Consider the following statements about science and diversity:

We are at a critical juncture where there is a rapidly growing need in the technology and science work force, and we cannot afford to waste anybody. Women's and girls' experience is needed to contribute to the development of these fields.

—Linda Basch, Executive Director, National Council on Research for Women

While few solid figures exist, corporate officers uniformly agree that increased diversity in companies has a beneficial effect on the bottom line. The mixture of ideas from several different cultures, they feel, automatically makes scientific teams and entire laboratories more productive.

—Peter Gwynne, American Association for the Advancement of Science

The great and invigorating influences in American life have been the unorthodox: the people who challenge an existing institution or way of life, or say and do things that make people think.

—U.S. Supreme Court Justice William O. Douglas

America is not like a blanket—one piece of unbroken cloth. America is more like a quilt—many patches, many pieces, many colors, many sizes, all woven together by a common thread.

—Rev. Jesse Jackson
History of Diverse Learners in the Science Classroom

Our perceptions of science and scientists come from a variety of different sources. They may start with personal experiences with science in school and then be further reinforced by the media; the larger culture; and by one's family, friends, and community. Thus, when science is portrayed, sometimes subtly and at other times blatantly, as the domain of smart, eccentric white men working in laboratories, we all respond to these portraits in different ways (see Image 4.1). Some will see this as an inaccurate stereotype, others as a statement about who can be successful in science, and still others as evidence of an inequity in need of redress. Many children and young adults are familiar with this stereotype and, as a result, have feelings of adequacy or inadequacy, reinforced by the media, pop culture, and their personal experiences in school science classes.

For much of the past decade, how science is presented and represented in modern Western society has been a topic of debate in the science education community. Broadly speaking, two camps have emerged. One argues that the culture of science, whatever its shortcomings or flaws, has developed in ways that are self-monitoring and self-correcting, and thus, issues such as underrepresentation of women or people of color will be corrected over time. Additionally, science, as it has been practiced, has been highly successful and has led to important discoveries that advance the human condition. Proposing changes, therefore, to how science is done or to how it is represented in science education runs the risk of disrupting scientific progress. Individuals in this “camp” argue that students, whatever their backgrounds, need to be taught to adopt this culture and its worldview if they wish to participate in scientific endeavors (e.g., Good, 1995; Loving, 1997).

In contrast, others have argued that science educators need to be responsive to traditions of bias and prejudice that have existed in the culture of science and recognize that science has largely been the domain of privileged white males. This tradition has both limited the potential contributions of those underrepresented groups and minimized the contributions that have been made. According to this argument, creating a model of science education that acknowledges and addresses these biases...
will encourage the development of scientific learning for women, people of color, and other underrepresented groups. The model would include reforms to curriculum, instruction, and assessment that take into account issues such as learning styles, motivation, cultural and linguistic differences, and role models (e.g., Atwater, 1993; Brickhouse, 1994; Duschl, 1988; Stanley & Brickhouse, 1994).

For the purposes of our discussion in this book, we will consider diversity along five dimensions: gender, race/ethnicity, socioeconomic status (SES), learning exceptionalities, and linguistic difference. While other dimensions of diversity such as urbanicity (e.g., rural vs. urban), sexual orientation, and nationality might also be considered, we believe that the five dimensions we address are the ones that have played the most substantive roles in how opportunities to engage in science education have been allocated in this country.

We begin with a brief discussion of how each element of diversity has influenced the opportunity to learn and succeed in science and science education. We also provide examples of scientists from diverse backgrounds who have succeeded in making recognized contributions to science. We then map the role that the new wave of science education reform has played in promoting an awareness of issues of diversity in science education. Finally, we discuss concrete strategies that teachers can use to enhance the opportunities for diverse learners in the science classroom.

Gender in the Science Classroom. Historically, girls and women have faced inequality of representation and participation in the practice of the natural sciences. Pioneering women scientists like geneticist Barbara McClintock had to overcome significant barriers to their professional development to have their work recognized and accurately credited (see Image 4.2). While they have found increased opportunity in the sciences in recent years, women are still not represented in proportion to the national demographics (Rosser, 2000; Rossiter, 1997; Tonso, 1999). Also, the higher the status of the science field, subfield, or position in question, the greater the degree of inequality that
persists in terms of the representation of women (Phillips, 1990; Traweek, 1989). Additionally, even women who are successful in the natural sciences report less job satisfaction and more stress in their personal lives than their male colleagues. For example, Seymour and Hewitt (1997) conducted a detailed study of the reasons women drop out of university science majors and how these reasons often differ from the reasons that males give.

Feminist critiques of science and science education have largely been ignored in the scientific community. It is probably an unfortunate reality that most practicing scientists have not given much thought to issues of equity in their work. One of the most common responses to this claim is that science is fundamentally meritocratic and self-correcting. Thus, while it is possible that women have been discriminated against in the past, such inequities are being resolved now that women have equal access to the required training opportunities. The increased enrollment of women in medical and veterinary schools, where women now make up the majority of students, is often cited as evidence of the self-correcting nature of the field. A number of studies point out, however, that the widespread perception of science as male or masculine continues to be one of the greatest barriers to adolescent girls’ willingness to pursue advanced science education or to enter scientific fields (Howes, 1998; Oakes, 1990; Rosser, 1997; Tonso, 1999).

Table 4.1 provides a sampling of notable women scientists and their contributions to the field. Examples such as these can be used to complement the strategies for supporting girls in the science classroom that are discussed later in the chapter. It is worth noting that women’s contributions to science date back to ancient Egypt, India, and Greece. However, for the vast majority of this history, women scientists faced additional barriers to opportunity and access while striving to contribute to the field.

**Race/Ethnicity in the Science Classroom.** Racial discrimination has played an important part in the history of American education. In the case of science education, facilities have often been inadequate and opportunities to attend elite universities where scientific training is the best have been few and far between for students of color. Important exceptions to this tendency have occurred in historic black colleges, which during the late nineteenth and early twentieth centuries provided some of the only scientific training available to African Americans in the United States. Institutions such as Howard University in Washington, DC, for example, established not only dental and medical schools but sophisticated bacteriology and chemistry research and teaching labs that provided advanced scientific training for its students (see Image 4.3).

