**Lesson Plan: Chromosomes and DNA Structure**

*Last updated: 3/27/2024*

**Total Expected Time**

This set of labs includes four labs, approximately 30 minutes each, for a total expected time of 2 hours.

**Resources**

Required resources for students:

* Visible Biology: <https://www.visiblebody.com/teaching-anatomy/courseware-biology>
  + Use Visible Body’s interactive 3D models and 3D simulation models to learn about the structure and functions of chromosomes and DNA. Select the info icon to learn more about each model. Select any structure and then select the book icon to read its definition and select the audio icon to hear the pronunciation of the structure name.
  + Use Visible Body’s animations to learn more about mitosis, transcription, and translation.
* Visible Body’s Biology Learn Site articles and glossaries
  + DNA and Chromosomes Overview: <https://www.visiblebody.com/learn/biology/dna-chromosomes/overview>
  + Eukaryotic Chromosomes: <https://www.visiblebody.com/learn/biology/dna-chromosomes/eukaryotic-chromosomes>
  + Prokaryotic Chromosomes: <https://www.visiblebody.com/learn/biology/dna-chromosomes/prokaryotic-chromosomes>
  + Eukaryotic vs. Prokaryotic Chromosomes: <https://www.visiblebody.com/learn/biology/dna-chromosomes/eukaryotic-vs-prokaryotic>
  + DNA Structure: <https://www.visiblebody.com/learn/biology/dna-chromosomes/dna-structure>
  + DNA and Chromosomes Glossary: <https://www.visiblebody.com/learn/biology/dna-chromosomes/glossary>
* Lab Activity: Chromosomes and DNA Structure: <https://www.visiblebody.com/hubfs/lab-activities/biology-site-license/visible-biology-site-license-lab-activities_chromosomes-and-dna-structure_student.pdf?hsLang=en>

Additional resources for students and teachers:

* This lesson assumes that students have a basic understanding of chromosomes and DNA structure. Students can read each of the following sections of the OpenStax Biology textbook to learn more about the following topics:
  + [Chromosomes and DNA structure overview](https://openstax.org/books/concepts-biology/pages/9-1-the-structure-of-dna)
  + [Eukaryotic chromosomes and DNA structure](https://openstax.org/books/biology-2e/pages/3-5-nucleic-acids)
  + [Eukaryotic DNA replication](https://openstax.org/books/biology-2e/pages/14-5-dna-replication-in-eukaryotes)
  + [Prokaryotic chromosomes and prokaryotic cell division](https://openstax.org/books/biology-2e/pages/10-5-prokaryotic-cell-division)
  + [Eukaryotic vs. prokaryotic chromosomes](https://openstax.org/books/biology-2e/pages/10-1-cell-division)
  + [DNA structure](https://openstax.org/books/biology-2e/pages/14-2-dna-structure-and-sequencing#77299)

**Objectives**

At the end of this lesson, students should be able to:

1. Identify the key structures of eukaryotic chromosomes.
2. Explore the functions of eukaryotic chromosome structures.
3. Identify the key structures of prokaryotic chromosomes.
4. Explore the functions of prokaryotic chromosome structures.
5. Compare the structure of eukaryotic and prokaryotic chromosomes.
6. Identify the components that make up DNA.
7. Explore the components of DNA and how they’re bound together to form the double helix.

**Essential Questions**

1. What is the difference between eukaryotic and prokaryotic chromosomes?
2. How is DNA compacted to fit inside eukaryotic and prokaryotic chromosomes?
3. What are the components that make up DNA and how are they arranged to create the double helix?

**Key Structure Identification**

In their answers, students will identify the following structures:

* Eukaryotic chromosome structures: Centromere, chromatid, chromatin (or DNA molecule), DNA double helix, histones, nucleosomes, P arm, Q arm, and telomeres.
* Prokaryotic chromosome structures: Chromosome, nucleoid-associated proteins (NAPs), and plasmids.
* DNA structures: Adenine, cytosine, guanine, thymine, and sugar-phosphate backbone.

**Introduction**

10 minutes: Use the content in Visible Biologyand the Biology Learn Site, as well as the OpenStax pages referenced in the additional resources above, to give students a brief introduction to the basic structures of eukaryotic and prokaryotic chromosomes and the DNA double helix. Distinguish between eukaryotic and prokaryotic chromosomes, focusing on their structure, their arrangement in the cell, and the compaction of their DNA.

**Student Activities**

These lab activities are designed to be modular and can be used as individual labs or grouped together into one lab session.

* Background Questions: These could be assigned as homework before lab
* Lab 1: Eukaryotic Chromosome Structure (30 minute lab session)
  + Activity 1: Label a eukaryotic chromosome
  + Activity 2: Explore the functions of eukaryotic chromosome structures
* Lab 2: Prokaryotic Chromosome Structure (20-30 minute lab session)
  + Activity 1: Label a prokaryotic chromosome
  + Activity 2: Explore the functions of prokaryotic chromosome structures
* Lab 3: Compare Eukaryotic and Prokaryotic Chromosomes (20-30 minute lab session)
* Lab 4: DNA Structure (30 minute lab session)
  + Activity 1: Label a DNA double helix
  + Activity 2: Explore the components of DNA

Check students’ work using the answer key.

