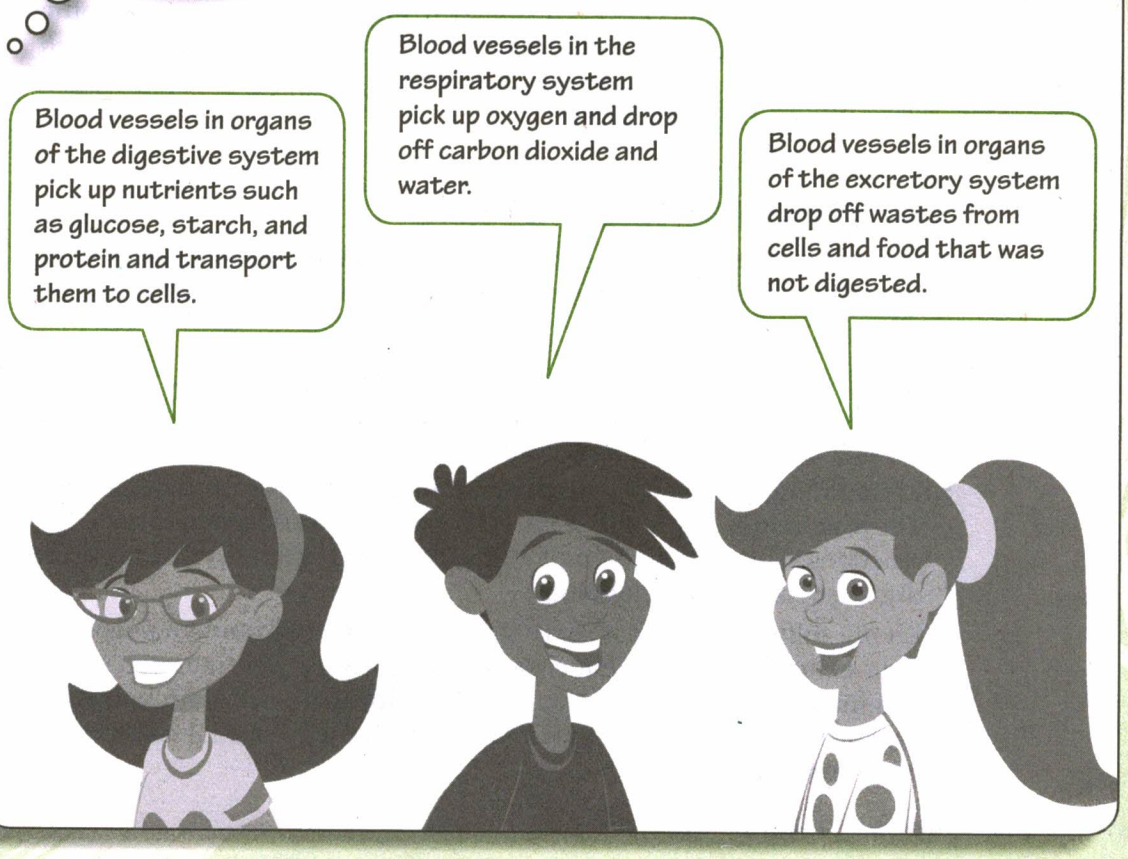
Similarities and Differences Among Living Organisms

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.

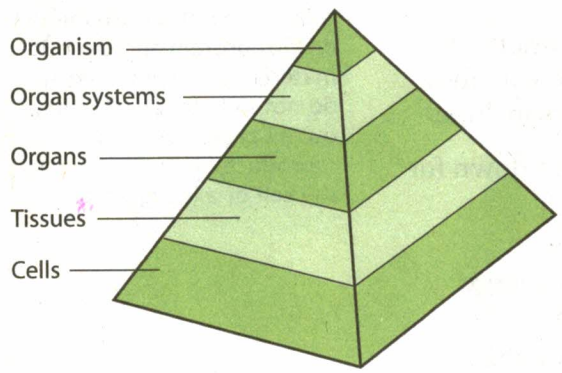


Figure 1-1. The structural organization of organisms

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

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 (3) genes
   (2) cells (4) organelles

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

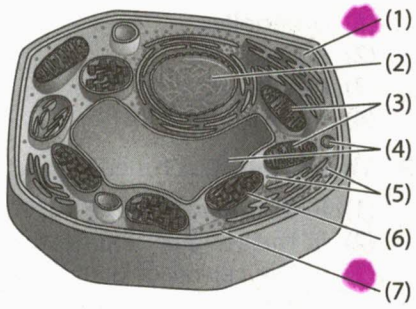
Organelles Organelles are formed of many different molecules and vary in size, shape, and function. They interact to transport materials, extract energy from nutrients, build proteins, dispose of waste, and store information. Figure 1-2 shows several vital organelles.

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

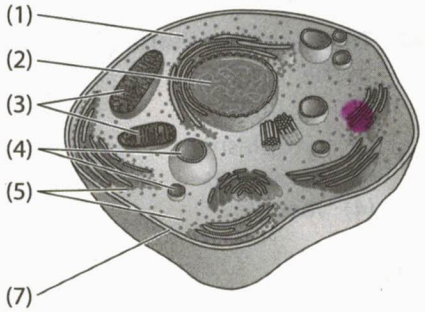


Figure 1-2. Some parts of plant and animal cells: (1) cytoplasm, (2) nucleus, (3) mitochondria, (4) vacuoles, (5) ribosomes, (6) chloroplast, (7) cell membrane.

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.

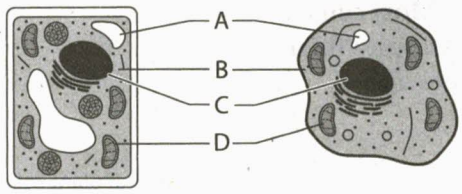
Chloroplasts The green structures found in plants and some one-celled organisms are **chloroplasts.** They contain the green pigment chlorophyll and capture light energy, which is then used to produce food for the plant. Animal cells do not contain chloroplasts.

Review Questions

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

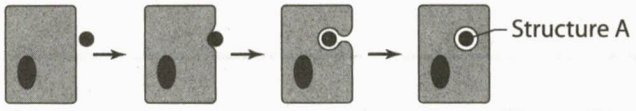
13. The cell nucleus functions

(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?

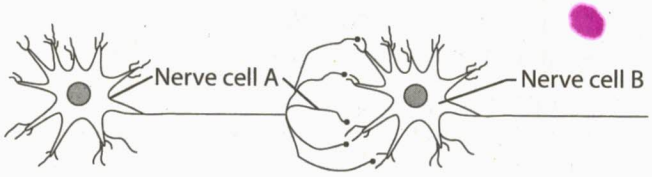
(1) Proteins are synthesized by mitochondria in all living cells.
(2) Proteins are synthesized at the ribosomes in all living cells.
(3) Proteins are synthesized at the ribosomes in plant cells only.
(4) Proteins are synthesized by nuclei in animal cells only.

Review Questions

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

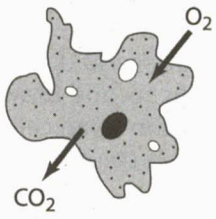
(1) homeostasis
(2) muscle activity
(3) nerve signals
(4) diffusion

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

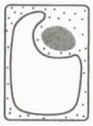
24. Since the relative concentration of water in the pond in which a paramecium (a single-celled organism) lives is greater than the concentration of water in its cytoplasm, water molecules constantly move from the pond into the paramecium. The best long-term solution to the problem of maintaining a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

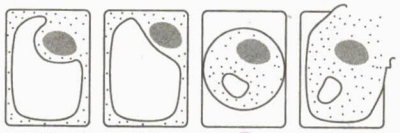
25. A biologist diluted a blood sample with distilled water. While observing the sample with a microscope, she noted that the red blood cells had burst. This bursting is most likely the result of which process?

(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.



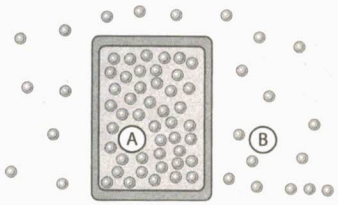
Which diagram best illustrates how the plant cell will appear after being placed in a solution that has a lower water concentration than the cell?



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.

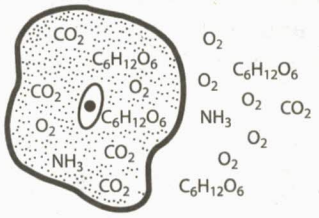
29. Nutrients that are not used as building blocks for the cell may be broken down to release the energy stored in their chemical bonds. This process, which provides cells with energy, is called

(1) chemical synthesis (3) digestion
(2) cell respiration (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 (3) active transport
(2) excretion (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.

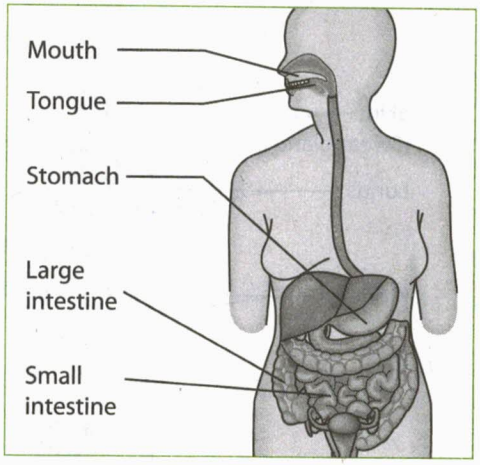


Figure 1-8. The human digestive system

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.

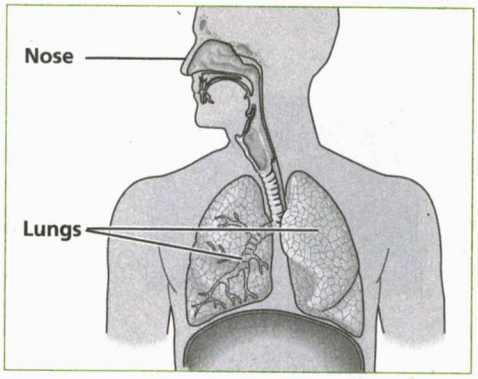


Figure 1-9. The human respiratory system

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.

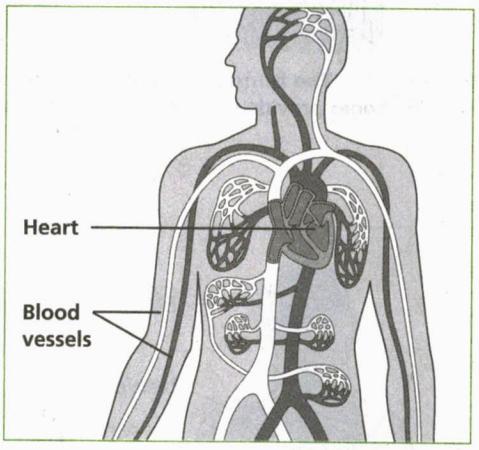


Figure 1-10. The human circulatory system

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.

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

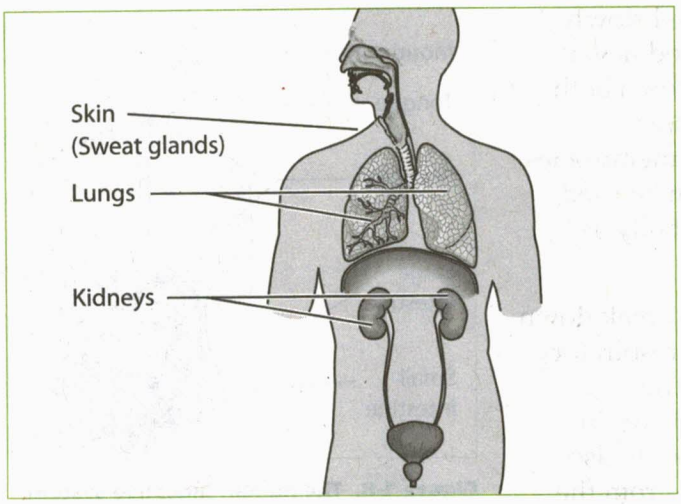


Figure 1-11. The human excretory system

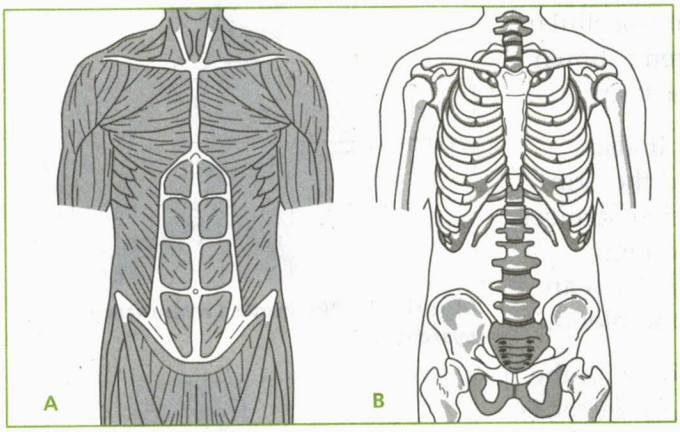


Figure 1-12. The human muscular (A) and skeletal systems (B): The bones provide support; the muscles allow movement.

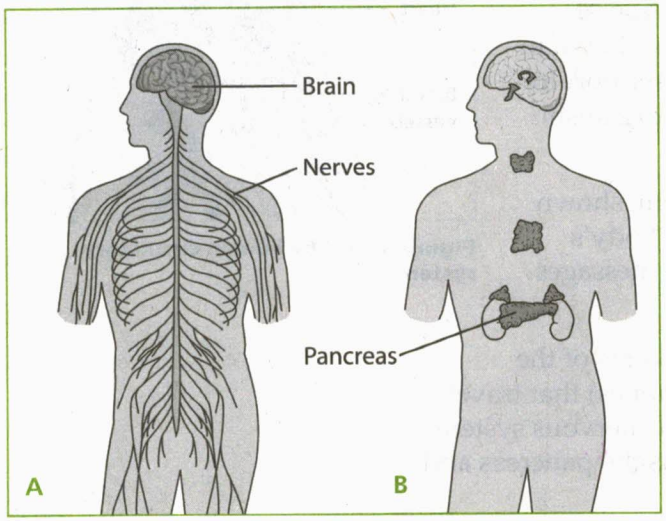


Figure 1-13. The human nervous (A) and endocrine (B) systems

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.

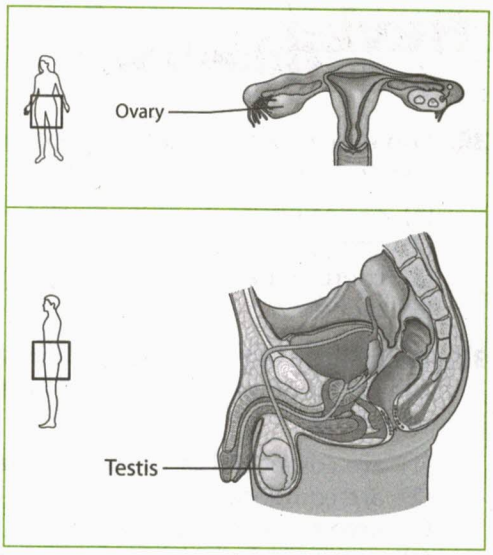


Figure 1-14. The reproductive systems of the human male and female

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.

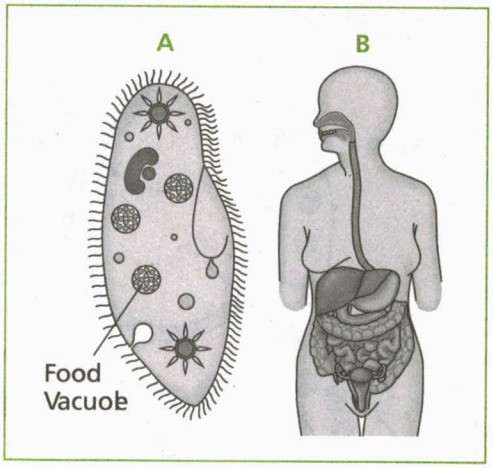


Figure 1-15. Single-celled and multicellular function: The food vacuoles in a one-celled organism (A) are much simpler than the human digestive system (B), but they still digest the organism's food.

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

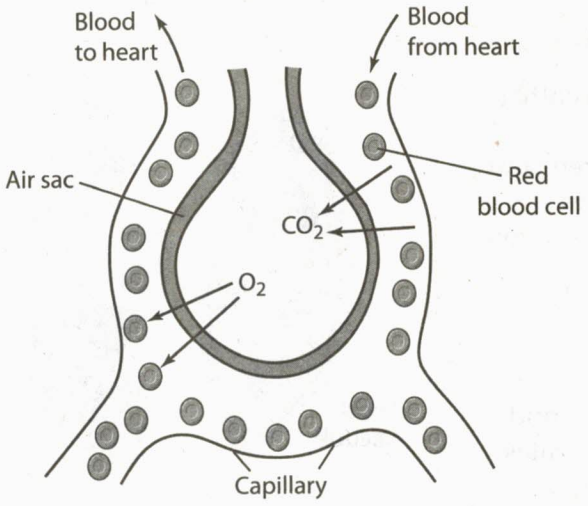
36. Organisms remove metabolic cellular wastes by the process of

(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.



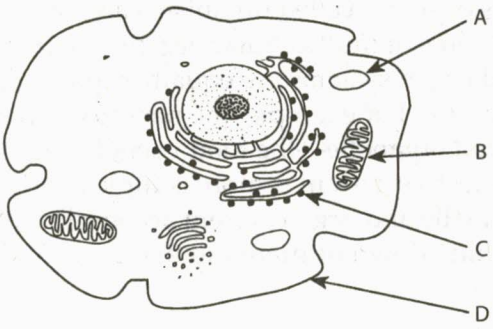
Which two body systems are interacting in the diagram?

(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 an organelle 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. Before it can be used by individual cells, food must be broken down and distributed throughout the human body. Identify the two systems that must interact to accomplish this. [1]

44. Your finger brushes against a hot stove and you quickly pull away. Identify which two human body systems work together to respond to this painful stimulus and explain the specific interaction between them. [1]

45. Compare the chemical composition and genetic information of humans to the chemical composition and genetic information found in other organisms. [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

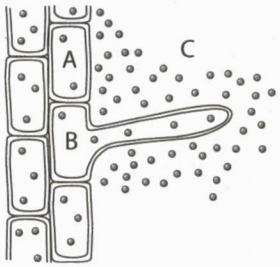
4 Which statement best describes a cell membrane?
(1) It is found only in animal cells.
(2) It is a nonliving structure.
(3) It controls reproduction in a cell.
(4) It controls the passage of materials into the cell.

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

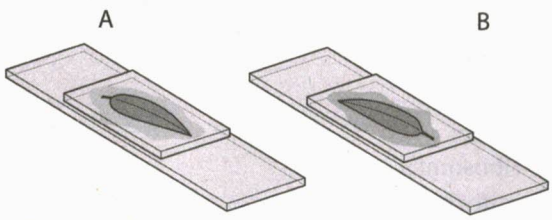
6 After a cookie has been eaten and digested, sugar molecules enter the bloodstream by the process of
(1) active transport
(2) diffusion
(3) excretion
(4) cellular respiration

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



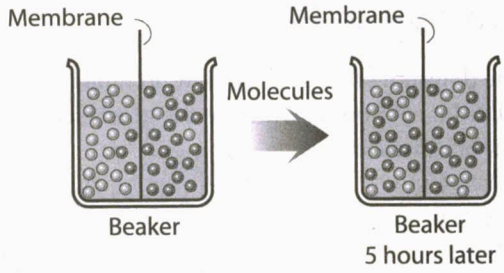
9 Diagrams A and B represent two slide preparations of *Elodea* leaves (an aquatic plant).



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

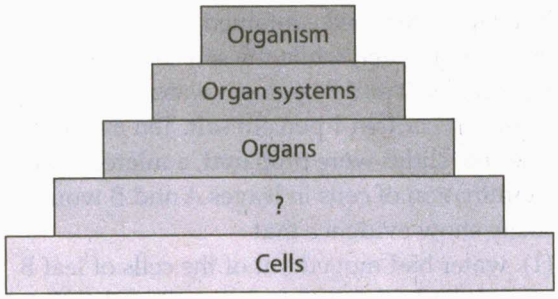
11 Refer to the diagram below of a beaker with a membrane dividing it into two halves containing two kinds of molecules.



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.



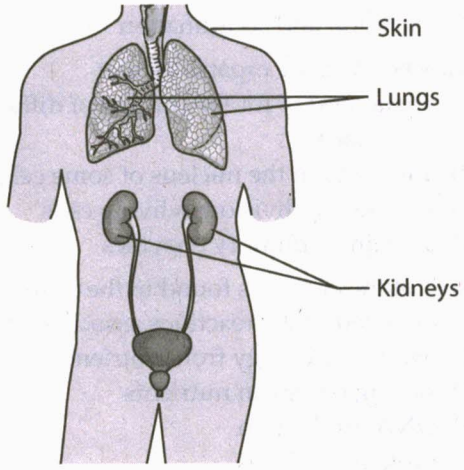
Which label is needed to complete the diagram?
(1) atoms
(2) molecules
(3) organelles
(4) tissues

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

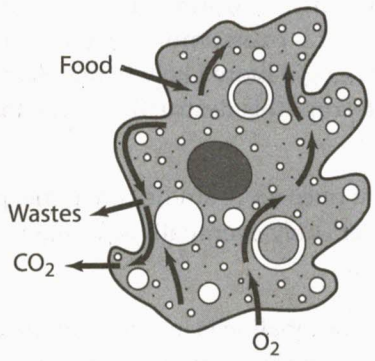
17 The diagram below shows several organs of the human body.



