In addition to the demands of learning the meanings of multiple new words, students are required to engage in a range of cognitive processes characteristic of scientific inquiry. As we have emphasized, these cognitive processes find expression in text structures (grammatical and discourse patterns) that are quite different from the way we use language in everyday interpersonal communication.
The challenges of teaching science to students who are in the early stages of learning English were vividly expressed in a letter written by a high-school science teacher and published as the “Letter of the Week” by the Toronto Star. In his letter, he talked about the growing numbers of ELLs who had come into his science classes, most of whom had limited English skills. He explained that because of their limited English skills, they were unable to take part in class discussions, complete assignments, or succeed on tests. He went on to say:

I respect these students as I recognize that often they have a superior prior education in their own language. They are well-mannered, hard-working, and respectful of others. I enjoy having a multiracial society in my classroom, because I like these students for themselves and their high motivational level. However, I am troubled by my incompetence in adequately helping many individual students of that society. Because of language difficulties, they often cannot understand me, nor can they read the text or board notes. Each of these students needs my personal attention, and I do not have that extra time to give.

This teacher feels he has to give ELLs a failing mark because they are unable to show what they understand of science. He questions the “educational decisions made to assimilate ESL students into academic subject classes before they have minimal skills in English.”

Many of us can relate to this teacher’s commitment to help his students learn science and his frustration that their limited English skills impede this process. However, the letter also points to the problematic nature of seeing ESL teachers as those primarily responsible for teaching academic English to ELLs. As we have emphasized, teachers have multiple opportunities to extend students’ knowledge of academic English as they are learning subject-matter content. In order to avail of these opportunities, K–12 content teachers must know how to scaffold their instruction so that (a) it becomes comprehensible to ELLs and (b) students are enabled to use language effectively to talk and write about the concepts embedded in the curriculum.

In the example sketched above, it would probably have been very useful for the science teacher to collaborate with one or more of the ESL teachers in the school to discuss scaffolding strategies he could use to help students understand the scientific content. Collaboration might also have extended to sharing the content he will be teaching in the coming weeks so that the ESL teacher could prepare students for some of the linguistic demands of this content. The ESL teacher might also have been able to suggest ways that language objectives could be included in the science teacher’s instruction so that students’ grasp of academic language could be reinforced in the process of learning science. In addition, the ESL teacher might have been able to explain the typical trajectory of five or more years that ELLs demonstrate as they catch up academically in English. Under most circumstances, it is clearly not feasible to “fix” students’ academic English in one or two years. There is also no justification for excluding students from academic content learning for the more than five years it may take them to fully acquire academic English. Finally, the teachers might have been able to discuss alternative assessment strategies so that students could show their learning of science despite their current English language limitations.
In this chapter, we elaborate on the instructional strategies that content teachers can employ as they teach science to their students.

The scientific inquiry process

Any examination of provincial science frameworks and learning standards highlights both the challenges and opportunities ELLs encounter when they attempt to engage in scientific inquiry. The big ideas embedded in science curricula are frequently difficult to understand for all students and their expression in complex, dense, and abstract language makes them particularly challenging for ELLs. For example, a big idea such as *Biodiversity is important for all living things* presents students with a new compound word, and the unit requires students to learn the meaning of many additional specialized scientific terms (e.g., *ecosystem*, *fungi*, *cell*, *mammal*, etc.) as well as more general academic vocabulary (*organize*, *pollute*, *protect*, *survive*, etc.).

In addition to the demands of learning the meanings of multiple new words, students are required to engage in a range of cognitive processes characteristic of scientific inquiry. As we have emphasized, these cognitive processes find expression in text structures (grammatical and discourse patterns) that are quite different from the way we use language in everyday interpersonal communication. The cycle of practices entailed in the work of scientists includes the following:

- Making observations about a topic or phenomenon
- Generating questions to solve a problem
- Making predictions or formulating hypotheses
- Planning and conducting an experiment or investigation
- Gathering and analyzing information
- Drawing and evaluating conclusions and recommendations
- Considering the social, environmental, and ethical implications of the recommendations made

The characteristics of scientific language are discussed in the following pages with reference to both vocabulary and text structure.

