Cell Similarities

Cells come in many different shapes and sizes and perform a wide variety of functions, but they all have the following things in common:

Figure 13 *The cell membrane holds the contents of the cell together.*

Cell Membrane All cells are surrounded by a **cell membrane.** This membrane acts as a barrier between the inside of the cell and the cell's environment. It also controls the passage of materials into and out of the cell. **Figure 13** shows the outside of a cell.

Hereditary Material Part of the cell theory states that all cells are made from existing cells. When new cells are made, they receive a copy of the hereditary material of the original cells. This material is *DNA* (deoxyribonucleic acid). It controls all of the activities of a cell and contains the information needed for that cell to make new cells.

Cytoplasm and Organelles All cells have chemicals and structures that enable the cell to live, grow, and reproduce. The structures are called **organelles.** Although all cells have organelles, they don't all have the same kind. Some organelles are surrounded by membranes, but others are not. The cell in **Figure 14** has membrane-covered organelles. The chemicals and structures of a cell are surrounded by fluid. This fluid and almost everything in it are collectively called the **cytoplasm** (SIET oh PLAZ uhm).

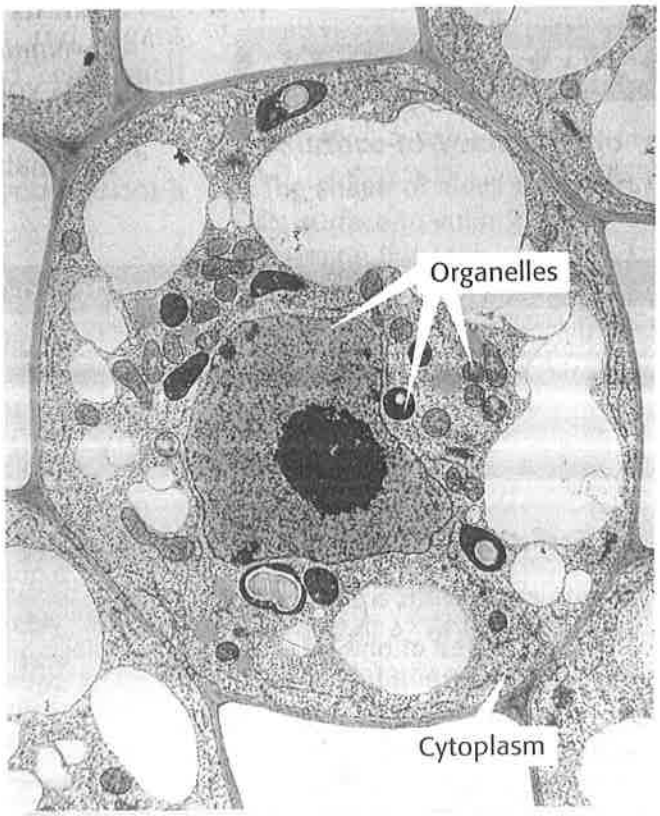


Figure 14 *This cell has many organelles. These organelles are surrounded by membranes.*

Small Size Almost all cells are too small to be seen with the naked eye. You are made up of 100 trillion cells, and it would take 50 of these cells just to cover up the dot on the letter *i*.

Self-Check

Why do all cells need DNA? *(See page 782 to check your answer.)*

Self-Check

1. As a cell grows larger, what happens to its surface-to-volume ratio?
2. What does a eukaryotic cell have that a prokaryotic cell does not?

(See page 782 to check your answer.)

Quick Lab

Do Bacteria Taste Good?

If they're the kind found in yogurt, they taste great! Using a **cotton swab,** put a small dot of **yogurt** on a **plastic microscope slide.** Add a drop of **water,** and use the cotton swab to stir. Add a **plastic coverslip,** and examine the slide using a **microscope.** Draw what you see.

The masses of rod-shaped bacteria feed on the sugar in milk (lactose) and convert it into lactic acid. Lactic acid causes milk to thicken, which makes yogurt!

Two Types of Cells

The many different kinds of cells that exist can be divided into two groups. As you have already learned, all cells have DNA. In one group, cells have a **nucleus,** which is a membrane-covered organelle that holds the cells' DNA. In the other group, the cells' DNA is not contained in a nucleus. Cells that do not have a nucleus are **prokaryotic** (proh KAR ee AH tik), and cells that have a nucleus are **eukaryotic** (yoo KAR ee AH tik).

Prokaryotic Cells Prokaryotic cells are also called **bacteria.** They are the world's smallest cells, and they do not have a nucleus. A prokaryotic cell's DNA is one long, circular molecule shaped sort of like a rubber band.

