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Bio_Unit1_CellBio

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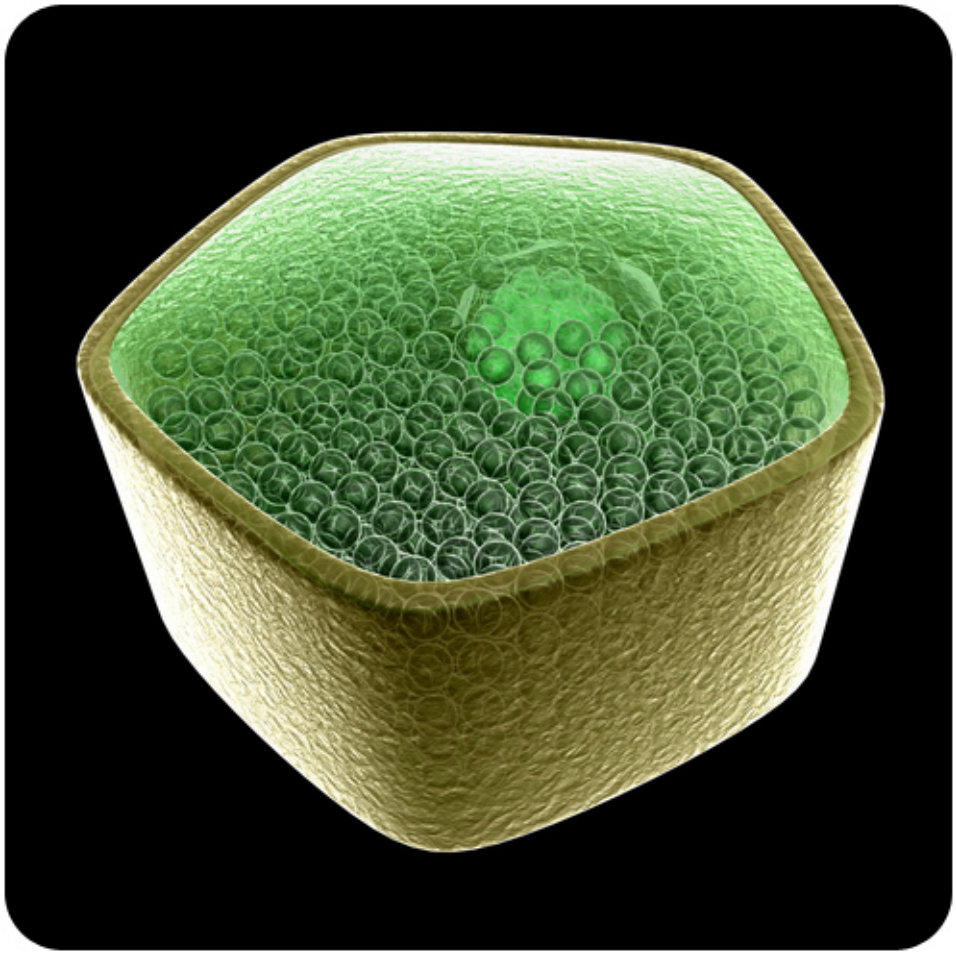
Contents

CHAPTER 1

Plant Cell Structures

- List special structures of plant cells, and state what they do.



What do plants have to do that animals don't?

Many plant cells are green. Why? Plant cells also usually have a distinct shape. The rigid exterior around the cells is necessary to allow the plants to grow upright. Animal cells do not have these rigid exteriors. There are other distinct differences between plant and animal cells. These will be the focus of this concept.

Plant Cells

Special Structures in Plant Cells

Most organelles are common to both animal and plant cells. However, plant cells also have features that animal cells do not have: a cell wall, a large central vacuole, and plastids such as chloroplasts.

Plants have very different lifestyles from animals, and these differences are apparent when you examine the structure of the plant cell. Plants make their own food in a process called **photosynthesis**. They take in carbon dioxide (CO_2) and water (H_2O) and convert them into sugars. The features unique to plant cells can be seen in **Figure** 1.1.

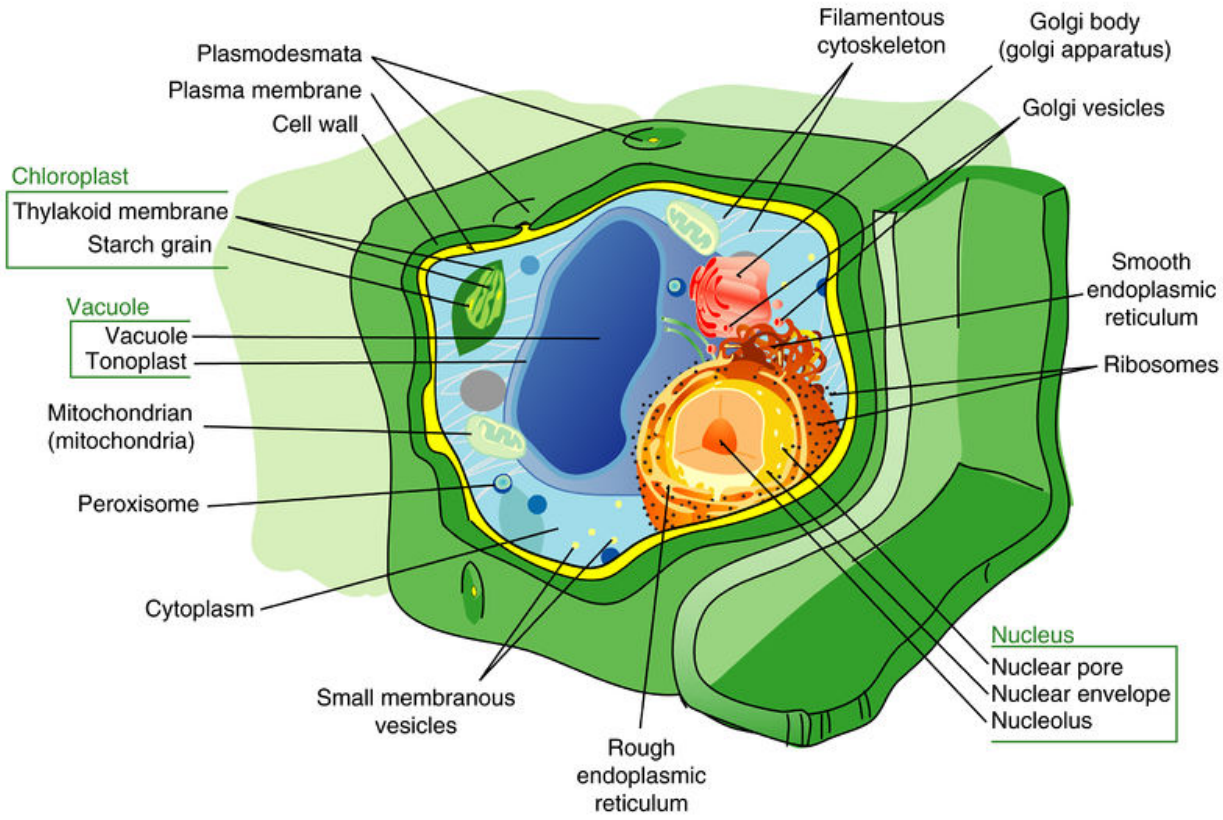


FIGURE 1.1

In addition to containing most of the organelles found in animal cells, plant cells also have a cell wall, a large central vacuole, and plastids. These three features are not found in animal cells.

