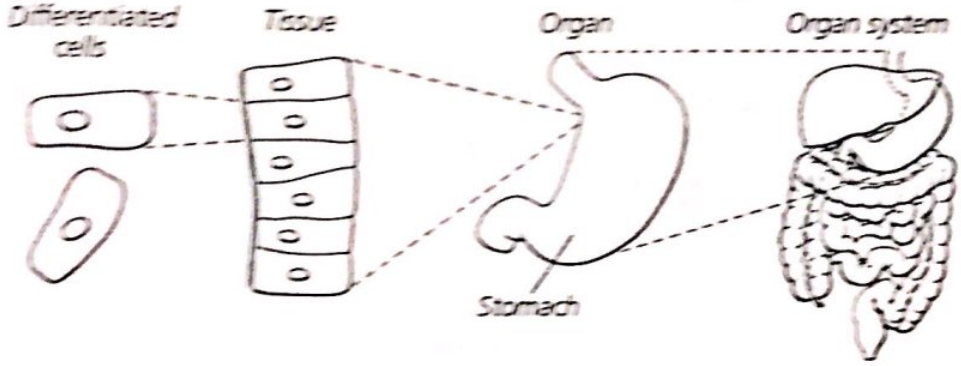
LESSON 2

Organization of Multicellular Organisms

BIO.A.1.2.2

All organisms are systems, with parts that work together to help them live, grow, and reproduce. Each of these parts has a structure that helps it to carry out its function. The parts of a multicellular organism can be examined at different levels. The simplest level is the cell, while the most complex is the individual organism.



The human digestive system has different levels of organization.

An object's *structure* is the arrangement of its parts. Its *function* is its specific activity or role.

An organism's cells make up its tissues. Tissues compose organs. Different organs work together as organ systems.

Cells and Tissues

The basic structural unit of a living thing is the cell. Cells themselves are tiny systems with organelles and membranes that allow them to carry out life processes. The individual cells in a multicellular organism do not carry out every life function of the organism. Instead, different cells perform different jobs. They are *differentiated*, or specialized to perform particular functions.

Differentiated cells are specialized to perform particular functions within a multicellular organism.

In mammals, red blood cells are specialized to deliver oxygen to body tissues. Red blood cells are small, round disks that are thin and flexible. Their shape allows them to move easily through even the narrowest blood vessels. In contrast, nerve cells have long, thin branches that extend from the main part of the cell. These structures help them deliver information from one part of the body to another.

In multicellular organisms, cells are differentiated because they have specialized functions.

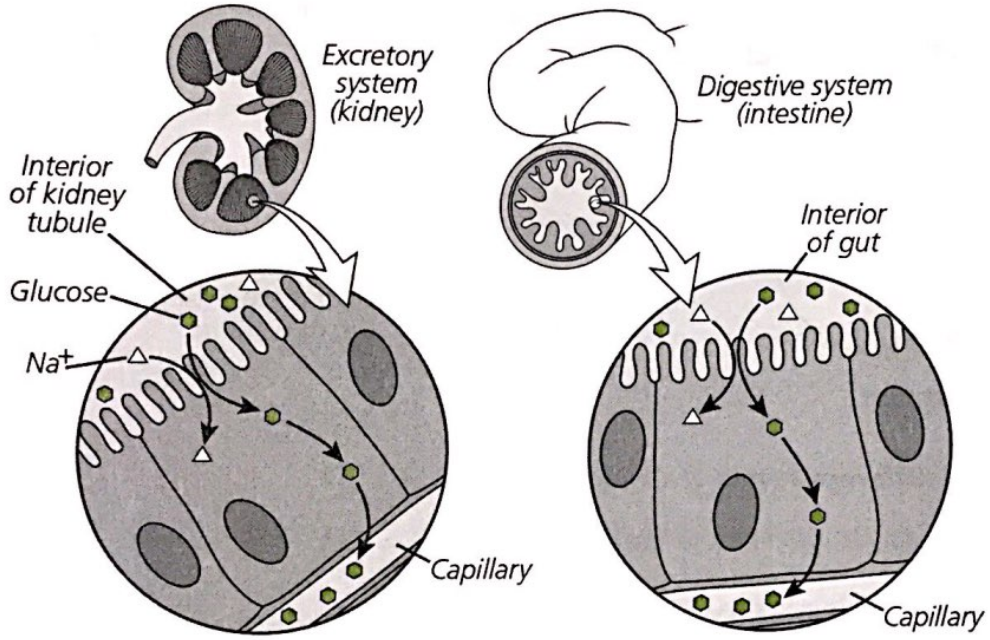
Cells form tissues. A **tissue** is a group of similar cells that share a structure and function. For example muscle tissues are made up of very long, thin cells that can *contract*, or shorten, to allow movement. Groups of muscle cells work together to move the body.