Bacteria do not have any membrane-covered organelles, but they do have tiny, round organelles called *ribosomes.* These organelles work like little factories to make proteins.

Most bacteria are covered by a hard cell wall outside a softer cell membrane. Think of the membrane pressing against the wall as an inflated balloon pressing against the inside of a glass jar. But unlike the balloon and jar, the membrane and the wall allow food and waste molecules to pass through. **Figure 16** shows a generalized view of a prokaryotic cell.

Bacteria were probably the first type of cells on Earth. The oldest fossils ever found are of prokaryotic cells. Scientists have estimated these fossils to be 3.5 billion years old.

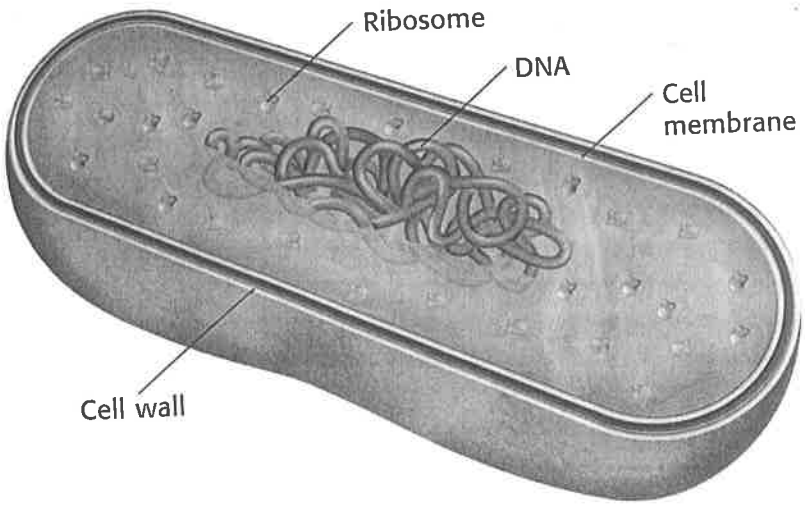


Figure 16 *Prokaryotic cells do not have a nucleus or any other membrane-covered organelles. The circular DNA is bunched up in the cytoplasm.*

Eukaryotic Cells Eukaryotic cells are more complex than prokaryotic cells. Although most eukaryotic cells are about 10 times larger than prokaryotic cells, they still have a high enough surface-to-volume ratio to survive. Fossil evidence suggests that eukaryotic cells first appeared about 2 billion years ago. All living things that are not bacteria are made of one or more eukaryotic cells. This includes plants, animals, fungi, and protists.

Eukaryotic cells have a nucleus and many other membrane-covered organelles. An advantage of having the cell divided into compartments is that it allows many different chemical processes to occur at the same time. A generalized eukaryotic cell is shown in **Figure 17.**

There is more DNA in eukaryotic cells than in prokaryotic cells, and it is stored in the nucleus. Instead of being circular, the DNA molecules in eukaryotic cells are linear.

All eukaryotic cells have a cell membrane, and some of them have a cell wall. Those that have cell walls are found in plants, fungi, and some unicellular organisms. The tables below summarize the differences between eukaryotic and prokaryotic cells.

