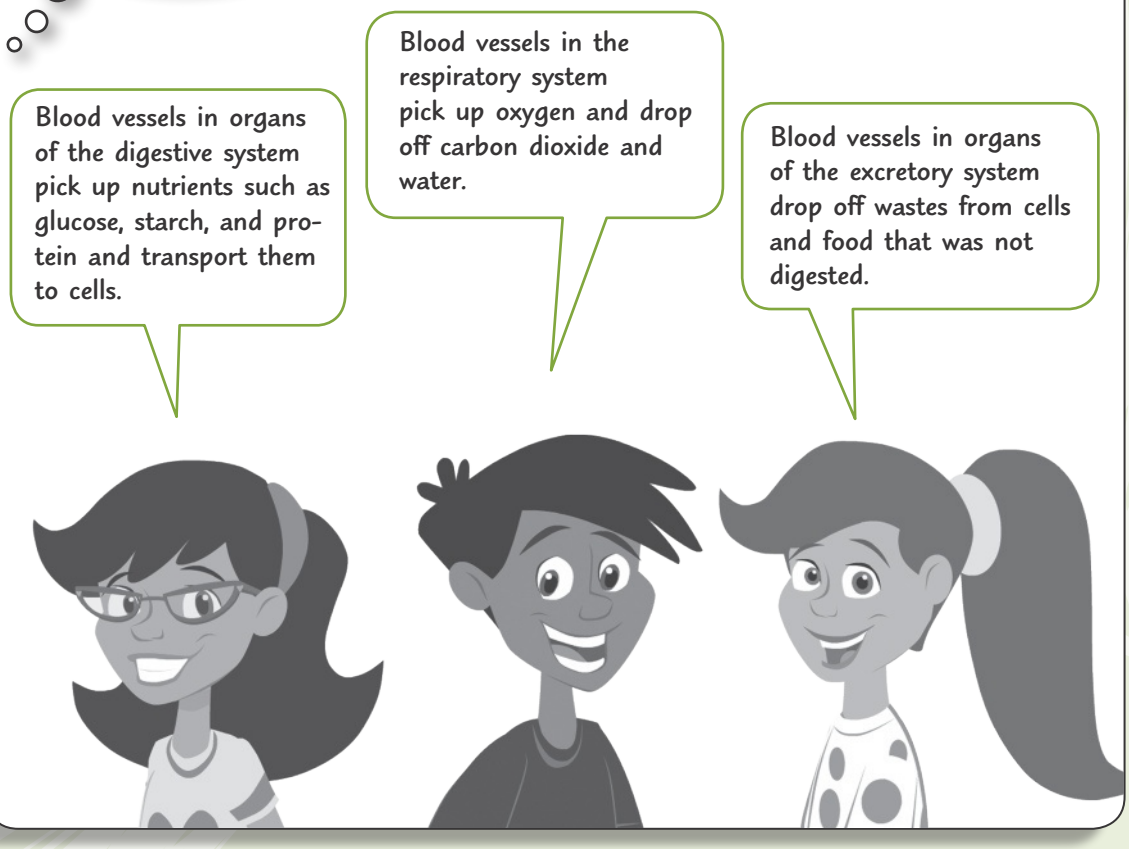
Similarities and Differences Among Living Organisms

TOPIC 1

What do You Think?

Body Systems at Work



TOPIC 1

Similarities and Differences Among Living Organisms

Vocabulary

active transport
amino acids
cell
cell membrane
cell respiration
chloroplast
circulation
cytoplasm
diffusion
digestion
enzymes
excretion
homeostasis
hormone
immunity
inorganic
metabolism
mitochondria
nucleus
organ
organ system
organelle
organic
receptor molecule
reproduction
respiration
ribosome
simple sugars
synthesis
tissue
vacuole

Topic Overview

Earth's living environment is made up of millions of diverse organisms, from towering redwood trees, sleek antelope, and mushrooms that grow in huge circles, to microscopic bacteria, one-celled organisms that turn the tides red, and the students in your class.

These living organisms are both similar to and different from each other. They also differ from the nonliving parts of the environment. Although that difference may seem obvious, scientists have not been able to agree upon a simple definition of life.

The Characteristics of Life

Although there is no simple definition of life, most scientists agree that living things share certain characteristics that distinguish them from nonliving things.

- Living things are organized structures. All are made of one or more **cells,** which are the basic units of structure and function. They maintain their cellular organization throughout life.
- Living things use energy to maintain life and to grow and develop. These activities require that the cells carry out various chemical reactions. The combination of all the chemical reactions that occur in an organism is called **metabolism.**
- Living things maintain a fairly stable internal environment even when their external environment changes dramatically. The maintenance of this internal stability is known as **homeostasis.** To maintain homeostasis, organisms must respond and adapt to both their internal and external environments.

- Living things pass hereditary information to new organisms of the same type in the process of **reproduction.**

Only living things share the characteristics of life. Nonliving things have no functioning cells and no metabolic activity; they do not maintain homeostasis, nor do they reproduce.

Diversity Among Living Things

Although living things share the characteristics of life, there are differences among the many kinds of organisms. Throughout history, people have tried to bring order to all the varieties of life on Earth by grouping, or classifying, them. Several classification systems have been popular at different times. As we learn more about the similarities among organisms and how they carry out their life processes, classification systems change. Currently, biologists classify organisms into kingdoms, which are large groups of related organisms.

Similarities Among Living Things

Although living things have many differences, they are also alike in important ways. The first similarity is that they share the characteristics of life. They are made of cells, reproduce, maintain homeostasis, and carry out metabolic activities. They also share similar life processes, chemical composition, and organization.

Life Processes Living things are similar in that they rely on a variety of specific processes to maintain life. Organisms may differ in the way they carry out these processes, however. Some of these life processes include

- obtaining nutrients from the environment and breaking them down for transport
- transporting materials throughout the organism
- breaking nutrients into smaller units to release the chemical energy stored in them through the process known as **cell respiration**
- combining simple substances into complex substances during the process known as **synthesis**
- increasing the size or number of cells through the process of growth
- removing waste products from the organism through the process known as **excretion**
- responding to internal and external stimuli
- reproducing more of their own species

Chemical Composition All living things are made of four main elements—carbon, hydrogen, oxygen, and nitrogen—as well as many other elements in smaller amounts. The elements combine to form molecules.

Organic molecules contain BOTH carbon and hydrogen. Organic molecules include all of the major molecules of life: structural molecules, such as those in cell walls and membranes, as well as biologically active molecules, such as the enzymes that help carry out the chemical reactions of life. DNA, protein, fats, and carbohydrates—such as glucose ($C_6H_{12}O_6$) and starch—are **organic** molecules.

Digging Deeper

Many scientists do not include viruses with living things. The reason is that viruses are not cells. Instead they are made only of protein and genetic material. As a result, viruses do not independently carry out all processes of life. To reproduce, they must invade the cell of a living organism.

Inorganic molecules do *not* contain *both* carbon and hydrogen, but can contain any other combination of elements. Inorganic molecules include salts and minerals, most acids and bases, oxygen (O_2), carbon dioxide (CO_2), and water (H_2O), the most abundant substance in any organism.

Organization The shared organization of specialized structures that work together to accomplish a specific task is another similarity of living things. In other words, organisms share a similar "building plan." The basic structural and functional unit of living things is the cell.

