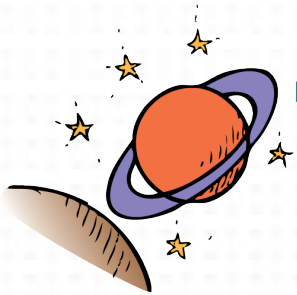


THE BIG IDEA

Science is the study of nature's rules.

We can't control Earth's motion, but we have learned the rules by which it moves. The study of nature's rules is what this book is about. Understanding these rules adds richness to the way we see our world.

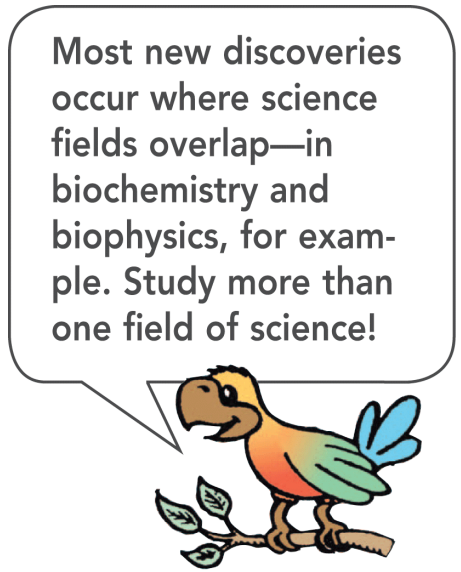
1.1 The Basic Science—Physics

Physics is about the nature of basic things such as motion, forces, energy, matter, heat, sound, light, and the composition of atoms.

1.1 The Basic Science—Physics

The study of science branches into the study of living things and nonliving things.

- The life sciences include biology, zoology, and botany.
- The physical sciences include geology, astronomy, chemistry, and physics.



1.1 The Basic Science—Physics

You can understand other sciences much better if you first understand physics.

- Physics is the most basic of all the sciences.
- Chemistry is about how matter is put together.
- Biology is still more complex and involves matter that is alive.

1.1 The Basic Science—Physics

What is physics about?

1.2 Mathematics—The Language of Science

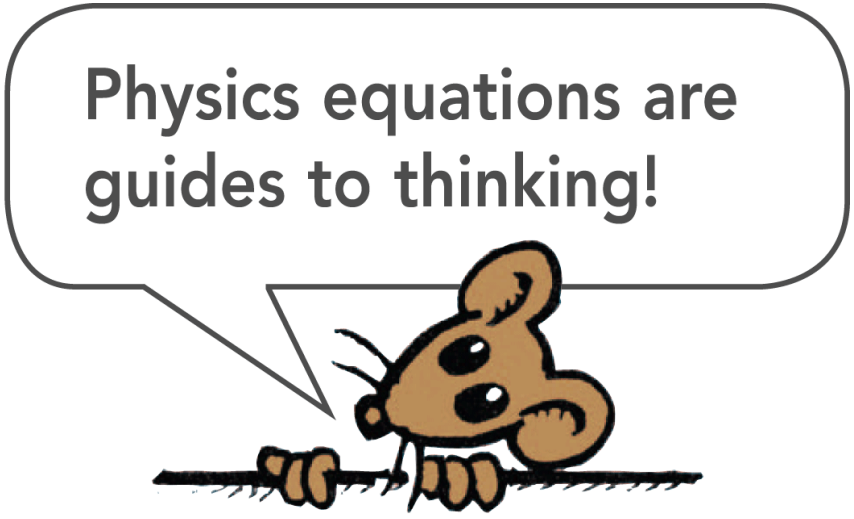
When scientific findings in nature are expressed mathematically, they are easier to verify or to disprove by experiment.

1.2 Mathematics—The Language of Science

When the ideas of science are expressed in mathematical terms, they are unambiguous.

The equations of science provide compact expressions of relationships between concepts.

The methods of mathematics and experimentation have led to enormous successes in science.



