

The Nature of Life

UNIT 1

Chapters

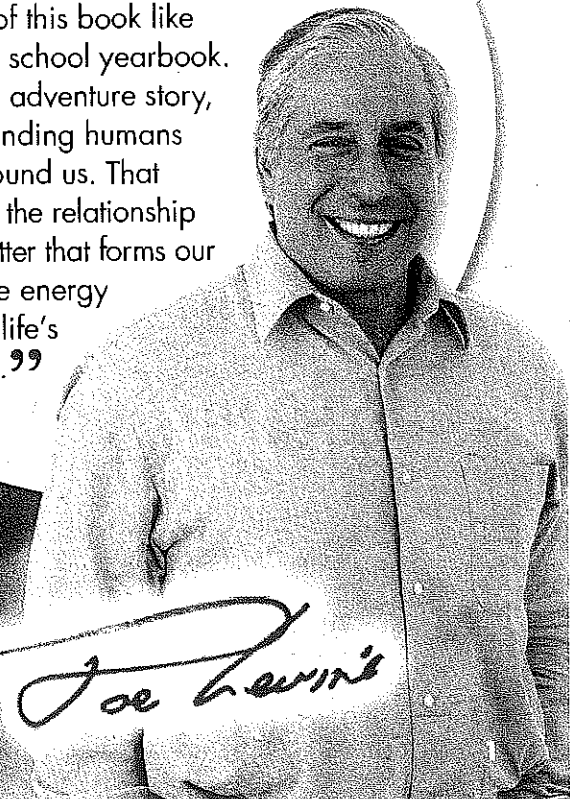
- 1 The Science of Biology
- 2 The Chemistry of Life

INTRODUCE the

Big ideas

- Science as a Way of Knowing
- Matter and Energy

“Science is ‘a way of knowing’—a way of explaining the natural world through observations, questions, and experiments. But science isn’t just dry old data, pressed between pages of this book like prom flowers in a school yearbook. Science is a living adventure story, aimed at understanding humans and the world around us. That story begins with the relationship between the matter that forms our bodies and the energy that powers life’s processes.”



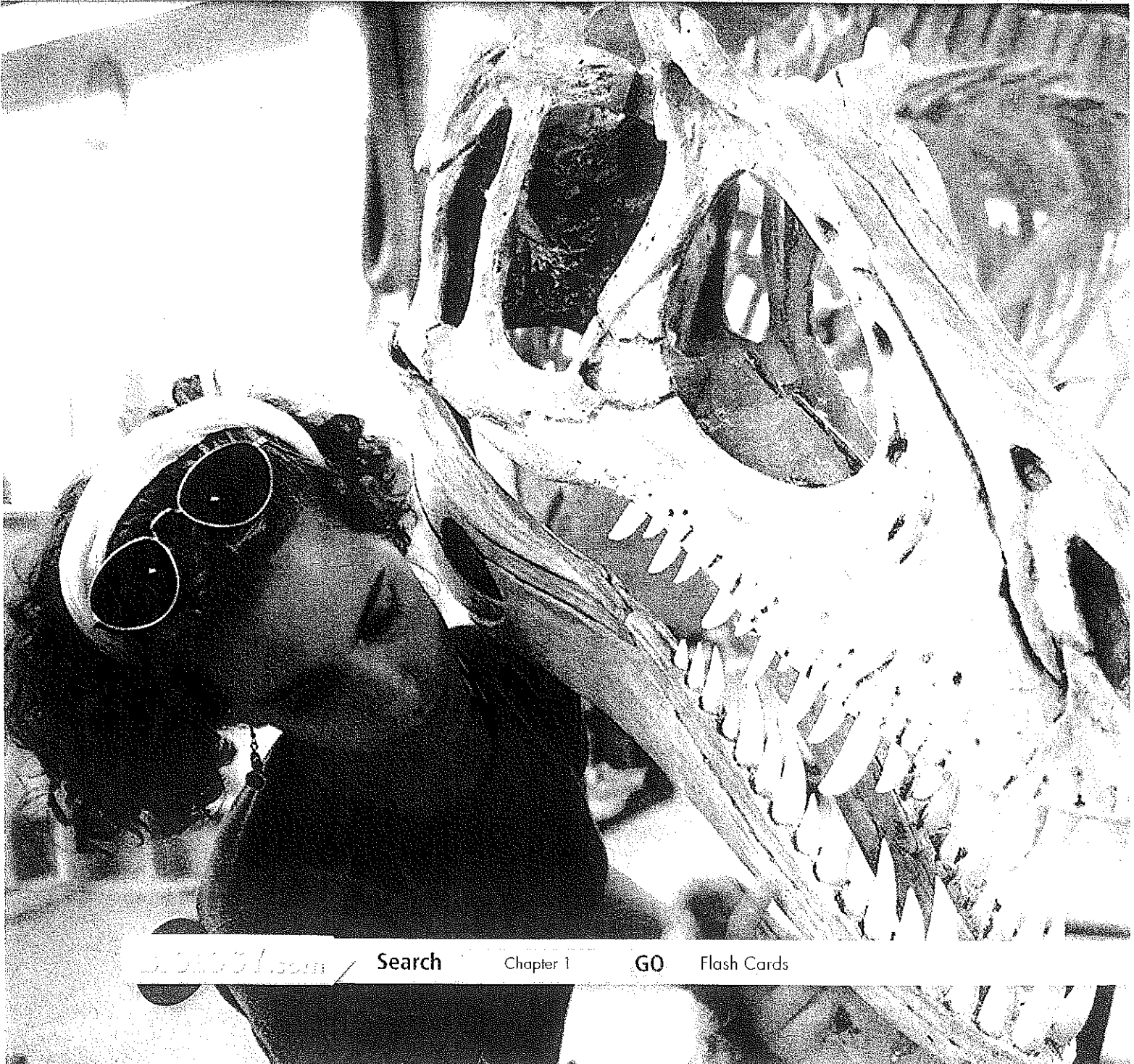
Joe Levine

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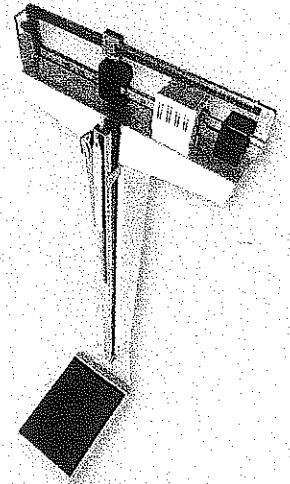
The Science of Biology



Q: What role does science play in the study of life?

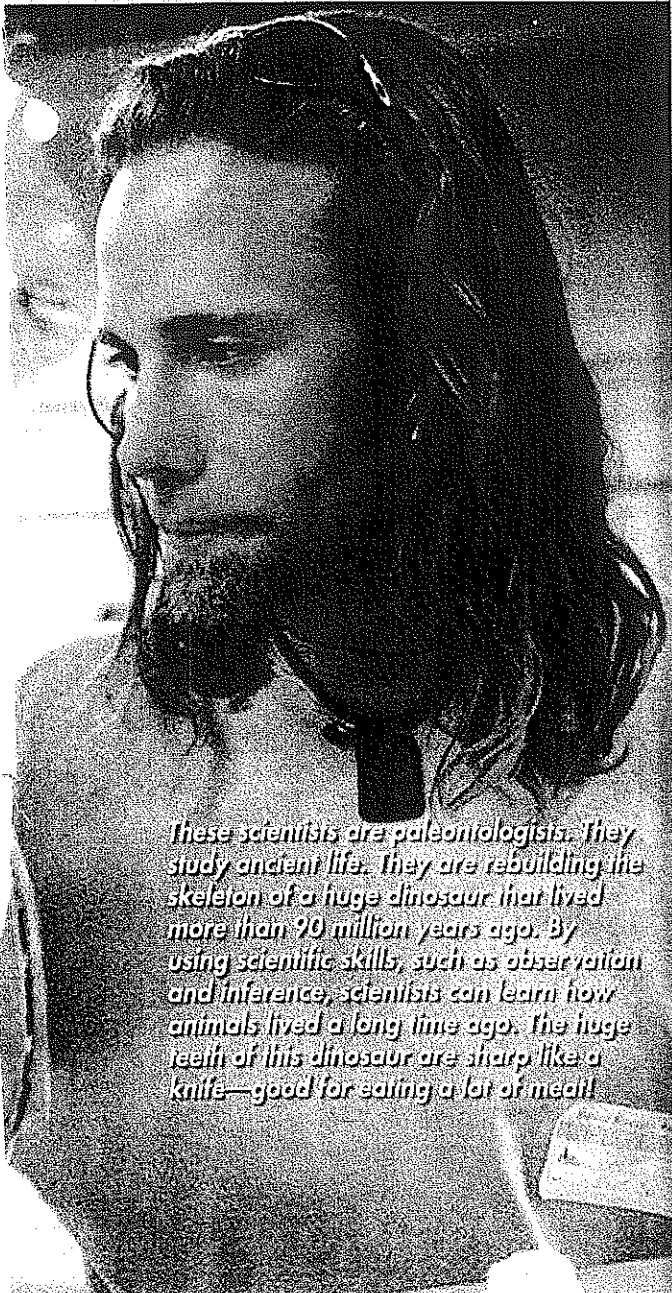


CHAPTER MYSTERY



INSIDE:

- 1.1 What Is Science?
- 1.2 Science in Context
- 1.3 Studying Life



These scientists are paleontologists. They study ancient life. They are rebuilding the skeleton of a huge dinosaur that lived more than 90 million years ago. By using scientific skills, such as observation and inference, scientists can learn how animals lived a long time ago. The huge teeth of this dinosaur are sharp like a knife—good for eating a lot of meat!

HEIGHT BY PRESCRIPTION

A doctor gives a shot of a powerful chemical to an eight-year-old boy named David. This boy is perfectly healthy. He shows no signs of being sick. The “problem” that he is being treated for is very common. He is short for his age.

The chemical David is being given is human growth hormone, or HGH. HGH, together with genes and diet, controls growth during childhood. Some people produce little or no HGH. These people are extremely short and may have other health problems. But David has a normal amount of HGH. He is short because his parents are both healthy, short people.

But if David isn’t sick, why does his doctor prescribe HGH? Where does HGH come from? Is it safe? And what does its use in David’s case say about science and society?

Read for Mystery Clues As you read this chapter, look for clues about the nature of science, the role of technology in our modern world, and the relationship between science and society. Then, solve the mystery.

FOUNDATIONS for Learning

All living things share certain characteristics. Biology is the study of these characteristics. Before you read the chapter, make an Inspired Shape Tree. Your tree should have a trunk and eight branches. Write “Characteristics of Living Things” on the trunk. Then, as you read Lesson 3, describe a different characteristic on each branch. At the end of the chapter are two activities that use your tree to help answer the question: What role does science play in the study of life?

Homeostasis DNA Stimulus Evolution

Characteristics
of living things



1.1 What Is Science?

Key Questions

📌 *What are the goals of science?*

📌 *What are the parts of scientific methodology?*

BUILD Understanding

Flowchart As you read, create a flowchart showing the steps scientists use to answer questions about the natural world.

In Your Workbook Go to your workbook to learn more about making a flowchart.

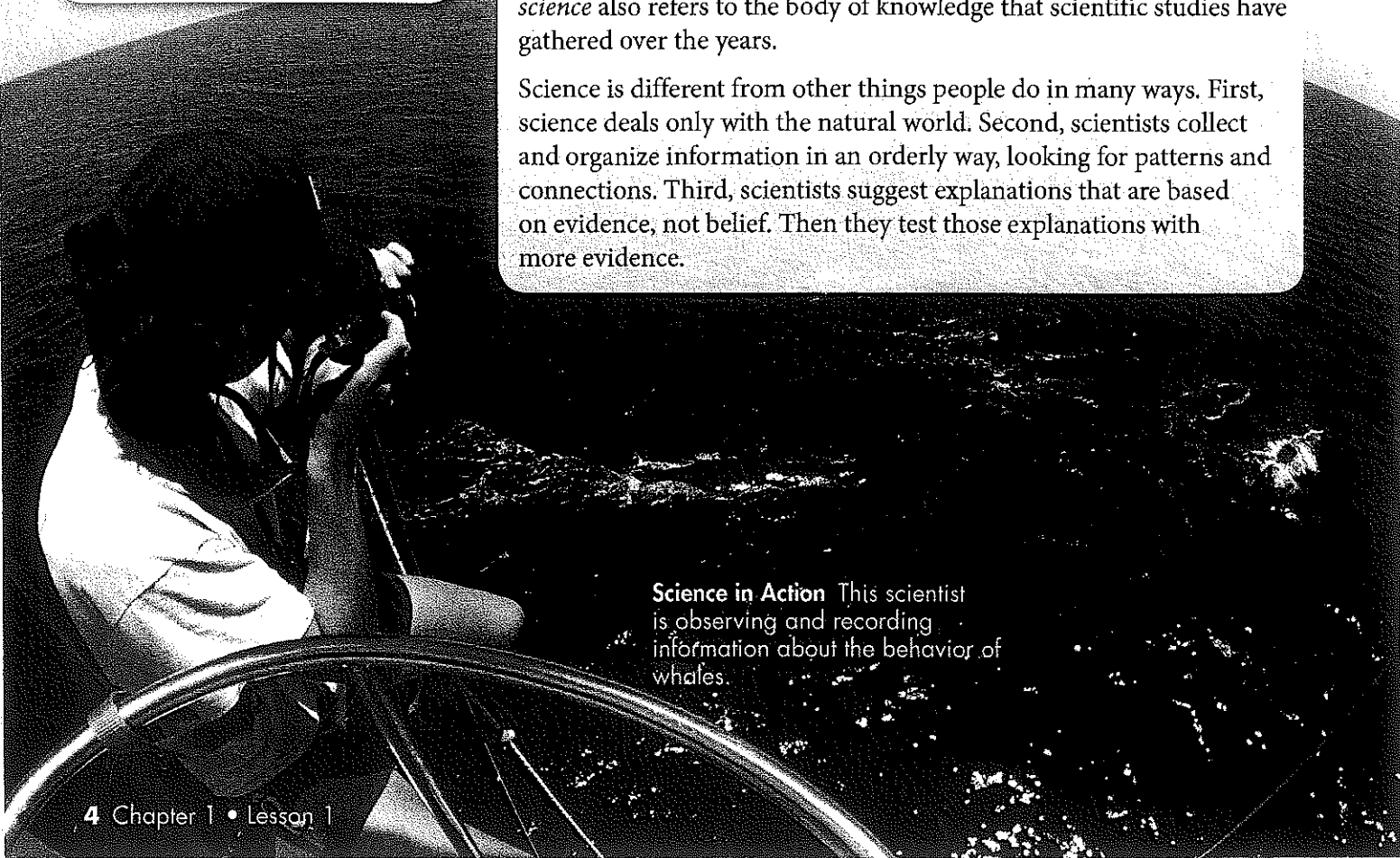
What Science Is and Is Not

Where did plants and animals come from? How did I come to be? People have tried to answer those questions in different ways. Some ways of explaining the world have stayed the same over time. Science, however, is always changing.

This book has lots of facts and ideas about living things. But biology, or any science, is not just a collection of never-changing facts. Some of the facts in this book will change soon—if they have not changed already! What's more, science is not a lot of unchanging ideas about the world. Scientific ideas are open to testing, discussion, and change. If science is neither a list of facts nor a lot of unchanging ideas, what is it?

Science as a Way of Knowing Science is an organized way of gathering and analyzing evidence about the natural world. It is a way of looking, a way of thinking, and “a way of knowing” about the world. In other words, science is a *process*, not a “thing.” The word *science* also refers to the body of knowledge that scientific studies have gathered over the years.

Science is different from other things people do in many ways. First, science deals only with the natural world. Second, scientists collect and organize information in an orderly way, looking for patterns and connections. Third, scientists suggest explanations that are based on evidence, not belief. Then they test those explanations with more evidence.



Science in Action This scientist is observing and recording information about the behavior of whales.

The Goals of Science From a scientific view, objects in the universe, and all interactions among those objects, are ruled by natural laws. One goal of science is to use an understanding of those laws to give 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.

Key Question What are the goals of science?

The goals of science are to give explanations for natural events, to understand patterns, and to make predictions.

Science, Change, and Uncertainty Scientists know a lot about nature. Yet, much of nature remains a mystery because science never stands still. This constant change does not mean science has failed. It shows that science is always improving.

Science rarely “proves” anything in absolute terms. Scientists aim for the best understanding that can be found. Uncertainty is a part of science and is part of what makes science exciting!

