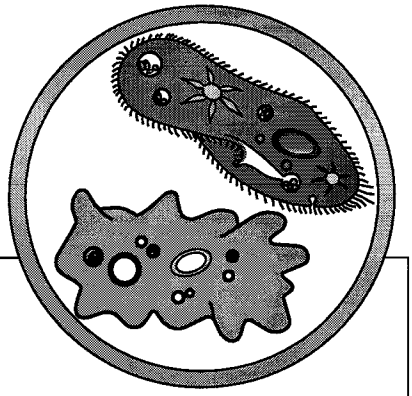
Cell Structure and Function

Section 6.1
Prokaryotic and Eukaryotic Cells



Pre-View 6.1

- **Cell** – the smallest unit of life
- **Cell membrane** – a barrier that separates a cell from its surroundings
- **DNA** – molecules in a cell that contain genetic information
- **Prokaryotic cells** – simple cells that do not have a nucleus; this type of cell is found in bacteria
- **Eukaryotic cells** – cells that have a true nucleus and make up all other organisms other than bacteria
- **Flagella** – long, hairlike filament that some single-celled organisms use to propel them forward
- **Cilia** – short, hairlike projections that some cells use for movement

You probably already know that all living things are made of cells. A **cell** is the smallest unit of life. It is the basic unit of structure of all living organisms. It is a collection of living and nonliving materials that is separated from its surroundings by a barrier called the **cell membrane**. Some organisms are made up of one single cell. Other organisms are made up of many cells that work together.

Biologists classify cells into two main groups — prokaryotic cells and eukaryotic cells. **Prokaryotic cells** are bacteria cells. All other cells are **eukaryotic cells**, so the cells that make up your body, or the cells in a rose bush, or even the cells in a ladybug are eukaryotic cells. Prokaryotic cells are much simpler than eukaryotic cells, as you'll see with the chart below and in figures 6-1 and 6-2.

Similarities and Differences in Prokaryotic and Eukaryotic Cells

	PROKARYOTIC CELLS	EUKARYOTIC CELLS
Average Cell Size	1-10μm	10-100μm
Have a Cell Wall?	YES	SOMETIMES
Have a Cell Membrane?	YES	YES
Have a Nucleus?	NO	YES
Have Cytoplasm?	YES	YES
Have DNA?	YES, in cytoplasm	YES, in nucleus
Have Ribosomes?	YES	YES
Have Membrane Enclosed Organelles?	NO	YES
Mode of Locomotion?	May have one or more flagella for locomotion	May have one or two flagella or cilia for locomotion
Found in —	bacteria only	fungi, protists, plants, animals

Although both types of cells have DNA, the DNA is found in different places. Remember that **DNA** contains the genetic material for an organism. In prokaryotic cells, the DNA is located in the cytoplasm of the cell. In eukaryotic cells, the DNA is found inside the cell's nucleus.

Both prokaryotic bacteria and single-celled eukaryotic organisms can have one or more **flagella** for locomotion. The flagellum is a long, hair-like filament that propels a cell forward.

Eukaryotic cells may also have **cilia**, which are shorter hair-like projections used like oars for movement. Multicellular organisms may have ciliated cells to produce movement, not necessarily for the cells themselves, but to produce the movement of debris. For example, cells in your nose are ciliated to move mucus and debris!

When you compare the two diagrams given in figures 6-1 and 6-2 below, you can tell how much more complex eukaryotic cells are than prokaryotic cells. The eukaryotic cell has more organelles (cell parts). Examples of cell organelles are ribosomes, mitochondria, endoplasmic reticulum, etc.

