SECTION 3

Scientific Models

How much like a penguin is *Proteus*? *Proteus* doesn't have feathers and isn't a living thing. But its "flippers" create the same kind of motion that a penguin's flippers do.

The MIT engineers built *Proteus* to mimic the way a penguin swims so that they could gain a greater understanding about boat propulsion. In other words, they made a model.

What You Will Learn

- Explain how models represent the natural world.
- Identify three types of models used in science.
- Describe theories and laws.

Vocabulary

model
theory
law

READING STRATEGY

Discussion Read this section silently. Write down questions that you have about this section. Discuss your questions in a small group.

Models in Science

A **model** is a representation of an object or system. A model uses something familiar to help you understand something that is not familiar. For example, models of human body systems can help you understand how the body works. Models can also be used to explain the past and the present. They can even be used to predict future events. There are three common kinds of scientific models. They are physical, mathematical, and conceptual (kuhn SEP choo uhl) models. However, models have limitations because they are never exactly like the real thing.

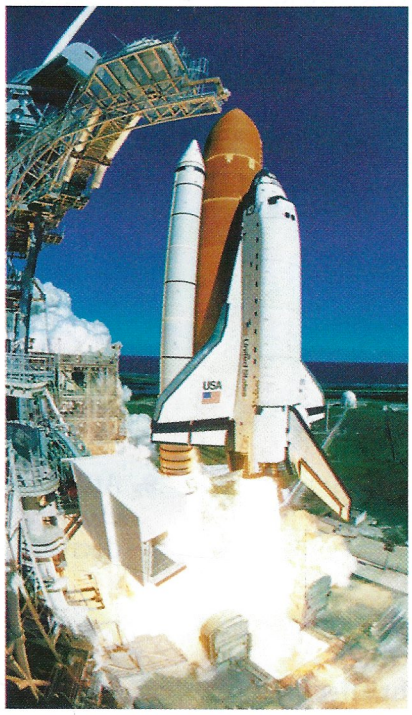


Figure 1 *Using a model of a space shuttle can help you understand how a real space shuttle works.*

Physical Models

Model airplanes, dolls, and drawings are examples of physical models. A model of a molecule can show you the shape of the molecule, which you cannot see. But this model wouldn't let you see how the molecule interacts with other molecules. Other kinds of physical models can help you understand certain concepts. For example, look at the model space shuttle and the real space shuttle in **Figure 1.** Launching a model like the one on the left can help you understand how a real space shuttle blasts off into space.

Mathematical Models

Every day, people try to predict the weather. One way to predict the weather is to use mathematical models. A mathematical model is made up of mathematical equations and data. Some mathematical models are simple. These models allow you to calculate things such as forces and acceleration. But other mathematical models are so complex that only computers can handle them. Some of these very complex models have many variables. Sometimes, certain variables that no one thought of exist in a model. A change in any variable could cause the model to fail.

model a pattern, plan, representation, or description designed to show the structure or workings of an object, system, or concept

Reading Check **Name a possible limitation of a mathematical model.** (*See the Appendix for answers to Reading Checks.*)

Conceptual Models

The third kind of model is a conceptual model. Some conceptual models are systems of ideas. Others are based on making comparisons with familiar things to help illustrate or explain an idea. The big bang theory is a conceptual model that describes how the planets and galaxies formed. This model is described in **Figure 2.** Although the big bang theory is widely accepted by astronomers, some data do not fit the model. For example, scientists have calculated the ages of some old, nearby stars. If the calculations are right, some of these stars are older than the universe itself. So, conceptual models may not take certain data into account. Or the models may rely on certain ideas but not on others.

SCHOOL to HOME

Weather Forecasting

Watch the weather forecast on TV. You will see several models that a weather reporter uses to inform you about the weather in your area. In your **science journal,** describe two of these models and explain how each model is used to represent the weather. Describe some of the advantages and disadvantages of each model.