Racial discrimination in science education has also come in the form of white role models being emphasized more than black persons who have contributed to the development of science. One of the important results of the civil rights movement and the black history and pride movement during the 1960s was the rediscovery of significant black individuals, including
### Table 4.1. A Sampling of Notable Women Scientists

<table>
<thead>
<tr>
<th>Scientist</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypatia (310–415)</td>
<td>Probably the first well-known woman scientist, Hypatia was primarily a mathematician. She also studied science, however, and was eventually murdered by a mob that objected to scientific study.</td>
</tr>
<tr>
<td>St. Hildegard of Bingen (1098–1179)</td>
<td>Like many scientists of her era, as was discussed in Chapter 1, St. Hildegard simultaneously studied the natural and supernatural worlds. She wrote extensively on the use of plants, animals, and metals in medicine.</td>
</tr>
<tr>
<td>Marie Curie (1867–1934)</td>
<td>Surely the most well-known woman scientist, Curie won the Nobel Prize twice for her pioneering work in both chemistry and physics, most notably for the study of radioactivity.</td>
</tr>
<tr>
<td>Florence Rena Sabin (1871–1953)</td>
<td>Sabin was the first woman to be elected to the National Academy of Sciences, over 80 years after it was founded by President Lincoln. Sabin was a medical researcher who primarily studied the disease tuberculosis.</td>
</tr>
<tr>
<td>Maria Goeppert Mayer (1906–1972)</td>
<td>The second woman to be awarded the Nobel Prize for physics in 1963 after a 60-year gap (Marie Curie was a recipient in 1903). Mayer’s work was primarily on the shell theory of the structure of atoms.</td>
</tr>
<tr>
<td>Dorothy Crowfoot Hodgkin (1910–1994)</td>
<td>The second woman to receive the Nobel Prize in chemistry in 1964 (again, after Marie Curie, who was awarded the prize in chemistry in 1911). Hodgkin researched the structure of the antibiotic penicillin.</td>
</tr>
<tr>
<td>Edith Hinckley Quimby (1891–1982)</td>
<td>Quimby was the first to determine that radiation could be used in the treatment of cancer. The fact that Quimby became known as “America’s Madame Curie” further highlights the huge role that Curie played as a trailblazer for women in science.</td>
</tr>
<tr>
<td>Jane Goodall (1934– )</td>
<td>Well-known for her studies of the behavior of chimpanzees in the wild, Goodall, as well as other women primatologists, is often cited by feminist scholars as an example of how women can bring alternative perspectives and modes of inquiry to science that men would be unlikely to adopt.</td>
</tr>
</tbody>
</table>
scientists, as potential role models. Highlighting the scientific contributions of people such as Benjamin Banneker, George Washington Carver, and Charles Drew is important not only for black students but for all students because it gives the scientific community a more diverse human face. More examples of the contributions of black scientists can be found in Table 4.2.

Despite the important contributions of black scientists described here, and the significant advances in educational equity since the 1960s, it must also be realized that many black students continue to attend schools with inadequate resources for the teaching of science. Good science instruction is expensive and takes a social and educational commitment to be fully realized. Racial discrimination in the education of Hispanic students in the United States has a shorter history and a lower profile than that of African American students. As the Hispanic population in the United States continues to grow, however, inequity of opportunity is now becoming evident in the science education of Hispanic students. The recognition of successful role models can again be one way to bring to light the importance and value of ensuring that all individuals be given the opportunity to study and pursue careers in science if they feel called to do so. Notable contributions of Hispanic scientists can be found in

Image 4.3. Students in the Bacteriology Laboratory at Howard University in 1900
### Table 4.2. Notable African American Scientists

<table>
<thead>
<tr>
<th>Scientist</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benjamin Banneker (1731–1806)</td>
<td>Banneker became an accomplished mathematician and astronomer despite being almost completely self-taught. He is best known for his farmers’ almanacs based on his astronomical calculations.</td>
</tr>
<tr>
<td>Rebecca Cole (1846–1922)</td>
<td>Cole was the second black woman to graduate from an American medical school in the aftermath of the Civil War (1867). She became well-known for advocating the importance of teaching hygiene and childcare to poor families.</td>
</tr>
<tr>
<td>Edward Alexander Bouchet (1852–1918)</td>
<td>Bouchet became the first African American Ph.D. recipient in physics in 1876. Because of his race, however, Bouchet was not able to get a university faculty position. He spent his career teaching high school at the Institute for Colored Youth in Philadelphia, where he inspired a generation of African American science students, some of whom did go on to hold the kinds of positions that Bouchet had been denied.</td>
</tr>
<tr>
<td>Daniel Hale Williams (1856–1931)</td>
<td>Williams was a medical doctor and surgeon who founded the Provident Hospital in Chicago in 1891. It was there that he performed the first successful open heart surgery in 1893.</td>
</tr>
<tr>
<td>George Washington Carver (1865–1943)</td>
<td>Probably the most well-known African American scientist, Carver was the director of agricultural research at the Tuskegee Institute in Alabama. He is remembered for his research on sustainable agricultural practices. He developed hundreds of applications for farm products such as the peanut, sweet potato, and soybean—most famously, peanut butter.</td>
</tr>
<tr>
<td>Charles Henry Turner (1867–1923)</td>
<td>Turner did important foundational research in entomology after receiving his Ph.D. from the University of Chicago in 1907. Among other discoveries, Turner was the first to prove that insects can hear.</td>
</tr>
<tr>
<td>Archibald Alexander (1888–1958)</td>
<td>Alexander was a distinguished civil engineer who designed two of the most famous bridges in Washington, DC.: the Tidal Basin Bridge across the Potomac River to the Jefferson Memorial and the Whitehurst Freeway.</td>
</tr>
<tr>
<td>Roger Arliner Young (1889–1964)</td>
<td>Young was the first African American woman to receive a Ph.D. in zoology. Rumor has it that she was accepted into graduate school because her first name was Roger. She went on to conduct research at the famous Woods Hole Marine Laboratory on Cape Cod, where she studied the role of osmosis in controlling the salt concentration in aquatic organisms.</td>
</tr>
<tr>
<td>Charles Richard Drew (1904–1950)</td>
<td>Drew was a medical researcher who studied blood plasma and transfusions. He discovered that blood could be preserved by separating the red blood cells from the plasma, which could then be frozen. This allowed for the creation of the first blood bank. Drew also organized the world’s first blood drive.</td>
</tr>
</tbody>
</table>
### Table 4.3. Notable Hispanic Scientists

<table>
<thead>
<tr>
<th>Scientist</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Narciso Monturiol (1819–1885)</td>
<td>Monturiol was a physicist and inventor who was interested in underwater navigation. In 1859 he created and drove the first fully operable submarine.</td>
</tr>
<tr>
<td>Carlos Finlay (1847–1915)</td>
<td>Finlay was a medical doctor in Cuba who first proposed that yellow fever was transmitted by mosquito bites. He attempted to convince the Cuban government to begin a mosquito eradication and control program. It was not until 20 years later, however, that Finlay’s theory was finally accepted and action was taken to control mosquito populations.</td>
</tr>
<tr>
<td>Severo Ochoa (1905–1993)</td>
<td>Ochoa was a biomedical researcher at New York University. His research helped us understand the role of ribonucleic acid (RNA) in carrying hereditary information during reproduction. He received the 1959 Nobel Prize in medicine for this discovery.</td>
</tr>
<tr>
<td>Luis Walter Alvarez (1911–1988)</td>
<td>Alvarez designed the ground-controlled radar system for aircraft landings and was awarded the Nobel Prize for physics in 1968. He also helped develop the meteorite theory of dinosaur extinction.</td>
</tr>
<tr>
<td>Baruj Benacerraf (1920– )</td>
<td>Benacerraf was awarded the Nobel Prize for medicine in 1980 for discovering the structures on the cell surface that control immunological reactions. This discovery has led to increased understanding of cell recognition, immune responses, and graft rejection in transplant patients.</td>
</tr>
<tr>
<td>Mario Molina (1943– )</td>
<td>Molina did the research showing that chlorofluorocarbons (CFCs) could destroy the ozone layer in the stratosphere, allowing more ultraviolet light to get through to Earth and potentially increasing the rate of skin cancer. This led to CFCs being banned in most countries. Molina received the 1995 Nobel Prize in chemistry for this work.</td>
</tr>
<tr>
<td>Ellen Ochoa (1958– )</td>
<td>Ochoa became the world’s first Hispanic female astronaut in 1991. She is a mission specialist and flight engineer and has logged more than 900 hours in space on four flights.</td>
</tr>
</tbody>
</table>
Table 4.3. Equal education for all students—no matter what their race or background—remains a significant challenge for American educators.

