1 Select quantities and use units as a way to: i) interpret and guide the solution of multi-step problems; ii) choose and interpret units consistently in formulas; and iii) choose and interpret the scale and the origin in graphs and data displays. (HS-LS2-1),(HS-LS2-2),(HS-LS2-7)

AI-N.Q.3 Choose a level of accuracy appropriate to limitations on measurement and context when reporting quantities. (HS-LS2-1),(HS-LS2-2),(HS-LS2-7)

AI-S.ID.1 Represent data with plots on the real number line (dot plots, histograms, and box plots). (HS-LS2-6)

AII-S.IC.6a Use the tools of statistics to draw conclusions from numerical summaries. (HS-LS2-6)

AII-S.IC.6b Use the language of statistics to critique claims from informational texts. For example, causation vs correlation, bias, measures of center and spread. (HS-LS2-6)

*Connection boxes updated as of September 2018

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New York State P-12 Science Learning Standards

HS. Inheritance and Variation of Traits

**HS-LS1-4. Use a model to illustrate cellular division (mitosis) and differentiation.** [Clarification Statement: Emphasis should be on the outcomes of mitotic division and cell differentiation on growth and development of complex organisms and possible implications for abnormal cell division (cancer) and stem cell research.] [Assessment Boundary: Assessment does not include specific gene control mechanisms or recalling the specific steps of mitosis.]

**HS-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.** [Clarification Statement: Emphasis should be on the distinction between coding and non-coding regions of DNA.]

**HS-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, (3) mutations caused by environmental factors and/or (4) genetic engineering.** [Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs including the relevant processes in meiosis and advances in biotechnology.] [Assessment Boundary: Assessment does not include recalling the specific details of the phases of meiosis or the biochemical mechanisms of the specific phases in the process.]

**HS-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.] [Assessment Boundary: Assessment does not include Hardy-Weinberg calculations.]

**HS-LS1-8. Use models to illustrate how human reproduction and development maintains continuity of life.** [Clarification Statement: Emphasis is on structures and function of human reproductive systems, interactions with other human body systems, embryonic development, and influences of environmental factors on development.] [Assessment Boundary: Assessment does not include the details of hormonal regulation or stages of embryonic development.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education:*

### Science and Engineering Practices

#### 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 designing experiments using models and simulations.
- Ask questions that arise from examining models or a theory to clarify relationships. (HS-LS3-1)

#### 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 components of a system. (HS-LS1-4), (HS-LS1-8)

#### 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 consistencies, 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. (HS-LS3-3)

#### 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. (HS-LS2-2)

### Disciplinary Core Ideas

#### 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 to HS-LS1-1) (Note: Disciplinary Core Idea is also addressed by HS-LS1-4)
- (NYSED) The structures and functions of the human female reproductive system produce gametmes in ovaries, allow for internal fertilization, support the internal development of the embryo and fetus in the uterus, and provide essential materials through the placenta, and nutrition through milk for the newborn. The structures and functions of the human male reproductive system produce gametmes in testes and make possible the delivery of these gametmes for fertilization. (HS-LS1-8)

#### LS1.B: Growth and Development of Organisms
- 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. (HS-LS1-4)
- (NYSED) The continuity of life is sustained through reproduction and development. Human development, birth, and aging should be viewed as a predictable pattern of events influenced by factors such as gene expression, hormones, and the environment. (HS-LS1-8)

#### LS2.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. (HS-LS1-3)

#### LS2.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. (HS-LS3-2)
- (NYSED) Environmental factors can cause mutations in genes. Only mutations in sex cells can be inherited. (HS-LS1-8)

### Crosscutting Concepts

#### Cause and Effect
- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS3-1), (HS-LS3-2)

#### 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). (HS-LS3-3)

#### 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—with and between systems at different scales. (HS-LS1-4), (HS-LS1-8)

### Connections to Nature of Science

Science is a Human Endeavor
- Technological advances have influenced the progress of science and science has influenced advances in technology. (HS-LS3-2), (HS-LS3-3), (New NYSED PE)
- Science and engineering are influenced by society and society is influenced by science and engineering. (HS-LS3-2), (HS-LS3-3), (HS-LS1-8)

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### ELA/Literacy – 11-12.RST.1
Cite specific evidence to support analysis of scientific and technical texts, charts, diagrams, etc., attending to the precise details of the source, and attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-LS3-1), (HS-LS3-2)

### 11-12.RST.9
Compare and contrast findings presented in a source to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts. (HS-LS3-1)

### 9-12.WHST.1
Write arguments focused on discipline-specific content. (HS-LS3-2)

### 11-12.SL.5
Make strategic use of digital media and/or visual displays in presentations to enhance understanding of findings, reasoning, and evidence, and to add elements of interest to engage the audience. (HS-LS1-4), (HS-LS1-8)

### Mathematics –

#### MP.2
Reason abstractly and quantitatively. (HS-LS3-2), (HS-LS3-3), (HS-LS1-8)

#### MP.4
Model with Mathematics. (HS-LS1-4)

#### AI-F.IF.7
Graph functions and show key features of the graph by hand and by using technology where appropriate. (HS-LS1-4)

#### AII-F.BF.1
Write a function that describes a relationship between two quantities. (HS-LS1-4)

*Connection boxes updated as of September 2018*
Students who demonstrate understanding can:

**HS-LS4-1. 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 to relating common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and behavior.]

**HS-LS4-2. 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. The 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 analyzing evidence to explain the influence of each of the four factors has on the number of organisms, behaviors, morphologic, or physiology to a 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-LS4-3. 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-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations.** [Clarification Statement: Emphasis is on using data to provide evidence for 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-LS4-5. 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, introduction of invasive species, application of fertilizers, drought, flood, and the rate of change on the environment affect distribution or disappearance of traits in species.]

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### Science and Engineering Practices

**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. (HS-LS4-3)

**Constructing Explanations and Designing Solutions**
Constructing explanations and designs building in 9–12 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. (HS-LS4-2),(HS-LS4-4)

**Engaging in Argument from Evidence**
Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to use 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 current accepted explanations or solutions to determine the merits of arguments. (HS-LS4-5)

**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). (HS-LS4-1)