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Science High School Course Maps for Life Sciences: Biology Courses that will Culminate in a Corresponding Regents Examination in Science

Background

The New York State P-12 Science Learning Standards are based on guiding documents ([A Framework for K-12 Science Education](#)¹ and the [Next Generation Science Standards](#)²) grounded in the most current research in science and scientific learning. They reflect the importance of every student's engagement with natural scientific phenomenon at the nexus of three dimensions of learning: Science and Engineering Practices, Disciplinary Core Ideas, and Cross-cutting concepts. Performance expectations are the way to integrate the three dimensions guiding student sense-making of science as discussed in the [New York State P-12 Science Learning Standards Introduction](#).

Development Process

The four high school science course maps have been developed by the Department to assist school districts in developing specific courses at the local level that align to the high school level (grades 9-12) performance expectations included in the [New York State P-12 Science Learning Standards](#). Each science course map (Life Sciences: Biology; Earth and Space Sciences; Physical Sciences: Chemistry; and Physical Sciences: Physics), delineates specific performance expectations for courses that culminate in a corresponding Regents examination in science. This is the [Implementation Timeline and Dates](#) for the rollout of new science assessments.

The course maps were developed using a similar four course model to what is included in the [Next Generation Science Standards Appendix K, Table 7](#). The first step in mapping performance expectations to courses was to examine the Science and Engineering Practices, Cross-Cutting Concepts, and component idea level of the Disciplinary Core Ideas from the *A Framework for K-12 Science Education*. The course that the associated performance expectations (as noted in the foundation boxes of the [New York State P-12 Science Learning Standards](#)) align was then decided. New York State subject area teacher experts provided input and feedback delineating the overlaps for each of the performance expectations for proposed high school science Regent's exam course. The decisions were made through a careful reading of the grade-band endpoints for each component idea in the Framework and were reviewed by multiple committees made up of New York State teachers and administrators.

¹National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington, DC: The National Academies Press.

² National Research Council. (2013). *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press.



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Important Considerations

It is important to note the performance expectations do not dictate curriculum, which is locally decided by school districts; rather, they were coherently developed to allow flexibility in classroom instruction. The [New York State P-12 Science Learning Standards](#) performance expectations reflect what a student should know and be able to do—they do not dictate the manner or methods by which the performance expectations are taught. The performance expectations are written in a way that expresses the concepts and skills to be performed by students. For example: HS-ESS2-6. Is listed in both Earth and Space Sciences and Life Sciences: Biology. For Life Sciences: Biology only the biochemistry aspects of carbon cycling are eligible for testing on the Life Sciences: Biology exam. The remainder of HS-ESS2-6 concepts are within the Earth and Space Sciences course.

Program choices, instructional decisions and pathways for students will vary across schools and school systems, and educators should make every effort to meet the needs of individual students, based on their local curriculum and instruction should consider the variety of student learning needs. The course maps presented are the guide for courses that culminate in a corresponding Regents examination in science. The options presented do not preclude the offering of other courses or sequences of instruction.

Order of Performance Expectations

The order in which the performance expectations are presented in the course maps is not the order in which the performance expectations need to be taught. As performance expectations from various domains are connected, educators will need to determine the best overall design and approach, as well as the instructional strategies needed to support their learners to attain course expectations and the knowledge articulated in the performance expectations. For the performance expectations that appear in more than one course, each map outlines the context regarding the intent or specific concepts appropriate for the course.

It is recognized that the course maps will have different numbers of performance expectations. The focus was on associating performance expectations with the high school courses where three-dimensional teaching and learning of the content was most appropriate. Educators are encouraged to instruct beyond performance expectations where appropriate. For more information regarding the [New York State P-12 Science Learning Standards](#) and connections that can be made with diverse learner populations, such as English Language Learners/Multilingual Learners and Students with Disabilities, refer to the [New York State P-12 Science Learning Standards Introduction](#).

Key Notes: Diagram 1 provides visual representation

1. In order to eliminate potential redundancy, seek an appropriate grain size, and seek natural connections among the Disciplinary Core Ideas (DCIs) identified within [A Framework for K-12 Science Education](#). New York State arranged the performance expectations into topics.