1.2 Mathematics—The Language of Science

CONCEPT CHECK

Why is mathematics the language of science?

1.3 Scientific Methods

Scientific methods generally include some, if not all, of the following:

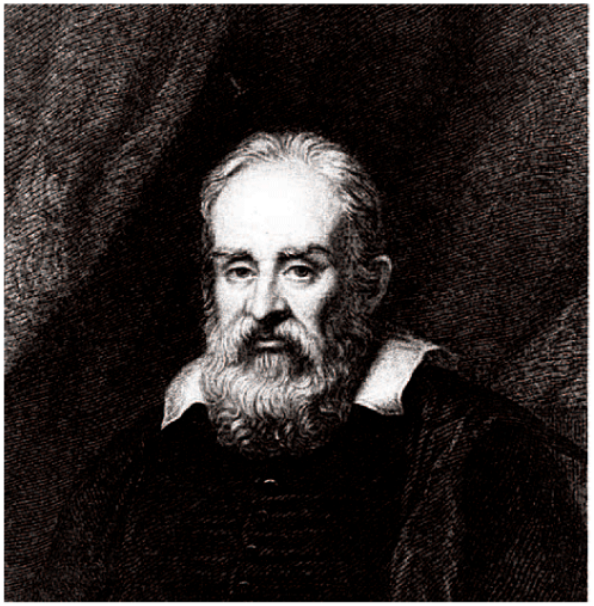
1. Recognize a problem.
2. Make an educated guess—a hypothesis—about the answer.
3. Predict the consequences of the hypothesis.
4. Perform experiments to test predictions.
5. Formulate the simplest general rule that organizes the main ingredients: hypothesis, prediction, and experimental outcome.

1.3 Scientific Methods

Scientific methods are extremely effective in gaining, organizing, and applying new knowledge.

The scientific method is often credited to the Italian physicist Galileo Galilei (a.) and the English philosopher Francis Bacon (b.).

a



b

1.3 Scientific Methods

Although the scientific method is popular, it is not the universal key to discoveries and advances in science.

- Trial and error, experimentation without guessing, and accidental discovery account for much of the progress in science.
- The success of science has more to do with an attitude of inquiry, experimentation, and humility than with a particular method.

1.3 Scientific Methods

CONCEPT CHECK

What are the steps of a scientific method?

1.4 The Scientific Attitude

If a scientist finds evidence that contradicts a hypothesis, law, or principle, then the hypothesis, law, or principle must be changed or abandoned.

1.4 The Scientific Attitude

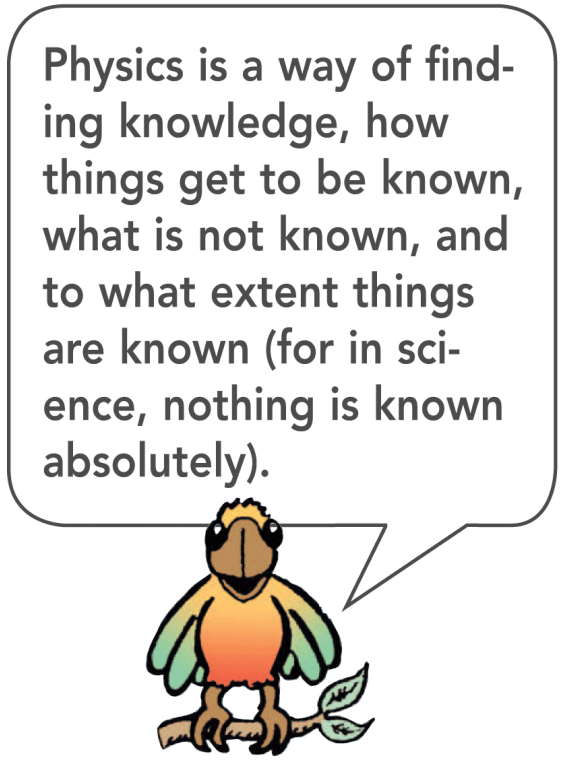
In science, a fact is a close agreement by competent observers who make a series of observations of the same phenomenon.