**NGSS and State Science Correlations**

| **Next Generation Science Standards (NGSS)** |
| --- |

| **Science** |
| --- |

| Grades **9-12** - Adopted: **2013** | | |
| --- | --- | --- |
| **STRAND** | **NGSS.HS-LS** | **LIFE SCIENCE** |
| **TITLE** | **HS-LS1** | **From Molecules to Organisms: Structures and Processes** |
|  |  | **Students who demonstrate understanding can:** |
| **PERFORMANCE EXPECTATION** | **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.** |
| **PERFORMANCE EXPECTATION** | **HS-LS1-2** | **Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.** |
| **PERFORMANCE EXPECTATION** | **HS-LS1-4** | **Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.** |
| **PERFORMANCE EXPECTATION** | **HS-LS1-6** | **Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.** |

| **STRAND** | **NGSS.HS-LS** | **LIFE SCIENCE** |
| --- | --- | --- |
| **TITLE** | **HS-LS3** | **Heredity: Inheritance and Variation of Traits** |
|  |  | **Students who demonstrate understanding can:** |
| **PERFORMANCE EXPECTATION** | **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.** |
| **PERFORMANCE EXPECTATION** | **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, and/or (3) mutations caused by environmental factors.** |

| **Texas Essential Knowledge and Skills (TEKS)** |
| --- |

| **Science** |
| --- |

| Grades **9-12** - Adopted: **2017** | | |
| --- | --- | --- |
| **TEKS** | **§112.34** | **Biology (One Credit), Adopted 2017 – The provisions of §§112.34, 112.35, 112.38, and 112.39 of this subchapter adopted in 2017 shall be implemented by school districts beginning with the 2018-2019 school year.** |
| **STUDENT EXPECTATION** | **§112.34.c** | **Knowledge and skills.** |
| **GRADE LEVEL EXPECTATION** | **§112.34.c.3** | **Scientific processes. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to:** |
| **INDICATOR** | **§112.34.c.3.E** | **evaluate models according to their limitations in representing biological objects or events** |

| **TEKS** | **§112.34** | **Biology (One Credit), Adopted 2017 – The provisions of §§112.34, 112.35, 112.38, and 112.39 of this subchapter adopted in 2017 shall be implemented by school districts beginning with the 2018-2019 school year.** |
| --- | --- | --- |
| **STUDENT EXPECTATION** | **§112.34.c** | **Knowledge and skills.** |
| **GRADE LEVEL EXPECTATION** | **§112.34.c.4** | **Science concepts. The student knows that cells are the basic structures of all living things with specialized parts that perform specific functions and that viruses are different from cells. The student is expected to:** |
| **INDICATOR** | **§112.34.c.4.A** | **compare and contrast prokaryotic and eukaryotic cells, including their complexity, and compare and contrast scientific explanations for cellular complexity** |
| **INDICATOR** | **§112.34.c.4.B** | **investigate and explain cellular processes, including homeostasis and transport of molecules** |

| **TEKS** | **§112.34** | **Biology (One Credit), Adopted 2017 – The provisions of §§112.34, 112.35, 112.38, and 112.39 of this subchapter adopted in 2017 shall be implemented by school districts beginning with the 2018-2019 school year.** |
| --- | --- | --- |
| **STUDENT EXPECTATION** | **§112.34.c** | **Knowledge and skills.** |
| **GRADE LEVEL EXPECTATION** | **§112.34.c.5** | **Science concepts. The student knows how an organism grows and the importance of cell differentiation. The student is expected to:** |
| **INDICATOR** | **§112.34.c.5.A** | **describe the stages of the cell cycle, including deoxyribonucleic acid (DNA) replication and mitosis, and the importance of the cell cycle to the growth of organisms** |
| **INDICATOR** | **§112.34.c.5.B** | **describe the roles of DNA, ribonucleic acid (RNA), and environmental factors in cell differentiation** |

| **TEKS** | **§112.34** | **Biology (One Credit), Adopted 2017 – The provisions of §§112.34, 112.35, 112.38, and 112.39 of this subchapter adopted in 2017 shall be implemented by school districts beginning with the 2018-2019 school year.** |
| --- | --- | --- |
| **STUDENT EXPECTATION** | **§112.34.c** | **Knowledge and skills.** |
| **GRADE LEVEL EXPECTATION** | **§112.34.c.6** | **Science concepts. The student knows the mechanisms of genetics such as the role of nucleic acids and the principles of Mendelian and non-Mendelian genetics. The student is expected to:** |
| **INDICATOR** | **§112.34.c.6.A** | **identify components of DNA, identify how information for specifying the traits of an organism is carried in the DNA, and examine scientific explanations for the origin of DNA** |
| **INDICATOR** | **§112.34.c.6.B** | **recognize that components that make up the genetic code are common to all organisms** |
| **INDICATOR** | **§112.34.c.6.G** | **recognize the significance of meiosis to sexual reproduction** |

| **TEKS** | **§112.34** | **Biology (One Credit), Adopted 2017 – The provisions of §§112.34, 112.35, 112.38, and 112.39 of this subchapter adopted in 2017 shall be implemented by school districts beginning with the 2018-2019 school year.** |
| --- | --- | --- |
| **STUDENT EXPECTATION** | **§112.34.c** | **Knowledge and skills.** |
| **GRADE LEVEL EXPECTATION** | **§112.34.c.9** | **Science concepts. The student knows the significance of various molecules involved in metabolic processes and energy conversions that occur in living organisms. The student is expected to:** |
| **INDICATOR** | **§112.34.c.9.A** | **compare the functions of different types of biomolecules, including carbohydrates, lipids, proteins, and nucleic acids** |

| **TEKS** | **§112.34** | **Biology (One Credit), Adopted 2017 – The provisions of §§112.34, 112.35, 112.38, and 112.39 of this subchapter adopted in 2017 shall be implemented by school districts beginning with the 2018-2019 school year.** |
| --- | --- | --- |
| **STUDENT EXPECTATION** | **§112.34.c** | **Knowledge and skills.** |
| **GRADE LEVEL EXPECTATION** | **§112.34.c.10** | **Science concepts. The student knows that biological systems are composed of multiple levels. The student is expected to:** |
| **INDICATOR** | **§112.34.c.10.C** | **analyze the levels of organization in biological systems and relate the levels to each other and to the whole system** |

| **California Content Standards** |
| --- |

| **Science** |
| --- |

| Grades **9-12** - Adopted: **2013** | | |
| --- | --- | --- |
| **CONTENT STANDARD / DOMAIN / PART** | **CA.HS-LS.** | **LIFE SCIENCE** |
| **PERFORMANCE STANDARD / MODE** | **HS-LS1.** | **From Molecules to Organisms: Structures and Processes** |
| **EXPECTATION / SUBSTRAND** |  | **Students who demonstrate understanding can:** |
| **FOUNDATION / PROFICIENCY LEVEL** | **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.** |
| **FOUNDATION / PROFICIENCY LEVEL** | **HS-LS1-2.** | **Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.** |
| **FOUNDATION / PROFICIENCY LEVEL** | **HS-LS1-4.** | **Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.** |
| **FOUNDATION / PROFICIENCY LEVEL** | **HS-LS1-6.** | **Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.** |

