a task of synthesis and summarization—skills that need to be taught. Science writing is precise and concise. It employs technical and academic language. To support students, Mr. Clayton shares his Wiki example with writing on another science topic—one that connects to this previously studied standard. *MS-PS1-5. Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.* Mr. Clayton shares his electronic writing.

> The Law of Conservation of Matter states that you cannot create nor destroy matter. In the following example, the number of hydrogen and oxygen atoms is the same before and after the reaction: $2\,H_2 + O_2 \rightarrow 2\,H_2O$. Even during chemical reactions, the total number of each type of atom is conserved. Because of this, I know that mass doesn't change.

With this example, students are able to see that Mr. Clayton draws on known laws in science to support his statements, and provides a concrete science example. To augment his example, Mr. Clayton points out these elements of science writing so that students have a model to work from. The writing is technical (i.e., words like *conserved* and *resulting*) and concise.

WRITING FRAMES: SCAFFOLDS FOR SCIENTIFIC WRITING

In Table 4.3 we identify both the NGSS and CCSS that call for students to evaluate and share evidence using very precise scientific language. The scenario of a ninth-grade class taught by Mr. Williams illustrates how to provide instructional supports that enable students to accomplish the scientific knowledge and language sophisticated identified by these standards.

Sentence Frames

Imagine that the students in Ms. Williams' ninth-grade Earth science class have an understanding of Alfred Wegener's continental drift idea and about the sea-floor spreading theory developed by Harry Hess and R. Deitz. They've worked with animated models of plates on computer screens and have collaborated in teams to use magnetic anomalies to calculate spreading rates. In essence, the students have studied the most relevant work of researchers in this field and have engaged in problem-based activities. Given this, we have to ask whether every student is ready to respond in writing to a prompt that asks them to relate the history and development of the theory of plate tectonics. Most likely, even some of the most diligent students will not be able to respond to such a prompt.

Table 4.3 Address CCSS for Writing and NGSS in a Ninth-Grade Earth Science Classroom

Crosscutting Concepts: Patterns, Stability, and Change

Core Ideas: ESS1.C: The History of Planet Earth; ESS2.A: Earth Materials and Systems

Lesson Purpose: To evaluate and explain evidence of the past and current movements of continental and oceanic crust in terms of the theory of plate tectonics.

Focus Strategy: Writing Frames

NGSS

> HS-ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.

CCSS

Writing Standards

> CCSS.ELA-Literacy.W.9-10.2. Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content.
>
> a. Introduce a topic; organize complex 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.
> 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.
> c. Use appropriate and varied transitions to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts.
> d. Use precise language and domain-specific vocabulary to manage the complexity of the topic.
> 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.
> 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).

Sonia, an eager, hardworking ninth grader, sits with a blank paper on her desk, twirling her pencil as she flips through the pages of Chapter 5 in her text. It's clear that Sonia, an active participant in labs and an avid reader in science class, is still unable to begin. Perhaps for some students, there is still something missing. Are there ways for teachers to help students like Sonia, students who have the information they need and who have been engaged in meaningful science activities? One of the most difficult aspects of the writing process is knowing where to start. A

science teacher can help a student with this task by providing sentence starters and paragraph frames. Sentence starters are writing frames that provide writers with phrases that connect to the topic to be explored and act as a means of framing a written response to a question or prompt. Sonia was able to respond to the plate tectonics prompt because Ms. Williams had provided her and her classmates with the following sentence starter:

The theory of plate tectonics, which originated in the 1960s as an outgrowth of Wegener's continental drift idea, helped to explain _____.

This sentence frame was shared to provide students with a topic sentence that would serve as a springboard for continued writing. For students who need further scaffolding, Ms. Williams provided other sentence frames to support students developing more than a one sentence or paragraph response. For example, the previously mentioned sentence frame supported beginning the initial paragraph, and the following one supported students beginning the second paragraph:

Alfred Wegener identified three types of evidence to support his theory, including _____.

The third paragraph might start with this:

The theory of plate tectonics differed from the idea of continental drift because _____.

A concluding paragraph could start with this:

Plate tectonics theory currently helps scientists to explain various features seen on Earth, including _____.

So as not to neglect the ever-present laboratory write-up—the staple of most science classrooms—consider the use of sentence frames to scaffold the lab report. Many teachers already provide headings for students to use: *problem, hypothesis, data, analysis,* and *conclusion.* For some students, more support may be needed. For example, a data analysis section could have the following sentence frames to get them started:

My data show that over time bacteria _____.

The evidence for this is _____.

Based on this evidence, I determine that _____.

Especially when students are just learning to connect data to concluding ideas, a structured framework can be very helpful. Sentence starters provided guide students in terms of organization and logical structure.

Additionally, they help trigger recall of information. As students become more familiar with organizing science paragraphs, the sentence starter scaffolds can be reduced and eventually eliminated in a way that provides a gradual release of responsibility (Fisher & Frey, 2014; Pearson & Gallagher, 1983). It is important to remember that vocabulary knowledge, discussed in Chapter 4, is an underpinning of scientific writing. In addition to developing word knowledge as a foundational tool of effective science writing, it is important for writers to be able to organize content in a logical and sophisticated manner. Sentence frames help students learn how to present information. Paragraph frames similar to the following can also support students sharing ideas in larger chunks of connected discourse. After sharing a paragraph like the following, use the Analysis and Hypothesis paragraph frames to identify the scientific understandings that were shared. Post the blank frame and encourage students to refer to it when they are composing a written analysis of data.

Analysis:

The results of the experiment show that the speed of the marble increased when it was dropped from higher up on the ramp. This was caused by gravity accelerating the marble. Therefore, my hypothesis that the longer an object falls, the faster it goes, was correct because my data showed that the marble that was dropped from 10 cm was traveling slower at the bottom of the ramp than the marble dropped from 50 cm.

Analysis Paragraph Frame:

The results of the experiment show that _____.

This was caused by_____.

Therefore, my hypothesis that _____was/was not correct because _____.

Hypothesis:

I hypothesize that the water evaporated because it was in a puddle in the morning, but disappeared when the sun came out later in the day.

Hypothesis Paragraph Frame:

I hypothesize_____ *because of* _____.

Graphic Organizers

Graphic organizers are organizational frames that are designed using visual symbols to illustrate the connections among relationships, knowledge,