Epithelial tissues cover body surfaces in animals. The outer layer of skin is epithelial tissue made up of small, flat interlocking cells. This epithelial tissue encloses and protects the organism. *Connective tissues* hold organs in place and attach epithelial tissue to other tissues.

A **tissue** is a structure made of similar cells that perform a specific function.

Epithelial cells form sheets of tissue that enclose or line body parts. Epithelial tissue may have one or many layers.

Fat and bone are *connective tissues.* Blood is a form of connective tissue, even though it is a fluid.



Capillaries are the narrowest blood vessels, with walls only one cell thick. Substances in the blood move across capillary walls, into and out of cells.

The image above shows cells from two different organ systems. These specialized cells form tissues that line the kidney tubule and intestine. How do the cells' similar structures help them to carry out their functions?

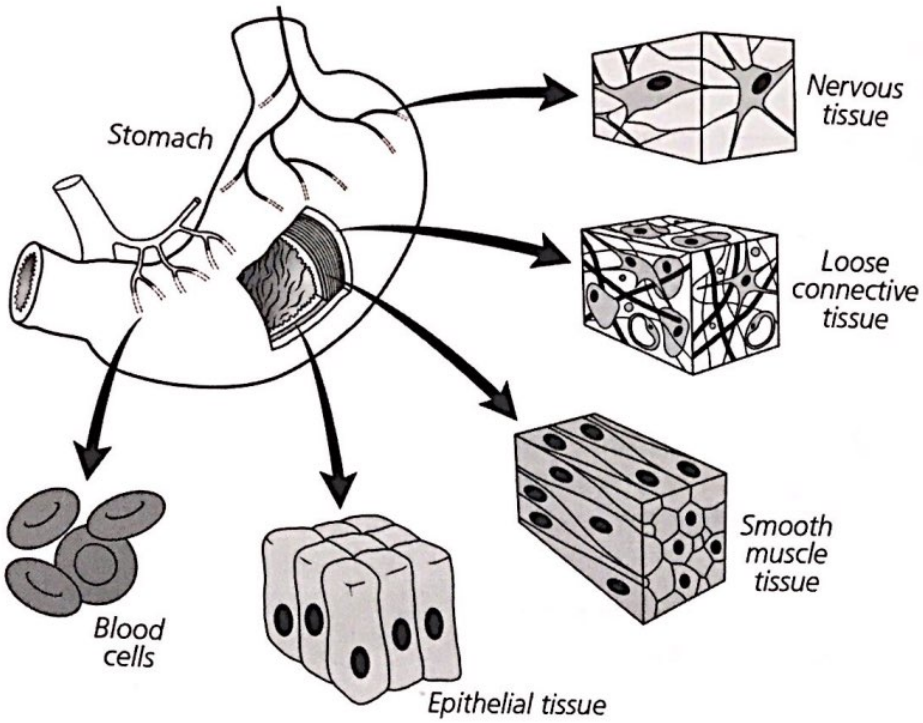
The function of the cells is to absorb dissolved minerals and nutrients and allow them to cross into the circulatory system. Both cells have a surface with projections of the plasma membrane. This aids in absorption by increasing the surface area over which solutes may cross into the cell.