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

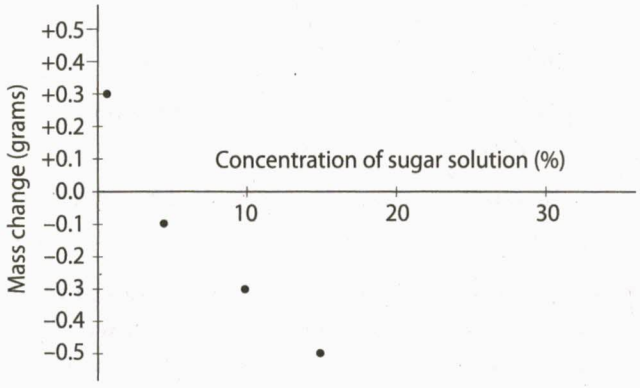
Part B

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]

23 Explain why cell-to-cell communication is important to a multicellular organism, such as a human. [1]

Base your answers to questions 24 through 26 on the information and the graph below and on your knowledge of biology.



24 Four pieces of apple were cut so that all were the same mass and shape. The pieces were placed in four different concentrations of sugar water. After 24 hours, the pieces were removed and their masses determined. The graph indicates the change in the mass of each piece. What was the change in mass of the apple piece in the 10 percent sugar solution?
(1) a decrease of 0.45 grams
(2) an increase of 0.30 grams
(3) a decrease of 0.30 grams
(4) an increase of 0.10 grams

25 At approximately what sugar concentration should pieces neither lose nor gain weight?
(1) 6 percent
(2) 10 percent
(3) 3 percent
(4) 20 percent

26 The four points on the graph represent
(1) assumptions
(2) data
(3) hypotheses
(4) conclusions

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.

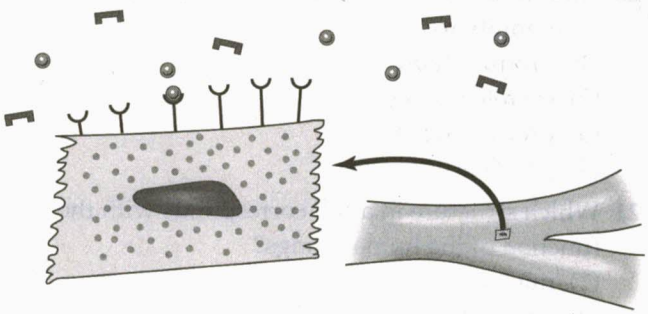
Although beta-blockers have long been used for treating heart attacks and other medical problems, doctors thought them too dangerous for patients with congestive heart failure. Their reason was that beta-blockers counteract the body's response to adrenaline, a hormone that prepares the body for emergencies 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]

Homeostasis in Organisms

TOPIC 2

What do You Think?

Respiration and Photosynthesis

TOPIC 2

Homeostasis in Organisms

Vocabulary

AIDS
allergy
antibiotics
antibodies
antigen
ATP
bacteria
biochemical processes
catalyst
cellular respiration
chloroplast
disease
dynamic equilibrium
enzyme
feedback mechanism
fungi
gas exchange
glucose
guard cells
homeostasis
immune system
insulin
microbe
mitochondria
pancreas
parasite
pathogen
pH
photosynthesis
respiration
stimuli
synthesis
vaccine
virus

Topic Overview

All living things—from the simplest single-celled bacteria to the most complex multicellular animals—are organized biological systems. To stay alive, all organisms must keep their biological systems stable even though they live in a changing, and sometimes life-threatening, environment. To maintain this stability, organisms continually monitor and respond to changes in the environment. The internal stability that organisms maintain is known as **homeostasis.**

Homeostasis is the maintenance of internal conditions within a narrow range that varies only slightly over time. For example, your body temperature must stay within a specific temperature range (approximately 98.6°F, or 37°C) for you to survive. If you become too hot or too cold, the biochemical processes that keep you alive will begin to fail.

Digging Deeper

Homeostasis sometimes appears with the words *dynamic equilibrium* or *steady state*. These terms all involve the idea of "a constant balance." To picture this concept, it may help to think of a child learning to balance a bicycle. There may be some wobbling back and forth, but generally the rider remains upright.

Basic Biochemical Processes of Living Organisms

Biochemical processes are the chemical processes that occur in living things. All organisms need both energy and raw materials (atoms and molecules) to carry on the internal biochemical processes that are essential for their survival. Two of these enzyme-controlled biochemical processes are photosynthesis and respiration. **Photosynthesis** is the process by which energy is stored in chemical bonds of organic molecules such as carbohydrates. Plants, algae, and many single-celled organisms carry out photosynthesis. Recall that **respiration** is the process by which chemical energy stored in nutrients is released for use in cells. All living organisms carry out respiration.

Storing Energy: Photosynthesis

The energy for life comes primarily from the sun. In Figure 2-1, notice that photosynthesis is the connection between the energy released by the sun and the energy available to living systems.

The cells of organisms that carry out photosynthesis contain light-capturing molecules. In plant cells, these molecules are located in the **chloroplasts,** which are green-colored organelles where photosynthesis occurs. In Figure 2-2, the chloroplasts are the oval structures. You may have seen these green structures on microscope slides of cells prepared from plant leaves.

All plants, algae, and many one-celled organisms use solar energy to convert inorganic molecules (carbon dioxide and water) into any one of several energy-rich organic compounds. One such organic compound is the sugar **glucose**—a simple carbohydrate.

In the chemical reaction shown in Figure 2-3, notice that water and carbon dioxide from the environment are combined to make glucose. Oxygen gas, which is also formed in the process, is released into the environment.

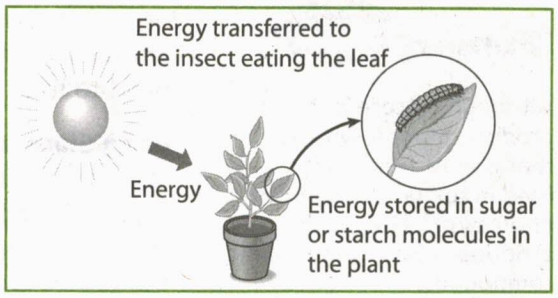


Figure 2-1. Energy transfer: The sun provides energy for most of the life on Earth.

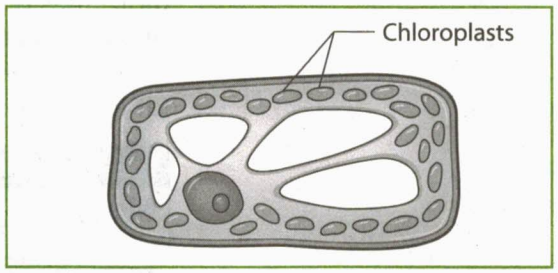


Figure 2-2. Chloroplasts in a typical plant cell: The chloroplasts capture light energy.

light energy + water + carbon dioxide ⟶ glucose + oxygen

$$\text{light energy} + 6\,H_2O + 6\,CO_2 \longrightarrow C_6H_{12}O_6 + 6\,O_2$$

Figure 2-3. Photosynthesis

What Happens to the Sugar Produced by Photosynthesis? Plant cells use the organic compounds (such as glucose) from photosynthesis in two ways. Their primary use is to generate ATP molecules during **cellular respiration,** which is the process of releasing the energy in chemical bonds. Glucose is also used as a raw material for building more complex molecules, such as those listed in Table 2-1.

Using Glucose to Produce ATP Molecules One way plants (and animals) use glucose is to generate high energy molecules known as **ATP.** This process occurs during cellular respiration. Energy stored in the chemical bonds of ATP molecules is the energy source for almost all life processes from obtaining, transforming, and transporting materials to eliminating wastes. Because cell processes actually "run" on ATP (rather than glucose), the transfer of energy from glucose to ATP is essential to both plants and the

Table 2-1. Complex Molecules and Their Functions

Molecule	Function
ATP	Supplies energy for cells to run on
DNA	Carries hereditary information
Carbohydrates	Acts as a food reserve molecule
Lipids (fats and oils)	Acts as a food reserve molecule
Protein	Makes up enzymes and many cell parts

MemoryJogger

Although glucose is the product of photosynthesis that is most frequently used in textbook examples, photosynthesis actually produces a variety of organic compounds.

organisms that consume them. All organisms—not just plants and animals—use organic food compounds to supply the ATP energy they need to live.

Using Glucose to Build Complex Molecules Cells also use glucose as the starting point for **synthesis** (chemical combining) that forms complex organic compounds. For example, plants store much of the glucose from photosynthesis as starch. Table 2-1 provides some examples of complex molecules and how they are used.

When animals eat plants or other animals, they digest the complex molecules into simpler molecules for their own cells to use. Some of these molecules provide energy for the organism. For example, starches from plants and fats from animals can both be digested and used right away for energy. If they are not all needed for energy, the molecules can be stored as fat to provide a food reserve for the animal.

Table 2-2. Summary of Photosynthesis

Energy	The energy comes from sunlight as solar energy and ends up in glucose molecules as chemical bond energy.
Materials used	Carbon dioxide gas and water are used; both molecules come from the environment.
Materials produced	Molecules made from the carbon dioxide and water include molecules of the sugar glucose (a simple carbohydrate) and oxygen gas. Oxygen is actually released as a byproduct of photosynthesis.
Time frame	Photosynthesis occurs in plant cells when light is available, which is generally during the daytime.
Location	Photosynthesis occurs in the chloroplasts of plant cells, algae, and some one-celled organisms when they are exposed to light.
Importance of photosynthesis	Organisms either (1) use glucose to synthesize other molecules they need or (2) break down the glucose to release its stored energy.
Relationship to respiration	The energy originally stored in glucose during photosynthesis is transferred to the chemical bonds of ATP. All cells "run" on the energy released from ATP.

Review Questions

1. In a plant cell, the synthesis of sugar compounds from inorganic raw materials occurs in the

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

2. Which word equation represents the process of photosynthesis?

(1) glucose → alcohol + carbon dioxide
(2) carbon dioxide + water → glucose + oxygen
(3) chlorophyll + water → glucose + alcohol
(4) glucose + oxygen → carbon dioxide + water

3. Which factor *least* influences the rate of photosynthesis?

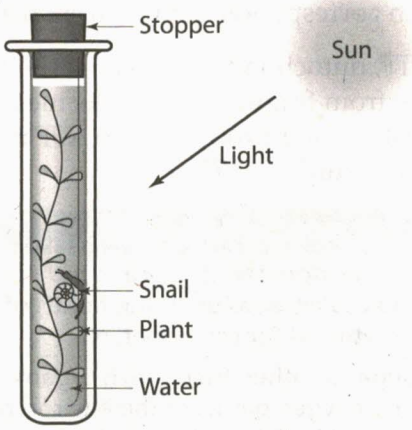
(1) atmospheric concentration of carbon dioxide
(2) time of day
(3) number of chloroplasts
(4) concentration of nitrogen in the air

4. The basic raw materials of photosynthesis are

(1) sugar and carbon dioxide
(2) oxygen and water
(3) water and carbon dioxide
(4) oxygen and sugar

5. Which compound is formed as a common product of the process of photosynthesis?
   (1) DNA
   (2) sugar
   (3) chlorophyll
   (4) carbon dioxide

6. In the test tube shown, what is produced by the snail that is used by the plant?
   (1) oxygen
   (2) carbon dioxide
   (3) food
   (4) egg cells



7. Which activity occurs during the process of photosynthesis?
   (1) Chemical energy from organic molecules is converted into light energy
   (2) Organic molecules are absorbed from the environment.
   (3) Organic molecules are converted into inorganic food molecules.
   (4) Light energy is stored as chemical energy in organic molecules.

8. Photosynthesis in plants requires chloroplasts and light energy.
   - Identify two raw materials plants also use in this process [1]
   - Explain why these two substances are needed [1]

Releasing Energy: Cell Respiration

All living things need energy to stay alive. Before the energy in the bonds of complex carbohydrates, such as starch, can be used, the molecules must be broken down (digested) into simpler ones, such as glucose.

Then, the glucose (or other simple molecules) must be broken down further. This process involves a series of chemical reactions controlled by **enzymes,** which are special proteins that affect the rate of chemical reactions.

In the final step, the chemical bonds of the glucose molecule are broken, and the energy in those bonds is released. This process of releasing the energy in chemical bonds is called cellular respiration.

In many organisms, cellular respiration requires oxygen, which must be brought into the organism from the environment. Obtaining oxygen from the environment and releasing carbon dioxide is called **gas exchange.**

During cellular respiration, cells capture much of the energy that is released from the glucose bonds. The captured energy is then used to form new bonds in high-energy molecules known as ATP. Figure 2-4 shows how ATP temporarily stores energy. Most of the energy that the cell fails to capture to make ATP is lost to the environment as heat.

Memory Jogger

Sometimes people use the term *respiration* when they really mean *breathing. Respiration* is the process that involves oxygen and breaks down food molecules to release energy. *Cellular respiration* refers specifically to the transfer of energy from simple organic molecules like glucose to ATP molecules within cells.

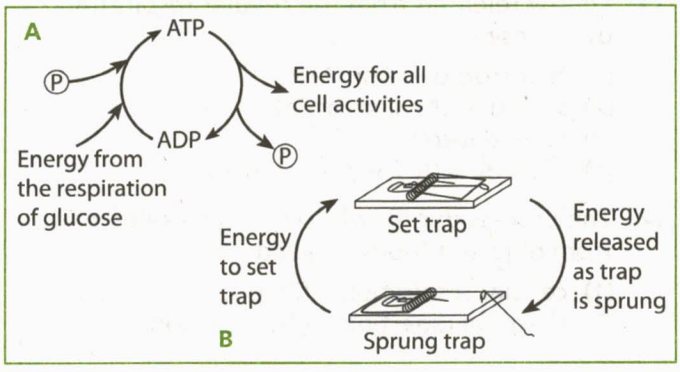


Figure 2-4. Energy storage in ATP molecules: (A) Chemical energy from the breakdown of glucose molecules is used to attach a phosphate (P) to a molecule of ADP. The result is called ATP. When the cell needs energy, the ATP is broken down into ADP. During that process, the phosphate (P), along with the energy that was stored in its chemical bond, is released. (B) A similar form of temporary energy storage occurs when a mousetrap is set. The mechanical energy that is put into the act of setting the trap is stored in the spring. When the trap is sprung, that energy is released.

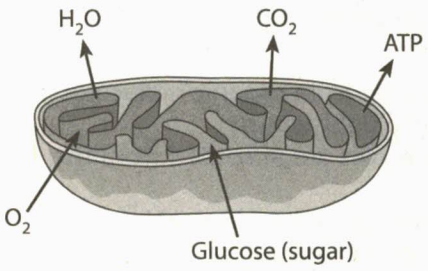


Figure 2-5. Cellular respiration in a mitochondrion: Partially broken down glucose molecules and oxygen (O_2) enter the organelle and are rearranged, with the help of enzymes. Water (H_2O) and carbon dioxide (CO_2) are released as waste products. The energy that was stored in the glucose is transferred to ATP molecules.

Cellular respiration in many organisms is completed in organelles called **mitochondria.** (See Figure 2-5.) Mitochondria are common in animal cells. Cells that require more energy contain more mitochondria. For example, muscles require more energy to complete their functions than skin cells do. Muscle cells usually contain mitochondria, which corresponds with their increased energy needs.

As they generate ATP, mitochondria release carbon dioxide and water molecules that come from fragments of molecules that were involved in the reactions. Most cellular processes use ATP as a direct source of energy. Basically, cells "run" on ATP.

Table 2-3. Summary of Cellular Respiration

Energy	Comes from the chemical bond energy of glucose molecules; ends up in the bonds of ATP where it can be utilized for cell activities
Materials used	Sugar or other energy-rich organic food compounds and oxygen gas from the environment • Food is obtained through photosynthesis in producers and by feeding in consumers. • Oxygen is obtained through gas exchange.
Materials produced	ATP molecules and two waste products— carbon dioxide gas and water. The release of carbon dioxide into the environment is part of the process of gas exchange.
Time frame	Cellular respiration occurs in all cells (including plant cells) 24 hours a day.
Location	Respiration occurs in the cells of all living things. In most organisms, cellular respiration is concluded in mitochondria.
Importance of respiration	All cells "run" on the energy released from ATP. Organisms can use the ATP they make as the source of energy to help them obtain raw materials and nutrients, to transform materials in chemical reactions, to transport materials (for example, active transport), and to eliminate wastes. ATP is essential for metabolic processes. The energy is also used to allow the organism to grow and to move from one place to another.

Digging Deeper

The D in ADP is for **Di**phosphate, or two phosphates. The T in ATP is for **Tri**phosphate, or three phosphates. ADP and ATP are converted back and forth as a phosphate is added or removed.

$$ADP + P = ATP$$
$$ATP - P = ADP$$

Review Questions

9. Energy for use in cells is stored in the form of
(1) chemical bond energy
(2) physical energy
(3) heat energy
(4) mechanical energy

10. In which process do organisms transfer the chemical bond energy in organic molecules to ATP molecules?
(1) excretion (3) autotrophic nutrition
(2) cellular respiration (4) photosynthesis

11. Energy released from the cellular respiration of glucose is
(1) first stored within ATP
(2) stored in the liver as fat
(3) turned into fat
(4) used directly for body activity

12. The process during which energy is released from digested foods is called
(1) cellular respiration (3) photosynthesis
(2) chemical digestion (4) excretion

13. As a direct result of the life process called cellular respiration in humans,

(1) liquid wastes are eliminated from the body
(2) food is digested and absorbed into the blood
(3) energy is released from digested food within the cells
(4) nutrients are transported within the cells

14. Which process involves the transfer of energy from carbohydrates to ATP molecules?

(1) photosynthesis (3) digestion
(2) respiration (4) circulation

15. During respiration, the energy within the bonds of a glucose molecule is released in small amounts in a step-by-step, enzyme-controlled reaction. In this process, the energy released is used to

(1) synthesize ATP
(2) control the process of diffusion
(3) synthesize more glucose
(4) produce oxygen molecules

16. Which statement best describes one of the events taking place in the chemical reaction represented below?

$$H_2O + ATP \xrightarrow{\text{enzymes}} ADP + P + \text{energy}$$

(1) Energy is being stored as a result of cellular respiration.
(2) Energy is being released for metabolic processes.
(3) Decomposition is taking place, resulting in the synthesis of ATP.
(4) Photosynthesis is taking place, resulting in the storage of energy.

17. Compare photosynthesis and respiration with regard to each of the following:

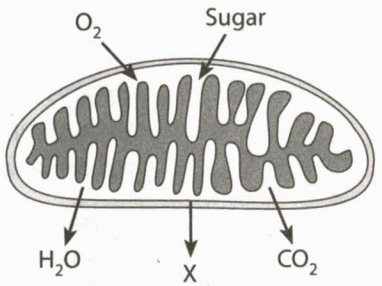
- source of energy [1]
- materials used by each process [1]
- location of each process in the cell [1]
- when each process occurs in plants and animals [1]

18. Which statement most accurately describes the process of respiration?

(1) It occurs only in plants during the daylight hours and usually involves the exchange of gases.
(2) It occurs only in plants during the daylight hours and involves the taking in of preformed organic molecules.
(3) It occurs continuously in the cells of all organisms and involves the synthesis of carbohydrate molecules.
(4) It occurs continuously in the cells of all organisms and often involves an exchange of gases.

19. During daylight hours green plants carry out photosynthesis. Do they also carry out respiration at this time? Support your answer. [1]

Base your answers to questions 20 through 22 on the diagram of a mitochondrion below and on your knowledge of biology.



20. The process represented in this diagram is

(1) respiration (3) photosynthesis
(2) coordination (4) immunity

21. What term would most appropriately be represented by the "X"?

(1) ATP (3) antibodies
(2) chlorophyll (4) glucose

22. What is present within the mitochondrion that allows the reaction to occur?

(1) enzymes (3) bacteria
(2) chlorophyll (4) carbon dioxide

Enzymes

A **catalyst** is any substance that can affect the rate of a chemical reaction without itself being changed or used up during the reaction. Because it is neither changed nor used up, the catalyst is capable of carrying out the same function again and again. Protein catalysts known as enzymes affect the chemical reactions in living things.

The Function of Enzymes Biochemical processes, such as digestion (breakdown), synthesis (building up), cellular respiration (energy release),

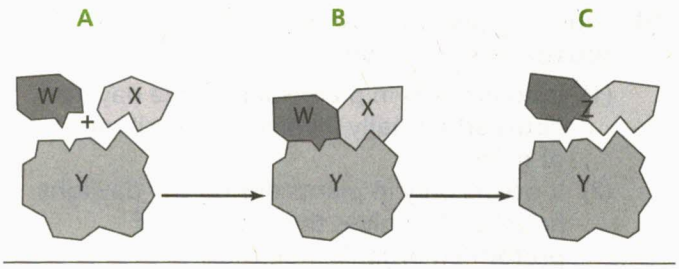


Figure 2-6. Enzymes interact with specific molecules: Enzyme interactions are determined by molecular shape. After the two molecules W and X collide with enzyme Y (A), the enzyme forms a temporary physical connection with them (B) and then separates after a reaction has occurred (C). As a result, the molecules W and X have chemically bonded for the synthesis of the new molecule Z. If the arrows in the illustration were reversed, the reaction would involve splitting molecule Z into two smaller molecules, W and X. This reverse process is digestion.

and photosynthesis (energy capture), are made possible in living things by enzymes.

All living organisms contain enzymes. Enzymes interact with other molecules when they collide. Chemical reactions in living organisms are regulated by many different enzymes that function best at whatever the normal "body" temperature is for the organism.

Importance of Molecular Shape Enzymes and several other molecules, such as hormones, antibodies, and receptor molecules on cell membranes, have specific shapes that influence both how they function and how they interact with other molecules. Many enzymes will interact with some substances, but not others. The enzyme salivary amylase, for example, acts on starches but not proteins. In Figure 2-6, notice how the shapes of W, X, and Y fit together precisely. If the shape of an enzyme is altered, it will not interact with other molecules the way it must to catalyze a reaction, and its function will be impaired.

Enzyme Reaction Rates

Several conditions, such as shape, temperature, and pH, can either speed up or slow down the rate of enzyme action.