A scientific hypothesis is an educated guess that is not fully accepted until demonstrated by experiment.

When hypotheses about the relationship among natural quantities are tested over and over again and not contradicted, they may become laws or principles.

1.4 The Scientific Attitude

Scientists must accept their findings even when they would like them to be different. They must distinguish between what they see and what they wish to see.



1.4 The Scientific Attitude

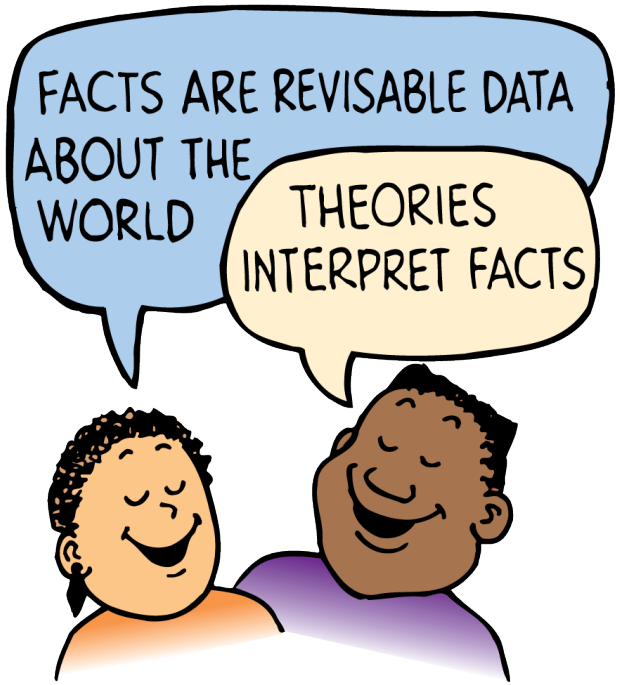
Scientific Theories

A scientific theory is a synthesis of a large body of information that encompasses well-tested and verified hypotheses about certain aspects of the natural world.

1.4 The Scientific Attitude

The theories of science evolve as they go through stages of redefinition and refinement.

- The refinement of theories is a strength of science, not a weakness.
- More important than defending beliefs is improving upon them.
- Better hypotheses are made by those who are honest in the face of experimental evidence.



1.4 The Scientific Attitude

CONCEPT CHECK

When must a hypothesis, law, or principle be changed or abandoned?

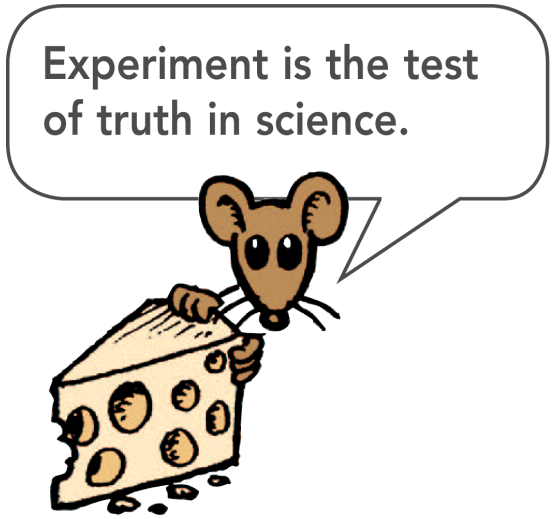
1.5 Scientific Hypotheses

To determine whether a hypothesis is scientific or not, look to see if there is a test for proving it wrong.

1.5 Scientific Hypotheses

A scientific hypothesis must be testable.

- It is more important that there be a way of proving it *wrong* than that there be a way of proving it correct.
- If there is no test for its possible wrongness, then it is not scientific.



1.5 Scientific Hypotheses

Here is a hypothesis that is scientific:

"No material object can travel faster than light."