**Socioeconomic Status (SES) in the Science Classroom.** While public schools are meant to be the great equalizer in addressing poverty in American society, the reality is that children in poor neighborhoods, whether urban, suburban, or rural, are less likely to have access to high-quality science education than students from more affluent backgrounds. As has been noted earlier, high-quality, hands-on, inquiry-based science instruction requires substantial material resources and well-prepared and qualified teachers, and it is substantially easier to do when class sizes are smaller. Schools that serve poor children frequently suffer in all of these areas, typically having limited and outdated science equipment, a higher percentage of uncertified teachers and higher rates of teacher turnover, and large class sizes. Additionally, schools that enroll large numbers of students from low-SES backgrounds are more likely to focus their instruction on “basic skills,” such as basic literacy and numeracy, and are likely to devote less instructional time to science.

Because poverty and race/ethnicity tend to co-vary in the U.S., students of color are more likely to face the hurdle of under-resourced school science programs as well as the challenges they may face in school because of perceptions about their race. At the same time, white students from low-SES backgrounds are also likely to face many of these challenges to a high-quality science education.

**Students With Exceptionalities in the Science Classroom.** Disability affects everyone either directly or indirectly. It is estimated that there are between 38 and 52 million people with disabilities in the United States. Practically everyone will either experience disability directly or have a family member, loved one, or friend who has a mental or physical impairment.

People with disabilities are visible in society as never before, including in our public schools. Because of laws prohibiting discrimination—specifically Section 504 of the Rehabilitation Act and the Americans With Disabilities Act—people with disabilities are increasingly present in America’s workplaces, stores, transportation systems, and public facilities. Prior to 1975 and the passage of the Individuals With Disabilities Education Act (IDEA—Public Law 94-142), many students with severe disabilities attended separate schools where they never interacted with their non-disabled peers. Students with even mild or moderate disabilities were usually taught in completely separate resource room settings and only occasionally interacted with their general education peers, perhaps during lunch or recess.

As a result of IDEA and the guaranteed right of all students to an education in the “least restrictive environment” that meets each individual student’s needs, there has been an increased emphasis on inclusive education; students with disabilities are placed in general education settings to the
greatest degree possible. Both teachers and non-disabled, general education students have increased exposure to students with disabilities.

While the placement of students with disabilities into general education classrooms has been shown to provide benefits to disabled and non-disabled students alike, teachers in these inclusive classrooms regularly face the difficult task of having to modify their curriculum, instruction, and assessment to meet the needs of students with a range of special needs. Without these modifications, students with disabilities often find themselves blocked from access to essential aspects of their education. Teachers have a legal as well as an ethical obligation to do their best to break down the barriers and assist these students to learn.

The teaching of science to students with disabilities involves some special challenges as well as some unique opportunities to provide meaningful and engaging education. A good teacher with the proper tools, preparation, and instructional methods can support and encourage each member of her class to participate directly in science learning experiences. Again, it should be noted that major contributions to science and technology have been made by individuals with a range of disabilities (see Table 4.4).

**English Language Learners in the Science Classroom.** Historically, students who spoke a language other than English as their home language (English language learners) were not provided with instruction in science until they demonstrated at least intermediate conversational fluency in English. The rationale for this decision was that it was more important for these students to put all their energy into learning English than it was for them to try to remain at grade level in the content areas of science, math, or social studies. The result of this approach was that English language learners either never received science instruction or by the time they did, they were already several years behind grade level (Rosebery, Warren, & Conant, 1992).

When science instruction did take place for these students, it was usually in a way that was grossly unequal to that of students in mainstream science classes. The “special” science instruction in English as a Second Language (ESL) classes was frequently inadequate for several reasons. First of all, science classes for linguistically diverse students were frequently taught by bilingual paraprofessionals rather than by certified science teachers. Second, in these settings, class work generally focused on learning science vocabulary, with a heavy dependence on worksheets, drill and practice methods, and an emphasis on lower-order thinking skills (Mason & Barba, 1992). At the other extreme, some English language learners, placed from the outset in mainstream science classes (the submersion or “sink or swim” model), were expected to learn science, often through a text and lecture format, at a level of English that was far beyond their comprehension. In either case, these students were not given an equal opportunity to learn science as compared to native English language speakers.

Another obstacle to content area success for linguistically diverse students is the inherent mismatch between the cultural backgrounds of these
students and the mainstream culture of schools. Roland Tharp and his colleagues have explored how views of cultural difference are often used to explain student failure but are rarely accessed to support the content area instruction. They conclude that misunderstanding between the cultures of students and the culture of school is one of the major factors responsible for widespread school failure among students from culturally and linguistically diverse groups (D’Amato & Tharp, 1997).

### Table 4.4. Notable Scientists and Inventors With Disabilities

<table>
<thead>
<tr>
<th>Scientist</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isaac Newton (1642–1727)</td>
<td>Newton, who articulated the theory of gravity and laws of motion that continue to govern our understanding of force and motion in the visible world, suffered both from epilepsy and from a speech impediment (stuttering).</td>
</tr>
<tr>
<td>Alexander Graham Bell (1847–1922)</td>
<td>Bell, who is most famous for inventing the telephone, suffered from a fairly severe learning disability that caused him to struggle in school and also inspired him to start a school for the deaf.</td>
</tr>
<tr>
<td>Thomas Alva Edison (1847–1931)</td>
<td>Famous for inventing the electric light and the record player, Edison suffered from partial deafness, learning disabilities (he didn’t learn to read until he was 12), and, in later life, diabetes. It is said that Edison never developed good writing skills, yet his inventions literally changed the world.</td>
</tr>
<tr>
<td>Henry Ford (1863–1947)</td>
<td>Ford, one of the developers and the first to mass produce the automobile, suffered from dyslexia. As a youth, he struggled with reading and writing but had been drawn to tinkering with machinery, a path that eventually led him to engineering.</td>
</tr>
<tr>
<td>Albert Einstein (1879–1955)</td>
<td>Arguably the most well-known scientist of all time, Einstein is thought to have suffered from Asperger Syndrome, which is a form of autism, as well as dyslexia.</td>
</tr>
<tr>
<td>Stephen Hawking (1942–)</td>
<td>Probably the greatest living physicist, Hawking did much of the foundational work on black holes and has developed several theories about the nature and origins of our universe. Hawking has motor neuron disease (ALS) and is forced to use a wheelchair and voice synthesizer.</td>
</tr>
</tbody>
</table>
Thus, the science classroom has often been overlooked as a place where academic success among English language learners can occur. We believe, however, that science learning can actually become one of the principle resources for simultaneously teaching linguistically diverse students English, providing them opportunities for academic success, and setting these students on a course that can lead to sought-after professional jobs.