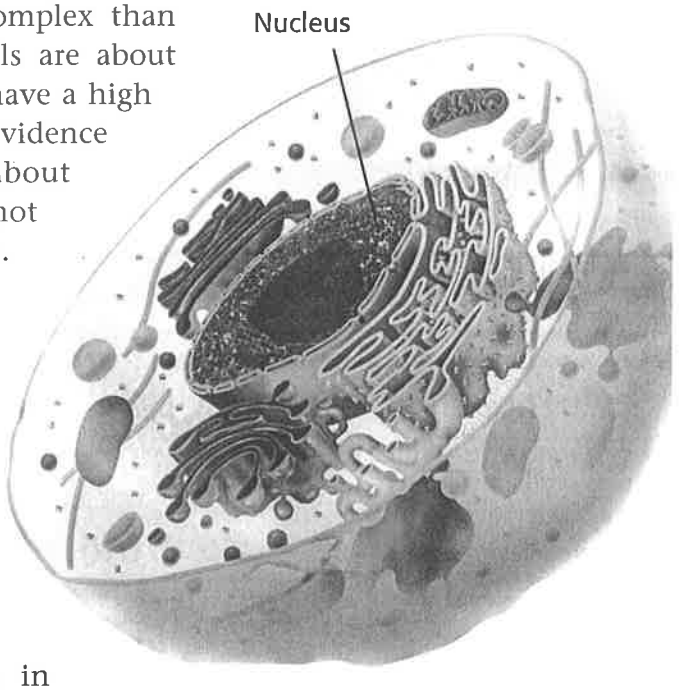


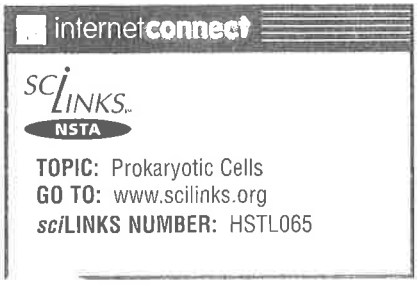
Figure 17 *Eukaryotic cells contain a nucleus and many other organelles.*

Prokaryotic Cells	Eukaryotic Cells
No nucleus	Nucleus
No membrane-covered organelles	Membrane-covered organelles
Circular DNA	Linear DNA
Bacteria	All other cells

A new way to cure sick cells? See page 80.

REVIEW

1. What are the three parts of the cell theory?
2. What do all cells have in common?
3. What are two advantages of being multicellular?
4. If a unicellular organism has a cell wall, ribosomes, and circular DNA, is it eukaryotic or prokaryotic?
5. **Applying Concepts** Which has the greater surface-to-volume ratio, a tennis ball or a basketball? Explain your answer. What could be done to increase the surface-to-volume ratio of both?



Section 3

Eukaryotic Cells: The Inside Story

Terms to Learn

cell wall
ribosome
endoplasmic reticulum
mitochondria
chloroplast
Golgi complex
vesicle
vacuole
lysosome

What You'll Do

- Explain the function of each part of a eukaryotic cell.
- Describe the differences between animal cells and plant cells.

For a long time after the discovery of cells, scientists did not really know what cells were made of. Cells are so small that the details of their structure could not be seen until better methods of magnifying and staining were developed. We now know that cells are very complex, especially eukaryotic cells. Everything, from the structures covering the cells to the organelles inside them, performs a task that helps to keep the cells alive.

Holding It All Together

All cells have outer coverings that separate what is inside the cell from what is outside. One kind of covering, called the cell membrane, surrounds all cells. Some cells have an additional layer outside the cell membrane called the cell wall.

Cell Membrane All cells are covered by a cell membrane. The job of the cell membrane is to keep the cytoplasm inside, to allow nutrients in and waste products out, and to interact with things outside the cell. In **Figure 18,** you can see a close-up view of the cell membrane of a cell that has had its top half cut away.

