

What Is Science?

READING TOOL Sequence of Events List in order the parts of a typical experiment that uses scientific methodology. Use the headings in your text as a guide. Give a brief explanation or example of each. The first one is filled in for you.

	Scientific Methodology	Explanation or Example
1	observing and asking questions	Scientists observe and ask questions.
2	_____	_____
3	_____	_____
4	_____	_____
5	_____	_____

Lesson Summary

What Science Is and Is Not

KEY QUESTION *What are the goals of science?*

Biologists try to understand life and nature. Scientific knowledge is always changing, so scientists have to constantly test, debate, and revise explanations of the natural world.

The Nature of Science Science is a process of explaining natural events. Scientists observe and ask questions about the natural world, then use their observations to make explanations that can be tested in experiments. Scientists gather and analyze data to support or reject their explanations.

The word *science* also refers to the accumulated knowledge about the natural world. Scientific explanations are based on evidence and understanding, not just beliefs, therefore, they are not concerned with supernatural explanations or events.

Q As you read, circle the answers to each Key Question. Underline any words you do not understand.

BUILD Vocabulary

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

inference a logical interpretation based on prior knowledge and experience

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

controlled experiment

experiment in which only one variable is changed

independent variable factor in a controlled experiment that is deliberately changed; also called manipulated variable

dependent variable variable that is observed and that changes in response to the independent variable; also called the responding variable

control group 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

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

Multiple Meanings In everyday life, when something is controlled, its action is regulated by something else. An example is keeping your dog under control during a walk. ☒ Which of the options below describes a controlled experiment?

Experiment 1: Scientists observe how lions interact in a zoo.

Experiment 2: Scientists investigate how different amounts of sunlight affect plant growth.

The Goals of Science A goal of science is to provide natural and testable explanations for natural events. Science also uses explanations that are supported by data to understand patterns in nature. Scientific explanations can be used to make useful predictions about natural events.

Science, Change, and Uncertainty Scientists have learned many things about the natural world. However, there is much about the natural world that is not yet understood. New scientific discoveries often lead to surprises and new questions. Changes in scientific knowledge are not a failure of science, but show that science continues to move forward. Studying science also means understanding what is not known. Uncertainty is part of science. Understanding science is also about learning how scientists work and think and where scientific ideas come from.

Scientific Methodology

KEY QUESTION *What procedures are at the core of scientific methodology?*

People other than scientists use scientific methods to solve everyday problems. There is not just one scientific method, but there is a common style of investigation. Scientific methodology involves observing and asking questions, forming hypotheses, conducting controlled experiments, collecting and analyzing data, and drawing conclusions.

Observing and Asking Questions Scientific investigations begin with observation. **Observation** is the act of noticing and describing events and processes. Observation leads to the asking of new questions that have not been answered.

Inferring and Forming a Hypothesis After asking questions, scientists use further observation to make inferences. An **inference** is a logical interpretation of an event. Inference and imagination can lead to a hypothesis. A **hypothesis** is a possible scientific explanation that can be tested by further observation or by experimentation. Testing gathers data that can support or reject the hypothesis.

Designing Controlled Experiments Testing a hypothesis involves designing experiments to measure changes in factors. Factors that can change are called variables. An experiment ideally changes only one variable. This is called a **controlled experiment**.

Controlling Variables Variables must be controlled because if several variables are changed, scientists will not know which variable causes an effect. The variable that is deliberately changed in an experiment is called the **independent variable**. The variable that is observed and changes in response to the independent variable is called the **dependent variable**.

Control and Experimental Groups Experiments are ideally divided into control and experimental groups. In the experimental group, the independent variable is changed. In the **control group**, the independent variable is not changed.

Collecting and Analyzing Data Scientists collect two main types of information, or **data**, from observations and experiments. *Quantitative data* are numbers obtained from counting or measuring. *Qualitative data* are descriptions of events that cannot be measured.