Scientific Methodology

There isn't any single “scientific method.” But there is a general style of investigation that can be called scientific methodology. The parts of scientific methodology are described below.

Observing and Asking Questions Scientific studies begin with **observation**, the act of noticing and describing what is happening in an orderly way. Observation leads to new questions.

Inferring and Forming a Hypothesis After asking questions, scientists use further observations to make inferences. An inference is an idea based on what is already known. Inference, along with imagination, can lead to a hypothesis. A **hypothesis** is a scientific explanation for a set of observations that can be tested.

Vocabulary

science

an organized way of gathering and analyzing evidence about the natural world

observation

a process of noticing and describing events or processes in a careful, orderly way

hypothesis

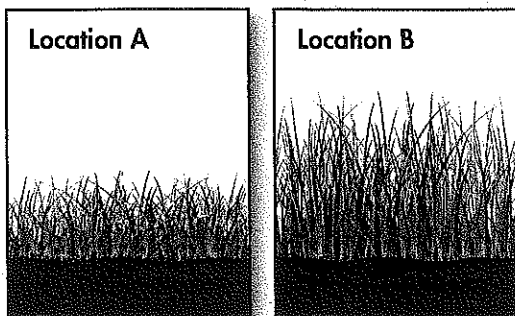
a possible explanation for a set of observations or a possible answer to a scientific question

WORD ORIGINS

The word *science* comes from the Latin word *scientia*, which means “knowledge.” Science represents knowledge that has been gathered over time.

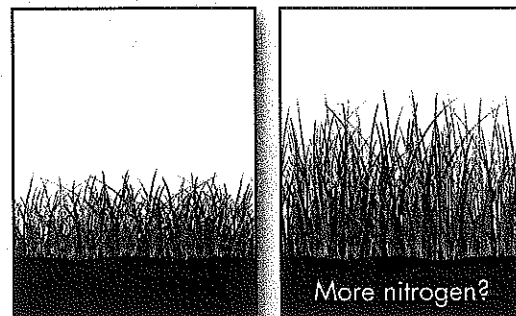
Salt Marsh Experiment Scientists made observations about a salt marsh. Then they used scientific methodology to answer the questions that came from their observations.

Observing and Asking Questions



Scientists observed that marsh grass grows taller in some places than others. This observation led to a question: *Why do marsh grasses grow to different heights in different places?*

Inferring and Hypothesizing



The scientists inferred that something limits grass growth in some places. Temperature, sunlight, water, or nutrients could cause the difference. Based on their knowledge of salt marshes, they proposed a hypothesis: *Marsh grass growth is limited by available nitrogen.*

Vocabulary

controlled experiment

an experiment in which only one variable is changed

control group

the group in an experiment that is exposed to the same conditions as the experimental group except for one independent variable

data

evidence; information gathered from observations

RELATED WORD FORMS

The word *data* is plural for *datum*. To help you remember that *data* is plural, you can think of *data* as being a lot of information and *datum* as just one piece of information.

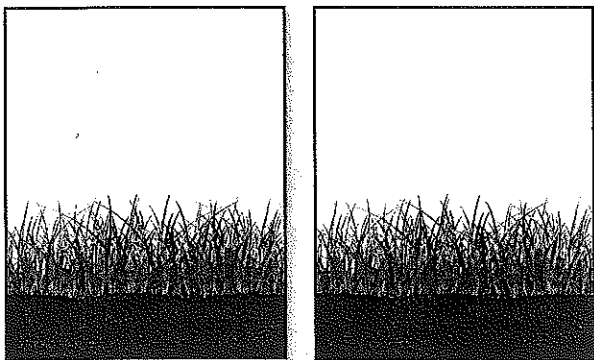
Designing Controlled Experiments Testing a hypothesis often involves an experiment that keeps track of variables, or the things that can change. A few examples of variables include temperature, light, and time. Whenever possible, a hypothesis should be tested by an experiment in which only one variable is changed. All other variables should be kept unchanged, or controlled. An experiment in which only one variable is changed is called a **controlled experiment**.

► **Controlling Variables** Why are variables controlled? The reason is that if more than one variable is changed in an experiment, scientists cannot easily tell which variable caused the results. The variable that is changed is called the independent variable. The variable that is observed and that changes because of modifications to the independent variable is called the dependent variable.

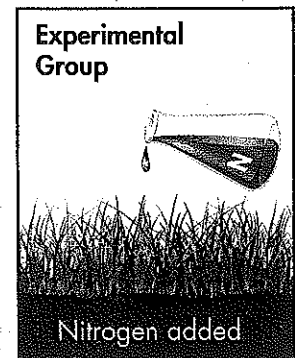
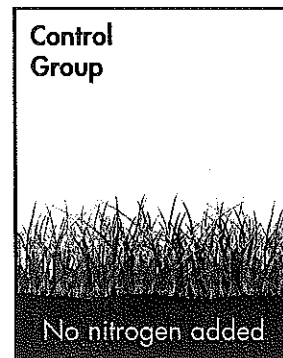
► **Control and Experimental Groups** An experiment is usually divided into control and experimental groups. A **control group** is treated the same as the experimental group except for one independent variable. Scientists often repeat their experiments several times to see if they get the same results. This process is called replicating the experiment. So, scientists set up several sets of control and experimental groups, rather than just a single pair.

Collecting and Analyzing Data Scientists make detailed records of experimental observations by gathering information called **data**. There are two main kinds of data. Quantitative data are numbers found by counting or measuring. Qualitative data describe things that cannot be counted.

Designing Controlled Experiments



The scientists selected areas that had similar numbers of plants and similar soil type, water supply, and height above the water level. The areas were divided into control and experimental groups.




The scientists added nitrogen fertilizer (the independent variable) to the experimental groups. They then observed the growth of marsh grass (the dependent variable) in both experimental and control groups.

► **Research Tools** Scientists pick the right tools for collecting and analyzing data. The tools may be simple, such as metersticks and calculators, or they may be complex, such as computers or robots. Charts and graphs are also tools that help scientists organize data.

► **Sources of Error** Scientists must avoid errors in data collection and analysis. Errors may happen when using tools. Tools have limited accuracy or can be read incorrectly. Data analysis and decisions about sample size must be carried out carefully to avoid errors. Sometimes experimental and control groups are very large. Why? The reason is because there are always differences among subjects in the groups. The larger the sample size, the more sure scientists are about their data analysis.

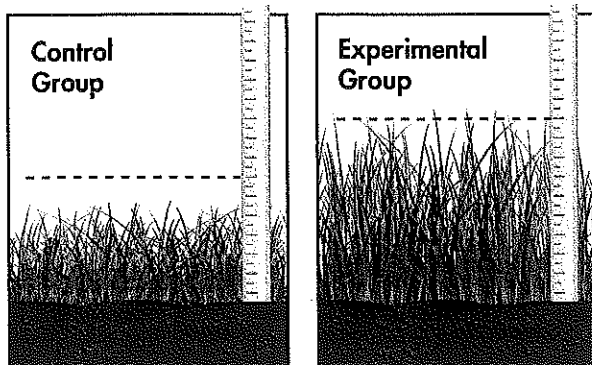
Drawing Conclusions Scientists use data to support or refute the hypothesis, to change the hypothesis, or to draw a valid conclusion. Hypotheses are often not shown to be completely right or wrong by an experiment. Rather, the data may show that the scientists have the right idea but are wrong about a few things. In that case, scientists change the first hypothesis, make new predictions, and design new experiments.

