**New York State P-12 Science Learning Standards**

**HS. Structure and Properties of Matter**

Students who demonstrate understanding can:

**HS-PS1-1.** Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [Assessment Boundary: Assessment does not include quantitative understanding of ionization energy beyond relative trends.]

**HS-PS1-3.** Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. [Clarification Statement: Emphasis is on understanding the strengths of forces between particles in solids, liquids, and gases, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and network solids. Examples of bulk scale properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.]

**HS-PS1-8.** Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. [Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.] [Assessment Boundary: Assessment does not include quantitative calculation of energy released. Assessment is limited to alpha, beta, positron, and gamma radioactive decays.]

**HS-PS2-6.** Communicate scientific and technical information about why the particulate-level structure is important in the functioning of designed materials.* [Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.] [Assessment Boundary: Assessment is limited to provided particulate structures of specific designed materials.]

**HS-PS1-9.** Analyze data to support the claim that the combined gas law describes the relationships among volume, pressure, and temperature for a sample of an ideal gas. [Clarification Statement: Real gases may be included at conditions near STP. The relationships of the variables in the combined gas law may be described both qualitatively and quantitatively.] [Assessment Boundary: Assessment is limited to the relationships among the variables of the combined gas law, not the gas law names, i.e. Boyle’s Law.]

**HS-PS1-10.** Use evidence to support claims regarding the formation, properties, and behaviors of solutions at bulk scales. [Clarification Statement: Examples of physical properties could include colligative properties, degree of saturation, physical behavior of solutions, solvation process and conductivity. Examples of solution types could include solid-liquid, liquid-liquid, and gas-liquid solutions. Concentrations can be quantitatively expressed in ppm, molarity, and percent by mass] [Assessment Boundary: Assessment of colligative properties is limited to qualitative statements of boiling point elevation and freezing point depression.]

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

### Disciplinary Core Ideas

**PS1.A: Structure and Properties of Matter**

- Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1)
- The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1)
- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3, secondary to HS-PS2-6)
- (NYSed) The concept of an ideal gas is a model to explain behavior of gases. A real gas is most like an ideal gas when the real gas is at low pressure and high temperature. (HS-PS1-9)
- (NYSed) Solutions possess characteristic properties that can be described qualitatively and quantitatively. (HS-PS1-10)

**PS1.C: Nuclear Processes**

- Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process. (HS-PS1-8)

**PS2.B: Types of Interactions**

- Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (secondary to HS-PS1-1, secondary to HS-PS1-3, HS-PS2-6).

### Crosscutting Concepts

**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. (HS-PS1-1, HS-PS1-3, HS-PS1-10)
- Mathematical representations can be used to identify certain patterns. (HS-PS1-9)

**Energy and Matter**

- In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-PS1-8)

**Structure and Function**

- Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-PS2-6)

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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

<table>
<thead>
<tr>
<th>Connections to other DCIs in this grade-band:</th>
<th>HS.PS3.A (HS-PS1-8); HS.PS3.B (HS-PS1-8); HS.PS3.C (HS-PS1-8); HS.PS3.D (HS-PS1-8); HS.LS1.C (HS-PS1-1); HS.ESS1.A (HS-PS1-8); HS.ESS1.C (HS-PS1-8); HS.ESS2.C (HS-PS1-3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Articulation of DCIs across grade-bands:</td>
<td>MS.PS1.A (HS-PS1-1),(HS-PS1-3),(HS-PS1-8); MS.PS1.B (HS-PS1-1),(HS-PS1-8); MS.PS1.C (HS-PS1-8); MS.PS2.B (HS-PS1-3),(HS-PS2-6); MS.ESS2.A (HS-PS1-8)</td>
</tr>
</tbody>
</table>

**New York State Next Generation Learning Standards:**

**ELA/Literacy –**

| 9-12.RST.7 | Translate scientific or technical information expressed as written text into visual form (e.g., a table or chart), and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1) |
| 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-PS1-3),(HS-PS1-10),(HS-PS2-6) |
| 9-10.WHST.2 | Write informative/explanatory text focused on discipline-specific content. (HS-PS1-3) |
| 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-PS1-3) |
| 9-12.WHST.5 | Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3), (HS-PS1-10) |
| 11-12.WHST.6 | Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience as well as by applying discipline-specific criteria used in the social sciences or sciences; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS1-3),(HS-PS1-9) |

**Mathematics –**

| MP.4 | Model with Mathematics. (HS-PS1-8),(HS-PS1-9) |
| 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 formulars; and iii) choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-3),(HS-PS1-8),(HS-PS1-9),(HS-PS1-6), (HS-PS1-3),(HS-PS1-8),(HS-PS1-10),(HS-PS2-6) |
| AI-N.Q.3 | Choose a level of accuracy appropriate to limitations on measurement and context when reporting quantities. (HS-PS1-3),(HS-PS1-8),(HS-PS1-10),(HS-PS2-6) |

*Connection boxes updated as of September 2018*

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*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).*
### Students who demonstrate understanding can:

**HS-PS1-2.** Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. [Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.] [Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.]

**HS-PS1-4.** Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. [Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.] [Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.]

**HS-PS1-5.** Apply scientific principles and evidence to explain how the rate of a physical or chemical change is affected when conditions are varied. [Clarification Statement: Explanations should be based on three variables in collision theory: number of collisions per unit time, particle orientation on collision, and energy required to produce the change. Conditions that affect these three variables include temperature, pressure, nature of reactants, concentrations of reactants, mixing, particle size, surface area, and addition of a catalyst.] [Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants and to specifying the change in only one condition at a time.]

**HS-PS1-6.** Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium. [Clarification Statement: Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.] [Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium yields and concentrations.]

**HS-PS1-7.** Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. [Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.] [Assessment Boundary: Assessment does not include complex chemical reactions.]

**HS-PS1-11.** Plan and conduct an investigation to compare properties and behaviors of acids and bases. [Clarification Statement: Examples of properties could include pH values (concentration), neutralization capability and conductivity. Observations of behaviors could include the effects on indicators, reactions with other substances, and efficacy in performing titrations.] [Assessment Boundary: Reactions are limited to Arhenius and Bronsted-Lowry acid-base reactions.]

**HS-PS1-12.** Use evidence to illustrate that some chemical reactions involve the transfer of electrons as an energy conversion occurs within a system. [Clarification Statement: Evidence could include half-reactions, net ionic equations, and electrochemical cells to illustrate the mechanism of electron transfer.] [Assessment Boundary: Assessment is limited to completing and/or balancing oxidation and reduction half-reactions. Energy conversions are limited to qualitative statements.]