Even if it were supported by a thousand other experiments, this hypothesis could be proven wrong by a single experiment. (So far, we find it to be true.)

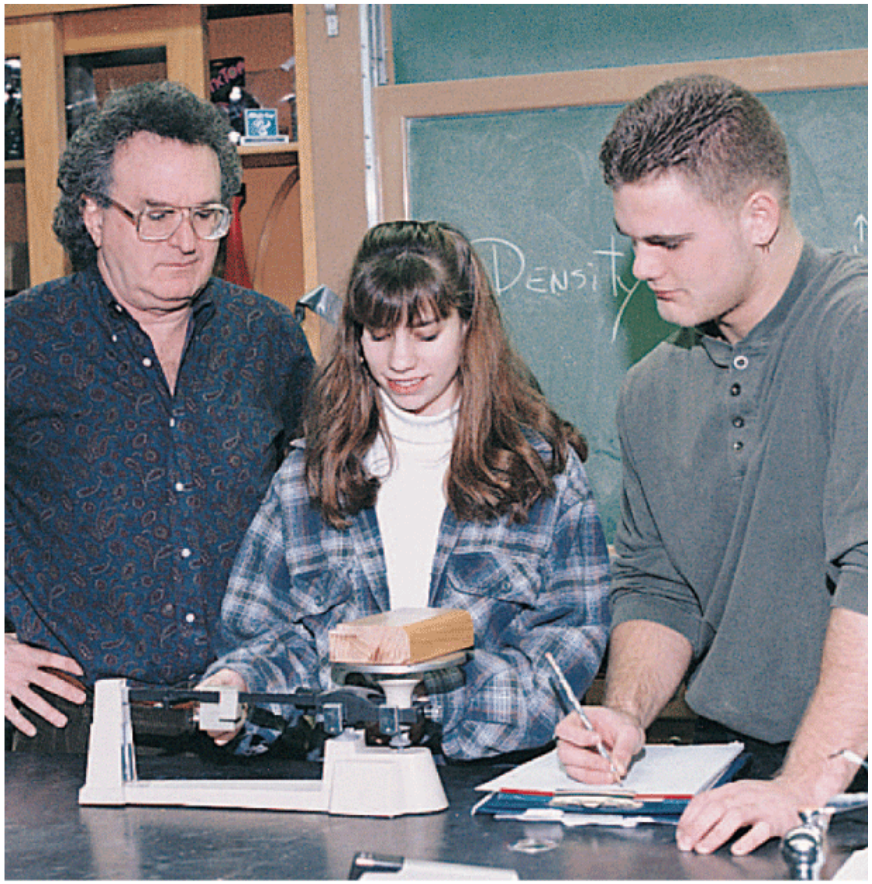
1.5 Scientific Hypotheses

Here are hypotheses that are not scientific:

- The hypothesis: "The alignment of planets in the sky determines the best time for making decisions" cannot be proven wrong, nor can it be proven right. It is *speculation.*
- The hypothesis: "Intelligent life exists on other planets somewhere in the universe" can be proven correct, but there is no way to prove it wrong if no life is ever found.
- The hypothesis: "Most people stop for red lights" doesn't link up to our general understanding of nature, so it doesn't fit into the structure of science.

1.5 Scientific Hypotheses

Experiments are conducted to test scientific hypotheses.



1.5 Scientific Hypotheses

think!

Which of these is a scientific hypothesis?

a. Atoms are the smallest particles of matter.

b. The universe is surrounded by a second universe, the existence of which cannot be detected by scientists.

c. Albert Einstein was the greatest physicist of the 1900s.

1.5 Scientific Hypotheses

think!

Which of these is a scientific hypothesis?

a. Atoms are the smallest particles of matter.

b. The universe is surrounded by a second universe, the existence of which cannot be detected by scientists.

c. Albert Einstein was the greatest physicist of the 1900s.

Answer:

(a) is scientific, because there is a test for its wrongness.

