

Cells and Cell Systems

Have you ever been part of a team? Successful teams are not always the ones with the most gifted players; success depends upon how well the players cooperate.

A multicellular organism, such as yourself, can be compared to a team: all of your cells must work together. A cell that works on its own faster or more efficiently than other cells is not necessarily a better cell. It can even be life-threatening. For example, a cell that uses nutrients more quickly or reproduces faster than other cells could be a cancer cell.

Cell Organization

A group of cells that are similar in shape and function is called a **tissue**. For example, skin that covers the outside surfaces of your body is made of epithelial tissue. Epithelial tissue also covers the inside surfaces of your body and provides support and protection for your body structures.

Tissues are often organized into larger structures called **organs**. Many organs are composed of several different types of tissues. Each organ has at least one function. For example, the heart is an organ. It pumps blood through your body. It is made of several tissues, as you can see in **Figure 1**.

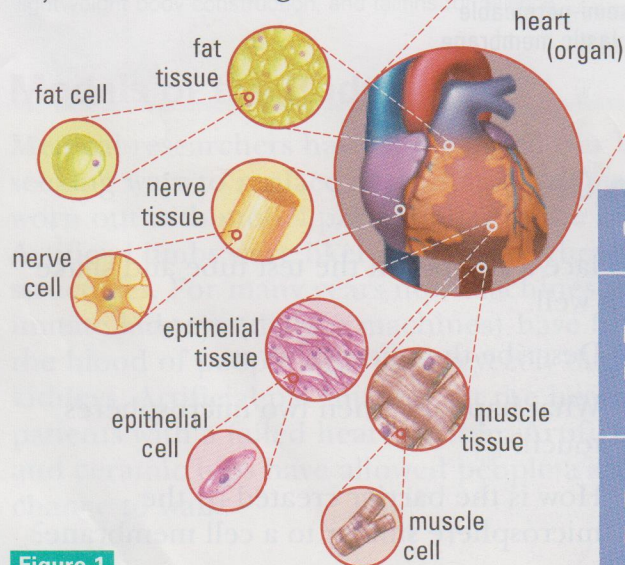
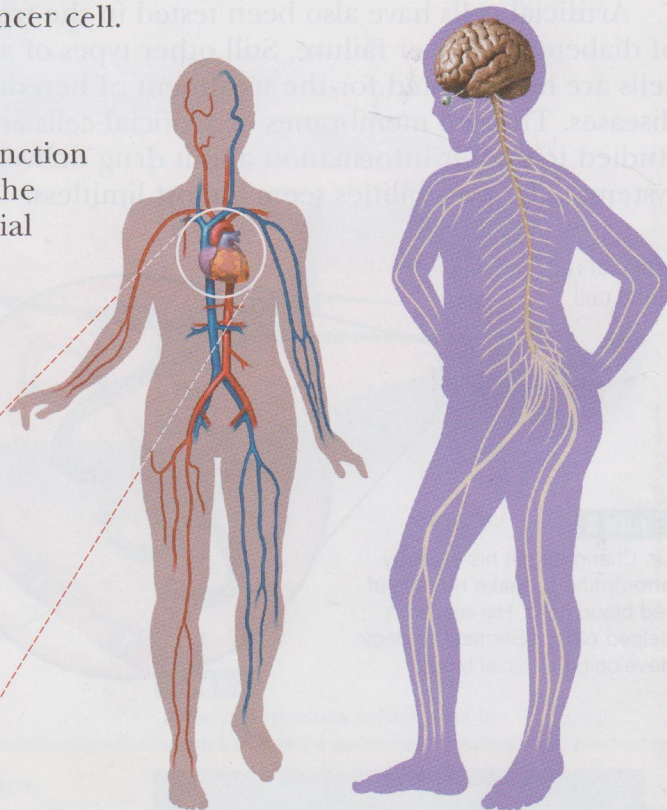


Figure 1

Your heart, an organ, is made of several different kinds of tissue. Each tissue is made of cells that are similar. For example, epithelial cells tend to be long and flat. Cells from different tissues look different. Cells in nerve tissue do not look like cells in muscle tissue.