### Science and Engineering Practices

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<thead>
<tr>
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<tbody>
<tr>
<td>Modeling in 9–12 builds on K–8 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.</td>
<td>Plan a design based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-4)</td>
<td>Mathematical and computational thinking at the 9–12 level builds on K–8 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.</td>
<td>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. (HS-PS1-2), (HS-PS1-5), (HS-PS1-11)</td>
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<td>▪ Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-4)</td>
<td>Planning and carrying out investigations to answer questions or test problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.</td>
<td>▪ Use mathematical representations of phenomena to support claims. (HS-PS1-7)</td>
<td>Energy and Matter • The total amount of energy and matter in closed systems is conserved. (HS-PS1-7), (HS-PS1-12)</td>
</tr>
<tr>
<td>▪ Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-11)</td>
<td>▪ Select appropriate tools to collect, record, analyze, and evaluate data. (HS-PS1-11)</td>
<td>▪ The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2), (HS-PS1-7)</td>
<td>Stability and Change • Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1-6)</td>
</tr>
<tr>
<td>### Disciplinary Core Ideas</td>
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<tr>
<td><strong>PS1.1A:</strong> Structure and Properties of Matter</td>
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<tr>
<td>▪ The periodic table orders elements horizontally by the number of protons in the atom’s nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-2) (Note: This Disciplinary Core Idea is also addressed by HS-PS1-1.)</td>
<td>▪ Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of particles and the rearrangements of particles into new substances, with consequent changes in the sum of all bond energies in the set of substances that are matched by changes in energy. (HS-PS1-4), (HS-PS1-5)</td>
<td>Connections to Nature of Science</td>
<td></td>
</tr>
<tr>
<td>▪ A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. (HS-PS1-4)</td>
<td>(NYSED) Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of particles and the rearrangements of particles into new substances, with consequent changes in the sum of all bond energies in the set of substances that are matched by changes in energy. (HS-PS1-4), (HS-PS1-5)</td>
<td>▪ Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS1-7)</td>
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<tr>
<td><strong>PS1.1B:</strong> Chemical Reactions</td>
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<td>▪ The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2), (HS-PS1-7)</td>
<td>(NYSED) In many situations, a dynamic and unifying perspective provides a useful way to understand chemical systems, their rates, and the conditions that affect or limit the rates. (HS-PS1-12)</td>
<td>Scientific Knowledge Assumes an Order and Consistency in Natural Systems</td>
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<td>▪ (NYSED) In many situations, a dynamic and unifying perspective provides a useful way to understand chemical systems, their rates, and the conditions that affect or limit the rates. (HS-PS1-12)</td>
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### New York State P-12 Science Learning Standards

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<th>Articulation of DCIs across grade-bands:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• <strong>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.</strong> (HS-PS1-2)</td>
<td>• <strong>Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed.</strong> (secondary to HS-PS1-6)</td>
</tr>
<tr>
<td>• <strong>Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.</strong> (HS-PS1-6)</td>
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</tbody>
</table>

#### 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 natural and designed worlds. 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-PS1-12)

### 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-PS1-5)

- **9-10.WHST.2**
  - Write informative/explanatory text focused on discipline-specific content. (HS-PS1-2), (HS-PS1-5)

- **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-PS1-2), (HS-PS1-5)

- **9-12.WHST.5**
  - Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-6), (HS-PS1-11)

- **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-PS1-4), (HS-PS1-12)

**Mathematics**

- **MP.2**
  - Reason abstractly and quantitatively. (HS-PS1-5), (HS-PS1-7), (HS-PS1-12)

- **MP.4**
  - Model with Mathematics. (HS-PS1-4), (HS-PS1-11)

- **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-PS1-2), (HS-PS1-4), (HS-PS1-5), (HS-PS1-7), (HS-PS1-11)

- **AI-N.Q.3**
  - Choose a level of accuracy appropriate to limitations on measurement and context when reporting quantities. (HS-PS1-2), (HS-PS1-4), (HS-PS1-5), (HS-PS1-7)

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### Science and Engineering Practices

**Planning and Carrying Out Investigations**
- Planning and carrying out investigations to answer questions or test problems to solutions in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.
  - Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS2-5)

**Analyzing and Interpreting Data**
- Analyzing data in 9–12 builds on K–8 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.
  - Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-PS2-1)

**Using Mathematics and Computational Thinking**
- Mathematical and computational thinking at the 9–12 level builds on K–8 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 to describe explanations. (HS-PS2-2), (HS-PS2-4)

**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.
  - Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (HS-PS2-3)

**Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena**
- Theories and laws provide explanations in science. (HS-PS2-1), (HS-PS2-4)

### Disciplinary Core Ideas

<table>
<thead>
<tr>
<th>PS2.A: Forces and Motion</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ Newton’s second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1)</td>
</tr>
<tr>
<td>▪ Motion is defined for a particular frame of reference; it is the mass times the velocity of the object. (HS-PS2-2)</td>
</tr>
<tr>
<td>▪ If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS-PS2-2), (HS-PS2-3)</td>
</tr>
</tbody>
</table>

**PS2.B: Types of Interactions**
- Newton’s law of universal gravitation and Coulomb’s law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4)
- Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-4), (HS-PS2-5)

**ETS1.A: Defining and Delimiting Engineering Problems**
- Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (secondary to HS-PS2-3)

**ETS1.C: Optimizing the Design Solution**
- Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (secondary to HS-PS2-3)

### Crosscutting Concepts

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<td>▪ Different patterns may be observed at each of the scales at which a phenomenon is studied and can provide evidence for causality in explanations of phenomena. (HS-PS2-4)</td>
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<th>Cause and Effect</th>
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<tr>
<td>▪ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2-1), (HS-PS2-5)</td>
</tr>
<tr>
<td>▪ Systems can be designed to cause a desired effect. (HS-PS2-3)</td>
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<tbody>
<tr>
<td>▪ When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (HS-PS2-2)</td>
</tr>
</tbody>
</table>

### Connections to other DCIs in this grade-band:

- HS.PS3.A (HS-PS2-4), (HS-PS2-5);
- HS.PS3.C (HS-PS2-1, HS-PS2-5); HS.PS4.B (HS-PS2-5);
- HS.ESS1.B (HS-PS2-1), (HS-PS2-5);
- HS.ESS1.A (HS-PS2-1, HS-PS2-2, HS-PS2-4);
- HS.ESS2.C (HS-PS2-1, HS-PS2-5); HS.ESS3.A (HS-PS2-4), (HS-PS2-5)

### Articulation of DCIs across grade-bands:

- MS.PS2.A (HS-PS2-1), (HS-PS2-4), (HS-PS2-5);
- HS.PS2.B (HS-PS2-4), (HS-PS2-5);
- HS.PS3.C (HS-PS2-1), (HS-PS2-4, HS-PS2-5);
- HS.ESS1.B (HS-PS2-4), (HS-PS2-5)
### New York State P-12 Science Learning Standards

**11-12.WHST.7**
Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS2-5)

**Mathematics –**

**MP.2**
Reason abstractly and quantitatively. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4)

**MP.4**
Model with Mathematics. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4)

**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-PS2-1),(HS-PS2-2),(HS-PS2-4),(HS-PS2-5)

**AI-N.Q.3**
Choose a level of accuracy appropriate to limitations on measurement and context when reporting quantities. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),(HS-PS2-5)

**AI.SSE.1**
Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1),(HS-PS2-2)

**AI.SSE.3**
Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1),(HS-PS2-2)

**AI.CED.1**
Create equations and inequalities in one variable to represent a real-world context. (HS-PS2-1),(HS-PS2-2)

**AI.CED.2**
Create equations and linear inequalities in two variables to represent a real-world context. (HS-PS2-1),(HS-PS2-2)

**AI.CED.4**
Rewrite formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-1),(HS-PS2-2)

**AI-F.IF.7**
Graph functions and show key features of the graph by hand and by using technology where appropriate. (HS-PS2-1)

**AI-S.ID.1**
Represent data with plots on the real number line (dot plots, histograms, and box plots). (HS-PS2-1)

*Connection boxes updated as of September 2018*

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*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).*
Students who demonstrate understanding can:

**HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.**

[Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions for energy, work, and power used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to work, power, thermal energy, and/or electrical energy in gravitational, magnetic, or electric fields.]

**HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).**

[Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above Earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.]

**HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.**

[Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, sound level or light meters, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.] [Assessment Boundary: Assessment is limited to quantitative evaluations is limited to total output for a given input.]

**HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).**

[Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.] [Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.]

**HS-PS3-5. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.**

[Clarification Statement: Examples of models could include diagrams, texts, algebraic expressions, and drawings representing what happens when two charges of opposite polarity are near each other.] [Assessment Boundary: Assessment is limited to devices constructed with materials provided to students.]

**HS-PS3-6. Analyze data to support the claim that Ohm’s Law describes the mathematical relationship among the potential difference, current, and resistance of an electric circuit.**

[Clarification Statement: Emphasis should be on arrangements of series circuits and parallel circuits using conventional current.] [Assessment Boundary: Assessment is limited to direct current (DC) circuits.]