Simple organisms may consist of just one cell; complex organisms may consist of billions of cells. Most cells contain specialized structures called **organelles,** which have specific life maintenance functions.

This organization of cells into increasingly specialized structures is the basis for much of the complex life on Earth. Complex organisms have several advantages over simpler organisms. For example, many complex organisms can explore their environment or gain energy in ways that simpler organisms cannot. In Figure 1-1, notice that the organizational structure of organisms resembles a pyramid with a base of cells.

In multicellular organisms, groups of specialized cells may be grouped into **tissues** to expand how they function. For example, a single muscle cell would not be strong enough to move any organism—not even one as light as a hummingbird. Grouped with other muscle cells, however, muscle tissue can move an elephant.

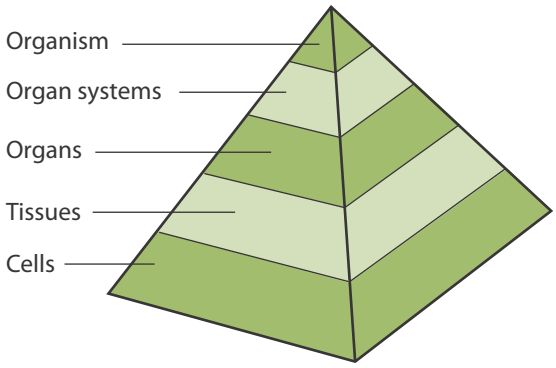


Figure 1-1. The structural organization of organisms

Different kinds of tissues may be combined to form an **organ** that performs one of the life processes. Several organs may work together as an **organ system** that also performs one of the life processes. For example, the heart is an organ with the function of pumping blood. The organ may be a simple "arch" like the heart of the earthworm, or it may be a complex four-chambered structure like the heart of a monkey. In either case, the organ's function is to pump blood. Each heart is part of an organ system that transports materials throughout the body.

Review Questions — Set 1.1

1. State two ways in which a single-celled organism, such as an amoeba, and a human body cell are alike.

2. One characteristic of all living organisms is that they

(1) make food
(2) live on land
(3) maintain homeostasis
(4) move from place to place

3. Which sequence is listed in order from simplest to most complex?

(1) tissue → cell → organ system → organ
(2) cell → tissue → organ → organ system
(3) cell → tissue → organism → organ
(4) organism → tissue → organ → organ system

4. A student brings a specimen and claims it is a living organism. Explain how a microscope could be used to determine if the specimen is a living thing.

5. A biologist would most likely study all of the chemical activities of an organism to obtain information about the organism's
   (1) number of mutations
   (2) reproductive cycle
   (3) development
   (4) metabolism

6. Cells are to tissues as organs are to
   (1) organ systems
   (2) cells
   (3) genes
   (4) organelles

7. The ability of an organism to maintain internal stability is known as
   (1) metabolism
   (2) homeostasis
   (3) circulation
   (4) excretion

8. State two ways living and nonliving things differ.

9. Which statement about cells is *not* true?
   (1) One or more cells make up all living organisms.
   (2) Cells carry on the basic life functions of living organisms.
   (3) Cells contain structures that carry on life functions.
   (4) Most cells cannot reproduce.

10. Living things are made mostly of these four main elements:
   (1) hydrogen, oxygen, nitrogen, and protein
   (2) water, protein, carbohydrate, and fat
   (3) carbon, hydrogen, oxygen, and nitrogen
   (4) glucose, salt, mineral, and base

Cells: The Basic Structure of Life

Many of the world's organisms are made of only one cell, but all organisms—no matter how simple or complex—are made of cells. Each cell contains a jellylike substance surrounded by a thin membrane. Most cells also contain organelles that perform specific tasks for the cell. Despite their seemingly "simple" structure, cells carry out the processes of life and function together in a coordinated manner.

Inside the Cell

The jellylike substance inside the cell is known as the **cytoplasm.** The cytoplasm contains specialized structures, transports materials through the cell, and is the site of many chemical reactions associated with the cell's metabolism.

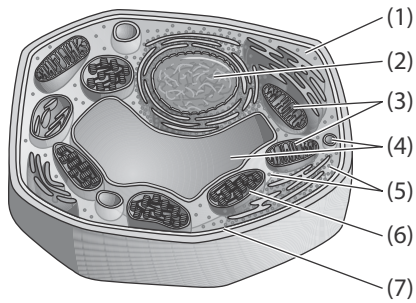
Organelles Organelles are formed of many different molecules and vary in size, shape, and function. They interact to transport materials, extract energy from nutrients, build proteins, dispose of waste, and store information. Figure 1-2 shows several vital organelles.

Nucleus The **nucleus** is a large structure that controls the cell's metabolism and stores genetic information (DNA in chromosomes). Many people think of the nucleus as the cell's "control center" because it directs the cell's activities.

Vacuoles The storage sacs within the cytoplasm are **vacuoles.** They may contain either wastes or useful materials such as water or food. Some vacuoles are specialized to digest food; others pump excess water out of the cell. Vacuoles in plant cells are usually a lot larger than the vacuoles in animal cells, as shown in Figure 1-2.

Ribosomes The cell contains many tiny structures, called **ribosomes,** that are important to the process of making protein. Some ribosomes are attached to membranes in the cell. Others float in the cytoplasm.

(A) A typical plant cell



(B) A typical animal cell

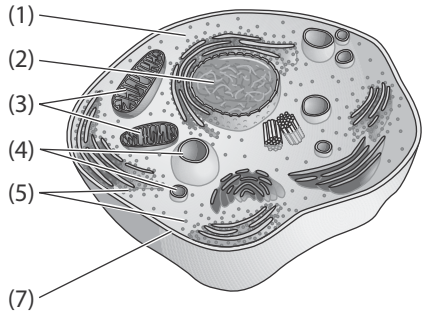


Figure 1-2. Some parts of plant and animal cells: (1) cytoplasm, (2) nucleus, (3) mitochondria, (4) vacuoles, (5) ribosomes, (6) chloroplast, (7) cell membrane.

MemoryJogger

Bacteria cells contain no nucleus; their genetic material simply floats in the cytoplasm as a large chromosome. Some bacteria have smaller loops of DNA as well.

Mitochondria **Mitochondria** are pod-shaped structures that contain special proteins, known as **enzymes,** used to extract energy from nutrients. Mitochondria are sometimes called the cell's powerhouses because they release most of the cell's energy.

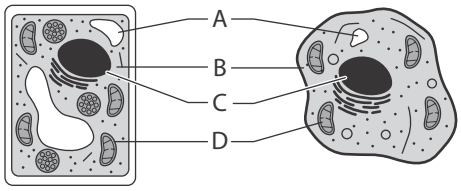
Chloroplasts The green structures found in plants and some one-celled organisms are **chloroplasts.** They contain the green pigment chlorophyll and capture light energy, which is then used to produce food for the plant. Animal cells do not contain chloroplasts.