Shape Enzymes are chain-like protein molecules that are folded into precise shapes. Each enzyme must have a specific shape to work correctly, and anything that alters that shape will affect the enzyme's ability to function properly. High temperatures and strong acids or bases can change the enzyme's shape either temporarily or permanently. When this happens, the enzyme cannot function, and the reaction rate will decrease in proportion to the number of enzyme molecules that are altered.

Temperature Most enzymes have an optimum temperature at which they function most efficiently and produce the highest reaction rate. For human enzymes, this temperature is typically 98.6°F (37°C). As the temperature of a cell or organism reaches its optimum level, enzymes and the molecules they are interacting with will move faster and collide more often, causing the reaction rate to increase. Beyond the optimum temperature, the rate falls rapidly because the fragile enzyme molecules begin to change shape or break apart. Trace the rise and fall of an enzyme reaction rate in Figure 2-7.

pH The **pH** of a substance is a measure of whether a substance is acidic, neutral, or basic. Placing enzymes in solutions of varying pH values affects their activity. Many enzymes work best in an optimum pH of about 7, which is neutral. This makes sense, since most body fluids and cells maintain a pH of near 7. However, some parts of organisms have typical pH values that are far from neutral. For example, the human stomach is acidic and has a pH of 2 or 3. The small intestine has a pH around 8. Enzymes in these locations typically have optimum rates that correspond to the pH of their environment, as shown in Figure 2-8.

MemoryJogger

A pH of about 7 is neutral, the same as pure water. A low pH, such as 1 or 2, indicates a strong acid. A high pH, such as 13 or 14, indicates a strong base. In a typical high school biology laboratory, pH is measured with pH paper treated with various indicator dyes.

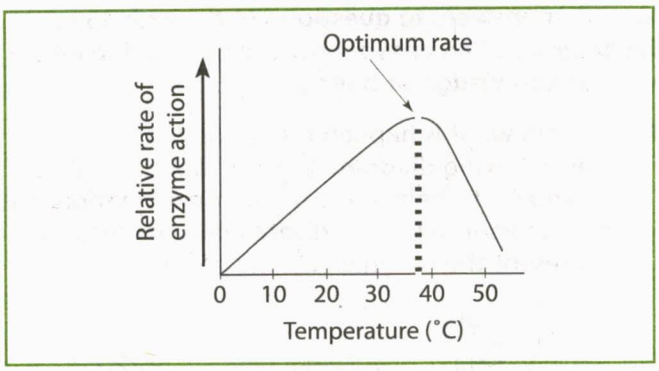


Figure 2-7. Enzymes and temperature: Note that the rate of enzyme action is fastest at about 37°C, which is typical of a human enzyme. The reason the rate declines so quickly beyond the optimum is that the higher temperature alters the shape of the enzyme. In this example, by the time the temperature reaches 55°C, all the enzyme molecules have been altered, and as a result, they no longer function.

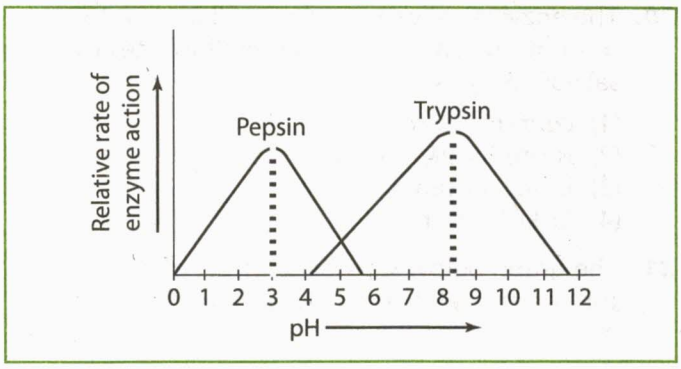


Figure 2-8. Enzymes and pH: Pepsin is found in the human stomach and has a pH that matches the acid environment found there. Trypsin is an enzyme located in the small intestine where the pH is close to 8. Notice that each enzyme is less effective if the pH is either raised or lowered from its optimum point.

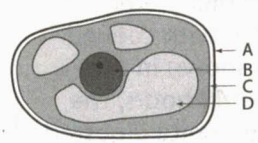
Review Questions

23. Only small amounts of enzymes are required for reactions within cells because enzymes are

(1) fragile
(2) reused
(3) small molecules
(4) constantly synthesized

24. Which cell organelle indicated in the diagram below controls the synthesis of enzymes?

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



25. In order to survive, all organisms must carry out

(1) autotrophic nutrition
(2) heterotrophic nutrition
(3) enzyme-controlled reactions
(4) the process of reproduction

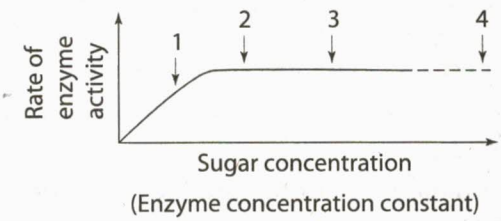
26. Which group of organic compounds includes the enzymes?

(1) proteins
(2) carbohydrates
(3) sugars
(4) fats

27. Luciferin is a molecule that, when broken down in fireflies, produces heat and light. The rate at which luciferin is broken down in cells is controlled by

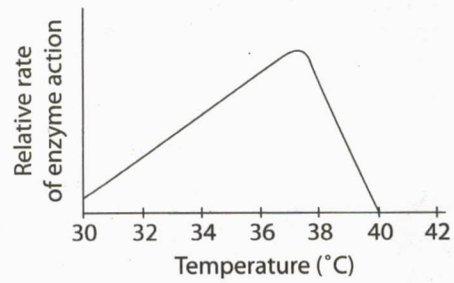
(1) a carbohydrate
(2) a simple sugar
(3) an enzyme
(4) a complex fat

28. At which point on the graph below can the rate of enzyme activity be increased by increasing the concentration of sugar molecules?



(1) 1
(2) 2
(3) 3
(4) either 2, 3, or 4

29. Which statement best describes the relationship between enzyme action and temperature shown in the graph below?

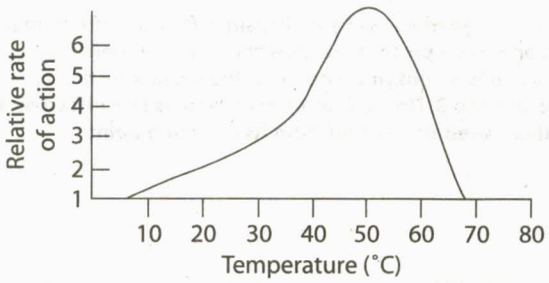


(1) Enzyme synthesis begins at 30°C.
(2) Enzyme activity constantly increases with increasing temperature.
(3) The pH has a greater effect on this enzyme than temperature does.
(4) Enzyme activity increases as the temperature increases from 32°C to 34°C.

30. The enzyme salivary amylase will act on starch but not on protein. This action illustrates that salivary amylase

(1) contains starch
(2) is chemically specific
(3) is not reusable
(4) lacks protein

31. The graph below shows the effect of temperature on the relative rate of action of enzyme X on a protein.



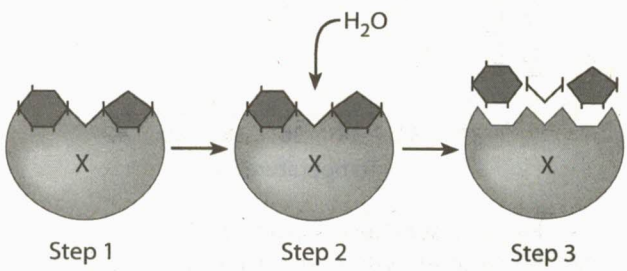
Which change would not affect the relative rate of action of enzyme X?

(1) the addition of cold water when the reaction is at 50°C
(2) an increase in temperature from 70°C to 80°C
(3) the removal of the protein when the reaction is at 30°C
(4) a decrease in temperature from 40°C to 10°C

32. Enzymes influence chemical reactions in living systems by

(1) becoming part of the product after the reactions occur
(2) combining with atmospheric gases to form waste products
(3) affecting the rate at which reactions occur
(4) absorbing water during synthesis and digestion

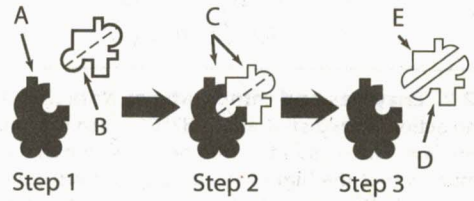
33. The diagram below represents three steps in the digestion of the sugar sucrose. In this diagram, structure X is most likely



(1) a molecule of oxygen
(2) the end product
(3) an enzyme molecule
(4) the sugar

Base your answers to questions 34 through 36 on the diagram of an enzyme-controlled reaction and on your knowledge of biology.

34. Explain what is happening during Steps 1-3 in the following diagram. Use the labels—A, B, C, D, and E—to help you with your explanation. As part of your answer, indicate which molecules represent the enzyme and the product.

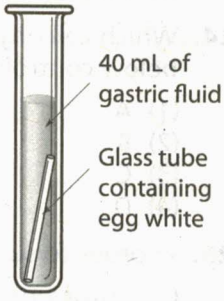


35. Is this reaction an illustration of synthesis or digestion? Support your answer. [1]

36. Explain why heating these molecules might *slow* the rate at which this reaction occurs? [1]

Base your answers to questions 37 through 41 on the diagram and data table below and on your knowledge of biology.

A student is studying the effect of temperature on the action of a protein-digesting enzyme that is contained in stomach fluid. An investigation is set up using five identical test tubes. Each test tube contains 40 milliliters of stomach fluid as well as a 20-millimeter glass tube filled with cooked egg white, as shown in the diagram. After 48 hours, the amount of egg white digested in each tube was measured. The data collected are shown in the following table.



Digestion at Different Temperatures

Tube	Temperature (°C)	Amount of Digestion After 48 Hours
1	4	0.0 mm
2	8	2.5 mm
3	21	4.0 mm
4	37	7.5 mm
5	100	0.0 mm

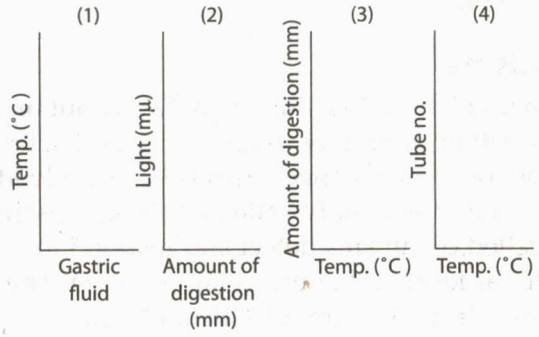
37. Identify the independent variable in this investigation.

(1) gastric fluid
(2) length of glass tubing
(3) temperature
(4) time

38. State the amount of digestion (in mm) that might be expected after 48 hours in a test tube that is identical to the other 5 test tubes, but at a temperature of 15°C.

(1) less than 2.5 mm
(2) between 2.5 and 4 mm
(3) between 4.0 and 7.5 mm
(4) more than 7.5 mm

39. The best graph of the results of this investigation would be made by plotting the data on which set of axes?



40. The student repeated this same experiment using a glass tube containing potato instead of egg white. After 48 hours, he found no evidence of any digestion.

Explain why no digestion occurred. [1]

41. During the winter, many fish eat very little. Some students thought this might be because less oxygen is dissolved in the cold winter water than in the same water during the warm summer months. The students tested the water and found that cold water holds more dissolved oxygen than warm water. They also discovered that the fish have nearly as much food available during the winter as in the summer.

Explain why the fish eat very little during the winter. [1]

Feedback and Homeostasis

Because an organism's external and internal environment is constantly changing, its homeostasis is constantly threatened. As a result, living things must monitor and respond to changes in the environment. Stability (homeostasis) results when the organism detects deviations (changes) in the environment and responds with an appropriate corrective action that returns the organism's systems to normal. If an organism's monitoring systems or control mechanisms fail, disease or even death can result.

As you go about your daily tasks, your body temperature readjusts, your heart and breathing rates alter slightly, and your blood flow increases or decreases. If your monitoring were to fail, these small adjustments would not be made. Soon, your body's homeostasis would begin to deteriorate. Under extreme conditions, you could become quite ill or even die. However, simple corrective actions usually take care of problems with your homeostasis and life goes on. Some examples of responses organisms have to changes they encounter are shown in Table 2-4.

Table 2-4. Responses to Environmental Change

Organism	Change (stimulus)	Response
Species of bacterium	Temperature falls below a certain point.	Bacterium produces a chemical that acts as an antifreeze.
Many plants	Air is hot and dry.	Leaf pores close to conserve water.
Monarch butterflies	Seasons change.	Butterflies migrate.
Human	Person hears a loud noise.	The person becomes alert; heart rate increases for "fight or flight."

Dynamic Equilibrium

Organisms have a variety of mechanisms that maintain the physical and chemical aspects of the internal environment within the narrow limits that are favorable for cell activities. The stability that results from these responses is called homeostasis or a "steady state." To many biologists, the phrase *steady state* suggests an

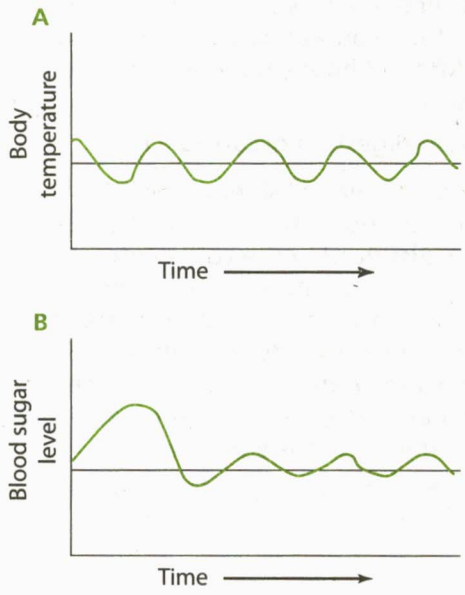


Figure 2-9. Dynamic equilibrium: (A) Temperature: Our body temperature shows a regular pattern of slight changes around a "normal" temperature of about 98.6°F (37°C). The graph represents the slight differences in temperature that are part of a daily cycle. Mechanisms such as shivering and sweating help maintain this range. (B) Blood sugar: Normal blood sugar levels show a rise in blood sugar after a meal, but blood sugar level is quickly restored to equilibrium as the hormone insulin prompts glucose to move from the blood to body cells.

unchanging condition. They prefer to use the term **dynamic equilibrium** to describe the constant small corrections that normally keep the internal environment within the limits needed for survival.

In Figure 2-9, notice that these small corrections include a normal range of variations. Certain microorganisms or diseases can interfere with dynamic equilibrium, and therefore with homeostasis. Organisms, including humans, have mechanisms to deal with such interference and restore the normal state. Homeostatic adjustments have their limits. They can operate only within certain set ranges.

Feedback Mechanisms

A **feedback mechanism** involves a cycle in which the output of a system "feeds back" to either modify or reinforce the action taken by the system. A variety of feedback mechanisms have evolved for helping organisms detect and respond to **stimuli** (changes in the environment). Multi-celled organisms detect and respond to change both at the cellular level and at the organism level. Their systems detect deviations from the normal state and take corrective actions to restore homeostasis.

Feedback responses can be simple or complex. A simple feedback response might involve a hormone that regulates a particular chemical process in a cell. A complex feedback response might be an elaborate behavior, such as bird migration.

Positive Feedback Feedback mechanisms can be either positive or negative. In positive feedback systems, a change prompts a response, which leads to a greater change and a greater response. Childbirth is an example of a positive feedback system. The first contractions push the baby's head against the base of the uterus, which causes stronger contractions in the muscles surrounding the uterus. This increases the pressure of the baby's head against the base of the uterus, which causes stronger contractions and so on. Eventually the baby is born, and the feedback cycle ends.

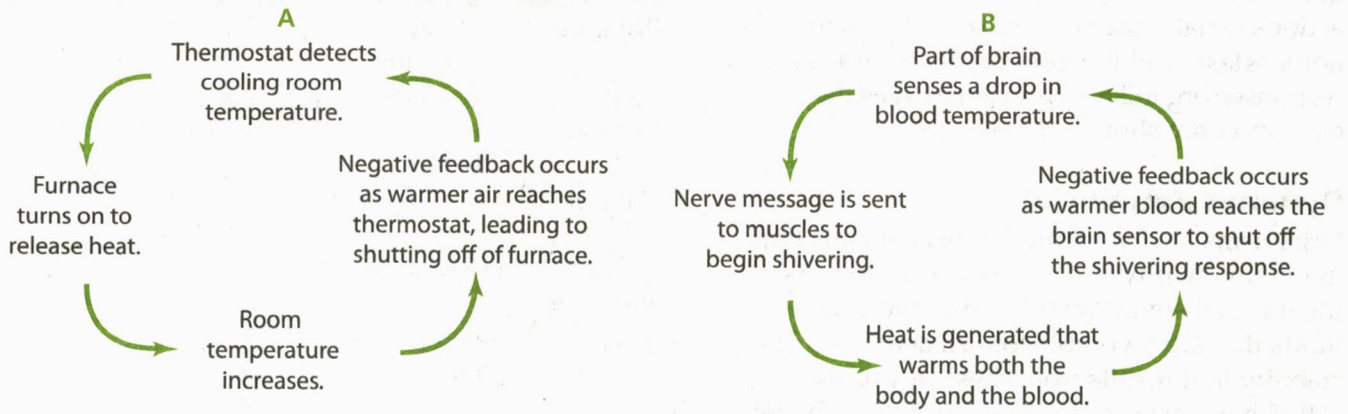


Figure 2-10. Negative feedback systems: (A) The furnace and thermostat in most houses are part of a negative feedback system. (B) Like the household heating system, the regulation of body temperature is a negative feedback system.

Negative Feedback Negative feedback systems are the most common. In this case, a change in the environment can prompt system 1 to send a message (often a hormone) to system 2, which responds by attempting to restore homeostasis. When system 1 detects that system 2 has acted, it stops signaling for further action.

A typical house heating system is an example of negative feedback. The furnace has a thermostat that is set to a specific temperature called the set point. When the room cools below the set point, the thermostat sends a message to turn on the furnace. When the room temperature rises above the set point, the thermostat stops sending the message, and the furnace shuts down. (See Figure 2-10.)

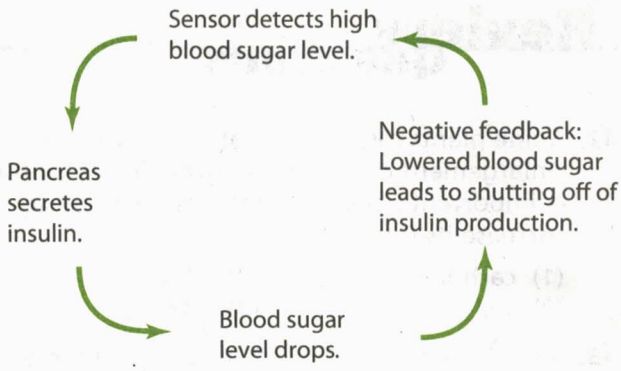


Figure 2-11. Negative feedback involving blood sugar level

Regulating human body temperature uses a similar system. A structure in the brain detects that the temperature of the blood is too low. This brain structure then sends a signal to muscles, causing them to contract and relax in rapid cycles. The result is shivering, which generates body heat. When shivering has sufficiently warmed the body and blood, sensors in the brain detect the change, and the signal to shiver stops.

Negative Feedback and Cell/Organ System Interaction

Maintaining dynamic equilibrium often involves interactions between cells and body organs or systems. For example, certain cells in the body monitor the level of glucose in the blood. When the glucose level is above normal limits, an endocrine organ called the **pancreas** secretes insulin. **Insulin** is a hormone that prompts glucose to move from the blood into body cells, resulting in a lower glucose level in the blood. Another hormone secreted by the pancreas works in the opposite way. When the glucose level in the blood is too low, this hormone prompts the release of glucose stored in the liver. The negative feedback process involving insulin is shown in Figure 2-11.

Other examples of cell/organ feedback interactions include:

- Increased muscle activity is often accompanied by an increase in heart rate and breathing rate. If this did not occur, the muscles would not receive the increase in blood flow and oxygen they need to continue working.
- When plant leaves detect a shortage of water, **guard cells**—specialized cells that surround pores on the surface of the leaf—change shape to close the pores and reduce evaporation. The process is shown in Figure 2-12.

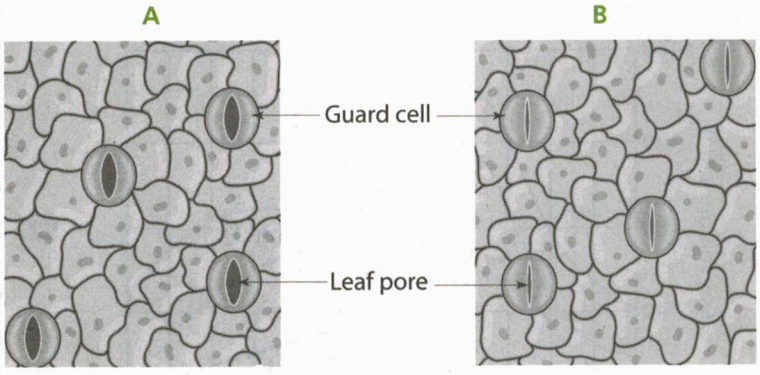


Figure 2-12. Guard cell activity on the surface of a leaf: (A) The guard cells have opened the pores in the leaf, allowing gas exchange between the leaf and the environment. Water can exit from the leaf, and CO_2 can enter. This situation commonly exists when the sun is shining, the air is warm, and water is available from the soil. (B) The guard cells have nearly closed the pores in the leaf, thus protecting the leaf from drying out. Under these conditions, gas exchange is limited. Photosynthesis slows down because little CO_2 is available. This situation commonly exists when the sun is shining, the air is hot and dry, and little water is available from the soil.