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.
  - Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS3-2, HS-PS3-5)

- Planning and Carrying Out Investigations
  - Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.
  - Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the process decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS3-1)

- Analyzing and Interpreting Data
  - Analyzing data in 9–12 builds on K–8 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.
  - Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or to determine an optimal design solution. (HS-PS3-6)

- Using Mathematics and Computational Thinking
  - Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.
  - Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-PS3-1)

**Disciplinary Core Ideas**

**PS3A: Definitions of Energy**

- Energy is a quantitative property of systems that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system’s total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.
  - At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS-PS3-2, HS-PS3-3)
  - These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with motion of particles. Energy is conserved when the relative position of the particles. In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles).
  - This concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2)

**PS3B: Conservation of Energy and Energy Transfer**

- Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1)
  - Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring, or how kinetic energy depends on mass and speed), allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1)
  - The availability of energy limits what can occur in any system. (HS-PS3-1)
  - Uncontrolled systems always evolve toward more stable states— that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS-PS3-4)
  - (NYSED) Energy exists in many forms, and when these forms change, energy is conserved. (HS-PS3-6)

**Crosscutting Concepts**

- 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. (HS-PS3-6)
  - Mathematical representations can be used to identify certain patterns. (HS-PS3-6)

- Cause and Effect
  - Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS3-5)

- System and System Models
  - When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-PS3-4)
  - Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. (HS-PS3-1)

- 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-PS3-3)
  - Energy can be transferred between one place and another place, between objects and/or fields, or between systems. (HS-PS3-2, HS-PS3-6)

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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/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS3-3)

1. (HS-PS3-3), (HS-PS3-4)
   - (NYSED) Electrical power and energy can be determined for electric circuits. (HS-PS3-6)

**PS3.C: Relationship Between Energy and Forces**

- When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5)

**Connections to Engineering, Technology, and Applications of Science**

**Influence of Science, Engineering, and Technology on Society and the Natural World**

- Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-PS3-3)

**Connections to Nature of Science**

**Scientific Knowledge Assumes an Order and Consistency in Natural Systems**

- Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS3-1)

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### New York State P-12 Science Learning Standards

**Constructions to other DCIs in this grade-band:**

<table>
<thead>
<tr>
<th>DCI</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HS-PS1.A</td>
<td>(HS-PS3-2); HS-PS1.B</td>
</tr>
<tr>
<td>HS-PS2.A</td>
<td>(HS-PS3-2); HS-PS2.B</td>
</tr>
<tr>
<td>HS-PS3.A</td>
<td>(HS-PS3-1); HS-PS3.B</td>
</tr>
<tr>
<td>HS-PS4.A</td>
<td>(HS-PS3-1); HS-PS4.B</td>
</tr>
<tr>
<td>HS-PS5.A</td>
<td>(HS-PS3-1); HS-PS5.B</td>
</tr>
</tbody>
</table>

**Articulation of DCIs across grade-bands:**

- **HS-PS1.A** (HS-PS3-2); **HS-PS2.B** (HS-PS3-2); **HS-PS3.A** (HS-PS3-1); **HS-PS3.B** (HS-PS3-1); **HS-PS3.C** (HS-PS3-2); **HS-PS3.D** (HS-PS3-1); **HS-PS4.A** (HS-PS3-1); **HS-PS4.B** (HS-PS3-2); **HS-PS4.C** (HS-PS3-5); **HS-PS4.D** (HS-PS3-2); **HS-PS5.A** (HS-PS3-1); **HS-PS5.B** (HS-PS3-2); **HS-PS5.C** (HS-PS3-5); **HS-PS5.D** (HS-PS3-2)

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### 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-PS3-4); (HS-PS3-6)

**9-12.WHST.5**

- Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS3-3); (HS-PS3-4); (HS-PS3-5)

**11-12.WHST.6**

- Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience as well as by applying discipline specific criteria used in the social sciences or sciences; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS3-4); (HS-PS3-5)

**11-12.WHST.7**

- Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS3-4); (HS-PS3-5); (HS-PS3-6)

**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-PS3-1); (HS-PS3-2); (HS-PS3-5)

**Mathematics –**

- **MP.2** Reason abstractly and quantitatively. (HS-PS3-1); (HS-PS3-2); (HS-PS3-3); (HS-PS3-4); (HS-PS4-5); (HS-PS4-6)

- **MP.4** Model with Mathematics. (HS-PS3-1); (HS-PS3-2); (HS-PS3-3); (HS-PS4-4); (HS-PS4-5); (HS-PS4-6)

- **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-PS3-1); (HS-PS3-2); (HS-PS4-3); (HS-PS4-6)

- **AI-N.Q.3** Choose a level of accuracy appropriate to limitations on measurement and context when reporting quantities. (HS-PS3-1); (HS-PS3-2)

*Connection boxes updated as of September 2018*

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**New York State P-12 Science Learning Standards**

**HS. Waves and Electromagnetic Radiation**

Students who demonstrate understanding can:

**HS-PS4-1.** Use mathematical representations to support a claim regarding relationships among the period, frequency, wavelength, and speed of waves traveling and transferring energy (amplitude, frequency) in various media. [Clarification Statement: Examples of data could include descriptions of waves classified as transverse, longitudinal, mechanical, or standing, electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, seismic waves traveling through Earth, and direction of waves due to refraction and reflection.] [Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively.]

**HS-PS4-2.** Evaluate questions about the advantages of using a digital transmission and storage of information. [Clarification Statement: Examples of advantages could include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly. Disadvantages could include issues of easy deletion, security, and theft.]

**HS-PS4-3.** Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model (quantum theory), and that for some situations one model is more useful than the other. [Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and the photoelectric effect.] [Assessment Boundary: Assessment is limited to qualitative descriptions.]

**HS-PS4-4.** Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. [Clarification Statement: Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include scientific journals, trade books, magazines, web resources, videos, and other passages that may reflect bias.] [Assessment Boundary: Assessment is limited to qualitative descriptions.]

**HS-PS4-5.** Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.* [Clarification Statement: Examples could include Doppler effect, solar cells capturing light and converting it to electricity; medical imaging; and communications technology.] [Assessment Boundary: Assessments are limited to qualitative information. Assessments do not include band theory.]

**HS-PS4-6.** Use mathematical models to determine relationships among the size and location of images, size and location of objects, and focal lengths of lenses and mirrors. [Clarification Statement: Emphasis should be on analyzing ray diagrams to determine image size and location.] [Assessment Boundary: Assessment is limited to analysis of plane, convex, and concave mirrors, and biconvex and biconcave lenses.]

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### Science and Engineering Practices

**Asking Questions and Defining Problems**

Asking questions and defining problems in grades 9–12 builds from grades K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

- Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design. (HS- PS4-2)

**Using Mathematics and Computational Thinking**

Mathematical and computational thinking at the 9–12 level builds on K–8 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 describe and/or support claims and/or explanations. (HS-PS4-1), (HS-PS4-6)

**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 natural and designed worlds. 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-PS4-3)

**Obtaining, Evaluating, and Communicating Information**

Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs.

- Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible. (HS-PS4-4)

- Communicate technical information or ideas (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-PS4-5)

### Disciplinary Core Ideas

**PS3.D: Energy**

- Solar cells are human-made devices that likewise capture the sun’s energy and produce electrical energy. (secondary to HS-PS4-5)

**PS4.A: Wave Properties**

- The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. (HS-PS4-1)

- Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. (HS-PS4-2), (HS-PS4-5)

- [From the 3–5 grade band endpoints] Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: the discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) (HS-PS4-3)

- [NYSED] The location and size of an image are related to the location and size of an object for a plane mirror. The location and size of an image of a real (or virtual) are related to the location and size of an object and the focal distance for convex and concave mirrors. (HS-PS4-6)

- [NYSED] The location and size of an image of a real (or virtual) are related to the location and size of an object and the focal distance for biconvex and biconcave lenses. (HS-PS4-6)

**PS4.B: Electromagnetic Radiation**

- Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. (HS-PS4-3)

- When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.

