Safety Scientists working in a laboratory or in the field are trained to use safe procedures when carrying out investigations. Laboratory work may involve flames or heating elements, electricity, chemicals, hot liquids, sharp instruments, and breakable glassware. Laboratory work and fieldwork may involve contact with living or dead organisms—not just potentially poisonous plants and venomous animals but also disease-carrying mosquitoes and water contaminated with dangerous microorganisms.

Whenever you work in your biology laboratory, you must follow safe practices as well. Careful preparation is the key to staying safe during scientific activities. Before performing any activity in this course, study the safety rules in Appendix B. Before you start each activity, read all the steps and make sure that you understand the entire procedure, including any safety precautions.

The single most important safety rule is to always follow your teacher's instructions and directions in this textbook. Any time you are in doubt about any part of an activity, ask your teacher for an explanation. And because you may come in contact with organisms you cannot see, it is essential that you wash your hands thoroughly after every scientific activity. Remember that you are responsible for your own safety and that of your teacher and classmates. If you are handling live animals, you are responsible for their safety too.

FIGURE 1–16 Science Safety Wearing appropriate protective gear is important while working in a laboratory.

1.3 Assessment

Review Key Concepts

1. a. Review List the characteristics that define life.

b. Applying Concepts Suppose you feel hungry, so you reach for a plum you see in a fruit bowl. Explain how both external and internal stimuli are involved in your action.

2. a. Review What are the themes in biology that come up again and again?

b. Predict Suppose you discover a new organism. What would you expect to see if you studied it under a microscope?

3. a. Review At what levels do biologists study life?

b. Classify A researcher studies why frogs are disappearing in the wild. What field of biology does the research fall into?

4. a. Review Why do scientists use a common system of measurement?

b. Relate Cause and Effect Suppose two scientists are trying to perform an experiment that involves dangerous chemicals. How might their safety be affected by not using a common measurement?

PRACTICE PROBLEM

5. In an experiment, you need 250 grams of potting soil for each of 10 plant samples. How many kilograms of soil in total do you need? MATH

BIOLOGY.com Search Lesson 1.3 GO • Data Analysis • Self-Test • Lesson Assessment

Pre-Lab: Using a Microscope to Estimate Size

Problem How can you use a microscope to estimate the size of an object?

Materials compound microscope, transparent 15-cm plastic ruler, prepared slide of plant root or stem, prepared slide of bacteria

Lab Manual Chapter 1 Lab

Skills Focus Observe, Measure, Calculate, Predict

Connect to the Big idea Science provides a way of knowing the world. The use of technology to gather data is a central part of modern science. In biology, the compound microscope is a vital tool. With a microscope, you can observe objects that are too tiny to see with the unaided eye. These objects include cells, which are the basis for all life.

In this lab, you will explore another important use of the microscope. You will use the microscope to estimate the size of cells.

Background Questions

a. Explain How did the invention of the microscope help scientists know the natural world?

b. Explain How can a microscope help a scientist use scientific methodology?

c. Infer List one important fact about life that scientists would not know without microscopes. *Hint:* Review the characteristics of living things.

Pre-Lab Questions

Preview the procedure in the lab manual.

1. Review Which lens provides more magnification—a low-power lens or a high-power lens? Which lens provides the larger field of view?

2. Use Analogies A photographer may take wide views and close-ups of the same scene. How are these views similar to the low-power and high-power lenses on a microscope? What is an advantage of each view?

3. Calculate Eight cells fit across a field of view of 160 μm. What is the width of each cell? MATH

4. Predict Which cell do you think will be larger, the plant cell or the bacterial cell? Give a reason for your answer.

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Visit Chapter 1 online to test yourself on chapter content and to find activities to help you learn.

Untamed Science Video Be prepared for some surprise answers as the Untamed Science crew hit the streets to ask people basic questions about science and biology.

Art in Motion Learn about the steps scientists use to solve problems. Change the variables, and watch what happens!

Art Review Review your understanding of the various steps of experimental processes.

InterActive Art Design your own experiment to test Redi's and Pasteur's spontaneous generation experiments.

Data Analysis Investigate the different strategies scientists use for measurement.

1 Study Guide

Big idea Science as a Way of Knowing

By applying scientific methodology, biologists can find answers to questions that arise in the study of life.