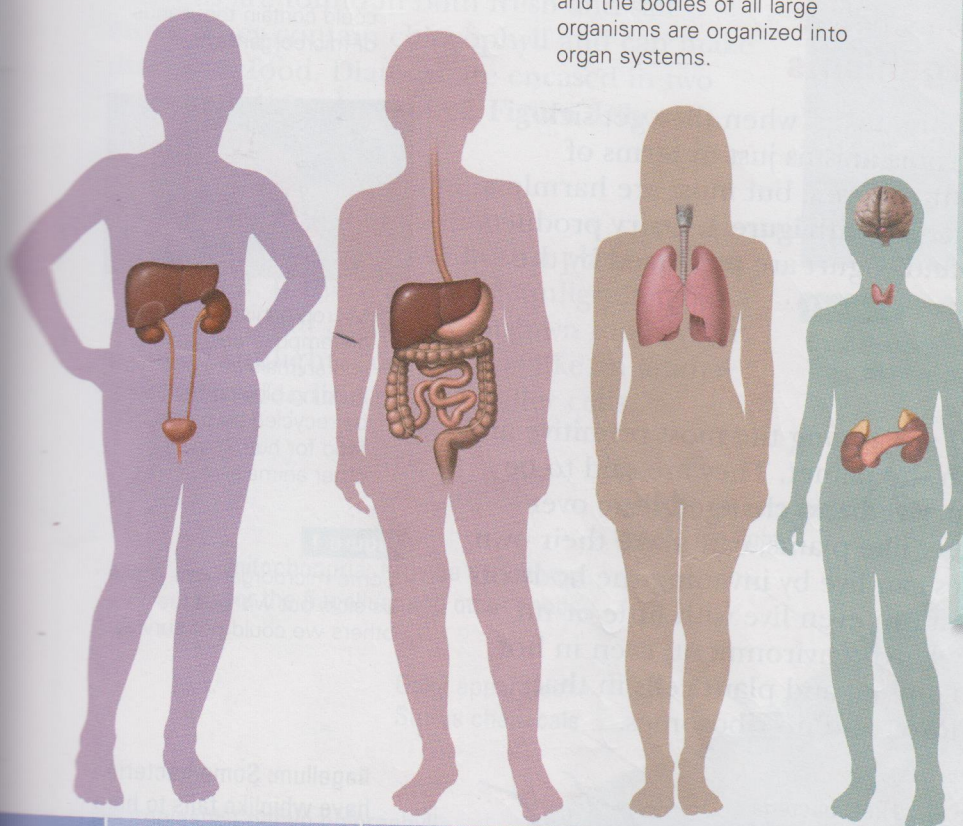
Organ system	Circulatory system	Nervous system	
Major organs in the system	heart, arteries, capillaries, veins	brain, spinal cord, eyes, ears, nerves to and from body parts	
Major tissues in the system	epithelial, nerve, connective, muscle, blood	nerve, connective, epithelial	
Major functions	transportation of nutrients, dissolved gases, and wastes to and from body cells	response to environment and control of body activities	

LEVELS OF CELL ORGANIZATION

Organ systems are groups of organs that have related functions. The circulatory system includes the heart; arteries that carry blood from the heart to the tissues; capillaries where nutrients and wastes are exchanged; and veins that carry blood and wastes from the tissues back to the heart. Nerve tissue, blood, epithelial tissue, connective tissue, and muscle tissue are all found in the circulatory system. Many of the other organ systems in the body appear in **Figure 2**, the Levels of Cell Organization chart.

Figure 2

The organs of the human body and the bodies of all large organisms are organized into organ systems.



Understanding Concepts

1. Define *tissue*, *organ*, and *organ system*. Describe three levels of organization in complex, multicellular organisms. Give an example of each.
2. Organize the following structures from smallest to largest and give an example of each: *organ system*, *tissue*, *cell*, *organ*, and *molecule*.
3. Choose one of the human organ systems and construct a concept map. Arrange the structures in your concept map from smallest to largest.

Making Connections

4. Make a chart comparing the levels of cell organization to the levels in an organization that you are familiar with, such as a sports organization.

Reflecting

5. If cells are the basic unit of life, why are tissues, organs, and organ systems required in large multicellular organisms?

Excretory system	Digestive system	Respiratory system	Endocrine system
kidneys, bladder, ureters, urethra, liver	esophagus, stomach, intestines, liver	lungs, windpipe, blood vessels	pancreas, adrenal glands, pituitary gland
epithelial, nerve, connective, muscle	epithelial, nerve, connective, muscle	epithelial, nerve, connective, muscle	epithelial, nerve, connective
removal of wastes	chemical and physical breakdown of food into molecules small enough to pass into cells	gas exchange	coordination and regulation of body activities

Fluid Movement in Animals

Life for the sponge in **Figure 1** is very straightforward. The sea water acts as a transport system, carrying nutrients and removing wastes. Simple diffusion across cell membranes accomplishes both tasks.

For larger and more complex animals, specialized cells must work together to move fluids. In animals, a circulatory system is responsible for carrying nutrient-rich fluids to body cells, and the excretory system is responsible for eliminating the wastes.

