Session 2: The Process of Science

Science is a marvelous, fruitful, and constantly changing way of looking at the world. It strives to not be dogmatic, and to be based on evidence, testability, consistency, objectivity, and peer review. Like many other systems of thought, science is a quest for truth, yet one of its greatest strengths is that it recognizes that it can never arrive at the truth. It helps us understand the world around us, and in a practical sense, it has great predictive value. Some people perceive science as infallible. Others see it as arrogant, biased or heartless. It is neither.

Science is an extremely valuable way of knowing. Through attempting to define science, we gain an understanding of its strengths and pitfalls. We take a critical look at what often passes for science, but on closer examination does not stand up to evidence-based scrutiny. These misinterpretations, conscious and unconscious, are widespread, and examining them can help hone our own understanding of what science is and is not.

Understanding the process of science is important not only for students, but for anyone who teaches science. As such this session represents an important early experience in the Communicating Ocean Science course. Tinker and Thornton describe: "...science not as a noun...but as a process, a set of activities, a way of proceeding and thinking..." Not all of us learned science in this way. Science *can* be introduced to the youngest of students in ways that engage them in the first hand collection and evaluation of evidence. When a teacher grasps and appreciates the process of science, s/he can truly embrace the process of science teaching that is advocated in the National Science Education Standards and taught through the Communicating Ocean Science course.

> "Science not as a noun...but as a process, a set of activities, a way of proceeding and thinking." *(Tinker & Thornton, 1992, p. 155)*

Tinker, R. F. & Thornton, R. K. (1992). Constructing student knowledge in science. In E. Scanlon & T. O'Shea (Eds.), New directions in educational technology (pp. 153-170). Berlin: Springer-Verlag.

The reading for this session examines the nature of science by reflecting on what constitutes a scientific world view and what values, attitudes, and skills are important habits of mind in scientific reasoning.

If this session catalyzes your interest in the nature and process of science, you may want to explore the following authors:

Stephen Jay Gould dealt with the nature of science and the scientific enterprise in each of his books and collected essays. Hen's Teeth and Horses Toes and The Panda's Thumb are great places to start.

Carl Sagan's A Candle in the Dark makes a compelling argument for a more scientifically literate citizenry and the importance of scientific reasoning in everyday life.

Michael Shermer has written several books exploring the nature of science. Why People Believe Weird Things offers several chapters on the scientific enterprise, skepticism, and critical thinking.

Chapter 1 THE NATURE OF SCIENCE

A THE SCIENTIFIC WORLD VIEW
B SCIENTIFIC INQUIRY
C THE SCIENTIFIC ENTERPRISE

... ver the course of human history, people have developed many interconnected and validated ideas about the physical, biological, psychological, and social worlds. Those ideas have enabled successive generations to achieve an increasingly comprehensive and reliable understanding of the human species and its environment. The means used to develop these ideas are particular ways of observing, thinking, experimenting, and validating. These ways represent a fundamental aspect of the nature of science and reflect how science tends to differ from other modes of knowing.

It is the union of science, mathematics, and technology that forms the scientific endeavor and that makes it so successful. Although each of these human enterprises has a character and history of its own, each is dependent on and reinforces the others. Accordingly, the first three chapters of recommendations draw portraits of science, mathematics, and technology that emphasize their roles in the scientific endeavor and reveal some of the similarities and connections among them.

SCIENCE FOR ALL AMERICANS

The study of science as an intellectual and social endeavor—the application of human intelligence to figuring out how the world works—should have a prominent place in any curriculum that has science literacy as one of its aims. Consider the following:

> When people know how scientists go about their work and reach scientific conclusions, and what the limitations of such conclusions are, they are more likely to react thoughtfully to scientific claims and less likely to reject them out of hand or accept them uncritically.
>
> Once people gain a good sense of how science operates—along with a basic inventory of key science concepts as a basis for learning more later—they can follow the science adventure story as it plays out during their lifetimes.
>
> The images that many people have of science and how it works are often distorted. The myths and stereotypes that young people have about science are not dispelled when science teaching focuses narrowly on the laws, concepts, and theories of science. Hence, the study of science as a way of knowing needs to be made explicit in the curriculum.

Acquiring scientific knowledge about how the world works does not necessarily lead to an understanding of how science itself works, and neither does knowledge of the philosophy and sociology of science alone lead to a scientific understanding of the world. The challenge for educators is to weave these different aspects of science together so that they reinforce one another.