Organs and Systems

Within a multicellular organism, different types of tissues can form an **organ.** For example, the stomach is an organ that *digests*, or breaks down, food. Muscle tissues in the stomach help mix food with gastric juices. Epithelial tissues in the inner lining of the stomach secrete acidic fluids that aid in digestion. Other tissues secrete mucus to protect the stomach from being harmed by these acids, and blood supplies oxygen to stomach tissues.

An **organ** is a structure, made up of two or more tissue types, that performs a specific job.

Glands in the stomach lining secrete strong acids. Gastric (stomach) acid has a pH between 1 and 3.



The stomach is an organ made up of various kinds of tissue.

Organs form **organ systems,** groups of related organs that work together to do a particular job. For example, the human *digestive system* includes the mouth, esophagus, stomach, intestines, gallbladder, liver, and pancreas. These organs work together to break down food into small molecules.

After food is digested, blood vessels in the intestines absorb useful molecules. These molecules are transported to cells in every part of the body, where they are used for energy and as raw materials to repair and build new cells.

In a complex multicellular organism, organ systems function to meet the basic needs of cells throughout the body. Recall that cells are specialized and cannot carry out all life functions on their own. They rely on the body's systems to meet some of their needs. Functions of organ systems include the following:

- Exchanging materials with the environment
- Transporting materials to and from cells
- Allowing movement
- Storing nutrients for later use
- Responding to stimuli

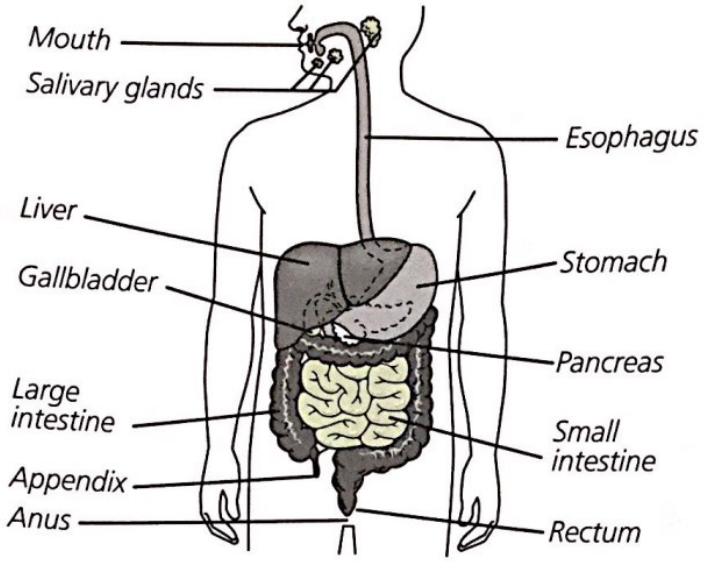
Muscle tissues may be under voluntary control or involuntary control, as with the smooth muscle lining the stomach.

An **organ system** is a group of organs that work together to perform a specific function.

Human organ systems include:

- Nervous
- Endocrine
- Skeletal
- Muscular
- Integumentary
- Immune
- Circulatory
- Respiratory
- Digestive
- Urinary
- Reproductive

In a unicellular organism, a single cell would carry out all of these functions.