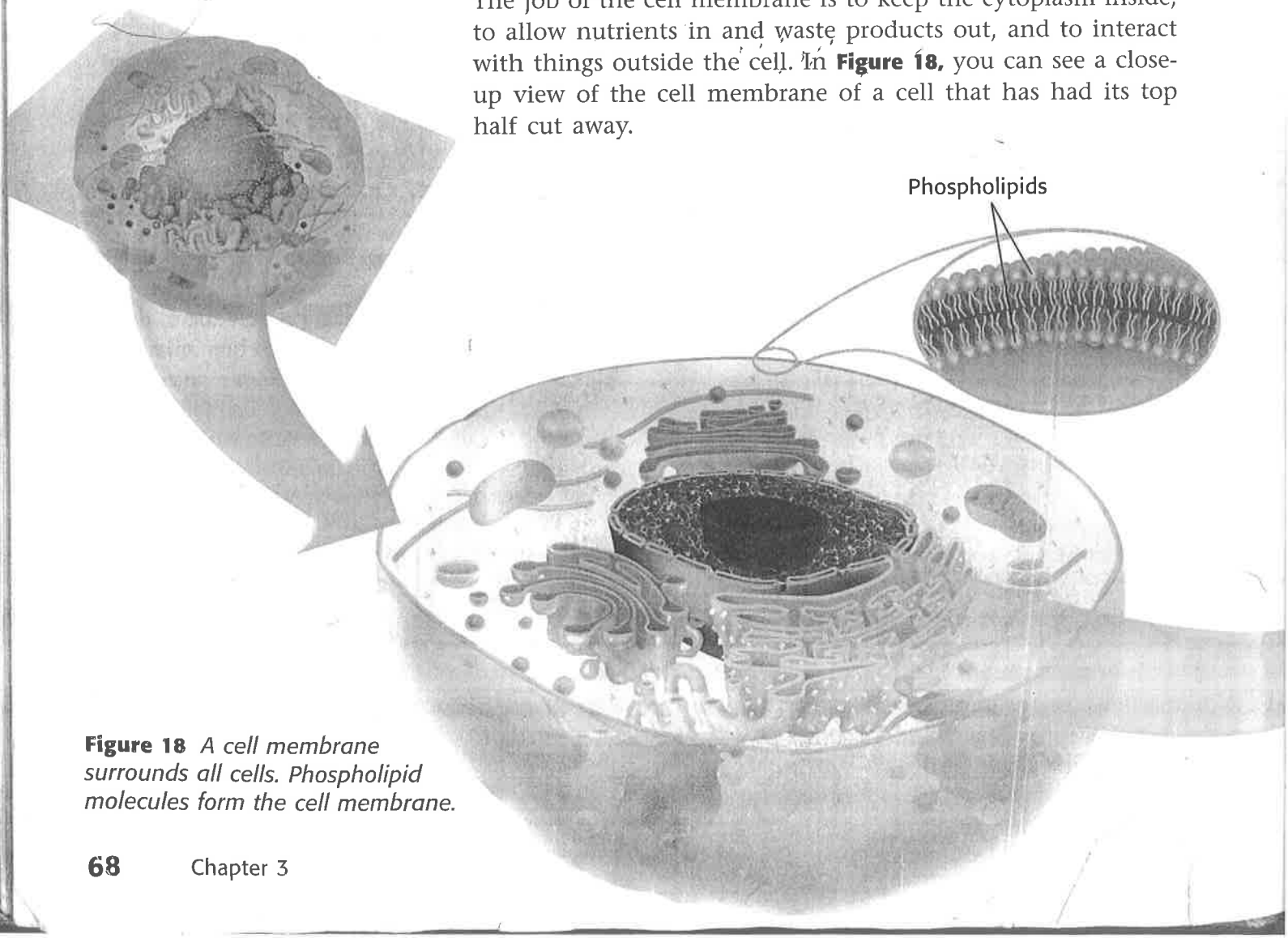


Figure 18 *A cell membrane surrounds all cells. Phospholipid molecules form the cell membrane.*

Cell Wall The cells of plants and algae have a hard cell wall made of cellulose. The **cell wall** provides strength and support to the cell membrane. When too much water enters or leaves a plant cell, the cell wall can prevent the membrane from tearing. The strength of billions of cell walls in plants enables a tree to stand tall and its limbs to defy gravity. When you are looking at dried hay, sticks, and wooden boards, you are seeing the cell walls of dead plant cells. The cells of fungi, such as mushrooms, toadstools, mold, and yeasts, have cell walls made of a chemical similar to that found in the hard covering of insects. **Figure 19** shows a cross section of a generalized plant cell and a close-up view of the cell wall.