Review Questions

42. Some plants respond to light with a sudden enlargement of their leaf pores. This response is important because it enables the plant to increase its intake of

(1) carbon dioxide (3) oxygen
(2) soil (4) nitrogen

43. An increase in the blood's level of a thyroid gland hormone decreases the release of thyroid-stimulating hormone. This mechanism illustrates

(1) negative feedback
(2) enzyme action
(3) immune response
(4) positive feedback

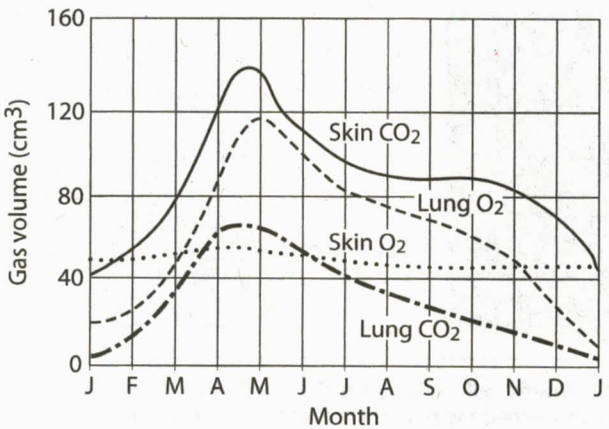
44. Maintenance of the pH of human blood within a certain range is an example of

(1) chemical digestion
(2) synthesis
(3) respiration
(4) dynamic equilibrium

45. Homeostasis is illustrated in the human body by the effects of insulin on the amount of

(1) proteins digested
(2) amino acids absorbed into the blood
(3) oxygen transport to the lungs
(4) glucose in the blood

46. The chart below shows the amount of oxygen and carbon dioxide exchanged through the skin and lungs of a frog for a period of one year.



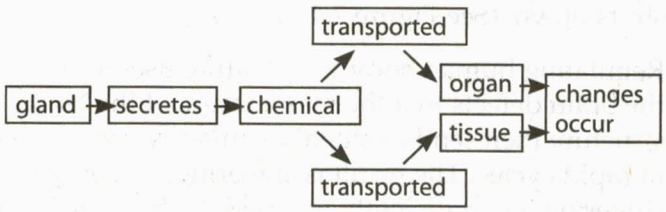
The lowest rate of gas exchange is most likely the result of

(1) increased mating activity
(2) elevated body temperature
(3) environmental conditions
(4) competition with other species

47. A student is frightened by a loud noise, which results in a hormone being released into the blood. The hormone causes the student's heart to beat rapidly. The two systems that work together to cause this reaction are the endocrine system that secretes the hormone and the

(1) nervous system (3) excretory system
(2) reproductive system (4) digestive system

48. Which important human process is represented in the diagram below?



(1) coordination (3) excretion
(2) digestion (4) cell respiration

49. Describe what normally happens to a person's blood sugar level soon after he or she eats a meal that contains carbohydrates. [1]

50. Describe the role of insulin in regulating blood sugar levels. [1]

51. On a sheet of graph paper, mark an X and a Y-axis, then draw a line representing the relative blood sugar levels for two individuals (Person A and Person B) over a 5-hour period after a meal. Both people ate the same foods. Person A produces a normal amount of insulin, and Person B does not.

Explain any differences in the lines representing Persons A and B. [1]

52. During hot weather and vigorous exercise, people sweat. As the water on their skin evaporates, the water molecules absorb heat energy.

Explain why this process is important to the individual. [1]

53. Many different feedback mechanisms have evolved over time. These mechanisms allow an organism to respond to changes in both its internal and external environment.

Select an organism from those you have learned about and describe how a specific feedback process works within that organism. Include how the feedback specifically helps the organism maintain homeostasis. [1]

Disease as a Failure of Homeostasis

Disease is any condition that prevents the body from working as it should. As a result, the body may fail to maintain homeostasis. Diseases in humans may result from foreign invader organisms, called **pathogens,** or from abnormal cells in the body that lead to cancer. Disease may also result from toxic substances, poor nutrition, organ malfunction, an inherited disorder, or risky personal behavior. All can lead to a disruption of the body's ability to function normally—that is, to maintain homeostasis.

Sometimes the onset of a disease becomes apparent right away, as in the case of some birth defects or poisoning. Sometimes, however, the disease may not show up for many years, as is the case with lung cancer caused by exposure to tobacco smoke. Some examples of these kinds of diseases are noted in Table 2-5.

Table 2-5. Causes of Disease

Cause of Disease	Examples
Inherited disorders	Down syndrome, cystic fibrosis, sickle cell disease
Exposure to toxins	Lead poisoning, radiation poisoning
Poor nutrition	Scurvy (vitamin C deficiency), goiter (iodine deficiency)
Organ malfunction	Heart attack, diabetes
High-risk behaviors	Lung cancer, drug addiction, skin cancer

Pathogens There are many potentially dangerous disease-causing organisms in the air, water, and food we take in every day. A variety of pathogens—viruses, bacteria, fungi, and other parasites—can interfere with our normal functioning and make us seriously ill. Plants and other animals can also be infected by these and similar organisms. Some examples of pathogens and the diseases they cause are shown in Table 2-6.

Cancer Certain genetic mutations in a cell can result in uncontrolled cell division called cancer. Exposing cells to certain chemicals and radiation increases mutations and thus increases the chance of cancer. In this disease, genes that control and coordinate a cell's normal cycle of growth and division are altered by mutation. As a result, the cell begins to divide abnormally and uncontrollably. The result is a mass of abnormal cells referred to as a tumor.

Table 2-6. Pathogens and Disease

Pathogen	Description of Pathogen	Examples of Disease
Virus	**Viruses** are particles composed of nucleic acid and protein. They reproduce when they invade living cells.	Examples include the common cold, influenza, AIDS, and chicken pox. Immunizations have been developed to combat many viral diseases.
Bacterium	**Bacteria** are one-celled organisms.	Bacterial illnesses include strep throat, syphilis, and food poisoning. **Antibiotics**, drugs like penicillin that we get from microorganisms, are used to treat many bacterial diseases.
Fungus	**Fungi** are organisms made of either one or many cells. They include yeasts and molds. They eat by absorbing organic substances.	Examples include athlete's foot and ringworm. Fungicides and antibiotics are used to fight fungal diseases.
Parasites	Some animals and one-celled organisms are **parasites** that survive by living and feeding on other organisms.	Parasites include leeches and tapeworms. Malaria is a disease caused by a one-celled organism. It is transmitted to humans by mosquitoes. Heartworm is a parasitic worm that lives in dogs and cats. Medicines are available to treat some parasitic diseases. Avoiding exposure to the parasite is also effective.

Once they are identified, often by abnormal proteins on their surfaces, cancer cells may be attacked by the immune system and destroyed. If the immune system is unable to destroy the cancer cells, the disease may become life-threatening.

The Immune System

Humans have many ways of protecting themselves from danger and disease. For example:

- Our eyes, ears, and sense of smell help us detect danger.
- We release hormones that stimulate emergency responses to danger.
- Our muscles allow us to fight off some threats and to flee from others.
- Our skin—when unbroken—keeps out many foreign organisms that could be harmful.
- Our tears, saliva, and other body secretions trap and/or destroy invaders that come into contact with them.
- Our nervous system provides rapid coordination of many of our responses to danger.

Once invaded, however, the body needs an effective way to combat invaders or body cells that malfunction. The **immune system** is the body's primary defense against disease-causing pathogens.

Pathogens, foreign substances, or cancer cells that threaten our homeostasis can usually be identified by molecules on their outer surfaces or membranes. These molecules, called **antigens,** trigger a response from the immune system. Toxins, the poisonous wastes of certain pathogens, can also act as antigens.

All cells have potential antigens on their surfaces. However, the immune system can usually tell the difference between the molecules of "self" cells, which belong to the body, and "non-self" (foreign) cells, which come from outside the body. When cells of our immune system recognize foreign antigens, specialized white blood cells and antibodies attack them and the cells that display them.

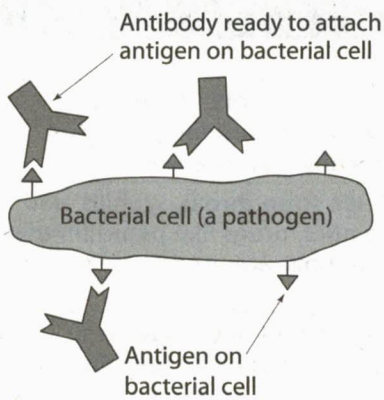


Figure 2-13. Certain white blood cells produce Y-shaped antibodies: The antibodies match the shape of certain antigens on pathogens or abnormal proteins on cancer cells. Note that the antibodies and antigens are not drawn to scale. They would be MUCH smaller than the pathogen cell.

White Blood Cells and Antibodies Some white blood cells are specialized to surround and engulf invading pathogens that are recognized as a threat. Others produce **antibodies**—proteins that either attack the invaders or mark them for killing. The marked invaders may then be destroyed by other white blood cells. In Figure 2-13, notice the Y-shaped antibodies that match the shape of antigens.

Most of the antibodies and white blood cells that attack an invader break down soon after they have defended the body. However, some specialized white blood cells will remain. These cells are capable of quickly dividing and producing more antibodies of the same kind to fight off later invasions of the same **microbes** (microscopic organisms). Antibodies are effective even against microbes that appear years later.

Vaccinations Scientists have discovered that weakened microbes (pathogens) or even parts of microbes can stimulate the immune system to react. The antigens found on the live pathogens are

usually present on the weakened or killed ones, too. As shown in Figure 2-14, **vaccines** are made using these weakened, killed, or parts of microbes (pathogens). When vaccines are injected into the body, the immune system responds just as if it had been invaded by a live pathogen. It produces antibodies. These antibodies can attack and destroy any of that pathogen that is still present in the body.

After a vaccination, the immune system "remembers" specific pathogens by leaving behind white blood cells that protect the body for years. The vaccinated body reacts as if it has already defeated the specific pathogen and responds faster in the future than it did when attacked the first time. The second response is so rapid that in most cases the disease will not even have time to develop before the immune system wipes it out.

Damage to the Immune System A person's immune system may weaken with age or other factors. Stress and fatigue, for example, can lower our resistance and make us more vulnerable to disease. Some viral diseases, such as **AIDS,** result from an attack on the immune system. Damage from the disease may leave the person with AIDS unable to deal with infections and cancerous cells. Their weakened immune system is one reason people with AIDS often die of infections that a healthy immune system would easily destroy.

Problems Associated with the Immune Response Although our immune system is essential for our survival, it creates problems for some people. These people have an **allergy**—a rapid immune system reaction to environmental substances that are normally harmless. Examples of such substances include certain foods, pollen, and chemicals from insect bites.

In people with allergies, the immune system reacts by releasing histamines. This leads to anything from a runny nose and sneezing to a rash and swelling. It is the swelling that makes some allergies dangerous: Occasionally, the throat swells, interfering with the victim's ability to breathe. People with allergies often use antihistamines to reduce the effects of the histamines and the symptoms they cause.

Sometimes the immune system fails to recognize the "self" molecules and attacks the body's own cells. For example, in some cases, the immune system attacks and destroys the pancreas cells that produce insulin. The result is one type of diabetes.

Since transplanted organs come from another person, they have foreign antigens on their cells. As a result, the immune system recognizes transplants as "invaders" and attacks them. To avoid "rejection" of their new organ, transplant patients receive injections of special drugs to reduce the effectiveness of their immune system. Of course, because the immune system's ability to protect the transplant patient from normal pathogens is reduced, the patient may become ill from a pathogen that normally would be no threat.

MemoryJogger

Remember germs? At one time *germ* was the word of choice for people who were talking about the tiny living things that cause disease. *Germ*, however, had two meanings in science, so the term *microbe* became the more accurate word choice. You still need to know that a microbe is any microscopic organism, but scientists now usually use the term *pathogen*. The reason is that the meaning of pathogen also includes viruses, those tiny "almost-organisms" that don't quite fit the description of a living thing.

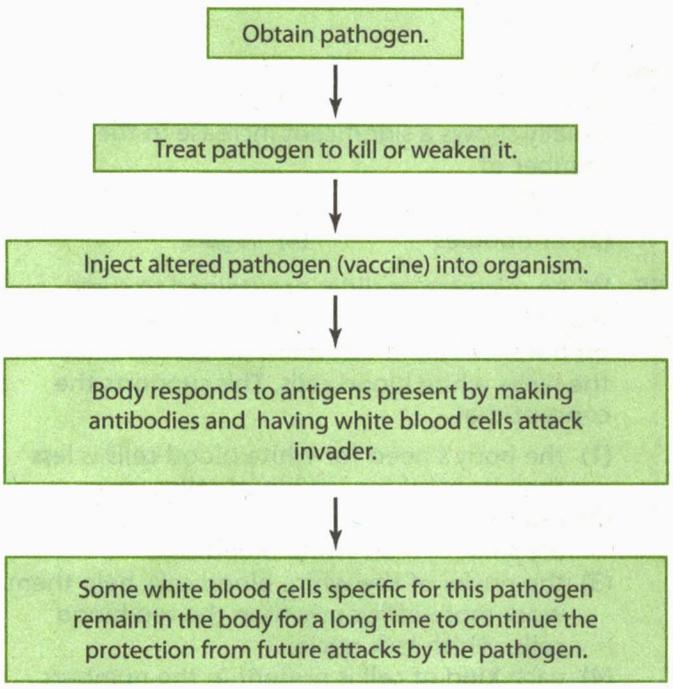


Figure 2-14. Preparation and use of a vaccine

Research and Progress Against Disease Biological research of diseases and their causes has generated a vast amount of knowledge that is used to find ways of diagnosing, preventing, controlling, or curing diseases of plants and animals. Some examples of how medical knowledge has developed are shown in Table 2-7.

Table 2-7. Biological Research of Diseases

Category of Research	Methods Developed
Diagnosing disease	• Culturing (growing) bacteria from the infected person to determine what specific pathogen is responsible for the illness • Using X-rays, CAT scans, ultrasound, blood pressure monitoring devices, and other methods to determine the cause or extent of the illness • Detecting genetic abnormalities that may be present in cells
Preventing and controlling disease	• Promoting improved sanitation measures, including frequent hand washing, safe garbage disposal, and sewage treatment • Sterilizing surgical instruments and treating wounds with antiseptics and other chemicals • Controlling populations of rats, flies, mosquitoes, and other disease-carrying organisms with pesticides or sanitation measures • Treating water, milk, and other foods to reduce the presence of pathogens • Vaccinating to promote the body's immune response to pathogens • Identifying the dangers of risky behaviors such as tobacco use
Treating and curing disease	• Developing antibiotics and other drugs to kill pathogens • Developing medical procedures, including surgical operations and laser techniques, to remove damaged or diseased tissue from the body

Review Questions

54. When a person is suffering from an infection, such as strep throat or chicken pox, his blood usually shows a significant increase in the number of

(1) enzymes (3) hormones
(2) antibodies (4) sugars

55. When microscope slides are stained to show blood cells, the small red blood cells that appear on the slides are much more numerous than the large white blood cells. This supports the concept that

(1) the body's need for white blood cells is less than its need for red blood cells
(2) red cells are more numerous because they are smaller than white blood cells
(3) the nuclei of the white blood cells help them work more efficiently than the red blood cells, which lack nuclei
(4) each kind of cell is present in the numbers best suited to meet the needs of the body

56. Which response usually occurs after an individual receives a vaccination for the influenza virus?

(1) Hormones in the blood stop reproduction of the virus.
(2) Pathogens from the vaccine deactivate the virus.
(3) Enzymes released from antigens digest the virus.
(4) Antibodies against the virus are found in the blood.

57. A patient has just received an organ transplant. Which treatment would be most effective in preventing the patient's body from rejecting the organ?

(1) Treat the patient with medications that decrease the immune system's response.
(2) Treat the patient with antibiotics to fight off a possible viral infection.
(3) Restrict the patient's salt intake.
(4) Give the patient blood transfusions.

58. The body makes chemicals that can help to destroy harmful viruses and bacteria. These chemicals are called

(1) antibodies
(2) vaccines
(3) hormones
(4) antibiotics

59. A vaccine can protect you against a disease because it

(1) destroys toxic substances from bacteria before they can make you sick
(2) stimulates your immune system against the pathogen
(3) kills any pathogenic bacteria in your body
(4) changes pathogenic bacteria into harmless bacteria

60. The body is protected against harmful flu viruses by

(1) red blood cells and hormones
(2) white blood cells and antibodies
(3) white blood cells and enzymes
(4) red blood cells and antibodies

61. A scientist wishes to determine how effective a vaccine is in protecting rats against a contagious disease. Which experimental procedure should the scientist use to determine the vaccine's effectiveness?

(1) Expose 100 rats to the disease and then vaccinate them all.
(2) Give vaccinations to 50 of the 100 rats and then expose all 100 to the disease.
(3) Give vaccinations to 100 of the rats and expose them all to the disease.
(4) Vaccinate 50 of the 100 rats and then expose only the 50 vaccinated rats to the disease.

62. Parasitic strains of *E. coli* may produce poisonous chemicals that attack living tissue and cause disease in humans. These chemicals are called

(1) antibodies
(2) toxins
(3) viruses
(4) antibiotics

63. Uncontrolled cell division is known as

(1) meiosis
(2) cancer
(3) antibody production
(4) sexual reproduction

64. The resistance of the body to a pathogen is called

(1) immunity
(2) antigen
(3) cancer
(4) infection

65. Diseases can be caused by inherited disorders, exposure to toxic substances, organ malfunction and certain personal behaviors.

Choose *two* of the above causes and *for each one* give a specific example of an associated disease. [1]

66. Our immune system normally helps us resist infection and disease. Sometimes, however, it may actually work against us by attacking certain tissues or organs in the body.

State one example of the immune system attacking the body and explain how we try to counteract the problem. [1]

67. Vaccinations play a major role in medicine today. Explain the role of vaccines in the prevention of disease. Your answer must include at least:

- a description of the contents of a vaccine [1]
- a description of how a vaccine protects the body from disease [1]
- one specific reason certain vaccinations are required for students to attend public schools. [1]

68. Biological research has generated much knowledge about diagnosing and preventing disease.

Give one specific example of how research has helped us *diagnose* a disease and one specific example of how research has helped us *prevent* a disease. [1]

69. Various kinds of pathogens cause illness or interfere with body functioning. For each pathogen type listed below, identify one specific organism or disease associated with that type of pathogen.

Pathogen Types:

(a) virus
(b) bacteria
(c) fungus
(d) other parasites

Practice Questions
for the New York Regents Exam

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 Most of the oxygen in our atmosphere comes from processes carried out
(1) in the soil
(2) by animals
(3) in factories
(4) by plants

2 Which organism releases oxygen into the atmosphere?
(1) mold
(2) bird
(3) fish
(4) tree

3 Plants provide food for animals through the process of
(1) respiration
(2) digestion
(3) photosynthesis
(4) excretion

4 Which word equation represents the process of photosynthesis?
(1) starch → many glucose molecules
(2) glucose + oxygen → carbon dioxide + water + energy
(3) carbon dioxide + water → glucose + oxygen
(4) fats → sugar molecules

---

5 Which statement correctly relates the two organisms in the illustration below?

A B

(1) A carries out cell division, but B does not.
(2) B transports needed organic materials, but A does not.
(3) Both A and B carry out cellular respiration to release energy from organic molecules.
(4) Neither A nor B is able to use energy to combine carbon dioxide and water to make organic compounds.

6 A plant cell that lacks chloroplasts will not
(1) give off oxygen
(2) take in food
(3) give off carbon dioxide
(4) take in water

7 Which process removes carbon dioxide from the atmosphere rather than adding it?
(1) cellular respiration
(2) combustion of gasoline
(3) photosynthesis
(4) deforestation

8 Which process in plants produces carbon dioxide?
(1) respiration
(2) photosynthesis
(3) coordination
(4) digestion

9 The size of the openings in a leaf through which gases move in and out is controlled by the
(1) root cells
(2) chloroplasts
(3) chromosomes
(4) guard cells

10 What process does the word equation below represent?

$$\text{glucose} + \text{oxygen} \xrightarrow{\text{enzymes}} \text{carbon dioxide} + \text{water} + \text{energy}$$

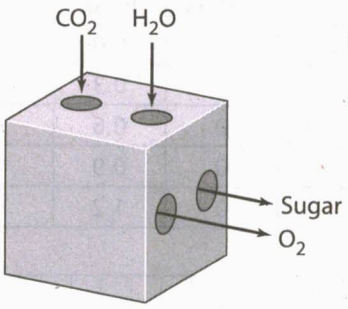
(1) photosynthesis
(2) breathing
(3) transport
(4) respiration

---

11 The major source of weight gain in a growing plant is
(1) sunlight
(2) carbon dioxide
(3) oxygen
(4) soil

12 Green plants do not release large amounts of CO_2 all the time because they use CO_2 in the process of
(1) photosynthesis
(2) respiration
(3) reproduction
(4) evolution

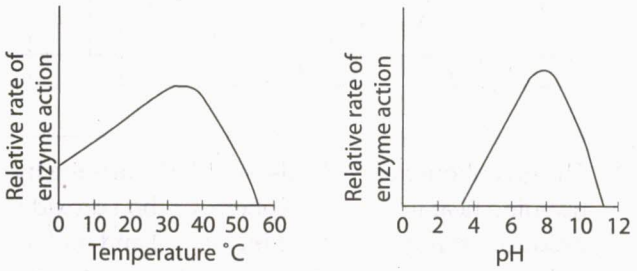
13 The diagram below represents some events that take place in a plant cell. With which organelle would these events be most closely associated?



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

14 An enzyme that digests starch will not act upon the sugar sucrose. This fact is an indication that enzymes are
(1) specific
(2) synthetic
(3) starches
(4) generalized

15 Which statement best describes the enzyme represented in the graphs below?



(1) This enzyme works best at a temperature of 37°C and a pH of 8.
(2) This enzyme works best at a temperature of 55°C and a pH of 12.
(3) Temperature and pH have no effect on the action of this enzyme.
(4) This enzyme works best at a temperature near freezing and a pH above 4.