The Circulatory System

Relying on diffusion to deliver oxygen and nutrients is too limiting for a complex multicellular animal. A circulatory system brings every cell into almost direct contact with oxygen and nutrients. In fact, no cell in your body is farther than two cells away from a blood vessel that carries nutrients. Your circulatory system has 96 000 km of blood vessels to sustain your 60 trillion cells.

Open and Closed Circulatory Systems

In an open circulatory system, like that of the snail in **Figure 2**, blood carrying oxygen and nutrients is pumped into body cavities, where it bathes the cells. When the heart relaxes, blood is drawn back toward the heart through open-ended pores.

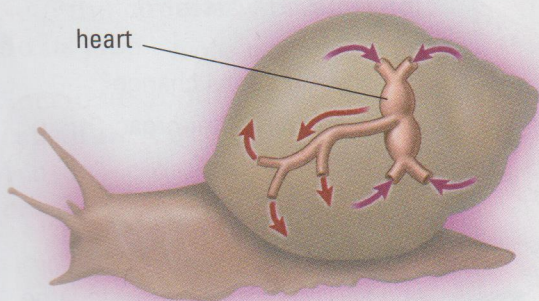


Figure 2

The snail has an open circulatory system.

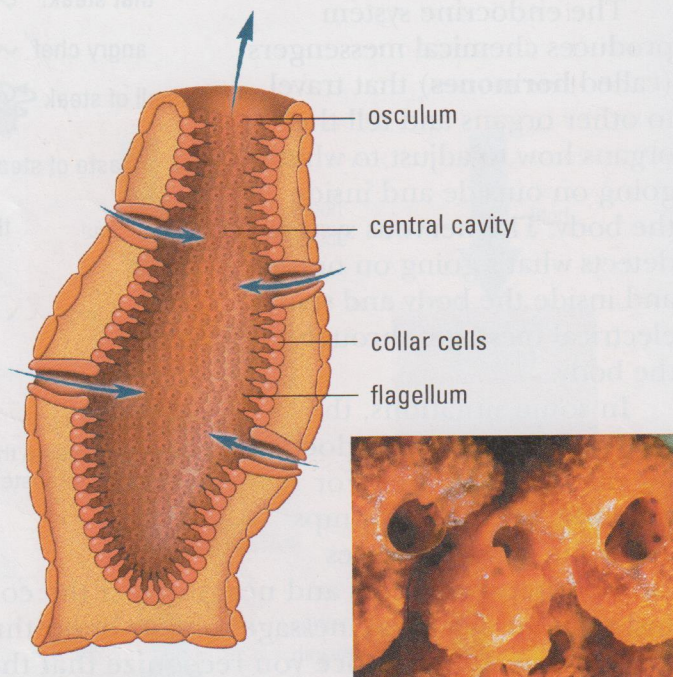


Figure 1

Sponges live anchored to the sea floor. They do not need a fluid transport system because they have only two cell layers. Water and nutrients are drawn into the sponge by cells that have a flagellum. Once inside the body, the water and wastes are expelled through the large pore at the top of the body.

In a closed circulatory system, like that of the worm in **Figure 3**, the blood is always contained within blood vessels. The earthworm has five heartlike vessels that pump blood through three major blood vessels. Larger blood vessels branch into smaller vessels that supply blood to the various tissues. Blood vessels that carry blood away from the heart are called **arteries**, and vessels that return blood to the heart are called **veins**.

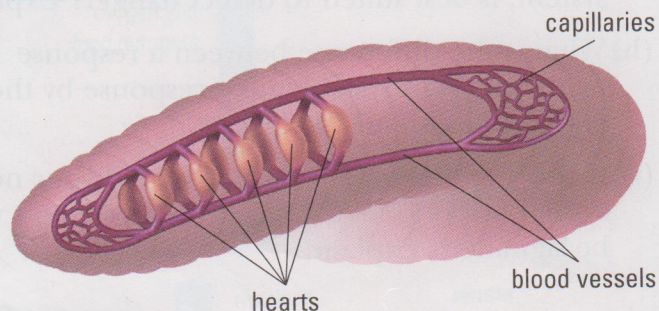


Figure 3

The worm has a closed circulatory system.