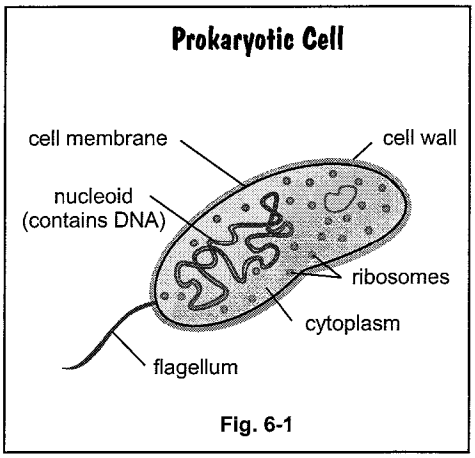


Fig. 6-1

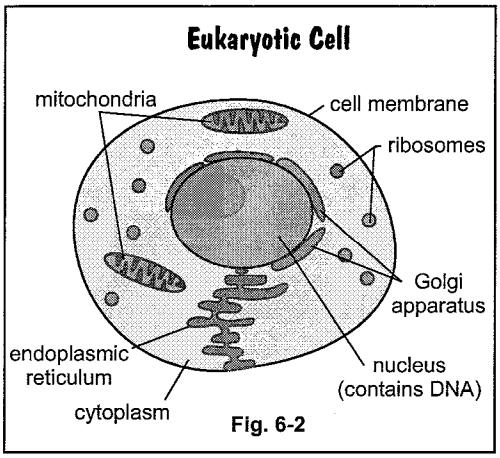


Fig. 6-2

Hint: To help you remember that eukaryotic cells are the cells that make up most organisms, including humans, think about how eukaryote is pronounced. It sounds like "you" and you are human!

Cell Structure and Function

Section 6.2
Cell Organelles

Eukaryotic cells carry out many different processes and functions, and they have specialized cell parts called **organelles** to do so. Many of these organelles are labeled in figure 6-3.

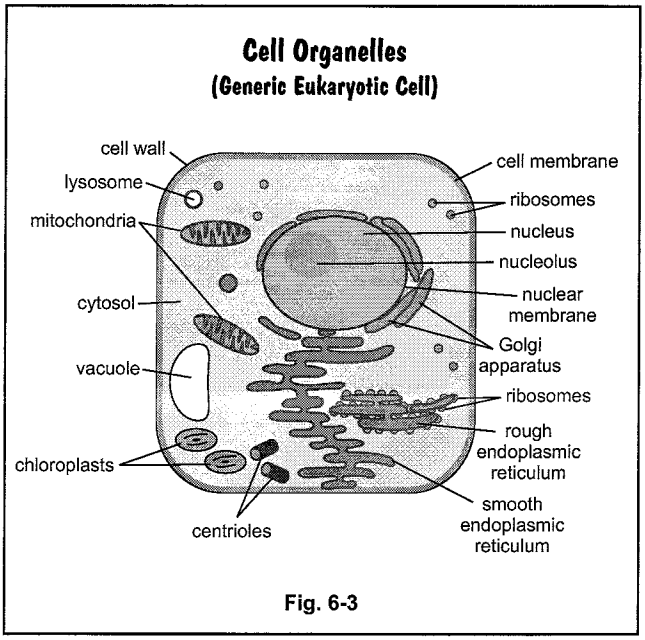


Fig. 6-3

Outside of the Cell

Cell Membrane: Around the outside of all cells is a **cell membrane**. The cell membrane is a phospholipid bilayer, which means that it is made of two layers of lipid tails (fats) and phosphate heads with water "sandwiched" between the two layers. The cell membrane is important because it controls what goes into and out of the cell.

Cell Wall: Many cells, such as plant and fungus cells, also have a **cell wall** around them. The cell wall helps provide extra shape and support for the cell. The cell wall allows the stems of plants to stand upright, and it protects the plant cell from expanding under pressure.

The Control Center

Nucleus: Inside almost all eukaryotic cells is a **nucleus**. The nucleus controls most of the processes in the cell and is surrounded by a **nuclear membrane** that keeps it separated from the rest of the cell. Inside the nucleus is the DNA—material that helps form the chromosomes. **Chromatin** are made of DNA and protein. They are threadlike structures that carry hereditary (or genetic) information. When a cell is ready to divide, the chromatin coils up and condenses into structures called **chromosomes**. Chromosomes are only visible when a cell is preparing for or undergoing division.

Nucleolus: Inside of most nuclei is a darker portion called the **nucleolus**. The nucleolus is an area where ribosomes are produced before they move into the cytoplasm.

Between the Cell Membrane and the Nucleus

Cytosol (or **Cytoplasm**)**:** The jelly-like fluid that fills the space between the nucleus and the cell membrane is called **cytosol** (also called **cytoplasm**). Most of the cell's metabolic processes occur in the cytosol.

Ribosomes: Ribosomes are small organelles that help to build proteins. They form peptide bonds between amino acids in order to make proteins. They can be attached to the endoplasmic reticulum, or they can float around in the cytoplasm.