By promoting strategies that aid in the development of academic (rather than just conversational) language skills, and by making explicit the kinds of content-specific learning strategies used by successful students, English language learners can develop and flourish in the science classroom. Failure of the teacher to attend to the language needs of these students, however, serves to continue the unfortunate historic trend of poor academic performance and high dropout rates later in school.

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**Theory Into Practice 4.1**

**Draw a Scientist**

Perform the following visualization exercise with your students:

Close your eyes and picture a scientist. Summon up an image of what that scientist looks like and what that scientist is doing. When you have a clear visual image of your scientist, open your eyes and draw a picture of what your scientist looks like and what your scientist is doing.

As students finish, have them tape their pictures on the board. Next, ask everyone to take a look at all the pictures in the “scientist museum.” Tell them to look for similarities and differences between the pictures.

While they are looking at the pictures, you may wish to slip on a lab coat and goggles and get a flask of colored water for effect.

Students are likely to note similarities (many) and differences (few) among their scientist pictures, as most will have drawn a stereotypical “geeky” scientist (usually white and male) with a lab coat, glasses, and crazy hair working in a lab with chemicals.

Why do you think that so many people of all ages, all education levels, both genders, and all races and ethnicities tend to draw the same stereotypical scientist?

Where do these stereotypes of scientists come from?

Are these stereotypes problematic? Why?

What can be done to combat these stereotypes?
Current Science Education Reforms and Their Impact on Diverse Learners

In Chapter 2, we discussed the Sputnik-era reforms that led to increased attention to and funding for science education, which lasted into the late 1960s. Because the intention of the Cold War reforms was primarily to produce the next generation of competitive, highly trained scientists, females, students of color, students with disabilities, and English language learners failed to reap the benefits of these reforms proportionally with their more mainstream peers.

The 1990s saw a new wave of science education reforms brought about by a growing realization, based on international comparisons, that the U.S. was no longer at (or even near) the top when it came to science education. (See, for example, the U.S. TIMSS National Research Center Web site, http://ustimss.msu.edu/, for a detailed analysis of the results of the Third International Mathematics and Science Study.) A fundamental shift in science education reform has been the emphasis on scientific literacy for all students, as opposed to scientific mastery for a small, elite number of students. The push for broad scientific literacy has implications for the science education of diverse learners.

At the forefront of this latest reform effort has been the work of the American Association for the Advancement of Science (AAAS) through two books they have published: Science for All Americans (Rutherford & Ahlgren, 1990) and Benchmarks for Science Literacy (AAAS, 1993). In 1996, the National Science Education Standards (National Research Council [NRC], 1996) largely stemmed from the work of AAAS and the National Science Teachers Association. Still more recently, Inquiry and the National Science Education Standards: A Guide for Teaching and Learning (NRC, 2000) furthered the argument for hands-on, inquiry-based science for all students. In the following section, we briefly discuss the contributions of these reform documents.

Science for All Americans: Setting the Agenda

Science for All Americans (Rutherford & Ahlgren, 1990) was the first component of an AAAS endeavor named Project 2061, in reference to both the long-term, systemic perspective it takes toward the reform of science education in the United States and to the year of the return of Haley’s Comet to Earth. Science for All Americans (SFAA) set an agenda for the reform movement and identified the basic scientific concepts that all citizens in today’s technological world should be familiar with in order to be scientifically literate. While the stated goal of SFAA was to promote science for all, and current inequities experienced by female and minority students in science
are condemned throughout, little space is devoted to concrete or specific suggestions for including traditionally underserved populations.

SFAA points out a number of educational practices, common in the typical science classroom, that are detrimental to the goals of science reform. Many of these practices are particularly harmful to culturally and linguistically diverse students. These include (a) an overemphasis on student competition with a focus on grades, rather than on student collaboration with a focus on learning (p. 193); (b) the role of imagination going unrewarded as compared to the role of memorizing and following directions (p. 191); (c) the tendency to keep science and mathematics restricted to the classroom, rather than expanding them into the larger community where children spend most of their time and do most of their learning (p. 193); and (d) the entrenched nature of the teaching schedule that does not allow time for collaboration and sharing of ideas (p. 201).

To make scientific literacy a reality for all, a serious and significant reform of the current education system will be required. SFAA concludes by recommending a series of “next steps” to achieve this goal. One of the book’s concluding comments is that

progress will have been made if, by 1992, educators and education policy makers have begun to develop a strong consensus on what it will take to restructure the school system so that all students—including especially those it has failed in the past—will emerge well educated in science, mathematics, and technology. (p. 213)

Clearly, this has not come to pass. In summary, while SFAA is short on concrete strategies to address the specific needs of diverse students in the science classroom, attention is paid to the importance of universal science literacy, inclusive of culturally diverse and traditionally underserved populations.

National Science Education Standards: Reform Into Practice

The current version of the National Science Education Standards (NRC, 1996) is meant to address and set standards for all aspects of science education. The document includes not only content standards, but also standards for teaching, professional development, assessment, science education programs, and science education systems. The importance of all in science education is given a central place in the National Science Education Standards (NSES). The first of the guiding principles said to drive the development of the NSES is “science is for all students” (p. 19):

[The standards] emphatically reject any situation in science education where some people—for example, members of certain populations—are discouraged from pursuing science and excluded
from opportunities to learn science. Excellence in science education embodies the ideal that all students can achieve understanding of science if they are given the opportunity. (p. 20)

However, while support for the creation of a functional, inclusive science classroom is clearly present throughout the document, as is the case with SFAA, detailed discussion of the practical aspects of this guiding principle are scant. For example, Teaching Standard B, Substandard 4 states, “Teachers of science recognize and respond to student diversity and encourage all students to participate fully in science learning” (p. 36). The discussion of this substandard further states, “Students with limited English ability might be encouraged to use their own language as well as English and to use forms of presenting data such as pictures and graphs that require less language proficiency” (p. 37). Although these are two effective strategies that could be used by a science teacher working with English language learners, they are just the tip of the iceberg of the repertoire of strategies and techniques used routinely by language specialists.

Assessment Standard B, Substandard 3 addresses the issue of equal opportunity and equal access to quality instruction, stating, “Equal attention must be given to the assessment of opportunity to learn and to the assessment of student achievement” (p. 83). In other words, it is unfair to hold students who are receiving poor instruction to the same achievement standards as those students who are receiving high-quality instruction. Because many girls, students of color, students with disabilities, and English language learners have, in fact, been receiving inferior science instruction, this issue is highly relevant when considering diverse learners and science assessment, especially the high-stakes variety.

Standard D deals with issues of equality of resources, including updated texts, access to sufficient laboratory equipment, adequate time devoted to the study of science, and most importantly, well-trained professional teachers (pp. 218–220, 232–233). All of these resources, however, require substantial funding—funding that is often distributed to schools in a less than equitable fashion. Standard E deals with equitable access to the opportunities to achieve the content standards, and discusses issues of bias, exclusion, and tracking as ways that some students have traditionally been denied access to high-quality science education (pp. 221–222). In contrast to the economic equity issue, the task of ensuring that all students receive science education in an environment that is unbiased and inclusive seems more attainable; individual teachers have a significant amount of control over issues of inclusion in their classrooms. The standards summarize these issues as follows:

In particular, the commitment to science for all implies inclusion of those who have traditionally not received encouragement and
opportunity to pursue science—women and girls, students of color, students with disabilities, and students with limited English proficiency. It implies attention to various styles of learning, adaptations to meet the needs of special students, and differing sources of motivation. (p. 221)

In summary, the NSES is a step forward in addressing the needs of diverse learners in the science classroom in that the standards point to many of the issues that have hindered the success of a wide range of students in science. However, increasing teachers’ awareness of these issues is only a first step. Teachers must also learn to apply the specific skills that have been shown to increase successful science learning for girls, students of color, students with disabilities, and English language learners.