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New York State P-12 Science Learning Standards

**Connection to Nature of Science**

Science Models, Laws, Mechanisms, and Theories

- A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-PS4-3)

**Connections to other DCIs in this grade-band:** HS.PS1.C (HS-PS4-4); HS.PS3.A (HS-PS4-4),(HS-PS4-5); HS.PS3.D (HS-PS4-3),(HS-PS4-4); HS.LS1.C (HS-PS4-4); HS.ESS1.A (HS-PS4-3); HS.ESS2.A (HS-PS4-1); HS.ESS2.D (HS-PS4-3)

Articulation of DCIs across grade-bands: MS.PS4.D (HS-PS4-4); MS.PS4.A (HS-PS4-1),(HS-PS4-2),(HS-PS4-5); MS.PS4.B (HS-PS4-1),(HS-PS4-2),(HS-PS4-3),(HS-PS4-4),(HS-PS4-5); MS.PS4.C (HS-PS4-2),(HS-PS4-5); LS.LS1.C (HS-PS4-4); HS.ESS2.D (HS-PS4-4)

**Influence of Engineering, Technology, and Science on Society and the Natural World**

- Modern civilization depends on major technological systems. (HS-PS4-2),(HS-PS4-5)
- Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-PS4-2)

*Connection boxes updated as of September 2018*

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**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-PS4-2),(HS-PS4-3),(HS-PS4-4)
- **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-PS4-2),(HS-PS4-3),(HS-PS4-4)
- **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-PS4-2),(HS-PS4-3),(HS-PS4-4)
- **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-PS4-2),(HS-PS4-3),(HS-PS4-4)
- **9-10.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-PS4-5)
- **11-12.WHST.2** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience as well as by applying discipline specific criteria used in the social sciences or sciences; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS4-4)

**Mathematics**

- **MP.2** Reason abstractly and quantitatively. (HS-PS4-1),(HS-PS4-3),(HS-PS4-6)
- **MP.4** Model with Mathematics. (HS-PS4-1),(HS-PS4-6)
- **AI.SSE.1** Interpret expressions that represent a quantity in terms of its context. (HS-PS4-1),(HS-PS4-3),(HS-PS4-6)
- **AI.SSE.3** Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS4-1),(HS-PS4-3),(HS-PS4-6)
- **AI.CED.4** Rewrite formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS4-1),(HS-PS4-3),(HS-PS4-6)

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HS. Structure and Function

Students who demonstrate understanding can:

**HS-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. [Clarification Statement: Emphasis should be on how the DNA code is transcribed and translated in the synthesis of proteins. Types of proteins involved in performing life functions include enzymes, structural proteins, cell receptors, hormones, and antibodies.] [Assessment Boundary: Assessment does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the detailed biochemistry of protein synthesis.]

**HS-LS1-2.** Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. [Clarification Statement: Emphasis is on functions at the organism’s system level such as nutrient uptake, water delivery, immune response, and organism response to stimuli. An example of an interacting system could be 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 assess interactions and functions at the molecular or chemical reaction level.]

**HS-LS1-3.** Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis [Clarification Statement: Examples of investigations could include heart rate response to exercise, stomate response to moisture and temperature, and root development in response to water levels.] [Assessment Boundary: Assessment does not include the cellular processes involved in the feedback mechanisms.]

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 world.

- Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-2)

**Planning and Carrying Out Investigations**
Planning and carrying out in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-LS1-3)

**Constructing Explanations and Designing Solutions**
Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student generated sources of evidence consistent with scientific ideas, principles, and theories.

- Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students’ own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-LS1-1)

### Disciplinary Core Ideas

**LS1A: Structure and Function**

- Systems of specialized cells within organisms help them perform the essential functions of life. (HS-LS1-1)

- All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (HS-LS1-1)

- Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (HS-LS1-2)

- Feedback mechanisms maintain a living system’s internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. (HS-LS1-3)

- (NYSED) Disease is a failure of homeostasis. Organisms have a variety of mechanisms to prevent and combat disease. Technological advances including vaccinations and antibiotics have contributed to the prevention and treatment of disease. (HS-LS1-2), (HS-LS1-3)

### 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 flow—within and between systems at different scales. (HS-LS1-2)

**Structure and Function**

- Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-LS1-1)

**Stability and Change**

- Feedback (negative or positive) can stabilize or destabilize a system. (HS-LS1-3)

*Connections to other DCl's in this grade-band: HS.LS1.A (HS-LS1-1)*

### Articulation of DCIs across grade-bands:

- MS.LS1.A (MS-LS1-1), (MS-LS1-2), (MS-LS1-3), (MS-LS1-4), (MS-LS3.A) (HS-LS1-1), (HS-LS1-2), (HS-LS1-3)

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 to and any gaps or inconsistencies in the account. (HS-LS1-1)

  **9-10.WHST.2** Write explanatory/expository text focused on discipline-specific content. (HS-LS1-1)

  **9-12.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-LS1-1)

  **9-12.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-LS1-3)

  **11-12.WHST.6** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience as well as by applying discipline specific criteria used in the social sciences or sciences; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-LS1-3)

  **11-12.WHST.7** Draw evidence from informational texts to support analysis, reflection and research. (HS-LS1-1)

  **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-LS1-2)

*Connection boxes updated as of September 2018*

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

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New York State P-12 Science Learning Standards

HS. Matter and Energy in Organisms and Ecosystems

Students who demonstrate understanding can:

**HS-LS1-5. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.** [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] [Assessment Boundary: Assessment does not include specific biochemical steps.]

**HS-LS1-6. Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules can combine with other elements such as nitrogen, sulfur, and phosphorus to form amino acids and other carbon-based molecules.** [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.]

**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 the bonds in new compounds are formed resulting in a net transfer of energy.** [Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of aerobic cellular respiration.] [Assessment Boundary: Assessment should not include identification of the steps or specific processes involved in aerobic respiration.]

**HS-LS2-3. Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in ecosystems.** [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.]

**HS-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 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.]

**HS-LS2-5. Develop a model to illustrate the role of various processes in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.** [Clarification Statement: Examples of models could 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.]

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

<table>
<thead>
<tr>
<th>Science and Engineering Practices</th>
<th>Disciplinary Core Ideas</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td>- 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)</td>
<td>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)</td>
</tr>
<tr>
<td>Using Mathematics and Computational Thinking</td>
<td>- 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)</td>
<td>Energy and Matter</td>
</tr>
<tr>
<td>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, experimental data and logic based on 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.</td>
<td>- (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)</td>
<td>- 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)</td>
</tr>
<tr>
<td>Constructing Explanations and Designing Solutions</td>
<td>- (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)</td>
<td>- Energy can be transferred between one place and another place, between objects and/or fields, or between systems. (HS-LS1-7), (HS-LS2-4)</td>
</tr>
<tr>
<td>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.</td>
<td>LS2.B: Cycles of Matter and Energy Transfer in Ecosystems</td>
<td>- Energy drives the cycling of matter within and between systems. (HS-LS2-3)</td>
</tr>
<tr>
<td>- 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)</td>
<td>- Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. (HS-LS2-3)</td>
<td></td>
</tr>
<tr>
<td>Connections to Nature of Science</td>
<td>- 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)</td>
<td></td>
</tr>
<tr>
<td>Scientific Knowledge is Open to Revision in Light of New Evidence</td>
<td>- (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)</td>
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</tbody>
</table>

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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 expository/explanatory text focused on discipline-specific content. (HS-LS1-6),(HS-LS2-3)

**11-12.WHST.2** Write expository/explanatory 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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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.)

