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.
1.3 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.).
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.
What are the steps of a scientific method?
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.

Physics is a way of finding knowledge, how things get to be known, what is not known, and to what extent things are known (for in science, nothing is known absolutely).
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.
When must a hypothesis, law, or principle be changed or abandoned?
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.
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?
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

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   b. is one of many ways that scientific discoveries are made.
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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

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   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