Review Questions — Set 1.2

11. Which structure is the boundary between a living cell and its environment?

(1) cell membrane
(2) cytoplasm
(3) vacuole
(4) ribosome

12. The structures labeled A, B, C, and D in the diagram below represent



(1) organelles
(2) organs
(3) nuclei
(4) mitochondria

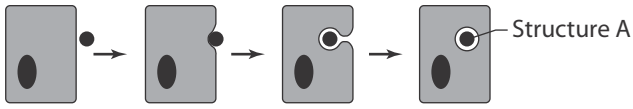
13. The cell nucleus functions

(1) in obtaining energy for the cell
(2) in the storage of digestive enzymes
(3) as the center of control for cell metabolism and reproduction
(4) in the transport of materials throughout the cell

14. The genetic material of an animal cell is found in the

(1) nucleus
(2) cytoplasm
(3) ribosomes
(4) vacuole

15. In the diagram below, structure A is most probably a



(1) mitochondrion
(2) ribosome
(3) vacuole
(4) nucleus

16. Current evidence indicates that ribosomes are most closely associated with

(1) contraction of the cytoplasm
(2) production of DNA
(3) synthesis of protein
(4) regulation of mitosis

17. Mitochondria are organelles that

(1) store digestive enzymes
(2) package cell products
(3) release energy from nutrients
(4) manufacture cell protein

18. Which cell organelles are most closely associated with energy changes in a plant?

(1) mitochondria and chromosomes
(2) chloroplasts and mitochondria
(3) chromosomes and nucleus
(4) chloroplasts and nucleus

19. Which is the most accurate statement concerning protein synthesis in cells?

(1) Proteins are synthesized by mitochondria in all living cells.
(2) Proteins are synthesized at the ribosomes in all living cells.
(3) Proteins are synthesized at the ribosomes in plant cells only.
(4) Proteins are synthesized by nuclei in animal cells only.

The Cell Membrane

The **cell membrane** is a thin structure that surrounds the cell. It is made mainly of fats (lipids), with some proteins embedded throughout. Some of the functions of the cell membrane include

- separating the contents of the cell from the outside environment
- controlling the transport of materials—including waste products—into and out of the cell
- recognizing and responding to chemical signals

Maintaining Separation Cells are organized internally. Without the cell membrane, this organization would be lost.

Unlike animals, plants and most bacteria and fungi have a cell wall outside the cell membrane. This wall of plant cells is made of nonliving material (a carbohydrate called cellulose) that surrounds the cell and gives it strength and rigidity. If the plant gains too much water, its membranes could burst. The cell wall helps prevent this.

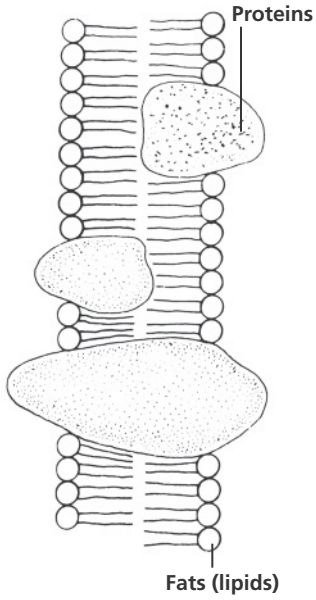


Figure 1-3. The cell membrane

Controlling Transport In and Out of the Cell If the cell is to survive, the membrane cannot totally separate the cell from its environment. Some materials, such as water, oxygen, and nutrients, must pass through the membrane and into the cell. Other materials, such as waste products, must pass out of the cell. Molecules can enter or leave a cell through either diffusion or active transport.

Diffusion Molecules are constantly in motion. As they jiggle, they bump into one another, then bounce away like bumper cars at an amusement park. In time, the molecules will have bumped and bounced until they are evenly distributed. The result is that the concentration of molecules in any container remains approximately the same everywhere in the container.

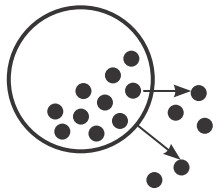


Figure 1-4. Diffusion: These molecules are moving from an area of high concentration to an area of low concentration.

However, when the concentration of molecules is greater in one part of a substance, molecules will spread into areas where their concentration is lower. This movement of molecules from areas of high concentration to areas of low concentration is called **diffusion.** (See Figure 1-4.) Because diffusion results from the normal jiggling of molecules, it requires no outside energy. It is like sledding downhill.

Many molecules diffuse into and out of cells. One of the most important of these molecules is water. The diffusion of water into and out of cells is important to the maintenance of homeostasis. For example, plant cells maintain a stable balance of water and dissolved minerals. This is typically about 98% water and 2% dissolved materials. When salt is spread on roads and walkways, that balance changes. The runoff water from these salted roads may reach concentrations of 5% salt (which means only 95% water). Damage can occur when water in the plant cells diffuses from the higher (98%) concentration in the cell to the lower (95%) concentration outside the cell. Under these conditions, the loss of water places serious stress on the plant. In some cases the plant may die.

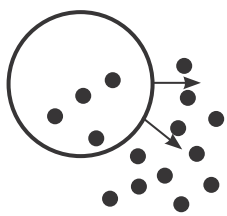


Figure 1-5. Active transport: These molecules are moving from an area of low concentration to an area of high concentration.

Active Transport Moving a molecule from an area of low concentration to an area of high concentration is like pulling a sled uphill. (See Figure 1-5.) It requires energy. Cells must use energy from ATP to transport molecules

from areas of low concentration through the cell membrane to areas of high concentration. The process is called **active transport.**

Many desert plants use active transport to bring water (which is at low concentrations in the soil) into root cells where the water concentration is higher. Some pond organisms use active transport to "collect" calcium or other minerals that are in very low concentrations in the pond water.

Molecules in Cells Both organic and inorganic substances are dissolved in cells and are involved in the chemical reactions that maintain life. Some organic molecules, such as proteins and starches, are too large and complex to enter the cell. Large molecules must first be broken down into simpler molecules in the process known as **digestion**.

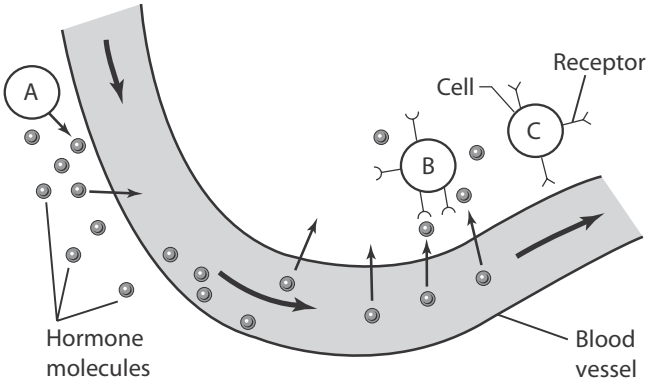


Figure 1-6. Receptor molecules: Specific receptor molecules on the membranes of some cells detect hormones that stimulate the cell to respond. In this case, only cell B (not cell C) will respond to the hormone from cell A.