The Cell Wall

A **cell wall** is a rigid layer that is found outside the cell membrane and surrounds the ce ll. The cell wall contains not only cellulose and protein, but other polysaccharides as well. The cell wall provides structural support and protection . Pores in the cell wall allow water and nutrients to move into and out of the cell. The cell wall also prevents the plant cell from bursting when water enters the cell.

Plastids

Plant **plastids** are a group of closely related membrane-bound organelles that carry out many functions.

- **One Example : Chloroplasts** are the organelle of photosynthesis. They capture light energy from the sun and use it with water and carbon dioxide to make food (sugar) for the plant. The arrangement of chloroplasts in a plant#8217;s cells can be seen in **Figure** 1.2

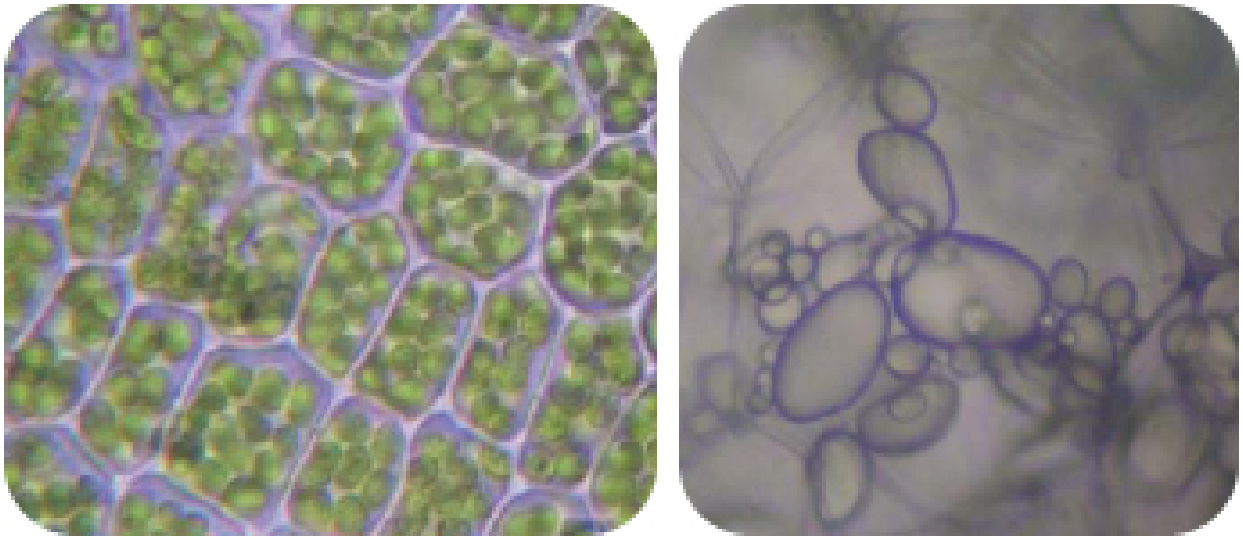


FIGURE 1.2

Plant cells with visible chloroplasts (left). Starch-storing potato leucoplasts (right).

Chloroplasts

Chloroplasts capture light energy from the sun and use it with water and carbon dioxide to produce sugars for food. Chloroplasts look like flat discs and are usually 2 to 10 micrometers in diameter and 1 micrometer thick. A model of a chloroplast is shown in **Figure** 1.3. The chloroplast is enclosed by an inner and an outer phospholipid membrane. Between these two layers is the intermembrane space. The fluid within the chloroplast is called the **stroma**, and it contains one or more molecules of small, circular DNA. The stroma also has ribosomes. Within the stroma are stacks of **thylakoids**, sub-organelles that are the site of photosynthesis. The thylakoids are arranged in stacks called **grana** (singular: granum). A thylakoid has a flattened disk shape. Inside it is an empty area called the thylakoid space or lumen. Photosynthesis takes place on the thylakoid membrane.

Vocabulary

- **cell wall**: Rigid layer that surrounds the plasma membrane of a plant cell; helps support and protect the cell; also characteristic of many prokaryotes.
- **central vacuole**: Large saclike organelle in plant cells; stores substances such as water; helps keep plant tissues rigid.
- **chloroplast**: Organelle in the cells of plants and algae; site of photosynthesis.
- **chromoplast**: Plastid that makes and stores pigments.
- **grana** (singular: **granum**): Stacks of thylakoid membranes within the chloroplast.
- **leucoplast**: Plastid used for bulk storage of starch, lipid, or protein; also makes molecules such as fatty acids and many amino acids.
- **photosynthesis**: Process of using the energy in sunlight to make food (glucose).
- **plastids**: A group of closely related membrane-bound plant cell organelles; includes chloroplasts, chromoplasts and leucoplasts.
- **stroma**: Space outside the thylakoid membranes of a chloroplast; site of the Calvin cycle of photosynthesis.