(b) has no test for possible wrongness and is therefore unscientific.

(c) is an assertion that has no test for possible wrongness.

1.5 Scientific Hypotheses

How do you know if a hypothesis is scientific?

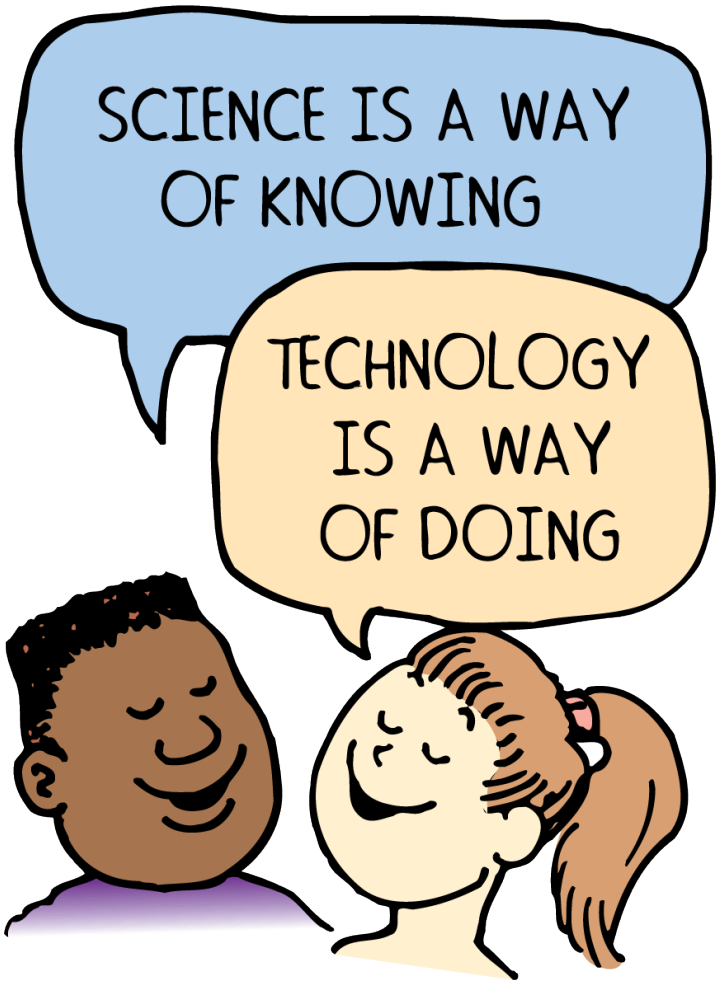
1.6 Science, Technology, and Society

Science is a method of answering theoretical questions; technology is a method of solving practical problems.

1.6 Science, Technology, and Society

Science has to do with discovering facts and relationships between observable phenomena in nature and with establishing theories that organize and make sense of these facts and relationships.

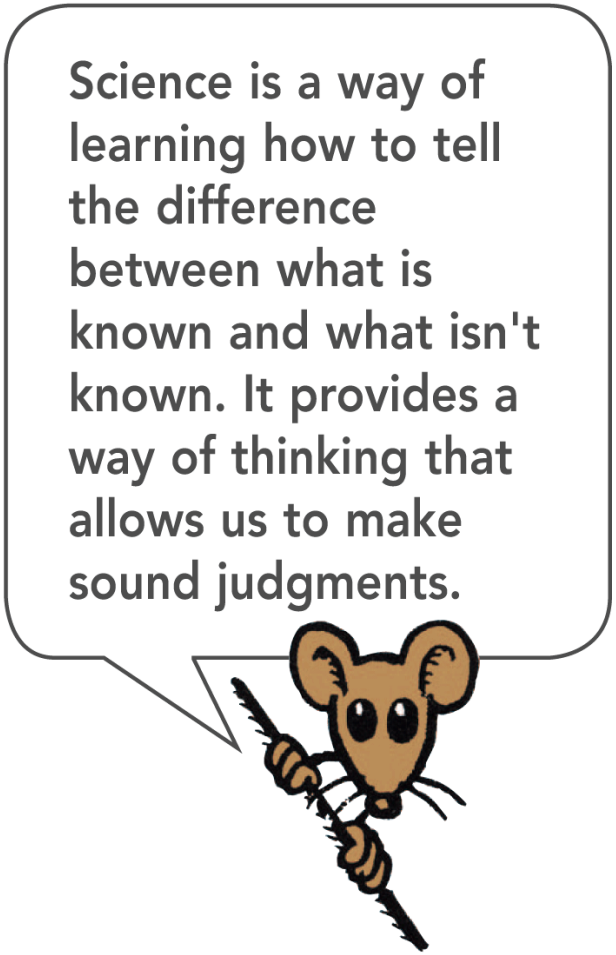
Technology has to do with tools, techniques, and procedures for putting the findings of science to use.