Vocabulary

Attention to vocabulary in science requires more than simply supplying definitions. Consider, for example, the definition of the concept of *pure substance* provided by the *Dictionary of Scientific and Technical Terms*: “A sample of matter, either an element or a compound that consists of only one component with definite physical and chemical properties and a definite composition.” To understand this definition, students must first understand the technical terms *element*, *compound*, and *properties*. They also need to understand more general academic vocabulary such as *sample*, *consists*, *component*, *definite*, and *composition*.

Particular challenges for ELLs in learning scientific vocabulary can be considered within the three-tiered vocabulary framework articulated by Isabel Beck and colleagues (Chapter 4). Words reflecting all three tiers present challenges. Common everyday Tier 1 words present challenges because they frequently have specialized...
Teaching the language of scientific inquiry

As they engage in scientific inquiry, students are frequently invited to generate questions, make predictions, formulate hypotheses, and generate explanations of their hypotheses or findings. These practices once again provide rich opportunities for language exploration. For example, as students prepare to carry out an experiment, simple yes/no questions can be generated and practised such as Will a rock float or sink in water? and Will a cork float or sink in water?

Similarly, as illustrated in the following chart (Figure 6.2), teachers can ask questions designed to evoke predictions and also model some common expressions of prediction in response to these questions. As they participate in these dialogues over time, students will develop the ability to ask these questions of one another.

Teachers can also model for ELLs the most common grammatical structure for writing a hypothesis, which is similar to more general cause and effect reasoning: If [x: state the condition], then [y] will happen.

**Figure 6.2 Prediction**

<table>
<thead>
<tr>
<th>Suggested questions to prompt a prediction</th>
<th>Common expressions of prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td>What do you think is likely going to happen?</td>
<td>It is likely that ...</td>
</tr>
<tr>
<td>What do you predict?</td>
<td>I predict that ...</td>
</tr>
<tr>
<td>What is your prediction?</td>
<td>My prediction is that ...</td>
</tr>
<tr>
<td>What do you expect will happen now?</td>
<td>My expectation is ...</td>
</tr>
<tr>
<td>What do you project will happen next?</td>
<td>I project that ...</td>
</tr>
<tr>
<td>What will probably occur?</td>
<td>The probability is that ...</td>
</tr>
</tbody>
</table>

With respect to explanations, How and Why questions are common. These questions help us to comprehend our universe and how things within it operate and are dependent upon one another. As ELLs engage with explanatory discourse, they will have opportunities to ask questions such as the following: How does electricity work? Why does an electric current start to flow? and How are you affected by electricity?

Grade 4/5 students in Admiral Seymour Elementary School provide several examples of the language of explanations in the Introduction to their report on the water quality of their school (see Chapter 4). They point out:
We were worried about our drinking water because our pipes are old and we have to leave the water fountains running all the time. ... It is important that the water should be good and fit to drink because we don’t want to be sick and we care about our water and how good it is. It is also important because we don’t want to waste water by having the water running all day and night.

The students are explaining the reasons for their science project, why it is important to drink clean water, and why it is important not to waste water, and they explained how they went about getting the help of UBC scientists to test the water quality in their school. They used the language features required to convey reasons and cause/effect relationships (e.g., because, if, that is the reason why, so). They also used the present tense when making generalizations and they employed appropriate technical vocabulary. Figure 6.3 provides an overview of the features of explanatory discourse and how it is organized.  

**Figure 6.3 Features of Explanatory Discourse**

A generalized statement concerning the series of events or phenomena that occurred.

State the phenomena, the series of events, or the processes to be explained.

Explains steps in chronological order in a way that differs from simple description of steps in a process (life cycles, water cycles, etc.). Explanatory language explains cause/effect relationships.