Theory Into Practice 4.2

Mapping the Increasing Diversity in American Classrooms

Using Web sites such as the Historical Census Browser (http://fisher.lib.virginia.edu/collections/stats/histcensus/) or the U.S. Census Bureau (http://www.census.gov/), create a data table showing how the population of children attending school has changed over the last century. Look for data from 1900, 1950, and 2000.

Look for data on gender, race/ethnicity, disabilities, and home language. Plot a graph showing your results and compare your graph your neighbor’s.

If you have time, go back and look for data specific to your state. How does your state compare to the national figures?

Strategies for Working With Diverse Learners in the Science Classroom

Strategies for Working With Girls in the Science Classroom

As awareness of the need to more actively encourage girls in science has grown over the past few decades, support has come from several arenas.
Successful women scientists have begun to look at the educational and professional factors that allowed them to be successful and how these factors could be fostered in younger generations of girls and young women. Feminist science educators have worked to develop guiding principles for equitable science education grounded in feminist pedagogies. Teachers have reflected on the concrete, practical strategies they have found to be successful in encouraging success in science for the girls in their classes. Across this variety of settings and diversity of advocates, a fairly consistent set of recommendations and strategies has emerged for promoting women’s and girls’ success in science (as well as math and technology—two other areas where women and girls have historically faced challenges):

1. Assume that girls are interested in math, science, and technology, and make clear your expectations that they will succeed in these areas.

2. Have your class research and assemble a directory of “Women in Math, Science, and Technology in Our Community.” This directory can then serve as a resource for setting up mentorship or internship opportunities. Have the students share the directory as part of a parents’ night to educate parents about successful local women in math, science, and technology careers.

3. Promote and create mentorship and internship programs in the local community, to give girls and young women a realistic idea of potential careers in science.

4. Foster active and cooperative learning and group success over individual competition. At the same time, provide some opportunities for competition to teach students that competition is sometimes required but that collaboration is often the best way to achieve goals.

5. Integrate science, math, and technology with other disciplines, drawing connections to topics your students find engaging.

6. Arrange opportunities for younger girls to speak with older girls who are taking more advanced science and math courses, to share their experiences and insights.

7. Promote opportunities for girls and their parents to engage in science and technology together, such as a parent-daughter science and technology night at school. Encourage them to explore hands-on science activities or computer software together. Remember that girls need support and encouragement at home as well as in school to promote continued interest in math, science, and technology.

8. Present your students with current data on salaries for various careers in science, math, and technology as compared to salaries
for careers that have traditionally been “women’s work,” such as teaching, nursing, and administration.

9. Highlight a wide range of possible science careers, including those with community-building and people-helping components.

10. Review the science curriculum materials that are used in your school to ensure that they represent diversity issues in positive and proactive ways.

Theory Into Practice 4.3

Two-Column Girls and Scientists Activity

The following activity is meant to demonstrate how some of the characteristics associated with scientists are often constructed in opposition to the characteristics associated with girls, while other characteristics seem well-aligned.

1. Fold a piece of paper lengthwise, then unfold to make two columns.

2. Title the left-hand column “Girls” and brainstorm a list of all the qualities and characteristics that you associate with girls. Try to list at least a dozen.

3. Title the right-hand column “Scientists” and brainstorm a list of all the qualities and characteristics that you associate with scientists. Try to list at least a dozen.

4. Compare the two lists and, using a colored marker, connect terms that seem to be antonyms (opposites).

5. Compare the two lists and, using a colored marker, connect terms that seem to be synonyms.

6. Discuss the implications of the similarities and differences between your two lists.

Strategies for Working With Students From Diverse Racial, Ethnic, and Cultural Backgrounds in the Science Classroom

Much has been written in the past two decades about the role that multicultural education must play in our increasingly diverse schools and classrooms.
On the one hand, this literature has argued that all students, regardless of their racial, ethnic, and cultural backgrounds, must learn to be aware and tolerant of the differences between individuals and groups. On the other hand, some multicultural education literature has focused on ideas and strategies for more effectively teaching culturally diverse learners.

Within this second branch of multicultural education, which is focused on enhancing the education of non-mainstream students, the majority of the work has been content-general rather than content-specific. That is to say, it provides strategies that teachers might use in any situation to more effectively work with students from a particular cultural group or with non-mainstream students in general.

For example, McBay (1989) provided a list of recommendations for improving education for students of color: (1) early intervention in preschool and enhanced parental education; (2) restructured school systems to encourage success for all students; (3) curriculum that is sensitive to the ethnic and cultural identities of students; (4) making the best teachers available to the most needy students; (5) schools learning to also function as social service providers; (6) better communication between school services and other community services; (7) use of role models and support from the community; (8) earlier exposure to higher, more challenging levels of education; and (9) clarifying incentives for all students to participate in higher education.

Although strategies of this generic nature have been adopted, to a greater or lesser extent, in most schools with significant numbers of ethnically, racially, and culturally diverse students, it is our belief that content-specific strategies are at least as important, but are less often known to teachers. The multicultural education literature has few specific strategies for promoting science education for students from diverse races, ethnicities, and cultures. A study by Atwater (1993) is one often-cited example of this topic.

In the following section, we present six different perspectives based on the work of Banks (1995) that highlight how various generic principles of multicultural education can be explicitly applied to science teaching. Together, the following six perspectives on multicultural science teaching form a continuum from traditional science teaching, which does not consider multicultural issues, to a range of substantive changes. We believe that these changes are largely cumulative: A teacher who adopts one of the more substantive change models is also likely to adopt the less substantive changes as well. As someone preparing to be a teacher, you need to weigh these perspectives and consider which ones fit best with your personal philosophy about teaching science to diverse learners.

1. **No Significant Changes.** Students need to adapt to and learn Western science as it is. Science is a “culture of power,” and to access this power structure, students must deal with science on its own terms. Modifying how we represent science in the classroom is doing a disservice to students because no one will make such modifications for them later in life if they wish to pursue careers in science.
2. **Additive Changes.** The most important issue is that diverse students fail to see themselves represented in positive ways within science. To address this problem, the teacher should look for opportunities to include contributions of minority and women scientists to Western science (e.g., posters in the classroom, special days celebrating the contributions of female scientists and scientists of color). Teaching of the actual science content is not modified in any way in this approach.

3. **Methods Changes.** The most important issue is that racially, ethnically, and culturally diverse learners are likely to have preferred learning styles that are somewhat different from their mainstream peers. To address this issue, instruction and assessment should be modified to better accommodate these learning styles, such as through greater use of cooperative learning, increased wait time, performance assessment, kinesthetic learning experiences, and so on. The teacher attempts to increase awareness of cultural differences between students and how this affects their preferred methods of learning. Again, teaching of the actual science content is not modified in any way in this approach.