1.6 Science, Technology, and Society

Science and technology make up a larger part of our everyday lives than ever before.

The scientific way of thinking becomes vital to society as new facts are discovered and new ideas for caring for the planet are needed.



1.6 Science, Technology, and Society

What is the difference between science and technology?

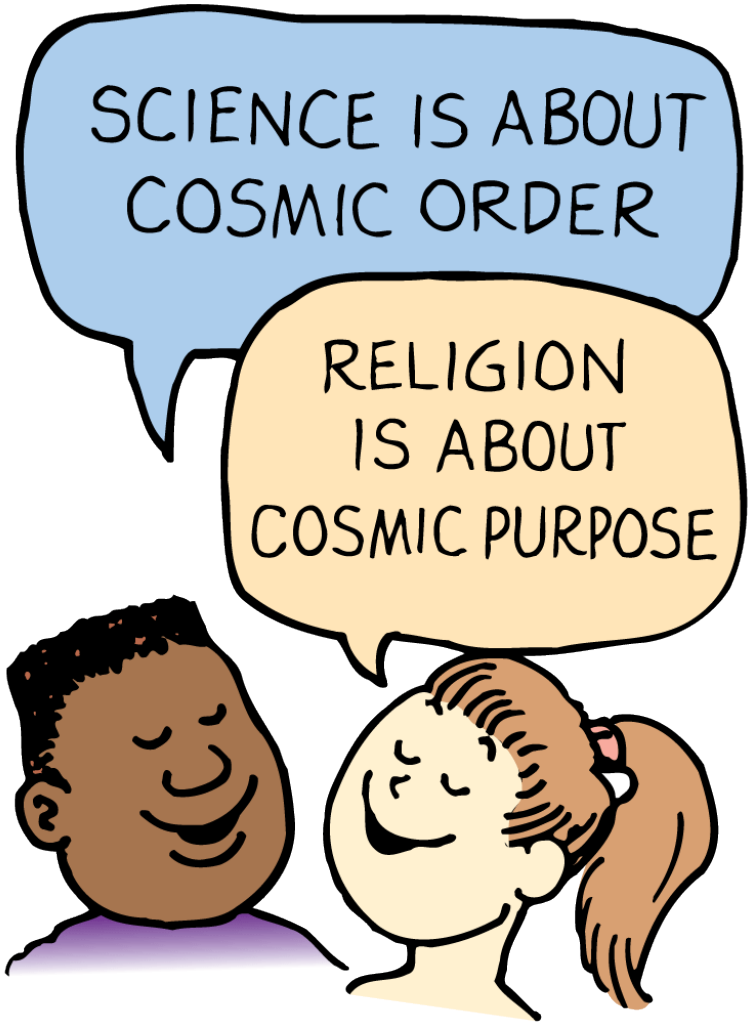
1.7 Science, Art, and Religion

Science is mostly concerned with discovering and recording natural phenomena, the arts are concerned with the value of human interactions as they pertain to the senses, and religion is concerned with the source, purpose, and meaning of everything.

