

Chapter 2

THE SCIENTIFIC PROCESS

2.3 The Nature of Science and Technology

Science is a way of knowing that is based on evidence, logic, and skepticism. The purpose of scientific study is to learn about our natural world. Technology is a way of using scientific knowledge to create devices, such as mobile phones and medical instruments, which meet needs and solve problems. Science and technology are closely related, as you will see in this section.

Ethical traditions

Truthful reporting	Scientists all over the world conduct experiments every day, in colleges and universities, in industry, and for government agencies. Truthful reporting is the most important tradition of science. When scientists collect data, organize it, report it, and write about their results and conclusions, they must be unbiased and honest in their communication.
Scientific journals and peer review	How do scientists communicate their findings? Often, scientists write a report about their experiments and submit it to a <i>scientific journal</i> . A scientific journal is a publication, like a magazine, that comes out on a regular basis. There are hundreds of major scientific journals in print. Before a paper is published in a scientific journal, the work is reviewed by peers. Only if the work is approved by independent scientists can the paper be published.
Science news for everyone	Scientific journals can be very technical, and cannot be read like an ordinary magazine. Other periodicals such as <i>Popular Science</i> or <i>Scientific American</i> are also published. Their articles are less technical. They are selected from the thousands of papers that are published each month in scientific journals. These magazines are not scientific journals, but they are good sources of current science research findings. Daily news broadcasts on television, radio, and the Internet also carry headlines about recent scientific discoveries. Sometimes these headlines are unintentionally misleading, because they are just quick summaries of technical research explanations. Keep this in mind when you hear science news “sound bytes.” Remember, good science is always repeatable, reliable, based on evidence, and unbiased.

JOURNAL

Scientific Journals

Perhaps you are keeping a journal for your science class. Your science journal can contain notes, thoughts, reflections, scientific data, experimental procedures, tables, graphs, and lab reports.

A *scientific journal* is a specific kind of publication that is different from a science journal you might create in class. A scientific journal is a periodical publication that contains the results and conclusions of many different experiments. All of the papers (you might think of them as articles) submitted to a scientific journal must be reviewed by peers and accepted before they are published.

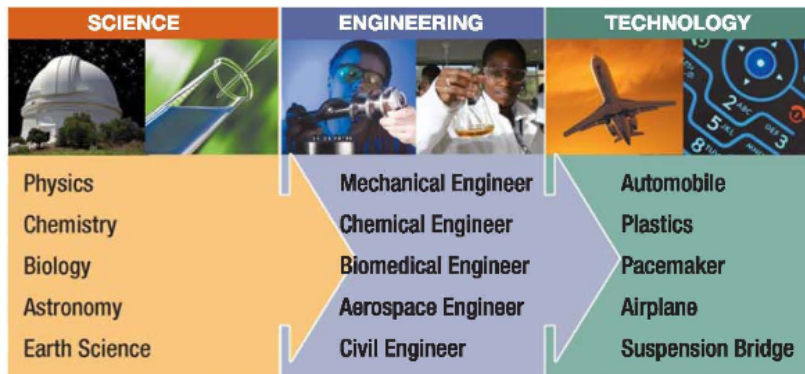
Have you heard of any of these scientific journals?

- *Nature*
- *Science*
- *Proceedings of the National Academy of Sciences*
- *Journal of the American Medical Association*
- *Journal of the American Chemical Society*
- *Advances in Physics*

Science and technology

Inventions solve problems You are surrounded by inventions, from the toothbrush you use to clean your teeth to the computer you use to do your school projects (and play games). Where did these inventions come from? Most of them came from a practical application of scientific knowledge.

What is technology? Science helps us understand the natural world. **Technology** is the application of science to meet human needs and solve problems. All technology—from the windmill to the supersonic jet—arises from someone thinking, “There must be a better way to do this!” Although technology is widely different in the details, there are some general principles that apply to all forms of technological design or innovation. People who design technology to solve problems are called **engineers**. Scientists study the natural world to learn the basic principles behind how things work. Engineers use scientific knowledge to create or improve inventions that solve problems.



VOCABULARY

technology - the application of science to meet human needs and solve problems.

engineer - a professional who uses scientific knowledge to create or improve inventions that solve problems and meet needs.

TECHNOLOGY

GPS Technology

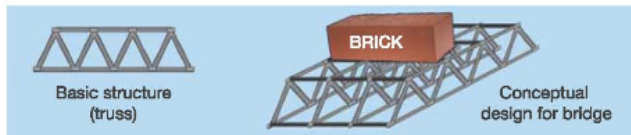
GPS stands for **Global Positioning System**. A GPS receiver can determine its position to within a few meters anywhere on Earth’s surface. How does this work? How does the GPS receiver “know” its position?