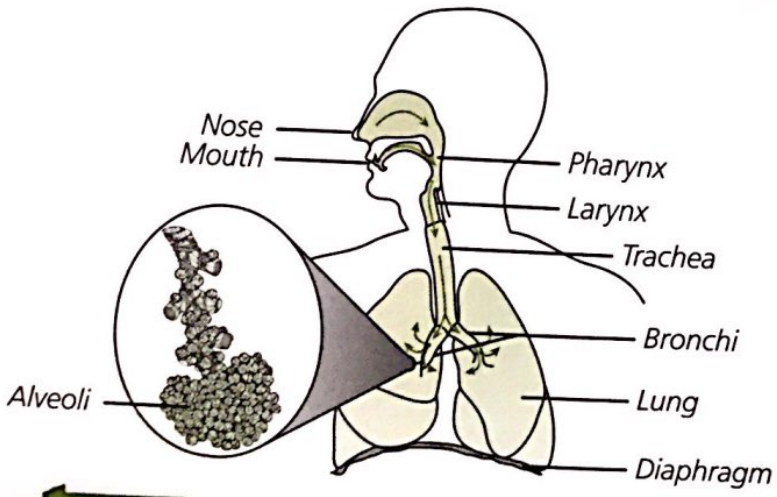


The diagram above shows the digestive system. How do the organs of the digestive system work together to carry out the function of digestion?

The mouth moistens and breaks down ingested food, which is carried to the stomach by the esophagus. There, it is broken down by stomach acids and released into the small intestine. The pancreas and liver secrete substances into the small intestine to help complete digestion. Then, the digested nutrients and minerals are absorbed into the body by the small intestine. Any undigested material passes into the large intestine, where water is reabsorbed and bacteria convert some of the waste into vitamins.

Interrelated Organs Systems

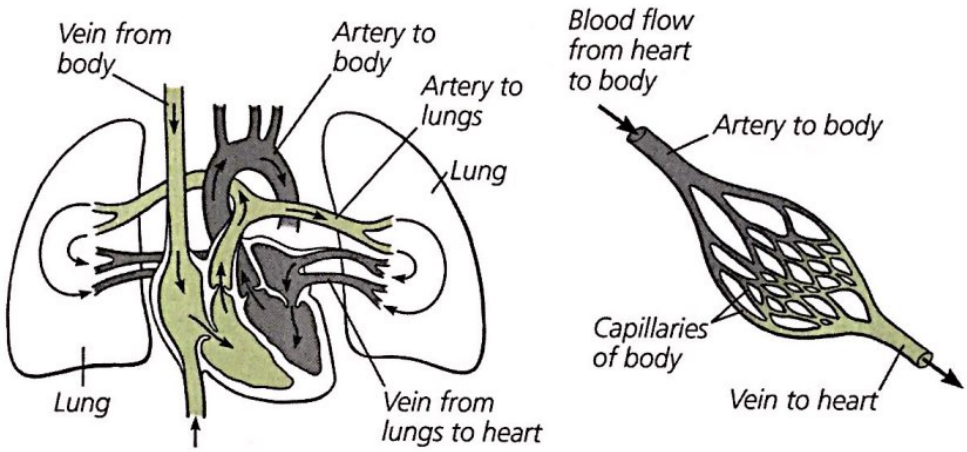
An organ system may be dedicated to a single function or share multiple functions with other systems. For example, the main functions of the *respiratory system* are to bring oxygen into the body and to remove the carbon dioxide produced by cells from the body. The organs of the respiratory system work together to accomplish these functions.



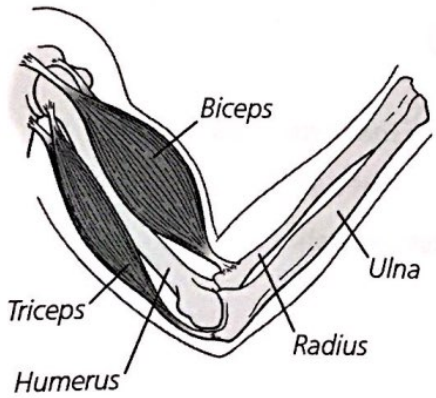
The diaphragm contracts to expand the lungs, causing air to move through the nose and mouth and into the trachea and bronchi. The bronchi branch into smaller tubes that lead to microscopic, sac-like *alveoli* in the lungs.