Selecting Equipment and Technology Scientists collect data using simple tools such as a measuring stick, or complex tools such as instruments that measure the chemical composition of a substance. Data is collected and analyzed on computers. Statistics are used to determine if a significant difference exists between an experimental group and a control group.

Sources of Error Scientists must avoid errors in data. Tools for measurement have limits to their accuracy. Data analysis must take into account the sample size. Larger sample sizes allow scientists to more confidently identify differences between experimental groups and control groups.

Interpreting Data and Drawing Conclusions

Analyzing data may lead to conclusions that support or reject the hypothesis that is being tested by the experiment. Data may show that a hypothesis is partly correct but must be adjusted. Data can sometimes lead to new questions and hypotheses.

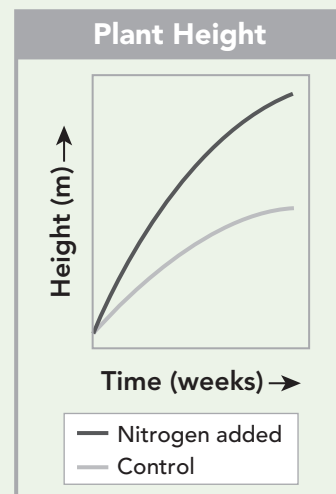
When Experiments Aren't Possible Not all hypotheses can be tested in experiments. Some hypotheses about animals must be tested by observation of natural behavior. Scientists cannot carry out experiments that they know will harm humans.

Scientific Theories

KEY QUESTION *What is a scientific theory?*

In science, a **theory** is a scientific explanation of events in the natural world that has been tested and is reliable. A scientific theory comes from many repeated observations and includes several well-supported hypotheses. Scientific theories can be used to make accurate predictions. In everyday language, *theory* is sometimes used to mean a guess. In science, *hypothesis* is used to mean a guess. Charles Darwin developed his theory of evolution from many hypotheses. Today, evolutionary theory is one of the central organizing principles of biology. Theories can be revised or replaced by better theories if they are supported by new data.

Visual Reading Tool: Analyzing Data



1. Identify the independent variable.

2. Identify the dependent variable.

3. Which plants grew taller: those in the experimental group or those in the control group?

4. Describe why this is a controlled experiment.

Science in Context

READING TOOL Connect to Visuals Before you read, study Figure 1-4. As you read, list examples of each of the different aspects of science in the table below. Then use Figure 1-9 to add examples for engineering. Some answers may be the same for both science and engineering.

	Exploration and Discovery	Community Analysis and Feedback	Benefits and Outcomes
SCIENCE			
ENGINEERING			

Lesson Summary

The process of science includes exploration and discovery, community analysis and feedback, and benefits and outcomes.

Exploration and Discovery

Q As you read, circle the answers to each Key Question. Underline any words you do not understand.

Q KEY QUESTION What attitudes and experiences generate new ideas?

Scientific Attitudes Scientific attitudes like curiosity, skepticism, open-mindedness, and creativity help scientists and engineers ask new questions and define new problems.

Curiosity A scientist will make an observation and then ask questions about it. An engineer will see a problem and ask how to solve it.

Skepticism Scientists and engineers should be skeptical, question hypotheses, and demand evidence before accepting explanations.

Open-Mindedness Scientists and engineers should be willing to accept data that disagree with their hypotheses, or to consider hypotheses that disagree with their own.

Creativity Scientists and engineers must be creative and apply critical thinking when asking questions, proposing hypotheses, and designing experiments.

Practical Problems Many scientific investigations come from attempts to solve problems involving humans, health, or environmental issues.

New Technology New technology provides scientists and engineers with new and better ways to make observations and collect data.

Community Analysis and Feedback

 **KEY QUESTION** *Why is peer review important?*

Scientists usually work in groups and collaborate and communicate with other groups. Research must be shared with the scientific community in order to be accepted. Scientists also communicate with the general public.