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2. Student performance expectations (PEs) may be taught in any sequence or grouping within a course.
3. The highlighted performance expectations are performance expectations that are unique to New York State.
4. An asterisk (*) indicates an engineering connection to a practice, core idea, or crosscutting concept.
5. The Clarification Statements are examples and additional guidance for the instructor. (NYSED) or a highlight indicates New York specific statement/wording.
6. The Assessment Boundaries delineate content limits of concepts that may be assessed in large-scale assessments.
7. Within the standards, the section entitled “foundation boxes” is reproduced verbatim from *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*, except for statements that contain (NYSED). The material is integrated and reprinted with permission from the National Academy of Sciences.
8. Within the standards, Three Connection Boxes (not shown in the diagram), located below the Foundation Boxes, are designed to support a coherent vision of the standards by showing how the performance expectations in each standard connect to other PEs in science, as well as to Common Core State Standards. The three boxes include:
 - Connections to other DCIs in this grade level. This box contains the names of science topics in other disciplines that have related disciplinary core ideas at the same grade level. For example, both Physical Science and Life Science performance expectations contain core ideas related to Photosynthesis and could be taught in relation to one another.
 - Articulation of DCIs across grade levels. This box contains the names of other science topics that either 1) provide a foundation for student understanding of the core ideas in this set of performance expectations (usually at prior grade levels); or 2) build on the foundation provided by the core ideas in this set of PEs (usually at subsequent grade levels).
 - Connections to the New York State Next Generation Learning Standards. This box contains the coding and names of [New York State Next Generation Mathematics Learning Standards \(2017\)](#), and [New York State Next Generation English Language Arts Learning Standards \(Revised 2017\)](#) that align to the performance expectations. An effort has been made to ensure that the mathematical skills students need for science were taught in a previous year where possible.

Diagram 1: the New York State P-12 Science Learning Standards



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Topic area

Student Performance Expectations (PE)

Highlighting indicates expectations that are different from the Next Generation Science Standards.

An asterisk indicates an engineering connection to a practice or disciplinary core idea.

Clarification Statements are examples and additional guidance.

The Assessment Boundaries delineate content limits of concepts that may be assessed in large-scale assessments

Foundation box: Designates which PE uses this practice.

Foundation box: Designates which PE incorporates this disciplinary core idea (DCI). (NYSED) indicates New York specific wording.

Foundation box: Designates which PE incorporates this crosscutting concept.

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 is limited to main group elements. 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 simple 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 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 NYS document *A Framework for K-12 Science Education*

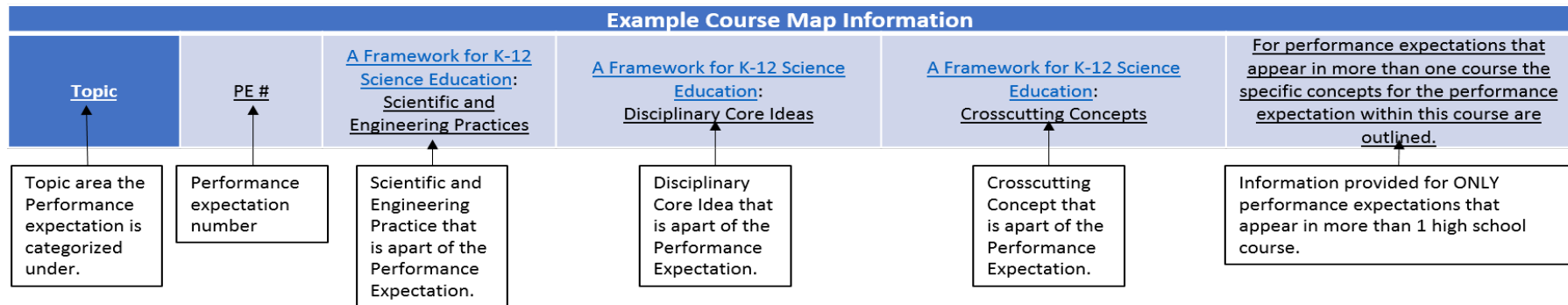
| Science and Engineering Practices | Disciplinary Core Ideas | Crosscutting Concepts |
|--|--|--|
| Developing and Using Models Modeling in 9-12 builds on K-8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. <ul style="list-style-type: none">Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-9)Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1) Planning and Carrying Out Investigations Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. <ul style="list-style-type: none">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-PS1-3)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.<ul style="list-style-type: none">Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and scientific claims or determine an optimal design solution. (HS-PS1-9) Evidence 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. <ul style="list-style-type: none">Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (HS-PS1-10) Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 9-12 builds on K-8 and progresses to evaluating the validity and | PS1.A: Structure and Properties of Matter <ul style="list-style-type: none">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 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 <ul style="list-style-type: none">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) PS1.B: Types of Interactions <ul style="list-style-type: none">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). | Patterns <ul style="list-style-type: none">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 <ul style="list-style-type: none">In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-PS1-8) Structure and Function <ul style="list-style-type: none">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) |