Oxygen moves from the alveoli into the surrounding capillaries. At the same time, carbon dioxide moves from the capillaries into the alveoli and is exhaled. This process is called *gas exchange.*

Capillaries are part of the *circulatory system,* which includes the heart, blood, arteries, and veins. This system transports oxygen, nutrients, carbon dioxide, and metabolic wastes throughout the body. The diagram shows the main parts of the circulatory system. Notice that there are two circulatory pathways: one between the right side of the heart and the lungs, and another between the left side of the heart and the body.



Just as the respiratory and circulatory systems work together, so do other organ systems. The *muscular system* consists of muscles, organs that can contract in response to a nerve signal. Contracting muscles can exert forces on the bones they are attached to, allowing the organism to move. Muscles work in opposing pairs. One muscle in a pair causes motion in one direction around a joint. Its partner causes motion in the opposite direction, as shown below.



Gas exchange refers to the movement of carbon dioxide and oxygen between an organism and its environment. Because most cells of a multicellular organisms are not in direct contact with the environment, gas exchange is a function of organ systems.

All veins carry blood toward the heart. All arteries carry blood away from the heart.

Bones are part of the skeletal system.

Muscles exert force by contracting, not by lengthening. Muscles work in opposing pairs to move the bones of the body.

Skeletal muscle tissue is under voluntary control. You can decide whether to move these muscles.

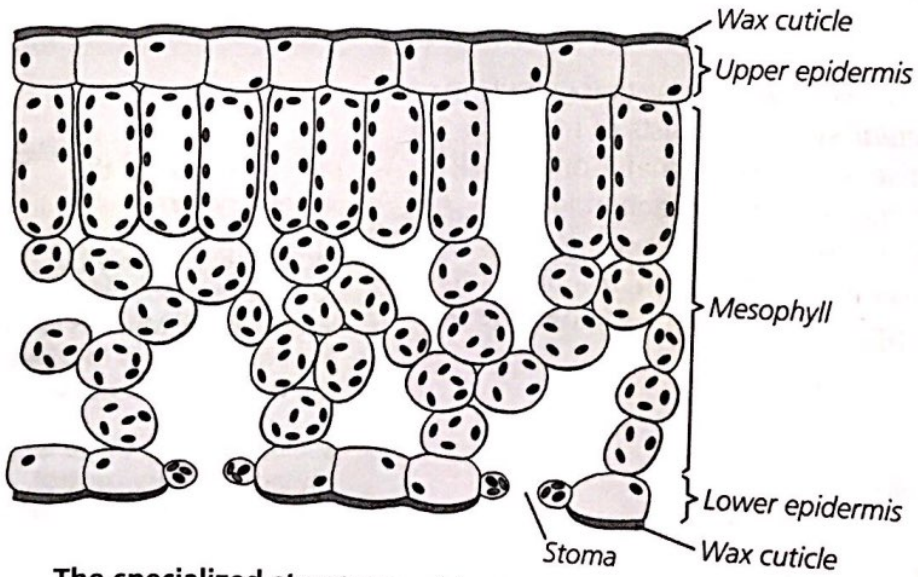
Describe how two or more organ systems work together to provide cells with needed oxygen and remove carbon dioxide they produce.

The respiratory system functions to bring oxygen into the body and expel carbon dioxide. Gas exchange occurs in the alveoli, where dissolved oxygen enters the capillaries and carbon dioxide in the capillary blood crosses into the lungs. Capillaries are part of the circulatory system, which transports blood to all the cells of the body. When blood from the lungs is pumped to cells and tissues, gases are again exchanged with the cells.

Structure and Function in Plants

The structures of plant cells, tissues, and organs help them to carry out their specific functions. Plant *vascular tissues* are made of differentiated cells that stack together to form tube-like structures. This structure allows them to transport food, water, and minerals throughout the plant body.