Peer Review Scientists share their research and ideas with other scientists by publishing their hypotheses, experimental methods, results, data analysis, and conclusions. Scientific papers are reviewed by other scientists before publication. Reviewers look for mistakes and fraud in methods and analysis. This process allows other scientists to evaluate and test the data and analysis. Peer review does not guarantee that research is correct, but that it meets certain standards.

Sharing Knowledge and New Ideas After research is published, scientists who read it will come up with new questions. New questions lead to new hypotheses that must be supported or rejected by experiments.

READING TOOL

Connecting to Visuals

View Figure 1-4 in your textbook. It outlines the three different processes that define science.

☒ **Is this process a rigid order of events, or is it a flexible process?**

READING TOOL

Academic Words

Peer Someone who belongs to the same group in society and is equal in rank or level. Scientists have their research reviewed by their peers, who are other scientists. As a student, you have your work reviewed by your teachers and parents, but they are not your peers. ☒ **Who are your peers?**

Benefits and Outcomes

KEY QUESTION *What is the relationship between science and society?*

Science interacts with society, laws, and moral principles. Science also has a big impact on health, medical issues, and environmental issues such as energy and waste disposal.

Science, Ethics, and Morality Science and engineering usually only tell us what is possible or what we *could* do. They do not tell us what we *should* or *should not* do. Applying scientific information involves understanding the role of science in society and its limitations. Science by itself does not include ethical or moral viewpoints.

Avoiding Bias Scientists should be objective, but like everyone else, they have likes, dislikes, and biases. A **bias** is a personal, rather than scientific, view for or against something. Scientists with different personal biases may interpret data in different ways. Bias affects what actions scientists recommend.

Science and Engineering Practices

KEY QUESTION *What practices are shared by science and engineering?*

Although some of the specifics vary, the steps in scientific inquiry and engineering design are basically the same.

Developing and Using Models Scientists and engineers both use models. Models include diagrams and three-dimensional models, but also include mathematical models and computer simulations. Models help people to visualize and summarize ideas.

Using Mathematics and Computational Thinking Mathematics is important to science and engineering. Ratios, rates, percentages, and unit conversions are some basic ways to analyze data. A mathematical representation can model data and support explanations.

Constructing Explanations and Designing Solutions Scientists attempt to answer questions about the natural world. Scientists then construct explanations that are supported by evidence. Engineers design solutions to problems.

Engaging in Argument From Evidence In science, an argument is a set of reasons that explain why an idea is right or wrong. Scientists must respond thoughtfully to criticisms. Engineers must argue that their design solutions will work and compare them to competing design solutions.

BUILD Vocabulary

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

Word Origins *Bias* comes from the French word *biais*, meaning "slant" or "slope." Therefore, when someone has a bias, his or her point of view is "slanted" in one direction.

✓ A scientist who works for a company that makes products from plants publishes a paper on energy efficiency. They claim that converting corn to ethanol is more efficient than solar power. Describe their possible bias.

READING TOOL Main Idea and Details Complete the chart. Write the main ideas in the left column and the details or examples that explain the main idea in the right column. Part of the table is filled out for you.

Characteristics of Living Things	
Main Idea	Details
Made up of cells	Cells are the smallest units of living things.

Lesson Summary

Characteristics of Living Things

KEY QUESTION What characteristics do all living things share?

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

As you read, circle the answers to each Key Question. Underline any words you do not understand.

BUILD Vocabulary

biology scientific study of life

sexual reproduction type of reproduction in which cells from two parents unite to form the first cell of a new organism

asexual reproduction process of reproduction involving a single parent that results in offspring that are genetically identical to the parent

DNA deoxyribonucleic acid; genetic material that organisms inherit from their parents

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

stimulus signal to which an organism responds

homeostasis relatively constant internal, physical, and chemical conditions that organisms maintain

evolve change over time

Word Origins Homeostasis comes from the Greek words *homio-*, meaning "like" or "similar to," and *stasis*, meaning "standing still."

☑ **Diseases can alter an organism's homeostasis. When you get sick and have a fever, what internal condition has changed?**

Made Up of Cells All living things, or organisms, are made up of cells. Cells are the smallest living units of an organism.