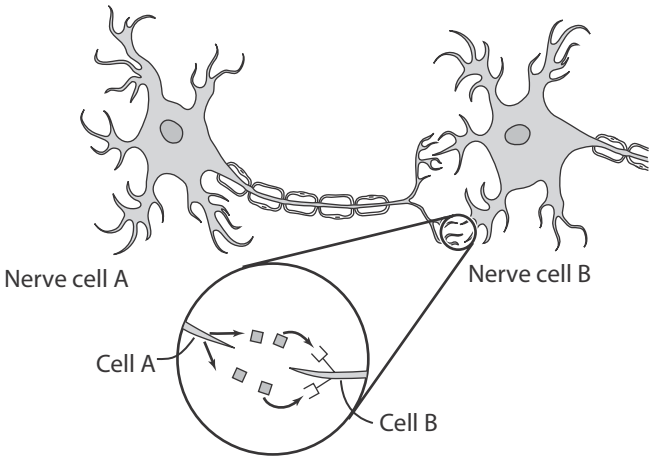


Figure 1-7. Receptor molecules: Nerve cells secrete chemicals that signal adjacent nerve, muscle, or gland cells. These secretions are detected by specific receptor molecules on cell membranes.

The digestion of proteins results in smaller molecules of **amino acids;** the digestion of starches results in **simple sugars.** Digestion is vital because only small molecules, such as amino acids and simple sugars, can enter blood vessels or cells.

When some nutrients from our food enter a cell, they become the building blocks of compounds necessary for life. This process, called cell synthesis, is like manufacturing. Simple molecules (such as amino acids and sugars) are assembled or reassembled into more complex molecules of proteins, starches, DNA, or other substances necessary for life.

Not all nutrients are used as building blocks. Some nutrients that enter a cell are broken down even more to release the energy stored in their chemical bonds. This is the process of cell respiration. All of these processes will be reviewed in detail in later topics.

Recognizing Signals Scientists have learned that certain protein molecules in the cell membrane can receive chemical messages from other cells. These molecules are called **receptor molecules.**

When cells are part of a larger organism, receptor molecules play an important role in the interactions between cells. As shown in Figures 1–6 and 1–7, chemicals produced in the endocrine glands—**hormones**—and chemicals produced by nerve cells are primarily responsible for communication between cells. If nerve or hormone signals are blocked, cellular communication is interrupted, and the organism's homeostasis may be affected.

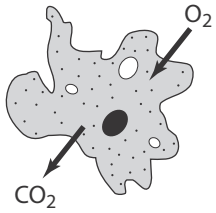
20. Defective receptor proteins on a cell membrane have the *least* effect on

(1) homeostasis
(2) muscle activity
(3) nerve signals
(4) diffusion

21. In the following diagram, nerve cell A is communicating with nerve cell B. Identify the structures present on the membranes of nerve cell B that enable it to detect a message from nerve cell A.

22. Which process accomplishes the movement of gases illustrated by the arrows in the diagram?

(1) excretion
(2) diffusion
(3) active transport
(4) chemical digestion



23. In both plant and animal cells, the cell membrane

(1) produces enzymes
(2) controls reproduction
(3) is composed of sugars
(4) regulates diffusion

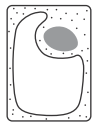
24. Since the relative concentration of water in the pond in which a paramecium (a single-celled organism) lives is greater than the concentration of water in its cytoplasm, water molecules constantly move from the pond into the paramecium. The best long-term solution to the problem of maintaining a stable internal environment is for the paramecium to

(1) change the water into carbon dioxide and excrete it
(2) store water molecules
(3) incorporate water molecules into its structure
(4) actively transport water molecules out of its cell

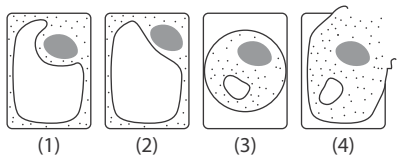
25. A biologist diluted a blood sample with distilled water. While observing the sample with a microscope, she noted that the red blood cells had burst. This bursting is most likely the result of which process?

(1) staining
(2) diffusion
(3) digestion
(4) active transport

26. A student using a compound light microscope to study plant cells observed that most of the cells resembled the one shown in the following diagram.



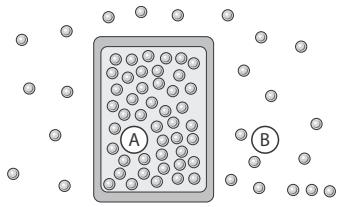
Which diagram best illustrates how the plant cell will appear after being placed in a solution that has a lower water concentration than the cell?



27. Amino acids tend to diffuse from a blood capillary to the adjacent cell because

(1) this is the only direction they can move
(2) the brain directs the movement into cells
(3) the cell needs the amino acids to make protein
(4) the concentration of amino acids is lower in the cell

28. In the following diagram of a plant cell, the small circles represent water molecules.



Which statement *best* describes the behavior of most of these water molecules?

(1) They move from region A to region B.
(2) They move from region B to region A.
(3) They do not move in either direction.
(4) Their overall movement is equal in both directions.

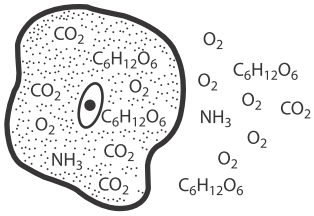
29. Nutrients that are not used as building blocks for the cell may be broken down to release the energy stored in their chemical bonds. This process, which provides cells with energy, is called

(1) chemical synthesis
(2) cell respiration
(3) digestion
(4) homeostasis

30. Cytoplasm in a plant cell will shrink if the cell is

(1) placed in a concentrated salt solution
(2) kept warm and moist and in medium light
(3) placed in distilled water
(4) exposed to a different concentration of nitrogen gas

31. The diagram below represents a cell in water. Formulas of molecules that can move freely across the membrane are shown. Some molecules are located inside the cell and others are in the water outside the cell.



Based on the distribution of molecules, what would most likely happen to these molecules after a few hours?

(1) The concentration of $C_6H_{12}O_6$ will increase inside the cell.
(2) The concentration of CO_2 will increase outside the cell.
(3) The concentration of NH_3 will increase inside the cell.
(4) The concentration of O_2 will increase outside the cell.

32. A cell containing 98% water in its cytoplasm is placed in a 2% salt solution. It should

(1) lose water
(2) gain water
(3) neither lose nor gain water
(4) gain salt because of the high rate of diffusion

33. A cell is placed in distilled water and then transferred to a 5% salt solution. As a result of this procedure, the cell would be likely to

(1) get larger
(2) get smaller
(3) get larger, then smaller
(4) get smaller, then larger

34. A high concentration of calcium salts is normally found within the cytoplasm of a certain protozoan, while the surrounding environment contains a lower concentration of the calcium salts. The higher concentration in the protozoan is most probably the result of

(1) diffusion
(2) excretion
(3) active transport
(4) cellular dehydration

35. A student prepared a normal wet mount slide of an *Elodea* leaf and observed it with a compound microscope. He then made drawing A from his observations. His second drawing, B, shows his observations of the same cell after it was mounted in a 5% salt solution.

The results are most fully explained by

(1) loss of water from the cell
(2) entrance of water into the cell
(3) shrinkage of the cell wall
(4) entrance of salt into the cell

Multicellular Organisms

Multicellular organisms can be highly complex. They require multiple organs and systems to complete their life processes. These systems must interact to maintain the life of the organism.

Human Body Systems

Humans are complex organisms. Their specialized cells must interact to maintain life. Humans require a variety of organs and organ systems to complete the life processes of digestion, respiration, circulation, excretion, movement, coordination, immunity, and reproduction.

Digestion The human digestive system, shown in Figure 1-8, is a one-way passage through the body. This passageway includes the mouth, stomach, and intestines as well as other organs.