1.7 Science, Art, and Religion

The domains of science, art, and religion are different, even though they overlap.

- The domain of science is natural order.
- The domain of religion is nature's purpose.



1.7 Science, Art, and Religion

The principal values of science and the arts are comparable.

- Literature describes the human experience. The arts do not necessarily give us experiences, but they describe them to us and suggest what may be in store for us.
- Science tells us what is possible in nature. Scientific knowledge helps us to predict possibilities in nature even before these possibilities have been experienced.

1.7 Science, Art, and Religion

think!

Which of the following involves great amounts of human passion, talent, and intelligence?

a. art

b. literature

c. music

d. science

1.7 Science, Art, and Religion

think!

Which of the following involves great amounts of human passion, talent, and intelligence?

a. art

b. literature

c. music

d. science

Answer:

All of them!

1.7 Science, Art, and Religion

CONCEPT CHECK

How are science, art, and religion different?

1.8 In Perspective

Progress in our age is much quicker than it was thousands of years ago.

1.8 In Perspective

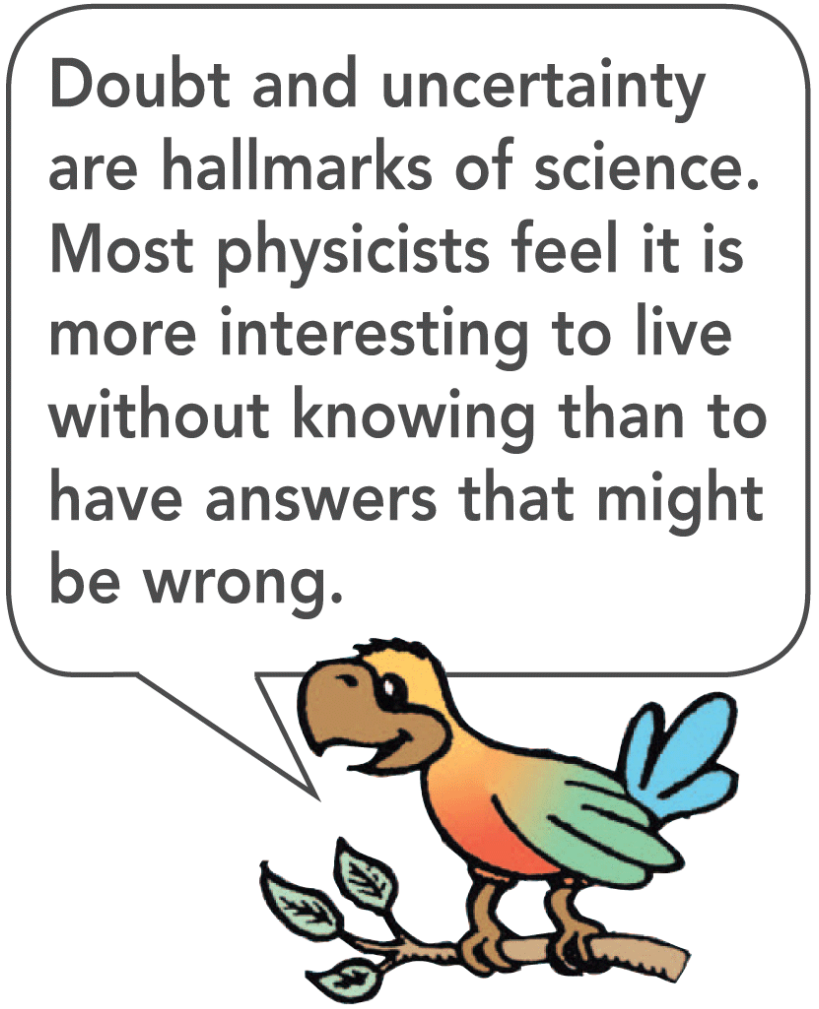
The pyramids testify to human genius, endurance, and thirst for deeper understanding.