| **CONTENT STANDARD / DOMAIN / PART** | **CA.HS-LS.** | **LIFE SCIENCE** |
| --- | --- | --- |
| **PERFORMANCE STANDARD / MODE** | **HS-LS3.** | **Heredity: Inheritance and Variation of Traits** |
| **EXPECTATION / SUBSTRAND** |  | **Students who demonstrate understanding can:** |
| **FOUNDATION / PROFICIENCY LEVEL** | **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.** |
| **FOUNDATION / PROFICIENCY LEVEL** | **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, and/or (3) mutations caused by environmental factors.** |

| **CONTENT STANDARD / DOMAIN / PART** | **CA.RST.9-10.** | **Reading Standards for Literacy in Science and Technical Subjects** |
| --- | --- | --- |
| **PERFORMANCE STANDARD / MODE** |  | **Key Ideas and Details** |
| **EXPECTATION / SUBSTRAND** | **RST.9-10.2.** | **Determine the central ideas or conclusions of a text; trace the text’s explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.** |

| **CONTENT STANDARD / DOMAIN / PART** | **CA.RST.9-10.** | **Reading Standards for Literacy in Science and Technical Subjects** |
| --- | --- | --- |
| **PERFORMANCE STANDARD / MODE** |  | **Craft and Structure** |
| **EXPECTATION / SUBSTRAND** | **RST.9-10.4.** | **Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9–10 texts and topics.** |
| **EXPECTATION / SUBSTRAND** | **RST.9-10.5.** | **Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).** |

| **CONTENT STANDARD / DOMAIN / PART** | **CA.RST.9-10.** | **Reading Standards for Literacy in Science and Technical Subjects** |
| --- | --- | --- |
| **PERFORMANCE STANDARD / MODE** |  | **Integration of Knowledge and Ideas** |
| **EXPECTATION / SUBSTRAND** | **RST.9-10.7.** | **Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.** |
| **EXPECTATION / SUBSTRAND** | **RST.9-10.9.** | **Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.** |

| **CONTENT STANDARD / DOMAIN / PART** | **CA.RST.9-10.** | **Reading Standards for Literacy in Science and Technical Subjects** |
| --- | --- | --- |
| **PERFORMANCE STANDARD / MODE** |  | **Range of Reading and Level of Text Complexity** |
| **EXPECTATION / SUBSTRAND** | **RST.9-10.10.** | **By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.** |

| **CONTENT STANDARD / DOMAIN / PART** | **CA.WHST.9-10.** | **Writing Standards for Literacy in Science and Technical Subjects** |
| --- | --- | --- |
| **PERFORMANCE STANDARD / MODE** |  | **Text Types and Purposes** |
| **EXPECTATION / SUBSTRAND** | **WHST.9-10.1.** | **Write arguments focused on discipline-specific content.** |
| **FOUNDATION / PROFICIENCY LEVEL** | **WHST.9-10.1.d.** | **Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.** |

| **CONTENT STANDARD / DOMAIN / PART** | **CA.WHST.9-10.** | **Writing Standards for Literacy in Science and Technical Subjects** |
| --- | --- | --- |
| **PERFORMANCE STANDARD / MODE** |  | **Text Types and Purposes** |
| **EXPECTATION / SUBSTRAND** | **WHST.9-10.2.** | **Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.** |
| **FOUNDATION / PROFICIENCY LEVEL** | **WHST.9-10.2.a.** | **Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.** |
| **FOUNDATION / PROFICIENCY LEVEL** | **WHST.9-10.2.b.** | **Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience’s knowledge of the topic.** |
| **FOUNDATION / PROFICIENCY LEVEL** | **WHST.9-10.2.c.** | **Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts.** |
| **FOUNDATION / PROFICIENCY LEVEL** | **WHST.9-10.2.d.** | **Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers.** |
| **FOUNDATION / PROFICIENCY LEVEL** | **WHST.9-10.2.e.** | **Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.** |
| **FOUNDATION / PROFICIENCY LEVEL** | **WHST.9-10.2.f.** | **Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).** |

| **CONTENT STANDARD / DOMAIN / PART** | **CA.WHST.9-10.** | **Writing Standards for Literacy in Science and Technical Subjects** |
| --- | --- | --- |
| **PERFORMANCE STANDARD / MODE** |  | **Production and Distribution of Writing** |
| **EXPECTATION / SUBSTRAND** | **WHST.9-10.4.** | **Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.** |
| **EXPECTATION / SUBSTRAND** | **WHST.9-10.5.** | **Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.** |

| **CONTENT STANDARD / DOMAIN / PART** | **CA.WHST.9-10.** | **Writing Standards for Literacy in Science and Technical Subjects** |
| --- | --- | --- |
| **PERFORMANCE STANDARD / MODE** |  | **Range of Writing** |
| **EXPECTATION / SUBSTRAND** | **WHST.9-10.10.** | **Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.** |

| **Florida Standards** |
| --- |

| **Science** |
| --- |

| Grades **9-12** - Adopted: **2008** | | |
| --- | --- | --- |
| **BODY OF KNOWLEDGE** | **FL.SC.912.N.** | **Nature of Science** |
| **BIG IDEA** | **SC.912.N.1.** | **The Practice of Science - A: Scientific inquiry is a multifaceted activity; The processes of science include the formulation of scientifically investigable questions, construction of investigations into those questions, the collection of appropriate data, the evaluation of the meaning of those data, and the communication of this evaluation. B: The processes of science frequently do not correspond to the traditional portrayal of ''the scientific method.'' C: Scientific argumentation is a necessary part of scientific inquiry and plays an important role in the generation and validation of scientific knowledge. D: Scientific knowledge is based on observation and inference; it is important to recognize that these are very different things. Not only does science require creativity in its methods and processes, but also in its questions and explanations.** |
| **BENCHMARK** | **SC.912.N.1.1.** | **Define a problem based on a specific body of knowledge, for example: biology, chemistry, physics, and earth/space science, and do the following:** |
| **INDICATOR** | **SC.912.N.1.1.7.** | **Pose answers, explanations, or descriptions of events** |

