**Lesson Plan: Blood Cells**

*Last updated: 3/27/2024*

**Total Expected Time**

This set of labs includes five labs, approximately 30 minutes each, for a total expected time of 2.5 hours.

**Resources**

Required resources for students:

* Visible Biology: <https://www.visiblebody.com/teaching-anatomy/courseware-biology>
  + Use Visible Body’s interactive 3D models to learn about the structure and functions of blood cells. 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 the different types of blood cells.
* Visible Body’s Biology Learn Site articles and glossaries
  + Overview of Blood: [www.visiblebody.com/learn/biology/blood-cells/blood-overview](http://www.visiblebody.com/learn/biology/blood-cells/blood-overview)
  + Red Blood Cells and Platelets: [www.visiblebody.com/learn/biology/blood-cells/red-blood-cells-platelets](http://www.visiblebody.com/learn/biology/blood-cells/red-blood-cells-platelets)
  + Granular Myeloid White Blood Cells: [www.visiblebody.com/learn/biology/blood-cells/granular-myeloid-white-blood-cells](http://www.visiblebody.com/learn/biology/blood-cells/granular-myeloid-white-blood-cells)
  + Agranular Myeloid White Blood Cells: [www.visiblebody.com/learn/biology/blood-cells/agranular-myeloid-white-blood-cells](http://www.visiblebody.com/learn/biology/blood-cells/agranular-myeloid-white-blood-cells)
  + Lymphoid White Blood Cells: [www.visiblebody.com/learn/biology/blood-cells/agranular-lymphoid-white-blood-cells](http://www.visiblebody.com/learn/biology/blood-cells/agranular-lymphoid-white-blood-cells)
  + Blood Cells Glossary: <https://www.visiblebody.com/learn/biology/blood-cells/glossary>
* Lab Activity: Blood Cells: <https://www.visiblebody.com/hubfs/lab-activities/biology-site-license/visible-biology-site-license-lab-activities_blood-cells_student.pdf?hsLang=en>

Additional resources for students and teachers:

* This lesson assumes that students have a basic understanding of blood cells. Students can read each of the following sections of the OpenStax Biology textbook to learn more about the following topics:
  + [Components of blood](https://openstax.org/books/biology-2e/pages/40-2-components-of-the-blood)
  + [Innate immune response](https://openstax.org/books/biology-2e/pages/42-1-innate-immune-response)
  + [Adaptive immune response](https://openstax.org/books/biology-2e/pages/42-2-adaptive-immune-response)

**Objectives**

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

1. Identify the components of blood, including plasma, red blood cells, platelets, and the five types of white blood cells.
2. Examine histology slides of peripheral blood smears to learn about the size, shape, stain color, spatial distribution, and relative abundance of blood cells you would see when viewing them using a microscope.
3. Compare red blood cells and platelets (activated and inactivated), in terms of size and structure.
4. Explore the structure and functions of red blood cells.
5. Explore the structure and functions of platelets.
6. Compare the structure and functions of the three types of granular myeloid white blood cells: neutrophils, basophils, and eosinophils.
7. Explore the structure and functions of monocytes (activated and inactivated), which are agranular myeloid white blood cells.
8. Compare the structure and functions of the three types of lymphoid white blood cells, or lymphocytes: B cells, T cells, and natural killer cells.
9. Compare the structure and functions of the five types of white blood cells: neutrophils, basophils, eosinophils, monocytes, and lymphocytes.

**Essential Questions**

1. What are the components that make up blood and what are their functions?
2. How are blood cells produced?
3. What are the five types of white blood cells and how do they compare, in terms of structure and functions?

**Key Structure Identification**

In their answers, students will identify the following structures:

* Red blood cells and platelets: Platelet (activated), platelet (inactivated), and red blood cell.
* Granular myeloid white blood cells: Basophil, eosinophil, neutrophil, cytoplasm, granules, and nucleus.
* Agranular myeloid white blood cells: Monocyte (activated), monocyte (inactivated), cytoplasm, nucleus, and pseudopodia.
* Lymphoid white blood cells (lymphocytes): B cell or T cell, natural killer cell, granules, microvilli, and nucleus.

**Introduction**

10 minutes: Use the content in Visible Biology and the Biology Learn Site, as well as the OpenStax pages referenced in the additional resources above, to give students a brief introduction to blood cells. Distinguish between red blood cells, platelets, and the five types of white blood cells, focusing on their structure and functions.

**Introductory Note About the Visuals in These Labs**

In labs on blood cells, you’d normally have your students look at blood smears using a microscope. In this set of labs, your students will examine 3D models of blood cells suspended in plasma.

* To make it possible for you to view the cells in 3D, we’ve created these models to look like drops of blood before they’re smeared.
* To set the different structures apart, we’ve applied the stain colors as they would appear when viewed on a microscope slide. You can rotate the model and view it from above to see a 3D representation of what the cells might look like once they’ve been smeared, fixed, and stained.
* You can rotate the model and zoom inside the plasma to take a closer look at the structure of the blood cells, see how different types of blood cells compare to each other, and see how blood cells might be spatially distributed in a peripheral blood sample.

