Disciplinary Literacy in High School Science

Purpose of this Document

This document is intended to illustrate how disciplinary literacy skills develop in science and possible strategies that teachers can use while helping their students deepen their understanding of science content and practices. It is important to note that the 2016 ELA Standards are meant to complement the specific content demands of the Arizona High School Science Standards, not replace them.

In this document, **text** is broadly defined as any communication, spoken, written, or visual, involving language. This include written words, numbers, and symbols; visual representations in graphs, pictures, flowcharts, videos, and computer simulations; information provided by reading scientific tools and instruments; published documents in print or electronic format; unpublished documents written by students, peers, or teachers; or other sources of information.

Science Sense-Making

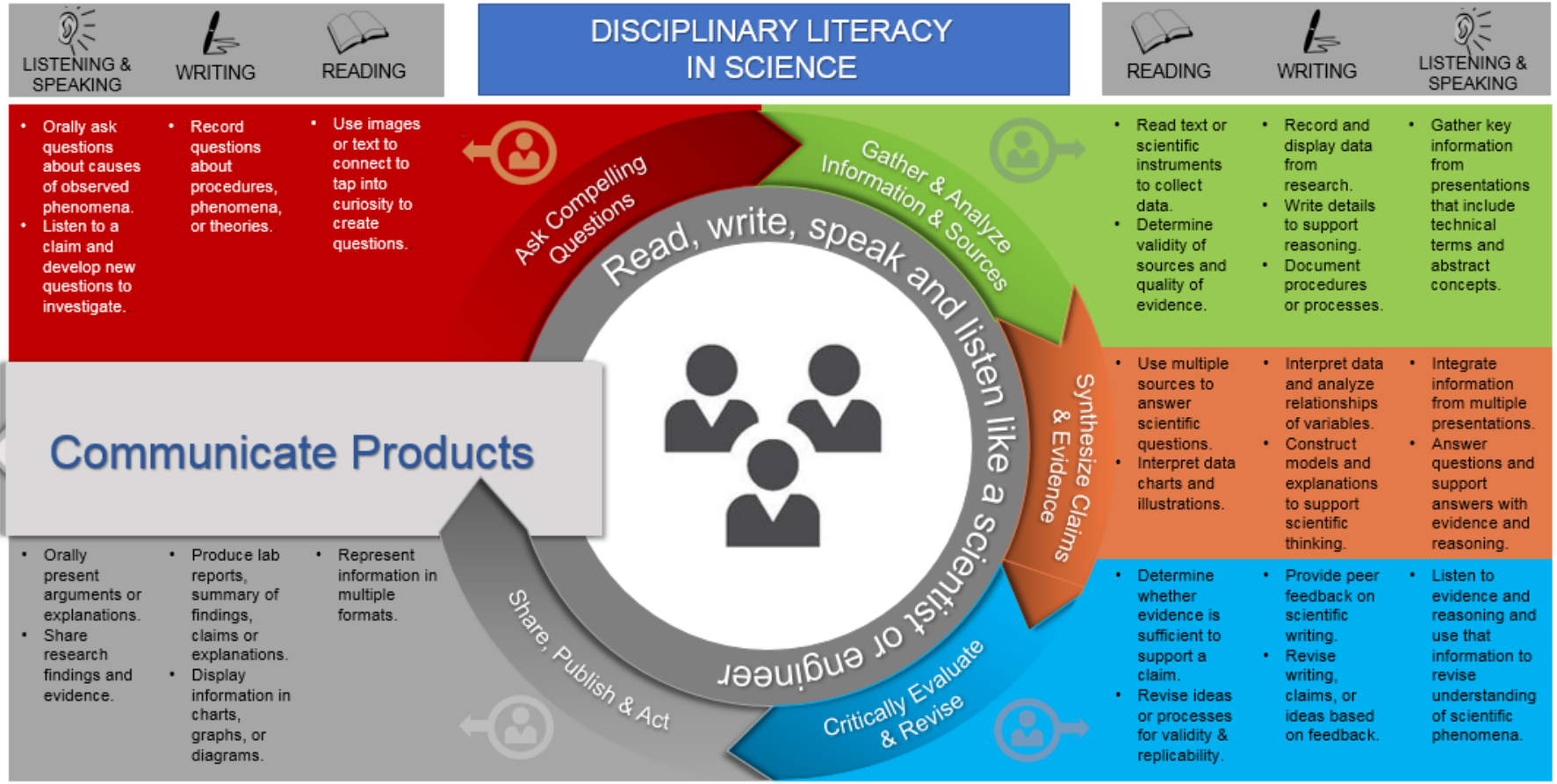
A fundamental goal of science education is to help students figure out how the world works and make sense of scientific phenomena or compelling questions. A scientific phenomenon is an event or situation that is observed to exist or happen, especially one whose cause or explanation is in question. Sense-making is a conceptual process in which a learner actively engages with scientific phenomena to construct logical and coherent explanations that incorporate their current understanding of science and are consistent with the available evidence. To develop a scientific understanding of the natural and designed worlds, and to answer compelling questions in science, students must be able to:

- **Gather and analyze** sources and information
- **Synthesize claims and evidence** to support reasoning
- **Critically evaluate and revise** ideas and connect them to scientific principles and theories
- **Communicate** understanding and reasoning through a variety of methods or products

Disciplinary Literacy in Science

Disciplinary literacy in science focuses on how reading, writing, speaking, and listening are used to develop sense-making in science. It emphasizes the content knowledge, experiences and skills, and ability to acquire new knowledge that experts within science disciplines use to apply and generate new knowledge.

As students begin to develop disciplinary literacy in science, they use strategies to build background knowledge and experiences specific to science content and practices, learn specialized vocabulary, deconstruct complex text structures, map graphic and mathematical representations against explanations in text, pose discipline-specific questions, and provide evidence to support, evaluate, and communicate claims. As students develop disciplinary literacy in science, they strengthen their ability to think critically in a way that is meaningful to developing scientific understanding of the world and scientific habits of mind.



Reading Informational Text

Reading and interpreting scientific and technical text is critical to building knowledge in science and engineering. The 2016 ELA Standards provide the skills for students to do this. This section of the document illustrates ways science teachers can help students apply reading standards as they develop disciplinary literacy in science.

Key Ideas and Details	Using **Key Ideas and Details** to Build Disciplinary Literacy in Science
(Link to 9-10.RI.1, 9-10.RI.2, 9-10.RI.3 and 11-12.RI.1, 11-12.RI.2, 11-12.RI.3) These ELA standards help students gather and analyze sources and information (evidence from text) that can be used to support their reasoning as they develop conceptual understanding of science phenomena.	Key Ideas and Details standards can be applied to help students: • Find answers to relevant science questions or problems. • Understand and follow a written lab protocol, scientific process or procedure. • Connect new understandings with background knowledge. • Determine which information is important to answering scientific questions. • Pay attention to details, accuracy, and precision when reading/collecting data from scientific instruments. • Interpret diagrams, pictures, charts, graphs, and data to gather information. • Interpret and evaluate quality and quantity of data, evidence, and scientific reasoning. • Determine the credibility and validity of information, including research design, sample size, date of publication, visual representations of data and findings, or whether the supporting research has been peer reviewed.

Craft and Structure	Using **Craft and Structure** to Build Disciplinary Literacy in Science
Link to 9-10.RI.4, 9-10.RI.5, 9-10.RI.6 and 11-12.RI.4, 11-12.RI.5, 11-12.RI.6) These ELA standards help students navigate the norms and conventions of complex science text. Scientific and technical text often contains a variety of text structures, visual representations, and vocabulary that has a very specific meaning across science disciplines (theory) or within a single discipline (precipitation in weather vs. precipitation in chemical reactions).	Craft and Structure standards can be applied to help students: • Use strategies (context clues, linguistic roots and affixes, restatement, examples, contrast, glossary, etc.) to determine the meaning of words and phrases in the text. • Use context to determine meanings of words and differentiate how vocabulary may be used differently in a science context compared to non-science contexts. • Identify structures within a text (headings, sub-headings, bold words, pictures, graphs, data tables, and paragraphs) and explain how they support or supplement information in the paragraph text. • Explain how key terms relate to each other or to broader science concepts and general understanding. • Use information to answer questions and support reasoning and conclusions. • Make meaning out of mathematical symbols and equations; diagrams, flow charts and other visual representations; and abstract ideas.