Food enters the body through the mouth and is moved slowly through the system by muscular contractions. The food never actually enters the body tissue. Instead, it is broken down both mechanically (by chewing) and chemically. This produces molecules that are small enough to pass through cell membranes and that can be transported to wherever nutrients can be used by the body. Undigested food is eliminated from the body as solid waste.

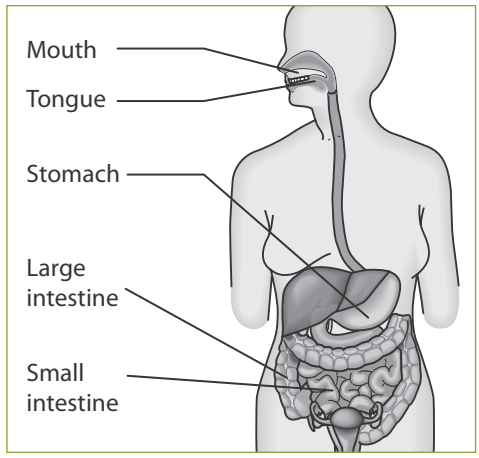


Figure 1-8. **The human digestive system**

Respiration The process of **respiration** uses oxygen to break down food molecules to release energy. The function of the respiratory system is the exchange of gases between the blood of the circulatory system and the environment. The system takes in oxygen for cell respiration and transfers it to the blood. It also removes carbon dioxide—a waste of cell respiration—from the bloodstream and releases it from the body. As shown in Figure 1-9, the lungs and nose are parts of the respiratory system.

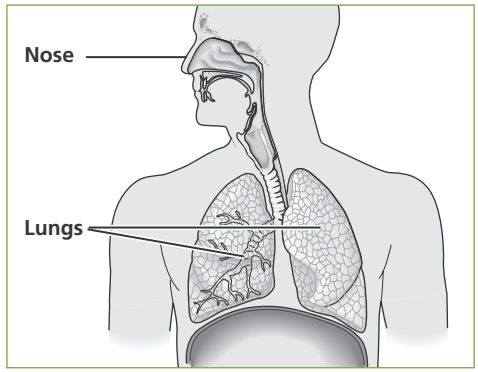


Figure 1-9. **The human respiratory system**

Circulation **Circulation** involves the movement of materials inside the cell as well as the movement between parts of a multicellular organism. The function of the human circulatory system, shown in Figure 1-10, is to transport materials throughout the body.

The system carries digested food and oxygen to cells. It also carries wastes from the cells to the lungs, kidneys, and the skin for excretion. The blood vessels of the system also carry chemical messengers (hormones) and the proteins that attack foreign substances to give the body immunity (antibodies). The human circulatory system includes the heart, blood vessels, and blood.

Excretion Many people confuse the process of excretion with the removal of the waste products of digestion. **Excretion,** however, is actually the removal of all the waste produced by the cells of the body. The human excretory system, shown in Figure 1-11, includes the lungs and kidneys as well as the sweat glands in the skin.

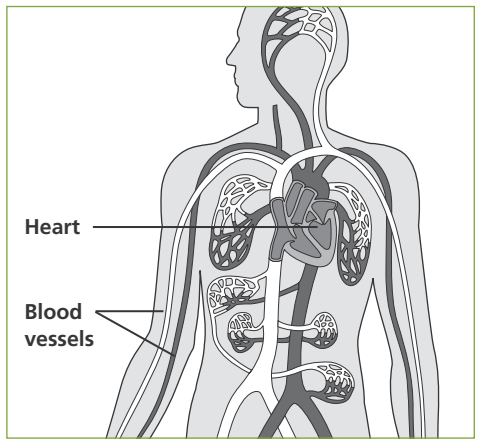


Figure 1-10. **The human circulatory system**

Movement Movement of the body involves the interaction of muscles and bones. The muscular and skeletal systems, shown in Figure 1-12, work together to provide movement and support for the body. These body systems make it possible for the organism to avoid danger and to find food, mates, and shelter.

Coordination The nervous system and endocrine system, shown in Figure 1-13, control the coordination of many of the body's activities. Together these systems respond to and send messages to cells throughout the body.

The nervous system sends signals along nerves. The glands of the endocrine system produce chemical messengers (hormones) that travel in the bloodstream. The brain and nerves are part of the nervous system. The endocrine system includes several glands—such as the pancreas and ovaries or testes.

Immunity The immune system increases the body's **immunity**—its ability to resist disease. Some white blood cells of the immune system engulf and

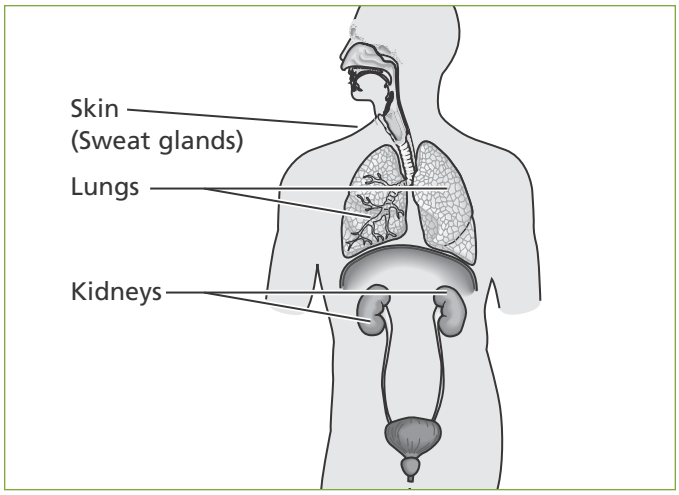


Figure 1-11. **The human excretory system**

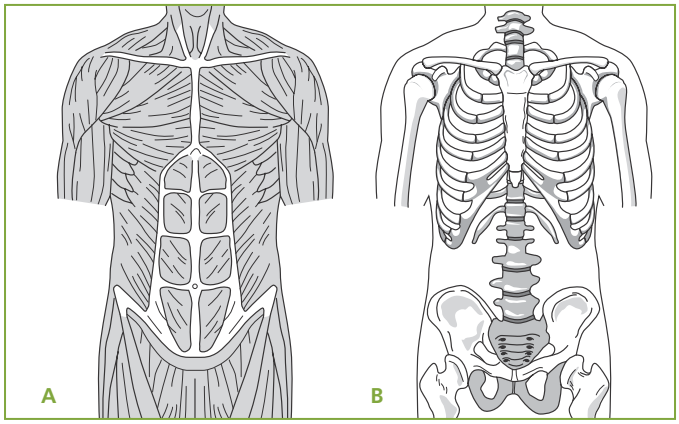


Figure 1-12. **The human muscular (A) and skeletal systems (B): The bones provide support; the muscles allow movement.**

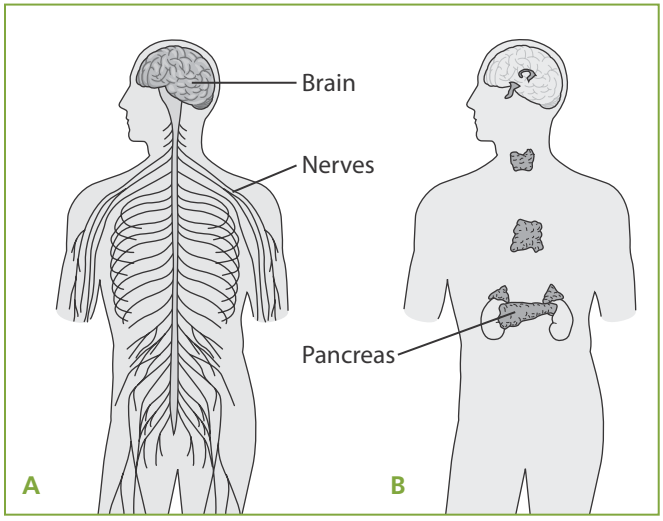


Figure 1-13. **The human nervous (A) and endocrine (B) systems**

destroy invading bacteria and viruses by digesting them. Others protect the body against specific foreign invaders.