| **BODY OF KNOWLEDGE** | **FL.SC.912.N.** | **Nature of Science** |
| --- | --- | --- |
| **BIG IDEA** | **SC.912.N.3.** | **The Role of Theories, Laws, Hypotheses, and Models - The terms that describe examples of scientific knowledge, for example: ''theory,'' ''law,'' ''hypothesis'' and ''model'' have very specific meanings and functions within science.** |
| **BENCHMARK** | **SC.912.N.3.5.** | **Describe the function of models in science, and identify the wide range of models used in science.** |

| **BODY OF KNOWLEDGE** | **FL.SC.912.L.** | **Life Science** |
| --- | --- | --- |
| **BIG IDEA** | **SC.912.L.14.** | **Organization and Development of Living Organisms - A. Cells have characteristic structures and functions that make them distinctive. B. Processes in a cell can be classified broadly as growth, maintenance, reproduction, and homeostasis. C. Life can be organized in a functional and structural hierarchy ranging from cells to the biosphere. D. Most multicellular organisms are composed of organ systems whose structures reflect their particular function.** |
| **BENCHMARK** | **SC.912.L.14.2.** | **Relate structure to function for the components of plant and animal cells. Explain the role of cell membranes as a highly selective barrier (passive and active transport).** |
| **BENCHMARK** | **SC.912.L.14.3.** | **Compare and contrast the general structures of plant and animal cells. Compare and contrast the general structures of prokaryotic and eukaryotic cells.** |
| **BENCHMARK** | **SC.912.L.14.5.** | **Explain the evidence supporting the scientific theory of the origin of eukaryotic cells (endosymbiosis).** |

| **BODY OF KNOWLEDGE** | **FL.SC.912.L.** | **Life Science** |
| --- | --- | --- |
| **BIG IDEA** | **SC.912.L.16.** | **Heredity and Reproduction - A. DNA stores and transmits genetic information. Genes are sets of instructions encoded in the structure of DNA. B. Genetic information is passed from generation to generation by DNA in all organisms and accounts for similarities in related individuals. C. Manipulation of DNA in organisms has led to commercial production of biological molecules on a large scale and genetically modified organisms. D. Reproduction is characteristic of living things and is essential for the survival of species.** |
| **BENCHMARK** | **SC.912.L.16.3.** | **Describe the basic process of DNA replication and how it relates to the transmission and conservation of the genetic information.** |
| **BENCHMARK** | **SC.912.L.16.14.** | **Describe the cell cycle, including the process of mitosis. Explain the role of mitosis in the formation of new cells and its importance in maintaining chromosome number during asexual reproduction.** |
| **BENCHMARK** | **SC.912.L.16.15.** | **Compare and contrast binary fission and mitotic cell division.** |
| **BENCHMARK** | **SC.912.L.16.16.** | **Describe the process of meiosis, including independent assortment and crossing over. Explain how reduction division results in the formation of haploid gametes or spores.** |
| **BENCHMARK** | **SC.912.L.16.17.** | **Compare and contrast mitosis and meiosis and relate to the processes of sexual and asexual reproduction and their consequences for genetic variation.** |

| **BODY OF KNOWLEDGE** | **FL.SC.912.L.** | **Life Science** |
| --- | --- | --- |
| **BIG IDEA** | **SC.912.L.18.** | **Matter and Energy Transformations - A. All living things are composed of four basic categories of macromolecules and share the same basic needs for life. B. Living organisms acquire the energy they need for life processes through various metabolic pathways (primarily photosynthesis and cellular respiration). C. Chemical reactions in living things follow basic rules of chemistry and are usually regulated by enzymes. D. The unique chemical properties of carbon and water make life on Earth possible.** |
| **BENCHMARK** | **SC.912.L.18.1.** | **Describe the basic molecular structures and primary functions of the four major categories of biological macromolecules.** |

| Grades **9-12** - Adopted: **2014** | | |
| --- | --- | --- |
| **BODY OF KNOWLEDGE** | **FL.LAFS.910.RST.** | **READING STANDARDS FOR LITERACY IN SCIENCE AND TECHNICAL SUBJECTS 6-12** |
| **BIG IDEA** | **LAFS.910.RST.1.** | **Key Ideas and Details** |
| **BENCHMARK** | **LAFS.910.RST.1.2.** | **Determine the central ideas or conclusions of a text; trace the text’s explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.** |

| **BODY OF KNOWLEDGE** | **FL.LAFS.910.RST.** | **READING STANDARDS FOR LITERACY IN SCIENCE AND TECHNICAL SUBJECTS 6-12** |
| --- | --- | --- |
| **BIG IDEA** | **LAFS.910.RST.2.** | **Craft and Structure** |
| **BENCHMARK** | **LAFS.910.RST.2.4.** | **Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9–10 texts and topics.** |
| **BENCHMARK** | **LAFS.910.RST.2.5.** | **Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).** |

| **BODY OF KNOWLEDGE** | **FL.LAFS.910.RST.** | **READING STANDARDS FOR LITERACY IN SCIENCE AND TECHNICAL SUBJECTS 6-12** |
| --- | --- | --- |
| **BIG IDEA** | **LAFS.910.RST.3.** | **Integration of Knowledge and Ideas** |
| **BENCHMARK** | **LAFS.910.RST.3.7.** | **Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.** |
| **BENCHMARK** | **LAFS.910.RST.3.9.** | **Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.** |