For students in the early grades, the emphasis should overwhelmingly be on gaining experience with natural and social phenomena and on enjoying science. Abstractions of all kinds can gradually make their appearance as students mature and develop an ability to handle explanations that are complex and abstract. This phasing-in certainly applies to generalizations about the scientific world view, scientific inquiry, and the scientific enterprise.

That does not mean, however, that abstraction should be ignored altogether in the early grades. By gaining lots of experience *doing* science, becoming more sophisticated in conducting investigations, and explaining their findings, students will accumulate a set of concrete experiences on which they can draw to *reflect* on the process. At the same time, conclusions presented to students (in books and in class) about how scientists explain phenomena should gradually be augmented by information on how the science community arrived at those conclusions. Indeed, as students move through school, they should be encouraged to ask over and over, "How do we know that's true?"

History provides another avenue to the understanding of how science works, which is one of the chief reasons why a chapter on historical perspectives is included in both *Science for All Americans* and *Benchmarks*. Although that chapter emphasizes the great advances in science, it is equally important that students should come to realize that much of the growth of science and technology has resulted from the gradual accumulation of knowledge over many centuries.

This realization runs counter to widely held misconceptions about scientific progress. What has been called normal science, in contrast to scientific revolutions, is what goes on most of the time, engages most of the people, and yields most of the advances. While "breakthroughs" and "revolutions" attract people's attention more than step-by-step growth, focusing on those rare events exclusively will give students a distorted idea of science, in that both incremental growth and occasional radical shifts are part of the story of science.

For the same reason, not all of the historical emphasis should be placed on the lives of great scientists, those relatively few figures who, owing to genius and opportunity and good fortune, are best known. Students should learn that all sorts of people, indeed, people like themselves, have done and continue to do science.

To gain this understanding, students will need appropriate learning materials. Historical case studies, backed up by a solid collection of biographies and other reference works and films, will be essential. Also, science and history textbooks will need to be modified to include the history of science. Beginning with science, mathematics, and technology in the early Egyptian, Greek, Chinese, and Arabic cultures, these materials should extend to modern times and include information on the contributions of men and women from every part of the world. ■

1A The Scientific World View

A scientific world view is not something that working scientists spend a lot of time discussing. They just do science. But underlying their work are several beliefs that are not always held by nonscientists. One is that by working together over time, people can in fact figure out how the world works. Another is that the universe is a unified system and knowledge gained from studying one part of it can often be applied to other parts. Still another is that knowledge is both stable and subject to change.

Little is gained by presenting these beliefs to students as dogma. For one thing, such beliefs are subtle. The first one cited above says only that scientists believe that the world *can* be understood, not that it ever *will* be so completely understood that science can shut down once and for all, the job done. Indeed, in finding answers to one set of questions about how the world works, scientists inevitably unearth new questions, so the quest will likely continue as long as human curiosity survives. Also, the human capacity for generating trustworthy knowledge about nature has limits. Scientific investigations often fail to find convincing answers to the questions they pursue. The claim that science will find answers always carries the implied disclaimers, "in many cases" and "in the very long run."

The belief that knowledge gained by studying one part of the universe can be applied to other parts is often confirmed but turns out to be true only part of the time. It happens, for example, that the behavior of a given organism is sometimes different when observed in a laboratory instead of its natural environment. Thus, a belief in the unity of the universe does not eliminate the need to show how far the findings in one situation can be extended.

The notion that scientific knowledge is always subject to modification can be difficult for students to grasp. It seems to oppose the certainty and truth popularly accorded to science, and runs counter to the yearning for certainty that is characteristic of most cultures, perhaps especially so among youth. Moreover, the picture of change in science is not simple. As new questions arise, new theories are proposed, new instruments are invented, and new techniques are developed. In response, new experiments are conducted, new specimens collected, new observations made, and new analyses performed. Some of the findings challenge existing theories, leading to their modification or to the invention, on very rare occasions, of entirely new theories—which, in turn, leads to new experiments, new observations...and so on.

But that ferment of change occurs mostly at the cutting edge of research. In fact, it is important not to overdo the "science always changes" theme, since the main body of scientific knowledge is very stable and grows by being corrected slowly and having its boundaries extended gradually. Scientists themselves accept the notion that scientific knowledge is always *open* to improvement and can never be declared absolutely certain.