16 The body usually responds to foreign material by forming
(1) hormones
(2) antibodies
(3) vaccines
(4) antigens

17 A sudden increase in the number of white blood cells in a human may be an indication of
(1) growth
(2) color blindness
(3) mental retardation
(4) an infection

Part B

Base your answers to questions 18 and 19 on the equation below and on your knowledge of biology.

$$C_6H_{12}O_6 + 6\,O_2 \rightarrow H_2O + 6\,CO_2 + 36\,ATP$$

(glucose) + (oxygen) → (water) + (carbon dioxide) + ATP

18 The equation represents the process of
(1) excretion
(2) photosynthesis
(3) respiration
(4) coordination

19 Explain the energy connection between the glucose and the formation of ATP in this process. [1]

Base your answers to questions 20 through 24 on the following selection from the work of an early scientist and on your knowledge of biology.

A sprig (stem with leaves) of a nettle plant was put in a jar full of air fouled by breathing so as to extinguish a candle; it was placed in a room and left overnight; the next morning the air was found to be as bad as before. At 9 o'clock in the morning, the jar was put in the sunshine and, in the space of two hours, the air was so much corrected that it was found to be nearly as good as common air.

20 The "jar full of air fouled by breathing" probably contained an excess of what gas? [1]

21 The fact that "the air was found to be as bad as before" was due to a process taking place in the plant. Name that process. [1]

22 What process did the plant perform to produce air nearly as good as "common air"? [1]

23 Identify the gas produced by the plant in the process that improved the air in the jar. [1]

24 Identify the gas that was produced by the plant in the dark. [1]

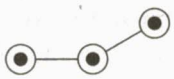
Base your answers to questions 25 through 29 on the information and data table below and on your knowledge of biology.

An investigation was designed to determine the effect of temperature on respiration in germinating seeds. Two sets of test tubes were prepared. In each set of two test tubes, one tube contained a number of germinating peas, and the other tube contained an equal number of glass beads. An equal amount of chemical was placed in each tube to absorb the carbon dioxide produced so that the volume of oxygen consumed could be measured. One set of tubes was placed in a controlled-temperature water bath at 10°C. The other set of test tubes was placed in a controlled-temperature water bath at 26°C. Total oxygen consumption was measured every 5 minutes for a period of 20 minutes. The data are summarized in the data table.

Use the information in the data table at the right and follow the directions in questions 25 through 27 to construct a line graph on the grid provided.

25 Label each axis and mark an appropriate scale on each axis, without any breaks. [1]

26 Plot the data for oxygen consumption by peas at 10°C on the grid. Surround each point with a small circle and connect the points. [1]

Example: 

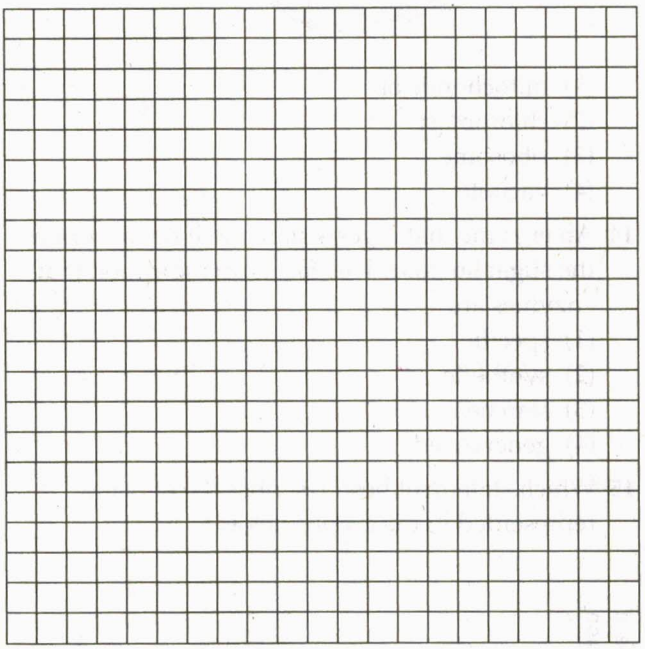
27 Plot the data for oxygen consumption by peas at 26°C on the grid. Surround each point with a small triangle and connect the points. [1]

Example: 

28 State one conclusion that relates the rate of respiration in germinating peas to temperature. [1]

29 State one reason for including the tube containing the glass beads in each set. [1]

Total Oxygen Consumption (mL)				
Time (in minutes)	Temperature			
	10°C		26°C	
	Beads	Peas	Beads	Peas
0 (Start)	0	0.0	0	0.0
5	0	0.3	0	0.5
10	0	0.6	0	1.0
15	0	0.9	0	1.5
20	0	1.2	0	2.0



30 The greenhouse effect leads to global warming by trapping heat in our atmosphere. Carbon dioxide produced through the burning of coal and oil for industrial processes, power generation, and transportation is one of the main atmospheric gases that contributes to the problem.

Some people have suggested that planting many long-lived trees along the interstate highways in New York and other states could help counteract the greenhouse effect. Explain how this could help. [1]

Base your answers to questions 31 through 34 on the passage below and on your knowledge of biology.

Lyme Disease

Since 1980, the number of reported cases of Lyme disease in New York State has been increasing. The vector (carrier)of Lyme disease is the black-legged tick, *Ixodes scapularis*. The disease is spread from infected animals to ticks that bite these animals. Humans bitten by these ticks may then become infected.

The symptoms of Lyme disease do not always occur immediately after a tick bite. An individual may develop a skin rash several days to weeks after being bitten by a tick. Flu-like symptoms, such as headaches, muscle aches, joint pain, and fever, may also develop. Generally, these symptoms clear up even if the individual does not seek medical help. In some cases, there may be no symptoms other than a sudden onset of arthritis. However, in a small number of cases, if the infection is not treated, it may lead to chronic arthritis, disorders of the heart and nervous system, or in a few cases, death. A blood test can help to confirm a diagnosis, and antibiotics are effective in treating the infection.

People may take preventive action by frequently checking themselves and their pets for ticks, tucking their pant legs into socks when walking through woods or high grass, wearing light-colored clothing to aid in spotting a tick, and using insect repellent.

31 Describe how Lyme disease is transmitted. [1]

32 State one way people might protect themselves from Lyme disease. [1]

33 State two symptoms that may occur if a person has Lyme disease. [2]

34 State one danger of ignoring any symptoms that may develop after a tick bite. [1]

Base your answers to questions 35 through 37 on the information and data table below and on your knowledge of biology.

Twenty-five geranium plants were placed in each of four closed containers and then exposed to the light conditions shown in the data table. All other environmental conditions were held constant for a period of two days. At the beginning of the investigation, the quantity of carbon dioxide (CO_2) present in each container was 250 cm^3 (cubic centimeters). The data table shows the amount of CO_2 remaining in each container at the end of two days.

Changes in CO_2 Levels

Container	Color of Light	CO_2 (cm^3) at Start	CO_2 (cm^3) After 2 Days
1	blue	250	50
2	red	250	75
3	green	250	200
4	orange	250	150

35 The independent variable in this investigation was the
(1) type of plant
(2) color of light
(3) amount of CO_2 in each container at the beginning of the investigation
(4) number of days needed to complete the investigation

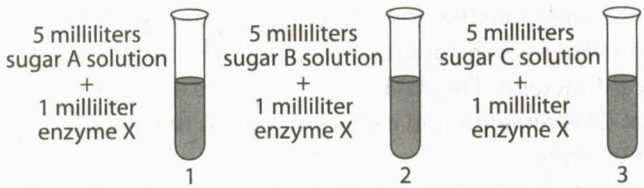
36 State the problem being investigated in this experiment. [1]

37 Identify the source of the carbon used in photosynthesis. [1]

Part C

Base your answers to questions 38 through 40 on the information below and on your knowledge of biology.

An investigation was performed to determine the effects of enzyme X on three different disaccharides (double sugars) at 37°C. Three test tubes were set up as shown in the diagram below.



At the end of 5 minutes, the solution in each test tube was tested for the presence of disaccharides (double sugars) and monosaccharides (simple sugars). The results of these tests are shown in the table below.

Result of Sugar Test			
	Test Tube 1	**Test Tube 2**	**Test Tube 3**
Monosaccharide	not present	not present	present
Disaccharide	present	present	not present

38 What can be concluded about the activity of enzyme X from the data table? [1]

39 With only the materials list supplied below and common laboratory equipment, design an investigation that would show how a change in pH would affect the activity of enzyme X. Your design must include a *detailed procedure* and a *data table*. [3]

Materials
Enzyme *X*
Sugar C Solution
Indicators
Substances of various pH values —
vinegar (acidic)
water (neutral)
baking soda (basic)

40 State one safety precaution that should be used during the investigation. [1]

---

41 Enzyme molecules are affected by changes in conditions within organisms. Explain how a prolonged, excessively high body temperature during an illness could be fatal to humans. your answer must include:

- the role of enzymes in a human [1]
- the effect of this high body temperature on enzyme activity [1]
- the reason this high body temperature can result in death [1]

Base your answers to questions 42 and 43 on the statement below and on your knowledge of biology.

Some internal environmental factors may interfere with the ability of an enzyme to function efficiently.

42 Identify two internal environmental factors that directly influence the rate of enzyme action. [2]

43 Explain why changing the shape of an enzyme could affect the ability of the enzyme to function. [1]

Base your answer to question 44 on the information below and on your knowledge of biology.

Immunization protects the human body from disease. The success of vaccinations can be seen in the fact that smallpox has been eliminated worldwide from the list of common infectious diseases. The only remaining smallpox viruses on Earth are thought to be those kept in certain research laboratories.

The United States is now committed to the goal of immunizing all children against common childhood diseases. However, many parents are choosing not to immunize their children against childhood diseases such as diphtheria, whooping cough, and polio.

For example, the mother of a newborn baby is concerned about having her child receive the DPT (diphtheria, whooping cough, and tetanus) vaccine. Since these diseases are caused by bacteria, she believes antibiotic therapy is a safe alternative to vaccination.

44 Discuss the use of antibiotics and vaccines in the treatment and prevention of bacterial diseases. In your answer be sure to include:

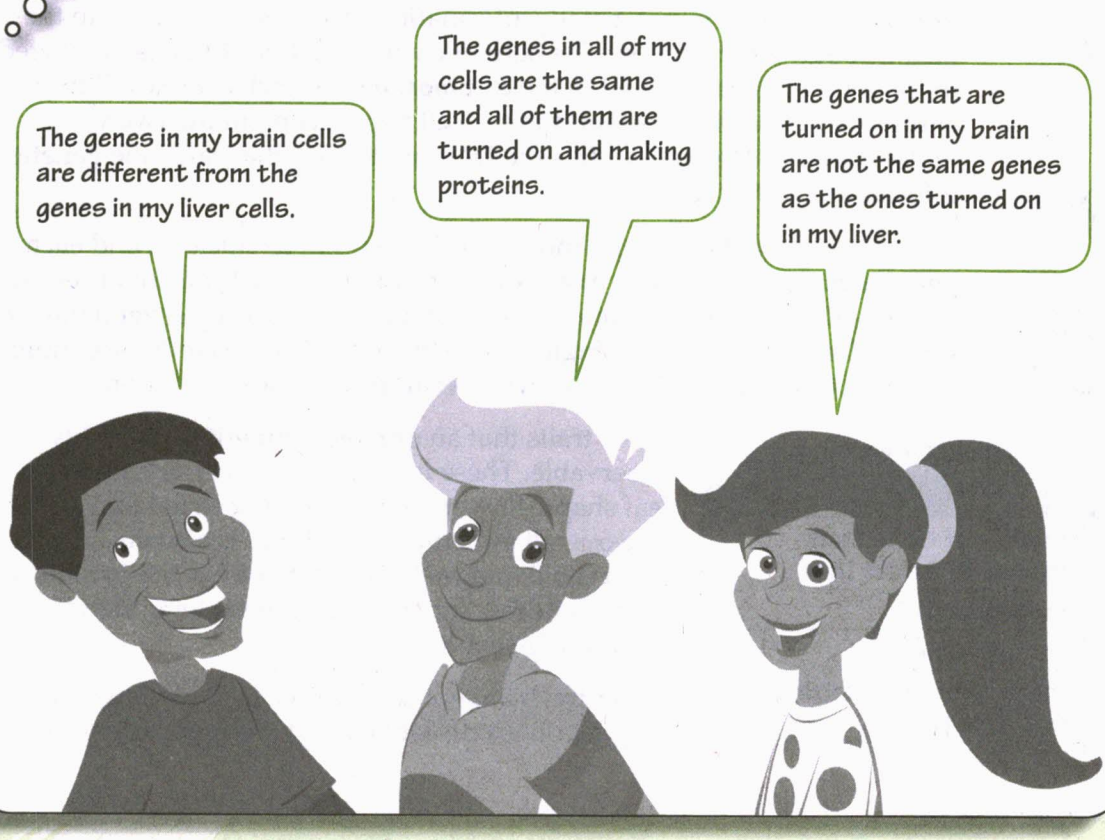
- what is in a vaccine [1]
- how a vaccine promotes immunity [1]
- one advantage of the use of vaccinations to fight bacterial diseases [1]
- one disadvantage of the use of antibiotics to fight bacterial diseases [1]

Genetic Continuity

TOPIC 3

What do You Think?

Genes in Cells



TOPIC 3

Genetic Continuity

Vocabulary

asexual reproduction	egg	replicate
biotechnology	expressed	selective breeding
body cell	genes	sexual reproduction
bond	genetic engineering	sperm
chromosome	genetic recombination	subunit
clone	heredity	template
DNA	mutation	traits

Topic Overview

When two organisms reproduce, their offspring receive genetic instructions, called **genes**, from each parent. The genes determine which **traits**—or characteristics—each offspring will have. All organisms—whether they are animals, plants, or members of one of the other kingdoms—pass their genetic characteristics along in this manner. Because of this transfer of genetic information, offspring tend to resemble their parents.

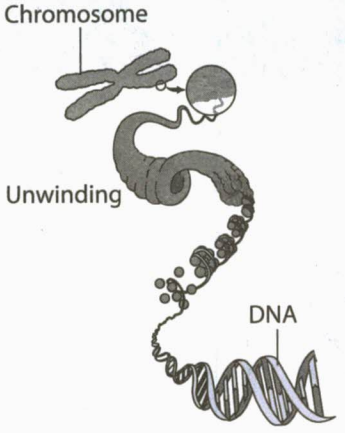


Figure 3-1. Chromosomes contain DNA: Notice that the chromosome contains one very long double strand of DNA.

Heredity and Genes

Heredity is the passing of genetic information from one generation to the next through reproduction. The hereditary information (**DNA**) is organized in the form of genes located in the **chromosomes** of each cell. Recall that chromosomes, which are found in the cell nuclei, contain the DNA molecules. (See Figure 3-1.) It is the DNA molecules that carry the genetic information of the cell.

A human cell contains many thousands of genes in its nucleus, and each gene carries a separate piece of coded information. The traits inherited by an individual can be determined by one pair of genes or by several pairs of genes. It is also true that a single gene pair can sometimes influence more than one trait. Table 3-1 shows several examples of these variations.

Table 3-1. Human Traits Inherited with Different Numbers of Genes

Trait	Number of Gene Pairs Needed to Affect Trait
Cystic fibrosis	Single gene pair
Skin color	Multiple gene pairs
Sickle cell disease	Single gene pair affecting multiple traits

Some traits that an organism inherits are readily observable. These include traits such as hair color, leaf shape, flower scent, and wing structure. The overall structure of the body is also an observable trait that is inherited from the parents. Some children, for example, inherit long, slender toes or large ear lobes.

Other traits are not so obvious. Less obvious traits may involve a defective heart, a single kidney, or

how some of the body's chemicals function. Examples include the ability to produce insulin, the types of receptors present on a cell membrane, and whether an individual can make a particular respiratory enzyme.

Methods of Reproduction

There are two common methods of reproduction: asexual and sexual. The major difference between these two methods is whether one or two parents are involved in producing the offspring. **Asexual reproduction** involves one parent or individual (often a single-celled organism); **sexual reproduction** involves two parents.

Asexual Reproduction In organisms that reproduce asexually, all the genetic instructions (genes) come from one individual or parent. Since the genes are all from one parent, offspring are usually identical to the parent.

Because the coded instructions in their cells are the same as the instructions in their parent's cells, asexually produced offspring are genetically identical to their parents. Identical genetic copies are known as **clones.** Because they are asexually produced, entire populations of bacteria—perhaps millions of cells—may be genetically identical clones.

Sexual Reproduction In organisms that reproduce sexually, two parents are required to produce offspring. Each parent produces sex cells. **Sperm** are the sex cells produced by the male; the **egg** is the sex cell produced by the female. Recall that genes in **body cells**—cells other than sex cells—occur in pairs, but each sex cell contains only one gene from each pair. The offspring that results from sexual reproduction therefore receives half of its genetic information from the female parent (via the egg) and half from the male parent (via the sperm).

Genetic Recombination When a sperm and egg combine to form a new cell with a complete set of genetic instructions, a unique combination of genes results. The term for this is **genetic recombination.** This unique combination of thousands of genes produces an offspring that may resemble either or both parents in many ways but will not be identical to either of them.

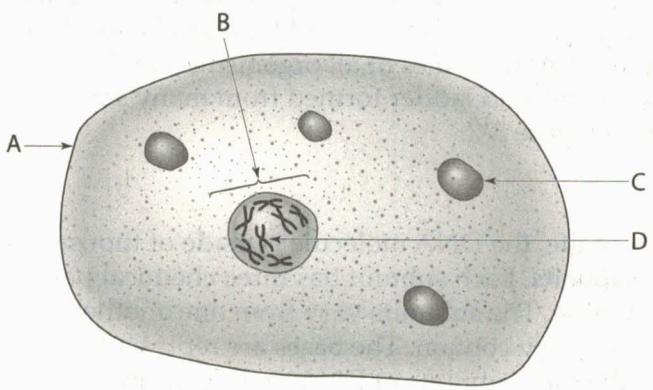
Digging Deeper

Sometimes people use the word *gene* when they really mean *allele*. A gene is actually an area or part of a chromosome with coded information about some trait or characteristic of the organism. In many cases, there are two or more ways for this trait to appear. The alternate forms of the genes are the alleles—the actual information contained in the gene.

In pea plants, for example, genes carry information about the color of their seeds. However, the seeds can be either green or yellow. The actual color of the seeds will be determined by the alleles. If the plant has two alleles with genetic instructions for yellow seeds, the seeds will be yellow. If they both have genetic instructions for green, the seeds will be green. However, if there is one allele for yellow and one for green, the seeds will be . . . yellow. In this case, the yellow allele is referred to as the dominant allele.

Review Questions

1. A cell is represented in the diagram below.



Which statement about the cell is correct?

(1) Structure A synthesizes and secretes cellular products.
(2) Structure B contains chromosomes involved in transmitting genetic information.
(3) Structure C utilizes DNA in the process of photosynthesis.
(4) Structure D is the site of protein synthesis.

2. Which materials are composed of DNA?

(1) proteins
(2) genes
(3) nerve secretions
(4) fluid in vacuoles

3. In an animal cell, DNA is found in the greatest concentration in the

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

4. Cystic fibrosis is a genetic disease. Examine the illustration below.

Father with cystic fibrosis
Father has two abnormal genes for the trait

Mother who does not have cystic fibrosis
Mother has ???

Child with cystic fibrosis
Child has two abnormal genes for the trait

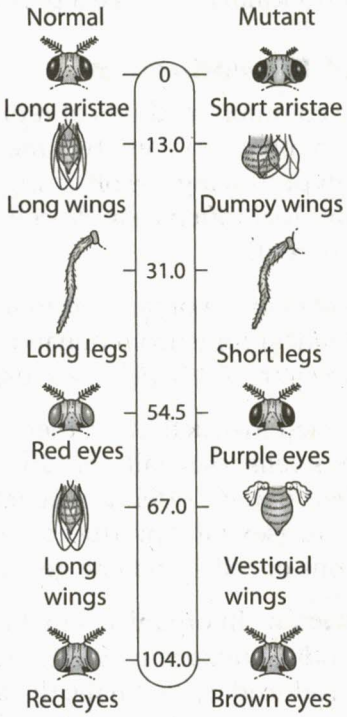
The mother's cells most likely contained

(1) a disease-causing virus
(2) one normal gene and one abnormal gene
(3) two normal genes
(4) an abnormal number of chromosomes

5. Bacteria in culture A produce slime capsules around their cell walls. A biologist removed the DNA from some of the bacteria in culture A. He then injected it into bacteria in culture B, which normally do not produce slime capsules. After the injection, bacteria with slime capsules began to appear in culture B. What conclusion could best be drawn from this investigation?

(1) The bacteria in culture A are mutations.
(2) Bacteria reproduce faster when they have slime capsules.
(3) The slime capsules of bacteria in culture B contain DNA.
(4) DNA is most likely involved in the production of slime capsules.

6. The diagram below represents the gene map of a fruit-fly chromosome.



A valid observation based on this gene map is that

(1) more than one gene may affect a single trait such as eye color
(2) each trait is influenced by genes that are identical
(3) each trait is influenced by only one pair of genes
(4) genes for traits such as eye color are always next to each other

7. Which cell structure includes all of the others?

(1) nucleus
(2) gene
(3) DNA
(4) chromosome

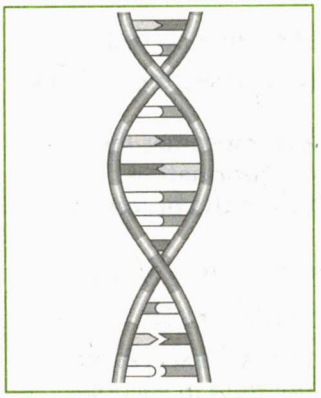


Figure 3-2. Model of a section of a DNA molecule

The Genetic Code

The inherited instructions (genes) that are passed from parent to offspring exist in the form of a chemical code. This genetic code, as the chemical code is called, is contained in the DNA molecules of all organisms. DNA molecules resemble a flexible, twisted ladder formed from many smaller repeating units, as shown in Figure 3-2.