*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).



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Table I contains the recommended performance expectations for guiding curriculum programming and instruction within four high school science courses aligned to Regents examinations. Please note: no course sequences have been assumed in this model and the map does not preclude other performance expectations from being taught.



| Life Sciences: Biology -Instructional sequences are not assumed- | | | | | |
|---|-----------|--|---|---|--|
| Topic | PE # | K-12 Science Education Framework: Scientific and Engineering Practices | K-12 Science Education Framework: Disciplinary Core Ideas | K-12 Science Education Framework: Crosscutting Concepts | <u>For performance expectations that appear in more than one course the specific concepts for the performance expectation within this course are outlined.</u> |
| HS. Structure and Function | HS-LS1-1. | Constructing Explanations and Designing Solutions | LS1.A: Structure and Function | Structure and Function | |
| HS. Structure and Function | HS-LS1-2. | Developing and Using Models | LS1.A: Structure and Function | Systems and System Models | |



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|---|-----------|--|---|--|--|
| HS. Structure and Function | HS-LS1-3. | Planning and Carrying Out Investigations; Connections to Nature of Science Scientific Investigations Use a Variety of Methods | LS1.A: Structure and Function | Stability and Change | |
| HS. Inheritance and Variation of Traits | HS-LS1-4. | Developing and Using Models | LS1.B: Growth and Development of Organisms: Growth and Development of Organisms | Systems and System Models | |
| HS. Inheritance and Variation of Traits | HS-LS1-8 | Developing and Using Models | LS1.A: Structure and Function; LS1.B: Growth and Development of Organisms: Growth and Development of Organisms | Systems and System Models; Connections to Nature of Science Science is a Human Endeavor | |
| HS. Matter and Energy in Organisms and Ecosystems | HS-LS1-5. | Developing and Using Models | LS1.C*: Organization for Matter and Energy Flow in Organisms | Energy and Matter | |
| HS. Matter and Energy in Organisms and Ecosystems | HS-LS1-6. | Constructing Explanations and Designing Solutions | LS1.C*: Organization for Matter and Energy Flow in Organisms | Energy and Matter | |
| HS. Matter and Energy in Organisms and Ecosystems | HS-LS1-7. | Developing and Using Models | LS1.C*: Organization for Matter and Energy Flow in Organisms * | Energy and Matter | |
| HS. Interdependent Relationships in Ecosystems | HS-LS2-1. | Using Mathematics and Computational Thinking | LS2.A: Independent Relationships in Ecosystems | Scale, Proportion, Quantity | |



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|---|-----------|--|---|---|--|
| HS. Interdependent Relationships in Ecosystems | HS-LS2-2. | Using Mathematics and Computational Thinking; Connections to Nature of Science Scientific Knowledge is Open to Revision in Light of New Evidence | LS2.A: Independent Relationships in Ecosystems; LS2.C: Ecosystem Dynamics, Functioning, and Resilience | Scale, Proportion, Quantity | |
| HS. Interdependent Relationships in Ecosystems | HS-LS2-6. | Constructing Explanations and Designing Solutions; Connections to Nature of Science Scientific Knowledge is Open to Revision in Light of New Evidence | LS2.C: Ecosystem Dynamics, Functioning, and Resilience | Stability and Change | |
| HS. Interdependent Relationships in Ecosystems | HS-LS2-7. | Using Mathematics and Computational Thinking; Constructing Explanations and Designing Solutions | LS2.C: Ecosystem Dynamics, Functioning, and Resilience; LS4.D: Biodiversity and Humans; ETS1.B: Developing Possible Solutions | Cause and Effect; Stability and Change | |
| HS. Interdependent Relationships in Ecosystems | HS-LS2-8. | Constructing Explanations and Designing Solutions; Connections to Nature of Science Scientific Knowledge is Open to Revision in Light of New Evidence | LS2.D: Social Interactions and Group Behavior | Cause and Effect | |