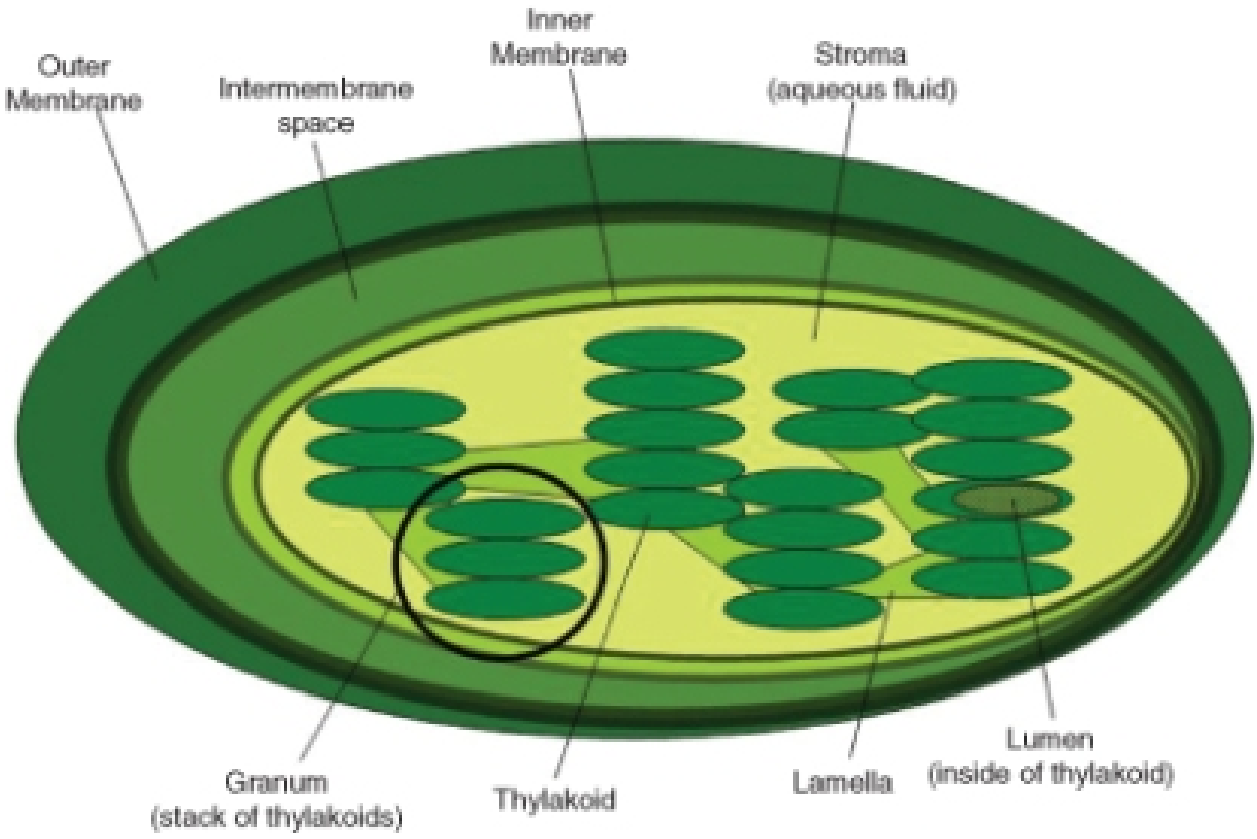


FIGURE 1.3

The internal structure of a chloroplast, with a granal stack of thylakoids circled.

- **thylakoid**: Sub-organelle within the chloroplast; site of photosynthesis.
- **tonoplast**: Membrane that surrounds the central vacuole.

Summary

- Plant cells have a cell wall, a large central vacuole, and plastids such as chloroplasts.
- The cell wall is a rigid layer that is found outside the cell membrane and surrounds the cell, providing structural support and protection.
- The central vacuole maintains turgor pressure against the cell wall.
- Chloroplasts capture light energy from the sun and use it with water and carbon dioxide to produce sugars for food.

Practice I

Use this resource to answer the questions that follow.

- http://www.hippocampus.org/Biology → Biology for AP* → Search: **Prokaryotes and Eukaryotes**

1. List the three distinguishing features of a plant cell. Describe their roles.
2. In addition to plants, what other organisms have chloroplasts?
3. How is the vacuole related to plant death?

Practice II

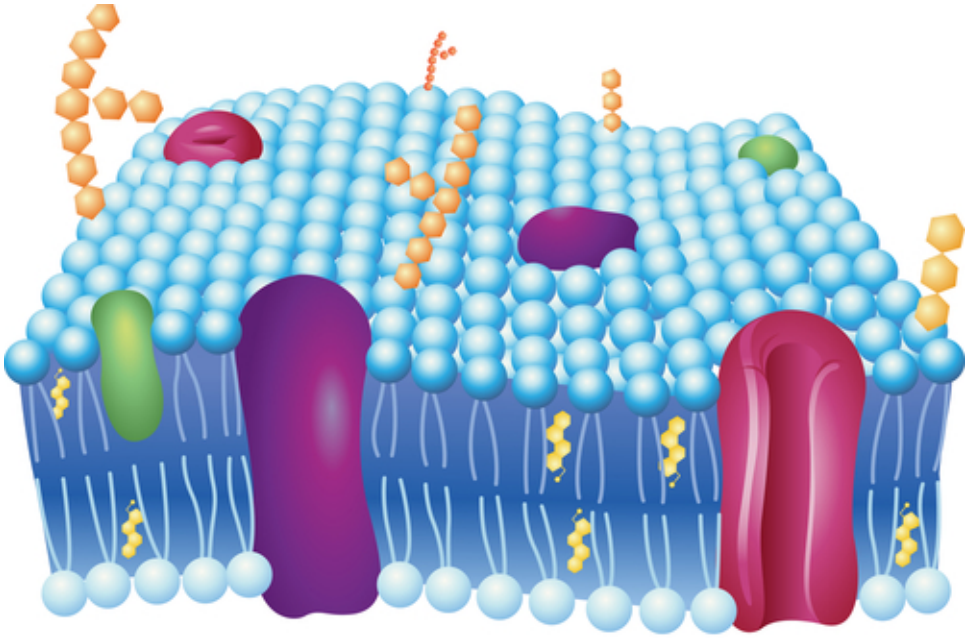
- **Label the Diagram of Plant Cell** at http://www.neok12.com/diagram/Cell-Structures-01.htm.
- **Plant vs. Animal Cells** at http://www.neok12.com/quiz/CELSTR08.
- **Eucaryotic Cell Interactive Animation: Plant Cell** at http://www.cellsalive.com/cells/cell_model.htm.

Review

1. List three structures that are found in plant cells but not in animal cells.
2. Identify two functions of plastids in plant cells.
3. What is the role of the cell wall?

CHAPTER 2 Cell Membrane - Phospholipid Bilayers

- Describe the structure and function of the plasma membrane.



All cells have a plasma membrane. This membrane surrounds the cell. So what is its role?

Can molecules enter and leave the cell? Yes. Can anything or everything enter or leave? No. So, what determines what can go in or out? Is it the nucleus? The DNA? Or the plasma membrane?

The Plasma Membrane

The **plasma membrane** (also known as the **cell membrane**) forms a barrier between the cytoplasm inside the cell and the environment outside the cell. It protects and supports the cell and also controls everything that enters and leaves the cell. It allows only certain substances to pass through, while keeping others in or out.

The ability to allow only certain molecules in or out of the cell is referred to as selective permeability or **semipermeability**.