There are 24 satellites in orbit around Earth that transmit radio signals as part of a global navigation system. The satellites are in the sky, all transmitting their unique codes and locations. At any given time, a GPS receiver can receive signals from 6 to 11 of these 24 satellites. A GPS receiver determines its own position on Earth by comparing the signals from four different GPS satellites.

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Engineering

A sample engineering problem Suppose you are given a box of toothpicks and some glue and are told to build a bridge that can support a brick without breaking. After doing research, you come up with an idea for how to make the bridge. Your idea is to make the bridge from four structures connected together. Your idea is called a *conceptual design*.



The importance of a prototype You need to test your idea to see if it works. If you could figure out how much force it takes to break *one* structure, you would know if four structures will hold the brick. Your next step is to build a **prototype** and test it. Your prototype should be close enough to the real bridge so that what you learn from testing the prototype can be applied to the actual bridge.

Testing the prototype You test the prototype by applying more and more force until it breaks. You learn that your structure (called a truss) breaks at a force of 5 newtons. The brick weighs 25 newtons. Four trusses are not going to be enough. You have two choices now. You can make each truss stronger by using thread to tie the joints. Or, you could use more trusses in your bridge (Figure 2.10). The *evaluation* of test results is a necessary part of any successful design. Testing identifies potential problems in the design in time to correct them.

Changing the design and testing again If you decide to build a stronger structure, you will need to make another prototype and test it again. Good engineers often build many prototypes and keep testing them until they are successful under a wide range of conditions. The process of designing, prototyping, testing, and evaluating is the **engineering cycle**. The best inventions go through the cycle many times, being improved after each cycle until all the problems are worked out.



VOCABULARY
prototype - a working model of a design that can be tested to see if it works.
engineering cycle - a process used to build and test devices that solve technical problems.

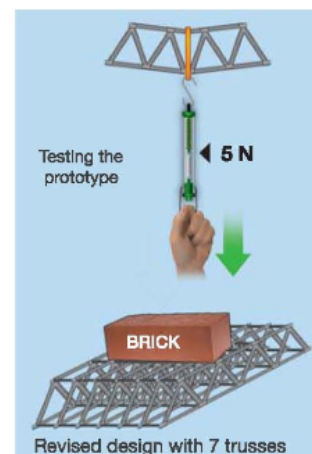
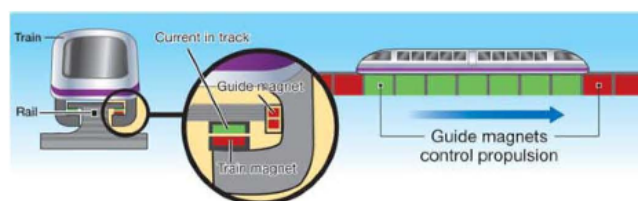


Figure 2.10: By testing the prototype, you find out if it is strong enough. Testing often leads to an updated design, such as this one of a bridge that uses more trusses.

Section 2.3 Review

1. Why are scientific journals such as *Nature* and *Journal of the American Medical Association* extremely important to scientific progress?
2. Suppose a scientist conducts a series of experiments and the results are so amazing she wants to share them with other experts in the field. Why would it be risky for her to make the results public on her own website before publishing them in a scientific journal?
3. Identify whether each item below is an example of science or technology.
 - a. digital music player
 - b. Newton's laws of motion
 - c. atomic theory
 - d. windmill
 - e. universal law of gravitation
 - f. GPS
 - g. biochemistry
 - h. maglev train
4. Discuss what might happen if an automobile manufacturer began making and selling cars based on a prototype that went through only one engineering design cycle.



A maglev train track has electromagnets in it that both lift the train and pull it forward. See the technology box in the sidebar.

TECHNOLOGY

Magnetic Levitation

In the previous section, you read about Michael Faraday's experiments with electromagnetism. A powerful new technology based on Faraday's experiments is currently in development. Magnetically levitated, or maglev, train technology uses electromagnetic force to lift a train a few inches above its track (see the figure below). By "floating" the train on a powerful magnetic field, the friction between wheel and rail is eliminated. Maglev trains can reach high speeds using less power than an ordinary train. In 2003, a Japanese prototype three-car maglev train carrying 12 people reached a record speed of 360 miles per hour! Maglev trains are now being developed and tested in Germany and the United States. Many engineers believe maglev technology will become the standard for mass transit systems over the next 100 years. Perhaps someday you will commute to work on a maglev train!