| **BODY OF KNOWLEDGE** | **FL.LAFS.910.RST.** | **READING STANDARDS FOR LITERACY IN SCIENCE AND TECHNICAL SUBJECTS 6-12** |
| --- | --- | --- |
| **BIG IDEA** | **LAFS.910.RST.4.** | **Range of Reading and Level of Text Complexity** |
| **BENCHMARK** | **LAFS.910.RST.4.10.** | **By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.** |

| **BODY OF KNOWLEDGE** | **FL.LAFS.910.WHST.** | **WRITING STANDARDS FOR LITERACY IN SCIENCE AND TECHNICAL SUBJECTS** |
| --- | --- | --- |
| **BIG IDEA** | **LAFS.910.WHST.1.** | **Text Types and Purposes** |
| **BENCHMARK** | **LAFS.910.WHST.1.1.** | **Write arguments focused on discipline-specific content.** |
| **INDICATOR** | **LAFS.910.WHST.1.1.d.** | **Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.** |

| **BODY OF KNOWLEDGE** | **FL.LAFS.910.WHST.** | **WRITING STANDARDS FOR LITERACY IN SCIENCE AND TECHNICAL SUBJECTS** |
| --- | --- | --- |
| **BIG IDEA** | **LAFS.910.WHST.1.** | **Text Types and Purposes** |
| **BENCHMARK** | **LAFS.910.WHST.1.2.** | **Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.** |
| **INDICATOR** | **LAFS.910.WHST.1.2.a.** | **Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.** |
| **INDICATOR** | **LAFS.910.WHST.1.2.b.** | **Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience’s knowledge of the topic.** |
| **INDICATOR** | **LAFS.910.WHST.1.2.c.** | **Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts.** |
| **INDICATOR** | **LAFS.910.WHST.1.2.d.** | **Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers.** |
| **INDICATOR** | **LAFS.910.WHST.1.2.e.** | **Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.** |

| **BODY OF KNOWLEDGE** | **FL.LAFS.910.WHST.** | **WRITING STANDARDS FOR LITERACY IN SCIENCE AND TECHNICAL SUBJECTS** |
| --- | --- | --- |
| **BIG IDEA** | **LAFS.910.WHST.2.** | **Production and Distribution of Writing** |
| **BENCHMARK** | **LAFS.910.WHST.2.4.** | **Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.** |
| **BENCHMARK** | **LAFS.910.WHST.2.5.** | **Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.** |

| **BODY OF KNOWLEDGE** | **FL.LAFS.910.WHST.** | **WRITING STANDARDS FOR LITERACY IN SCIENCE AND TECHNICAL SUBJECTS** |
| --- | --- | --- |
| **BIG IDEA** | **LAFS.910.WHST.4.** | **Range of Writing** |
| **BENCHMARK** | **LAFS.910.WHST.4.10.** | **Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.** |

| **Pennsylvania STEELS Standards (AD 2022/IMP 2025)** | | |
| --- | --- | --- |
| **Science** | | |
| Grades **9-12** - Adopted: **2022** | | |
| **Discipline** | **3.1.** | **Life Science** |
| **Strand** |  | **Structure and Function** |
| **Standard** | **3.1.9-12.A.** | **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.** |
| **Standard** | **3.1.9-12.B.** | **Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.** |
| **Discipline** | **3.1.** | **Life Science** |
| **Strand** |  | **Growth and Development of Organisms** |
| **Standard** | **3.1.9-12.D.** | **Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.** |
| **Discipline** | **3.1.** | **Life Science** |
| **Strand** |  | **Organization for Matter and Energy Flow in Organisms** |
| **Standard** | **3.1.9-12.F.** | **Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.** |
| **Discipline** | **3.1.** | **Life Science** |
| **Strand** |  | **Inheritance of Traits** |
| **Standard** | **3.1.9-12.P.** | **Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.** |
| **Discipline** | **3.1.** | **Life Science** |
| **Strand** |  | **Variation of Traits** |
| **Standard** | **3.1.9-12.Q.** | **Make and defend a claim based on evidence that inheritable genetic variations may result from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.** |