A few centuries ago, cathedrals, synagogues, temples, and mosques were manifestations of people's vision.

This enormous focus of human energy was inspired by a vision that went beyond world concerns—a vision of the cosmos.

1.8 In Perspective

Today the efforts of many of our most skilled scientists, engineers, and artisans are directed toward building the spaceships that orbit Earth. Many people working on today's spaceships were alive before the first jetliner carried passengers. Where will younger lives lead in a comparable time?



1.8 In Perspective

Astronauts may one day travel in this spaceship of the future.

1.8 In Perspective

CONCEPT CHECK

How does progress today differ from progress thousands of years ago?

Assessment Questions

1. The science that is basic to the other sciences is

a. physics.
b. chemistry.
c. biology.
d. astronomy.

Assessment Questions

1. The science that is basic to the other sciences is

a. physics.
b. chemistry.
c. biology.
d. astronomy.

Answer: A

Assessment Questions

2. The language of science is

a. mathematics.
b. nature.
c. common language.
d. English.

Assessment Questions

2. The language of science is

a. mathematics.
b. nature.
c. common language.
d. English.

Answer: A

Assessment Questions

3. The classic scientific method, followed by Galileo and Bacon,

a. is the method guaranteed to lead to scientific discoveries.
b. is one of many ways that scientific discoveries are made.
c. is today outmoded, and of little value.
d. required memorization.

Assessment Questions

3. The classic scientific method, followed by Galileo and Bacon,

a. is the method guaranteed to lead to scientific discoveries.
b. is one of many ways that scientific discoveries are made.
c. is today outmoded, and of little value.
d. required memorization.

e. Answer: B

Assessment Questions

4. When someone says, "That's only a theory," that person likely doesn't know that a scientific theory is a(n)

a. guess that involves a bunch of facts.
b. type of hypothesis.
c. vast synthesis of well-tested hypotheses and facts.
d. untested explanation.

Assessment Questions

4. When someone says, "That's only a theory," that person likely doesn't know that a scientific theory is a(n)

a. guess that involves a bunch of facts.
b. type of hypothesis.
c. vast synthesis of well-tested hypotheses and facts.
d. untested explanation.

Answer: C

Assessment Questions

5. For a hypothesis to be scientific, it must

a. be in agreement with what we know is true.
b. have a test for proving it right.
c. have a test for proving it wrong.
d. be based on an existing scientific theory.

Assessment Questions

5. For a hypothesis to be scientific, it must

a. be in agreement with what we know is true.
b. have a test for proving it right.
c. have a test for proving it wrong.
d. be based on an existing scientific theory.

Answer: C

Assessment Questions

6. Technology is a

a. body of scientific knowledge.
b. tool of science.
c. form of science.
d. solution to all of humankind's problems.

Assessment Questions

6. Technology is a

a. body of scientific knowledge.
b. tool of science.
c. form of science.
d. solution to all of humankind's problems.

Answer: B

Assessment Questions

7. Science differs from art and religion because it

a. describes the human experience.

b. discovers and records natural phenomena.

c. describes the source, purpose, and meaning of everything.

d. is based on faith.

Assessment Questions

7. Science differs from art and religion because it

a. describes the human experience.
b. discovers and records natural phenomena.
c. describes the source, purpose, and meaning of everything.
d. is based on faith.

Answer: B

Assessment Questions

8. Which of the following statements about progress today compared with progress centuries ago is true?

a. Progress today is slower than it was centuries ago.

b. Progress today is faster than it was centuries ago.

c. Progress today is the same as it was centuries ago.

d. There is no way to determine if progress today differs from progress centuries ago.

Assessment Questions

8. Which of the following statements about progress today compared with progress centuries ago is true?

a. Progress today is slower than it was centuries ago.
b. Progress today is faster than it was centuries ago.
c. Progress today is the same as it was centuries ago.
d. There is no way to determine if progress today differs from progress centuries ago.

Answer: B