 **Key Question** What are the seven parts of scientific methodology?

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

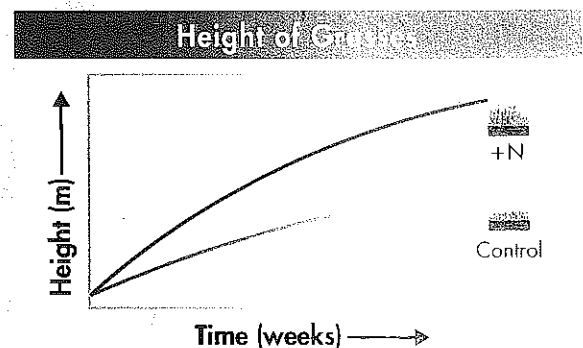


Collecting and Analyzing Data

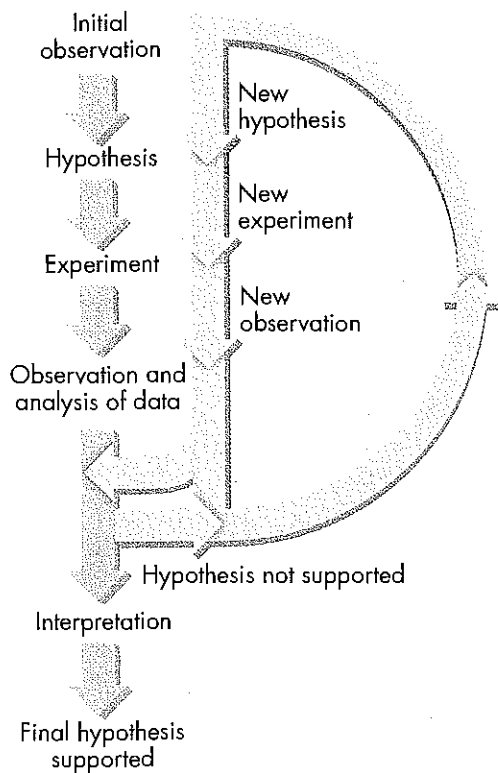


The scientists sampled all the areas during the growing season. They measured growth rates and plant sizes, and analyzed the chemicals in the leaves.

Drawing Conclusions



Data from all the areas were compared and evaluated. Data confirmed that marsh grasses with added nitrogen grow taller and larger than marsh grasses without added nitrogen. The hypothesis and its predictions were supported.



Revising Hypotheses During an investigation, scientists may have to change their hypotheses and redo experiments several times.

When Experiments Are Not Possible It is not always possible to test a hypothesis with an experiment. In some cases, scientists come up with hypotheses that can be tested by observations. For example, scientists who study how animals behave might want to learn how animal groups act in the wild. Studying this kind of natural behavior means that the scientists must go into the wild and watch the animals without bothering them. When scientists analyze data from these observations, they may come up with hypotheses that can be tested in different ways.

Sometimes, ethics keeps scientists from doing certain kinds of experiments. Ethics are beliefs about what is wrong or right. Some experiments on people are not ethical to do. For example, suppose that some scientists think that a chemical causes cancer in people who breathe it in. The scientists cannot make people breathe the chemical to see if they are correct! Instead, the scientists search for people who have already breathed in the chemical. Then, the scientists study people who have not breathed in the chemical.

When experiments are not possible, scientists still try to control as many variables as possible. They might not use people in their study who have serious health problems or known genetic conditions. Medical scientists often study large groups of subjects so that genetic differences between people do not give results that may not be correct.

Understanding

Apply Vocabulary

Use the highlighted words from the lesson to complete each sentence correctly.

1. If you measure the width of this book with a ruler, you are collecting _____.
2. A good experiment should have an experimental group and a(n) _____.
3. A(n) _____ is a possible explanation for a set of observations.

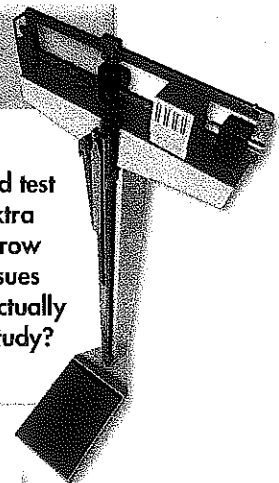
Critical Thinking

4. **Explain** List the goals of science.
5. **Explain** Why are hypotheses so important to controlled experiments?

6. **Write to Learn** Answer the first clue of the mystery. Be sure your answer identifies the independent and dependent variables.

MYSTERY CLUE

Describe a controlled experiment that would test the hypothesis that extra HGH helps children grow taller. What ethical issues can you imagine in actually carrying out such a study? (Hint: See p. 6.)





1.2 Science in Context

Exploration and Discovery: Where Ideas Come From

Scientific methodology is the heart of science. But that “heart” is only part of the full “body” of science. The full body of science is shown in the Process of Science at the bottom of this page. Part of science is exploration and discovery. How do exploration and discovery start? They often begin with scientific attitudes, practical problems, and new technology.

Scientific Attitudes Good scientists share scientific attitudes that lead them to exploration and discovery.

- ▶ **Curiosity** Scientists are curious and ask questions about what they observe. Results from previous studies also raise curiosity and lead to new questions.
- ▶ **Skepticism** Scientists are skeptics, which means that they question existing ideas and hypotheses. They also do not believe ideas without evidence.
- ▶ **Open-Mindedness** Scientists must be open-minded. They must be willing to accept new ideas that they may not agree with.
- ▶ **Creativity** Scientists need to think creatively to design experiments that provide good data.

Key Question What scientific attitudes help make new ideas? **Curiosity, skepticism, open-mindedness, and creativity help scientists come up with new ideas.**

Practical Problems Sometimes, ideas for scientific investigations come from practical problems. For example, people want cars that do not cause air pollution. Practical problems lead to questions, hypotheses, and experiments.

The Process of Science The arrows show that the different parts of science are connected in many ways. So, the process of science is flexible, unpredictable, and always changing.

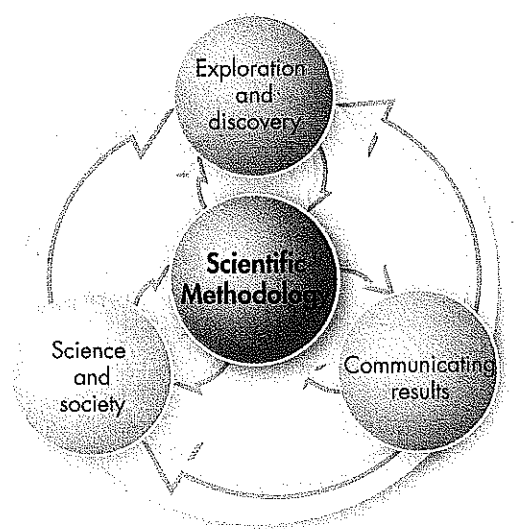
Key Questions

- ▶ What scientific attitudes help make new ideas?
- ▶ Why is peer review important?
- ▶ What is a scientific theory?
- ▶ How are science and society related?

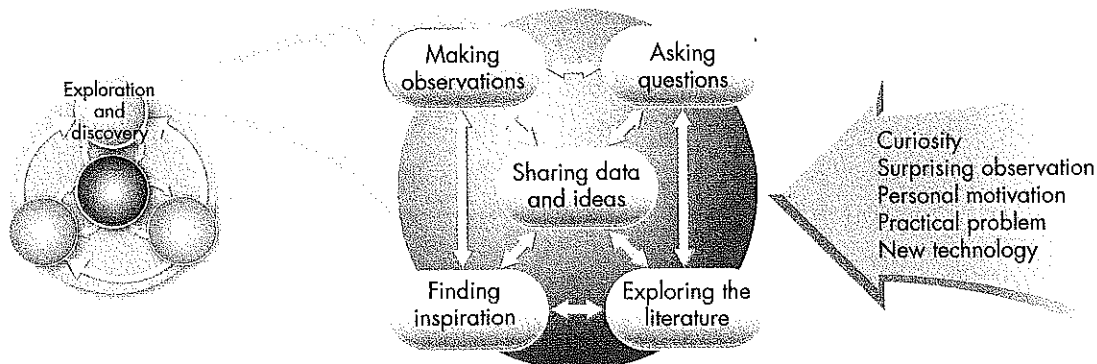
BUILD
Understanding

Previewing Visuals Before you read, study the figure on the last page of this section. As you read, use the figure to describe the role that science plays in society.

In Your Workbook Go to your workbook to learn more about previewing visuals.

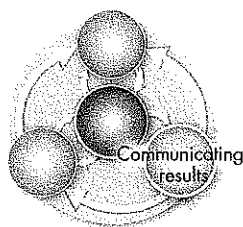


Exploration and Discovery Ideas in science can turn up in many ways—from curiosity to the need to solve a certain problem. Scientists often begin investigations by making observations, asking questions, talking to other scientists, and reading about other experiments.



Adapted from *Understanding Science*, UC Berkeley, Museum of Paleontology

The Role of Technology Technology, science, and society are closely linked. Discoveries in science may lead to new technologies. Those technologies, in turn, enable scientists to ask new questions or to gather data in new ways. Technology can also have big impacts on daily life. For instance, it is now possible to make vitamins, antibiotics, and hormones that before were only available naturally.