| **Illinois Learning Standards** | | |
| --- | --- | --- |
| **Science** | | |
| Grades **9-10** - Adopted: **2014** | | |
| **STATE GOAL / DISCIPLINARY CONCEPT** | **IL.HS-LS.** | **LIFE SCIENCE** |
| **LEARNING STANDARD / DISCIPLINE** | **HS-LS1.** | **From Molecules to Organisms: Structures and Processes** |
| **DESCRIPTOR / CONTENT DISCIPLINE** |  | **Students who demonstrate understanding can:** |
| **STANDARD** | **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.** |
| **STANDARD** | **HS-LS1-2.** | **Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.** |
| **STANDARD** | **HS-LS1-4.** | **Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.** |
| **STANDARD** | **HS-LS1-6.** | **Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.** |
| **STATE GOAL / DISCIPLINARY CONCEPT** | **IL.HS-LS.** | **LIFE SCIENCE** |
| **LEARNING STANDARD / DISCIPLINE** | **HS-LS3.** | **Heredity: Inheritance and Variation of Traits** |
| **DESCRIPTOR / CONTENT DISCIPLINE** |  | **Students who demonstrate understanding can:** |
| **STANDARD** | **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.** |
| **STANDARD** | **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, and/or (3) mutations caused by environmental factors.** |
| Grades **9-10** - Adopted: **2010** | | |
| **STATE GOAL / DISCIPLINARY CONCEPT** | **IL.9-10.RST.** | **Reading Standards for Literacy in Science and Technical Subjects** |
| **LEARNING STANDARD / DISCIPLINE** |  | **Key Ideas and Details** |
| **DESCRIPTOR / CONTENT DISCIPLINE** | **CC.9-10.RST.2.** | **Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.** |
| **STATE GOAL / DISCIPLINARY CONCEPT** | **IL.9-10.RST.** | **Reading Standards for Literacy in Science and Technical Subjects** |
| **LEARNING STANDARD / DISCIPLINE** |  | **Craft and Structure** |
| **DESCRIPTOR / CONTENT DISCIPLINE** | **CC.9-10.RST.4.** | **Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.** |
| **DESCRIPTOR / CONTENT DISCIPLINE** | **CC.9-10.RST.5.** | **Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).** |
| **STATE GOAL / DISCIPLINARY CONCEPT** | **IL.9-10.RST.** | **Reading Standards for Literacy in Science and Technical Subjects** |
| **LEARNING STANDARD / DISCIPLINE** |  | **Integration of Knowledge and Ideas** |
| **DESCRIPTOR / CONTENT DISCIPLINE** | **CC.9-10.RST.7.** | **Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.** |
| **DESCRIPTOR / CONTENT DISCIPLINE** | **CC.9-10.RST.9.** | **Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.** |
| **STATE GOAL / DISCIPLINARY CONCEPT** | **IL.9-10.RST.** | **Reading Standards for Literacy in Science and Technical Subjects** |
| **LEARNING STANDARD / DISCIPLINE** |  | **Range of Reading and Level of Text Complexity** |
| **DESCRIPTOR / CONTENT DISCIPLINE** | **CC.9-10.RST.10.** | **By the end of grade 10, read and comprehend science/technical texts in the grades 9-10 text complexity band independently and proficiently.** |
| **STATE GOAL / DISCIPLINARY CONCEPT** | **IL.9-10.WHST.** | **Writing Standards for Literacy in Science and Technical Subjects** |
| **LEARNING STANDARD / DISCIPLINE** |  | **Text Types and Purposes** |
| **DESCRIPTOR / CONTENT DISCIPLINE** | **CC.9-10.WHST.1.** | **Write arguments focused on discipline-specific content.** |
| **STANDARD** | **CC.9-10.WHST.1.d.** | **Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.** |
| **STATE GOAL / DISCIPLINARY CONCEPT** | **IL.9-10.WHST.** | **Writing Standards for Literacy in Science and Technical Subjects** |
| **LEARNING STANDARD / DISCIPLINE** |  | **Text Types and Purposes** |
| **DESCRIPTOR / CONTENT DISCIPLINE** | **CC.9-10.WHST.2.** | **Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.** |
| **STANDARD** | **CC.9-10.WHST.2.a.** | **Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.** |
| **STANDARD** | **CC.9-10.WHST.2.b.** | **Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.** |
| **STANDARD** | **CC.9-10.WHST.2.c.** | **Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts.** |
| **STANDARD** | **CC.9-10.WHST.2.d.** | **Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers.** |
| **STANDARD** | **CC.9-10.WHST.2.e.** | **Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.** |
| **STANDARD** | **CC.9-10.WHST.2.f.** | **Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).** |
| **STATE GOAL / DISCIPLINARY CONCEPT** | **IL.9-10.WHST.** | **Writing Standards for Literacy in Science and Technical Subjects** |
| **LEARNING STANDARD / DISCIPLINE** |  | **Production and Distribution of Writing** |
| **DESCRIPTOR / CONTENT DISCIPLINE** | **CC.9-10.WHST.4.** | **Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.** |
| **DESCRIPTOR / CONTENT DISCIPLINE** | **CC.9-10.WHST.5.** | **Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.** |
| **STATE GOAL / DISCIPLINARY CONCEPT** | **IL.9-10.WHST.** | **Writing Standards for Literacy in Science and Technical Subjects** |
| **LEARNING STANDARD / DISCIPLINE** |  | **Range of Writing** |
| **DESCRIPTOR / CONTENT DISCIPLINE** | **CC.9-10.WHST.10.** | **Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.** |

| **Illinois Learning Standards** | | |
| --- | --- | --- |
| **Science** | | |
| Grades **11-12** - Adopted: **2014** | | |
| **STATE GOAL / DISCIPLINARY CONCEPT** | **IL.HS-LS.** | **LIFE SCIENCE** |
| **LEARNING STANDARD / DISCIPLINE** | **HS-LS1.** | **From Molecules to Organisms: Structures and Processes** |
| **DESCRIPTOR / CONTENT DISCIPLINE** |  | **Students who demonstrate understanding can:** |
| **STANDARD** | **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.** |
| **STANDARD** | **HS-LS1-2.** | **Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.** |
| **STANDARD** | **HS-LS1-4.** | **Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.** |
| **STANDARD** | **HS-LS1-6.** | **Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.** |
| **STATE GOAL / DISCIPLINARY CONCEPT** | **IL.HS-LS.** | **LIFE SCIENCE** |
| **LEARNING STANDARD / DISCIPLINE** | **HS-LS3.** | **Heredity: Inheritance and Variation of Traits** |
| **DESCRIPTOR / CONTENT DISCIPLINE** |  | **Students who demonstrate understanding can:** |
| **STANDARD** | **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.** |
| **STANDARD** | **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, and/or (3) mutations caused by environmental factors.** |
| Grades **11-12** - Adopted: **2010** | | |
| **STATE GOAL / DISCIPLINARY CONCEPT** | **IL.11-12.RST.** | **Reading Standards for Literacy in Science and Technical Subjects** |
| **LEARNING STANDARD / DISCIPLINE** |  | **Key Ideas and Details** |
| **DESCRIPTOR / CONTENT DISCIPLINE** | **CC.11-12.RST.2.** | **Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.** |
| **STATE GOAL / DISCIPLINARY CONCEPT** | **IL.11-12.RST.** | **Reading Standards for Literacy in Science and Technical Subjects** |
| **LEARNING STANDARD / DISCIPLINE** |  | **Craft and Structure** |
| **DESCRIPTOR / CONTENT DISCIPLINE** | **CC.11-12.RST.4.** | **Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.** |
| **DESCRIPTOR / CONTENT DISCIPLINE** | **CC.11-12.RST.5.** | **Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.** |
| **STATE GOAL / DISCIPLINARY CONCEPT** | **IL.11-12.RST.** | **Reading Standards for Literacy in Science and Technical Subjects** |
| **LEARNING STANDARD / DISCIPLINE** |  | **Integration of Knowledge and Ideas** |
| **DESCRIPTOR / CONTENT DISCIPLINE** | **CC.11-12.RST.9.** | **Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.** |
| **STATE GOAL / DISCIPLINARY CONCEPT** | **IL.11-12.RST.** | **Reading Standards for Literacy in Science and Technical Subjects** |
| **LEARNING STANDARD / DISCIPLINE** |  | **Range of Reading and Level of Text Complexity** |
| **DESCRIPTOR / CONTENT DISCIPLINE** | **CC.11-12.RST.10.** | **By the end of grade 12, read and comprehend science/technical texts in the grades 11-12 text complexity band independently and proficiently.** |
| **STATE GOAL / DISCIPLINARY CONCEPT** | **IL.11-12.WHST.** | **Writing Standards for Literacy in Science and Technical Subjects** |
| **LEARNING STANDARD / DISCIPLINE** |  | **Text Types and Purposes** |
| **DESCRIPTOR / CONTENT DISCIPLINE** | **CC.11-12.WHST.1.** | **Write arguments focused on discipline-specific content.** |
| **STANDARD** | **CC.11-12.WHST.1.d.** | **Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.** |
| **STATE GOAL / DISCIPLINARY CONCEPT** | **IL.11-12.WHST.** | **Writing Standards for Literacy in Science and Technical Subjects** |
| **LEARNING STANDARD / DISCIPLINE** |  | **Text Types and Purposes** |
| **DESCRIPTOR / CONTENT DISCIPLINE** | **CC.11-12.WHST.2.** | **Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.** |
| **STANDARD** | **CC.11-12.WHST.2.a.** | **Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.** |
| **STANDARD** | **CC.11-12.WHST.2.b.** | **Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.** |
| **STANDARD** | **CC.11-12.WHST.2.c.** | **Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts.** |
| **STANDARD** | **CC.11-12.WHST.2.d.** | **Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.** |
| **STANDARD** | **CC.11-12.WHST.2.e.** | **Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).** |
| **STATE GOAL / DISCIPLINARY CONCEPT** | **IL.11-12.WHST.** | **Writing Standards for Literacy in Science and Technical Subjects** |
| **LEARNING STANDARD / DISCIPLINE** |  | **Production and Distribution of Writing** |
| **DESCRIPTOR / CONTENT DISCIPLINE** | **CC.11-12.WHST.4.** | **Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.** |
| **DESCRIPTOR / CONTENT DISCIPLINE** | **CC.11-12.WHST.5.** | **Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.** |
| **STATE GOAL / DISCIPLINARY CONCEPT** | **IL.11-12.WHST.** | **Writing Standards for Literacy in Science and Technical Subjects** |
| **LEARNING STANDARD / DISCIPLINE** |  | **Range of Writing** |
| **DESCRIPTOR / CONTENT DISCIPLINE** | **CC.11-12.WHST.10.** | **Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.** |