Reproduction All organisms produce new organisms through a process called reproduction. There are two basic kinds of reproduction: sexual and asexual. In **sexual reproduction**, cells from two different parents come together to produce the first cell of the new organism. In **asexual reproduction**, the new organism has a single parent.

Based on a Universal Genetic Code New organisms usually resemble their parents because of inherited characteristics called traits. Traits are passed from parents to offspring by a molecule called **DNA**. DNA contains information in a genetic code. The genetic code, with a few small variations, is the same for every organism on Earth.

Growth and Development All organisms grow during part of their lives. Single-celled organisms simply increase in size. Multicellular organisms begin as a single cell. During a process called development, the single cell divides repeatedly. As the cells divide, they change in order to perform different functions. This process is called differentiation.

Need for Materials and Energy Organisms need energy and a constant supply of materials to grow, develop, reproduce, and to stay alive. The combination of chemical reactions a cell carries out is called **metabolism**.

Response to the Environment Organisms detect and respond to stimuli. A **stimulus** is a signal that leads to a response. External stimuli come from the environment outside an organism. Internal stimuli come from within the organism.

Maintaining Internal Balance Environmental conditions may vary widely, but most organisms must keep their internal conditions, such as temperature and water content, fairly constant. The process of maintaining internal conditions is called **homeostasis**. Internal stimuli, such as thirst, are important in maintaining homeostasis.

Evolution The traits an organism inherits from its parent usually do not change during its life. As a group, however, organisms **evolve**, or change over time. The ability of groups of organisms to change gradually is necessary for survival in a changing world.

What About Viruses? Viruses exist at the border between living and nonliving things. Viruses are parasites that cannot carry out the functions of life on their own. Viruses can only reproduce after infecting living organisms.

Crosscutting Concepts in Biology

KEY QUESTION *What are the crosscutting concepts of biology?*

All of the biological sciences are linked together by shared themes and methods of study. The study of biology revolves around several crosscutting concepts: cause and effect; systems and system models; stability and change; patterns; scale, proportion, and quantity; energy and matter; and structure and function.

Cause and Effect: Mechanism and Explanation

Science uses observations, questions, and experiments to explain the world in terms of natural forces and events, or cause and effect. Science reveals rules and patterns that can explain and predict events in nature.

Systems and System Models All living things on Earth form a system called the biosphere. The parts of this system interact and work together. Within an organism, different systems interact to maintain the organism.

Stability and Change Organisms must maintain a stable internal environment, a process called homeostasis.

Patterns Similar patterns occur throughout nature. Patterns can be linear, such as the increasing complexity of similar organs from fish to mammals. Patterns can also be cyclical, or repeating, such as seasonal changes in the behavior of living things.

Scale, Proportion, and Quantity Organisms can be described and studied at different scales. Studies at a very small, or molecular, scale might examine the proteins in an organism. Studies at a very large, or global, scale might examine the effects of humans on the atmosphere.

Energy and Matter: Flows, Cycles, and Conservation Organisms require material as nutrients to build body structures and provide energy. The need for matter and energy link all organisms on Earth in a web of interdependent relationships.

Structure and Function Each major group of organisms has evolved a particular collection of body parts, or structures, for carrying out particular functions. These structures have evolved as organisms have adapted to life in different environments.

READING TOOLS

Academic Words

scale the size of something, especially in comparison to something else

proportion the relation of the size of a part to the size of the whole

✓ **Place the following biological processes in order from smaller to larger according to the scale at which they would be studied.**

1. A cell reproduces by dividing.
 2. A multicellular animal obtains nutrients.
 3. The genetic code of a piece of DNA.
 4. The effects on the atmosphere of burning fossil fuels.
 5. The response of all the plants in a region to a change in climate.
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Fields of Biology

 **KEY QUESTION** *How do fields of biology differ in their approaches?*

Biology includes many overlapping fields that use different tools to study life from the molecular level to the planetary level.