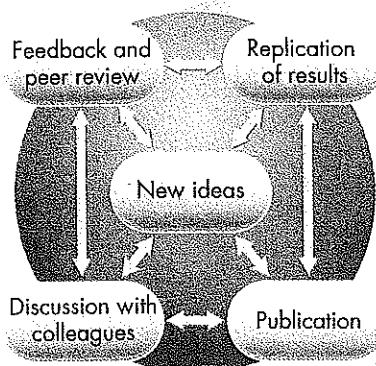
Communicating Results: Reviewing and Sharing Ideas

Data collection and analysis can take a long time. Scientists may work on a single study for months or even years. Then, the scientists communicate results to other scientists.

Peer Review Scientists share their findings with other scientists by publishing papers that go through peer review. In peer review, papers are reviewed by other scientists. These reviewers read papers looking for mistakes and other problems. Peer review does not make sure that a piece of work is correct, but it does make sure that the work meets standards set by the scientific community. Publishing peer-reviewed papers in journals lets scientists share ideas and review each other's work.

Sharing Knowledge and New Ideas How do new findings fit into what is already known about science? Perhaps the findings lead to new questions. Each of those questions could lead to new hypotheses and new controlled experiments.

Key Question Why is peer review important?
Publishing peer-reviewed papers in journals lets scientists share ideas and review each other's work.



Adapted from *Understanding Science*, UC Berkeley, Museum of Paleontology

Communicating Results Communication is an important part of science. Scientists look over one another's work to make sure it meets scientific standards. Results from one study may lead to new ideas and new studies.

Replicating Procedures

Scientists often repeat each other's experiments. They do this to make sure that the data and conclusions of the first scientist are correct. So, when scientists write papers to publish in journals, they must describe the procedures that they followed. The descriptions have to be good enough so that other scientists can repeat the first scientist's experiment.

- ① Working with a partner behind a screen, arrange ten blocks into an unusual structure.
- ② Write directions that others can use to build the same structure without seeing it.
- ③ Exchange directions with another team.
- ④ Build the other team's structure by following the directions.

- ⑤ Compare each new structure to the original. Identify which parts of the directions were clear and correct, and which parts were hard to understand or follow.

Analyze and Conclude

1. **Evaluate** How could you have written better directions?
2. **Infer** Why is it important that scientists write procedures that can be repeated?

In Your Workbook Get more help for this activity in your workbook.

Scientific Theories

In science, a **theory** is a well-tested explanation that accounts for a lot of observations and hypotheses and that lets scientists make good predictions. For example, Charles Darwin's early observations and hypotheses about change over time grew for years before he collected them into a theory of evolution by natural selection. Today, this theory is a central idea in biology.

A useful theory that has been tested and supported in many ways may become the most accepted view among scientists. But no theory is thought to be absolute truth. Science is always changing. As new evidence is found, a theory may be changed or replaced by a more useful explanation.

Key Question What is a scientific theory?

A scientific theory is a well-tested explanation that accounts for a lot of observations and hypotheses and that lets scientists make good predictions.

Vocabulary

theory

a well-tested explanation that unifies a broad range of observations and hypotheses, and enables scientists to make accurate predictions about new situations

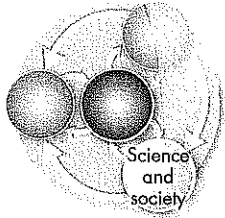
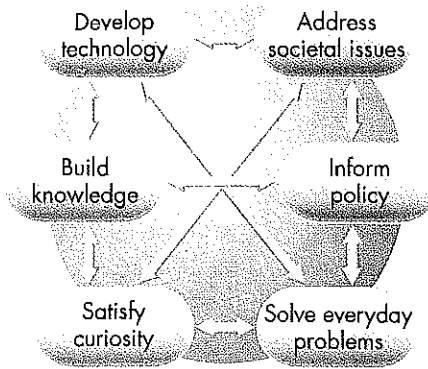
bias

a particular preference or point of view that is personal, rather than scientific

MULTIPLE MEANINGS

The word *theory* is used both in science and in everyday life. In everyday life, when you say, "I have a theory," you may mean, "I have a hunch." But in science, a theory is much stronger than a hunch—it is a well-tested explanation.

Adapted from *Understanding Science*,
UC Berkeley, Museum of Paleontology



Science and Society Science can help society or change how people in society do things. But society also affects science. Problems and questions in society may lead scientists to do new experiments.

Science and Society

Many important questions can only be answered with the help of scientific information. But very few of these questions can be answered by science alone. These questions involve the society in which we live. Using science involves understanding its limitations and how it fits into society.

Science, Ethics, and Morality When scientists explain “why” something happens, their explanation is about only nature. Science does not include ethical or moral views. Scientists can try to explain what life is. But science cannot answer questions about why life exists or what the meaning of life is.

Avoiding Bias How science is used in society can be affected by bias. A **bias** is a certain preference or point of view that is personal, rather than scientific. Examples of biases include personal taste and liking one thing over another.

Scientists try to avoid bias. But scientific data can be used in the wrong way by people who want to prove a certain point. However, if enough of us understand science, we can help make sure that science is used in only helpful, correct ways.

Understanding and Using Science As you read this book, don’t think of it as an encyclopedia. Don’t memorize the scientific facts and ideas. Instead, try to understand how scientists developed those ideas. Understanding science will help you make decisions that also fit with society’s values.

Key Question How are science and society related?
Using science involves understanding its limitations and how it fits into society.

Check Understanding

Apply Vocabulary

Use the highlighted words from the lesson to complete the sentence correctly.

1. A point of view that is personal rather than scientific is a _____.
2. Scientists can use a _____ to make good predictions.

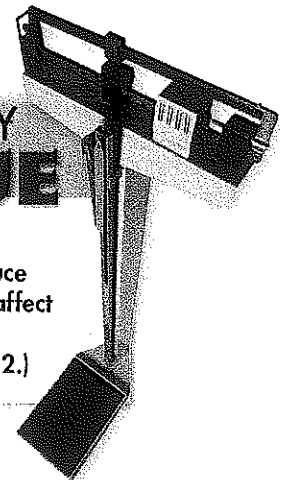
Critical Thinking

3. **Explain** What does it mean to be skeptical? Why is skepticism a good quality in a scientist?
4. **Explain** Describe some of the limitations of science.

5. **Write to Learn** Write the answer to the second clue of the mystery.

MYSTERY
CLUE

How does the ability to produce artificial HGH affect human life?
(Hint: See p. 12.)





1.3

Studying Life

Characteristics of Living Things

Think about news stories that you have seen or heard. Bird flu spreads around the world killing thousand of birds and threatening an epidemic. People who use illegal drugs get permanent brain damage. These and many other stories are about biology—the study living things. (The Greek word *bios* means “life,” and *-logy* means “study of.”)

Biology is the study of life. But what is life? What is the difference between living things and nonliving matter? It is not as simple as you might think to describe what makes something alive. No single characteristic is enough to describe a living thing. Also, some nonliving things share one or more traits with living things. For example, automobiles and clouds (which are not alive) move around. However, mushrooms and trees (which are alive) stay in one spot.

Despite these difficulties, we can list characteristics that most living things have in common. Living things are made up of basic 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.

Key Question What characteristics do all living things share? **Living things are made up of basic 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.**

Is It Alive? The fish are clearly alive, but what about the colorful structure above them? Is it alive? Yes! It is an animal called elkhorn coral. Corals show all the characteristics of living things.

Key Questions

- What characteristics do all living things share?
- What are the big ideas of biology?
- How do different fields of biology differ in the way they study life?
- Why is the metric system important in science?

BUILD

Understanding

Concept Map As you read, draw a concept map showing the big ideas in biology.

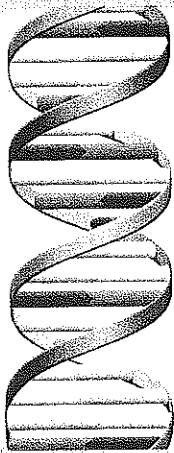
In Your Workbook Go to your workbook and finish the concept map for Lesson 1.3.



BUILD Connections

THE CHARACTERISTICS OF LIVING THINGS

Apple trees share certain characteristics with other living things. How are the apple tree and the grass growing below similar? How are they different?



Living things are based on a universal genetic code. All organisms store the information they need to live, grow, and reproduce in a genetic code written in a molecule called **DNA**. That information is copied and passed from parent to offspring. With a few small differences, life's genetic code is almost the same in every living thing on Earth.

