SECTION 3

Scientific Models

How can you see the parts of a cell? Unless you had superhuman eyesight, you couldn't see inside most cells without using a microscope.

What would you do if you didn't have a microscope? Looking at a model of a cell would help! A model of a cell can help you understand what the parts of a cell look like.

READING WARM-UP

Objectives

- Give examples of three types of models.
- Identify the benefits and limitations of models.
- Compare the ways that scientists use hypotheses, theories, and laws.

Terms to Learn

model
theory
law

READING STRATEGY

Reading Organizer As you read this section, create an outline of the section. Use the headings from the section in your outline.

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

Types of Scientific Models

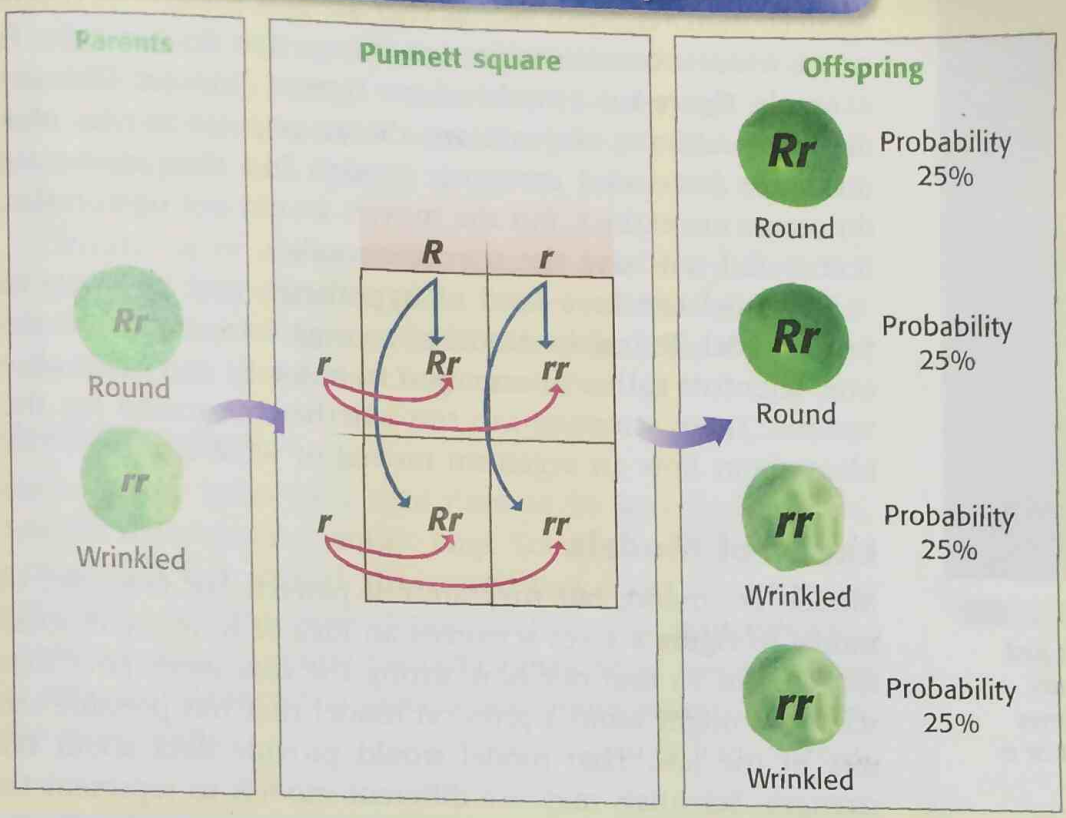
A **model** is a representation of an object or system. Scientific models are used to help explain how something works or to describe the structure of something. A model may be used to predict future events. However, models have limitations. A model is never exactly like the real thing. If it were, it would not be a model. Three major kinds of scientific models are physical, mathematical, and conceptual models.

Physical Models

A model volcano and a miniature steam engine are examples of physical models. Some physical models, such as a model of a cell, look like the thing that they model. But a limitation of the model of a cell is that the model is not alive and doesn't act exactly like a cell. Other physical models, such as the model of a skyscraper in **Figure 1,** look and act at least somewhat like the thing that they model. Scientists often use the model that is simplest to use but that still serves their purpose.

Figure 1 *The model of the skyscraper doesn't act like the real building in every way, which is both a benefit and a limitation of the model.*

Figure 2 Mathematical Model: A Punnett Square



Mathematical Models

A mathematical model may be made up of numbers, equations, and other forms of data. Some mathematical models are simple and can be used easily. The Punnett square shown in **Figure 2** helps scientists study the passing of traits from parents to offspring. Using this model, scientists can predict how often certain traits will appear in the offspring of certain parents.

Computers are useful for creating and manipulating mathematical models. They make fewer mistakes and can keep track of more variables than a person can. But a computer model can also be incorrect in many ways. The more complex a model is, the more carefully scientists must build and test the model.

Reading Check **What type of model is a Punnett square?** (*See the Appendix for answers to Reading Checks.*)

Conceptual Models

The third type of model is the conceptual model. Some conceptual models are systems of ideas. Others compare unfamiliar things with familiar things to help explain unfamiliar ideas. The idea that the solar system formed from a spinning disk of gas is a conceptual model. Scientists also use conceptual models to classify behaviors of animals. Scientists can then predict how an animal might respond to a certain action based on behaviors that have already been observed.

CONNECTION TO Environmental Science

Samples Scientists studying deformed frogs in Minnesota wanted to know at what stage in the frogs' development the deformities happened. So, the scientists collected a large sample of frogs in all stages of development.