**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 could 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, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.)

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**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)

Construcing Explanations and Designing Solutions
Construcing 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)

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**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.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. (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)

**LS3.D: 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 activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. (secondary to HS-LS2-7)

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**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.ESS3.B** (HS-LS2-2),(HS-LS4-6) | 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 to HS-LS2-7) |
<table>
<thead>
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<tr>
<td><strong>Articulation of DCIs across grade-bands:</strong> <strong>MS.LS1.B</strong> (HS-LS2-8); <strong>MS.LS2.A</strong> (HS-LS2-1),(HS-LS2-6); <strong>MS.LS2.C</strong> (HS-LS2-1),(HS-LS2-2),(HS-LS2-6),(HS-LS2-7),(HS-LS4-6); <strong>HS.ESS2.E</strong> (HS-LS2-6); <strong>HS.ESS3.A</strong> (HS-LS2-1); <strong>HS.ESS3.C</strong> (HS-LS2-1),(HS-LS2-2),(HS-LS2-6),(HS-LS2-7),(HS-LS4-6); <strong>HS.ESS3.D</strong> (HS-LS2-7)</td>
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### New York State Next Generation Learning Standards:

**ELA/Literacy – LS2-6**

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 to 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)

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 – MS.LS2.1**

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

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

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)

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

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

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

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)

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New York State P-12 Science Learning Standards

HS. Inheritance and Variation of Traits

Students who demonstrate understanding can:

**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-LS1-8.** [Clarification Statement: Emphasis is on using data to support arguments for the variation occurring 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-LS3-1. 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 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.]

**LS1.1: Science and Engineering Practices**

**Asking Questions and Defining Problems**

Asking questions and defining problems in 9–12 builds on K–8 experiences and progressions 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. (HS-LS3-1)

**Developing and Using Models**

Modeling in 9–12 builds on K–8 experiences and progressions 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-LS1-4, HS-LS1-8)

**Analyzing and Interpreting Data**

Analyzing data in 9–12 builds on K–8 experiences and progressions 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-LS3-3)

**Engaging in Argument from Evidence**

Engaging in argument from evidence in 9–12 builds on K–8 experiences and progressions to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(4). 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-LS2-1) (Note: Disciplinary Core Idea is also addressed by HS-LS1-1.)

- (NYSED) The structures and functions of the human female reproductive system produce gametes 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 gametes in testes and make possible the delivery of these gametes 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)

**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. (HS-LS3-1)

**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. (HS-LS3-2)

- (NYSED) Environmental factors can cause mutations in genes. Only mutations in sex cells can be inherited. (HS-
### New York State P-12 Science Learning Standards

**LS3-2**
- (NYSED) Advances in biotechnology have allowed organisms to be modified genetically. (HS-LS3-2)
- 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. (HS-LS3-2), (HS-LS3-3)

**Connections to other DCIs in this grade-band:** HS.LS2.A (HS-LS3-3), HS.LS2.C (HS-LS3-3), HS.LS4.B (HS-LS3-3), HS.LS4.C (HS-LS3-3)


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**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-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*

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# New York State P-12 Science Learning Standards

## HS. Natural Selection and Evolution

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 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 ontogeny and phylogenetic development.]

**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) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.** [Clarification Statement: Emphasis is on using evidence to explain the influence each of the four factors has on number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.] [Assessment Boundary: Assessment does not include other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution.]

**HS-LS4-3. 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 of 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 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.

**Engaging in Argument from Evidence**
- Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current or historical episodes in science.
  - Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments. (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)

### Disciplinary Core Ideas

**LS4.A: Evidence of Common Ancestry and Diversity**
- Genetic information provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence. (HS-LS4-1)

**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. (HS-LS4-2),(HS-LS4-3)
  - The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. (HS-LS4-3)

**LS4.C: Adaptation**
- Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. (HS-LS4-2)
  - 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 a decrease in the proportion of individuals that do not. (HS-LS4-3),(HS-LS4-4)
  - Adaptation also means that the distribution of traits in a population can change when conditions change. (HS-LS4-3)
  - 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 other species. (HS-LS4-3)

### Crosscutting Concepts

**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. (HS-LS4-1),(HS-LS4-3)

**Causation and Effect**
- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS4-2),(HS-LS4-4),(HS-LS4-5)

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**Connections to Nature of Science**

**Scientific Knowledge Assumes an Order and Consistency in Natural Systems**
- Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. (HS-LS4-1),(HS-LS4-4)

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### New York State P-12 Science Learning Standards

**Connections to Nature of Science**

**Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena**
- A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the scientific community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-LS4-1)
- Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost. (HS-LS4-5)

**Connections to other DCIs in this grade-band:**
- **HS.LS2.A** (HS-LS4-2), (HS-LS4-3), (HS-LS4-4), (HS-LS4-5); **HS.LS2.D** (HS-LS4-2), (HS-LS4-3), (HS-LS4-4), (HS-LS4-5); **HS.LS3.A** (HS-LS4-1); **HS.LS3.B** (HS-LS4-1), (HS-LS4-2), (HS-LS4-3), (HS-LS4-5); **HS.ESS1.C** (HS-LS4-1); **HS.ESS2.E** (HS-LS4-2), (HS-LS4-5); **HS.ESS3.A** (HS-LS4-2), (HS-LS4-5)

**Articulation of DCIs across grade-bands:**
- **MS.LS2.A** (HS-LS4-2), (HS-LS4-3), (HS-LS4-5); **MS.LS2.C** (HS-LS4-5); **MS.LS3.A** (HS-LS4-1); **MS.LS3.B** (HS-LS4-1), (HS-LS4-2), (HS-LS4-3); **MS.LS4.A** (HS-LS4-1), **MS.LS4.B** (HS-LS4-2), (HS-LS4-3), (HS-LS4-5); **MS.LS4.C** (HS-LS4-2), (HS-LS4-3), (HS-LS4-4), (HS-LS4-5); **HS.ESS1.C** (HS-LS4-1); **HS.ESS3.C** (HS-LS4-5)

### 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-LS4-1), (HS-LS4-2), (LS-LS4-3), (LS-LS4-4)

**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-LS4-5)

**9-10.WHST.2**
Write informative/explanatory text focused on discipline-specific content. (HS-LS4-1), (HS-LS4-2), (HS-LS4-3), (HS-LS4-4)

**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-LS4-1), (HS-LS4-2), (HS-LS4-3), (HS-LS4-4)

**11-12.SL.4**
Present claims, findings, and supporting evidence, conveying a clear and distinct perspective; alternative or opposing perspectives are addressed; organization, development, substance, and style are appropriate to task, purpose, and audience. (HS-LS4-1), (HS-LS4-2)

#### Mathematics

**MP.2**
Reason abstractly and quantitatively. (HS-LS4-1), (HS-LS4-2), (HS-LS4-3), (HS-LS4-4), (HS-LS4-5)

**MP.4**
Model with mathematics. (HS-LS4-2)

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### New York State P-12 Science Learning Standards

#### HS. Space Systems

**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 world.
  - Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS1-1)

- **Using Mathematical 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 or computational representations of phenomena to describe explanations. (HS-ESS1-4)

- **Constructing Explanations and Designing Solutions**
  - Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.
  - Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students’ own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-ESS1-2),(HS-ESS1-7)

- **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 ideas (e.g., about phenomena and/or the processes of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-ESS1-3)

**Disciplinary Core Ideas**

- **ESS1A: The Universe and Its Stars**
  - The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. (HS-ESS1-1)
  - The study of stars’ light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS-ESS1-2),(HS-ESS1-3)
  - The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. (HS-ESS1-4)
  - Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. (HS-ESS1-2),(HS-ESS1-3)