DNA Structure

Like other large molecules of life, the DNA molecule is made of thousands of smaller sections called **subunits.** Each subunit has three chemical parts: a sugar, a phosphate, and a base. The subunits vary from one another according to the kind of bases they contain. The bases are represented by the letters A, G, C, and T. The four subunits of DNA molecules are

arranged in pairs, each subunit forming one side and half of one rung of the "twisted ladder." Base A of one subunit always pairs with the base T of another subunit. In a similar way, base G always pairs with base C. Figure 3-3 shows the details of the structure in an untwisted molecule.

Once the chemical and structural properties of DNA were discovered by scientists, it became clear how this molecule could contain a kind of message that functions as a code. Notice in Figure 3-3 that the sequence of bases on this molecule's left strand, reading from top to bottom, is ACAG. A different molecule might have a sequence in the same position reading GCAG or AACG. The specific sequence of bases in a DNA molecule forms a coded message. The message of a single gene is often a sequence of hundreds of bases. The code for an entire human is estimated to be around 3 billion base pairs!

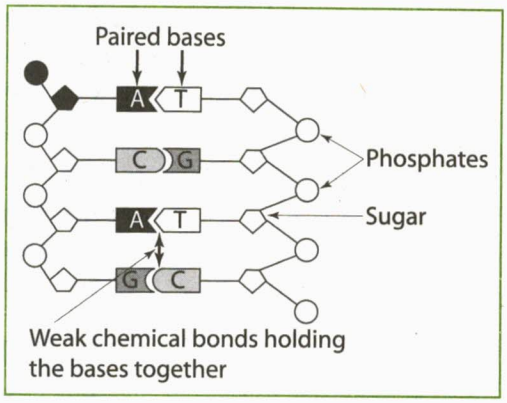


Figure 3-3. Portion of a DNA molecule: A single subunit is shown in black. The bases of the DNA molecule are arranged in pairs, represented here by letters. The base pairs form the rungs of the twisted DNA ladder. The sugar and phosphate of each subunit form the sides of the ladder and are connected by strong chemical bonds. The two sides are held together by weak chemical bonds between the paired bases. (Bonds are the links between atoms that hold molecules together.)

DNA Replication

The ability to copy the coded instructions in the DNA molecule is critical to its function. Knowing the chemical makeup and structure of DNA molecules gave scientists an immediate clue to how the molecule could be copied, or **replicated.** When scientists realized that the bases used weak chemical bonds to pair with each other, they also realized that the DNA could separate at that weak **bond** to form two single strands. Each single strand became a **template**, or pattern, for a new molecule.

The new molecule was built by attaching new subunits to each template strand, always following the base pairing rules of linking A with T and C with G. The result is the formation of two new molecules whose base pair sequences are exactly alike. See Figure 3-4.

When the structure of DNA was determined, scientists finally understood how cells could copy and transfer information to new cells each time they divide and to new offspring during reproduction. Replication produces two identical copies of the cell's genetic information, each ready to be passed from the parent cell to two offspring cells during cell division. Offspring cells are commonly called daughter cells.

Proteins and Cell Functioning

The work of the cell is carried out by the many types of molecules the cell assembles (synthesizes). Many of these molecules are proteins. Protein molecules are long chains. They are formed from various combinations of 20 kinds of amino acids arranged in a specific sequence.

The sequence of amino acids in a particular protein influences the shape of the molecule. This is because some of the amino acid parts are attracted to (and may bond with) other amino-acid parts of the chain. The connections that form between different parts of the chain cause it to fold and bend in a specific way. The final folded shape

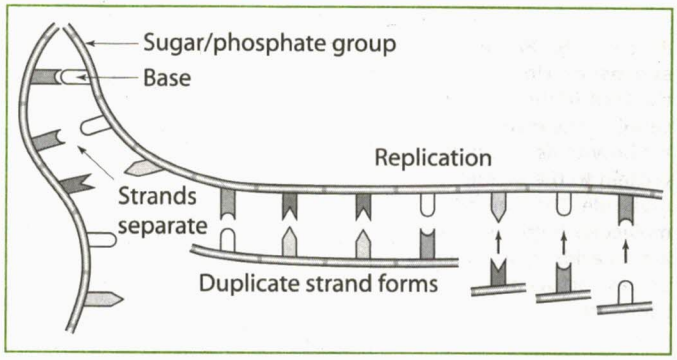


Figure 3-4. The replication of a DNA molecule: This is how cells copy their genetic information to be passed on to two offspring cells when cell division occurs. Both strands are replicated at the same time.

of the protein enables it to carry out its function in the cell. Many proteins made by a cell become enzymes that regulate chemical reactions. Remember that an enzyme can interact with a specific molecule because their shapes correspond.

Some of the proteins made in cells become parts of organelles, such as the cell membrane. Other proteins include the hormone insulin or the many antibodies that bind to antigen molecules on pathogens. The color of your eyes and skin are also the result of proteins synthesized by your body.

The DNA-Protein Connection

Cells store vast amounts of coded information in their genes. Much of this coded information is used to make the thousands of proteins that each cell requires for its functions and the structures it contains. The proteins for these structures and functions are made at the ribosomes according to the directions stored in the cell's DNA code.

Because offspring inherit genetic information from their parents, their cells make many of the same proteins. This is what causes the resemblance between some children and their parents. Making many of the same proteins causes both parent and offspring to form similar structures that give them similar features. One example of a protein-dependent trait includes hair texture (curly, straight, or kinky).

If a parent's DNA carries a code for a protein that does not function correctly, the children may also make that defective protein. For example, an albino does not produce the usual amount of eye, hair, or skin color pigment. The condition is caused by a defect in the gene that codes for the protein that produces color pigment. If albino parents pass this gene to their offspring, they, too, may not produce the normal color pigment.

Protein Synthesis The process of synthesizing a protein from DNA begins in the nucleus. There, the DNA code of a particular gene is "read" by a special enzyme and used to produce a "messenger" molecule. This messenger molecule then travels to the ribosomes in the cell's cytoplasm. With the aid of specialized transfer molecules, amino acids are moved to the ribosomes for assembly into protein. They are bonded in the order specified by the messenger molecule. In this way, the sequence of amino acids of any protein, and therefore its overall structure, is determined by the gene's DNA sequence in the nucleus. The process is shown in Figure 3-5.

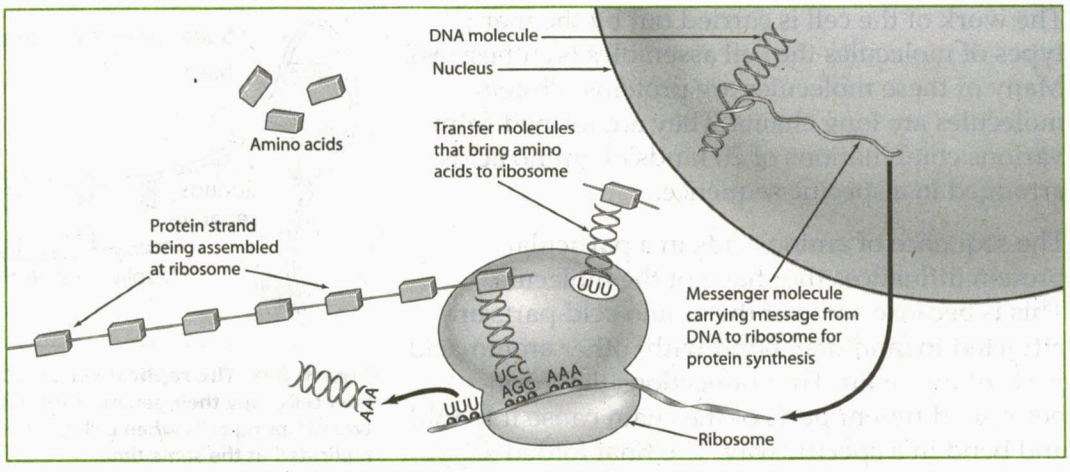


Figure 3-5. Protein synthesis: Notice that the DNA in the nucleus supplies the instructions for how to assemble the protein to the messenger molecule. The transfer molecules help assemble amino acids. The assembly process occurs at a ribosome.

8. In a DNA molecule, the letters A, T, C, and G represent

(1) bases
(2) sugars
(3) starches
(4) proteins

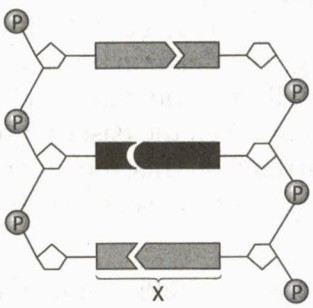
9. The individuality of an organism is determined by the organism's

(1) amino acids
(2) nitrogen bases
(3) DNA base sequence
(4) order of ribosomes

10. What would most likely happen if the ribosomes in a cell were not functioning?

(1) The cell would undergo uncontrolled mitotic cell division.
(2) The synthesis of enzymes would stop.
(3) The cell would produce antibodies.
(4) The rate of glucose transport in the cytoplasm would increase.

11. The diagram below represents a portion of a DNA molecule.



The letter X represents two bases that are

(1) identical and joined by weak bonds
(2) identical and joined by strong bonds
(3) a part of the genetic code of the organism
(4) amino acids used to build folded protein molecules

12. The kinds of genes an organism possesses are dependent on the

(1) type of proteins in the organism's nuclei
(2) sequence of bases in the organism's DNA
(3) number of ribosomes in the organism's cytoplasm
(4) size of the mitochondria in the organism's cells

13. What is the role of DNA molecules in the synthesis of proteins?

(1) They catalyze the formation of bonds between amino acids.
(2) They determine the sequence of amino acids in a protein.
(3) They transfer amino acids from the cytoplasm to the nucleus.
(4) They supply energy for protein synthesis.

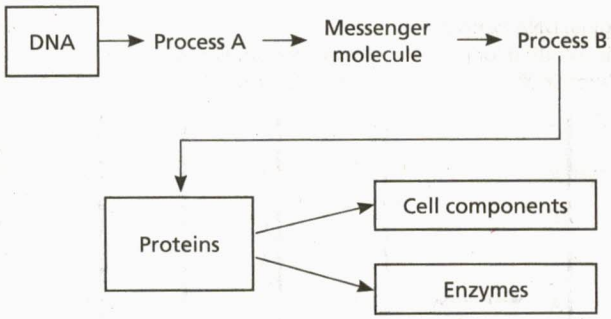
14. The diagram at the right represents a molecule of

(1) ATP
(2) protein
(3) carbohydrate
(4) DNA

15. During replication, the strands of a double-stranded DNA molecule separate when the bonds are broken between their paired bases.

Explain why, in terms of the genetic code, it is important that the molecule separate between the bases and not at some other point. [1]

Base your answers to questions 16 and 17 on the diagram below and on your knowledge of biology.



16. Within which organelle does process A occur?

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

17. Within a living cell, which organelles are directly necessary for process B to occur?

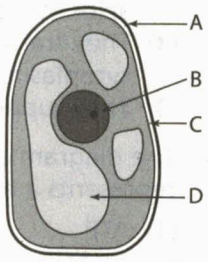
(1) ribosomes
(2) mitochondria
(3) vacuoles
(4) cell membranes

18. In all living cells, DNA controls cellular activities by

(1) determining the order of amino acids in protein molecules
(2) regulating the concentration of molecules on both sides of the cell membrane
(3) varying the rates of starch synthesis
(4) coordinating active and passive transport

19. Which cell organelle indicated in the diagram controls the synthesis of enzymes?

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



20. The sequence of amino acids that makes up a protein molecule is determined by the sequence of

(1) bases in DNA
(2) glucose in DNA
(3) ribosomes in the cytoplasm
(4) chloroplasts in the vacuoles

21. In DNA, the base represented by an A always pairs with the base represented by

(1) A (2) T (3) C (4) G

22. The presence of DNA is important for cellular metabolic activities because DNA

(1) directs the production of enzymes
(2) is a structural component of cell membranes
(3) directly increases the solubility of nutrients
(4) is a major component of the cytoplasm

Mutations

Genes are actually segments of DNA molecules. Any alteration of the DNA sequence is a **mutation**, which changes the normal message carried by the gene. Many mutations involve the substitution of one base for another. This often causes a different amino acid to be placed in a particular position in the growing protein chain. Some mutations involve the insertion of an additional base into an existing DNA sequence. This affects all of the code past the change, just as skipping a blank on the answer sheet for a test can cause all of the remaining answers to be shifted to the next blank, making almost all of them wrong. The deletion of a base from the normal gene sequence would also alter all the code past the change.

Some mutations occur when the bases within a gene are accidentally rearranged. This, too, alters the genetic code. Figure 3-6 shows several ways that DNA can mutate.

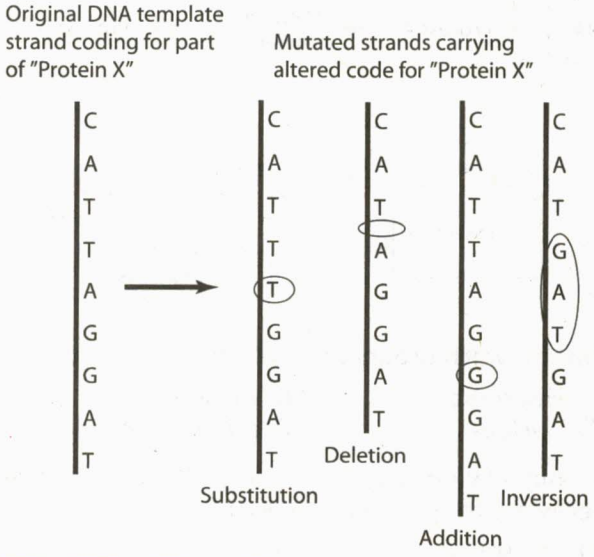


Figure 3-6. Mutation of DNA: The DNA on the left is part of the original template strand that codes for protein X. The four strands on the right show the DNA that would result from several types of mutations.

All of these alterations are totally random and can occur anywhere along the molecule, making the result of the change almost impossible to predict. However, when a DNA sequence is changed, it is quite likely that the protein it codes for may be assembled incorrectly. If some amino acids are replaced by others, or if their sequence is different, the folding of the protein may be different. Incorrect folding means that the protein's shape would not be normal. This could cause the protein to malfunction. One mutation caused by a substitution is sickle cell disease. (See Figure 3-7.)

Mutations can cause such serious changes that the cell may die. However, if a mutated cell does survive and can replicate its DNA, its changed instructions will be copied and passed on to every cell that develops from it. In sexually reproducing organisms, only mutations found in sex cells can be inherited by the offspring.

DNA and Individuality Although an individual's body cells all originally come from a single cell, the body is made up of many types of cells. Each body cell's nucleus—whether it is a nerve cell, skin cell, or bone cell—has a complete set of identical genetic instructions for that individual.

For years, scientists wondered how cells with identical genetic instructions could be so different. The answer is that each kind of cell uses only some of the genetic information it contains. It uses only the instructions it needs to operate its own kind of cell. For instance, information for building all of a person's enzymes is coded in the chromosomes of each cell, but a muscle cell uses only the specific enzymes that are needed by a muscle cell.

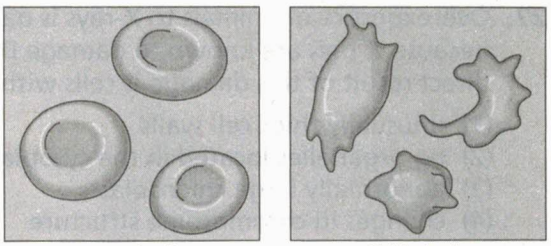


Figure 3-7. Effects of a substitution mutation: Normal red blood cells are round. The abnormal cell shapes are due to a substitution mutation that forms a defective protein which changes the cell's shape.

Both the internal and external environment of the cell can influence which genes are activated in that cell. Some of this influence may occur during development, leading to the many different types of cells that an organism needs.

The selective activation of genes in a cell may continue as conditions change throughout life. For instance, chemical signals from within the cell or from other cells may activate a particular gene. Hormones are one kind of molecule that can activate parts of a cell's DNA code, leading to the production of a particular protein.

Although genes are inherited, an organism's environment can affect the way some genes are revealed, or **expressed,** in the organism. For example, in some animals, such as the Himalayan rabbit, the outside temperature can cause the activation or inactivation of the genes for fur color. When the rabbit's body area is cold, black fur grows. If the same body area becomes warm, white fur grows instead. (See Figure 3-8.) The environment can also influence human genes. Studies of identical twins (those with identical genetic information) who were raised in different environments show that they have differences that can only be explained by the influence of the environment on gene expression.

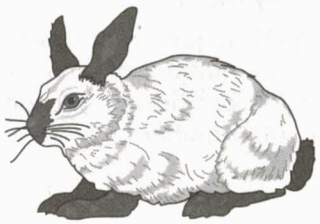


Figure 3-8. Body temperature and fur color in the Himalayan rabbit: From what you know about the activation and inactivation of the genes for fur color in this animal, why do you think the ears, feet, nose, and tail are black?

Review Questions

23. A dog breeder can determine that the sudden appearance of hairlessness in one of the puppies is a mutation if the dog

(1) is still hairless after 5 years
(2) shows no change in the hairless condition after its diet is changed
(3) develops other conspicuous differences from the parent
(4) is bred and the trait is capable of being inherited

24. Explain how a change in the sequence of nitrogen bases in a DNA molecule could result in a gene mutation. [1]

25. Which mutation could be passed on to future generations?

(1) a gene change in a liver cell
(2) cancer caused by excessive exposure to the sun
(3) a chromosomal alteration during gamete formation
(4) random breakage of a chromosome in a leaf cell of a maple tree

26. Mutations can be transmitted to the next generation if they are present in

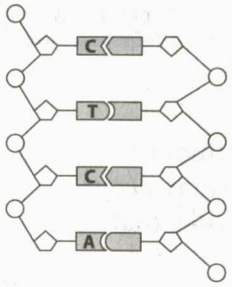
(1) brain cells
(2) sex cells
(3) body cells
(4) muscle cells

27. Overexposure of animals to X-rays is dangerous because X-rays are known to damage DNA. A direct result of this damage is cells with

(1) unusually thick cell walls
(2) no organelles located in the cytoplasm
(3) abnormally large chloroplasts
(4) changes in chromosome structure

28. The diagram below shows a portion of a DNA molecule. The base sequence of the unlabeled strand shown in the diagram is *most* likely

(1) G-A-G-T
(2) C-U-C-A
(3) T-C-T-G
(4) G-A-G-U



29. The individuality of an organism is determined by the

(1) sequence of bases in DNA
(2) number of amino acids in a cell
(3) position of ribosomes in the cytoplasm
(4) number of bases in the mitochondria

30. In which situation could a mutation be passed on to the offspring of one of the organisms listed in the data table below?

Data Table

Name of Organism	Number of Chromosomes in a Body Cell
Human	46
Fruit fly	8

(1) Ultraviolet radiation causes fruit-fly wing cells to undergo uncontrolled division, resulting in cells with 9 chromosomes.
(2) A cell in the wall of the human uterus undergoes a change, resulting in cells with 47 chromosomes.
(3) A primary sex cell in a human forms a sperm that contains 23 chromosomes.
(4) A cell in the ovary of the fruit fly undergoes a chromosomal change that results in 5 chromosomes per egg cell.

31. A change in the sequence of bases in a DNA molecule is most accurately referred to as

(1) an insertion, deletion, or substitution
(2) a chromosomal replication
(3) carbohydrate molecule synthesis
(4) selective breeding

Genetic Engineering

Genetic engineering is a new technology that humans use to alter the genetic instructions in organisms. The idea of altering organisms to have more desirable traits, however, is not new. In fact, **biotechnology**—the application of technology to biological science—has been producing useful products for thousands of years. Cheese and bread are just two examples of "biotech" products made with the use of microbes.

Throughout recorded history, humans have also used **selective breeding**—a process that produces domestic animals and new varieties of plants with traits that are particularly desirable. Many meat products, for example, come from animals that have been bred to contain less fat. In addition, many of the fruits and vegetables we consume have been selectively bred to be larger, sweeter, hardier, or even juicier.

To breed a better plant, farmers might select a bean plant that produces many pods and then crossbreed it with a bean plant that resists fungus infections. The farmers would expect to get seeds that would grow into bean plants with both features.

Gene Manipulation

In recent years, plants and animals have been genetically engineered by manipulating their DNA instructions. The result of this genetic

manipulation is new characteristics and new varieties of organisms. Consequently, we have been able to produce plants with many beneficial traits. In one instance, plants can now contain genes with the instructions for making chemicals that kill the insects that feed on them. Scientists have also engineered bacteria that can be used to clean up oil spills or that produce human growth hormone.

The basic method that alters genes in organisms uses special enzymes. These enzymes cut DNA segments in a way that allows the segments to be spliced, or moved and attached, to the DNA of a new organism. Once in the new organism, the transferred genes direct the new organism's cells to make the same protein product as the original organism. For example, when we move a human insulin-producing gene into a bacterial cell, the bacterium—and all its offspring—will produce human insulin. This provides a way to produce large quantities of a hormone at low cost. Genes for other human proteins have also been inserted into bacterial cells, as illustrated in Figure 3-9.

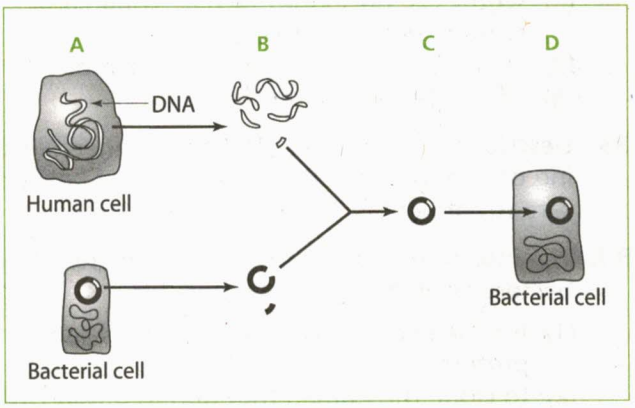


Figure 3-9. Genetic engineering using bacteria: On the left (area A), a special enzyme is used to cut a segment of DNA from a human cell and to also cut open a circular piece of DNA from a bacterial cell. When the piece of human DNA is mixed with the open loop of bacterial DNA (area B), they join to form a closed loop (area C). That loop is then taken up by another bacterial cell (area D). The transformed bacterial cell will produce the protein product of the human DNA segment and that DNA loop will be duplicated and passed to all future offspring.