We’ve taken some artistic license with these models, so please keep the following in mind:

* We’ve grouped the blood cells into commonly used categories for comparison purposes. As a result, some of these models may group blood cells together that normally would not be seen in the same blood smear.
* Some of the white blood cells look very similar or identical to each other. To set them apart, we’ve used color and labels.
* In some cases, we’ve included structural characteristics that would not be visible using a normal light microscope, such as microvilli.

**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: Red Blood Cells and Platelets (30 minute lab session)
  + Pre-Lab Activity: Examine red blood cells and platelets on a histology slide
  + Activity 1: Label red blood cells and platelets
  + Activity 2: Explore the structure and functions of red blood cells
  + Activity 3: Explore the structure and functions of platelets
* Lab 2: Granular Myeloid White Blood Cells (30 minute lab session)
  + Pre-Lab Activity: Examine neutrophils, basophils, and eosinophils on histology slides
  + Activity 1: Label a neutrophil, a basophil, and an eosinophil
  + Activity 2: Compare neutrophils, basophils, and eosinophils
* Lab 3: Agranular Myeloid White Blood Cells (30 minute lab session)
  + Pre-Lab Activity: Examine a monocyte on a histology slide
  + Activity 1: Label activated and inactivated monocytes
  + Activity 2: Explore the structure and functions of monocytes
* Lab 4: Lymphoid White Blood Cells (30 minute lab session)
  + Pre-Lab Activity: Examine a lymphocyte on a histology slide
  + Activity 1: Label a B cell, a T cell, and a natural killer cell
  + Activity 2: Compare B cells, T cells, and natural killer cells
* Lab 5: Compare the Five Types of White Blood Cells (20-30 minute lab session)

Check students’ work using the answer key.

**NGSS and State Science Correlations**

| **Next Generation Science Standards (NGSS)** |
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| **Science** |
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| Grades **9-12** - Adopted: **2013** | | |
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| **STRAND** | **NGSS.HS-LS** | **LIFE SCIENCE** |
| **TITLE** | **HS-LS1** | **From Molecules to Organisms: Structures and Processes** |
|  |  | **Students who demonstrate understanding can:** |
| **PERFORMANCE EXPECTATION** | **HS-LS1-2** | **Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.** |
| **PERFORMANCE EXPECTATION** | **HS-LS1-3** | **Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.** |

| **Texas Essential Knowledge and Skills (TEKS)** |
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| **Science** |
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| Grades **9-12** - Adopted: **2017** | | |
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| **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.** |
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| **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** |
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| **Science** |
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| Grades **9-12** - Adopted: **2013** | | |
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| **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-LS1-2.** | **Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.** |
| **FOUNDATION / PROFICIENCY LEVEL** | **HS-LS1-3.** | **Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.** |

| **CONTENT STANDARD / DOMAIN / PART** | **CA.RST.9-10.** | **Reading Standards for Literacy in Science and Technical Subjects** |
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| **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** |
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| **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** |
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| **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** |
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| **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** |
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| **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** |
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| **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** |
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| **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** |
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| **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** |
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| **Science** |
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| Grades **9-12** - Adopted: **2008** | | |
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| **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** |
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| **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** |
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| **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.14.34.** | **Describe the composition and physiology of blood, including that of the plasma and the formed elements.** |
| **BENCHMARK** | **SC.912.L.14.35.** | **Describe the steps in hemostasis, including the mechanism of coagulation. Include the basis for blood typing and transfusion reactions.** |
| **BENCHMARK** | **SC.912.L.14.42.** | **Describe the anatomy and the physiology of the lymph system.** |
| **BENCHMARK** | **SC.912.L.14.52.** | **Explain the basic functions of the human immune system, including specific and nonspecific immune response, vaccines, and antibiotics.** |

| Grades **9-12** - Adopted: **2014** | | |
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| **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** |
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| **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** |
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| **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** |
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| **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** |
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| **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** |
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| **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** |
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| **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)** | | |
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| **Science** | | |
| Grades **9-12** - Adopted: **2022** | | |
| **Discipline** | **3.1.** | **Life Science** |
| **Strand** |  | **Structure and Function** |
| **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.** |
| **Standard** | **3.1.9-12.C.** | **Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.** |

| **Illinois Learning Standards** | | |
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| **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-LS1-2.** | **Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.** |
| **STANDARD** | **HS-LS1-3.** | **Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.** |
| Grade **9** - 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.** |

| **New York State Learning Standards and Core Curriculum** | | |
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| **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-LS1-2.** | **Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **HS-LS1-3.** | **Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.** |
| 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** | | |
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| **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-LS1-2.** | **Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.** |
| **STANDARD / CONCEPTUAL UNDERSTANDING** | **HS-LS1-3.** | **Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.** |
| 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.** |