In a plant leaf, the inner mesophyll cells carry out **photosynthesis.** The upper layer of the leaf is transparent, so light can pass through them to the cells beneath. The wax cuticle keeps water in the leaf. The underside of a leaf contains *stomata,* openings that allow water vapor and other gases in and out of the plant.



The specialized structures of leaf cells and tissues help them carry out specific functions.

Without *vascular systems* to transport material, plants would grow no taller than mosses.

Photosynthesis is the process of using the energy from sunlight to convert water and carbon dioxide to glucose and oxygen.

A *stoma* (pl. *stomata*) is an opening that allows gases such as oxygen, carbon dioxide, and water vapor in and out of the leaf. Guard cells on either side of the stoma regulate the size of the opening.

The prefix *meso-* means "middle."

Many trees in temperate environments have broad, flat leaves. How does this leaf structure support the function of obtaining energy?

A A flatter surface allows more oxygen to enter the leaf.

B A flatter surface allows more water to be retained in the leaf.

C A larger surface area allows more light to reach the mesophyll.

D A larger surface area allows more room for photosynthetic cells.

Plants obtain energy from sunlight, which passes through the upper layers of a leaf. A broad, flat leaf has a large surface area, which provides more room for sunlight to enter the leaf. Thus, the shape of the leaf is suited for collecting the necessary amount of sunlight. A flatter, broader surface contains more stomata, allowing more oxygen to enter the leaf. However, oxygen is not a form of energy, so choice A is incorrect. A flatter surface makes water conservation more difficult, so choice B is incorrect. Compared to a thicker leaf of the same volume and a smaller surface area, one with a larger surface area does not have more room for mesophyll cells. Therefore, choice D is incorrect. The upper layers of a leaf allow sunlight to pass through and reach the middle layer, where photosynthesis takes place. A broad, flat leaf has a large surface area, which provides more area over which sunlight may enter the leaf and reach the mesophyll beneath. Choice C is correct.

Please read each question carefully. For a multiple-choice question, circle the letter of the correct response. For a constructed-response question, write your answers on the lines.

1 Which sequence is arranged from simplest to most complex?

A squamous cell → epithelial tissue → skin → integumentary system → human

B squamous cell → skin → integumentary system → epithelial tissue → human

C human → integumentary system → squamous cell → skin → epithelial tissue

D human → squamous cell → skin → epithelial tissue → integumentary system

2 Two types of tissues that compose the stomach organ are epithelial and connective. Which function of epithelial tissues distinguishes them from connective tissues?

A They support and link to other tissues.

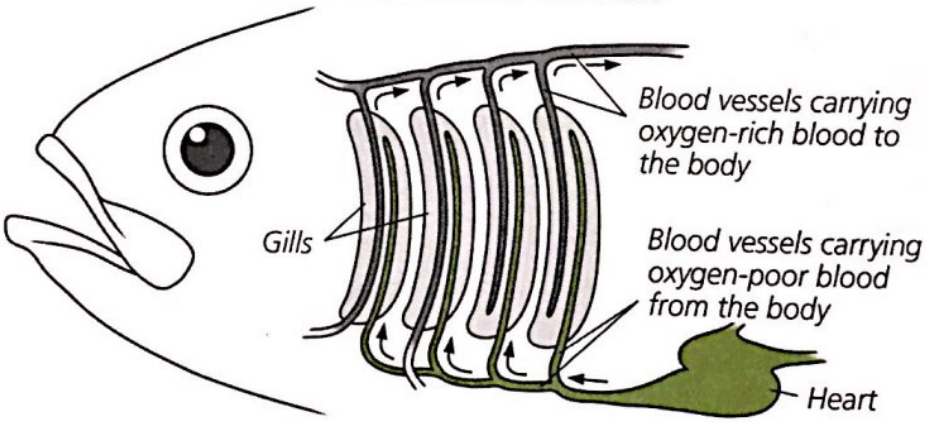
B They churn and move food through the stomach.