To understand how the plasma membrane controls what crosses into or out of the cell, you need to know its composition.

The plasma membrane is discussed at http://www.youtube.com/watch?v=-aSfoB8Cmic (6:16).

A Phospholipid Bilayer

The plasma membrane is composed mainly of phospholipids, which consist of fatty acids and alcohol. The phospholipids in the plasma membrane are arranged in two layers, called a **phospholipid bilayer**.

As shown in **Figure** 2.1, each phospholipid molecule has a head and two tails. The head #8220;loves#8221; water (**hydrophilic**) and the tails #8220;hate#8221; water (**hydrophobic**). The water-hating tails are on the interior of the

membrane, whereas the water-loving heads point outwards, toward either the cytoplasm or the fluid that surrounds the cell. Molecules that are hydrophobic can easily pass through the plasma membrane, if they are small enough, because they are water-hating like the interior of the membrane. Molecules that are hydrophilic, on the other hand, cannot pass through the plasma membrane#8212;at least not without help#8212;because they are water-loving like the exterior of the membrane.

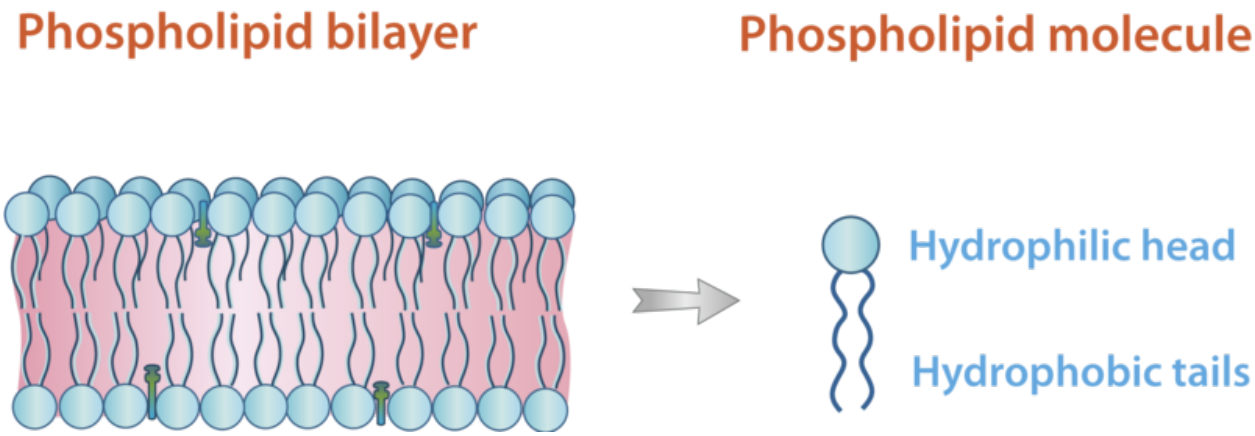


FIGURE 2.1

Phospholipid Bilayer. The phospholipid bilayer consists of two layers of phospholipids (left), with a hydrophobic, or water-hating, interior and a hydrophilic, or water-loving, exterior. A single phospholipid molecule is depicted on the right.

Vocabulary

- **cell membrane**: Barrier between the cytoplasm and the environment outside the cell; also known as the plasma membrane.
- **hydrophilic**: Characteristic of the phospholipid head group; water-loving.
- **hydrophobic**: Characteristic of the phospholipid tails; water-hating.
- **phospholipid bilayer**: Double layer of phospholipid molecules that makes up a plasma membrane
- **plasma membrane**: Thin coat of lipids (phospholipids) that surrounds and encloses a cell; also known as the cell membrane.
- **semipermeability**: The ability to allow only certain molecules to cross the plasma membrane; selective permeability.

Summary

- The plasma membrane forms a barrier between the cytoplasm and the environment outside the cell. The plasma membrane has selective permeability.
- The plasma membrane is primarily composed of phospholipids arranged in a bilayer, with the hydrophobic tails on the interior of the membrane, and the hydrophilic heads pointing outwards.

Practice

Use these resources to answer the questions that follow.

- **Construction of the Cell Membrane** at http://www.wisc-online.com/Objects/ViewObject.aspx?ID=AP1101 .

1. What are the two main components of the cell membrane?
2. Describe the types of proteins that live in the cell membrane.
3. Describe the orientation of the phospholipid molecule in the cell membrane.

- **Cell Membranes** at http://johnkyrk.com/cellmembrane.html.

1. Are *all* cells surrounded by a membrane?
2. Why are phospholipids considered an amphipathic molecule?
3. What is a glycolipid?
4. Describe the role of cholesterol in the cell membrane.

- http://www.hippocampus.org/Biology → Non-Majors Biology → Search: **Plasma Membrane Structure**

1. What are the roles of the plasma membrane?
2. What is the difference between hydrophilic and hydrophobic?
3. What are the functions of proteins associated with the cell membrane?
4. Why is the structure of the cell membrane described as "fluid mosaic"?

Review

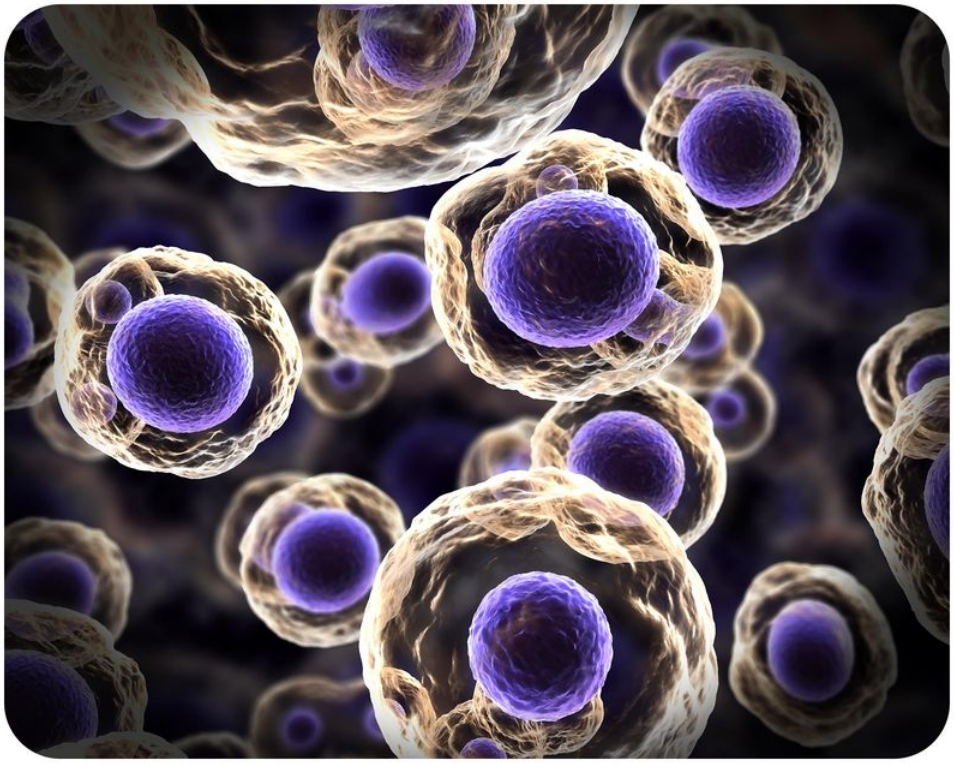
1. Describe the role of the plasma membrane.