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ALSO

Chapter 2 The Nature of Mathematics
3 The Nature of Technology
4 A The Universe (light from distant stars, universal gravitation)
D Structure of Matter (early ideas about atoms)
E Energy Transformation (atomic spectra, matter and energy conservation)
F Motion (substances identified by their emitted light)
G Forces of Nature (universal gravitation)
10 Historical Perspectives
12 A Values and Attitudes
E Critical-Response Skills

From their very first day in school, students should be actively engaged in learning to view the world scientifically. That means encouraging them to ask questions about nature and to seek answers, collect things, count and measure things, make qualitative observations, organize collections and observations, discuss findings, etc. Getting into the spirit of science and liking science are what count most. Awareness of the scientific world view can come later.

Anticipating an eventual understanding of the scientific world view, these early science experiences can be designed to bring out one aspect of the belief in the unity of nature: consistency. Students should sometimes repeat observations and investigations in the classroom, and then, when possible, do so again in the school yard and at home. For instance, students could be asked to compare what happens in different places when an egg is cooked, or how moving objects are affected when pushed or pulled, or what a seed looks like when it starts to grow. These activities should serve to stimulate curiosity and engage students in taking an interest in their environment and the workings of nature.

By the end of the 2nd grade, students should know that

When a science investigation is done the way it was done before, we expect to get a very similar result.

Science investigations generally work the same way in different places.

Grades 3 through 5

As children continue to investigate the world, the consistency premise can be strengthened by putting more emphasis on explaining inconsistency. When students observe differences in the way things behave or get different results in repeated investigations, they should suspect that something differs from trial to trial and try to find out what. Sometimes the difference results from methods, sometimes from the way the world is. The point is that different findings can lead to interesting new questions to be investigated.

This emphasis on scientific engagement calls for frequent hands-on activities. But that is not to say that students must, or even can, "discover" everything by direct experience. Stories about people making discoveries and inventions can be used to illustrate the kinds of convictions about the world and what can be learned from it that are shared by the varied people who do science.

By the end of the 5th grade, students should know that

- **Results of similar scientific investigations seldom turn out exactly the same. Sometimes this is because of unexpected differences in the things being investigated, sometimes because of unrealized differences in the methods used or in the circumstances in which the investigation is carried out, and sometimes just because of uncertainties in observations. It is not always easy to tell which.**

Grades 6 through 8

Most early adolescents have a more immediate interest in nature than in the philosophy of science. They should continue to be engaged in doing science and encouraged to reflect on the science they are engaged in, with the assumption that they will later acquire a more mature reflection on science as a world view.

Early adolescence, however, is not too early to begin to deal with the question of the durability of scientific knowledge, and particularly its susceptibility to change. Both incremental changes and more radical changes in scientific knowledge should be taken up. Radical changes in science sometimes result from the appearance of new information, and sometimes from the invention of better theories (for example, germ theory and geologic time, as discussed in Chapter 10: Historical Perspectives).

By the end of the 8th grade, students should know that

- **When similar investigations give different results, the scientific challenge is to judge whether the differences are trivial or significant, and it often takes further studies to decide. Even with similar results, scientists may wait until an investigation has been repeated many times before accepting the results as correct.**
- **Scientific knowledge is subject to modification as new information challenges prevailing theories and as a new theory leads to looking at old observations in a new way.**
- **Some scientific knowledge is very old and yet is still applicable today.**
- **Some matters cannot be examined usefully in a scientific way. Among them are matters that by their nature cannot be tested objectively and those that are essentially matters of morality. Science can sometimes be used to inform ethical decisions by identifying the likely consequences of particular actions but cannot be used to establish that some action is either moral or immoral.** ■

Grades 9 through 12

Aspects of the scientific world view can be illustrated in the upper grades both by the study of historical episodes in science and by reflecting on developments in current science. Case studies provide opportunities to examine such matters as the theoretical and practical limitations of science, the differences in the character of the knowledge the different sciences generate, and the tension between the certainty of accepted science and the breakthroughs that upset this certainty.