Reproduction The process by which organisms produce new organisms of the same kind is called **reproduction.** The reproductive system releases sex cells and hormones that are critical to the creation of offspring and the regulation of their development. The human reproductive system allows for sexual rather than asexual reproduction. Sexual reproduction makes it possible for two individuals to produce offspring that are of the same species but not exactly like either parent.

Interactions for Life Processes and Regulation

Like all organisms, the human body's systems continually interact to perform life processes. Examples of these interactions may involve several systems.

- Nutrients from the digestive system are transported to cells by the circulatory system.
- The functioning of the reproductive system is regulated by hormones from the endocrine system.
- Body systems also continuously interact to maintain a balanced internal environment (homeostasis). To successfully accomplish this, humans and other complex organisms have a variety of control mechanisms that constantly monitor and correct deviations that could throw the body's internal environment off balance. Examples of these control systems include the regulation of body temperature and blood sugar level.
  - When body temperature drops, nerve impulses from the brain signal the muscles to shiver, which generates heat and warms the body.
  - Blood sugar level is constantly monitored, and hormones are released as needed to keep it at acceptable levels.

If any organ or organ system does not function properly, the entire organism may fail to maintain homeostasis. The result may be disease or even death. For example, if the heart fails to beat regularly, the circulation of blood will be affected. This may result in a failure of certain materials

(oxygen, for example) to flow throughout the body. Without oxygen, cells may stop functioning and death may result.

Comparing Single-celled and Multicellular Organisms

The organelles of single-celled organisms are far less complex than organ systems of multicellular organisms. However, organelles and organ systems are equally capable of completing metabolic activities. For example, the paramecium in Figure 1-15 has a specialized organelle—the food vacuole—that digests food. The human digestive system is more complex and also digests food. The organelle and organ system accomplish the same function: breaking down nutrients so that they can be used by the organism.

Table 1-1 shows examples of life functions that are handled by organelles in single cells and by organ systems in multicellular organisms.

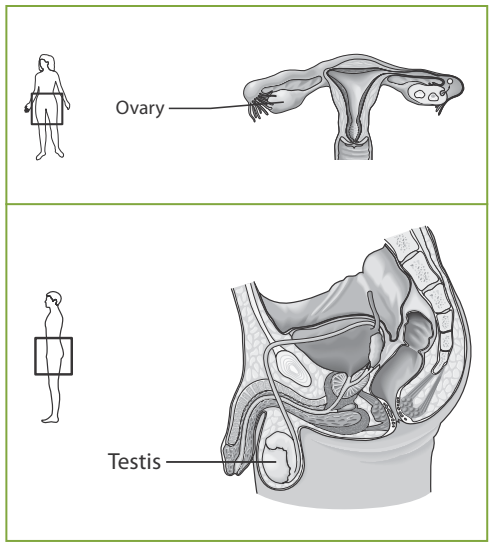


Figure 1-14. The reproductive systems of the human male and female

Comparing Humans and Other Organisms

In most biological respects, humans are like other organisms.

- Humans have much the same chemical composition as other organisms. All organisms—from bacteria to tulips to humans—are made of mainly carbon, hydrogen, oxygen, and nitrogen. These elements combine in different ways and amounts to form carbohydrates, proteins, and other essential organic molecules.
- Humans are made up of different kinds of cells that are similar to those found in other animals. For example, human muscles, nerves, and blood cells are similar in structure and function to the muscles, nerves, and blood cells of other complex animals—from geese to gorillas.
- Humans have organ systems and physical characteristics similar to many other complex animals. For example, worms, frogs, and pigs have digestive systems that break down large food molecules. They also have systems that circulate blood. Pig hearts, in fact, are so similar to human hearts that they can be used for transplants.
- Humans reproduce in the same way as many other organisms. For example, fish, amphibians, reptiles, birds, and mammals reproduce sexually; the sperm and egg cell combine, each contributing half of the genetic information to the offspring.
- Humans use the same kind of genetic information as other organisms. Like nearly every living organism—from *E. coli* bacteria and fruit flies to roses and dogs—humans use DNA as their genetic material.

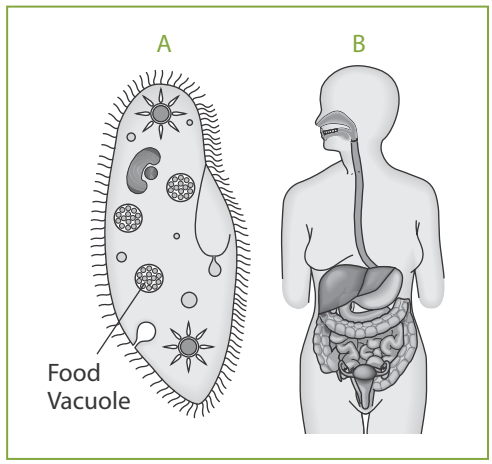


Figure 1-15. Single-celled and multicellular function: The food vacuoles in a one-celled organism (A) are much simpler than the human digestive system (B), but they still digest the organism's food.

Table 1-1. The Function of Organelles in Single Cells and Organ Systems in Multicellular Organisms

Function	Single Cell	Multicellular Organism
Gas exchange	Cell membrane	Respiratory system
Transport of substances	Cytoplasm	Circulatory system
Nutrition	Specialized vacuoles	Digestive system
Excretion	Cell membrane	Excretory system

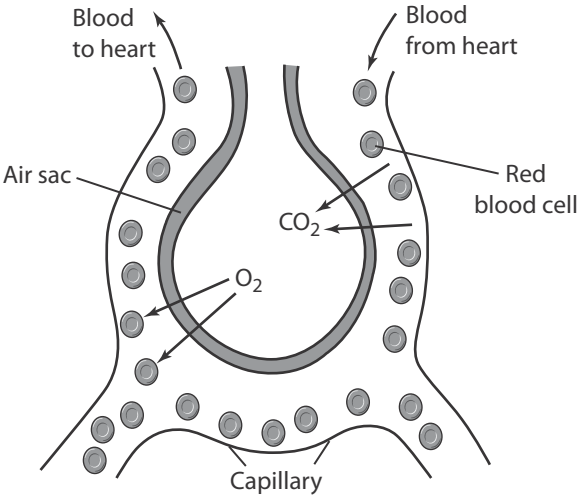
36. Organisms remove metabolic cellular wastes by the process of

(1) excretion
(2) absorption
(3) coordination
(4) digestion

37. A similarity between the nervous system and the hormone-secreting system in humans is that they both

(1) are composed of the same type of cells
(2) are composed of many glands
(3) help to maintain homeostasis
(4) secrete chemicals directly into the blood

38. The diagram below shows an air sac surrounded by the thin-walled blood vessels of a human lung.



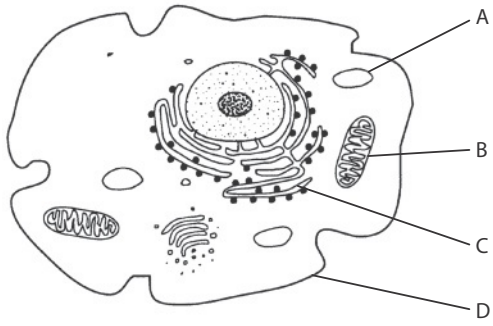
Which two body systems are interacting in the diagram?