2. Describe the composition of the plasma membrane.

3. Explain why hydrophobic (#8220;water-hating#8221;) molecules can easily cross the plasma membrane, while hydrophilic (#8220;water-loving#8221;) molecules cannot.

CHAPTER 3 Cell Nucleus

- Outline the form and function of the nucleus.



Where does the DNA live?

The answer depends on if the cell is prokaryotic or eukaryotic. The main difference between the two types of cells is the presence of a nucleus. And in eukaryotic cells, DNA lives in the nucleus.

The Nucleus

The **nucleus** is a membrane-enclosed organelle found in most eukaryotic cells. The nucleus is the largest organelle in the cell and contains most of the cell's genetic information (mitochondria also contain DNA, called mitochondrial DNA, but it makes up just a small percentage of the cell#8217;s overall DNA content). The genetic information, which contains the information for the structure and function of the organis encoded in DNA in the form of genes.

A **gene** is a short segment of DNA that contains information to encode an RNA molecule or a protein strand. DNA in the nucleus is organized in long linear strands that are attached to different proteins. These proteins help the DNA coil up for better storage in the nucleus. Think how a string gets tightly coiled up if you twist one end while holding the other end. These long strands of coiled-up DNA and proteins are called **chromosomes.** Each chromosome contains many genes. The function of the nucleus is to maintain the integrity of these genes and to control the activities of the cell by regulating gene expression. **Gene expression** is the process by which the information in a gene is "decoded" by various cell molecules to produce a functional gene product, such as a protein molecule or an RNA molecule.

The **nuclear envelope** is a double membrane of the nucleus that encloses the genetic material. It separates the contents of the nucleus from the cytoplasm. The nuclear envelope is made of two lipid bilayers, an inner membrane and an outer membrane. The outer membrane is continuous with the rough endoplasmic reticulum. Many tiny holes called **nuclear pores** are found in the nuclear envelope. These nuclear pores help to regulate the exchange of materials (such as RNA and proteins) between the nucleus and the cytoplasm.

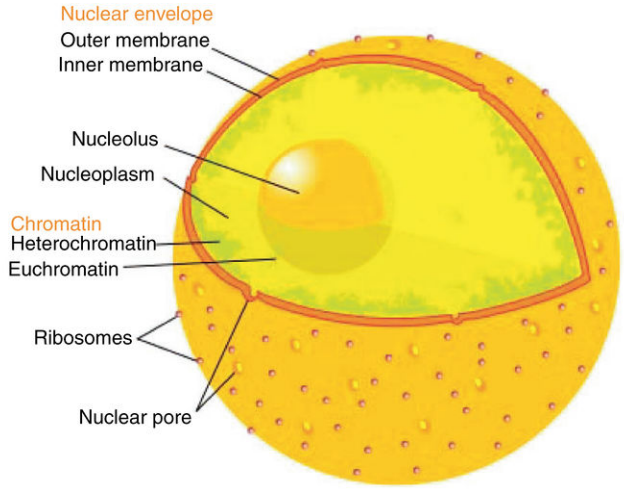


FIGURE 3.1

The eukaryotic cell nucleus. Visible in this diagram are the ribosome-studded double membranes of the nuclear envelope, the DNA (as chromatin), and the nucleolus. Within the cell nucleus is a viscous liquid called nucleoplasm, similar to the cytoplasm found outside the nucleus. The chromatin (which is normally invisible), is visible in this figure only to show that it is spread throughout the nucleus.

Vocabulary

- **chromatin**: Form of DNA when it is not coiled into chromosomes.
- **chromosome**: Coiled structure made of DNA and proteins; contains sister chromatids; the form of the genetic material of a cell goes during cell division.
- **gene**: Unit of DNA that is encoded with the instructions for a single polypeptide.
- **gene expression**: The use of a gene to make a mRNA/protein.
- **nuclear envelope**: Double membrane of the nucleus; encloses the genetic material.
- **nuclear pore**: Tiny hole in the nuclear envelope.
- **nucleolus**: Section of the nucleus; site of ribosome assembly.
- **nucleus** (plural, **nuclei**): Organelle inside eukaryotic cells that contains most of the cell#8217;s DNA; control center of the cell.
- **ribosome**: Organelle inside all cells where proteins are made; site of protein synthesis.

Summary

- The nucleus is a membrane-enclosed organelle, found in most eukaryotic cells, which stores the genetic material (DNA).
- The nucleus is surrounded by a double lipid bilayer, the nuclear envelope, which is embedded with nuclear pores.
- The nucleolus is inside the nucleus, and is where ribosomes are made.

Practice

Use this resource to answer the questions that follow.

- http://www.hippocampus.org/Biology → Biology for AP* → Search: **Cellular Organelles**

1. How big is a typical nucleus?
2. Describe the structure and role of the nuclear envelope.
3. What is a nuclear pore?
4. What is chromatin?
5. What is the difference between nucleoplasm and cytoplasm?
6. What occurs in the nucleolus?

Review

1. What is the role of the nucleus of a eukaryotic cell?
2. Describe the nuclear membrane.
3. What are nuclear pores?
4. What is the role of the nucleolus?

CHAPTER 4 Ribosomes and Mitochondria

- Outline the form and function of organelles, including ribosomes and mitochondria.

Sperm cells and muscle cells need lots of energy. What do they have in common?

They have lots of mitochondria. Mitochondria are called the power plants of the cell, as these organelles are where most of the cell's energy is produced. Cells that need lots of energy have lots of mitochondria.

Other Organelles

In addition to the nucleus, eukaryotic cells have many other organelles, including ribosomes and mitochondria. Ribosomes are present in all cells.

Ribosomes

Ribosomes are small organelles and are the site of protein synthesis (or assembly). They are made of ribosomal protein and ribosomal RNA. Each ribosome has two parts, a large and a small subunit, as shown in **Figure** 4.1.