4. **Substitution Changes.** The most important issue is that racially, ethnically, and culturally diverse students generally fail to see science as a worldview that comes from their cultural heritage, but rather as something that came from white European culture and has most benefited those of white European heritage. To address this incorrect notion that science has only Western European roots, the teacher looks to replace parts of the traditional curriculum with a study of the history of science, and especially how science evolved in other cultures, and how science is still used differently in other cultures today (see Teresi, 2002). For example, lessons and even whole curricula have been developed on topics such as Mayan and Incan agricultural practices (Incan farmers were doing controlled experiments on potato breeding long before the rise of science in Europe), Micronesian navigational practices (Micronesian sailors had mapped much of the Pacific Ocean while the Greeks were still constrained to the Mediterranean), and Egyptian architecture (the science behind the construction of the great pyramids fascinates people around the world to this day).

5. **Goal Changes.** The most important issue is that school culture and norms have evolved from a rationalist cultural model favored in Europe that leads to a focus on cognitive development of students without adequate attention to affective development. Students need to feel good about themselves as individuals, and about science as an area of study, if we expect them to be academic achievers and to conceive of themselves as potential scientists. Once a student has come to see science as a way of making sense of things that are important and valuable to him or her, then that student will feel good about science and be ready to succeed in learning academic science content. Thus, the teacher initially makes science content learning secondary to developing
settings that allow students to see science as personally relevant to positive student interests. Topics such as fashion, music, sports, community service, safety, and cooking have all been used by teachers to promote affinity towards science with racially, ethnically, and culturally diverse students.

6. Culture-Dependent Curriculum Changes. The most radical end of the continuum advocates a fundamental overhaul of the science curriculum to align what is taught with the empowerment of the dominant ethnicity, race, and/or gender in the school or classroom. This ethnic, racial, cultural, or gender group determines the curriculum by focusing both on how science has been used successfully by members of this group (an extension of the substitution changes model discussed above) and on how science and technology have been used to disadvantage, marginalize, or control the group in question. This approach is generally only proposed in homogeneous school settings, such as single-gender schools or charter schools catering to a single racial or ethnic group. Thus, Afrocentric, Hispanocentric, and women’s science curricula have all been developed under special circumstances, although the accuracy of some of the claims in these curricula has been challenged.

Strategies for Working With Children From Low-Socioeconomic Backgrounds in the Science Classroom

Children from low-SES backgrounds may also fall within one or more of the other diversity categories discussed in this chapter. For example, students of color are more likely to come from low-SES homes than are white children; thus, the teacher will want to consider strategies under the cultural and ethnic diversity section. Additionally, students from low-SES environments are overrepresented in special education placement and diagnosis of exceptionality. Such placements seem to result, in part, from added health risks and developmental challenges that are associated with poverty, but also from misidentification because students from poor backgrounds may be less likely to exhibit the “good student” identities that convince teachers that a student is making adequate progress. Thus, teachers may also wish to consider whether some of the strategies for working with students with disabilities may prove helpful.

The following strategies may also prove helpful when working with students from low-SES backgrounds:

1. Set high expectations but provide strong scaffolding. Many teachers fail to realize that they hold substantially lower expectations for the academic success of students from low-SES backgrounds, expectations that their students readily pick up on. Students must first be convinced that they are expected to succeed before they are likely to believe it themselves.

2. Learn about the students’ out-of-school experiences and build on them. Many teachers believe that students from poor backgrounds have only negative experiences in their communities. The stereotypes of drug-
violence-infested inner cities paint a one-dimensional picture of the neighborhoods where poor students might live. While these students may indeed have witnessed or experienced frightening things that students in more affluent neighborhoods may not have, students from low-SES backgrounds have positive experiences in their neighborhoods as well. Teachers who take the time to learn about these positive experiences can then look for ways to connect these experiences to school topics in ways that help students to scaffold this learning.

3. **Provide experiences for students that they may not otherwise have.** While students from low-SES backgrounds are not devoid of meaningful experiences, it is also the case that these students are less likely to have had some of the experiences common among more affluent children that can help support science learning. Teachers can help narrow this “experience gap” through strategies such as supporting meaningful field trips, providing students with opportunities to use science tools and equipment, and inviting guest speakers to the classroom to share experiences that are unfamiliar to the students.

4. **Reciprocal Peer Tutoring and Cross-Age Tutoring.** Reciprocal peer tutoring is a strategy in which classmates of approximately the same age take turns teaching material to each other. Cross-age tutoring is an older student helping a younger student to learn something. Both of these strategies have been shown to promote confidence and competence in students from low-SES backgrounds, as long as the teacher has set clear expectations about the tutoring process.

5. **Parental/Family Engagement.** Parents and guardians from low-SES backgrounds often have numerous reasons why they feel uncomfortable becoming involved in their children’s school. They may not have had good school experiences themselves, may not feel academically competent to help their children with their school work, may not speak English well, or may work multiple jobs and/or have multiple young children and simply not have the time to come to their children’s school during regular hours. Despite these challenges, teachers who find ways to engage their students’ parents in school activities report positive academic outcomes for their students as a result.

**Strategies for Working With Students With Disabilities in the Science Classroom**

Somewhat unlike the other areas of student diversity discussed in this chapter, the category of students with disabilities is extremely broad, covering a wide variety of disabilities, each with its own special needs. In this section, we will try to at least provide an overview of the kinds of student exceptionalities you might be asked to accommodate in your classroom and how you might begin that accommodation process.
Challenges in Gaining Knowledge

Many students with disabilities face challenges in gaining knowledge:

- A visual impairment requiring accommodation through materials in large print or Braille, on tape, or via computer;
- A hearing impairment requiring accommodation such as the use of an AM/FM system or an interpreter, additional printed materials, facing a student for lip reading, or increased use of an overhead projector or blackboard;
- A speech impairment requiring accommodations such as increased use of written or electronic communications where the ability to hear or speak is not required or the use of portable computer with speech output;
- A specific learning disability requiring accommodation such as increased visual, aural, and tactile demonstrations in class; extra time to complete assignments; and access to materials via a computer equipped with speech and/or large print output;
- A mobility impairment requiring accommodation such as in-class access to a computer with adaptive technology and a word processor, adaptive equipment for manipulating objects during a lab activity, or an adjusted table arrangement;
- A specific learning impairment (e.g., ADD or ADHD) requiring accommodations such as a specific seating location or attention to possible distracters in the classroom such as open windows that allow noise to filter in.

Challenges in Demonstrating Knowledge

Some students with disabilities face challenges in demonstrating their knowledge of a topic instead of, or in addition to, facing challenges in gaining that knowledge. The student might face challenges in writing, speaking, or working through a problem in a lab. Many of the same accommodations for assisting students in gaining knowledge that are discussed above can also help the student demonstrate mastery of a subject. Additional accommodations could include the following:

- A student with a visual impairment might need worksheets and tests in large print or Braille, on tape, or via computer, or access to adaptive technology that provides enlarged print, voice, and/or Braille as well as standard print output.
- A student with a specific learning disability may require extra time, alternative testing arrangements, or a particularly quiet space free of distractions.
• A student with a mobility impairment that leads to an inability to write may need in-class access to a computer with alternative native input (e.g., Morse code, speech, alternative keyboard) devices.