Humans' Twin Pumps

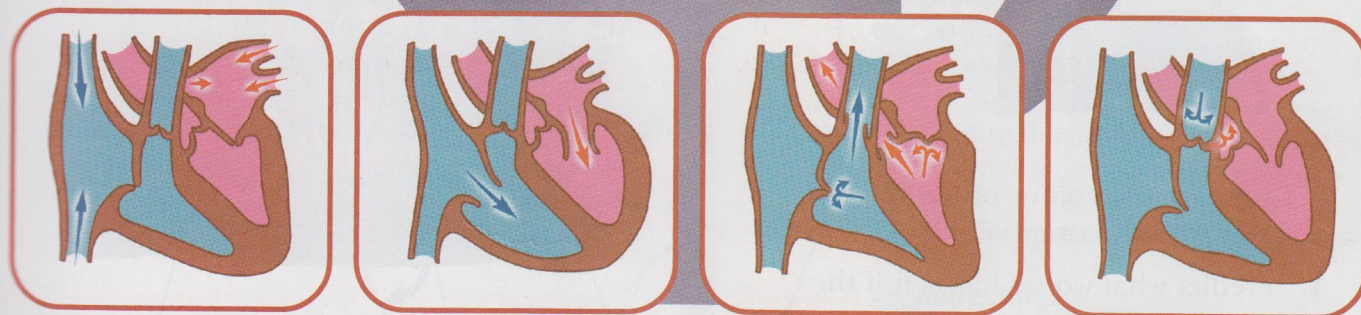
The heart of humans (**Figure 4**) and other mammals is not a single pump, but two parallel pumps separated by a wall of muscle. The right side of the heart receives blood low in oxygen from the body, which it delivers to the lungs. The left side of the heart accepts freshly oxygenated blood from the lungs and delivers it to the body cells. The body cells remove oxygen and nutrients. The blood completes its journey by travelling back to the right side of the heart.

Figure 4

The human heart has four chambers: two atria (singular atrium) and two ventricles. The atria are holding chambers for blood entering the heart. The stronger, more muscular ventricles pump the blood to distant tissues.

A One-Way Flow

Valves that operate as one-way doors keep blood flowing in one direction in the human heart. Valves are found in both sides of the heart, as you can see in **Figure 5**. The first set are located between the atria and ventricles. The second set lie between the ventricles and the arteries that carry blood away from the heart.



a Blood is carried to the heart by veins. As the heart relaxes, the atria fill with blood.

b The atria contract and blood is pushed into the ventricles. The ventricles fill with blood.

c The ventricles contract and blood is pushed against the valves that separate the atria and ventricles. The closing of the valves produces the first heart sound, "lubb." Blood is also pushed out to the arteries.

d The ventricle relaxes and because little blood remains, the pressure is low. Blood is drawn back toward the ventricle from the arteries. This causes the valves to close and the second heart sound, "dubb."

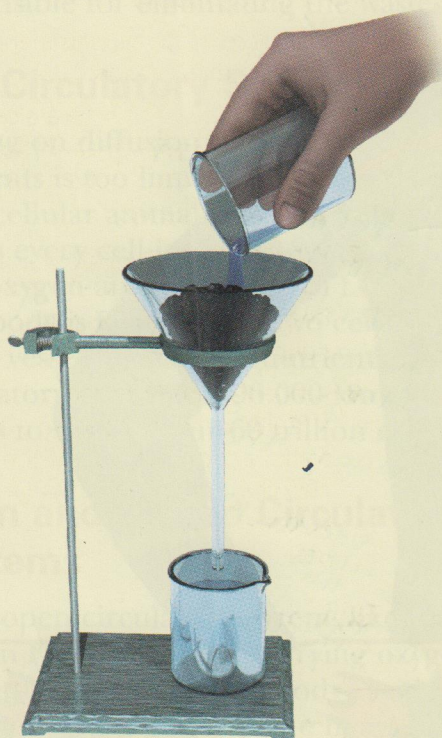
Figure 5

The human heart is a double pump, with four chambers and four sets of valves.

Try This A Filter Model

You can create a model of a filtering excretory system.

- Fill a funnel with aquarium charcoal and put a small beaker beneath it. Fill a second beaker with about 25 mL of water and add a few drops of food colouring.
- Pour the coloured water through the funnel and collect it in the small beaker.



- Compare the colour of the filtered water with the original.
1. Predict what would happen if the water was filtered once again.
- Test your prediction.

Excretory System

For unicellular organisms, getting wastes out of the cell is just as important as bringing in nutrients. Without a way to get rid of wastes, a cell would soon die. Multicellular organisms such as worms (**Figure 6**), insects (**Figure 7**), and humans (**Figure 8**) are faced with the same problem, on a much bigger scale. However, not every cell is designed to remove wastes. Specialized cells that work together in the excretory system are designed to remove wastes from the body or to store the wastes until it is appropriate to remove them. The excretory system also has a second function in most animals: it helps to regulate body water. As the contractile vacuole of the paramecium and amoeba prevent these cells from swelling, the excretory system ensures that water balance is maintained.