The information in an apple tree's DNA directs all of the tree's life processes.

Living things grow and develop. Every organism has a certain pattern of growth and development. During development, a single fertilized egg divides again and again. As these cells divide, they differentiate, which

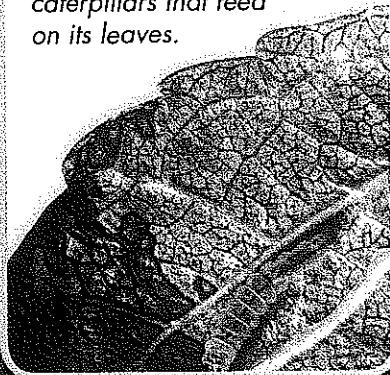
means they begin to look different from one another and to do different jobs.


An apple tree develops from a tiny seed.



Living things respond to their environment. Organisms notice and react to stimuli from their environment. A **stimulus** is a signal to which a living thing reacts.


Some plants can produce poisons to ward off caterpillars that feed on its leaves.





Living things reproduce. All living things make new similar living things. Most plants and animals engage in sexual reproduction. In sexual reproduction, cells from two parents come together to form the first cell of a new living thing. Other living things reproduce through asexual reproduction, in which a single living thing makes offspring exactly the same as itself.

Flowers form as part of the apple tree's reproductive cycle.



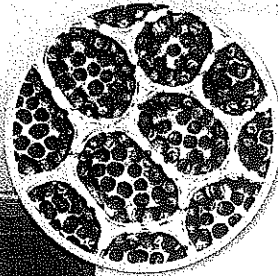
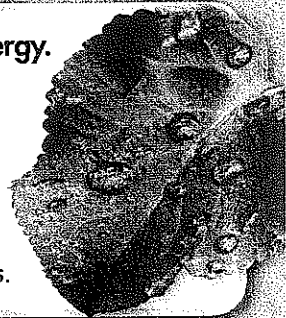
Living things maintain a stable internal environment. All living things need to keep conditions inside themselves as constant as possible, even when conditions outside of them change. All living things use energy to keep everything inside their cells within certain limits. This condition is called **homeostasis**.

These cells help leaves control gases that enter and leave the plant. SEM 1200X

Living things get and use material and energy.

All living things must take in materials and energy to grow, develop, and reproduce. The chemical reactions through which a living thing builds up or breaks down materials is called **metabolism**.

Different metabolic reactions happen in leaves.



Living things are made up of cells. Living things are made up of one or more cells—the smallest units considered fully alive.

Cells can grow, respond to their surroundings, and reproduce. Even though cells are small, they are complex and very organized.

One branch of a tree is made up of millions of cells. LM 800X

Taken as a group, living things evolve.

Over generations, groups of living things evolve, or change over time. Evolutionary change links all forms of life to a common origin more than 3.5 billion years ago. Evidence of this shared history is found in all parts of living things and fossils, from body parts to proteins to information in DNA.

Signs of one of the first land plants are preserved in rock over 400 million years old.



Vocabulary

biology

the scientific study of life

DNA

the genetic material that organisms inherit from their parents

stimulus

a signal to which an organism responds

homeostasis

the relatively constant internal physical and chemical conditions that organisms maintain

metabolism

the combination of chemical reactions through which an organism builds up or breaks down materials

biosphere

the part of Earth in which life exists, including land, water, and air or atmosphere

PREFIXES

The prefix *homeo-* means "the same" or "similar." Homeostasis is how the body keeps conditions inside the same at all times.

Big Ideas in Biology

All parts of biology are tied together by big ideas. These big ideas overlap and interlock with one another. They will come up again and again throughout the book. Many of these big ideas overlap with the characteristics of life or the nature of science.

Big idea **Cellular Basis of Life** Living things are made of cells. Many living things are made up of only a single cell; they are called unicellular organisms. Plants and animals are multicellular. Cells in multicellular organisms display many different sizes, shapes, and functions.


Big idea **Information and Heredity** Living things carry information written in a universal genetic code in their DNA. The information coded in DNA forms an unbroken chain that stretches back roughly 3.5 billion years. Yet, the DNA inside your cells right now can affect your future, such as your risk of getting cancer and the color of your children's hair.

Big idea **Matter and Energy** Life needs matter that serves as nutrients to build body parts and energy that fuels the body. Some living things, such as plants, get energy from sunlight and take up nutrients from air, water, and soil. Other living things, including most animals, eat plants or other animals to get both nutrients and energy. The need for matter and energy ties all living things on Earth together into a living web of relationships.

Big idea **Growth, Development, and Reproduction** All living things reproduce, which means that they make more individuals. Offspring are almost always smaller than adults, so they grow and develop as they mature.

Big idea **Homeostasis** Living things keep a fairly stable internal environment. For most organisms, any problems with homeostasis may have serious or deadly consequences.

Big idea **Evolution** Evolutionary change ties all forms of life to a common beginning more than 3.5 billion years ago. Evolution is the central organizing idea of all biology.



Different But Similar This colorful bird is different from the plant it is sitting on. Yet, the two living things are similar on the molecular level. Unity and diversity of life is a big idea in biology.

Big idea **Structure and Function** Each major group of living things has evolved its own set of body parts. These parts make certain functions possible. Living things have evolved into different forms as species have adapted to life in different places.

Big idea **Unity and Diversity of Life** Although life comes in a huge variety of forms, all living things are similar at the molecular level. All living things are made up of a common set of molecules, have DNA, and use proteins to build their body parts and carry out their functions. Evolutionary theory explains both this unity of life and its diversity.

Big idea **Interdependence in Nature** All forms of life on Earth are connected into a **biosphere**, which means “living planet.” Within the biosphere, living things are linked to one another and to the land, water, and air around them. Relationships between living things and where they live depend on the cycling of matter and the flow of energy.

Big idea **Science as a Way of Knowing** Science is not a list of facts. The job of science is to use observations, questions, and experiments to explain the natural world. Good scientific research finds rules and patterns that can explain and predict at least some events in nature.

Key Question What are the big ideas of biology?
Biology’s big ideas are 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.

Fields of Biology

Biology is made up of many overlapping fields that use different tools to study life from the level of molecules to the whole planet. Here’s a peek into a few of the many branches of biology.

Global Ecology The world is affected by everything that living things do. Global ecological studies using satellites and huge computers are letting us learn about people’s global impact, which affects all life on Earth.

Biotechnology This field is based on the ability to read, write, and edit the genetic code. We may soon learn to correct or replace genes that cause diseases. But biotechnology also raises a lot of ethical, legal, and social questions.

Building the Tree of Life Biologists have found about 1.8 million different kinds of living things. Scientists want to use computers to gather what is known about all organisms to put all living things into a single “Tree of All Life.”



Building the Tree of Life This paleontologist studies signs of ancient life—even fossilized dinosaur dung!



Evolution of Diseases This wildlife biologist is studying baboons. Germs that cause diseases in wild animals can evolve and infect people.



Genomics and Molecular Biology A molecular biologist is analyzing a DNA sequence.

Ecology and Evolution of Diseases Over time, viruses, bacteria, and other organisms that cause disease evolve so that they still infect people, even as we try to fight them. Understanding how germs change and react to their surroundings is important for keeping people healthy.

Genomics and Molecular Biology Scientists are looking at the DNA of many different living things. Scientists analyze the data with powerful computers to learn about growth, development, and the history of life on Earth.

Key Question How do different fields of biology differ in the way they study life?

Biology is made up of many overlapping fields that use different tools to study life from the level of molecules to the whole planet.

Performing Biological Investigations

Scientists use a common system of measurement and practice safety when doing studies.

Scientific Measurement Most scientists use the metric system when gathering data and doing experiments. The metric system is a system of measurement in which units are based on multiples of 10. A revised version of the metric system is called the International System of Units, or SI. The metric system is easy to use because it's based on multiples of 10.

Safety Scientists are trained to be safe when doing investigations. Whenever you work in your biology lab, you must follow safety rules, too. Careful preparation is the key to staying safe while doing activities. Before doing any activity, be sure you understand the safety rules. Also, read all the steps in the activity and make sure that you understand them.

The most important safety rule is to always follow your teacher's instructions. 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.