Students with a range of disabilities may require help from an itinerant special education teacher or paraprofessional to provide physical assistance in completing a test or assignment.

Theory Into Practice 4.4

Modifying Lab Activities

From Part II of this book, select three hands-on science experiments appropriate for the grade level you wish to teach.

Consider what accommodations you could make for each of the three activities to best meet the needs of students with the following disabilities:

- A student with a visual impairment
- A student with a mobility impairment who is in a wheelchair
- A student who has ADHD
- A student with a speech impairment

If you can, show your list of accommodations to a trained special educator to see what additional suggestions for accommodations he or she can provide.

Strategies for Working With English Language Learners in the Science Classroom

Inquiry-based science, because of its hands-on nature, is in many ways an ideal academic area in which English language learners can flourish. However, it can also be quite frustrating for these students as they try to figure out what to do, how to do it (often collaboratively with peers), and how to make sense of it. Remember that in a content-area class such as science, English language learners are being asked to learn the content and the language simultaneously—a cognitively demanding challenge! Meaning-rich learning opportunities can reduce the language load required for comprehension and promote student understanding. The combination of inquiry activities and non-linguistic means of expression (such as graphs and diagrams) can also help English language learners communicate their ideas.
The following strategies can be used to help English language learners simultaneously develop knowledge and skills in science and in English. Many of these strategies are valuable for all students and not just English language learners. Remember that all elementary and middle-grade students, even those whose first language is English, are still learning academic English as well as science content.

Multiple Representations. Ask students to express their ideas in multiple formats, such as drawings, graphs, and tables, as well as in written and oral communications. This will help students gain an understanding of the relationships among different modes of communication and the ideas they wish to express. Graphics production forces students to observe carefully, provides artifacts that foster discussion, and gives them something concrete and comprehensible to write about.

Key Science Terms in Multiple Languages. Science instruction is often associated with the use of many “scientific” terms. The acquisition of a massive science vocabulary should not be one of your instructional goals in teaching science. This applies to native English speakers as well as English language learners. Instead, you should guide students to comprehend and use a small number of key terms that are most important to the topic of study. It is worthwhile to create a multilingual basic vocabulary list in the languages prevalent in your class for the key science terms that you use repeatedly. Referring to these terms with the entire class will promote an understanding of science for your English language learners while promoting multiple language development in all your students. Keep this list posted on the wall and add to it throughout the year. Have native speakers of each language model correct pronunciation of the terms for the rest of the class.

Positional Terms and Phrases. In addition to key science terms, many English language learners, especially at the beginning levels of English acquisition, struggle to master positional terms, such as in/on, above/below, and inside/outside. These terms are critical in doing hands-on science because students are asked to make observations, take measurements, and draw pictures and graphs that all rely on correct use of positional terms. Participation in these activities can help English language learners to use these terms successfully, but only if the teacher is aware of students’ language-learning needs and provides the kinds of input that helps students learn and use these terms.

Use of Tools and Objects. The value of hands-on science for making learning (and the corresponding language) concrete for English language learners has already been discussed. Use of tools and objects has the added advantage of giving English language learners legitimate ways to contribute to class or small-group activities even when their English language skills are still emerging. Once students understand what is to be done with a tool or object, they
can carry out the task even if they cannot yet adequately express in English what they are doing. This legitimate participation further engrains the student into the workings of the class, helping build the relationships that are essential for developing opportunities for verbal communication.

Theory Into Practice 4.5

Sheltered Second-Language Activity

If you speak a second language (or can get the assistance of someone who does), teach a fairly simple hands-on inquiry-based lesson entirely in that language.

Be sure to use good ESOL teaching strategies such as modeling, gestures, repeated use of key vocabulary, simplified syntax, pictures, and so on.

Split the class into small groups. If there are some students in the class who speak the other language, so much the better—split them up between the groups.

Pose a question (in the second language) to be answered by manipulating the materials, then give each group some time to explore.

Let the students speak in English (or whatever language they prefer) while in their small groups to try to make sense of the task, but as you move around the class observing or answering questions, you should only use the second language. Likewise, when you bring the groups back together, have each group report what they did, but only in the second language—coach as needed.

Finally, switch back to English and debrief the experience. Many students are likely to express how frustrating and challenging it was to learn the content and language at the same time. Some may also point out, however, that with good teaching strategies, most of the students did manage to get at least the main ideas of the lesson even as they struggled with the language. Discuss how this experience was both similar to and different from the experiences of English language learners in their classrooms.

Gifted and Talented Students in the Science Classroom

All schools, no matter what other elements of student diversity might be present, have students who tend to think more quickly, more abstractly, and more divergently than their peers. Many of these students fall into the
category of gifted and talented (a label that some argue should apply to as much as 15% of the student population, whether or not they have officially been placed in a program to receive special services). Whatever other supplemental services these students receive (often a pull-out program for a part of each day or several times a week), when they are in your classroom, it is your responsibility to adopt strategies to meet their learning needs. Science can be an ideal content area for pushing gifted students to explore and develop their full academic potential. Suggestions offered in this section will help you develop a science learning environment that will challenge and nurture gifted learners.

Attending to the needs of students who are gifted or talented in science while simultaneously teaching the other groups of students in a classroom is very difficult, especially in light of all the other special student learning needs we have outlined in this chapter. It would not be surprising if by this point you are ready to throw up your hands in dismay, wondering how you will ever learn to juggle so many needs for so many students at the same time. While this challenge is, indeed, daunting, you can take some comfort in knowing that many of the “special” strategies for learners with special needs that we have discussed in this chapter are actually, when used judiciously, teaching strategies that can benefit all your students.

For example, items on the following list of strategies and methods considered appropriate for gifted students are, we believe, equally valuable for all students when done in a thoughtful and reflective way:

1. Vary your use of group and individual activities to accommodate different abilities, skills, and learning rates.

2. Vary the level of cognitive demand of your activities, requiring students to develop both basic skills and higher-order thinking skills and strategies.

3. Allow students to negotiate self-selected topics for learning within established curriculum parameters.

4. Encourage students to question assumptions, including assumptions about their own learning and how they construct knowledge.

5. Demonstrate logical, critical, creative, lateral, and parallel forms of thinking.

6. Pay attention to both product and process, teaching students to visualize the desired outcome of a task, and then map the process backwards to determine how to accomplish the outcome.

7. Encourage students to help other students with their learning.
More specific strategies for teaching science to students who are gifted and talented include the following:

**Independent Science Projects.** Many gifted and talented students tend to finish their work rather quickly. In fact, teachers sometimes find that these students become behavior problems during this “free time.” Have these students use this time to explore a special area of interest related to the science topic being studied. Many science texts, kits, and other curricular resources contain “extension” activities that teachers rarely have time to cover with the whole class. These extensions are frequently creative and engaging, and thus provide an excellent outlet for the gifted student’s creative energy. They are sometimes referred to as “vertical enrichment” activities because they push the student to build more advanced knowledge rather than just do more of the same level work.