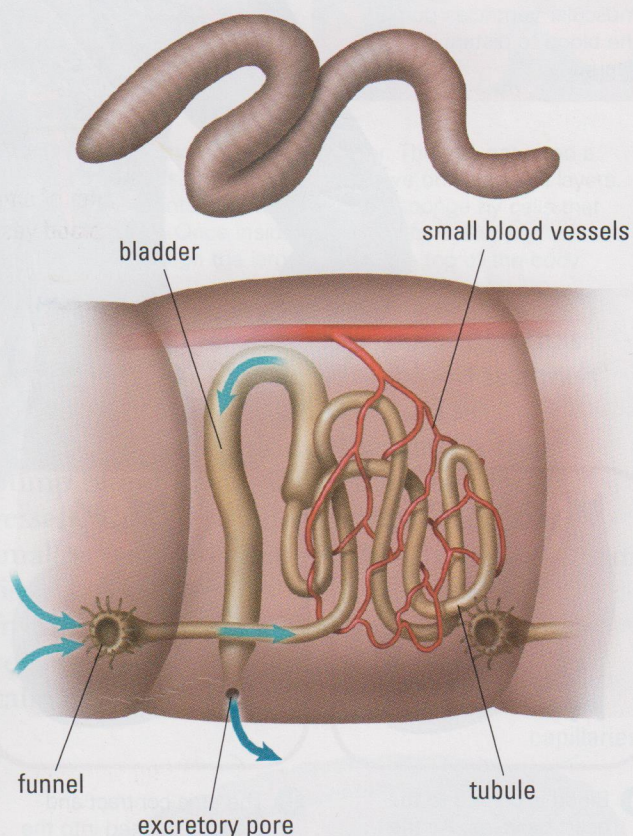


Figure 6

The earthworm uses a series of tubules to remove wastes from the blood and body cavity. Cells lined with cilia surround a funnel-like opening, and draw fluids from the body cavity into tiny tubules. The wastes are stored as urine and are held in a bladder for a short time. A series of small pores along the body wall are responsible for releasing the wastes from the tubules.

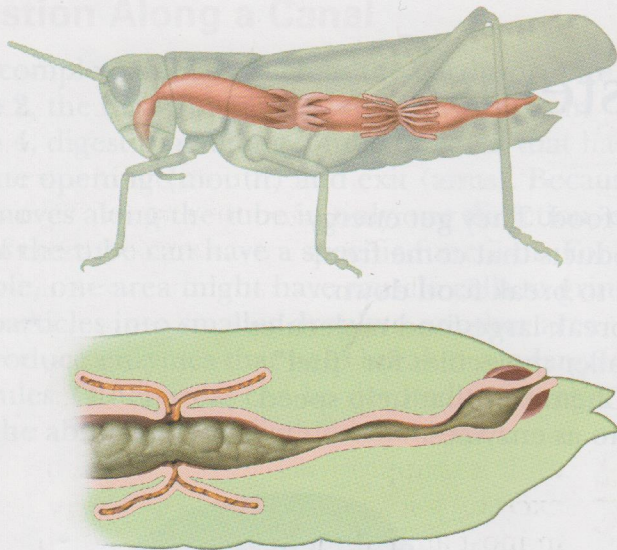


Figure 7

Tubules that run throughout the body cavity of an insect absorb wastes by diffusion. Wastes are released into the gut and eliminated with solid wastes from the anus.