Explain a series of steps arranged in chronological or logical order.

Causal language is required to express these realities, including conjunctions such as because, as a result, if/then, therefore, since, is a result of, and thus, and causal verbs such as cause, made, melt, boil, condense, and evaporate. Passive sentences, nominalizations, and technical vocabulary are common.

Another language demand of science relates to organizing information or data, for example, in producing a scientific report. In very general terms, a scientific report starts with a general statement that classifies or defines the topic. The report then goes on to provide a description of the different information or data gathered, with respect to their attributes or qualities, grouped together under various subheadings. As Pauline Gibbons has pointed out, reporting back, either orally or in writing, is an extremely valuable exercise in socializing students into the use of academic language. Students must communicate information to peers and/or the teacher who did not share in the experience, and this requires them to use precise, explicit language typical of scientific discourse.
The final science competency that we address relates to Evaluation, one of the major components of the Knowledge Framework. As outlined in Figure 3.3 (Chapter 3), Evaluation includes arguing and persuading, practices that we discussed in Chapter 4 in relation to language arts. The organizational structure and, to some extent, the language demands of these two practices remain the same across the curriculum.

A statement of the issue or problem is made together with the writer’s point of view. This is followed by an argument or series of arguments, each with supporting evidence. However, the nature of the supporting evidence differs from one subject area to another. For instance, whereas in a literary analysis activity such as the one described in Chapter 4, the author’s claim is supported by a quote from the literary work being studied, in science, evidence is provided in the form of facts and findings from the experiment or investigation. As students engage in the cognitive process of evaluation, they can be supported to learn verbs related to judgment, such as to judge, to regard, to consider, to evaluate, to rank, and to assess. Teachers can expand students’ knowledge of adjectives related to judgment, such as good/bad, right/wrong, accurate/inaccurate, strong/weak, and correct/incorrect. Additional linguistic tools to express scientific judgments might include based on evidence, according to the findings, from the data gathered, the observations support, and so on. As these are introduced in the context of scientific inquiry, students and/or the teacher could add them to the classroom word wall.

**Conclusion**

In this chapter, we have focused on how teachers can expand students’ knowledge of academic language as students engage in scientific inquiry. Cognitive psychologist John Guthrie’s observation that “expertise spirals upward with engaged participation” is equally true for science and other content areas as it is for literacy in general. Effective science teaching to ELLs will involve all of the components of the Literacy Engagement framework described in Chapter 2. Instruction must engage students with the fascination of finding out about the world we live in and enable them to learn about this world with their hands as well as their brains by actually doing science. The scaffolding tools we discussed in Chapter 5 in relation to the teaching of mathematics are equally relevant to the teaching of science. Highly informative and attractive visuals can be found not only in textbooks but also online. Students who are literate in their home language (L1) can be encouraged to explore the extent to which useful information on the scientific topics being discussed in class can be found through online L1 sources. Parents might also be able to assist in this process as well as in helping students transfer concepts across their languages.

Teachers can connect with students’ background knowledge in a variety of ways. For example, in discussing a science topic such as light and sound, students could investigate the sounds they hear throughout the day, both at school and at home, and then classify these sounds into various categories. Teachers can also ask questions that tap into students’ everyday experiences (e.g., Why does the sun come up in the east? Why do leaves fall in the autumn? Why does the ocean generate waves?), and then work with students to investigate these phenomena.
As students engage with these ideas and develop greater understanding of their own lives and the wider world, their sense of accomplishment grows. When they carry out projects either individually or in groups (such as the projects carried out by students at Admiral Seymour Elementary School) and share their findings with multiple audiences, their identity expands. In the case of ELLs, this kind of project enables them to emerge from the identity cocoon that defines them by what they lack (knowledge of English) into an identity defined by confidence, competence, and accomplishment.