By the end of the 12th grade, students should know that

- **Scientists assume that the universe is a vast single system in which the basic rules are the same everywhere. The rules may range from very simple to extremely complex, but scientists operate on the belief that the rules can be discovered by careful, systematic study.**
- **From time to time, major shifts occur in the scientific view of how the world works. More often, however, the changes that take place in the body of scientific knowledge are small modifications of prior knowledge. Change and continuity are persistent features of science.**
- **No matter how well one theory fits observations, a new theory might fit them just as well or better, or might fit a wider range of observations. In science, the testing, revising, and occasional discarding of theories, new and old, never ends. This ongoing process leads to an increasingly better understanding of how things work in the world but not to absolute truth. Evidence for the value of this approach is given by the improving ability of scientists to offer reliable explanations and make accurate predictions.** ■

Chapter 12 HABITS OF MIND

hroughout history, people have concerned themselves with the transmission of shared values, attitudes, and skills from one generation to the next. All three were taught long before formal schooling was invented. Even today, it is evident that family, religion, peers, books, news and entertainment media, and general life experiences are the chief influences in shaping people's views of knowledge, learning, and other aspects of life. Science, mathematics, and technology—in the context of schooling—can also play a key role in the process, for they are built upon a distinctive set of values, they reflect and respond to the values of society generally, and they are increasingly influential in shaping shared cultural values. Thus, to the degree that schooling concerns itself with values and attitudes—a matter of great sensitivity in a society that prizes cultural diversity and individuality and is wary of ideology—it must take scientific values and attitudes into account when preparing young people for life beyond school.

Similarly, there are certain thinking skills associated with science, mathematics, and technology that young people need to develop during their school years. These are mostly, but not exclusively, mathematical and logical skills that are essential tools for both formal and informal learning and for a lifetime of participation in society as a whole.

Taken together, these values, attitudes, and skills can be thought of as habits of mind because they all relate directly to a person's outlook on knowledge and learning and ways of thinking and acting.

Science for All Americans

In *Science for All Americans*, Project 2061 expresses the view that education has multiple purposes and that those purposes should serve as criteria for specifying what students need to know and be able to do. The criteria are philosophical and utilitarian, individual and social. While they speak to the intrinsic value of knowing for its own sake, they emphasize also the need for education to prepare students to make their way in the real world, a world in which problems abound—in the home, in the workplace, in the community, on the planet.

Hence, preparing students to become effective problem solvers, alone and in concert with others, is a major purpose of schooling. Science, mathematics, and technology can contribute significantly to that end because in their different ways they are enterprises in the business of searching for solutions to problems ranging from the highly theoretical to the entirely concrete. Moreover, in their interactions with society, science and technology create the context for many personal and community issues.

There is a large and growing literature on problem solving. Aside from exhortation, a staple of most educational writing (including this document, to be sure), the problem-solving literature deals mostly with what skills need to be learned, why skills should be expressed behaviorally, and how to teach the desired skills. After a study of that literature, wide consultation with experts, and intense discussion, Project 2061 has reached conclusions that are reflected in the content and language of this chapter. Chief among them are the following:

> Students' ability and inclination to solve problems effectively depend on their having certain knowledge, skills, and attitudes.
>
> Quantitative, communication, manual, and critical-response skills are essential for problem solving, but they are also part of what constitutes science literacy more generally. That is why they are brought together here as scientific habits of mind rather than more narrowly as problem-solving skills or more generally as thinking skills.
>
> Learning to solve problems in a variety of subject-matter contexts, if supplemented on occasion by explicit reflection on that experience, may result in the development of a generalized problem-solving ability that can be applied in new contexts; such transfer is unlikely to happen if either varied problem-solving experiences or reflection on problem solving is missing.
>
> The problem of rote learning is primarily a pedagogical one that applies to skills as well as knowledge, and it is not solved simply by stating learning goals in one way instead of another.

In the light of those conclusions, it is useful to explain why the skill goals in this chapter are separated from the knowledge goals in Chapters 1 through 11. One reason is that the knowledge called for in the previous 11 chapters responds to all of the science literacy criteria mentioned earlier, not solely those having to do with problem solving. Another reason is that the skills advocated in this chapter need to be learned in the context of all of the knowledge chapters and thus would have to be repeated chapter after chapter if we tried to present knowledge and skill goals in tandem. Finally, the skills are significant in their own right as part of what it means to be science-literate, and presenting them together should make it easier to consider them as such.