(1) respiratory and coordination
(2) respiratory and circulatory
(3) digestive and circulatory
(4) reproductive and coordination

39. Finding shelter, avoiding predators, and obtaining food are most closely related to the ability of an animal to

(1) use structures adapted for movement
(2) increase the rate of mitosis
(3) transport carbon dioxide to cells
(4) excrete waste products of metabolism

40. Which letter in the diagram below indicates a cell structure that functions primarily in the synthesis of protein?



(1) A (2) B (3) C (4) D

41. Inhaling carbon monoxide reduces the ability of red blood cells to carry oxygen. This can lead to brain damage. Which three systems of the body interact in this situation?

(1) digestive, respiratory, and circulatory
(2) immune, circulatory, and digestive
(3) respiratory, circulatory, and nervous
(4) excretory, nervous, and respiratory

42. The activity of all human body systems is coordinated by

(1) the secretion of hormones and the nervous system
(2) the interaction of nerve impulses with the excretory system
(3) the movement of digested food by the circulatory system
(4) the secretion of hormones and the circulatory system

43. Which two systems are most directly involved in providing molecules needed for the synthesis of fats in human cells?

(1) digestive and circulatory
(2) excretory and digestive
(3) immune and muscular
(4) reproductive and circulatory

44. Organ systems of the human body interact to maintain a balanced internal environment. As blood flows through certain organs of the body, the composition of the blood changes because of interactions with those organs. State one change in the composition of the blood as it flows through the respiratory system. [1]

Directions

Review the Test-Taking Strategies section of this book. Then answer the following questions. Read each question carefully and answer with a correct choice or response.

Part A

1 A few bacteria are placed in a nutrient solution. After several hours, thousands of bacteria are present. Which life activities are primarily responsible for this?
(1) digestion and movement
(2) digestion and reproduction
(3) circulation and respiration
(4) excretion and coordination

2 Mitochondria are organelles that
(1) are necessary for the process of diffusion to take place
(2) are found in the nucleus of some cells
(3) initiate cell division in living cells
(4) contain respiratory enzymes

3 Most of the enzymes found in the mitochondria are involved in the reactions associated with
(1) extracting energy from nutrients
(2) storing energy in nutrients
(3) DNA production
(4) protein synthesis

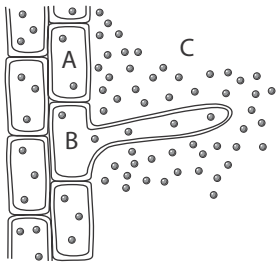
4 Which statement best describes a cell membrane?
(1) It is found only in animal cells.
(2) It is a nonliving structure.
(3) It controls reproduction in a cell.
(4) It controls the passage of materials into the cell.

5 The transfer of specific molecules through cell membranes is an important factor in the process of
(1) cytoplasmic flow
(2) mitotic division
(3) homeostasis
(4) nuclear transfer

6 After a cookie has been eaten and digested, sugar molecules enter the bloodstream by the process of
(1) active transport
(2) diffusion
(3) excretion
(4) cellular respiration

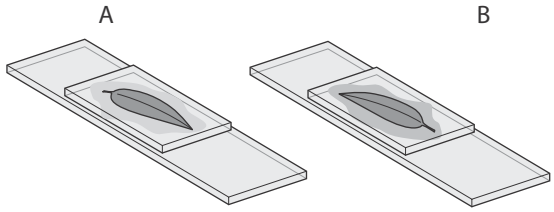
7 The concentration of nitrates is often higher in plant roots than it is in the soil around them. Plants maintain this difference in concentration through
(1) active transport
(2) diffusion
(3) excretion
(4) coordination

8 In the diagram of root cells below, in which direction would the net flow of water be the greatest as a result of diffusion?
(1) A to C
(2) A to B
(3) B to C
(4) C to B



Key
• = Water molecule

9 Diagrams A and B represent two slide preparations of *Elodea* leaves (an aquatic plant).



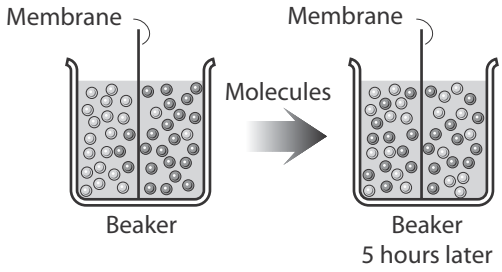
Elodea leaf mounted in tap water

Elodea leaf mounted in 6% salt solution

The tap water used contained 1 percent salt and 99 percent water, while the salt solution contained 6 percent salt and 94 percent water. *Elodea* cells normally contain 1 percent salt. Ten minutes after the slides were prepared, a microscopic examination of cells in leaves A and B would most likely show evidence that
(1) water had moved out of the cells of leaf B
(2) salt had moved out of the cells of leaf B
(3) water had moved into the cells of leaf A
(4) salt had moved into the cells of leaf A

10 One reason a fish that lives in the ocean may have trouble living in a freshwater lake is that
(1) there are more carnivores in freshwater habitats
(2) salt water holds more dissolved nitrogen than fresh water
(3) more photosynthesis occurs in fresh water than in salt water
(4) water concentration in the fish is affected by salt levels in its environment

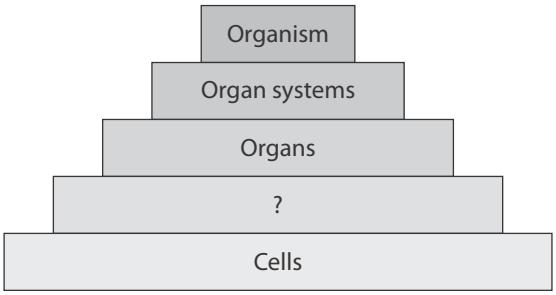
11 Refer to the diagram below of a beaker with a membrane dividing it into two halves containing two kinds of molecules.