Endoplasmic Reticulum: The **endoplasmic reticulum** (ER) is a membrane system inside the cell that is used to produce and transport materials, especially proteins, within the cell. Some ER has a rough appearance because it has ribosomes attached to it. Endoplasmic reticulum that has ribosomes attached is called **rough ER**, and this type of ER is responsible for much of a cell's protein production. Endoplasmic reticulum that doesn't have ribosomes attached is called **smooth ER**, and this type of organelle is responsible for other biological processes, such as making and storing lipids.

Golgi Apparatus: Another organelle made of membranes is the **Golgi apparatus**. The Golgi apparatus (sometimes called Golgi bodies or Golgi complex) looks like a stack of pancakes. They help package and distribute proteins and lipids to other areas outside the cell. They are found in abundance in cells that produce secretions, such as gland cells.

Vesicles, Vacuoles, and **Lysosomes:** Vesicles are sac-like structures that store and transport cellular products. Two types of vesicles are vacuoles and lysosomes. **Vacuoles** are vesicles that are used for storing of water, salts, wastes, etc. **Lysosomes** are vesicles that store digestive enzymes used to digest food particles, to remove worn-out organelles, or to engulf viruses or bacteria.

Mitochondria: The **mitochondria** are sometimes called the powerhouses of the cell because they use energy from food molecules to produce high-energy compounds. They have an outer membrane and a folded inner membrane.

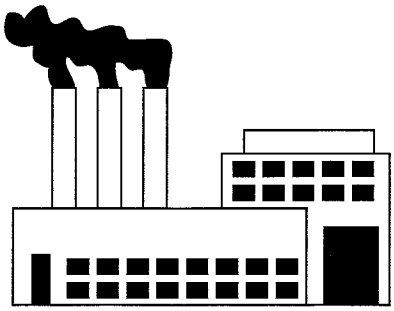
Chloroplasts: Plant cells contain another organelle called the **chloroplast**. Chloroplasts have two membranes, and they contain chlorophyll, a green pigment used in photosynthesis.

Cytoskeleton: Many cells have a network of very thin protein fibers called the **cytoskeleton**. The cytoskeleton helps the cell keep its shape and may be part of the way a cell moves. Two main components of the cytoskeleton are fibers called microtubules and microfilaments. **Microtubules** are thin, hollow tubes of protein that make up the largest strands of the cytoskeleton. **Microfilaments** are solid protein fibers that are the smallest strands in the cytoskeleton.

Centrioles: Centrioles are cylindrical organelles that are made up of microtubules. They are always found in pairs, and they are important in cell division.

The Cell as a Factory

Wow, that's a lot of stuff inside something as small as a cell. It may help you to remember the organelles and what they do by thinking of a cell as being a factory. The walls and doors of the factory would be the cell membrane, which controls what can get in and out. The nucleus would be the boss or supervisor of the factory, who controls what everyone does. The assembly line would be the endoplasmic reticulum, and the workers on the line would be the ribosomes that make proteins. The shipping and handling department would be the Golgi apparatus, which packages and distributes materials. The generators would produce energy like the mitochondria. Raw materials and finished products may be stored in the warehouse in barrels. These barrels are like vesicles that store materials to be used by the cell or to be transported out of the cell.



Cell Structure and Function

Section 6.3
Plant and Animal Cells

Pre-View 6.3

- **Cell wall** – cellulose structure that surrounds plant cells and gives them support and protection
- **Cellulose** – a type of carbohydrate that is unique to plants; found in the cell walls of plants and is also called "fiber"
- **Vacuole** – a large organelle in most plants cells that is filled mostly with water and helps to give the cell structural support
- **Chloroplasts** – organelles that are unique to plant cells (and some types of algae); used in photosynthesis
- **Photosynthesis** – a process used by plants that converts light energy, carbon dioxide, and water into glucose (sugar) and oxygen

Plant cells and animal cells are eukaryotic cells, so they are very similar. Plant cells are found in plants and include cells such as those found in plant leaves, onion skins, flowers, roots, etc. Animal cells are found in animals and include cells such as liver cells, blood cells, skin cells, etc. Plant and animal cells do have some differences that are listed in the chart below:

Similarities and Differences in Plant and Animal Cells

	PLANT CELLS	ANIMAL CELLS
Have a Cell Membrane, Nucleus, Mitochondria, Ribosomes, Golgi apparatus, and Endoplasmic Reticulum?	YES	YES
Have a Cell Wall?	YES	NO
Have Lysosomes?	NO (rarely)	YES
Have Vacuoles?	YES	NONE OR SMALL
Have Chloroplasts?	YES	NO

Figure 6-4 below shows a labeled diagram of a typical plant and animal cell.