The subunits are attached to one another. Ribosomes can be found alone or in groups within the cytoplasm. Some ribosomes are attached to the endoplasmic reticulum (ER) (as shown in **Figure** 4.2), and others are attached to the nuclear envelope.

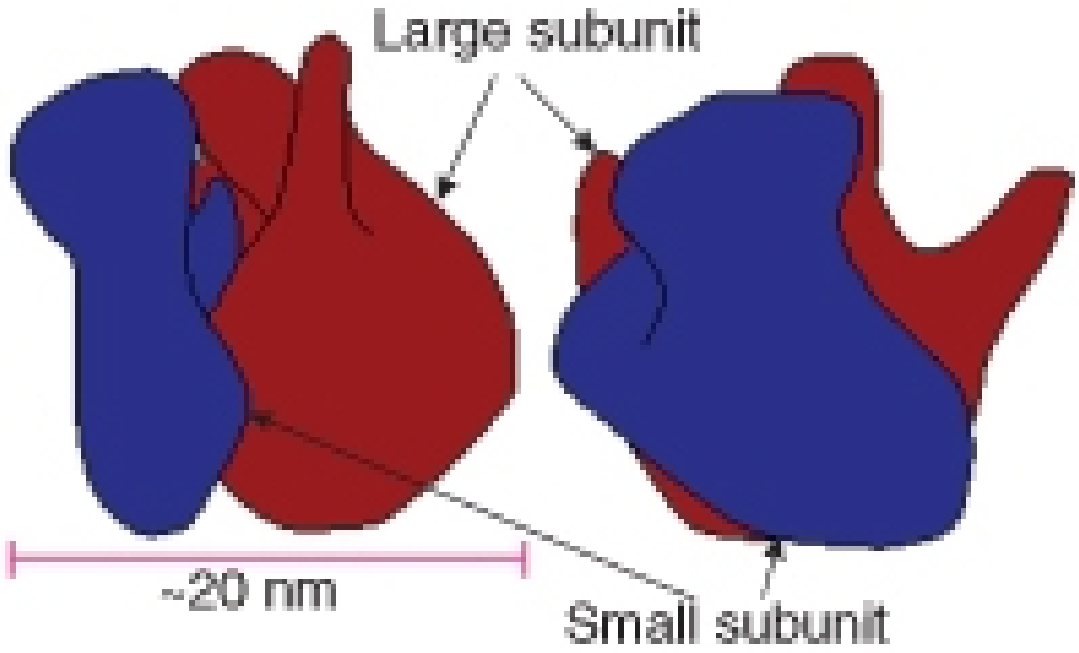


FIGURE 4.1

The two subunits that make up a ribosome, small organelles that are intercellular protein factories.

Mitochondria

A mitochondrion (**mitochondria**, plural), is a membrane-enclosed organelle that is found in most eukaryotic cells. Mitochondria are called the "power plants" of the cell because they use energy from organic compounds to make ATP (adenosine triphosphate). **ATP** is the cell's energy source that is used for such things such as movement and cell division.

Some ATP is made in the cytosol of the cell, but most of it is made inside mitochondria. The number of mitochondria in a cell depends on the cell#8217;s energy needs. For example, active human muscle cells may have thousands of mitochondria, while less active red blood cells do not have any.

As **Figure** 4.2 **(a)** and **(b)** show, a mitochondrion has two phospholipid membranes. The smooth outer membrane separates the mitochondrion from the cytosol. The inner membrane has many folds, called **cristae**. The fluid-filled inside of the mitochondrion, called **matrix**, is where most of the cell#8217;s ATP is made.

Although most of a cell's DNA is contained in the cell nucleus, mitochondria have their own DNA. Mitochondria are able to reproduce asexually, and scientists think that they are descended from prokaryotes. According to the endosymbiotic theory, mitochondria were once free-living prokaryotes that infected ancient eukaryotic cells. The invading prokaryotes were protected inside the eukaryotic host cell, and in turn the prokaryote supplied extra ATP

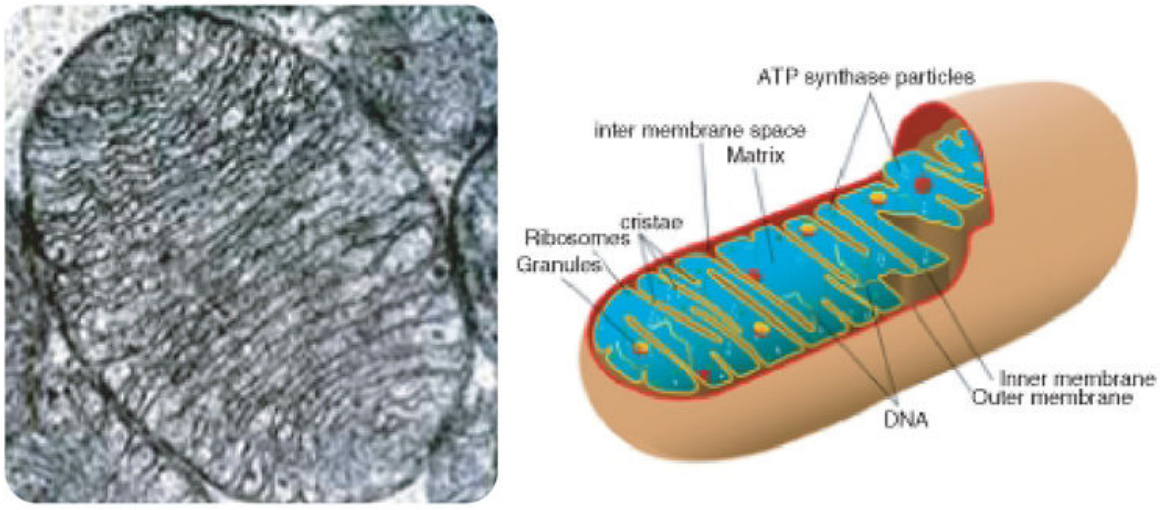


FIGURE 4.2

(a): Electron micrograph of a single mitochondrion, within which you can see many cristae. Mitochondria range from 1 to 10 #956;m in size. **(b):** This model of a mitochondrion shows the organized arrangement of the inner and outer membranes, the protein matrix, and the folded inner mitochondrial membranes.

to its host.