Other enzymes have been found that can be used to make many copies of segments of DNA. These can be used to increase the amount of DNA available from a tiny sample. This procedure is helpful even when only a drop of blood or saliva is found at a crime scene. By copying and re-copying the DNA in the sample, criminal investigators can produce a sample that is large enough to test. The test results may identify or clear suspects.

Applications of Biotechnology

The health care field has much to gain through our increasing knowledge of genetics and biotechnology. New methods enable us to locate and decode genes that cause diseases. Once we have a better understanding of the gene's specific defect, we may be able to develop ways to treat the disease. In some cases, we may be able to alter the DNA in affected cells and cure the person.

Due to mutations in their genes, people with genetic diseases are sometimes unable to produce certain hormones, enzymes, or other body chemicals. At times, we can extract these chemicals from animals, such as sheep and cattle. These extractions, however, can be expensive, and the chemicals may contain contaminants that cause side effects. If scientists can produce the chemicals using genetically engineered organisms, we may be able to economically provide the missing chemicals in a pure enough form to avoid the side effects associated with chemicals obtained from animal sources.

32. Genetic engineering is used in the biotechnology industry to

(1) eliminate all infections in livestock
(2) synthesize hormones such as insulin and human growth hormone
(3) increase the frequency of fertilization
(4) eliminate asexual reproduction

33. Describe two examples of how an understanding of genetics is making new fields of health care (treatment or diagnosis) possible. [1]

34. The insertion of a human DNA fragment into a bacterial cell might make it possible

(1) for the bacterial cell to produce a human protein
(2) to clone the human that donated that DNA fragment
(3) for humans to become immune to an infection by this type of bacteria
(4) to clone this type of bacteria

35. Assume that a section of double-stranded DNA contains 100 base pairs. If 40 of the pairs contain base C, how many of the pairs would contain base A?

Base your answers to questions 36 through 40 on the passage below and on your knowledge of biology.

Advances with Cells and Genes

Recent advances in cell technology and gene transplanting have allowed scientists to perform some interesting experiments, including splicing human DNA into the chromosomes of bacteria. The altered bacteria express the added genes.

Bacteria reproduce rapidly under certain conditions. This means that bacteria with the gene for human insulin could multiply rapidly, resulting in a huge bacterial population capable of producing large quantities of human insulin.

The traditional source of insulin has been the pancreases of slaughtered animals. Continued use of this insulin can trigger allergic reactions in some humans. The new bacteria-produced insulin is actually human insulin. As a result, it does not produce many side effects.

The bacteria used for these experiments are *E. coli*, which are found in the digestive system of humans and many other animals. Some scientists question these experiments and are concerned that the altered *E. coli* may accidentally get into water supplies.

For each of the statements below, write the number 1 if the statement is true according to the passage, the number 2 if the statement is false according to the passage, or the number 3 if not enough information is given in the passage.

36. Transplanting genetic material into bacteria is a simple task. [1]

37. Under certain conditions, bacteria reproduce at a rapid rate. [1]

38. The continued use of insulin from animals may cause harmful side effects in some people. [1]

39. The bacteria used in these experiments are normally found only in the nerve tissue of humans. [1]

40. Bacteria other than *E. coli* are unable to produce insulin. [1]

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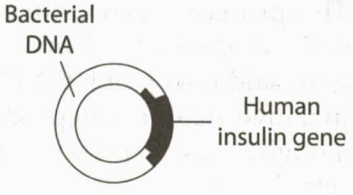
41. A product of genetic engineering technology is represented below.



Which substance was needed to join the insulin gene to the bacterial DNA as shown?

(1) a specific carbohydrate
(2) a specific enzyme
(3) hormones
(4) antibodies

42. Explain the following: An individual has a nutrient deficiency due to a poor diet and is missing a specific amino acid. How would this affect the ability of

- the individual's DNA code to replicate itself? [1]
- the cell to synthesize particular proteins? [1]

43. In recent research, the DNA that codes for a different key enzyme was removed from each of three different species of soil bacteria. A new bacterium, containing DNA for all three key enzymes, could be produced by

(1) selection breeding
(2) screening for mutations
(3) genetic engineering
(4) random alteration

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

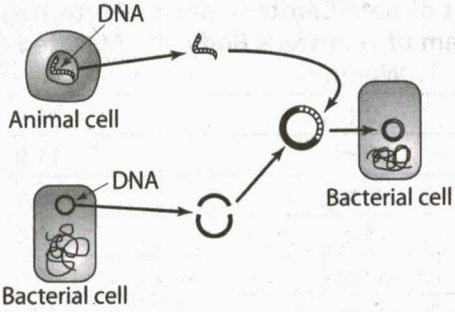
1 Hereditary information for most traits is generally located in
(1) genes found on chromosomes
(2) chromosomes found on genes
(3) the ribosomes of sperm cells
(4) the mitochondria in the cytoplasm

2 An analysis of chromosomes in a culture containing mutated cells may show the loss of one or more bases making up the chromosome. This type of chromosomal change is known as
(1) an addition
(2) an insertion
(3) a deletion
(4) a substitution

3 What is the genetic engineering technique in which DNA is transferred from the cells of one organism to the cells of another organism?
(1) gene splicing (3) electrophoresis
(2) chromatography (4) selective deleting

4 A change that alters the base sequence in an organism's DNA is a
(1) mutation (3) clone
(2) replication (4) zygote

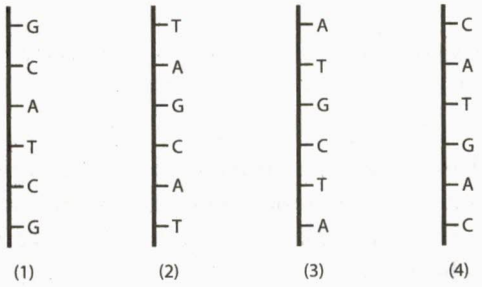
5 The technique illustrated in the diagram is known as



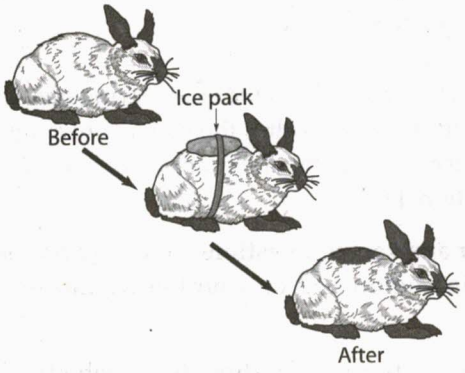
(1) genetic engineering
(2) protein synthesis
(3) internal fertilization
(4) external fertilization

6 The diagram represents a portion of DNA.

Which DNA strand could correctly pair with the one illustrated?



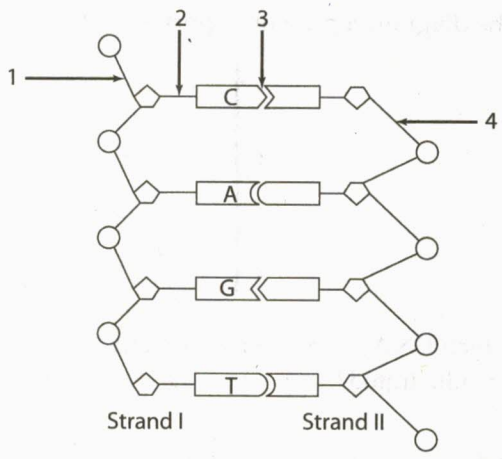
7 The diagram illustrates what happens to the fur color of a Himalayan rabbit after prolonged exposure to a low temperature.



The change in fur color is most likely due to
(1) the effect of heredity on gene expression
(2) the arrangement of genes on chromosomes
(3) environmental influences on gene action
(4) mutations resulting from a change in the environment

Part B

Base your answers to questions 8 and 9 on the diagram below and on your knowledge of biology. The diagram represents part of a double-stranded DNA molecule.



8 The base sequence of Strand II is most likely
(1) C–G–G–A
(2) G–A–G–T
(3) G–T–C–A
(4) T–G–A–C

9 Which event must occur if a nucleus containing this molecule is to undergo mitotic cell division?
(1) The bonds at point 3 break, and the molecule replicates.
(2) The molecule separates at point 2, and new bases attach.
(3) The bonds at point 3 break, and the molecule deletes bases.
(4) The bonds at points 1, 2, and 4 break, and new sequences of bases form.

---

10 The technology of genetic engineering has allowed humans to alter the genetic makeup of organisms. Describe one example of such an alteration. [1]

Base your answers to questions 11 and 12 on the information below and on your knowledge of biology.

Some geneticists are suggesting the possibility of transferring some of the genes that influence photosynthesis from an efficient variety of crop plant to a less efficient crop plant. The goal is to produce a new variety with improved productivity.

11 To produce this new variety, the project would most likely involve
(1) genetic engineering
(2) a gene mutation
(3) chromatography
(4) vaccinations

12 Which technique would most likely be used to produce large numbers of genetically identical offspring from this new variety of plant?
(1) cloning
(2) sexual reproduction
(3) electrophoresis
(4) selective breeding

Base your answers to questions 13 through 17 on the information and data table below and on your knowledge of biology.

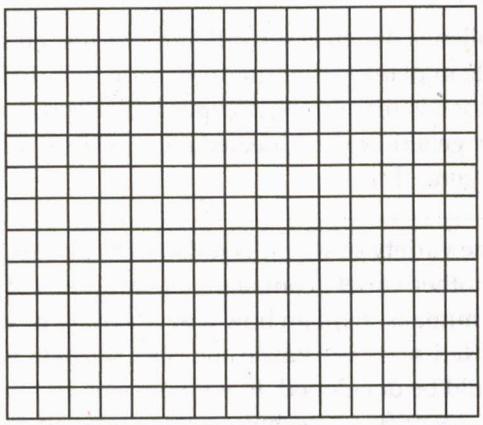
Certain chemicals cause mutations in cells by breaking chromosomes into pieces. Cells containing such broken chromosomes are known as mutated cells. Certain nutrients, such as beta carotene (a form of vitamin A), have the ability to prevent chromosome breakage by such mutagenic chemicals.

The results of an investigation of the effect of beta carotene in preventing chromosome damage are presented in the following data table. In the investigation, varying amounts of beta carotene per kilogram of body weight were added to the diets of hamsters. A mutagenic chemical at a constant dose rate was also added to the diets of the hamsters.

The Effect of Beta Carotene Added to Hamster Diet on Cell Mutation

Amount of Beta Carotene per Kilogram of Hamster's Body Weight	Percentage of Mutated Cells
0 mg	11.5
20 mg	11.0
30 mg	8.0
40 mg	7.0
50 mg	4.5
75 mg	3.5
100 mg	2.0
150 mg	1.2

Using the information in the data table, construct a line graph on the grid provided. Follow the directions given.



13 Mark an appropriate scale, without any breaks, on each of the axes. [1]

14 Label the axes. [1]

15 Plot the data from the table. Surround each point with a small circle and connect the points. [1]

Example: 

16 State an appropriate conclusion for the above experiment regarding the use of beta carotene for the prevention of chromosome damage. Use experimental data to support your conclusion. [1]

17 Vitamins A and E are essential vitamins that can dissolve in oil. A student, knowing this and seeing the above results with beta carotene, suggested that vitamin E will increase the percentage of mutations in the cells of hamsters. State whether or not this is a valid conclusion. Support your statement with an explanation. [1]

Part C

Base your answers to questions 18 through 22 on the passage below and on your knowledge of biology.

Genetic Engineering

Genetic engineering is a technique used by scientists to combine or splice genetic material from different organisms. Gene splicing involves changing the normal base sequences of DNA by removing a section of DNA and introducing another gene. The technique may involve the use of the bacterium *E. coli*. The bacterium has one large chromosome and several small plasmids, which are ring-shaped pieces of DNA found in the cytoplasm.

Genetic engineers have been able to extract plasmids from *E. coli*. Restriction enzymes are used to cut the DNA of the plasmid at designated places in the base sequence. The same enzymes are used to cut a section of human DNA. This section of human DNA is then placed into the space in the cut DNA of the bacterial plasmid. The human DNA codes for the synthesis of a product such as human growth hormone.

The spliced bacterial DNA, which now contains a piece of human DNA, is referred to as a hybrid. This hybridized plasmid is then taken in by *E. coli* cells. When the bacterium reproduces, the hybrid DNA will replicate. The offspring will possess the ability to synthesize the human growth hormone.

18 Describe a bacterial plasmid. [1]

19 Describe a hybrid plasmid. [1]

20 Explain how genetic engineers remove sections from human DNA for splicing into bacterial DNA. [1]

21 State one benefit of gene splicing. [1]

22 Explain why it is not necessary to continue splicing the gene for human growth hormone into *E. coli* once cultures of the bacteria with the spliced gene are established. [1]

Base your answers to questions 23 through 25 on the reading passage below and on your knowledge of biology.

The Plight of the Monarch

Along with producing most of the corn consumed by humans and livestock, the U.S. Corn Belt also produces about half of the monarch butterflies that migrate between Canada and Mexico. During migration, the butterflies mate and lay their eggs. The caterpillars that hatch from these eggs immediately begin to feed on milkweed leaves. This is what monarch butterflies have done successfully for decades. Now it seems that this behavior could be the cause of their extinction.

Cornell University scientists have discovered that the increased use of genetically engineered corn is the problem. Caterpillars feeding on milkweed dusted with pollen from this corn die. The new strain of corn has had the bacterial gene that codes for the production of a toxin referred to as Bt inserted. Bt functions as a natural pesticide and kills European corn borer caterpillars, which are responsible for the destruction of millions of ears of corn every year. The use of Bt corn saves crop growers from having to purchase and apply toxic chemical pesticides.

Originally everyone thought that Bt corn was the answer to many financial, environmental, and health issues associated with pesticide use. However, nearly half of the monarch butterfly caterpillars fed milkweed dusted with Bt corn pollen died within four days during the Cornell University study. None of the caterpillars in the control group died.

23 Corn plants that contain the Bt gene in their cells make the toxin that kills corn borer caterpillars. Explain how the gene enables the plants to make the toxin. [1]

24 Explain why more research is needed to know for sure if corn containing the Bt gene is responsible for the death of monarch butterflies on a large scale. [1]

25 Pollen is the male sex cell. It performs the same role in plants as sperm does in animals. Explain why it is reasonable to expect pollen produced by the genetically engineered corn plants to carry the Bt gene. [1]

---

26 One variety of wheat is resistant to disease. Another variety contains more nutrients of benefit to humans. Explain how a new variety of wheat with disease resistance and high nutrient value could be developed. In your answer, be sure to:

- identify one technique that could be used to combine disease resistance and high nutrient value in a new variety of wheat [1]
- describe how this technique would be carried out to produce a wheat plant with the desired characteristics [1]
- describe one specific difficulty (other than stating that it does not always work) in developing a new variety using this technique [1]

27 Animal cells utilize many different proteins. Discuss the synthesis of proteins in an animal cell. Your answer must include at least:

- the identity of the building blocks required to synthesize these proteins [1]
- the identity of the sites in the cell where the proteins are assembled [1]
- an explanation of the role of DNA in the process of making proteins in the cell [1]

Reproduction and Development

TOPIC 4

What do You Think?

Genes and Reproduction

TOPIC 4

Reproduction and Development

Vocabulary

asexual reproduction	fetus	sex cell
cloning	gamete	sexual reproduction
development	gene expression	species
differentiation	meiosis	sperm
egg	mitosis	testes
embryo	ovaries	testosterone
estrogen	placenta	uterus
expressed	progesterone	zygote
fertilization	recombination	

Topic Overview

A **species** is a group of closely related organisms that share certain characteristics and can produce new individuals through reproduction. For any species to survive past a single generation, reproduction is essential. All individuals eventually die, but the species continues because individuals reproduce. When individuals reproduce, their offspring begin a period of **development** that ends in adulthood. Once an individual reaches adulthood, it is usually able to reproduce and continue the species for another generation.

Types of Reproduction

Two methods of reproduction are associated with living organisms: asexual and sexual. **Asexual reproduction** involves just one parent and results in one or more offspring that are genetically identical to that parent. **Sexual reproduction** involves two parents and results in offspring that have some genetic material (DNA) from each parent. The result is an organism that may be similar to one or both parents, but is not identical to either.

Asexual Reproduction Organisms that reproduce asexually produce their offspring in a variety of ways. In some cases they merely divide in two, producing two new individuals. (The parent in this case *becomes* the offspring!) Other organisms produce special cells that have a complete set of genetic information, and these individual cells can develop into new members of the species. Still others produce an outgrowth of the body that later detaches to become a separate individual. Many plants can develop from parts that are either broken off intentionally by humans or separated naturally from the parent plant. In every case, organisms produced by asexual reproduction have only one parent, and they have the same genetic information (in the form of DNA) as the parent. Figure 4-1 shows some examples of asexual reproduction.

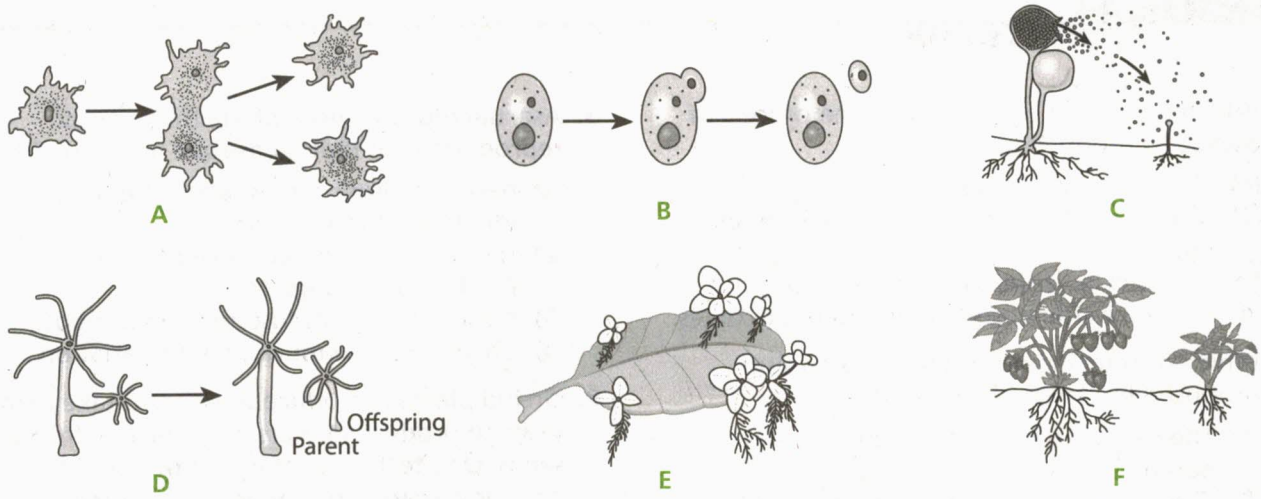


Figure 4-1. Examples of asexual reproduction: (A) An ameba divides to form two new amebas. (B) A yeast cell divides into two cells that are different sizes but genetically alike. (C) Mold spore cells reproduce the mold. (D, E, and F) Some offspring develop attached to the parent, but later separate to become independent individuals.

Sexual Reproduction In sexual reproduction, offspring receive half of their genes from one parent and half from the other. The genes are carried on chromosomes in **sex cells** (also known as **gametes** or egg or sperm cells), which join in **fertilization.** Each parent supplies half of the genetic information needed to form a complete individual. The **sperm,** which is the sex cell from the father, provides half of the information; the **egg,** which is the sex cell from the mother, provides the other half.

Offspring produced by sexual reproduction combine genes inherited from each parent's gametes. Since an offspring gets only half of its DNA from each parent, it will not be identical to either of its parents. Also, since each offspring gets a unique combination of genes from its parents, it will differ from its siblings (brothers and sisters).

Cloning **Cloning** is a technique that accomplishes the same end result as asexual reproduction. It is a way of making identical genetic copies. For example, if you cut a piece of stem from a plant and it grows roots and develops into a new plant, you have produced a genetically identical copy of the original plant. This could be called a clone of the plant.

Recently, however, it has also been possible to produce clones of animals that ordinarily only reproduce sexually. This is done by inserting a nucleus from a "parent" organism's cell (one that has a complete set of genetic information from that individual) into an egg cell from which the nucleus has been removed. The result is an egg that now contains not 50%, but 100% of the genetic information from a single parent. If this new egg cell with all of its genes can be made to develop normally, the resulting offspring is a clone of the individual that donated the original cell nucleus. (In mammals, the egg would be implanted and develop inside the body of the female.) Cloning has been accomplished with animals as complex as sheep and pigs.

Review Questions

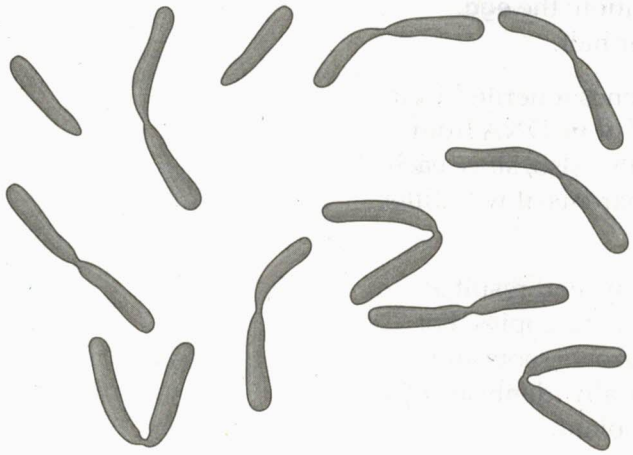
1. Which statement best describes the process of asexual reproduction?