The larger a sample is, the more accurately it represents the whole population. If, for example, a sample of frogs is too small, one unusual frog may make the results of the study inaccurate. If the sample has too many old frogs or too many tadpoles, the sample is unrepresentative of the whole population. Give an example of an unrepresentative sample. Make a poster describing how that sample might make the experimental results inaccurate.

ACTIVITY

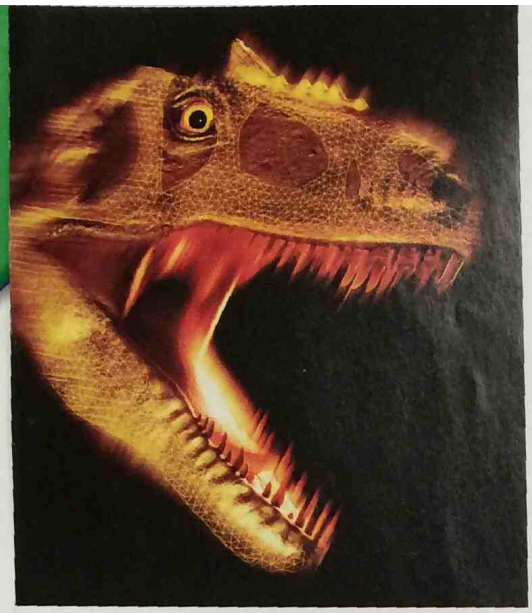


Figure 3 *This computer-generated model doesn't just look like a dinosaur. It may also open and close its jaws in much the same way that a dinosaur does.*

Benefits of Models

Models often represent things that are small, large, or complicated. Models can also represent things that do not exist. For example, **Figure 3** is a model of one type of dinosaur. Dinosaurs died out millions of years ago. Some popular movies about dinosaurs have used computer models like this one because dinosaurs are extinct. But the movies would not be as realistic if they did not have the scientific models.

A model can be a kind of hypothesis, and scientists can test a model. To build a model of an organism, even an extinct one, scientists gather information from fossils and other observations. Then, scientists can test whether the model fits their ideas about how an organism moved or what it ate.

Limits of Models

Models are useful, but they are not perfect. For example, the model in **Figure 3** gives scientists an idea of how the dinosaur looked. But to find out how strong the dinosaur's jaws were, scientists might build a physical model that has pressure sensors in the jaw. That model would provide data about bite strength. Scientists may use different models to represent the same thing, such as the dinosaur's jaw. But the kind of model and the model's complexity depend on the model's purpose.

Even a model jaw that has pressure sensors is not perfect. Scientists can compare the dinosaur bite with the bite of a crocodile. Next, scientists use their model to conduct tests. Scientists might then estimate how hard the dinosaur could bite. But without a live dinosaur, the result is still a hypothesis.

Building Scientific Knowledge

Sometimes, scientists draw different conclusions from the same data. Other times, new results show that old conclusions are wrong. Scientists are always asking new questions or looking at old questions from a different angle. As scientists find new answers, scientific knowledge continues to grow and change.

Scientific Theories

For every hypothesis, more than one prediction can be made. Each time another prediction is proven true, the hypothesis gains more support. Over time, scientists tie together everything that they have learned. An explanation that ties together many related observations, facts, and tested hypotheses is called a **theory.** Theories are conceptual models that help organize scientific thinking. Theories are used to explain observations and to predict what might happen in the future.

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

Reading Check How do scientists use theories?

Scientific Laws

What happens when a theory and its models correctly predict the results of many experiments? A scientific law may be formed. In science, a **law** is a summary of many experimental results and observations. A scientific law is a statement of what *will* happen in a specific situation. A law tells you how things work.

Scientific laws are at work around you every day. For example, the law of gravity states that objects will always fall toward the center of Earth. And inside your cells, many laws of chemistry are at work to keep you alive.

Scientific Change

New scientific ideas may take time to be accepted as facts, scientific theories, or scientific laws. Scientists should be open to new ideas but should always test new ideas by using scientific methods. If new evidence challenges an accepted idea, scientists must reexamine the old evidence and reevaluate the old idea. In this way, the process of building scientific knowledge never ends.

CONNECTION TO Chemistry

Model Cocaine in the Brain

Analyze and evaluate information from a scientifically literate viewpoint by reading scientific texts, magazine articles, and newspaper articles about how drugs, such as cocaine, affect brain chemistry. Create a model to show what you have learned. Use your model to describe possible treatments for drug addiction.

ACTIVITY

SECTION Review

Summary

- Models represent objects or systems. Often, they use familiar things to represent unfamiliar things. Three main types of models are physical, mathematical, and conceptual models. Models have limitations but are useful and can be changed based on new evidence.
- Scientific knowledge is built as scientists form and revise scientific hypotheses, models, theories, and laws.

Using Key Terms

In each of the following sentences, replace the incorrect term with the correct term from the word bank.

theory law hypothesis

1. A conclusion is an explanation that matches many hypotheses but may still change.
2. A model tells you exactly what to expect in certain situations.

Understanding Key Ideas

3. A limitation of models is that
   a. they are large enough to see.
   b. they do not act exactly like the things that they model.
   c. they are smaller than the things that they model.
   d. they model unfamiliar things.
4. What type of model would you use to test the hypothesis that global warming is causing polar icecaps to melt? Explain.

Math Skills

5. If Jerry is 2.1 m tall, how tall is a scale model of Jerry that is 10% of his size?

Critical Thinking

6. **Applying Concepts** You want to make a model of an extinct plant. What are two kinds of models that you might use? Describe the advantages and disadvantages of each type of model.

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Topic: Using Models

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