Finally, as further elaborated in the Teaching Vignettes, the teaching of science presents all kinds of opportunities to expand students’ knowledge of academic English. This expansion of linguistic expertise is not confined only to the sphere of science; with encouragement from teachers, it transfers to all areas of the curriculum as well as to students’ ability to write clearly, concisely, and effectively.
As with all academic subjects, the use of the students’ L1 and background knowledge can serve as powerful resources and support for learning the language of science in English. This is illustrated in the strategies articulated by Madiha, a student in Lisa Leoni’s class whose work we discussed in Chapter 1. Madiha, in answering several written questions about her use of her L1 in learning English, described how she created multilingual and multimodal dictionaries to help her to learn scientific content in English.

Teachers can promote this practice by working with students to build multilingual and multimodal word walls. This affirms the linguistic knowledge and identity of ELLs, but it also enriches the learning of all students by enabling them to become aware of the different languages represented in their class and, in some cases, observe linguistic similarities in terminology used in different languages (e.g., English/French).

Additionally, students can be encouraged to use the Internet to research a science topic (e.g., ecosystems and sustainability) in their home language(s). They can learn about the key concepts and build background knowledge so that the information in the English science text will be easier for them to understand as they transfer their science knowledge across languages. School libraries can include books, magazines, and resources in the dominant languages of the school (in addition to English). Students themselves can contribute dual language texts, informational pamphlets, or PowerPoints they have created (possibly with the help of parents or older students) to the library. These texts might explain the big ideas of a science topic or inquiry.

Teachers’ assessment of students’ work could include evaluation of students’ portfolios that contain both electronic and hard-copy dual language projects or syntheses of scientific issues and topics.
Building Students’ Knowledge of Science Terminology

Students’ knowledge of both science and academic language can be fostered by engaging them in language detective work in pairs or small groups. Students could use a template based on the Frayer Model (e.g., Chapter 4, Teaching Vignette 4.2) or one that focuses on Meaning, Form, and Use (e.g., Chapter 5, Teaching Vignette 5.5). For example, in a unit on rocks and minerals, one group could be asked to explore the origins and meaning of the word *metamorphic*. The prefix, *meta*, derives from the Greek word for *after* or *beyond* and the base or root, *morphe*, which means “form or shape” (*to morph* has recently been adopted in colloquial English meaning “to change”). Thus, metamorphic rock means that the properties of the original rock have been changed by some forces.

Students can be asked to research other examples of similar words in both everyday and scientific language (e.g., *metamorphosis*), or to find other science words that have *meta* as a word part (e.g., *metabolic, metabolism, metastasis, metaphysics*) or *morphe* as a root (e.g., *amorphous, anthropomorphic, morphine, isomorphic*). The prefix of the word can also be picked up in language arts by having students explore the meaning of the word *metaphor* and discuss the many ways we use metaphoric language in oral and written communication.

Another group could be given the word *igneous*. This time, the root is a Latin word *ignis*, which means “fire.” This group can similarly find other words based on this root, such as *ignite, ignescent, and ignition*. As a mini-homework assignment, students could research the meaning of the term *ignition switch* in the context of cars or other vehicles. They could also explore how the word is used in metaphoric language as in phrases such as “The speech ignited controversy.”

A third group could research the Latin origin of the term *sedimentary*. The word derives from the Latin *sedimentum*, meaning “a settling or sinking down,” which, in turn, derives from the verb *sedere*, meaning “to settle or sit.” Similar language detective work can be carried out for words such as *carnivore, herbivore, omnivore, and detrivore or evaporation, condensation, and precipitation*.

Teachers can explain to students that prefixes provide very useful clues, especially commonly used prefixes such as *un, re, in, dis, and mis*, as well as those indicating numbers or amounts, such as *bi, tri, deci, kilo, demi, macro, magna, medi, omni*, and so on.

The major thing to bear in mind as we engage students in language detective work is that it should be fun and intellectually satisfying for students. If it is tied to any high-stakes assessment, it will probably be carried out with reluctance and will result in little long-term learning.