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|---|-----------|--|--|---|--|
| HS. Matter and Energy in Organisms and Ecosystems | HS-LS2-3. | Constructing Explanations and Designing Solutions; Connections to Nature of Science Scientific Knowledge is Open to Revision in Light of New Evidence | LS2.B: Cycles of Matter and Energy Transfer in Ecosystems | Energy and Matter | |
| HS. Matter and Energy in Organisms and Ecosystems | HS-LS2-4. | Using Mathematics and Computational Thinking | LS2.B: Cycles of Matter and Energy Transfer in Ecosystems | Energy and Matter | |
| HS. Matter and Energy in Organisms and Ecosystems | HS-LS2-5. | Developing and Using Models | LS2.B: Cycles of Matter and Energy Transfer in Ecosystems | Systems and Systems Models | |
| HS. Inheritance and Variation of Traits | HS-LS3-1. | Asking Questions and Defining Problems; | LS3.A Inheritance of Traits; LS1.A: Structure and Function | Cause and Effect | |
| HS. Inheritance and Variation of Traits | HS-LS3-2. | Engaging in Argument from Evidence | LS3.B: Variation of Traits | Cause and Effect; Connections to Nature of Science Science is a Human Endeavor | |
| HS. Inheritance and Variation of Traits | HS-LS3-3. | Analyzing and Interpreting Data | LS3.B: Variation of Traits | Scale, Proportion and Quantity; Connections to Nature of Science Science is a Human Endeavor | |
| HS. Natural Selection and Evolution | HS-LS4-1. | Obtaining, Evaluating, and | LS4.A: Evidence of Common Ancestry and Diversity | Patterns | |



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| | | Communicating Information | | | |
| HS. Natural Selection and Evolution | HS-LS4-2. | Analyzing and Interpreting Data | LS4.B: Natural Selection; LS4.C: Adaption | Cause and Effect | |
| HS. Natural Selection and Evolution | HS-LS4-3. | Analyzing and Interpreting Data; Connections to Nature of Science Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena | LS4.B: Natural Selection; LS4.C: Adaption | Patterns | |
| HS. Natural Selection and Evolution | HS-LS4-4. | Analyzing and Interpreting Data; Connections to Nature of Science Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena | LS4.C: Adaption | Cause and Effect | |
| HS. Natural Selection and Evolution | HS-LS4-5. | Analyzing and Interpreting Data; Connections to Nature of Science Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena | LS4.C: Adaption | Cause and Effect | |
| HS. Earth Systems | HS-ESS2-6. | Developing and Using Models | ESS2.D: Weather and Climate | Energy and Matter | The biochemistry aspects of carbon cycling. |
| HS. Earth's Systems | HS-ESS2-7. | Engaging in Argument from Evidence | ESS2.E: Biogeology | Stability and Change | Changes in the atmosphere from plants and other organisms related to carbon |



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| | | | | | cycling and feedback mechanisms related to co-evolution. |
| HS. Engineering Design | HS-ETS1-1. | Asking Questions and Defining Problems | ETS1.A: Defining and Delimiting Engineering Problems | Connections to Engineering, Technology, and Applications of Science Influence of Science, Engineering, and Technology on Society and the Natural World | |
| HS. Engineering Design | HS-ETS1-2. | Constructing Explanations and Designing Solutions | ETS1.C: Optimizing the Design Solution | | |
| HS. Engineering Design | HS-ETS1-3. | Constructing Explanations and Designing Solutions | ETS1.B: Developing Possible Solutions | Connections to Engineering, Technology, and Applications of Science Influence of Science, Engineering, and Technology on Society and the Natural World | |
| HS. Engineering Design | HS-ETS1-4. | Using Mathematics and Computational Thinking | ETS1.B: Developing Possible Solutions | Systems and System Models | |