**Academic Competitions.** There are a growing number of academic science competitions for students of all ages: at the school level, such as a science fair; at the regional level, such as regional competitions of the Science Olympiad (http://www.soinc.org/); or even at national and international levels, such as Odyssey of the Mind (http://www.odysseyofthemind.com). Such experiences not only challenge students academically, they also provide an opportunity to develop skills in leadership and group dynamics.

**Mentoring.** Teachers frequently ask gifted students to work with struggling peers in the classroom as a peer tutor. There is a real cognitive and social value to be gained for the gifted student in attempting to teach his or her peers. It is true that one of the best ways to solidify one’s own understanding of a topic is to attempt to teach it to another. However, such individual attention should be provided to the gifted student as well. Try to find a mentor who will work with the gifted student in an area of interest. Parents and other school volunteers are one source of potential mentors; school business partners and community organizations are another source. This outside expertise can provide your gifted students with opportunities to engage in areas of science learning that you may be unable to provide.

**Learning Styles and Cognitive Demand.** It is now well-accepted by most educators that all people possess “multiple intelligences” in varying degrees and that teachers should attempt to stimulate and develop in their students as many of these intelligences as they can (Gardner, 1993, 1999). This approach provides limitless possibilities for teaching science. Challenge your gifted students (and the rest of your class as well) to find ways to apply all of their intelligences to the learning of science. Push students to take the initiative to write a poem or a song, to build a model, or choreograph a dance that explores a science concept such as the change of the seasons or the structure of an atom. Likewise, considering Bloom’s Taxonomy, or other models of cognitive demand, should help you determine whether you are requiring your
students to engage in an appropriate mix of “lower order” cognitive demand (such as recall and basic comprehension) and “higher order” cognitive demand (such as analyzing and evaluating knowledge claims).

Learning Centers. Many teachers already use learning centers in their classrooms to allow students to work independently at their own speed on certain projects. Because gifted students frequently work faster than other students in their class, learning centers work well for these students as a place in the classroom to go and engage in something exciting (if they finish an assignment early).

Leveling Assignments. Leveling an assignment is the process of differentiating expectations of quality and scope of an assignment depending on your students’ individual abilities. While teachers sometimes worry that setting different standards for different students does not treat their students fairly, in fact, using strategies that tailor the assignment to the needs of a given student is both more fair and more effective than expecting the same thing from every student. The one concern here is that using this approach puts the burden on the teacher to accurately diagnose students’ abilities, and not, for example, “shortchange” what a given student knows.

Theory Into Practice 4.6

Debating the “Fairness” of Gifted Education

Gifted and talented programs sometimes come under criticism for funneling additional resources to students who already tend to be privileged in a number of ways. While almost no one would argue that a student with a visual or a mobility impairment should not receive special services to accommodate his or her disability, some have argued that providing special services to gifted and talented students is simply compounding advantages these students already have and that those resources should be used, instead, to provide additional services to academically struggling students.

Imagine that you are a teacher who has been asked to defend the value of your school’s gifted program to a parent who does not believe that the program is fair.

Think about how you might respond to this parent and then write a one-page paper outlining your argument in support of gifted education programs.
Summary
In this chapter, we have discussed a wide range of diversity issues that are likely to influence the way you teach. While we have focused this discussion on teaching and learning science, issues of diversity obviously stretch across all content areas. We began by discussing the history of diverse learners in the science classroom, highlighting issues of gender; racial, ethnic, and cultural diversity; socioeconomic status (SES); students with exceptionalities; and English language learners and how each of these groups has historically been underrepresented both in science practice and in receiving high-quality science education. We then discussed the current wave of science education reforms and how they have impacted the education of diverse learners. While standards-based reforms make strong claims about the desirability of promoting science education for all students, they are generally short on substantive suggestions for how best to bring these changes about.

We attempted to address this shortcoming of the reform documents by providing a variety of specific strategies that can be used with diverse learners in the science classroom. Again, we focus on five categories of diversity: gender; racial, ethnic, and cultural diversity; SES; students with disabilities; and English language learners. We also highlighted the special needs of gifted and talented students in the science classroom. Working with gifted students in a general education setting differs from working with students with special needs: Teachers must push students to go beyond the standards rather than help students to meet the standards.

One thing we hope has become clear in this chapter is that the concept of a “mainstream student,” one who can be taught effectively without attending to issues of diversity, is a myth. Every student you have in your classroom every year is different, and each will have his or her own “special needs.” Some of the strategies we have discussed in this chapter will be effective for working with some students, and other strategies will be effective with others. Our best advice is to get to know each of your students as well as you can. Learning about and trying to draw pedagogical connections to their cultural and linguistic backgrounds, their likes and dislikes, their goals and aspirations is every bit as important as considering strategies based on the more obvious categories of gender, race, or diagnosed special needs. It is easy to label students as “at risk” or “problem students.” It is much more challenging to learn to work with these students in ways that acknowledge and build on their strengths while helping them learn to compensate for or overcome their weaknesses. This is the true meaning of teaching diverse students.

Student Study Site
The Companion Web site for Teaching Science in Elementary and Middle School
http://www.sagepub.com/buxtonstudy
Visit the Web-based student study site to enhance your understanding of the chapter content and to discover additional resources that will take your learning one step further. You can enhance your understanding of the
chapters by using the study materials, which include chapter objectives, flashcards, activities, practice tests, and more. You’ll also find special features, such as Resources for Experiments, the Links to Standards from U.S. States and associated activities, Learning From Journal Articles, Theory Into Practice resources, Reflections on Science exercises, a Science Standards-Based Lesson Plan Project, and PRAXIS resources.

Reflections on Science

1. Think back to when you were a student in elementary school. What memories do you have of students with special needs in your classes? If you don’t have many memories, why do you think this is?

2. Have you ever taken a basic conversation course in a foreign language? What topics did you cover? Have you ever taken an academic subject course in a foreign language? What topics did you cover? What is the difference between these two cases? How does this relate to the situation of English language learners you might have in your classroom?

3. Does science benefit everyone evenly? Why or why not? Are there patterns or trends in who benefits most? Might this be related to why some students are more enthusiastic about learning science than others?

4. Are there ways in which the standards-based reform movement has improved the educational opportunities in science for students with special needs? For English language learners? For girls? For racially, ethnically, and culturally diverse students? For students from low-SES backgrounds? Are there ways in which the standards-based reform movement has damaged or hindered the educational opportunities in science for students with special needs? For English language learners? For girls? For racially, ethnically, and culturally diverse students? For students from low-SES backgrounds? Explain.

Internet Connections: Science for Diverse Learners

Notable Hispanic Americans
http://www.factmonster.com/spot/bhmbio7.html

Notable African Americans
http://www.infoplease.com/spot/bhmbios1.html

Notable Native Americans
http://www.infoplease.com/spot/aihmbioaz.html

Notable Asian Americans
http://www.infoplease.com/spot/asianambios.html

American Association of University Women (AAUW)
http://www.aauw.org/
National Association of Bilingual Education (NABE)
http://www.nabe.org/

Teachers of English to Speakers of Other Languages (TESOL)
http://www.tesol.org/s_tesol/index.asp

Council for Exceptional Children
http://www.cec.sped.org//AM/Template.cfm?Section=Home

References