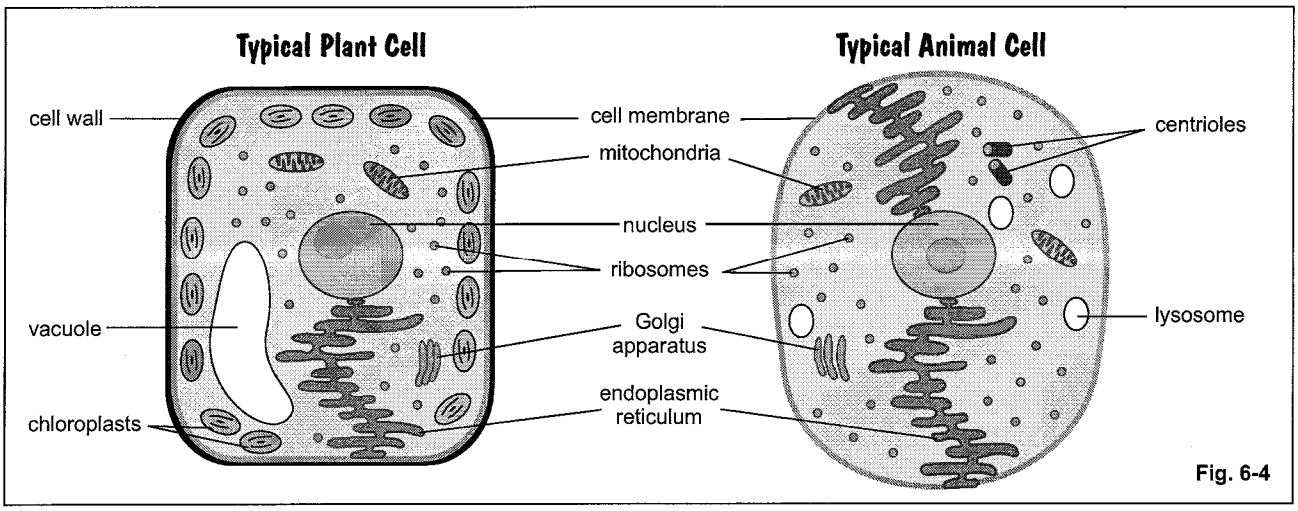


Fig. 6-4

Both plant and animal cells can reproduce, but the way that they divide into new cells is different. Both have some cell processes such as **cellular respiration** that are similar. In cellular respiration, cells use oxygen to help break down glucose to release energy and carbon dioxide. You'll see more about this process in Section 8.

Special Animal Organelles

Animal cells contain centrioles and lysosomes, neither of which are found in plant cells. Remember, centrioles play an important role in cell division, and lysosomes store enzymes that keep the cell free from debris.

Special Plant Organelles

From the chart on the previous page and the diagrams above, can you summarize a few things that are different between plant cells and animal cells? Hopefully, you see that the presence of a cell wall, the size of vacuoles, and the presence of chloroplasts make plant cells different. Let's take a closer look at each of these.

The Cell Wall

Plant cells have cell walls, but animal cells do not. The cell wall in a plant cell is made of **cellulose**, a material unique to plant cells. Similar to starch, cellulose is a type of carbohydrate. (Cellulose is also known as "fiber," an important part of a human diet.) The cell wall gives support and extra protection to the plant cell.

Vacuoles

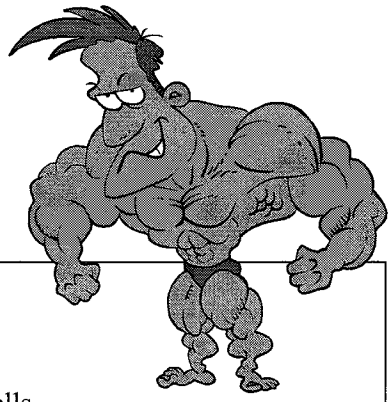
Many plant cells have one large vacuole that is filled with water. The vacuole may take up 50% or more of the space inside the cell. Vacuoles are used to store water, salts, sugars, wastes, etc. In plants, they can help provide support for the cell. Most animal cells do not contain vacuoles, and when found in cells other than plant cells, the vacuoles are small. Single-celled organisms such as paramecium contain contractile vacuoles that help control fluid balance.