ACTIVITY

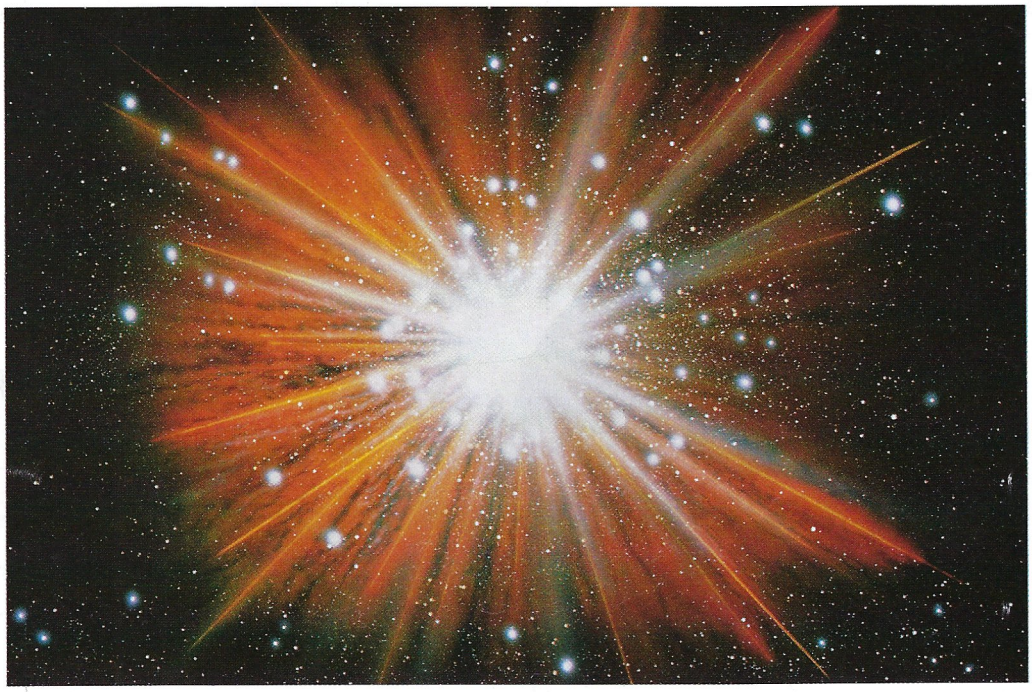


Figure 2 *The big bang theory says that 12 billion to 15 billion years ago, an event called the* big bang *sent matter in all directions. This matter eventually formed the galaxies and planets.*

Figure 3 *The compressed coils on the spring toy can be used to model the way air particles are crowded together in a sound wave.*

theory an explanation that ties together many hypotheses and observations

law a summary of many experimental results and observations; a law tells how things work

Models: The Right Size

Models are often used to represent things that are very small or very large. Some particles of matter are too small to see. The Earth and the solar system are too large to see completely. So, a model can help you picture the thing in your mind. Sometimes, models are used to learn about things you cannot see, such as sound waves. Look at **Figure 3.** A coiled spring toy is often used as a model of sound waves because the spring toy behaves similar to the way sound waves do.

Using Models to Build Scientific Knowledge

Models not only can represent scientific ideas and objects but also can be tools that are useful to help you learn new information.