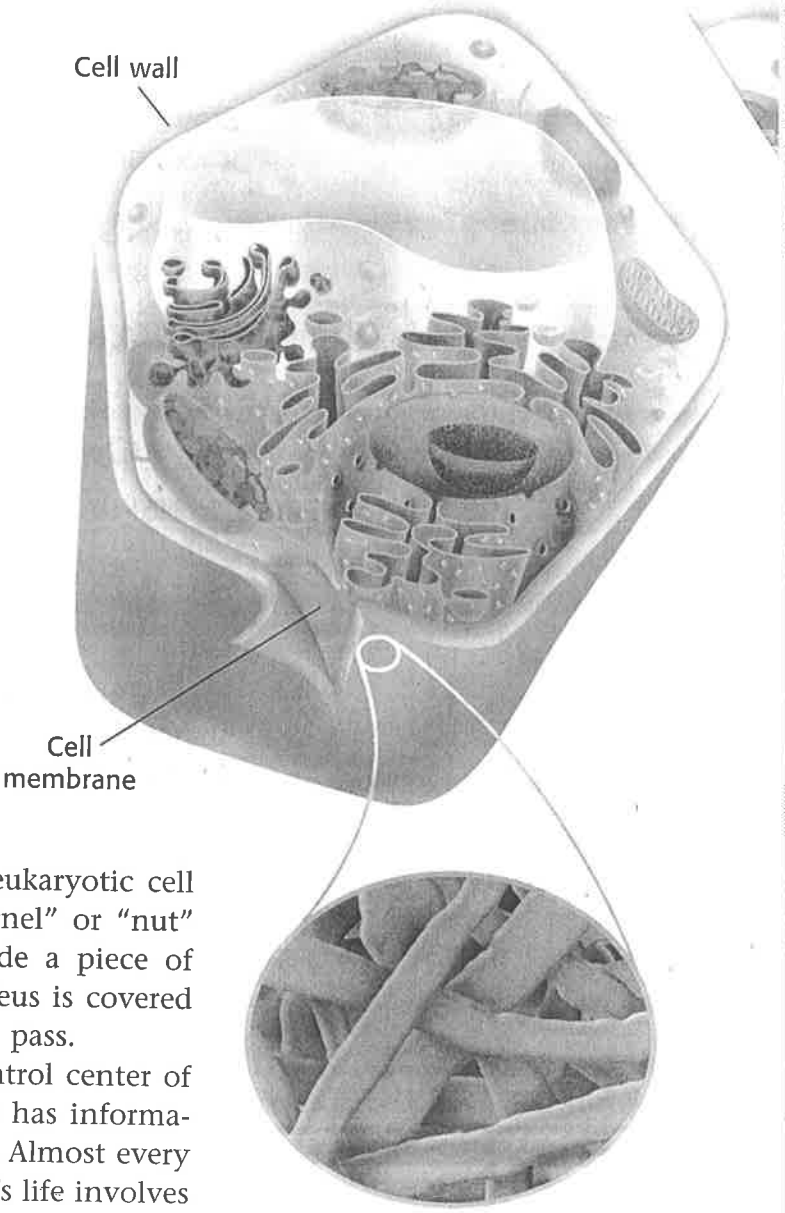


Figure 19 *The cell wall surrounds the cell membrane. In plant cells, the cell wall is made of cellulose fibers.*

The Cell's Library

The largest and most visible organelle in a eukaryotic cell is the nucleus. The word *nucleus* means "kernel" or "nut" (maybe it does look sort of like a nut inside a piece of candy). As you can see in **Figure 20,** the nucleus is covered by a membrane through which materials can pass.

The nucleus has often been called the control center of the cell. As you know, it stores the DNA that has information on how to make all of the cell's proteins. Almost every chemical reaction that is important to the cell's life involves some kind of protein. Sometimes a dark spot can be seen inside the nucleus. This spot is called a *nucleolus,* and it looks like a small nucleus inside the big nucleus. The nucleolus stores the materials that will be used later to make ribosomes in the cytoplasm.

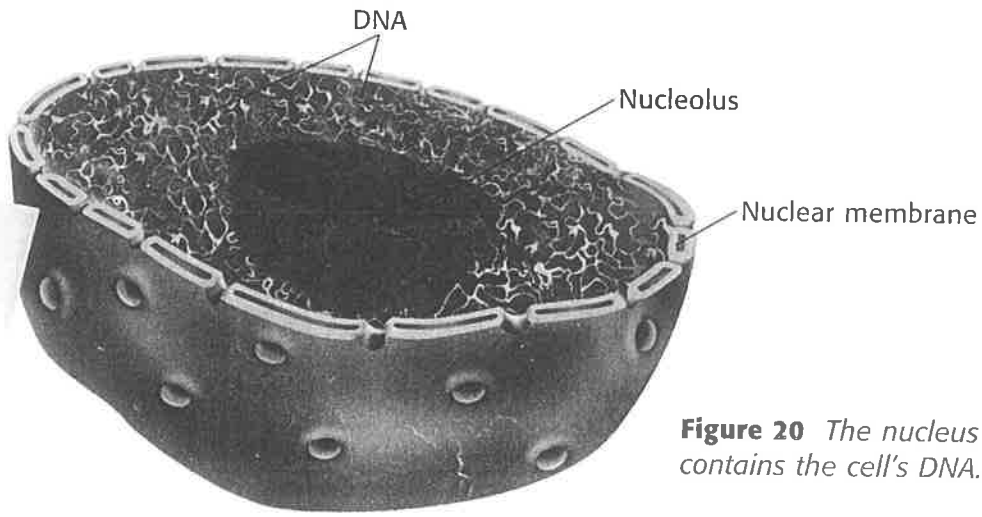


Figure 20 *The nucleus contains the cell's DNA.*

The Cell's Power Plants

In today's world, we use many sources of energy, such as oil, gas, and nuclear power. We need this energy to heat our homes, fuel our cars, and cook our food. Cells also need energy to function. Where do they get it?

Mitochondria Inside all cells, food molecules are "burned" (broken down) to release energy. The energy is transferred to a special molecule that the cell uses to get work done. As you learned earlier, this molecule is called ATP.

ATP can be made at several locations in eukaryotic cells, but most of it is produced at bean-shaped organelles called **mitochondria** (MIET oh KAHN dree uh), shown in **Figure 22.** These organelles are surrounded by two membranes. The inner membrane, which has many folds in it, is where most of the ATP is made.

