When people think about structures, they often think about towers and bridges. While these structures are impressive, the truth is that every object you encounter is a structure. If you pack snow to make a snowball, you have made a structure. If you combine ingredients and bake a loaf of bread, you have also made a structure.

If you look carefully at a wide variety of structures, you will notice that many of them have similarities. Different structures might serve the same function, like the structures in Figures 4.4 and 4.5. In this section, you will explore ways to classify structures.

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We often classify structures by looking at their functions. Some structures are made to contain something, some structures support something on top, and some span a space. For example, if you notice soil running out of your school garden when it rains, you may decide to build a retaining wall to hold the soil in. If you have trouble reaching a high shelf, you may use a step or stool to lift yourself up. If workers are building a wall, they build scaffolding first, and walk around safely (Figure 4.6).

A bridge is a structure designed to span a gap. Sometimes the gap is a stream or river (Figures 4.7 and 4.8). Other bridges span another roadway; if so, we call the bridge an overpass. Early bridges consisted of a log felled over a stream; modern bridges are designed in many different forms. Look at the bridges in your community. No matter how simple or complicated the form of each bridge, its function is still to span a gap safely.

Another way to sort structures is to examine how they are built and what they are built from. We will look at this in Chapter 5. A third way to classify structures is to divide them by their forms, into solid structures, frame structures, and shell structures.
Learning Checkpoint

Classifying Structures

Draw a table with four columns and six rows. In the first column, write the names of six structures you can see in your classroom. As you work through the chapter, write the function of each structure in Column 2. If you are unsure of the function, put a question mark. In Column 3, list the materials each is made of. In Column 4, write whether you think it is a solid structure, a frame structure, or a shell structure.

Compare your table with that of a classmate. Discuss the items you put question marks beside. Compile a class list for discussion. What types of structures come up the most often?

Solid Structures

Do you know what mountains, dams, sand castles, wax candles, and apples have in common? All are considered solid structures (Figure 4.9). Most solid structures are solid all the way through, although a mountain might contain caves, a dam might have rooms to hold electrical generators, and an apple may have a worm hole. A solid structure weighs more than a hollow structure of the same size and made of the same material.

Frame Structures

Frame structures are made of parts fastened together. The parts are often called structural components. For example, your skeleton is a frame structure. Its structural components — your bones, ligaments, and tendons — are joined together. A bicycle frame is another example of a frame structure (see Figure 4.10).
Frame structures can exist as just the frame or as a frame covered by a coating. For example, a tennis racket, dish-drying rack, and spider’s web are structures that are only frames. Umbrellas, cars, and bats’ wings consist of a frame covered by some sort of material.

Shell Structures

Most strong, hollow structures are shell structures. Have you ever been inside an igloo or looked up into a domed roof? Have you poured milk out of a carton into a glass or blown up a balloon? If so, you have seen a shell structure (Figure 4.11).

Since shell structures have space inside them, they often make good containers. They also use very little material in their construction. This means that they are quite light for their size. Clothing can even be considered shell structures.

Designers consider the form and the function of a structure and the forces that act on it.
Combination Structures

Many structures are combination structures because they are combinations of shell, frame, and solid structures. For example, Figure 4.12 shows how a house is built from solid structures — bricks, nails, and pieces of wood called boards. The boards are nailed together into a frame that gives the building strength. **Strength** is the ability of an object to withstand forces. Both the walls and the roof are now frame structures.

When the frame is finished, the wall and roof frames are covered with plywood. Windows and doors are placed into holes cut in the plywood.

The builder now covers the outside wall with bricks or siding, and the roof with shingles. These keep the house dry when it rains.

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**Figure 4.12** A house is built from solid structures that are put together to form a frame. The walls and the roof form a covering around the frame.
Structures that have the same function may have very different forms. For example, every chair is designed to support the weight of a person sitting on it (Figures 4.13, 4.14, and 4.15). In this lab, you will build different forms of chairs and test their strength.