Chloroplasts

Only plant cells (and some types of algae) have chloroplasts, so they can go through a special process called **photosynthesis**. In photosynthesis plant cells use light energy, carbon dioxide, and water to produce oxygen and glucose. Remember that glucose is a monosaccharide carbohydrate, or in other words, a simple sugar. Also remember that glucose and other carbohydrates store energy. (See Section 5.2 if you need more review on carbohydrates.) Glucose molecules "link" together to form starch molecules, which are stored in plant cells for future use.

Cell Structure and Function

Section 6.4
Cellular Organization



Pre-View 6.4

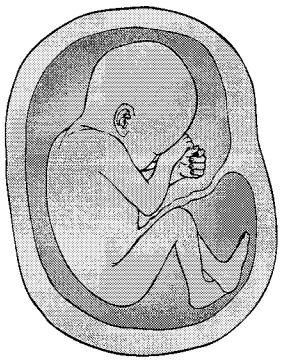
- **Cell** – the smallest unit of life
- **Cellular differentiation** – process that creates different types of specialized cells
- **Tissue** – a group of cells that work together to perform a function
- **Organ** – different types of tissue that work together to perform a function
- **Organ system** – different organs that work together to carry out a function

If the **cell** is the basic unit of structure of all living organisms, how do different kinds of cells make up an entire organism? That question can be answered by understanding cellular differentiation and organization.

Cellular Differentiation

So far, you've seen that cells are the basic unit of structure and function in living things and that cells have many organelles in common with most other cells. But you probably also know by using some common sense that cells within an organism can function quite differently, right? Do red blood cells look the same or act the same as the cells in your skin, your liver, your lungs, your stomach? Of course not! They are all different.

We have over 250 different kinds of cells in the human body. Cells are "specialized" through a process called **cellular differentiation**. Through cellular differentiation, different types of cells are created to carry out specific tasks or functions. In animals, the cells that can differentiate into many types are called *stem cells*. Higher level plants have cells called *meristematic cells* that can differentiate into many types.



Think about it. A person starts out as a single fertilized egg, which is only a single cell. That single cell is capable of developing into an entire human body. The egg cell grows, divides, and develops into three basic cell types, some of which are stem cells. These stem cells are the ones that will differentiate into all the other types of cells needed in the body.

During the process of differentiation, some of the genes in the stem cells become activated (scientists say "switched on"), and other genes become inactivated, or "switched off." This combination of turning genes on and off causes cells to develop certain structures so that they can perform specialized functions. For example, some of the stem cells will become bone marrow that produces red blood cells while others might become skin cells or muscle cells. Once a cell differentiates, it cannot change its type. In other words, skin cells can only reproduce other skin cells. A skin cell cannot produce a muscle cell. A stem cell, on the other hand, can differentiate into either a skin cell *or* a muscle cell *or* any other type of cell.

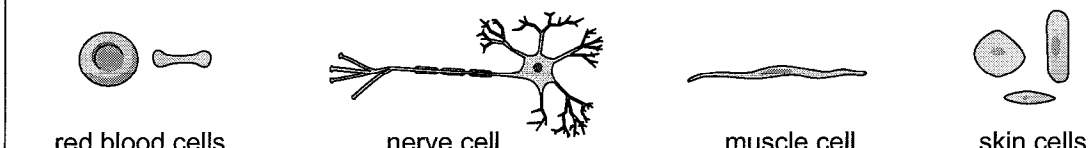
Plants also have different types of cells. A cell in a plant's leaf has a different function than a cell found in a plant's roots.

Cellular Organization

Now, how are all of these cells put together to form something as complex as a human being? They are organized into different levels. Cells make up tissues, tissues make up organs, organs make up organ systems, and organ systems make up an organism. Let's take a closer look.

Cells: So far, you've seen a diagram of a generic animal cell and a generic plant cell, but many cells have unique shapes and properties to perform specific functions. Look at some examples of different types of cells below that can be found in the human body. These, of course, are not the only types of cells, but they are common ones.