| **New York State Learning Standards and Core Curriculum** | | |
| --- | --- | --- |
| **Science** | | |
| Grades **9-10** - Adopted: **2016** | | |
| **STRAND / DOMAIN / UNIFYING THEME** | **NY.HS.6.** | **Structure and Function** |
| **CATEGORY / CLUSTER / KEY IDEA** |  | **Students who demonstrate understanding can:** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **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.** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **HS-LS1-2.** | **Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.** |
| **STRAND / DOMAIN / UNIFYING THEME** | **NY.HS.7.** | **Matter and Energy in Organisms and Ecosystems** |
| **CATEGORY / CLUSTER / KEY IDEA** |  | **Students who demonstrate understanding can:** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **HS-LS1-6.** | **Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements such as nitrogen, sulfur, and phosphorus to form amino acids and other carbon-based molecules.** |
| **STRAND / DOMAIN / UNIFYING THEME** | **NY.HS.9.** | **Inheritance and Variation of Traits** |
| **CATEGORY / CLUSTER / KEY IDEA** |  | **Students who demonstrate understanding can:** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **HS-LS1-4.** | **Use a model to illustrate cellular division (mitosis) and differentiation.** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **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.** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **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.** |
| Grades **9-10** - Adopted: **2011** | | |
| **STRAND / DOMAIN / UNIFYING THEME** | **NY.9-10.RST.** | **Reading Standards for Literacy in Science and Technical Subjects** |
| **CATEGORY / CLUSTER / KEY IDEA** |  | **Key Ideas and Details** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **9-10.RST.2.** | **Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.** |
| **STRAND / DOMAIN / UNIFYING THEME** | **NY.9-10.RST.** | **Reading Standards for Literacy in Science and Technical Subjects** |
| **CATEGORY / CLUSTER / KEY IDEA** |  | **Craft and Structure** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **9-10.RST.4.** | **Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **9-10.RST.5.** | **Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).** |
| **STRAND / DOMAIN / UNIFYING THEME** | **NY.9-10.RST.** | **Reading Standards for Literacy in Science and Technical Subjects** |
| **CATEGORY / CLUSTER / KEY IDEA** |  | **Integration of Knowledge and Ideas** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **9-10.RST.7.** | **Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **9-10.RST.9.** | **Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.** |
| **STRAND / DOMAIN / UNIFYING THEME** | **NY.9-10.RST.** | **Reading Standards for Literacy in Science and Technical Subjects** |
| **CATEGORY / CLUSTER / KEY IDEA** |  | **Range of Reading and Level of Text Complexity** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **9-10.RST.10.** | **By the end of grade 10, read and comprehend science/technical texts in the grades 9-10 text complexity band independently and proficiently.** |
| **STRAND / DOMAIN / UNIFYING THEME** | **NY.9-10.WHST.** | **Writing Standards for Literacy in Science and Technical Subjects** |
| **CATEGORY / CLUSTER / KEY IDEA** |  | **Text Types and Purposes** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **9-10.WHST.1.** | **Write arguments focused on discipline-specific content.** |
| **EXPECTATION / CONTENT SPECIFICATION** | **9-10.WHST.1.d.** | **Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.** |
| **STRAND / DOMAIN / UNIFYING THEME** | **NY.9-10.WHST.** | **Writing Standards for Literacy in Science and Technical Subjects** |
| **CATEGORY / CLUSTER / KEY IDEA** |  | **Text Types and Purposes** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **9-10.WHST.2.** | **Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.** |
| **EXPECTATION / CONTENT SPECIFICATION** | **9-10.WHST.2.a.** | **Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.** |
| **EXPECTATION / CONTENT SPECIFICATION** | **9-10.WHST.2.b.** | **Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.** |
| **EXPECTATION / CONTENT SPECIFICATION** | **9-10.WHST.2.c.** | **Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts.** |
| **EXPECTATION / CONTENT SPECIFICATION** | **9-10.WHST.2.d.** | **Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers.** |
| **EXPECTATION / CONTENT SPECIFICATION** | **9-10.WHST.2.e.** | **Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.** |
| **EXPECTATION / CONTENT SPECIFICATION** | **9-10.WHST.2.f.** | **Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).** |
| **STRAND / DOMAIN / UNIFYING THEME** | **NY.9-10.WHST.** | **Writing Standards for Literacy in Science and Technical Subjects** |
| **CATEGORY / CLUSTER / KEY IDEA** |  | **Production and Distribution of Writing** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **9-10.WHST.4.** | **Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **9-10.WHST.5.** | **Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **9-10.WHST.6.** | **Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.** |
| **STRAND / DOMAIN / UNIFYING THEME** | **NY.9-10.WHST.** | **Writing Standards for Literacy in Science and Technical Subjects** |
| **CATEGORY / CLUSTER / KEY IDEA** |  | **Range of Writing** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **9-10.WHST.10.** | **Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.** |