Vocabulary

- **ATP (adenosine triphosphate)**: Energy-carrying molecule that cells use to power their metabolic processes; energy-currency of the cell.
- **cristae**: Inner membrane folds of the mitochondrion.
- **matrix**: Fluid-filled inside of the mitochondrion.
- **mitochondria** (singular, **mitochondrion**): Organelle in eukaryotic cells that makes energy available to the cell in the form of ATP molecules.
- **ribosome**: Organelle inside all cells where proteins are made; site of protein synthesis.
- **ribozymes**: RNA molecules that catalyze chemical reactions; RNA molecules with enzymatic activity.
- **translation**: Process in which genetic instructions in mRNA are #8220;read#8221; to synthesize a protein.

Summary

- Ribosomes are small organelles and are the site of protein synthesis. Ribosomes are found in all cells.
- Mitochondria are where energy from organic compounds is used to make ATP.

Practice

Use this resource to answer the questions that follow.

- http://www.hippocampus.org/Biology → Biology for AP* → Search: **Cellular Organelles**

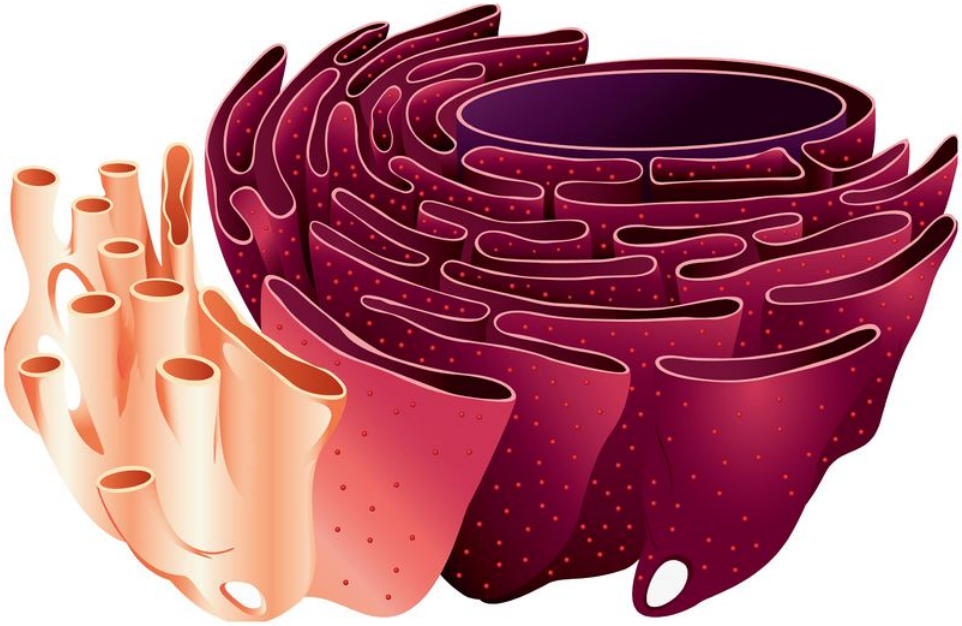
1. What happens at the ribosome?
2. Describe the structure of a ribosome.
3. How many ribosomes could a cell have?
4. Where in the cell are ribosomes located?
5. Why is the mitochondrion referred to as the "power plant" of the cell?
6. Describe the structure of a mitochondrion. What is the cristae?
7. What is located in the mitochondrial matrix?
8. How many mitochondria does a typical liver cell have?

Review

1. What is the function of a ribosome?
2. What is a significant difference between the structure of a ribosome and other organelles?
3. Identify the reason why mitochondria are called "power plants" of the cell.

CHAPTER 5 Other Cell Organelles

- Outline the form and function of organelles.



Does a cell have its own ER?

Yes, but in this case, the ER is not just for emergencies. True, there might be times when the cell responds to emergency conditions and the functions of the ER may be needed, but usually the cell's ER is involved in normal functions. Proteins are also made on the outside of the ER, and this starts a whole process of protein transport, both around the inside of the cell and to the cell membrane and out.

Other Organelles

In addition to the nucleus, eukaryotic cells have many other organelles, including the endoplasmic reticulum, Golgi apparatus, vesicles, vacuoles, and centrioles.

Endoplasmic Reticulum

The **endoplasmic reticulum (ER)** (plural, reticuli) is a network of phospholipid membranes that form hollow tubes, flattened sheets, and round sacs.

These flattened, hollow folds and sacs are called cisternae. The ER has two major functions:

- Transport: Molecules, such as proteins, can move from place to place inside the ER, much like on an intracellular highway.
- Synthesis: Ribosomes that are attached to ER, similar to unattached ribosomes, make proteins. Lipids are also produced in the ER.

There are two types of endoplasmic reticulum, rough endoplasmic reticulum (RER) and smooth endoplasmic reticulum (SER).

- **Rough endoplasmic reticulum** is studded with ribosomes, which gives it a "rough" appearance. These ribosomes make proteins that are then transported from the ER in small sacs called transport vesicles. The transport vesicles pinch off the ends of the ER. The rough endoplasmic reticulum works with the Golgi apparatus to move new proteins to their proper destinations in the cell. The membrane of the RER is continuous with the outer layer of the nuclear envelope.
- **Smooth endoplasmic reticulum** does not have any ribosomes attached to it, and so it has a smooth appearance. SER has many different functions, some of which include lipid synthesis, calcium ion storage, and drug detoxification. Smooth endoplasmic reticulum is found in both animal and plant cells and it serves different functions in each . The SER is made up of tubules and vesicles that branch out to form a network. In some cells there are dilated areas like the sacs of RER. Smooth endoplasmic reticulum and RER form an interconnected network.