It is widely argued that listing intended learning goals in specific detail is unwise because teachers will simply have their students memorize the individual entries as isolated facts. The same danger applies to stating skills in detail—procedures also can be memorized without comprehension, as veterans of "the scientific method" and mathematics algorithms can attest. Project 2061's response is the same in both cases, namely that there are better ways to deal with the problem of rote learning than by remaining vague on what knowledge and skills we want students to acquire.

The phrase "Students should know that . . ." used in benchmarks in the preceding chapters means that students should be able to connect one idea to other ideas and use it in thinking about new situations and in problem solving. But we surely want students to be likely to make such connections, not merely be able to do so. Similarly, with respect to this chapter, we want students not only to acquire certain skills but also to be inclined to use them in new situations, outside as well as inside school. Thus when the benchmarks specify that "Students should be able to" do something, we take that to mean they will in fact do so when appropriate circumstances present themselves.

One manifestation of such inclination is what someone thinks about when reading news articles. For example, on reading that trees were being logged for an important new drug found in their bark, the science-literate person might wonder about the yield from a single tree, the amount of drug needed, and how long a new tree would take to grow; or about the possibility of synthesizing the drug instead; or about what species in the forest might suffer from the loss of those particular trees; or about how complex ecological interactions are and the need for computer software to track the implications; or about possible bias in whoever was responsible for considering those various possibilities. ■

12A VALUES AND ATTITUDES

Honesty is a desirable habit of mind not unique to people who practice science, mathematics, and technology. It is highly prized in the scientific community and essential to the scientific way of thinking and doing. The importance of honesty is urged on children from every quarter, and most children are able to say what the general principle is. What honesty means in practice, however, probably comes from their seeing firsthand how it is applied in many different situations. In school science, mathematics, and technology, there are numerous opportunities to show what honesty means and how it is valued. Science: Always report and record what you observe, not what you think it ought to be or what you think the teacher wants it to be, and do not erase your notes. Math: Do not change an answer from a calculation because it is different from what others get. Technology: If your design has limitations, say so.

RESEARCH NOTES
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ALSO SEE
Chapter 1 THE NATURE OF SCIENCE
2 A PATTERNS AND RELATIONSHIPS
B MATHEMATICS, SCIENCE, AND TECHNOLOGY
3 B DESIGN AND SYSTEMS
7 A CULTURAL EFFECTS ON BEHAVIOR
9 D UNCERTAINTY
E REASONING

Children are curious about things from birth. Curiosity does not have to be taught. The problem is the reverse: how to avoid squelching curiosity while helping students focus it productively. By fostering student curiosity about scientific, mathematical, and technological phenomena, teachers can reinforce the trait of curiosity generally and show that there are ways to go about finding answers to questions about how the world works. Students will gradually come to see that some ways of satisfying one's curiosity are better than others and that finding good answers and solutions is as much fun as raising good questions.

Balancing open-mindedness with skepticism may be difficult for students. These two virtues pull in opposite directions. Even in science itself, there is tension between an openness to new theories and an unwillingness to discard current ones. As students come up with explanations for what they observe or wonder about, teachers should insist that other students pay serious attention to them. Students hearing an explanation of how something works proposed by another student or by teachers and other authorities should learn that one can admire a proposal but remain skeptical until good evidence is offered for it.

Highest priority should be given to encouraging the curiosity about the world that children bring to school. Natural phenomena easily capture the attention of these youngsters, but they should be encouraged to wonder about mathematical and technological phenomena as well. Questions about numbers, shapes, and artifacts, for example, should be treated with the same interest as those about rocks and birds. Typically, children raise questions that are hard to answer. But some of their questions are possible to deal with, and some of the impossible questions can be transformed.

As students learn to write, they should start keeping a class list of things they wonder about, without regard to how easy it might be to answer their own questions. Teachers should then help them learn to pick from the list the questions they can find answers to by doing something such as collecting, sorting, counting, drawing, taking something apart, or making something. At this level, questions that can be answered descriptively are to be preferred over those requiring abstract explanations. Students are more likely to come up with reasonable answers as to "how" and "what" than as to "why."