Integration of Knowledge and Ideas	Using **Integration of Knowledge and Ideas** to Build Disciplinary Literacy in Science
(Link to 9-10.RI.7, 9-10.RI.8, 9-10.RI.9 & 11-12.RI.7, 11-12.RI.8, 11-12.RI.9) These ELA standards help students integrate and synthesize scientific knowledge and ideas when obtaining, evaluating, and communicating information. Students integrate information to evaluate the merit, validity, and reliability of ideas, methods, claims, and designs. They use this knowledge to generate their own questions about scientific phenomena or to identify solutions to design problems.	Integration of Knowledge and Ideas standards can be applied to help students: • Extract information from multiple sources and text types; synthesize information to create an understanding that aligns to current scientific explanations and understanding. • Compare multiple representations of information (quantitative data, video, multimedia, articles, books, photographs, infographics, diagrams, etc.) related to the same phenomenon or science concept and explain whether the representations convey similar levels of detail or whether the information supports or contradicts each other. • Interpret data and analyze relationships of variables, using words and visual information. • Accurately depict written or spoken words through a visual representation (graph, chart, picture, etc.); or vice versa. • Synthesize multiple sources of information to support an evaluation of scientific research or reports, their experimental design, data collection methods, analysis, or conclusions. • Identify an argument or claim by distinguishing among facts, research findings, inferences, speculation, and reasoning; determine whether the evidence is relevant and sufficient to support the claim.

Range of Reading and Level of Complexity	Using **Range of Reading and Level of Complexity** to Build Disciplinary Literacy in Science
(Link to 9-10.RI.10, 11-12.RI.10) This ELA standard requires that students engage with different lengths, structures, types, and complexities of science text. Reading science texts requires a set of discipline-specific skills and strategies. Science texts use scientific vocabulary and present information in multiple formats.	Implementation strategies for this standard are embedded in the previous reading examples. Students in science classrooms often read at different levels of proficiency, and even the same student may read at different levels based on text structures or format. Teachers should understand the complexity of the text provided to students and implement appropriate strategies to support student conceptual understanding of science phenomena.

Writing

Writing is a key means of engaging in argument from evidence and requires students to construct a convincing argument that supports or refutes claims for explanations about the natural world. Students use appropriate and sufficient evidence and scientific reasoning to defend and critique the validity and reliability of claims and explanations about the natural world, or methods for collecting data and evidence.

The 2016 ELA Standards provide the skills for students to assert and defend claims, show what they know about a subject, and convey what they have experienced, thought, and designed. This section of the document illustrates ways science teachers can help students apply writing standards as they develop disciplinary literacy in science. Scientific writing may include:

- informal writing (notes based on observations, summarizations of technical texts, making thinking visible by tracking how understanding of phenomena changes over time)
- formal writing (lab reports, documenting procedures, investigation designs, explanations of models, and research)
- persuasive writing (calls for action, letters to editors/policy makers, position statements)

Text Types and Purposes	Using **Text Types and Purposes** to Build Disciplinary Literacy in Science
(Link to 9-10.W.1, 9-10.W.2, 9-10.W.3 and 11-12.W.1, 11-12.W.2, 11-12.W.3) These ELA standards help students write in formats that are typically found in science contexts or may be specific for their content area. Typically, only formal science writing is written in passive/third person voice. It is critical that students know how to incorporate appropriate visual representations to support the scientific explanations and arguments they write.	Text Types and Purposes standards can be applied to help students: • Record thoughts, ideas, sketches, or collected data in science notebooks to be used as evidence or to support reasoning. • Write a claim, evidence-based argument, or explanation that includes logical reasoning, accurate science content, and relevant and sufficient evidence to support the claim. Claims are created with effective word choice, appropriate use of science vocabulary, and writing style. • Write formal or informal texts. The product may include field notes, mind maps, research papers, laboratory reports, functional text, or visual displays of data. • Produce science writing in a voice appropriate for the type of writing and the audience. Objective or academic voice in science is used when a writer wants to deliver information in a neutral, factual, and unbiased way. • Write step-by-step procedures for experiments that are detailed enough that others would be able to replicate their experiments exactly and achieve the same results. • Produce texts that include charts, graphs, timelines, photographs, videos, maps, flowcharts, diagrams, models, or tables to supplement or support the text.

Production and Distribution of Writing	Using **Production and Distribution of Writing** to Build Disciplinary Literacy in Science
(Link to 9-10.W.4, 9-10.W.5, 9-10.W.6 and 11-12.W.4, 11-12.W.5, 11-12.W.6) These ELA standards help students develop scientific writing appropriate for task, purpose and audience.	Production and Distribution of Writing standards can be applied to help students: • Develop and strengthen writing; focus on purpose and audience. • Incorporate peer or adult feedback of drafts into writing; the writing process and review of drafts can be used for any writing assignments within the science classroom. • Use technology (Internet, keyboarding skills, formatting, storing) to create a published piece where information and ideas are connected and presented clearly and efficiently. • Use technology (blogs, wikis, smartboards, apps) to support collaborative brainstorming and writing. • Integrate graphs, data tables, drawings or illustrations, or other visual representations of information to support text.