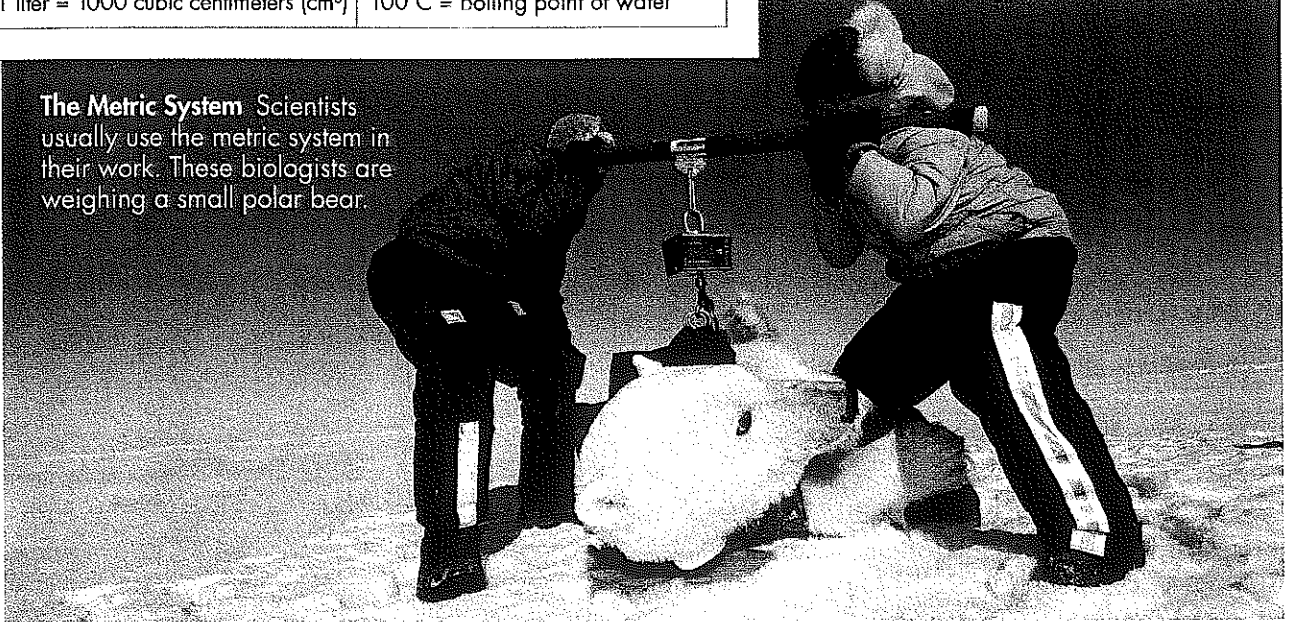
Key Question Why is the metric system important in science?

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

Common Metric Units

Length	Mass
1 meter (m) = 100 centimeters (cm) 1 meter = 1000 millimeters (mm) 1000 meters = 1 kilometer (km)	1 kilogram (kg) = 1000 grams (g) 1 gram = 1000 milligrams (mg) 1000 kilograms = 1 metric ton (t)
Volume	Temperature
1 liter (L) = 1000 milliliters (mL) 1 liter = 1000 cubic centimeters (cm ³)	0°C = freezing point of water 100°C = boiling point of water

The Metric System Scientists usually use the metric system in their work. These biologists are weighing a small polar bear.



CHECK Understanding

Apply Vocabulary

Use the highlighted words from the lesson to complete the sentence correctly.

- All the information that an animal needs to live is stored in its _____.
- The part of Earth where living things are found is called the _____.
- All the reactions by which a living thing builds up and breaks down matter is its _____.

Critical Thinking

- Applying Concepts** Suppose you feel hungry, so you reach for an apple in a fruit bowl. How do stimuli both outside and inside of your body lead you to take the apple?

- Relate Cause and Effect** Suppose that two scientists are doing an experiment using dangerous chemicals. How might their safety be affected by not using a common measurement?

- Write to Learn** Write the answer to the third clue of the mystery.

MYSTERY CLUE

What human values or biases are involved in the case of giving HGH to healthy children? What role does science play in this case?



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

- Explain** How did the invention of the microscope help scientists know the natural world?
- Explain** How can a microscope help a scientist use scientific methodology?
- 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.

- Review** Which lens provides more magnification—a low-power lens or a high-power lens?
- Infer** Which lens will provide the larger field of view—a low-power lens or a high-power lens?

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

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

BIOLOGY.com

Search

Chapter 1

GO

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.

CHAPTER Summary

1.1 What Is Science?

- The goals of science are to give natural explanations for natural events, to understand patterns, and to make predictions.
- Scientific methodology involves observing and asking questions, making inferences and forming hypotheses, doing controlled experiments, collecting and analyzing data, and drawing conclusions.

science (p. 4)

observation (p. 5)

hypothesis (p. 5)

controlled experiment

(p. 6)

control group (p. 6)

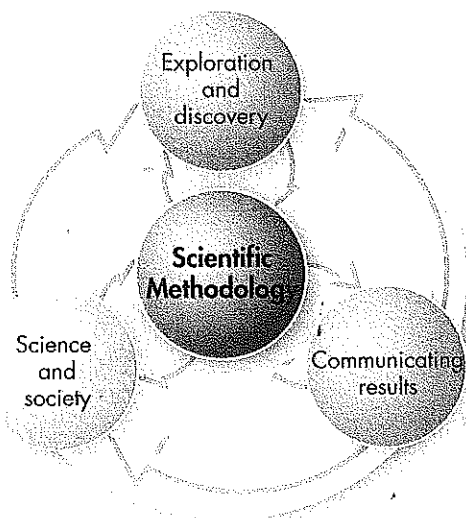
data (p. 6)

1.2 Science in Context

- Curiosity, skepticism, open-mindedness, and creativity help scientists come up with new ideas.
- Publishing peer-reviewed papers in journals lets scientists share ideas and review each other's work.
- A scientific theory is a well-tested explanation that accounts for a lot of observations and hypotheses and that lets scientists make good predictions.
- Using science involves understanding its limitations and how it fits into society.

theory (p. 11)

bias (p. 12)



1.3 Studying Life

- Living things are made up of basic 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.
- Biology's big ideas are 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 is made up of many overlapping fields that use different tools to study life from the level of molecules to the whole planet.
- Most scientists use the metric system when collecting data and performing experiments.

biology (p. 13)

DNA (p. 14)

stimulus (p. 14)

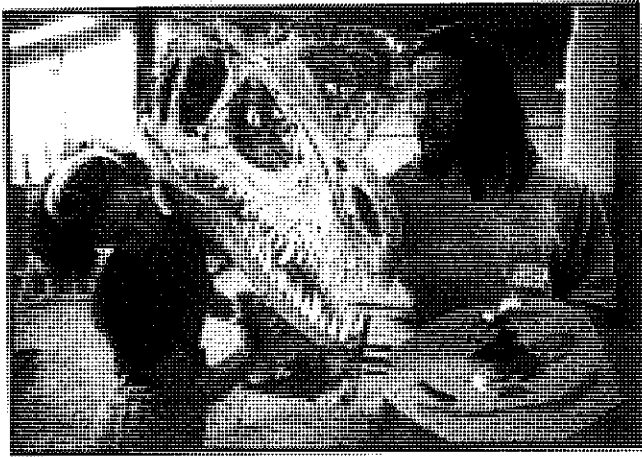
homeostasis (p. 15)

metabolism (p. 15)

biosphere (p. 17)



CHECK Understanding



Assess the
Big Idea

Science as a Way of Knowing

Write an answer to the question below.

Q: What role does science play in the study of life?

Constructed Response

Write an answer to each of the questions below. The answer to each question should be one or two paragraphs long. To help you begin, read the **Hints** below each of the questions.

- 1. Why are questions so important in the scientific method?**

Hint Scientific investigation begins with observation.

- 2. Predict some problems that might happen if some scientists used SI units to measure objects and other scientists used inches.**

Hint Scientists need to replicate each other's experiments.

Hint The metric system is based on multiples of 10.