| **New York State Learning Standards and Core Curriculum** | | |
| --- | --- | --- |
| **Science** | | |
| Grades **11-12** - Adopted: **2016** | | |
| **STRAND / DOMAIN / UNIFYING THEME** | **NY.HS.6.** | **Structure and Function** |
| **CATEGORY / CLUSTER / KEY IDEA** |  | **Students who demonstrate understanding can:** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **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.** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **HS-LS1-2.** | **Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.** |
| **STRAND / DOMAIN / UNIFYING THEME** | **NY.HS.7.** | **Matter and Energy in Organisms and Ecosystems** |
| **CATEGORY / CLUSTER / KEY IDEA** |  | **Students who demonstrate understanding can:** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **HS-LS1-6.** | **Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements such as nitrogen, sulfur, and phosphorus to form amino acids and other carbon-based molecules.** |
| **STRAND / DOMAIN / UNIFYING THEME** | **NY.HS.9.** | **Inheritance and Variation of Traits** |
| **CATEGORY / CLUSTER / KEY IDEA** |  | **Students who demonstrate understanding can:** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **HS-LS1-4.** | **Use a model to illustrate cellular division (mitosis) and differentiation.** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **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.** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **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.** |
| Grades **11-12** - Adopted: **2011** | | |
| **STRAND / DOMAIN / UNIFYING THEME** | **NY.11-12.RST.** | **Reading Standards for Literacy in Science and Technical Subjects** |
| **CATEGORY / CLUSTER / KEY IDEA** |  | **Key Ideas and Details** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **11-12.RST.2.** | **Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.** |
| **STRAND / DOMAIN / UNIFYING THEME** | **NY.11-12.RST.** | **Reading Standards for Literacy in Science and Technical Subjects** |
| **CATEGORY / CLUSTER / KEY IDEA** |  | **Craft and Structure** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **11-12.RST.4.** | **Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **11-12.RST.5.** | **Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.** |
| **STRAND / DOMAIN / UNIFYING THEME** | **NY.11-12.RST.** | **Reading Standards for Literacy in Science and Technical Subjects** |
| **CATEGORY / CLUSTER / KEY IDEA** |  | **Integration of Knowledge and Ideas** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **11-12.RST.9.** | **Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.** |
| **STRAND / DOMAIN / UNIFYING THEME** | **NY.11-12.RST.** | **Reading Standards for Literacy in Science and Technical Subjects** |
| **CATEGORY / CLUSTER / KEY IDEA** |  | **Range of Reading and Level of Text Complexity** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **11-12.RST.10.** | **By the end of grade 12, read and comprehend science/technical texts in the grades 11-12 text complexity band independently and proficiently.** |
| **STRAND / DOMAIN / UNIFYING THEME** | **NY.11-12.WHST.** | **Writing Standards for Literacy in Science and Technical Subjects** |
| **CATEGORY / CLUSTER / KEY IDEA** |  | **Text Types and Purposes** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **11-12.WHST.1.** | **Write arguments focused on discipline-specific content.** |
| **EXPECTATION / CONTENT SPECIFICATION** | **11-12.WHST.1.d.** | **Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.** |
| **STRAND / DOMAIN / UNIFYING THEME** | **NY.11-12.WHST.** | **Writing Standards for Literacy in Science and Technical Subjects** |
| **CATEGORY / CLUSTER / KEY IDEA** |  | **Text Types and Purposes** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **11-12.WHST.2.** | **Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.** |
| **EXPECTATION / CONTENT SPECIFICATION** | **11-12.WHST.2.a.** | **Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.** |
| **EXPECTATION / CONTENT SPECIFICATION** | **11-12.WHST.2.b.** | **Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.** |
| **EXPECTATION / CONTENT SPECIFICATION** | **11-12.WHST.2.c.** | **Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts.** |
| **EXPECTATION / CONTENT SPECIFICATION** | **11-12.WHST.2.d.** | **Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.** |
| **EXPECTATION / CONTENT SPECIFICATION** | **11-12.WHST.2.e.** | **Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).** |
| **STRAND / DOMAIN / UNIFYING THEME** | **NY.11-12.WHST.** | **Writing Standards for Literacy in Science and Technical Subjects** |
| **CATEGORY / CLUSTER / KEY IDEA** |  | **Production and Distribution of Writing** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **11-12.WHST.4.** | **Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **11-12.WHST.5.** | **Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.** |
| **STRAND / DOMAIN / UNIFYING THEME** | **NY.11-12.WHST.** | **Writing Standards for Literacy in Science and Technical Subjects** |
| **CATEGORY / CLUSTER / KEY IDEA** |  | **Range of Writing** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **11-12.WHST.10.** | **Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.** |