Concept 1.3: Scientists use two main forms of inquiry in their study of nature

• The word *Science* is derived from Latin and means “to know”

• *Inquiry* is the search for information and explanation

• There are two main types of scientific inquiry: discovery science and hypothesis-based science
Discovery Science

• **Discovery science** describes natural structures and processes
• This approach is based on observation and the analysis of data
Types of Data

- **Data** are recorded observations or items of information
- Data fall into two categories
  - *Qualitative*, or descriptions rather than measurements
  - *Quantitative*, or recorded measurements, which are sometimes organized into tables and graphs
Fig. 1-23

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Induction in Discovery Science

- **Inductive reasoning** draws conclusions through the logical process of induction
- Repeated specific observations can lead to important generalizations
  - For example, “the sun always rises in the east”
Hypothesis-Based Science

• Observations can lead us to ask questions and propose hypothetical explanations called hypotheses
The Role of Hypotheses in Inquiry

• A **hypothesis** is a tentative answer to a well-framed question

• A scientific hypothesis leads to predictions that can be tested by observation or experimentation
• For example,
  • Observation: Your flashlight doesn’t work
  • Question: Why doesn’t your flashlight work?
  • Hypothesis 1: The batteries are dead
  • Hypothesis 2: The bulb is burnt out
• Both these hypotheses are testable
Hypothesis #1: Dead batteries
Prediction: Replacing batteries will fix problem
Test prediction: Test falsifies hypothesis

Hypothesis #2: Burnt-out bulb
Prediction: Replacing bulb will fix problem
Test prediction: Test does not falsify hypothesis
Fig. 1-24a

Observations

Question

Hypothesis #1: Dead batteries

Hypothesis #2: Burnt-out bulb
Hypothesis #1: Dead batteries
Prediction: Replacing batteries will fix problem
Test prediction
Test falsifies hypothesis

Hypothesis #2: Burnt-out bulb
Prediction: Replacing bulb will fix problem
Test prediction
Test does not falsify hypothesis
Deduction: The “If...Then” Logic of Hypothesis Based Science

- **Deductive reasoning** uses general premises to make specific predictions.
- For example, *if* organisms are made of cells (premise 1), and humans are organisms (premise 2), *then* humans are composed of cells (deductive prediction).
A Closer Look at Hypotheses in Scientific Inquiry

• A hypothesis must be *testable* and *falsifiable*

• Hypothesis-based science often makes use of two or more alternative hypotheses

• Failure to falsify a hypothesis does not *prove* that hypothesis
  • For example, you replace your flashlight bulb, and it now works; this supports the hypothesis that your bulb was burnt out, but does not prove it (perhaps the first bulb was inserted incorrectly)
The Myth of the Scientific Method

• The *scientific method* is an idealized process of inquiry
• Hypothesis-based science is based on the “textbook” scientific method but rarely follows all the ordered steps
• Discovery science has made important contributions with very little dependence on the so-called scientific method
Designing Controlled Experiments

• A **controlled experiment** compares an experimental group with a control group

• Ideally, only the variable of interest differs between the control and experimental groups

• A controlled experiment means that control groups are used to cancel the effects of unwanted variables

• A controlled experiment does *not* mean that all unwanted variables are kept constant
Limitations of Science

• In science, observations and experimental results must be repeatable

• Science cannot support or falsify supernatural explanations, which are outside the bounds of science
Theories in Science

• In the context of science, a **theory** is:
  • Broader in scope than a hypothesis
  • General, and can lead to new testable hypotheses
  • Supported by a large body of evidence in comparison to a hypothesis
Model Building in Science

- **Models** are representations of natural phenomena and can take the form of:
  - Diagrams
  - Three-dimensional objects
  - Computer programs
  - Mathematical equations
Science, Technology, and Society

• The goal of science is to understand natural phenomena
• The goal of technology is to *apply* scientific knowledge for some specific purpose
• Science and technology are interdependent
• Biology is marked by “discoveries,” while technology is marked by “inventions”
• The combination of science and technology has dramatic effects on society
  • For example, the discovery of DNA by James Watson and Francis Crick allowed for advances in DNA technology such as testing for hereditary diseases

• Ethical issues can arise from new technology, but have as much to do with politics, economics, and cultural values as with science and technology