Research to Build and Present Knowledge	Using **Research to Build and Present Knowledge** to Build Disciplinary Literacy in Science
(Link to 9-10.W.7, 9-10.W.8, 9-10.W.9 and 11-12.W.7, 11-12.W.8, 11-12.W.9) These ELA standards help students synthesize multiple texts, observations, or experiments to answer questions, gather information, reason about the evidence, and communicate findings or conclusions. Final communication products typically follow a formal writing style (documenting or publishing procedures, investigation designs, explanations of models, and research) and are written in academic or passive/third person voice.	Research to Build and Present Knowledge standards can be applied to help students: • Conduct research projects or experimental investigations of differing lengths to provide enough information to construct claims, evidence, and explanations that answer scientific questions or solve a problem. • Integrate information from a variety of credible print and digital sources, taking care to use a consistent voice, avoid plagiarism, and appropriately cite resources in a standard recognized format in both the text and the bibliography. (APA style is most commonly used by scientists) • Use evidence from informational texts (e.g., research papers, credible web sites, journal articles, textbooks) to support claims, analyses, reflections, and/or research. • Convert informal writing in drafts while still synthesizing information and developing claims, to a formal academic voice when publishing formal writing of claims.

Range of Writing	Using **Range of Writing** to Build Disciplinary Literacy in Science
(Link to 9-10.W.10 and 11-12.W.10) This ELA standard requires that students produce informal, formal, and persuasive scientific writing across multiple delivery formats and topics, for different purposes and audiences.	Implementation strategies for this standard are embedded in the previous writing examples. • Writing assignments should be of varying lengths (field or research notes, one paragraph responses, multiple paragraph essays, lab reports or presentations, extended research). • Scientific writing often includes pictures, diagrams, charts, thinking maps, data, or statistics; these can be integrated with text or presented with minimal text.

Speaking and Listening

Students must have ample opportunities to engage in science discourse across a variety of rich, conversations—as part of a whole class, in small groups, and with a partner. Being productive members of these conversations requires that students contribute accurate, relevant information; respond to and extend what others have said; make comparisons and contrasts; and analyze and synthesize a multitude of ideas in various domains. The 2016 ELA Standards provide the skills for students to do this. This section of the document illustrates ways science teachers can help students apply speaking and listening standards as they develop disciplinary literacy in science.

Comprehension and Collaboration	Using **Comprehension and Collaboration** to Build Disciplinary Literacy in Science
(Link to 9-10.SL.1, 9-10.SL.2, 9-10.SL.3 and 11-12.SL.1, 11-12.SL.2, 11-12.SL.3) These ELA standards help students engage in scientific discourse to gather and evaluate information. Engaging in scientific discourse communities to collaborate and build comprehension is a fundamental practice of science and engineering.	Comprehension and Collaboration standards can be applied to help students: • Initiate and participate effectively in a range of collaborative discussions (one-on-one, small groups, teacher-led, digitally) to express their own ideas clearly and building on others' ideas. • Integrate multiple sources of information presented in diverse media or formats (e.g., visually, quantitatively, orally), evaluating the credibility and accuracy of each source. • Collaboratively plan an investigation or test a design solution, controlling variables and ensuring the data is collected with appropriate tools and in a safe and ethical manner, including considerations of environmental, social, and personal impacts. • Collaboratively conduct investigations; evaluate the types, amounts, and accuracy of data needed to produce reliable measurements; consider limitations on the precision of the data (e.g., number of trials, cost, risk, time); and refine the design accordingly.

Presentation of Knowledge and Ideas	Using **Presentation of Knowledge and Ideas** to Build Disciplinary Literacy in Science
(Link to 9-10.SL.4, 9-10.SL.5, 9-10.SL.6 and 11-12.SL.4, 11-12.SL.5, 11-12.SL.6) These ELA standards help students engage in scientific discourse to informally share ideas and develop understanding of scientific phenomena and provide a formal way to present information appropriate to the audience and task. Engaging in scientific discourse communities to communicate understanding and findings is a fundamental practice of science and engineering.	Presentation of Knowledge and Ideas standards can be applied to help students: • Engage in science discourse with a partner or small group by discussing questions, information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of thinking and reasoning; organization, substance, and style are appropriate to purpose, audience, and task. • Engage in formal presentations to small or large groups of students to share findings and supporting evidence. Presentation should be clear, concise, and logical organized, so listeners can follow the line of reasoning; organization, development, substance, and style are appropriate to purpose, audience, and task. • Use digital media (e.g., textual, graphical, audio, visual, video conferencing, or interactive elements) when presenting findings to support claims, evidence, reasoning, and to add interest.