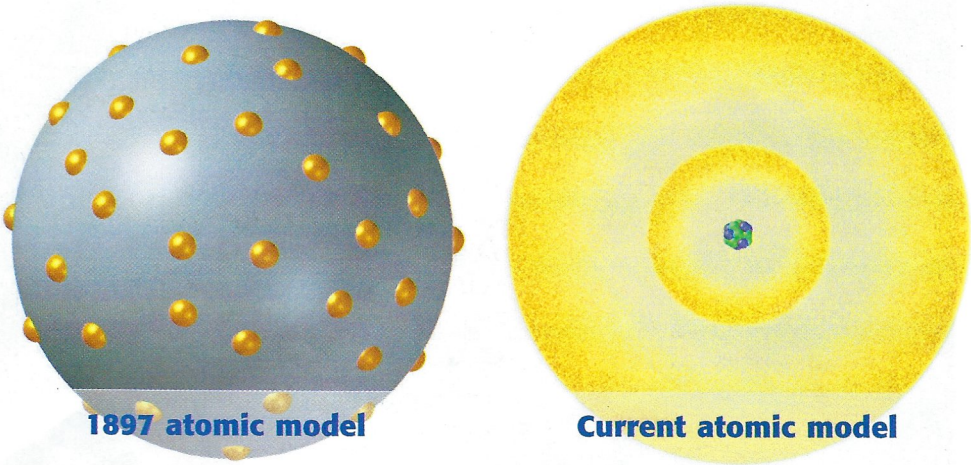
Scientific Theories

Models are often used to help illustrate and explain scientific theories. In science, a **theory** is an explanation for many hypotheses and observations. Usually, these hypotheses have been supported by repeated tests. A theory not only explains an observation you've made but also can predict what might happen in the future.

Scientists use models to help guide their search for new information. This information can help support a theory or can show that the theory is wrong. Keep in mind that models can be changed or replaced. These changes happen when scientists make new observations. Because of these new observations, scientists may have to change their theories. **Figure 4** compares an old model with a current model.

Reading Check **What two things can a theory explain?**

Figure 4 *These models show how scientists' idea of the atom has changed over time as new information was gathered.*



Scientific Laws

What happens when a model correctly predicts the results of many different experiments? A scientific law can be constructed. In science, a **law** is a summary of many experimental results and observations. A law tells you how things work. Laws are not the same as theories. Laws tell you only what happens, not why it happens. Look at **Figure 5.** A chemical change took place when the flask was turned over. A light blue solid and a dark blue solution formed. Notice that the mass did not change, which demonstrates the *law of conservation of mass*. This law says that during a chemical change, the total mass of the materials formed is the same as the total mass of the starting materials. However, the law doesn't explain why. It tells you only what will happen during every chemical change.

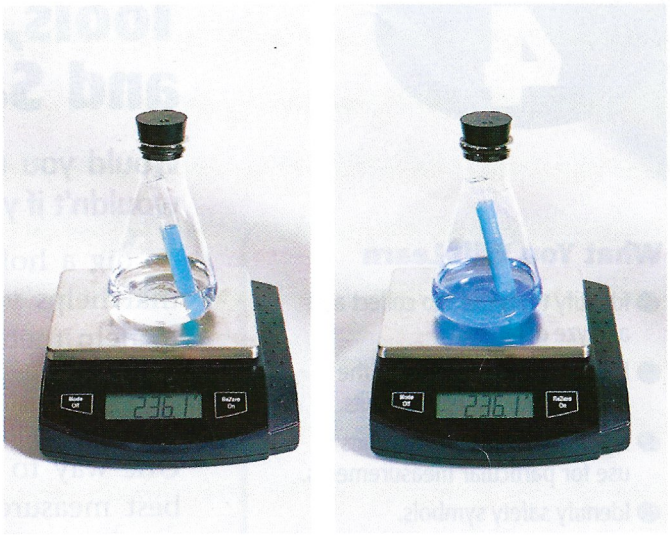


Figure 5 *The total mass before the chemical change is always the same as the total mass after the change.*

SECTION Review

Summary

- A model uses familiar things to describe unfamiliar things.
- Physical, mathematical, and conceptual models are commonly used in science.
- A scientific theory is an explanation for many hypotheses and observations.
- A scientific law summarizes experimental results and observations. It describes what happens but not why.

Using Key Terms

1. In your own words, write a definition for the term *model*.

Understanding Key Ideas

2. Which kind of model would you use to represent a human heart?
   - **a.** a mathematical model
   - **b.** a physical model
   - **c.** a conceptual model
   - **d.** a natural model
3. Explain the difference between a theory and a law.

Critical Thinking

4. **Analyzing Methods** Both a globe and a flat world map can model features of Earth. Give an example of when you would use each of these models.
5. **Applying Concepts** Identify two limitations of physical models.

Math Skills

6. For a science fair, you want to make a model of the moon orbiting Earth by using two different balls. The diameter of the ball that will represent Earth will be about 62 cm. You want your model to be to scale. If the moon is about 4 times smaller than Earth, what should the diameter of the ball that represents the moon be?