Reading and Writing in Science

There are three dimensions to the new science framework: Scientific Practices, Crosscutting Concepts, and Disciplinary Core Ideas. The practices and concepts are included below.

Scientific Practices

1. Asking questions
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Crosscutting Concepts

1. Patterns
2. Cause and effect: Mechanism and explanation
3. Scale, proportion, and quantity
4. Systems and system models
5. Energy and matter: Flows, cycles, and conservation
6. Structure and function
7. Stability and change

From this list, you can see where reading and writing is naturally embedded within the practices and concepts. Two practices, in particular, are where reading and writing could be emphasized: Practice 6 (Constructing Explanations) and Practice 7 (Engaging in argument from evidence).

Practice 6: Constructing Explanations

The framework says, "Scientific explanations are accounts that link scientific theory with specific observations of phenomena – for example, they explain observed relationships between variables and describe the mechanisms that support cause and effect inferences about them." (p. 3-15). Additionally, explanations can then be used for argumentation:

> "Explanations are especially valuable for the classroom because of, rather than in spite of, the fact that there often are competing explanations offered for the same phenomenon – for example, the recent gradual rise in the mean surface temperature on Earth. Deciding on the best explanation is a matter of argument that is resolved by how well any given explanation fits with all available data, how much it simplifies what would seem to be complex, and whether it produces a sense of understanding." (p. 3-15)

By grade 12, students should be able to:

- Construct their own explanations of phenomena using their knowledge of accepted scientific theory and linking it to models and evidence.
- Use primary or secondary scientific evidence and models to support or refute an explanatory account of a phenomenon.
- Offer causal explanations appropriate to their level of scientific knowledge.
- Identify gaps or weaknesses in explanatory accounts (their own or those of others).

Progression:
- Early in their science education:
    - Students need to engage in constructing and critiquing explanations.
        - Students need to develop explanations of what they observe when conducting their own investigations
        - Students need to evaluate their own and others' explanations for consistency with the evidence.
- As knowledge develops:
    - Students should identify and isolate variables and incorporate the resulting observations into their explanations of phenomena.
    - Use their measurements of how one factor does or doesn't affect another to develop causal accounts to explain what they observe
    - Students should revisit their initial ideas and produce more complete explanations that account for more of their observations.
- By middle school:
    - Students recognize that many science explanations rely on models or representations of entities that are too small to see or too large to visualize.
    - Students should start to use math or simulations to construct an explanation for a phenomenon.

Practice 7: Engaging in Argument from Evidence
Scientists produce knowledge through reasoning that requires justified claims about the world. In response, other scientists try to determine the limits and weaknesses to these claims. There is a general format we use: claim, evidence, reasoning.

By grade 12, students should be able to:
- Construct a scientific argument showing how the data support the claim.
- Identify possible weaknesses in scientific arguments, appropriate to the students' level of knowledge, and discuss them using reasoning and evidence
- Identify flaws in their own arguments and modify and improve them in response to criticism
- Recognize that the major features of scientific arguments are claims, data, and reasons and distinguish these elements in examples.
- Explain the nature of the controversy in the development of a given scientific idea, describe the debate that surrounded its inception, and indicate why one particular theory succeeded.

- Explain how claims to knowledge are judged by the scientific community today and articulate the merits and limitations of peer review and the need for independent replication of critical investigations
- Read media reports of science or technology in a critical manner so as to identify their strengths and weaknesses.

Progression:

- Early in their science education:
    - Students should construct arguments for their own interpretation of the phenomena they observe and of any data they collect.
    - Students need support to go beyond simply making claims – that is, to include reasons or references to evidence and to begin to distinguish evidence from opinion.
- As knowledge develops:
    - Students should start to draw on a wider range of reasons or evidence, so that their arguments become more sophisticated.
    - Students should discern what aspects of evidence are potentially significant for supporting or refuting a particular argument.
- By middle school:
    - Students should start learning to critique by asking questions about their own findings and those of others
    - Students should identify weaknesses in either the data or an argument and explain why their criticism is justified.
    - Here is when they should be introduced to the language of argumentation: claim, evidence, reason

Common Core Links to Reading Standards for Literacy in Science

Grades 6-8 students: While many of these can apply generally, I selected the standards that most directly link to reading about scientific explanations and arguments.

Key Ideas and Details	**Craft and Structure**	**Integration of Knowledge and Ideas**
1. Cite specific textual evidence to support analysis of science and technical texts.	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 6-8 texts and topics	7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
2. Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions	5. Analyze the structure an author uses to organize a text, including how the major sections contribute to the whole and to an understanding of the topic	8. Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.
3. Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.	6. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.	9. Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic

Common Core Links to Writing Standards for Literacy in Science

Grades 6-8 students: While many of these can apply generally, I selected the standards that most directly link to writing scientific explanations and arguments.

Text Types and Purposes	Production and Distribution of Writing	Research to Build and Present Knowledge
1. Write arguments focused on discipline-specific content a. Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically b. Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources. c. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence. d. Establish and maintain a formal style e. Provide a concluding statement or section that follows from and supports the argument presented.	4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.	7. Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.	5. With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed.	8. Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.
3. N/A	6. Use technology, including the internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently.	9. Draw evidence from informational texts to support analysis, reflection, and research.