- **ESS1B: Earth and the Solar System**
  - Kepler’s laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (HS-ESS1-4)
  - (NYSED) Earth and celestial phenomena can be described by principles of relative motion and perspective. (HS-ESS1-7)

- **PS3.D: Energy in Chemical Processes and Everyday Life**
  - Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (secondary to HS-ESS1-1)
  - Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. (secondary to HS-ESS1-2)

**Crosscutting Concepts**

- **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. (HS-ESS1-5)
  - Scale, Proportion, and Quantity
    - The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-ESS1-1)
    - 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-ESS1-4)

- **Energy and Matter**
  - Energy cannot be created or destroyed—only moved between one place and another place, between objects and/or fields, or between systems. (HS-ESS1-2)
  - In nuclear processes, atoms are not conserved, but the number of protons plus neutrons is conserved. (HS-ESS1-3)

**Connections to Nature of Science**

- **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena**
  - Understanding how science models, laws, mechanisms, and theories explain natural phenomena.
New York State P-12 Science Learning Standards

A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-ESS1-2)

<table>
<thead>
<tr>
<th>Connections to other DCIs in the grade-band:</th>
<th>Order and Consistency in Natural Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HS.PS1.A</strong> (HS-ESS1-2), (HS-ESS1-3); <strong>HS.PS1.C</strong> (HS-ESS1-1), (HS-ESS1-2), (HS-ESS1-3); <strong>HS.PS2.B</strong> (HS-ESS1-4); <strong>HS.PS3.A</strong> (HS-ESS1-1), (HS-ESS1-2); <strong>HS.PS4.B</strong> (HS-ESS1-2)</td>
<td>- Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. (HS-ESS1-2)</td>
</tr>
<tr>
<td><strong>Articulation of DCIs across grade-bands:</strong></td>
<td>- Science assumes the universe is a vast single system in which basic laws are consistent. (HS-ESS1-2)</td>
</tr>
<tr>
<td><strong>MS.PS1.A</strong> (HS-ESS1-1), (HS-ESS1-2), (HS-ESS1-3); <strong>MS.PS2.A</strong> (HS-ESS1-4); <strong>MS.PS2.B</strong> (HS-ESS1-4); <strong>MS.PS4.B</strong> (HS-ESS1-1), (HS-ESS1-2); <strong>MS.ESS1.A</strong> (HS-ESS1-1), (HS-ESS1-2), (HS-ESS1-3), (HS-ESS1-4); <strong>MS.ESS1.B</strong> (HS-ESS1-4); <strong>MS.ESS2.A</strong> (HS-ESS1-1); <strong>MS.ESS2.D</strong> (HS-ESS1-1)</td>
<td></td>
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</table>

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-ESS1-1), (HS-ESS1-2)

9-10.WHST.2 Write informative/explanatory text focused on discipline-specific content. (HS-ESS1-2), (HS-ESS1-3), (HS-ESS1-7)

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-ESS1-2), (HS-ESS1-3), (HS-ESS1-7)

11-12.SL.4 Present claims, findings, and supporting evidence, conveying a clear and distinct perspective; alternative or opposing perspectives are addressed; organization, development, substance, and style are appropriate to task, purpose, and audience. (HS-ESS1-3), (HS-ESS1-7)

**Mathematics** –

MP.2 Reason abstractly and quantitatively. (HS-ESS1-1), (HS-ESS1-2), (HS-ESS1-3), (HS-ESS1-4), (HS-ESS1-7)

MP.4 Model with Mathematics. (HS-ESS1-1), (HS-ESS1-4)

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-ESS1-1), (HS-ESS1-2), (HS-ESS1-4)

AI-N.Q.3 Choose a level of accuracy appropriate to limitations on measurement and context when reporting quantities. (HS-ESS1-1), (HS-ESS1-2), (HS-ESS1-4)

AI.SSE.1 Interpret expressions that represent a quantity in terms of its context. (HS-ESS1-1), (HS-ESS1-2), (HS-ESS1-4)

AI.CED.2 Create equations and linear inequalities in two variables to represent a real-world context. (HS-ESS1-1), (HS-ESS1-2), (HS-ESS1-4)

AI.CED.4 Rewrite formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-ESS1-1), (HS-ESS1-2), (HS-ESS1-4)

*Connection boxes updated as of September 2018

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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 world(s).

- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS2-1)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

- Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. (HS-ESS2-1)

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 evidence behind currently accepted explanations or solutions to determine the merits of arguments. (HS-ESS1-5)

Connections to Nature of Science

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

- A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-ESS1-6)

- Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. (HS-ESS2-6)

Crosscutting Concepts

Patterns

- Empirical evidence is needed to identify patterns. (HS-ESS1-5)

Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS1-6)

- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS2-1)

Disciplinary Core Ideas

ESS1.C: The History of Planet Earth

- Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. (HS-ESS1-5)

- Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS-ESS1-6)

ESS2.A: Earth Materials and Systems

- Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1) (Note: This Disciplinary Core Idea is also addressed by HS-ESS2-2)

ESS2.B: Plate Tectonics and Large-Scale System Interactions

- Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. (ESS2.B Grade 8 GBE) (secondary to HS-ESS1-5), (HS-ESS2-1)

- Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. (ESS2.B Grade 8 GBE) (HS-ESS2-1)

PSL.C: Nuclear Processes

- (NYSED) Spontaneous radioactive decay follows a characteristic exponential decay law allowing an element's half-life to be used for radiometric dating of rocks and other materials. (secondary to HS-ESS1-5), (secondary to HS-ESS1-6)
### New York State P-12 Science Learning Standards

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>11-12.SL.5</td>
<td>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.</td>
<td>(HS-ESS2-1)</td>
</tr>
</tbody>
</table>

**Mathematics**

- **MP.2** Reason abstractly and quantitatively. (HS-ESS1-5), (HS-ESS1-6), (HS-ESS2-1)
- **MP.4** Model with Mathematics. (HS-ESS2-1)
- **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-ESS1-5), (HS-ESS1-6), (HS-ESS2-1)
- **AI-N.Q.3** Choose a level of accuracy appropriate to limitations on measurement and context when reporting quantities. (HS-ESS1-5), (HS-ESS1-6), (HS-ESS2-1)
- **AI-F.IF.5** Determine the domain of a function from its graph and, where applicable, identify the appropriate domain for a function in context. (HS-ESS1-6)
- **AI.S.ID.6** Represent bivariate data on a scatter plot, and describe how the variables’ values are related. (HS-ESS1-6)

*Connection boxes updated as of September 2018*

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HS. Earth’s Systems

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 world(s).
- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS2-3), (HS-ESS2-6)

Planning and Carrying Out Investigations
Planning and carrying out investigations in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.
- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-ESS2-5)

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.
- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-ESS2-2)

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.
- Construct an oral and written argument or counter-arguments based on data and evidence. (HS-ESS2-7)

Disciplinary Core Ideas

ESS2.A: Earth Materials and Systems
- Earth’s systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes (HS-ESS2-2)
- Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth’s surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth’s interior and gravitational movement of denser materials toward the interior. (HS-ESS2-3)

ESS2.B: Plate Tectonics and Large-Scale System Interactions
- (NYSED) Residual heat from Earth’s formation and the radioactive decay of unstable isotopes in Earth’s interior continually generate energy that is absorbed by Earth’s mantle and crust, driving mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. (HS-ESS2-3)
- (NYSED) Minerals are the building blocks of igneous, metamorphic, and sedimentary rocks and can be identified using physical and chemical characteristics. These rock types are evidence of stages of constant recycling of Earth material by surface processes and convection currents in the mantle. (HS-ESS2-3)

ESS2.C: The Roles of Water in Earth’s Surface Processes
- The abundance of liquid water on Earth’s surface and its unique combination of physical and chemical properties are central to the planet’s dynamics. These properties include water’s exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)

ESS2.D: Weather and Climate

Crosscutting Concepts

Energy and Matter
- The total amount of energy and matter in closed systems is conserved. (HS-ESS2-6)

Structure and Function
- The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substrates of its various materials.