C They transmit messages rapidly through the body.

D They line the inner and outer surfaces of the stomach.

Use the diagram below to answer question 3.

ORGAN SYSTEMS IN A FISH



3 What function do these organ systems in the fish perform together?

A digestion

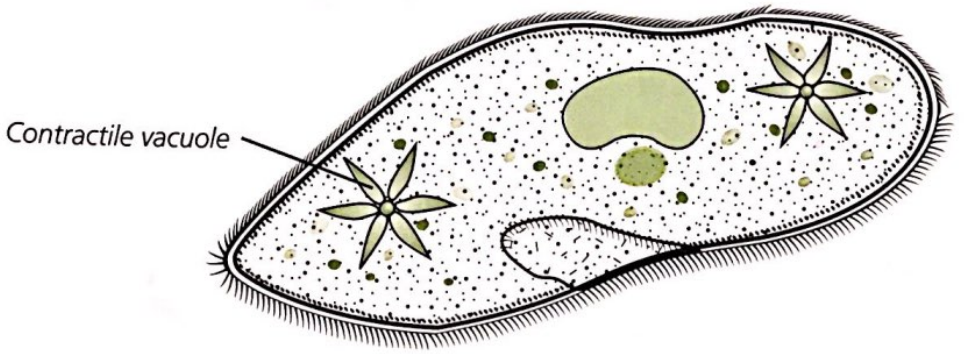
B locomotion

C obtaining energy

D exchanging gases

Use the diagram below to answer question 4.

FRESHWATER PROTIST



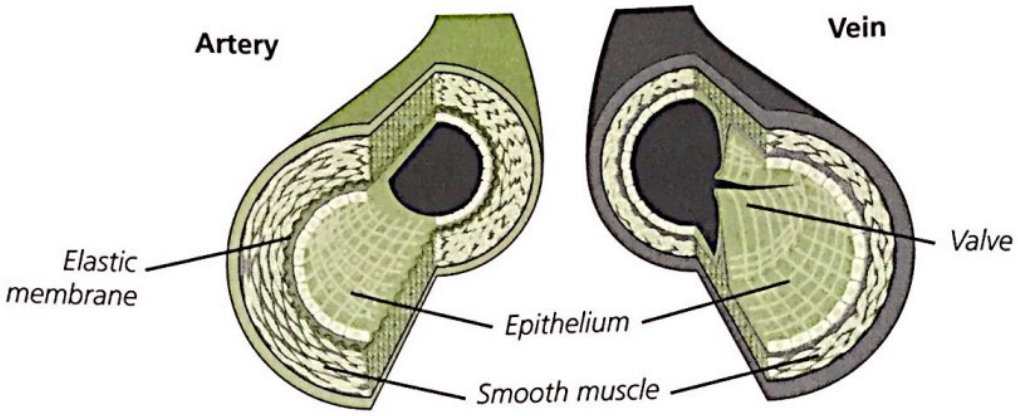
4 The diagram shows a single-celled freshwater protist. The contractile vacuole pumps water out of the cell.

A Describe how the function of the contractile vacuole helps the protist stay alive.

B Describe how the same function is carried out in animals. Identify at least one organ or system involved in this function.

C Describe how the same (or a similar) function is carried out in plants. Identify at least one organ, structure, or cell type involved in this function.

Use the diagram below to answer question 5.



5 The heart pumps blood forcefully through the arteries, which branch into smaller and smaller vessels until they form the smallest vessels, the microscopic capillaries. Minerals, nutrients, and dissolved gases pass between capillary blood and the cells of the body. After capillary networks pass through tissues, these vessels merge to form veins, which return the blood to the heart. The diagram above shows cross sections of an artery and a vein.

A Describe how the structures of arteries are specialized for their particular function.

B Describe how the structures of veins are specialized for their particular function.

C Describe how the function of capillaries is made possible by their structure.