Annotated Vignette - HS Science

In a high school environmental science class, students have been learning about natural resources and geochemical cycles. Students have examined factors that impact current and future water quantity and quality, and are learning methods for water reclamation and conservation (Strand 6 Concept 1). They are starting to examine the impacts of human activities on water availability (Strand 3 Concept 1) and develop interventions or solutions (Strand 3 Concept 2).

Disciplinary Literacy Skills	Vignette of Student Activities During a Science Lesson
• RI= Gather information using key ideas and details • W= Synthesize research to build and present knowledge	Students read a paper on water reclamation and conservation. While reading, students relate key terms within the text to each other and the overall meaning of the text. They draw a diagram or flow chart in their science notebooks to summarize their understanding of the key methods for reclaiming and conserving water.
• RI= Gather information using key ideas and details • SL= Gather information using comprehension and collaboration • SL= Synthesize claims and evidence using comprehension and collaboration	The class watches a short video that showcases water efficient homes in Arizona. These homes are designed to use reclaimed water as a strategy for reducing the amount of water needed from the public water supply. After watching this video, small groups of students discuss ideas presented in the video about the water reclamation process. Students then generate questions about the water reclamation process and how it could be improved by designing better and cheaper reclamation equipment.
• RI= Gather information using key ideas and details • RI= Synthesize information using integration of knowledge and ideas • W= Synthesize information using research to build and present knowledge • SL= Synthesize claims and evidence using comprehension and collaboration • W= Communicate/publish using production and distribution of writing • SL= Communicate/share claims and evidence using presentation of knowledge and ideas	To deepen their understanding of the water reclamation process, students read an article that evaluates different methods of water reclamation. They analyze the relevance of the evidence within the article to determine which methods are viable ways to reclaim water. Small groups of students work together to make a recommendation to a city's water department for implementing the best water reclamation process. Students cite evidence from the article and any additional sources that support their recommendation. Groups share their recommendations with the class. Students actively listen, asking questions about the reasoning and evidence that support the recommendations being made and presenters explain the evidence and reasoning they used when making their recommendations.
• SL= Gather and analyze information using comprehension and collaboration • RL= Gather and analyze information using craft and structure	After developing an understanding that there is more than one way to reclaim water, students generate questions that lead to a lab investigation to determine if the water reclamation process can be improved. Small groups discuss issues with current water reclamation processes and identify why few residential homes are using this type of water conservation practice. Small groups research and test methods to reclaim water, write a description of the procedures

• W= Gather and analyze information using research to build and present knowledge • W= Gather and analyze information using production and distribution of writing • W= Synthesize information using research to build and present knowledge	followed, and record observations or measurements collected during experimental trials. Students then develop claims that can be made from their observations and identify the evidence that supports their claim.
• W= Synthesize information using research to build and present knowledge • W= Synthesize information using production and distribution of writing • W=Communicate/publish using production and distribution of writing • SL=Synthesize information using comprehension and collaboration • SL=Critically evaluate and revise using comprehension and collaboration • W=Communicate/publish using research to build and present knowledge	Each lab group uses technology, such as Google Docs, to collaborate while writing a formal report on the results and conclusions from the lab investigation. The report includes illustrations of group developed designs and tables/graphs of collected results. Students use online resources to find evidence that supports their experimental data. In the conclusion of the lab report students write a claim on which methods best recover water, and students support that claim with all research and laboratory observations. They provide brief descriptions of all diagrams or images included in the report, and appropriately cite research sources.
• W=Communicate/publish using production and distribution of writing • SL=Communicate/publish using presentation of knowledge and ideas • RI= Critically evaluate and revise using key ideas and details • SL=Critically evaluate and revise using comprehension and collaboration	Each group presents their claim and experimental findings to a different group for peer feedback. While watching and listening to another group present their findings, each student listens for evidence from experimental data and research, and looks for appropriate displays of content and images (photos, illustrations, videos). Students actively listen, ask questions to clarify understanding of the presented information, and provide constructive feedback.
• SL=Critically evaluate and revise using comprehension and collaboration • W=Critically evaluate and revise using production and distribution of writing • W=Communicate/publish using production and distribution of writing	After receiving peer feedback, each group revises their final report to make any needed changes.