1.1 What Is Science?

One goal of science is to provide natural explanations for events in the natural world. Science also aims to use those explanations to understand patterns in nature and to make useful predictions about natural events.

Scientific methodology involves observing and asking questions, making inferences and forming hypotheses, conducting controlled experiments, collecting and analyzing data, and drawing conclusions.

science (5)
observation (6)
inference (7)
hypothesis (7)
controlled experiment (7)
independent variable (7)
dependent variable (7)
control group (7)
data (8)

1.2 Science in Context

Curiosity, skepticism, open-mindedness, and creativity help scientists generate new ideas.

Publishing peer-reviewed articles in scientific journals allows researchers to share ideas and to test and evaluate each other's work.

In science, the word *theory* applies to a well-tested explanation that unifies a broad range of observations and hypotheses and that enables scientists to make accurate predictions about new situations.

Using science involves understanding its context in society and its limitations.

theory (13)
bias (14)

1.3 Studying Life

Living things are made up of units called cells, are based on a universal genetic code, obtain and use materials and energy, grow and develop, reproduce, respond to their environment, maintain a stable internal environment, and change over time.

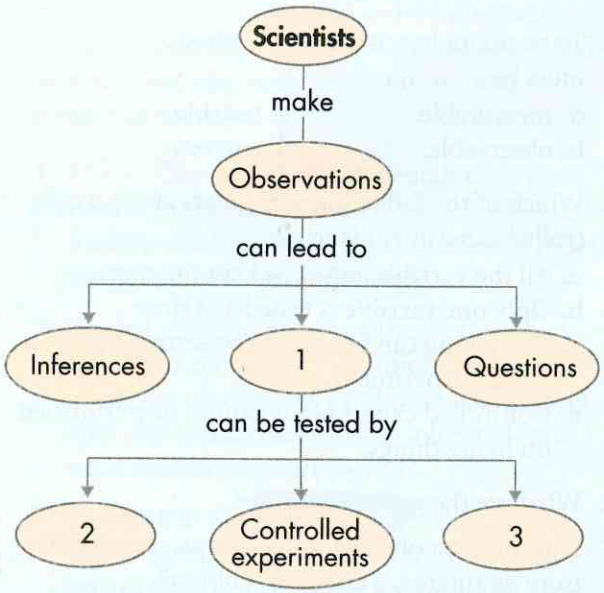
The study of biology revolves around several interlocking big ideas: the cellular basis of life; information and heredity; matter and energy; growth, development, and reproduction; homeostasis; evolution; structure and function; unity and diversity of life; interdependence in nature; and science as a way of knowing.

Biology includes many overlapping fields that use different tools to study life from the level of molecules to the entire planet.

Most scientists use the metric system when collecting data and performing experiments.

biology (17)
DNA (18)
stimulus (18)
sexual reproduction (19)
asexual reproduction (19)
homeostasis (19)
metabolism (19)
biosphere (21)

Think Visually Using the information in this chapter, complete the following concept map:



Assessment

1.1 What Is Science?

Understand Key Concepts

1. Which of the following statements about the image shown below is NOT an observation?
   a. The insect has three legs on the left side.
   b. The insect has a pattern on its back.
   c. The insect's pattern shows that it is poisonous.
   d. The insect is green, white, and black.

2. The statement "The worm is 2 centimeters long" is a(n)
   a. observation.
   b. theory.
   c. inference.
   d. hypothesis.

3. An inference is
   a. the same as an observation.
   b. a logical interpretation of an observation.
   c. a statement involving numbers.
   d. a way to avoid bias.

4. To be useful in science, a hypothesis must be
   a. measurable.
   b. observable.
   c. testable.
   d. correct.

5. Which of the following statements about a controlled experiment is true?
   a. All the variables must be kept the same.
   b. Only one variable is tested at a time.
   c. Everything can be studied by setting up a controlled experiment.
   d. Controlled experiments cannot be performed on living things.

6. What are the goals of science?

7. How does an observation about an object differ from an inference about that object?

8. How does a hypothesis help scientists understand the natural world?

9. Why does it make sense for scientists to test just one variable at a time in an experiment?

10. Distinguish between an experimental group and a control group.

11. What steps are involved in drawing a conclusion?

12. How can a graph of data be more informative than a table of the same data?

Think Critically

13. **Design an Experiment** Suggest an experiment that would show whether one food is better than another at speeding an animal's growth.