Examples of Different Types of Cells

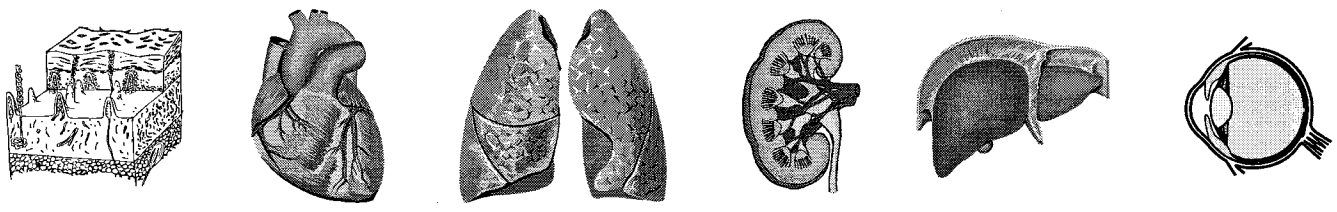


red blood cells | nerve cell | muscle cell | skin cells

Cells make up tissues. Groups of similar cells that work together to perform a certain function form a **tissue**. Humans and most animals have four basic types of tissue: epithelial, connective, muscular, and nervous. Each of these basic types can be further divided. ***Epithelial tissue*** acts as a lining, so it helps to make up the skin and the linings of internal organs. ***Connective tissue*** includes cartilage, bone, and even blood. ***Muscular tissue*** is broken down into three types: skeletal muscle, like the biceps in your arm; cardiac muscle found only in the heart; and smooth muscle found in internal organs such as the stomach. ***Nervous tissue*** sends and receives electrical impulses. It is found in peripheral nerves, in the spinal cord, and in the brain. Plants have tissues also. For example, plant cells that work together to carry water and minerals throughout a plant make up a plant tissue called xylem.

Tissues make up organs. When several different types of tissues work together to carry out a certain function, they form an **organ**. In your eyes, you have muscles, the optic nerve, the retina, and other specialized tissues that work together to help you see. Your eye is an example of an organ. Other common organs include the stomach, the heart, the lungs, the kidneys, and the liver, to name a few. Believe it or not, plants also have organs. Plant organs include the roots, the stems, and the leaves. Review some common human organs shown below.

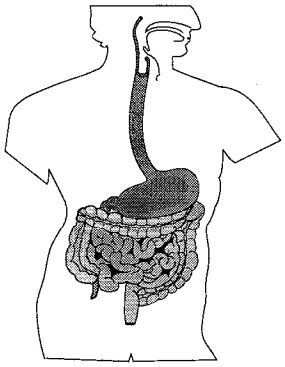
Examples of Human Organs



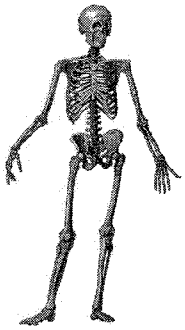
skin | heart | lungs | kidney | liver | eye

Organs make up organ systems. Organ systems are made of organs that work together. Your eyes are part of your nervous system, along with your brain, your spinal cord, and other tissues and specialized cells. Other human organ systems would include the digestive system made up of organs like the tongue, the esophagus, the stomach, and the small intestines. Organ systems are found in many living organisms. Plants have two organ systems: the shoot system above the ground and the root system below the ground. Review some of the common human organ systems pictured below. The common organs that make up each system are also listed although the lists are not necessarily complete.

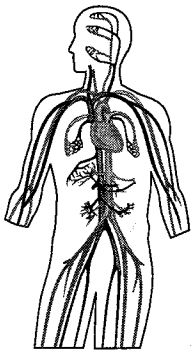
Examples of Human Organ Systems



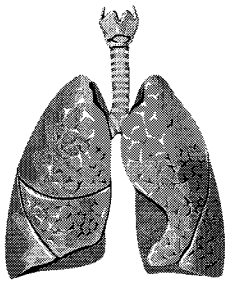
Digestive System:
esophagus, stomach, small intestines, large intestines



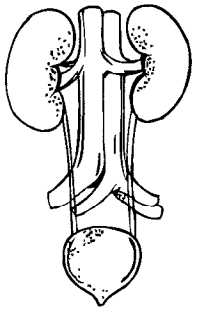
Skeletal System:
skull, ribs, vertebra, pelvis, etc.



Circulatory System:
heart, blood vessels



Respiratory System:
nose, larynx, trachea, bronchi, lungs



Urinary System:
kidneys, ureter, bladder

All the organ systems work together to form an organism. Examples of organisms would be a human being, a lady bug, a cat, a fish, or an oak tree.

Summary of Cellular Organization