READING TOOL

Cause and Effect The ability to read and alter the genetic information in DNA is a relatively recent achievement of modern biology.  **What fields listed under the Fields of Biology heading were made possible by the ability to read and/or alter genetic information?**

Global Ecology Life is shaped by weather and processes in the atmosphere. The activities of organisms, including humans, can affect the atmosphere and climate. Humans move more matter and use more energy than any other species on Earth. Global ecological studies help us to learn about human impacts on life on Earth.

Biotechnology Biotechnology is based on the ability to change genetic information to make changes in the living world. Scientists are working to change genes to cure diseases and to clean up the environment. Biotechnology involves ethical, legal and social issues because of the ability to change the genetic information that makes us human.

Building the Tree of Life Biologists have discovered about 1.8 million different organisms. However, there are still many organisms that have not yet been identified. Biologists wish to identify and catalogue all forms of life. Biologists also want to use genetic information to organize all organisms into a single "Tree of All Life."

Ecology and Evolution of Infectious Diseases New disease-causing organisms often appear. The relationships between organisms and pathogens that cause disease constantly change. Pathogens evolve in response to new medicines and changes in how humans interact with the environment. Understanding interactions between humans and pathogens is important to our health.

Genomics and Molecular Biology These fields focus on DNA and other molecules inside the cell. The entire DNA content of organisms can now be studied. This information is helping scientists to understand growth, development, aging, disease, cancer, and the history of life.

Performing Biological Investigations

KEY QUESTION *How is the metric system important to science?*

Biologists, like all scientists, rely on a common system of measurement and safety practices while carrying out research. You will learn about scientific measurement and safety as you begin to carry out experiments.

Scientific Measurement Scientists use a common system of measurement to understand and replicate each other's experiments. Scientists use the metric system when collecting data and performing experiments. The metric system is a decimal system, meaning that the units are scaled on multiples of 10. The basic units of length (meter), volume (liter), and mass (gram) can be multiplied or divided by multiples of 10 to measure amounts much larger or smaller than the basic unit.

Safety Laboratory work may involve flames, heat, electricity, chemicals, sharp instruments, or things that can break. Therefore, it is important to follow safe practices and to protect yourself with glasses and gloves. You must also wash your hands after every laboratory activity. The most important safety rule is to follow your teacher's instructions and the directions in the textbook. If you do not understand something, ask your teacher for an explanation. You are responsible for your own safety and the safety of your classmates and teacher. If you are using live animals, you are also responsible for their safety.

Visual Reading Tool: The Metric System



1. Using the ruler above, draw a centipede that is 6 centimeters long.
2. The centipede is about _____ millimeters long.
3. The bottle holds 1 _____ of water, which weighs 1 kilogram.
4. Samir drinks half of the bottle of water. It now has _____ milliliters of water, which weighs about 500 _____.

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Chapter Review

Review Vocabulary

Choose the letter of the best answer.

1. A possible explanation for a set of observations that must be tested is called a
A. theory.
B. law.
C. fact.
D. hypothesis.
2. A well-tested explanation for a broad range of natural events is called a
A. theory.
B. law.
C. fact.
D. hypothesis.

Match the vocabulary term to its definition.

3. _____ In an experiment, its variables are changed. a. bias
4. _____ All of the chemical reactions that an organism carries out to stay alive. b. control group
5. _____ A personal preference that is not scientific. c. metabolism

Review Key Questions

Provide evidence and details to support your answers.

6. A scientist grows tomatoes in greenhouses that differ only in the amount of carbon dioxide in the air. He determines the weight of tomatoes produced by plants in each greenhouse, and compares them to each other and to tomatoes grown in air with a natural, unaltered amount of carbon dioxide. Is this a controlled experiment? Why or why not?

7. A group of scientists decide to post their research results on the Internet instead of publishing in a scientific journal. What part of the scientific process have they skipped and why does it matter?

8. Why is a virus not considered a living organism?