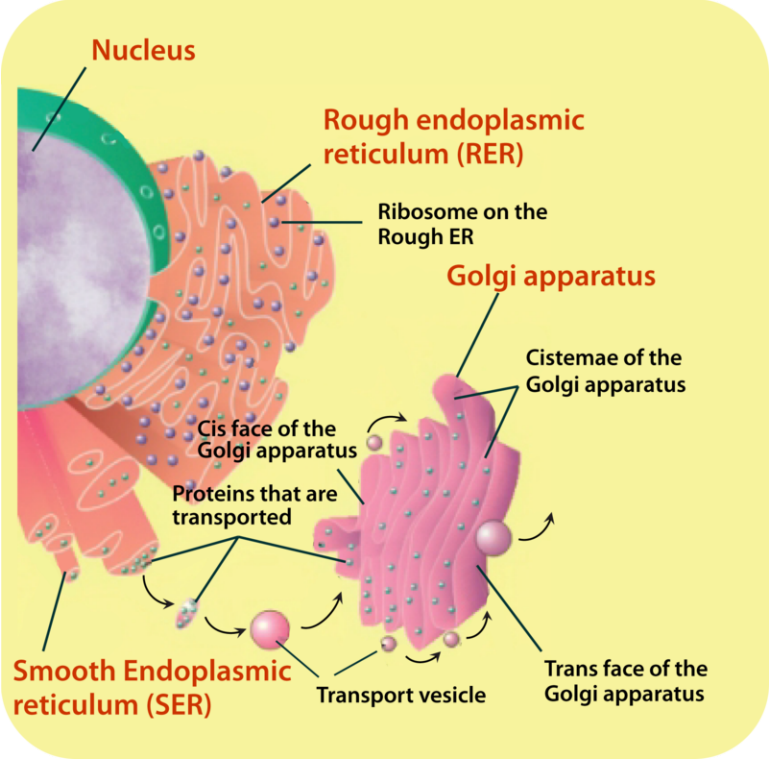


FIGURE 5.1

Image of nucleus, endoplasmic reticulum and Golgi apparatus, and how they work together. The process of secretion from endoplasmic reticuli (orange) to Golgi apparatus (pink) is shown.

Golgi Apparatus

The **Golgi apparatus** is a large organelle that is usually made up of five to eight cup-shaped, membrane-covered discs called cisternae, as shown in **Figure** 5.1. The cisternae look a bit like a stack of deflated balloons. The Golgi apparatus modifies, sorts, and packages different substances for secretion out of the cell, or for use within the cell. The Golgi apparatus is found close to the nucleus of the cell, where it modifies proteins that have been delivered in transport vesicles from the RER. It is also involved in the transport of lipids around the cell. Pieces of the Golgi membrane pinch off to form vesicles that transport molecules around the cell. The Golgi apparatus can be thought of as similar to a post office; it packages and labels "items" and then sends them to different parts of the cell. Both plant and animal cells have a Golgi apparatus. Plant cells can have up to several hundred Golgi stacks scattered throughout the cytoplasm. In plants, the Golgi apparatus contains enzymes that synthesize some of the cell wall polysaccharides.

Vesicles

A **vesicle** is a small, spherical compartment that is separated from the cytosol by at least one lipid bilayer. Many vesicles are made in the Golgi apparatus and the endoplasmic reticulum, or are made from parts of the cell membrane. Vesicles from the Golgi apparatus can be seen in **Figure** 5.1. Because it is separated from the cytosol, the space inside the vesicle can be made to be chemically different from the cytosol. V esicles are basic tools of the cell for organizing metabolis Vesicles are also used as chemical reaction chambers. They can be classified by their contents and function.

- T **ransport vesicles** are able to move molecules between locations inside the cell. For example, transport vesicles m the rough endoplasmic reticulum to the Golgi apparatus.
- **Lysosomes** are vesicles that are formed by the Golgi apparatus. They contain powerful enzymes that could break down (digest) the cell. Lysosomes break down harmful cell products, waste materials, and cellular debris and then force them out of the cell. They also digest invading organisms such as bacteria. Lysosomes also break down cells that are ready to die, a process called autolysis.
- **Peroxisomes** are vesicles that use oxygen to break down toxic substances in the cell. Unlike lysosomes, which are formed by the Golgi apparatus, peroxisomes self-replicate by growing bigger and then dividing. They are common in liver and kidney cells that break down harmful substances. Peroxisomes are named for the hydrogen peroxide (H_2O_2) that is produced when they break down organic compounds. Hydrogen peroxide is toxic, and in turn is broken down into water (H_2O) and oxygen (O_2) molecules.

Vacuoles

Vacuoles are membrane-bound organelles that can have secretory, excretory, and storage functions. Many organisms will use vacuoles as storage areas and some plant cells have very large vacuoles. Vesicles are much smaller than vacuoles and function in transporting materials both within and to the outside of the cell.

Vocabulary

- **centriole**: Structure that arrange the mitotic spindles; made of microtubules.
- **centrosome**: Structure formed of two centrioles arranged in a perpendicular manner.
- **endoplasmic reticulum (ER)**: Organelle in eukaryotic cells that helps make and transport proteins; site of lipid synthesis.
- **Golgi apparatus**: Organelle in eukaryotic cells that processes proteins and prepares them for use both inside and outside the cell.
- **lysosome**: Vesicle with powerful digestive enzymes; breaks down harmful cell products, waste materials, and cellular debris.
- **peroxisome**: Vesicle that uses oxygen to break down toxic substances in the cell.
- **rough endoplasmic reticulum**: Endoplasmic reticulum with ribosomes embedded on its surface.
- **smooth endoplasmic reticulum**: Endoplasmic reticulum without ribosomes embedded on its surface.
- **transport vesicle**: Vesicle that moves molecules between locations inside the cell.
- **vacuole**: Large saclike organelle that stores and transports materials inside a cell.
- **vesicle**: Small saclike organelle that stores and transports materials inside a cell.

Summary

- The endoplasmic reticulum (ER) is involved in the synthesis of lipids and synthesis and transport of proteins.

- The Golgi apparatus modifies, sorts, and packages different substances for secretion out of the cell, or for use within the cell.
- Vesicles are also used as chemical reaction chambers. Transport vesicles, lysosomes, and peroxisomes are types of vesicles.
- Vacuoles have secretory, excretory, and storage functions.
- Centrioles are made of short microtubules and are very important in cell division.

Practice I

Use this resource to answer the questions that follow.

- http://www.hippocampus.org/Biology → Biology for AP* → Search: **Cellular Organelles**

1. Where in the cell are the endoplasmic reticulum and Golgi apparatus located?
2. What are the roles of the ER, the Golgi apparatus, and the lysosome?
3. How do proteins move from the ER to the Golgi apparatus?
4. Why do digestive enzymes have to be located in a lysosome and not the cytosol?
5. What is the main difference between a lysosome and a peroxisome?

Practice II

- **Eucaryotic Cell Interactive Animation: Animal Cell** at http://www.cellsalive.com/cells/cell_model.htm.
- **Quiz on Cell Organelles #1** at http://www.neok12.com/quiz/CELSTR05.
- **Quiz on Cell Organelles #2** at http://www.neok12.com/quiz/CELSTR06.
- **Quiz on Cell Organelles #3** at http://www.neok12.com/quiz/CELSTR07.
- **Who Does What, Quiz #1** at http://www.neok12.com/quiz/CELSTR11.

Review

1. List five organelles eukaryotes have that prokaryotes do not have.

2. Explain how the following organelles ensure that a cell has the proteins it needs: nucleus, rough and smooth ER, vesicles, and Golgi apparatus.

3. What is the main difference between rough endoplasmic reticulum and smooth endoplasmic reticulum?

4. Describe the three types of vesicles.