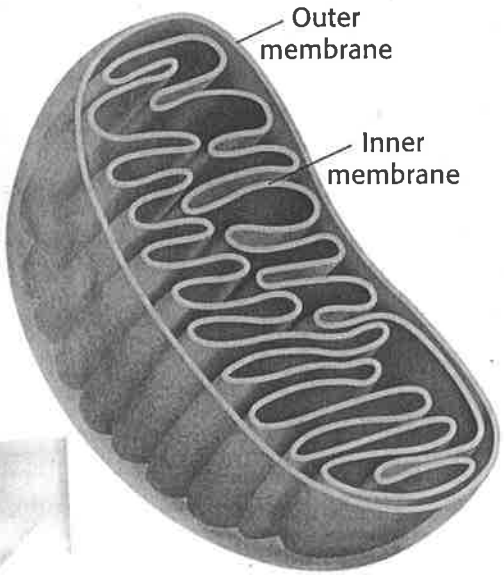


Figure 22 *Mitochondria have two membranes. The inner membrane has many folds.*

Mitochondria can work only if they have oxygen. The reason you breathe air is to make sure your mitochondria have the oxygen they need to make ATP. Highly active cells, such as those in the heart and liver, may have thousands of mitochondria, while other cells may have only a few.

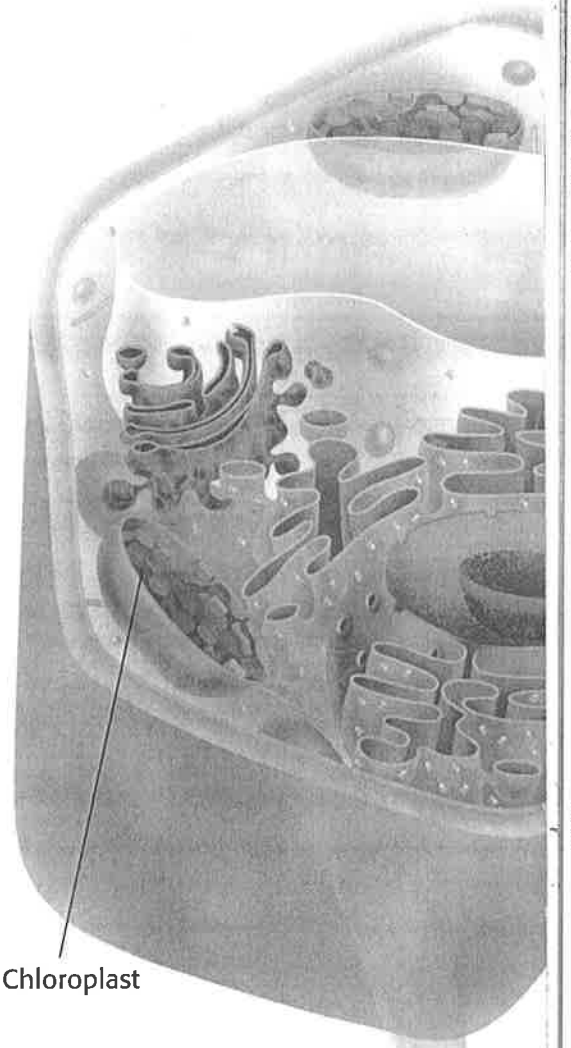
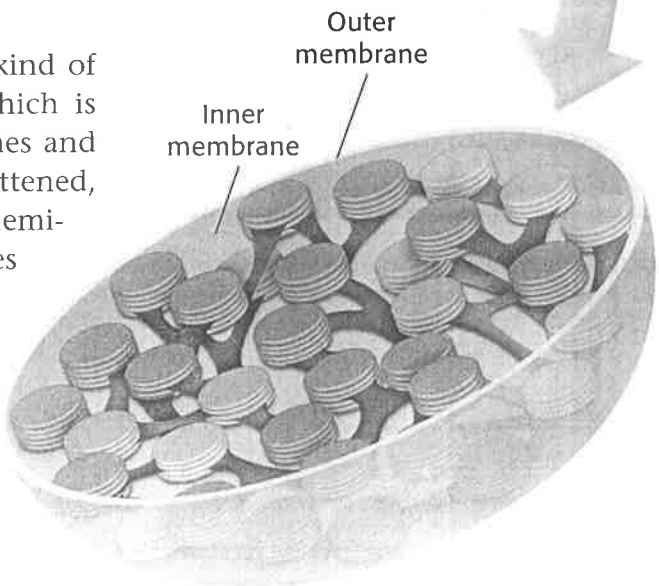


Figure 23 *Chloroplasts, found in plant cells, also have two membranes. The inner membrane forms stacks of flattened sacs.*

Chloroplasts Plants and algae have an additional kind of energy-converting organelle, called a **chloroplast,** which is shown in **Figure 23.** Chloroplasts have two membranes and structures that look like stacks of coins. These are flattened, membrane-covered sacs that contain an important chemical called chlorophyll. Chlorophyll is what makes chloroplasts green. The energy of sunlight is trapped by chlorophyll and used to make sugar. This process is called *photosynthesis*. The sugar that is produced is used by mitochondria to make ATP. You will learn more about photosynthesis in a later chapter.