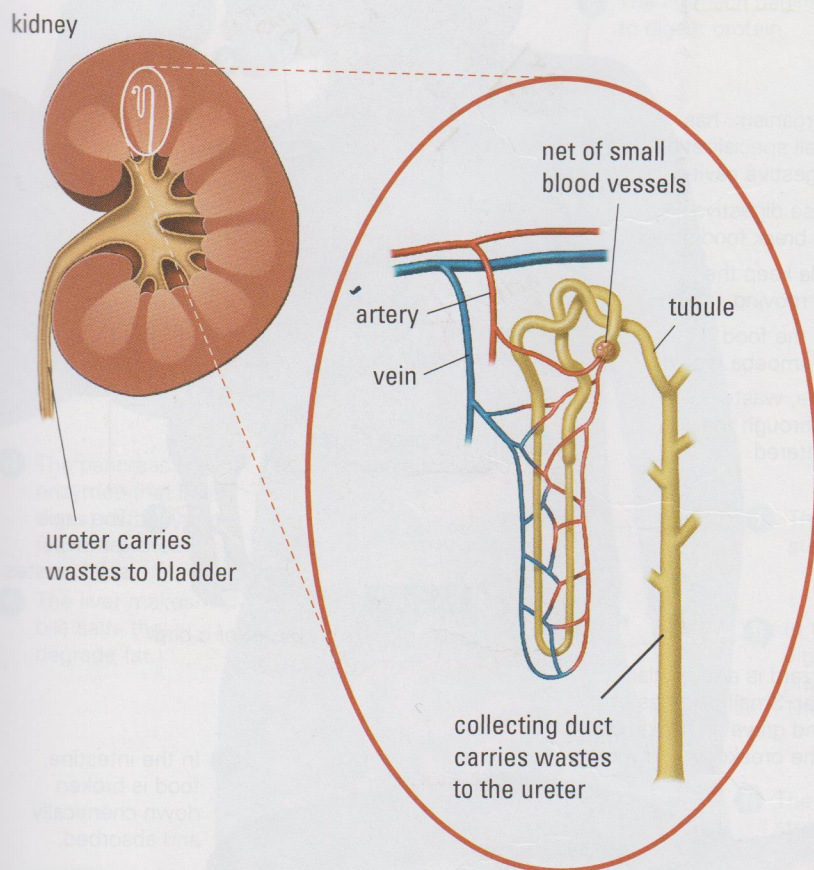


Figure 8

The human kidney contains millions of tubules. They filter wastes from the blood. High-pressure blood vessels push wastes across a thin membrane at the upper end of the tubules. Wastes are then carried to the bladder, where they are stored.

Understanding Concepts

1. Why do sponges not need a fluid transport system?
2. Why do multicellular animals need:
 - (a) an excretory system?
 - (b) a circulatory system?
3. What is the difference between a closed and an open circulatory system?
4. Draw a diagram of the movement of blood through the four chambers of the heart.

Making Connections

5. Compare the way plants and animals move fluids.
6. Compare an open and a closed circulatory system. Which one do you think is most efficient? Give your reasons.
7. Why is the muscle surrounding the left ventricle of a human heart larger than the muscle surrounding the right ventricle?
8. A heart murmur is caused by a faulty valve that allows blood to flow back into one of the chambers. Explain why this two-way flow of blood would create problems.

Exploring

9. Improve upon the design of the filtering system in the Try This. You will be allowed to run the fluid through the filter only once. Work with your classmates to set up a scale to rate the efficiency of the filtering system.

Reflecting

10. How could an animal use specialized cells to improve on one of the fluid transport systems described in this section?

Animal Digestive Systems

Unlike plants, animals cannot make their own food. They get energy either from other organisms, or from food products that come from another living thing. They use specialized cells to break food down.

Digestion is the process your body uses to break large food molecules into smaller molecules. Your body uses the smaller molecules for “fuel” and as building blocks for growth and repair. Chemicals that help speed up the process of digestion are often referred to as enzymes.

Digestion in a Sac

Many animals with simple body plans, such as the hydra in **Figure 1**, have a digestive system with a single opening. These saclike cavities both take in food and expel undigested wastes.

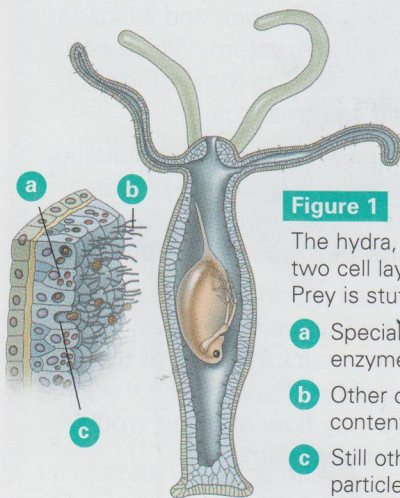


Figure 1

The hydra, a small pond organism, has two cell layers and little cell specialization. Prey is stuffed into the digestive cavity.

- a** Specialized cells release digestive enzymes that begin to break food down.
- b** Other cells with flagella keep the contents of the cavity moving.
- c** Still other cells engulf the food particles, much as an amoeba would.

Once digestion is complete, waste products are pushed out through the same opening the food entered.