Stability and Change
- Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS2-7)
- Feedback (positive or negative) can stabilize or destabilize a system. (HS-ESS2-2)

Connections to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology
- Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. (HS-ESS2-3)

Influence of Engineering, Technology, and Science on Society and the Natural World
- New technologies can have deep impacts on society and the environment.
New York State P-12 Science Learning Standards

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence
- Science knowledge is based on empirical evidence. (HS-ESS2-3)
- Science disciplines share common rules of evidence used to evaluate explanations about natural systems. (HS-ESS2-3)
Science includes the process of coordinating patterns of evidence with current theory. (HS-ESS2-3)

- The foundation for Earth’s global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy’s re-radiation into space. (HS-ESS2-2)
- Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6)
- Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-6)

ESS2.E: Biogeology
- The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth’s surface and the life that exists on it. (HS-ESS2-7)

PS4.A: Wave Properties
- Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet. (secondary to HS-ESS2-2)

Connections to other DCIs in this grade-band:  
- HS.PS1.A (HS-ESS2-5),(HS-ESS2-6);  
- HS.PS1.B (HS-ESS2-5),(HS-ESS2-6);  
- HS.PS2.B (HS-ESS2-3),( HS-ESS2-5);  
- HS.PS3.B (HS-ESS2-2),(HS-ESS2-6);  
- MS.PS3.D (HS-ESS2-3),(HS-ESS2-6);  
- HS.PS4.A (HS-ESS2-2);  
- HS.LS1.C (HS-ESS2-6);  
- HS.LS2.A (HS-ESS2-2),(HS-ESS2-6);  
- HS.LS2.B (HS-ESS2-6);  
- HS.LS2.C (HS-ESS2-2),(HS-ESS2-7);  
- HS.LS4.A (HS-ESS2-7);  
- HS.LS4.B (HS-ESS2-7);  
- HS.LS4.C (HS-ESS2-7);  
- HS.LS4.D (HS-ESS2-2),(HS-ESS2-7);  
- MS.ESS3.C (HS-ESS2-2),(HS-ESS2-7), (HS-ESS2-6)

Articulation of DCIs across grade-bands:  
- MS.PS1.A (HS-ESS2-3),(HS-ESS2-5),(HS-ESS2-6);  
- MS.PS1.B (HS-ESS2-3);  
- MS.PS2.B (HS-ESS2-3);  
- MS.PS3.A (HS-ESS2-3);  
- MS.PS3.B (HS-ESS2-3);  
- MS.PS3.D (HS-ESS2-2),(HS-ESS2-6);  
- MS.PS4.A (HS-ESS2-2);  
- MS.LS1.A (HS-ESS2-2);  
- MS.LS2.A (HS-ESS2-2),(HS-ESS2-6);  
- MS.LS2.B (HS-ESS2-2),(HS-ESS2-6);  
- MS.LS2.C (HS-ESS2-2),(HS-ESS2-7);  
- MS.LS4.A (HS-ESS2-7);  
- MS.LS4.B (HS-ESS2-7);  
- MS.LS4.C (HS-ESS2-7);  
- MS.LS4.D (HS-ESS2-2),(HS-ESS2-7);  
- MS.ESS1.C (HS-ESS2-7);  
- MS.ESS2.A (HS-ESS2-2),(HS-ESS2-6);  
- MS.ESS2.B (HS-ESS2-3),(HS-ESS2-6);  
- MS.ESS2.C (HS-ESS2-2),(HS-ESS2-5),(HS-ESS2-6);  
- MS.ESS2.D (HS-ESS2-2),(HS-ESS2-5);  
- MS.ESS3.C (HS-ESS2-2),(HS-ESS2-6);  
- MS.ESS3.D (HS-ESS2-2),(HS-ESS2-6)

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., attaining 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-ESS2-2),(HS-ESS2-3)

11-12.RST.2  
Determine the key ideas or conclusions of a source; summarize complex concepts, processes, or information presented in a source by paraphrasing in precise and accurate terms. (HS-ESS2-2)

9-12.WHST.1  
Write arguments focused on discipline-specific content. (HS-ESS2-2)

9-12.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-ESS2-5)

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-ESS2-3)

Mathematics –
MP.2  
Reason abstractly and quantitatively. (HS-ESS2-2),(HS-ESS2-3),(HS-ESS2-6)

MP.4  
Model with Mathematics. (HS-ESS2-3),(HS-ESS2-6)

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-ESS2-2),(HS-ESS2-3),(HS-ESS2-6)

AI-N.Q.3  
Choose a level of accuracy appropriate to limitations on measurement and context when reporting quantities. (HS-ESS2-2),(HS-ESS2-3),(HS-ESS2-5),(HS-ESS2-6)

*Connection boxes updated as of September 2018

*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

**HS. Weather and Climate**

**HS.ESS2-4.** Use a model to describe how variations in the flow of energy into and out of Earth’s systems result in changes in climate. [Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth’s orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition and plate tectonic movement.] [Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.]

**HS.ESS3-5.** Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. [Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).] [Assessment Boundary: Assessment is limited to one example of a climate change and its associated impacts.]

**HS.ESS2-8.** Evaluate data and communicate information to explain how the movement and interactions of air masses result in changes in weather conditions. [Clarification Statement: Examples of evidence sources could include station models, surface weather maps, satellite images, radar, and accepted forecast models. Emphasis should focus on communicating how the uneven heating of Earth’s surface and prevailing global winds drive the movement of air masses and their corresponding circulation patterns, the interaction of different air masses at frontal boundaries, and resulting weather phenomena.] [Assessment Boundary: Analysis is limited to surface weather maps and general weather patterns associated with high and low pressure systems.]

### 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 world(s).
- Use a model to provide mechanistic accounts of phenomena. (HS.ESS2-4)

**Analyzing and Interpreting Data**
- Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.
- Analyze data using tools, technologies and/or models (e.g., computational or mathematical) in order to make valid and reliable scientific claims or determine optimal design solution. (HS.ESS2-5)

**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 ideas (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.ESS2-8)

### Disciplinary Core Ideas

#### ESS1.B: Earth and the Solar System
- Cyclical changes in the shape of Earth’s orbit around the sun, together with changes in the tilt of the planet’s axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (secondary to HS.ESS2-4)

#### ESS2.A: Earth Materials and Systems
- The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun’s energy output or Earth’s orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. (HS.ESS2-4)

#### ESS2.D: Weather and Climate
- The foundation for Earth’s global climate system is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy’s re-radiation into space. (HS.ESS2-4, secondary to HS.ESS2-2)
- Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS.ESS2-4)
- (NYSED) Concepts of density and heat energy can be used to explain observations of weather patterns (HS.ESS2-8).