14. **Control Variables** Explain why you cannot draw a conclusion about the effect of one variable in an investigation when the other key variables are not controlled.

1.2 Science in Context

Understand Key Concepts

15. A skeptical attitude in science
   a. prevents scientists from accepting new ideas.
   b. encourages scientists to readily accept new ideas.
   c. means a new idea will only be accepted if it is backed by evidence.
   d. is unimportant.

16. The purpose of peer review in science is to ensure that
   a. all scientific research is funded.
   b. the results of experiments are correct.
   c. all scientific results are published.
   d. published results meet standards set by the scientific community.

17. A scientific theory is
   a. the same as a hypothesis.
   b. a well-tested explanation that unifies a broad range of observations.
   c. the same as the conclusion of an experiment.
   d. the first step in a controlled experiment.

18. Why are scientific theories useful?

19. Why aren't theories considered absolute truths?

20. **Evaluate** Why is it misleading to describe science as a collection of facts?

21. **Propose a Solution** How would having a scientific attitude help you in everyday activities, for example, in trying to learn a new skill?

22. **Conduct Peer Review** If you were one of the anonymous reviewers of a paper submitted for publication, what criteria would you use to determine whether or not the paper should be published?

1.3 Studying Life

Understand Key Concepts

23. The process in which two cells from different parents unite to produce the first cell of a new organism is called
    a. homeostasis.
    b. development.
    c. asexual reproduction.
    d. sexual reproduction.

24. The process by which organisms keep their internal conditions relatively stable is called
    a. metabolism.
    b. a genome.
    c. evolution.
    d. homeostasis.

25. How are unicellular and multicellular organisms alike? How are they different?

26. Give an example of changes that take place as cells in a multicellular organism differentiate.

27. List three examples of stimuli that a bird responds to.

Think Critically

28. **Measure** Use a ruler to find the precise length and width of this book in millimeters.

29. **Interpret Visuals** Each of the following safety symbols might appear in a laboratory activity in this book. Describe what each symbol stands for. (*Hint:* Refer to Appendix B.)

solve the CHAPTER MYSTERY

HEIGHT BY PRESCRIPTION

Although scientific studies have not proved that HGH treatment significantly increases adult height, they do suggest that extra HGH may help some short kids grow taller sooner. Parents who learn about this possibility may want treatment for their children. David's doctor prescribed HGH to avoid criticism for not presenting it as an option.

This situation is new. Many years ago, HGH was available only from cadavers, and it was prescribed only for people with severe medical problems. Then, genetic engineering made it possible to mass-produce safe, artificial HGH for medical use—safe medicine for sick people.

However, many people who are shorter than average often face prejudice in our society. This led drug companies to begin marketing HGH to parents of healthy, short kids. The message: "Help your child grow taller!"

As David's case illustrates, science has the powerful potential to change lives, but new scientific knowledge and advances may raise more questions than they answer. Just because science makes something *possible*, does that mean it's *right* to do it? This question is difficult to answer. When considering how science should be applied, we must consider both its limitations and its context in society.

1. **Relate Cause and Effect** Search the Internet for the latest data on HGH treatment of healthy children. What effect does early HGH treatment have on adult height?

2. **Predict** HGH was among the first products of the biotechnology revolution. Many more are in the pipeline. As products become available that could change other inherited traits, what challenges await society?

3. **Connect to the Big idea** Why would it be important for scientists to communicate clearly the results of HGH studies? How might parents benefit by understanding the science behind the results?

Connecting Concepts

Use Science Graphics

The following graphs show the size of four different populations over a period of time. Use the graphs to answer questions 30–32.

30. **Analyze Data** Write a sentence summarizing what each graph shows.

be used to make direct comparisons among the populations, what additional information would be necessary?

32. **Compare and Contrast** Graphs of completely different events can have the same appearance. Select one of the graphs and explain how the shape of the graph could apply to a different set of events.