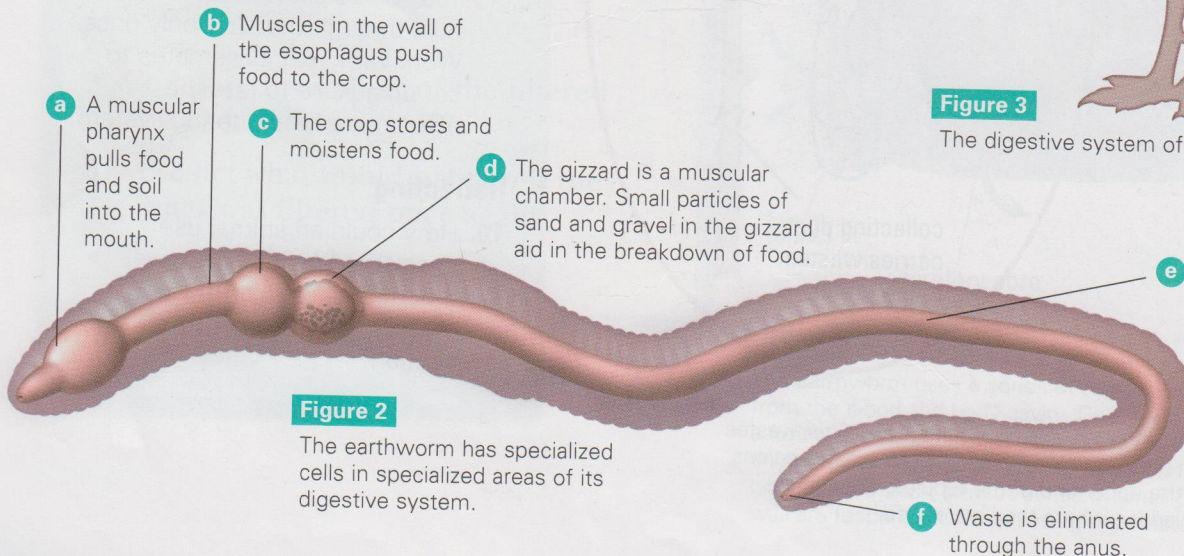


Figure 2

The earthworm has specialized cells in specialized areas of its digestive system.

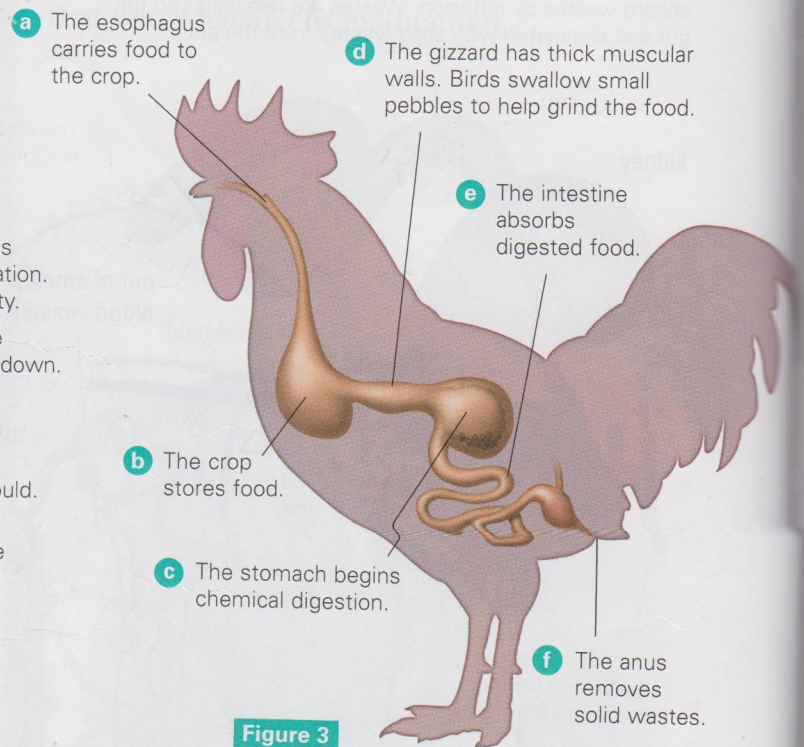


Figure 3

The digestive system of a bird

- a** The esophagus carries food to the crop.
- b** The crop stores food.
- c** The stomach begins chemical digestion.
- d** The gizzard has thick muscular walls. Birds swallow small pebbles to help grind the food.
- e** The intestine absorbs digested food.
- f** The anus removes solid wastes.

Digestion Along a Canal

More complex animals, such as the earthworm in **Figure 2**, the bird in **Figure 3**, and the human in **Figure 4**, digest food along a tube or canal that has a separate opening (mouth) and exit (anus). Because food moves along the tube in only one direction, each area of the tube can have a specific functions. For example, one area might have muscle cells to grind food particles into smaller droplets; another area can produce enzymes that help break down large molecules. Other areas can be devoted to storage or to the absorption of digested molecules.