**Purpose**
To build structures to illustrate solid, frame, and shell structures

**Materials & Equipment**
- toothpicks
- modelling clay

**Procedure**
1. Sketch three chairs: one that can be classified as a solid structure, one as a frame structure, and one as a shell structure.
2. Build a model of each chair with toothpicks and modelling clay. Try to build the chairs approximately the same size.
3. Think of a different structure and repeat steps 1 and 2 for the structure of your choice.
4. As a class, design a way to test the ability of each chair to support weight.

**Questions**
5. What did you notice about the use of materials when you built solid structures, frame structures, and shell structures?
6. Which type of structure was best able to support weight?
7. What generalizations can you make about solid, frame, and shell structures?
B8 Quick Lab

Unpacking the Packaging

Packaging is a structure that you encounter every day. It is used to protect other structures during transport. Packaging also displays the product in the store. Something as simple as a bar of soap (a solid structure) may come in a cardboard box (shell structure) that might be wrapped in plastic (another shell structure).

In this activity, you will study packaging as structures. When choosing your packaging, select a wide variety of products, such as food, school supplies, and electronics.

Purpose
To study the structures involved in packaging

Materials & Equipment
- all of the packaging associated with several recent purchases
- pencil and paper
- kitchen or bathroom scale

Procedure
1. You will look at all of the packaging that came with several different products. Keep the sets of packaging separate.
2. Take one set of packaging. What did it contain? Examine the packaging material. Describe the packaging qualitatively, in a chart like the one in Table 4.1. A qualitative description is a description just in words (e.g., describing the colour, the texture, the shape).
3. Describe the amount of packaging quantitatively by weighing it or finding its volume. A quantitative description is one that uses measurements to describe something (e.g., length, weight).

Table 4.1 Unpacking the Packaging Recording Chart

<table>
<thead>
<tr>
<th>Product</th>
<th>Qualitative Description</th>
<th>Amount of Material</th>
<th>Type(s) of Material</th>
</tr>
</thead>
</table>

4. Repeat the process for three more different items.

Questions
5. Compare your chart with those of your classmates. Do you agree with the way your classmates described the various packages?
6. What structures came with the most packaging? What structures came with the least? What structures do you buy that have no packaging?
7. Compare the weight or volume of each structure with the weight or volume of the packaging it came in. Do you notice any trends?
8. Do you think the packaging did its job?
9. Do you think each piece of packaging was necessary?
Key Concept Review

1. Define “structure” in your own words. Describe three ways in which you can classify structures.

2. Classify the following structures as a solid structure, a frame structure, or a shell structure.
   (a) a three-ring binder   (d) a basketball net
   (b) a tent                (e) an ice skate
   (c) a backpack           (f) a sand castle

Connect Your Understanding

3. Make a chart with four columns. In the first column, list five structures used in either a soccer or a basketball game.
   (a) In Column 2, classify each structure as solid, frame, or shell.
   (b) In Column 3, describe the form of each structure.
   (c) In Column 4, state the function of each structure.

4. Sometimes transporting structures exposes them to forces that they would not encounter during normal use.
   (a) List different ways that you have seen structures protected for shipping.
   (b) Describe one way that you feel is effective.
   (c) Describe one way that you feel is not.
   (d) What do you do with packaging materials after you unpack a structure?

5. Do you think a designer should begin work with form in mind or with function in mind? Give reasons for your thinking.

Practise Your Skills

6. Think of a structure that can be classified as both a frame structure and a shell structure. Draw a simple diagram to help you explain why the structure can be classified in both ways.

For more questions, go to ScienceSource.

Thinking about Science and Technology

Structures in Your Lunchbox

What to Do

1. Think about a packed lunch and the structures used to hold each item. What types of structure are they?

Consider This

With a classmate or as a whole class, discuss the following questions.

2. Are structures used to hold food usually shell structures, frame structures, or solid structures? Why do you think that is?

3. What materials are the structures that hold your lunch made from? Can they be reused or are they disposable?

4. How might the choices of structures we use to hold food affect the environment?

5. Which is more of a challenge to transport: solid food or liquid food? Why?