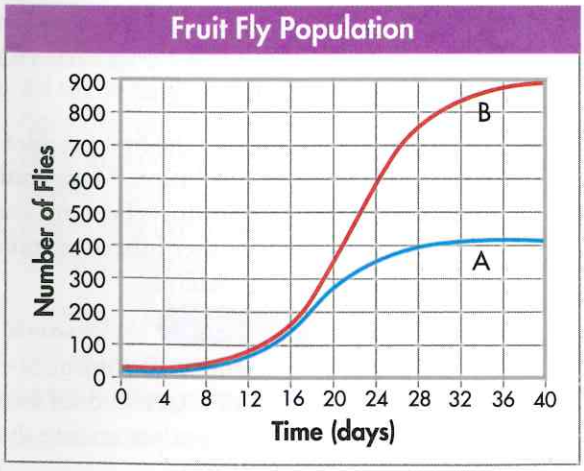
Write About Science

33. **Explanation** Suppose you have a pet cat and want to determine which type of cat food it prefers. Write an explanation of how you could use scientific methodology to determine the answer. (*Hint*: Before you start writing, list the steps you might take, and then arrange them in order beginning with the first step.)

34. **Assess the Big idea** Many people add fertilizer to their house and garden plants. Make a hypothesis about whether you think fertilizers really help plants grow. Next, design an experiment to test your hypothesis. Include in your plan what variable you will test and what variables you will control.

Analyzing Data

A researcher studied two groups of fruit flies: Population A was kept in a 0.5 L container; Population B was kept in a 1 L container.



35. **Interpret Graphs** The independent variable in the controlled experiment was the
- **a.** number of flies.
- **b.** number of groups studied.
- **c.** number of days.
- **d.** size of the containers.

36. **Infer** Which of the following is a logical inference based on the content of the graph?
- **a.** The flies in Group B were healthier than those in Group A.
- **b.** A fly population with more available space will grow larger than a population with less space.
- **c.** If Group B was observed for 40 more days, the size of the population would double.
- **d.** In 40 more days, the size of both populations would decrease at the same rate.

Standardized Test Prep

Multiple Choice

1. To ensure that a scientific work is free of bias and meets standards set by the scientific community, a research group's work is peer reviewed by
   A anonymous scientific experts.
   B the general public.
   C the researchers' friends.
   D lawmakers.

2. Which of the following characteristics is NOT shared by both a horse and the grass it eats?
   A uses energy
   B response to stimulus
   C movement from place to place
   D stable internal environment

3. Which of the following statements about a scientific theory is NOT true?
   A It has the same meaning in science as it does in daily life.
   B It enables scientists to make accurate predictions about new situations.
   C Scientific theories tie many hypotheses together.
   D It is based on a large body of evidence.

4. A bird-watcher sees an unusual bird at a feeder. He takes careful notes on the bird's color, shape, and other physical features and then goes to a reference book to see if he can identify the species. What aspect of scientific thinking is most apparent in this situation?
   A observation
   B inference
   C hypothesis formation
   D controlled experimentation

5. Unlike sexual reproduction, asexual reproduction involves
   A two cells.
   B two parents.
   C one parent.
   D one nonliving thing.

6. One meter is equal to
   A 1000 millimeters.
   B 1 millimeter.
   C 10 kilometers.
   D 1 milliliter.

Questions 7–8

Once a month, a pet owner recorded the mass of her puppy in a table. When the puppy was 3 months old, she started to feed it a "special puppy food" she saw advertised on TV.

Change in a Puppy's Mass Over Time

Age (months)	Mass at Start of Month (kg)	Change in Mass per Month (kg)
2	5	—
3	8	+3
4	13	+5

7. According to the table, which statement is true?
   A The puppy's mass increased at the same rate for each month shown.
   B The puppy's mass was less than 5 kg at the start of the new diet.
   C The puppy gained 5 kg between age 3 and 4 months.
   D The puppy had gained 13 kg as a result of the new diet.

8. All of the following statements about the pet owner's study are true EXCEPT
   A The owner used the metric system.
   B The owner recorded data.
   C The owner could graph the data.
   D The owner conducted a controlled experiment.

Open-Ended Response

9. Explain how a controlled experiment works.

If You Have Trouble With . . .

Question	1	2	3	4	5	6	7	8	9
See Lesson	1.2	1.3	1.2	1.1	1.3	1.3	1.1	1.1	1.1