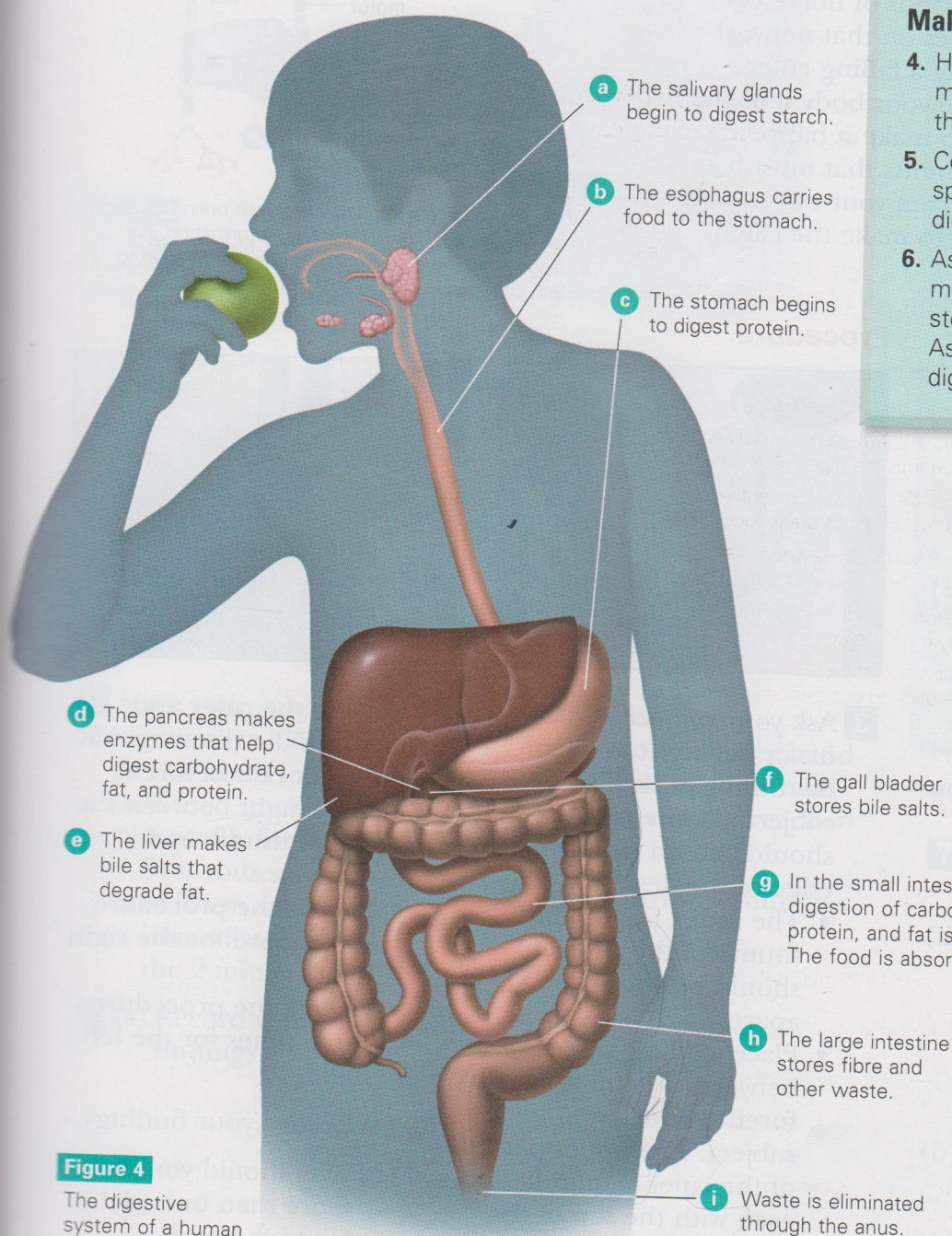


Figure 4

The digestive system of a human

Understanding Concepts

1. Explain *digestion* in your own words.
2. What advantage is there in having digestion take place in a tubelike structure rather than a saclike structure?
3. Summarize how human digestion occurs in the mouth, stomach, and small intestine. Show your answer in the form of a chart or diagram.

Making Connections

4. How is the bird's digestion more like that of an earthworm than that of a human?
5. Compare an amoeba with a specialized cell in the human digestive system.
6. Aspirin removes the protective mucous coating that lines the stomach. Explain why taking Aspirin tablets may cause digestive problems.

Design Challenge

What function is your model cell specialized to perform? Could you expect it to perform the functions needed in the digestive system? Can it live without the functions performed by the digestive system?