- 3. Suppose that a classmate says that a wooden chair is alive. He says that the wood comes from a tree and that trees are alive. Explain why your classmate is right or wrong.**

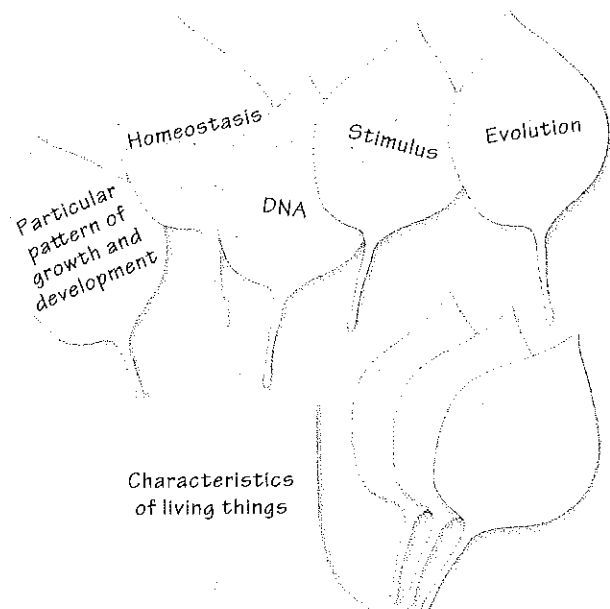
Hint If something does not have all the characteristics of living things, it is not alive.

Foundations for Learning Wrap-Up

Use the Inspired Shape Tree that you made when you started the chapter as a tool to help you learn the characteristics of living things.

Activity 1 Remove a branch from your Inspired Shape Tree. Write the characteristic on a sheet of paper. Then, write a brief description of what would happen to a tree if the tree did not have that characteristic.

Activity 2 Remove the branches from your Inspired Shape Tree. Turn each branch over and write one or two words related to the characteristic on the front side of the branch. Mix up the branches. Have a partner read the words on one of the branches. Try to explain the characteristic of that branch. If your partner thinks that you explained the characteristic clearly, he or she will give you the branch to attach to your tree trunk. Continue until all the branches are picked. Take turns.



1.1 What Is Science?

Understand Key Concepts

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

Test-Taking Tip

Read All the Answer Choices If you are not sure of the answer to a question, read all of the choices before picking one. Then begin to cross out incorrect answers. Read question 1 again. If all the variables are kept the same, the experiment would not show any changes in the dependent variable. So, **a** is not correct. Choices **c** and **d** are not correct. Some experiments cannot be tested with controlled experiments, and some controlled experiments can be done on living things. Therefore, **b** is the correct answer.

- An inference is
 - the same as an observation.
 - a logical interpretation of an observation.
 - a statement involving numbers.
 - a way to avoid bias.
- To be useful in science, a hypothesis must be
 - measurable.
 - observable.
 - testable.
 - correct.

Think Critically

- Apply Concepts** Suggest an experiment that would test the hypothesis that one food is better than another at speeding an animal's growth.
- Explain** Explain why you cannot draw a conclusion about the effect of one variable in an investigation when other key variables are not controlled.

1.2 Science in Context

Understand Key Concepts

- A skeptical attitude in science
 - prevents scientists from accepting new ideas.
 - makes the acceptance of new ideas more likely.
 - means a new idea will only be accepted if it is backed by evidence.
 - is unimportant.
- The purpose of peer review in science is to ensure that
 - all scientific research is funded.
 - the results of experiments are correct.
 - all scientific results are published.
 - published results meet standards set by the scientific community.
- A scientific theory is
 - the same as a hypothesis.
 - a well-tested explanation that unifies a broad range of observations.
 - the same as the conclusion of an experiment.
 - the first step in a controlled experiment.

Think Critically

- Infer** How would having a scientific attitude help you in everyday activities—in trying to learn a new skill, for example?
- Apply Concepts** If you were one of the reviewers of a paper submitted for publication, what criteria would you use to determine whether or not the paper should be published?

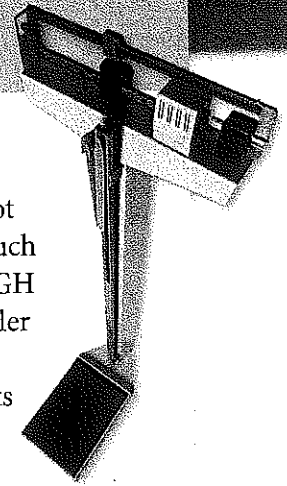
1.3 Studying Life

Understand Key Concepts

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

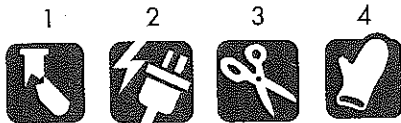
CHECK Understanding

solve the CHAPTER MYSTERY



Think Critically

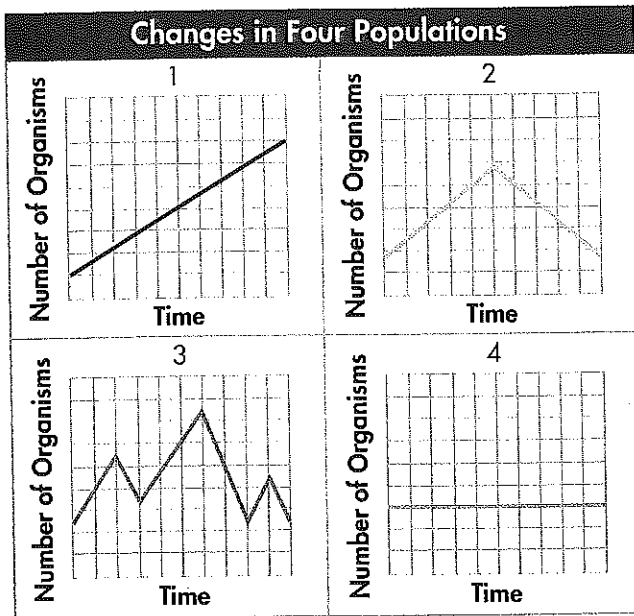
12. Interpret Visuals Each of the following safety symbols might appear in a laboratory activity in this book. Describe what each symbol stands for. (Hint: Refer to Appendix B.)



Connecting Concepts

Use Science Graphs

The following graphs show the size of four different populations over a period of time. Use the graphs to answer questions 13–15.



- Analyze Data** Write a sentence summarizing what each graph shows.
- Interpret Graphs** What information is missing from the graphs? (Hint: Look at the x and y axes.)
- Compare and Contrast** Graphs of completely different events can look alike. Select one of the graphs and explain how the shape of the graph could apply to a different set of events.

HEIGHT BY PRESCRIPTION

Although scientific studies have not proved that HGH makes adults much taller, studies suggest that extra HGH may help some short kids grow taller sooner. David's doctor prescribed HGH so that David and his parents would not complain that HGH was not given as an option.

This situation is new. HGH used to be available only from cadavers, or dead bodies, and it was given only to people who had severe medical problems. Then, genetic engineering made it possible to make a lot of HGH—safe medicine for sick people.

Soon drug companies began trying to sell HGH to parents of healthy, short kids.

As David's case shows, science can change lives, but new scientific knowledge 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 thinking about how science should be applied, we must consider both its limitations and its context in society.

- Relate Cause and Effect** Search the Internet for the latest data on the use of HGH by healthy children.
- Predict** HGH was among the first products to come out of genetic engineering. Many more will follow. As products become available that could change other inherited traits, what challenges will society face?



Never Stop Exploring Your World. Finding

the solution to the HGH mystery is only the beginning. Take a video field trip with the ecogeeks of Untamed Science to see where this mystery leads.

Standardized Test Prep

Multiple Choice

- 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
 - other scientists.
 - the general public.
 - the researchers' friends.
 - lawmakers.
- The term for the chemical reactions in which organisms build up or break down materials is
 - biotechnology.
 - genetics.
 - metabolism.
 - genomics.
- Which of the following is NOT an attitude that scientists need?
 - bias
 - skepticism
 - creativity
 - open-mindedness
- 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 part of scientific thinking is most apparent in this situation?
 - observation
 - inference
 - hypothesis formation
 - controlled experimentation
- Unlike sexual reproduction, asexual reproduction involves

A two cells.	C one parent.
B two parents.	D one nonliving thing.

- One meter is equal to
 - 1000 millimeters.
 - 1 millimeter.
 - 10 kilometers.
 - 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

- According to the table, which statement is true?
 - The puppy's mass increased at the same rate for each month shown.
 - The puppy's mass was less than 5 kg at the start of the new diet.
 - The puppy gained 5 kg between age 3 and 4 months.
 - The puppy had gained 13 kg as a result of the new diet.
- All of the following statements about the pet owner's study are true EXCEPT
 - The owner used the metric system.
 - The owner recorded data.
 - The owner could graph the data.
 - The owner conducted a controlled experiment.

Open-Ended Response

- 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