Which process explains the change in the positions of molecules after five hours?
(1) respiration
(2) photosynthesis
(3) diffusion
(4) excretion

12 Most of the reactions by which energy from sugars is released for use by the cell takes place within the
(1) vacuoles
(2) nuclei
(3) ribosomes
(4) mitochondria

13 The diagram below shows how an animal is organized.



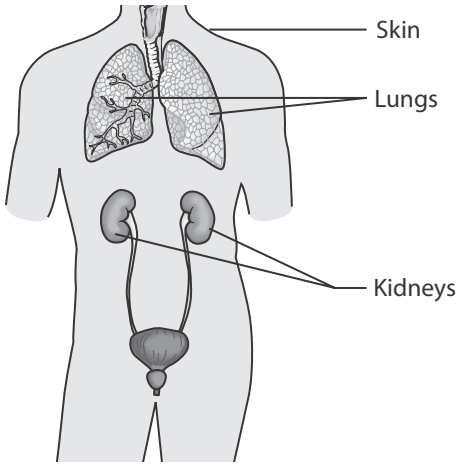
Which label is needed to complete the diagram?
(1) atoms
(2) molecules
(3) organelles
(4) tissues

14 Two organs are considered to be a part of the same body system if the organs
(1) are located next to each other
(2) work independently of each other
(3) work together to carry out a life function
(4) are made up of cells with organelles

15 During exercise, the heart beats faster to
(1) carry digestive juices to the small intestine
(2) provide muscles with additional oxygen
(3) lower the blood pressure
(4) digest more food

16 The ability to avoid danger is possible because of the life process of
(1) excretion
(2) reproduction
(3) nutrition
(4) movement

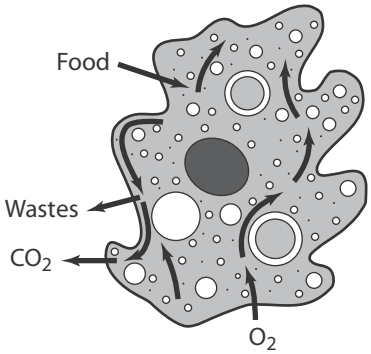
17 The diagram below shows several organs of the human body.



All of these organs interact to help carry out the
(1) removal of waste products
(2) digestion of food
(3) production of hormones
(4) coordination of body movements

18 The circulatory system helps to maintain homeostasis by interacting with the
(1) nervous system and transporting chemicals produced by nerve cells from one cell to another
(2) respiratory system and producing oxygen for gas exchange
(3) digestive system by removing undigested food from the stomach
(4) excretory system in helping to regulate body temperature through sweating

19 In the diagram of the ameba (a single-celled organism), the arrows show the direction of movement of various substances.



Which of the cell's life activities are represented by the arrows?

(1) digestion, reproduction, and respiration
(2) excretion, transport, and respiration
(3) immunity, digestion, and movement
(4) digestion, coordination, and reproduction

20 All cells are able to continue living because of their ability to

(1) produce food
(2) excrete wastes
(3) produce offspring
(4) produce hormones

21 Which structure in a cell corresponds with the function of the human lungs?

(1) nucleus
(2) vacuole
(3) cell membrane
(4) mitochondria

Part B

22 A scientist wanted to know whether the cells of a particular single-celled green algae could survive without any mitochondria. The scientist removed all of the mitochondria from hundreds of these cells. All of the cells died.

Explain the most likely reason the green algae could not survive without mitochondria. [1]

Base your answers to questions 23 and 24 on the information below and on your knowledge of biology.

Cell communication involves a cell detecting and responding to signals from other cells. Receptor molecules play an important role in these reactions. Human cells have insulin receptors that are needed for the movement of glucose out of the blood.

23 State one way that the shape of the insulin receptor is related to its role in cell communication. [1]

24 A typical human liver cell can have over 90,000 insulin receptors. If a genetic error occurred, resulting in each liver cell in a person having only 1,000 insulin receptors, what specific effect would this have on the liver cells? [1]

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25 If vegetables become wilted, they can often be made crisp again by soaking them in water. However, they may lose a few nutrients during this process.

Using the concept of diffusion and concentration, state why some nutrients would leave the plant cell. [1]

26 Describe *one* specific example of diffusion in the human body. In your description be sure to:

- identify the place where your example of diffusion occurs [1]
- identify a substance that diffuses in your example [1]
- state where that substance diffuses from and where it diffuses to, at the place you identified above [1]

Part C

27 A student claims that a dead cell can still carry out diffusion and active transport.

Explain why this claim is not entirely correct. In your answer be sure to explain why a dead cell can or cannot carry on

- diffusion [1]
- active transport [1]

28 Skin cells from a pond animal and skin cells from a land animal were placed in a solution with a 0.85% concentration of salt. When examined later, the cells of the pond animal had swollen and burst, while the cells of the land animal had shrunk.

Explain why the cells responded as they did. In your answer be sure to explain why

- the pond animal cells swelled and burst [1]
- the land animal cells got smaller [1]

29 People sometimes use large quantities of salt to preserve food. The salt kills bacteria that would otherwise cause the food to spoil. Based on your knowledge of diffusion, explain how the salt kills the bacteria. [1]

Base your answers to questions 30 through 33 on the information below and on your knowledge of biology.

The heart of an older person or of someone recovering from a heart attack may become severely weakened or damaged. This sometimes leads to a serious condition called congestive heart failure in which the heart muscle is too weak to pump enough blood throughout the body. As a result, the heart may become exhausted. Sometimes it completely stops.

In a recent study, 2647 patients were given medication called beta-blockers that lowered their risk of death by 34 percent over 15 months (compared to patients who did not take the drugs). Another study reached a similar conclusion.

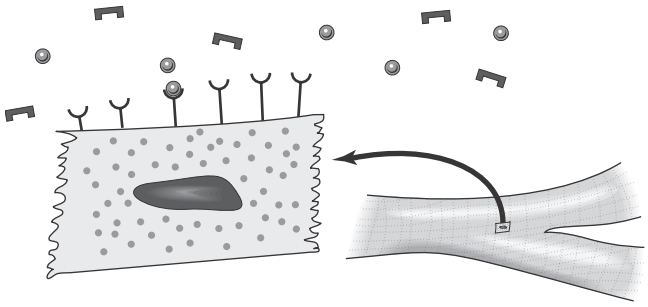
Although beta-blockers have long been used for treating heart attacks and other medical problems, doctors thought them too dangerous for patients with congestive heart failure. Their reason was that beta-blockers counteract the body's response to adrenaline, a hormone that prepares the body for emergencies by attaching to receptors on heart muscle cells, stimulating the heart to beat faster. Since beta-blockers attach to these adrenaline receptors too, they keep the adrenaline molecules from making contact. This leads to a slowing of the heart, which would appear to cause a problem for a person whose heart is not pumping blood effectively anyway.

The opposite turns out to be the case. When the heart of a person with congestive heart failure is not pumping enough blood, the body responds by releasing more adrenaline to stimulate the heart. As a result, the heart is overstimulated and works even harder—making it more likely to fail. Since beta-blockers interrupt this destructive cycle, the heart stabilizes.

Doctors hope that once more studies are done, proper use of beta-blockers may eventually save many thousands of lives.

30 Describe how adrenaline is involved in the cell-to-cell communication of a person with congestive heart failure. [1]

31 Label the following parts of the illustration of the heart muscle cell below:
1—beta-blocker molecule [1]
2—adrenaline molecule [1]
3—heart cell receptor [1]



32 Explain how you could tell which objects represent the adrenaline and which represent the beta-blocker in the illustration in question 31. [1]

33 Many drugs have side effects that make them dangerous to some people. For this reason, individuals who take prescription medicine must watch for any unexpected changes in their health.

Based on the information provided in the passage and on your knowledge of biology, describe one possible side effect that might result when people *without* congestive heart failure use beta-blockers. [1]