Still, students should not be expected to confine themselves to empirical questions only. Some questions requiring an explanation for an answer can be taken up to foster scientific habits of thought. Thus, to the question, "Why don't plants grow in the dark?" students should learn that scientists would respond by asking, "Is it true that plants don't grow in the dark?" and "How do you know?" or "How can we find out if it is true?" If the facts are correct, then reasons can be offered. Presumably children, like scientists, will propose different explanations, and some children may have a need to establish whose ideas are good or best. Comparisons will come in time, when students are able to imagine ways to make judgments. Everyone's ideas should be valued, and differing opinions should be regarded as interesting and food for thought.

By the end of the 2nd grade, students should

> **Raise questions about the world around them and be willing to seek answers to some of them by making careful observations and trying things out.**

Grades 3 through 5

Sustaining curiosity and giving it a scientific cast is still a high priority. Students should advance in their ability to frame their questions about the world in ways that lead to their finding answers by conducting investigations, building and testing things, and consulting reference works. In doing so, whether working alone or in teams, students should be required to keep written records in bound notebooks of what they did, what data they collected, and what they think the data mean. Emphasis should be placed on honesty in record-keeping rather than on reaching correct conclusions. To the extent that a judgment is made by one group of students about another's conclusions, it should be on the basis of its correspondence to the evidence presented, not on what a book says is true.

The thrust of the science experience is still to learn how to answer interesting questions about the world that can be answered empirically. But now students should also sometimes think up and propose explanations for their findings. In this introduction to the world of theory, the main point to stress is that for any given collection of evidence, it is usually possible to invent different explanations, and it is not always easy to tell which will prove to be best. That is one reason that scientists pay attention to ideas that may differ from what they personally believe.

By the end of the 5th grade, students should

- **Keep records of their investigations and observations and not change the records later.**
- **Offer reasons for their findings and consider reasons suggested by others.**

Grades 6 through 8

The scientific values and attitudes that are the focus of this section have all been introduced in the previous grades. Now they can be reinforced and developed further. Care should be taken, in an effort to cover content, not to stop fostering curiosity. Time needs to be found to enable students to pursue scientific questions that truly interest them. Inquiry projects, individual and group, provide that opportunity. Such projects also establish realistic contexts in which to emphasize the importance of scientific honesty in describing procedures, recording data, drawing conclusions, and reporting conclusions.

Consideration of the nature and uses of hypotheses and theory in science can give operational substance to the scientific habits of openness and skepticism. Hypotheses and explanations serve somewhat different purposes, but they both are judged, ultimately, by reference to evidence. Students can come to see that a hypothesis does not have to be correct—one can believe it or not—but that to be taken seriously, it should indicate what evidence would be needed to decide whether or not it is true, thus incorporating the notions of both openness and skepticism.

In this same vein, a start can be made toward legitimizing the notion that there are often several different ways of making sense out of a body of existing information. Having teams invent two or more explanations for a set of observations, or having different teams independently come up with explanations for the same set of observations, can lead to discussions of the nature of scientific explanation that are grounded in reality. Developmental psychologists doubt that alternative explanations are seriously examined by most students at this level, but at least the possibility of alternatives can be planted, not as an abstract notion but as something stemming from students' own experience.

By the end of the 8th grade, students should

- **Know why it is important in science to keep honest, clear, and accurate records.**
- **Know that hypotheses are valuable, even if they turn out not to be true, if they lead to fruitful investigations.**
- **Know that often different explanations can be given for the same evidence, and it is not always possible to tell which one is correct.** ■

Grades 9 through 12

Skepticism is not just a matter of willingness to challenge authority, though that is an aspect of it. It is a determination to suspend judgment in the absence of credible evidence and logical arguments. Students can learn its value in science, and that is important. Given that most of them will not be scientists as adults, the educational challenge is to help students internalize the scientific critical attitude so they can apply it in everyday life, particularly in relation to the health, political, commercial, and technological claims they encounter.

Openness to new and unusual ideas about how the world works can now be developed in the study of historical cases as well as in the context of continuing inquiry projects. The Copernican Revolution, for example, illustrates the eventual success of ideas that were initially considered outrageous by nearly everyone. This and other cases also illustrate that ideas in science are not easily or quickly accepted. Some such mixture of openness and conservatism will serve most people and societies well.

By the end of the 12th grade, students should

- **Know why curiosity, honesty, openness, and skepticism are so highly regarded in science and how they are incorporated into the way science is carried out; exhibit those traits in their own lives and value them in others.**
- **View science and technology thoughtfully, being neither categorically antagonistic nor uncritically positive.** ■