Chapter 1 Introduction to Science

CHAPTER OUTLINE

Section 1 The Nature of Science

Key Idea questions

> How do scientists explore the world?
> How are the many types of science organized?
> What are scientific theories, and how are they different from scientific laws?

How Science Takes Place

> How do scientists explore the world?

> How are the many types of science organized?

- Scientists investigate.
- Scientists plan experiments.
- Scientists observe.
- Scientists always test the results.

The Branches of Science

> How are the many types of science organized?

> Most of the time, natural science is divided into biological science, physical science and Earth science.

- science: the knowledge obtained by observing natural events and conditions in order to discover facts and formulate laws or principles that can be verified or tested

- The branches of science work together.
  - *biological science:* the science of living things
    - botany, ecology
  - *physical science:* the science of matter and energy
    - *chemistry:* the science of matter and its changes
    - *physics:* the science of forces and energy

  - *earth science:* the science of the Earth, the atmosphere, and weather
    - geology, meteorology

- Science and technology work together.

  - *pure science:* the continuing search for scientific knowledge

  - Advances in science and technology depend on each other.

- technology: the application of science for practical purposes

Scientific Laws and Theories

> What are scientific theories, and how are they different from scientific laws?

> Theories explain why something happens, laws explain how something works.

- law: a descriptive statement of equation that reliably predicts events under certain conditions

- theory: a system of ideas that explains many related observations and is supported by a large body of evidence acquired through scientific investigation

- Experimental results support laws and theories.

  - Scientific theories are always being questioned and examined. To be valid, a theory must:
    - explain observations
    - be repeatable
    - be predictable

- Mathematics can describe physical events.

  - *qualitative statement:* describes something with words

  - *quantitative statement:* describes something with mathematical equations

- Theories and laws are always being tested.

- Models can represent physical events.
  - *model:* a representation of an object or event that can be studied to understand the real object or event
  - Scientists use conceptual, physical, and computer models to study objects and events.
- We use models in our everyday lives.

Section 2 The Way Science Works

Key Idea questions
> How can I think and act like a scientist?
> How do scientists measure things?

Science Skills

> How can I think and act like a scientist?

> Identifying problems, planning experiments, recording observations, and correctly reporting data some of the most important science skills.

- Scientists approach a problem by thinking logically.
- Critical thinking helps solve problems logically.
- critical thinking: the ability and willingness to assess claims critically and to make judgments on the basis of objective and supported reasons
- Scientists use scientific methods to solve problems.
- scientific method: a series of steps followed to solve problems including collecting data, formulating a hypothesis, testing the hypothesis, and stating conclusions
  - The scientific methods are general description of scientific thinking rather than an exact path for scientists to follow.
- Scientists test hypotheses.
- *hypothesis:* a possible explanation or answer that can be tested
  - Scientists test a hypothesis by doing a controlled experiment.
  - *controlled experiment:* an experiment in which the variables that could affect the experiment are kept constant (controlled) except for the that one you want to measure
  - *variable:* a factor that changes in an experiment in order to test a hypothesis

- Experiments test ideas.
  - No experiment is a failure.
  - The results of every experiment can be used to revise the hypothesis or plan tests of a different variable.
  - *Peer-reviewed research:* research that has been reviewed by other scientists
- Scientists use special tools.
- There are many tools used by scientists for making observations, including
  - *telescopes*
  - *spectroscopes*
  - *particle accelerators*

Units of Measurement

> How do scientists measure things?

> Scientists use standard units of measure that together form the International System of Units, or SI.

- SI units are used for consistency.
  - SI has seven base units.
  - *derived units:* combinations of the base units
- SI prefixes are for very large and very small measurements.
  - The prefixes are multiples of 10.

- You can convert between small and large numbers.
  - To convert to a smaller unit, multiply the measurement by the ratio of units so that you get a larger number.
  - To convert to a larger unit divide the measurement by the ratio of units so that you get a smaller number.
- Measurements quantify your observations.
- length: a measure of the straight-line distance between two points
- mass: a measure of the amount of matter in an object
- volume: a measure of the size of a body or region in three-dimensional space
- weight: a measure of the gravitational force exerted on an object

Section 3 Organizing Data

Key Idea questions
> Why is organizing data an important science skill?
> How do scientists handle very large and very small numbers?
> How can you tell the precision of a measurement?

Presenting Scientific Data

> Why is organizing data an important science skill?

> Because scientists use written reports and oral presentations to share their results, organizing and presenting data are important science skills.

- *Line graphs* are best for continuous change.
  - *dependent variable:* values depend on what happens in the experiment
    - Plotted on the x-axis
  - *independent variable:* values are set before the experiment takes place
    - Plotted on the y-axis
- *Bar graphs* compare items.
  - A bar graph is useful for comparing similar data for several individual items or events.
  - A bar graph can make clearer how large or small the differences in individual values are.
- *Pie graphs* show the parts of a whole.
  - A pie graph is ideal for displaying data that are parts of a whole.
  - Data in a pie chart is presented as a percent.

Writing Numbers in Scientific Notation

> How do scientists handle very large and very small numbers?

> To reduce the number of zeros in very big and very small numbers, you can express the values as simple numbers multiplied by a power of 10, a method called scientific notation.

- scientific notation: a method of expressing a quantity as a number multiplied by 10 to the appropriate power
- Some powers of 10 and their decimal equivalents are shown below.
    - $10^3 = 1{,}000$
    - $10^2 = 100$
    - $10^1 = 10$
    - $10^0 = 1$
    - $10^{-1} = 0.1$
    - $10^{-2} = 0.01$
    - $10^{-3} = 0.001$
- Use scientific notation to make calculations.
- When you use scientific notation in calculations, you follow the math rules for powers of 10.
- When you multiply two values in scientific notation, you add the powers of 10.
- When you divide, you subtract the powers of 10.

Using Significant Figures

> How can you tell the precision of a measurement?

> Scientists use significant figures to show the precision of a measured quantity.

- precision: the exactness of a measurement
- significant figure: a prescribed decimal place that determines the amount of rounding off to be done based on the precision of the measurement
- Precision differs from accuracy.

- accuracy: a description of how close a measurement is to the true value of the quantity measured

- Round your answers to the correct significant figures.

- When you use measurements in calculations, the answer is only as precise as the least precise measurement used in the calculation.

- The measurement with the fewest significant figures determines the number of significant figures that can be used in the answer.