The Cell's Storage Centers

All eukaryotic cells have membrane-covered compartments called **vesicles.** Some of them form when part of the membrane pinches off the ER or Golgi complex. Others are formed when part of the cell membrane surrounds an object outside the cell. This is how white blood cells engulf other cells in your body, as shown in **Figure 26.**

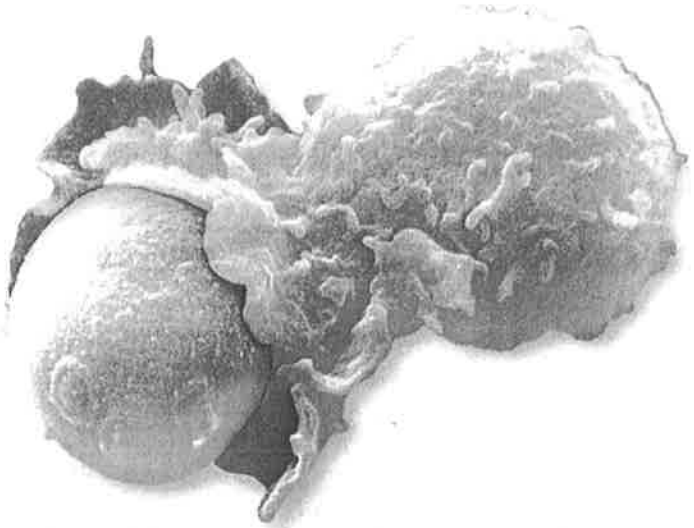


Figure 26 *The smaller cell is a yeast cell that is being engulfed by a white blood cell.*

Vacuoles Most plant cells have a very large membrane-covered chamber called a **vacuole,** as shown in **Figure 27.** Vacuoles store water and other liquids. Vacuoles that are full of water help support the cell. Some plants wilt when their cell vacuoles lose water. If you want crispy lettuce for a salad, all you need to do is fill up the vacuoles by leaving the lettuce in water overnight. Have you ever wondered what makes roses red and violets blue? It is a colorful liquid stored inside vacuoles. Vacuoles also contain the juices you associate with oranges and other fruits.

Some unicellular organisms that live in freshwater environments have a problem with too much water entering the cell. They have a special structure called a contractile vacuole that can squeeze excess water out of the cell. It works in much the same way that a pump removes water from inside a boat.