#### ESS3.D: Global Climate Change
- Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (HS.ESS3-5)

### Crosscutting Concepts

**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. (HS.ESS2-8)
- (NYSED) Empirical evidence is needed to identify patterns. (HS.ESS2-8)

**Cause and Effect**
- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS.ESS2-4)

**Stability and Change**
- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS.ESS3-5)

### Connections to Other DCIs in this grade-band:
- **HS.PS3.A** (HS.ESS2-4), (HS.ESS3-5)
- **HS.PS3.B** (HS.ESS2-4), (HS.ESS3-5)
- **HS.PS3.D** (HS.ESS2-4), (HS.ESS3-5)
- **HS.LS1.C** (HS.ESS3-5)
- **HS.LS2.C** (HS.ESS3-5)

### Connections to other DCIs across grade-bands:
- **MS.PS3.A** (HS.ESS2-4), (HS.ESS3-5)
- **MS.PS3.B** (HS.ESS2-4), (HS.ESS3-5)
- **MS.PS3.D** (HS.ESS2-4), (HS.ESS3-5)
- **MS.PS4.B** (HS.ESS2-4), (HS.ESS3-5)
- **MS.LS1.C** (HS.ESS2-4), (HS.ESS3-5)
- **MS.LS2.B** (HS.ESS2-4), (HS.ESS3-5)
- **MS.LS2.C** (HS.ESS2-4), (HS.ESS3-5)
- **MS.ESS2.A** (HS.ESS2-4), (HS.ESS2-5)
- **MS.ESS2.D** (HS.ESS2-4), (HS.ESS2-5)
- **MS.ESS3.B** (HS.ESS3-5)
- **MS.ESS3.C** (HS.ESS3-5)
- **MS.ESS3.D** (HS.ESS2-4), (HS.ESS2-5)
- **MS.ESS3.E** (HS.ESS3-5)
- **MS.ESS3.F** (HS.ESS3-5)

### 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.ESS2-5)
- **11-12.RST.2** Determine the key ideas or conclusions of a source; summarize complex concepts, processes, or information presented in a source by paraphrasing in precise and accurate terms. (HS.ESS3-5)
- **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...
### 11-12.SL.5
address a question or solve a problem. (HS-ESS3-5),(HS-ESS2-8)

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-ESS2-4)

### Mathematics –

**MP.2**
Reason abstractly and quantitatively. (HS-ESS2-4),(HS-ESS3-5),(HS-ESS2-8)

**MP.4**
Model with Mathematics. (HS-ESS2-4)

**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-ESS2-4),(HS-ESS3-5)

**AI-N.Q.3**
Choose a level of accuracy appropriate to limitations on measurement and context when reporting quantities. (HS-ESS2-4),(HS-ESS3-5),(HS-ESS2-8)

*Connection boxes updated as of September 2018*
**New York State P-12 Science Learning Standards**

**HS. Human Sustainability**

Students who demonstrate understanding can:

**HS-ESS3-1.** Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as blizzards, hurricanes, tornadoes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]

**HS-ESS3-2.** Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.* [Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]

**HS-ESS3-3.** Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. [Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.] [Assessment Boundary: Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.]

**HS-ESS3-4.** Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.* [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoenvironmental design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]

**HS-ESS3-6.** Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.* [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.]

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.

- Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-ESS3-3)
- Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations. (HS-ESS3-6)

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 knowledge, 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-ESS3-1)
- Design or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ESS3-4)

Engaging in Argument from Evidence
Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate evidence to support arguments.

**Disciplinary Core Ideas**

**ESS2.D: Weather and Climate**
- Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. (secondary to HS-ESS3-6)

**ESS3.A: Natural Resources**
- Resource availability has guided the development of human society. (HS-ESS3-1)
- All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS-ESS3-2)

**ESS3.B: Natural Hazards**
- Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. (HS-ESS3-1)

**ESS3.C: Human Impacts on Earth Systems**
- The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS-ESS3-3)
- Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste that preclude ecosystem degradation. (HS-ESS3-4)

**ESS3.D: Global Climate Change**
- Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. (HS-ESS3-6)

**ETS1.B: Developing Possible Solutions**
When evaluating solutions, it is important to take into account evidence generated sources of evidence, prioritized criteria, and tradeoff considerations (secondary to HS-ESS3-4).

**Crosscutting Concepts**

**Cause and Effect**
- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS3-1)

**Systems and System Models**
- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-ESS3-6)

**Stability and Change**
- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS3-3)
- Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS3-4)

**Connections to Engineering, Technology, and Applications of Science**

**Influence of Engineering, Technology, and Science on Society and the Natural World**
- Modern civilization depends on major technological systems. (HS-ESS3-1, HS-ESS3-3)
- Engineers continuously modify these systems to increase benefits while decreasing costs and risks. (HS-ESS3-2, HS-ESS3-4)
- New technologies can have deep impacts on society and the environment, including some that were not anticipated. (HS-ESS3-3)
- Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ESS3-2)

**Connections to Nature of Science**

Science is a Human Endeavor

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*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

<table>
<thead>
<tr>
<th>and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.</th>
<th>account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (secondary to HS-ESS3-2), (secondary to HS-ESS3-4)</th>
<th>• Scientific knowledge is a result of human endeavors, imagination, and creativity. (HS-ESS3-3)</th>
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</thead>
<tbody>
<tr>
<td>Connections to other DCIs in this grade-band:</td>
<td>Articulation of DCIs across grade-bands:</td>
<td>Science Addresses Questions about the Natural and Material World</td>
</tr>
<tr>
<td>HS.PS1.B (HS-ESS3-3); HS.PS3.B (HS-ESS3-2); HS.PS3.D (HS-ESS3-2); HS.LS2.A (HS-ESS3-2), (HS-ESS3-3), (HS-ESS3-6); HS.LS2.B (HS-ESS3-2), (HS-ESS3-3), (HS-ESS3-6); HS.LS2.C (HS-ESS3-3), (HS-ESS3-4), (HS-ESS3-6); HS.LS4.D (HS-ESS3-2), (HS-ESS3-3), (HS-ESS3-6); HS.ESS2.A (HS-ESS3-2), (HS-ESS3-3); HS.ESS2.E (HS-ESS3-3)</td>
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<td>• Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. (HS-ESS3-2)</td>
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<td>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-ESS3-1), (HS-ESS3-2), (HS-ESS3-4)</td>
<td>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-ESS3-2), (HS-ESS3-4)</td>
<td>• Science knowledge indicates what can happen in natural systems—not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge. (HS-ESS3-2)</td>
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<td>11-12.RST.8 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-ESS3-1)</td>
<td>9-10.WHST.2 Write informative/explanatory text focused on discipline-specific content. (HS-ESS3-1)</td>
<td>Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues. (HS-ESS3-2)</td>
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<td>11-12.WHST.2 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-ESS3-1), (HS-ESS3-2), (HS-ESS3-4)</td>
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<td>Mathematics –</td>
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<td>MP.2 Reason abstractly and quantitatively. (HS-ESS3-1), (HS-ESS3-2), (HS-ESS3-3), (HS-ESS3-4), (HS-ESS3-6)</td>
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New York State P-12 Science Learning Standards

HS. Engineering Design

Students who demonstrate understanding can:

**HS-ETS1-1.** Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

**HS-ETS1-2.** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

**HS-ETS1-3.** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

**HS-ETS1-4.** Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

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 design problems using models and simulations.
  - Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1)

** 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 models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. (HS-ETS1-4)

** 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 a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-2)

- Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-3)

### Disciplinary Core Ideas

** ETS1.A: Defining and Delimiting Engineering Problems **

- Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS-ETS1-1)
  - *Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.* (HS-ETS1-3)

** 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. (HS-ETS1-3)
  - 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 and environmental impacts. (HS-ETS1-3)

** ETS1.C: Optimizing the Design Solution **

- Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed. (HS-ETS1-2)

### 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-ETS1-4)

** Connections to Engineering, Technology, and Applications of Science **

- New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ETS1-1)

### Influence of Science, Engineering, and Technology on Society and the Natural World **

- New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ETS1-1)

### Articulation of DCLs across grade bands: **


### New York State Next Generation Learning Standards:

**ELA/Literacy –**

- **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-ETS1-1),(HS-ETS1-3)
  - 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-ETS1-1),(HS-ETS1-3)
  - 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-ETS1-1),(HS-ETS1-3)

- **Mathematics –**
  - **MP.2** Reason abstractly and quantitatively. (HS-EST1-1),(HS-ETS1-3),(HS-ETS1-4)
  - **MP.4** Model with Mathematics. (HS-ETS1-1),(HS-ETS1-2),(HS-ETS1-3),(HS-ETS1-4)

*Connection boxes updated as of September 2018*