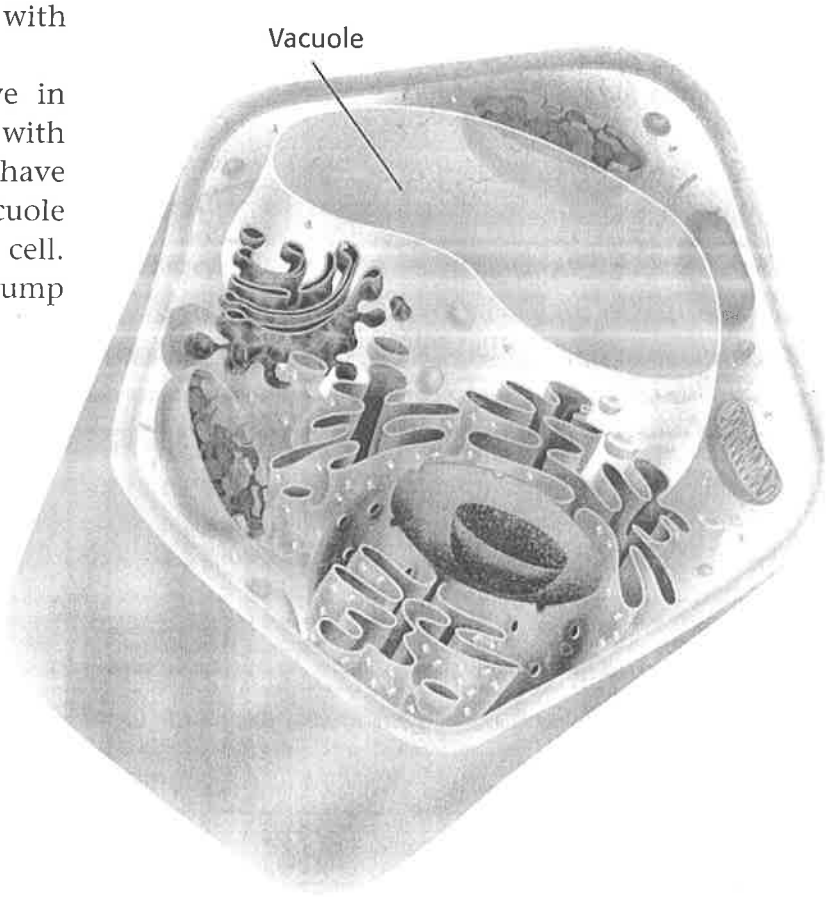


Figure 27 *This plant cell's vacuole is the large structure in the middle of the cell shown in blue. Vacuoles are usually the largest organelles in a plant cell.*

Plant or Animal?

How can you tell the difference between a plant cell and an animal cell? They both have a cell membrane, and they both have nuclei, ribosomes, mitochondria, endoplasmic reticula, Golgi complexes, and lysosomes. But plant cells have things that animal cells do not have: a cell wall, chloroplasts, and a large vacuole. You can see the differences between plant and animal cells in **Figure 29.**

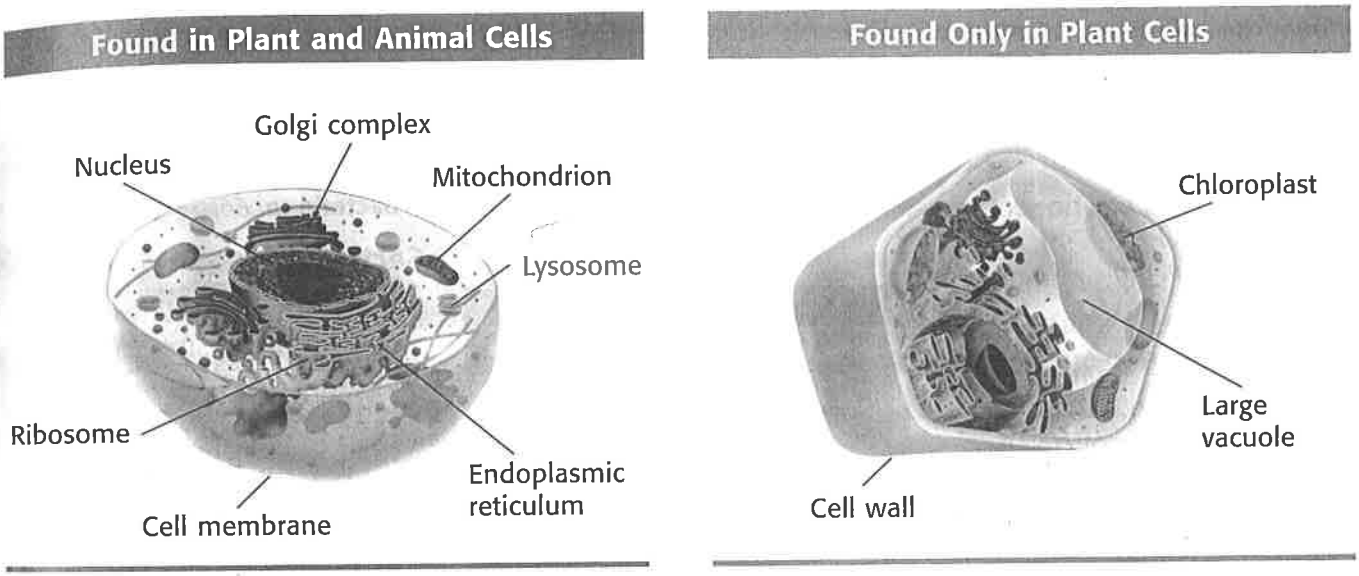


Figure 29 *Animal and plant cells have some structures in common, but they also have some that are unique.*

REVIEW

1. How does the nucleus control the cell's activities?
2. Which of the following would not be found in an animal cell: mitochondria, cell wall, chloroplast, ribosome, endoplasmic reticulum, Golgi complex, large vacuole, DNA, chlorophyll?
3. Use the following words in a sentence: oxygen, ATP, breathing, and mitochondria.
4. **Applying Concepts** You have the job of giving new names to different things in a city. The new names have to be parts of a eukaryotic cell. Write down some things you would see in a city. Assign the name of a cell part that is most appropriate to their function. Explain your choices.