(1) It involves two parents.
(2) It requires the combination of sperm and egg.
(3) It results in variation in the offspring.
(4) It involves the production of genetic copies.

2. Which statement concerning an organism produced by cloning is correct?

(1) The clone is genetically identical to its parent.
(2) The clone has the combined genes of both of its parents.
(3) The genetic makeup of the clone will be somewhat different from each of its parents.
(4) The appearance of the clone will be entirely different from that of its parents.

3. A student using a compound light microscope to observe a cell saw a number of threadlike nuclear structures resembling those shown below.



These threadlike structures are composed primarily of

(1) fat
(2) glucose
(3) DNA
(4) ATP

4. Plants with desirable qualities can be rapidly produced from the cells of a single plant by

(1) cloning
(2) gamete fusion
(3) meiosis
(4) immune response

5. Asexual reproduction differs from sexual reproduction in that, in asexual reproduction

(1) new organisms are usually genetically identical to the parent
(2) the reproductive cycle involves the production of gametes
(3) nuclei of sex cells fuse to form a zygote
(4) offspring show much genetic variation

6. Orchid plants reproduce slowly and take many years to produce flowers when grown from seeds. One technique that can be used in genetic research to reproduce rare orchid plants more rapidly is

(1) sexual reproduction
(2) fertilization
(3) selective breeding
(4) cloning

7. Some bacteria produce an enzyme known as penicillinase, which prevents their destruction by penicillin. Since these same organisms reproduce asexually, they normally produce offspring that

(1) can be killed by penicillin
(2) have an abnormally high rate of mutation
(3) have variable numbers of chromosomes
(4) are resistant to penicillin

8. In plants, one way sexual reproduction differs from asexual reproduction is that in sexual reproduction

(1) more offspring are produced
(2) more genetic variation is seen in the offspring
(3) the offspring and the parents are identical
(4) more offspring survive to maturity

9. A man cuts some stems from several plants that are growing in his garden. He places the stems in wet sand until they grow roots, and then he transplants them to new pots. This method of reproducing plants is most like

(1) sexual reproduction
(2) cloning
(3) natural selection
(4) fertilization

10. Compared to the offspring of sexual reproduction in animals, the offspring of asexual reproduction will

(1) show greater variety
(2) be more resistant to disease
(3) be genetically identical to the parent
(4) grow larger

Cell Division

Cell division is the orderly separation of one cell into two. Before a cell divides, the genetic information in the DNA of the cells is duplicated exactly.

The process, by which a cell's genetic material divides, creating two complete sets of the cell's genetic material, is known as **mitosis.** Mitosis produces two cells that each have a full set of identical genes and chromosomes (unless a mutation occurs somewhere along the way).

During mitosis, one copy of the genetic information is distributed to each new cell. As a result, each new cell has all the information it needs to function properly. One-celled organisms make use of mitosis for asexual reproduction. Multicellular organisms mainly use mitosis for growth and for cell replacement and repair.

A second type of cell division is **meiosis.** This process divides the genetic material in a way that results in the production of the sex cells required by organisms that reproduce sexually. Each sex cell has only half the genetic material needed for a cell to function properly.

Mitotic Division/Mitosis

During the process of mitotic cell division, the double-stranded chromosomes that are visible during mitosis split into two identical single strands and move apart to opposite ends of the cell. This process is shown in Figure 4-3.

The process concludes when the cytoplasm divides, resulting in two smaller, but genetically identical, cells. Mitotic cell division in plants is illustrated in Figure 4-4.

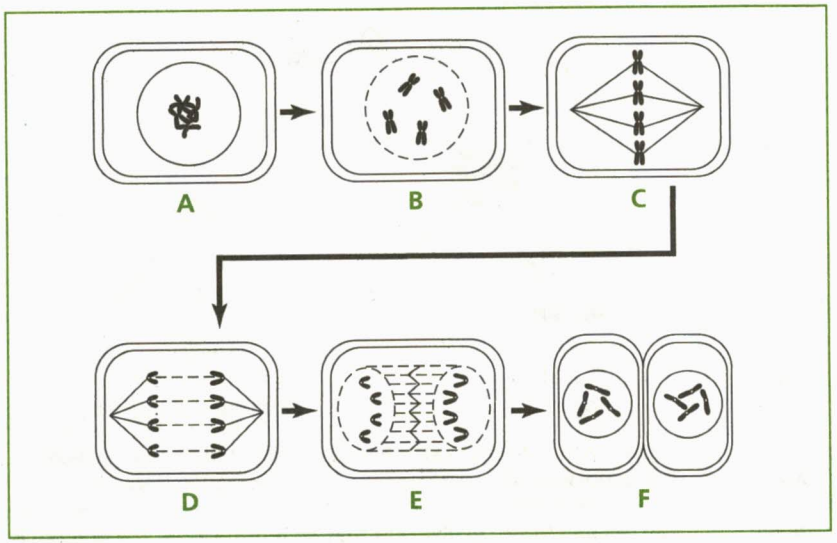


Figure 4-4. Mitotic cell division: The chromosomes in cell A have replicated, forming the double-stranded chromosomes that are finally visible in the cell at stage B. The four chromosomes line up single-file (C). Then the strands separate and move apart (D and E). The final result is two cells (F), each with four single-stranded chromosomes containing identical genetic information in their nuclei.

MemoryJogger

Recall that DNA replication makes an identical copy of all the genetic information in the molecule. The replicated strand carries the instructions for the same proteins as in the original strand. When the DNA replicates, it is actually turning a single-stranded chromosome into a double-stranded one. The double-stranded chromosome then has a duplicate set of instructions to pass on to each of two cells, as shown in Figure 4-2.

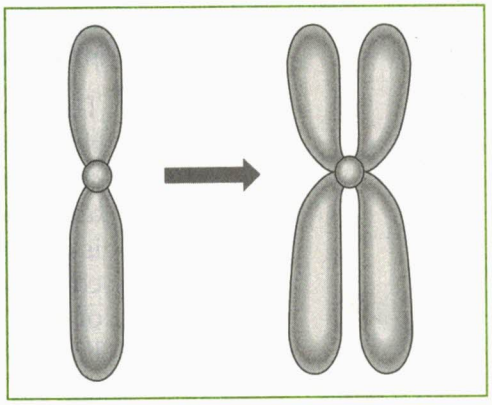


Figure 4-2. Chromosome duplication resulting from DNA replication: As a result of DNA replication, chromosomes become double-stranded.

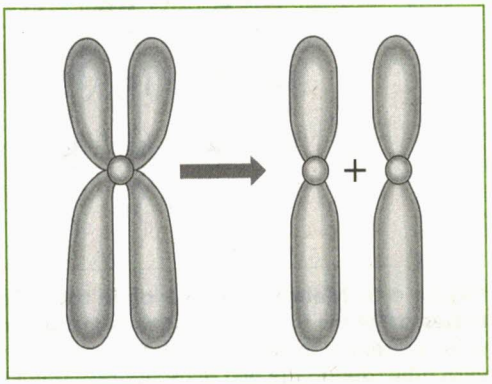


Figure 4-3. Chromosome during mitosis: When cells divide, each double-stranded chromosome separates into two identical single strands.

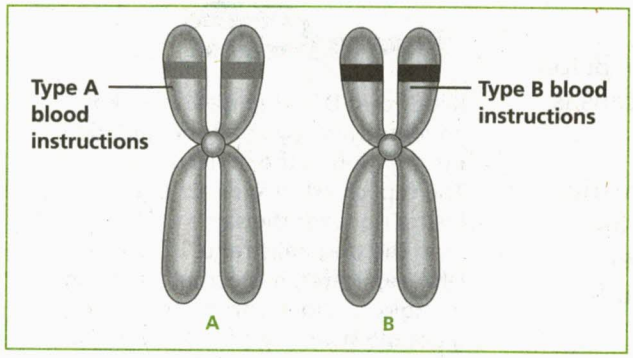


Figure 4-5. Two chromosomes with different information: The two chromosomes of each pair differ in the specific information they carry. For example, chromosome A may have coded gene instructions for type A blood, while the coded gene information on chromosome B may be for type B blood. Information for many other traits coded in the genes of these two chromosomes will be different, too, while some will be the same.

Meiotic Division/Meiosis

The gametes (sperm and eggs) formed during meiotic cell division each have only one half of the organism's genetic information—only one chromosome of each pair that is present in the body cells of that organism. However, a full set of genetic information is needed to produce a complete individual. When sperm and egg combine during **fertilization,** all of the newly paired chromosomes and all of the required genetic information are present in the fertilized egg.

Meiotic division begins with a body cell that has the full number of chromosomes typical of the species. Depending on the species, the cell contains one or more pairs of chromosomes that determine the traits of the organism. Figure 4-5 shows an example.

During the first phase of meiotic division, the double-stranded chromosomes line up in pairs in the center of the cell. The two chromosomes of each pair (still double-stranded) then separate, moving to opposite ends of the cell. Following this separation, the cell divides physically to form two cells.

The second phase involves the division of each of these two new cells. This time, however, the chromosomes line up in single file in the center of each cell. Each chromosome still consists of two strands. The strands separate and move to opposite ends of each of the dividing cells. When the process is complete, four cells have been formed, each having half the number of chromosomes of the organism's body cells. Each contains only one member of each original chromosome pair. Meiotic cell division is illustrated in Figures 4-6 and 4-7.

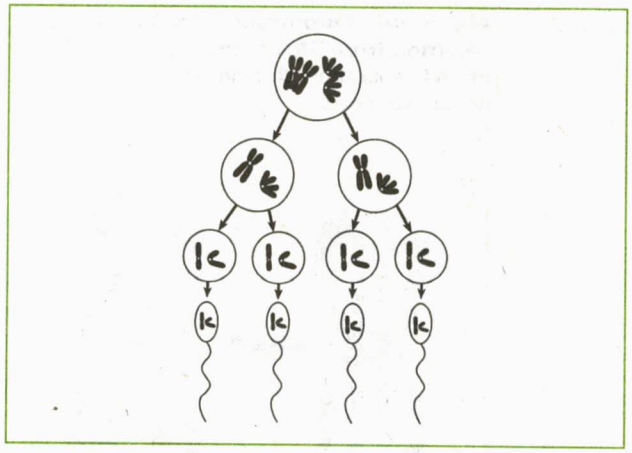


Figure 4-6. Meiotic cell division in the testes of males: Note the *four double-stranded chromosomes* (two pairs) present in the original cell. The pairs separate from each other during the first division—resulting in *two double-stranded chromosomes* in each of two cells. In the next division, the double-stranded chromosomes separate, leaving each final cell with *two single-stranded chromosomes*. These four cells can develop further into sperm cells in the testes of male individuals.

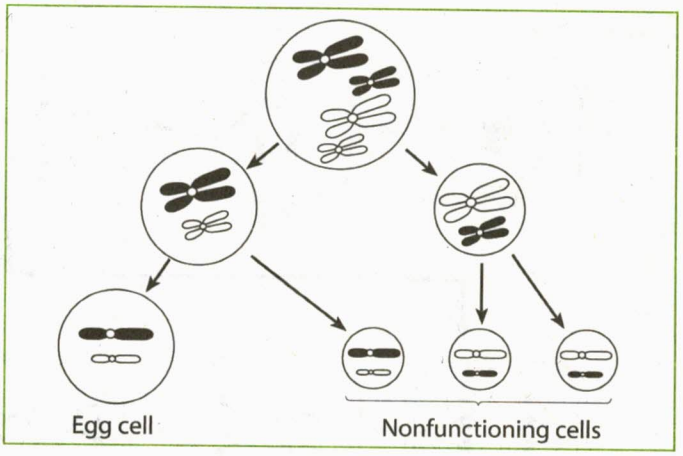


Figure 4-7. Meiotic cell division in the ovaries of females: This process is different from sperm cell formation because the cytoplasm divides unequally in each division, resulting in one large egg cell and three smaller cells that do not function. The egg cell is the one with the most cytoplasm.

Notice that the formation of cells during meiotic division, in which each cell has half the usual number of chromosomes, is very different from the duplication and distribution of a full set of chromosomes that occurs in mitotic division.

Meiotic division in females involves the same number of divisions and chromosome changes as in males. The division of the cytoplasm is where the two differ. The cytoplasm in a cell destined to become an egg cell divides unequally, resulting in one large egg cell and three small nonfunctioning cells. Meiotic division in females is shown in Figure 4-7.

Meiosis as a Source of Variation The events that occur during meiosis do more than simply divide chromosomes into smaller sets and form smaller cells. Meiosis is responsible for much of the genetic variation among the sex cells of each individual. For example, the two members of each pair of chromosomes carry different ways of expressing many of the organism's traits, so the way the different pairs randomly line up *in relation to other pairs* leads to many possible combinations in the sex cells that result. Two combinations are shown in Figure 4-8.

Another way variation can arise is by the exchange of parts of chromosomes, which occurs as they pair up during the first division. The process is sometimes called crossing-over. The result is shown in Figure 4-9. After separation, each set is unique. This means that there are no two sperm or egg cells, even from the same parent, that are alike. Each time a sperm and egg combine, a unique combination of genetic information results.

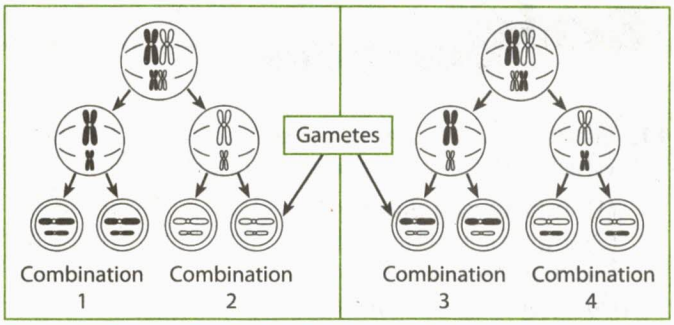


Figure 4-8. Two equally likely combinations of chromosomes lined up for meiotic division: A pair of chromosomes can be arranged in two ways when they pair up at the start of meiosis. This helps increase genetic variation. How many combinations do you see in the gametes? How would more pairs of chromosomes affect the number of possible arrangements?

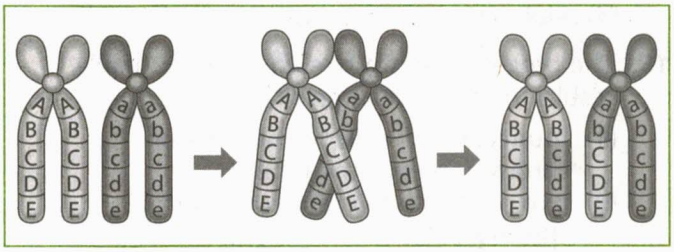


Figure 4-9. Result of exchanging parts between chromosomes: When chromosomes line up in pairs during meiosis (Step 1), their strands may connect or cross over (Step 2) and then separate in a way that parts are exchanged. All four strands now carry different combinations of information (Step 3).

Table 4-1. Summary of Mitotic and Meiotic Cell Division

Points of Comparison	Mitotic Division	Meiotic Division
Number of cell divisions	One	Two
Exchange of genetic material between chromosomes	No	Yes
Number of functioning cells produced from original	Two	Four sperm (in males) or one egg (in females)
Genetic makeup of final cells produced	Same as original	Highly variable gametes produced, each containing half of the genetic information of the original
Function of cells produced in multicellular organisms	Growth or replacement of body cells	Combine to form the zygote for reproduction

11. When complex plants are produced by cloning, which process is most directly involved?

(1) mitotic cell division
(2) meiotic cell division
(3) gamete production
(4) sperm cell fertilization

12. If a lobster loses a claw, it is capable of growing a new one. What process makes this possible?

(1) meiosis
(2) fertilization
(3) sexual reproduction
(4) mitosis

13. Organisms that reproduce asexually usually do so by a form of cell division called

(1) meiosis
(2) mitosis
(3) gamete formation
(4) sperm formation

14. A normal body cell of a fruit fly contains eight chromosomes. Each normal gamete of this organism contains

(1) four chromosomes as a result of meiosis
(2) four chromosomes as a result of mitosis
(3) eight chromosomes as a result of meiosis
(4) eight chromosomes as a result of mitosis

15. The process of mitotic cell division normally results in the production of

(1) four cells with half the number of chromosomes as the parent
(2) two cells with the same number of chromosomes as the parent
(3) two cells with only one chromosome from each parent
(4) one cell with a replicated set of matched chromosomes

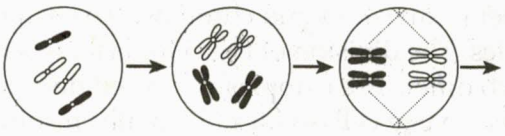
16. Each of the two daughter (or offspring) cells that result from the normal mitotic division of the original parent cell contains

(1) the same number of chromosomes but different genes than the parent cell
(2) the same number of chromosomes and genes identical to those of the parent cell
(3) one half of the number of chromosomes but different genes than those of the parent cell
(4) one half of the number of chromosomes and genes identical to those of the parent cell

17. All types of asexual reproduction involve the process known as

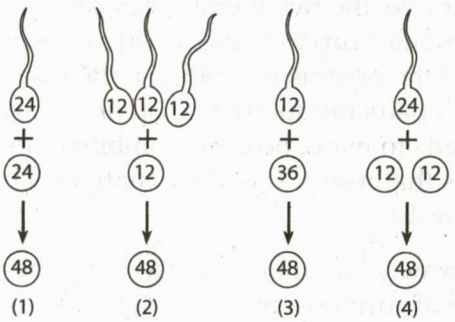
(1) mitosis
(2) fertilization
(3) meiotic division
(4) aging

18. The diagrams below represent the sequence of events in a cell undergoing normal meiotic cell division.

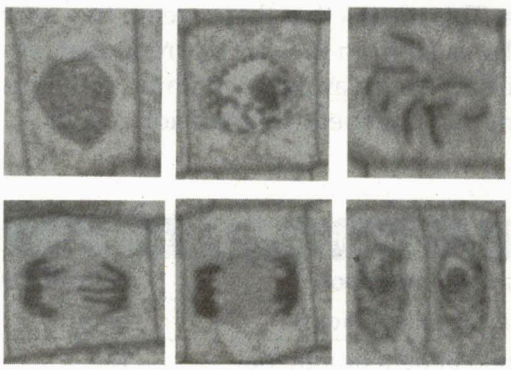


- How many cells will finally be produced? [1]
- How many chromosomes will be in each cell? [1]
- Sketch one of the final cells, showing its chromosomes. [1]

19. The species chromosome number of orangutans is 48. Which diagram represents normal fertilization in orangutans?



20. Which process is represented in the following photographs?



(1) mitotic cell division
(2) zygote formation
(3) fertilization
(4) recombination

21. If the sperm cells of a fish have 12 chromosomes, how many chromosomes would be found in the cells forming the scales of the fish?

(1) 6
(2) 12
(3) 24
(4) 48

Zygote Formation During fertilization, the gametes unite to form a **zygote**—a cell that contains all of the genetic information needed by the offspring. This process is known as **recombination,** since the genes from both parents recombine when fertilization occurs. Since a sex cell contains a unique combination of genetic material, the result of the random combination of any sperm and egg explains the variation found in offspring produced by sexual reproduction. This variation plays a key role in evolutionary change and species survival.

The zygote contains all the information necessary for growth, development, and eventual reproduction of the organism. The zygote divides by mitosis to form a multicellular organism. Fertilization, zygote formation, and some early mitotic divisions that occur in development are shown in Figure 4-10.

Early Development During the early stages of development, the cells that are formed by mitotic division begin to undergo **differentiation,** which simply means that they become different from one another. This leads to the formation of specialized cells, which form the tissues, and then the organs, of multicellular organisms.

In an **embryo,** an organism in an early stage of development, all the genetic information in each cell starts out the same. However, different genes are activated or deactivated in certain cells, causing them to make only some of the many proteins they are capable of synthesizing. As a result, these cells become different from others, and may develop into skin cells, muscle cells, or any of the other specialized cells of the organism. The activation or inactivation of genes can be due to environmental influences from within the cell, from surrounding cells, or from outside the organism.

When a gene is actively producing its protein, scientists say that the gene is **expressed.** There is much evidence that **gene expression,** which is the result of activated genes, can be modified through interaction with the environment. For example, fruit flies that have genes to develop curly wings will develop straight wings instead, if they are raised in a cooler than normal environment. Another example of an environmentally produced gene modification is a plant grown without light. Such a plant is white instead of green, because sunlight is needed to stimulate the gene that produces chlorophyll.

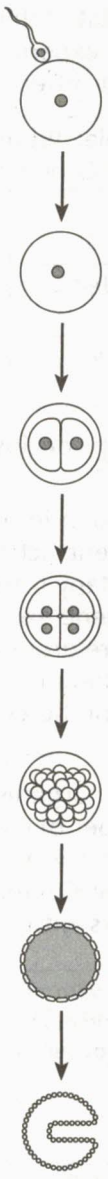


Figure 4-10. Fertilization, zygote formation, and early development: Note that all cell divisions here are by MITOTIC division.

Review Questions

22. An exact duplication of the complete set of chromosomes of a cell, followed by the separation of these duplicate sets into two new cells, is known as

(1) mitotic cell division (3) meiotic cell division
(2) zygote formation (4) fertilization

23. New cells are produced within the uterus as a direct result of

(1) gamete formation
(2) meiotic cell division
(3) mitotic cell division
(4) ecological succession

24. The data table below summarizes the results of an experiment using primrose plants grown under different temperature conditions.

Data Table: Primrose Color Under Two Growing Conditions				
Flower Color	**Temperature of 20°C**		**Temperature of 31°C**	
Color coded in DNA	Red	White	Red	White
Actual color expressed	Red	White	White	White

Which conclusion can be drawn from this data table?

(1) Color in primroses is determined only by gene action.
(2) Many traits are not inherited.
(3) Gene exchanges only occur when the plants are grown at lower temperatures.
(4) There is an interaction between environment and heredity.

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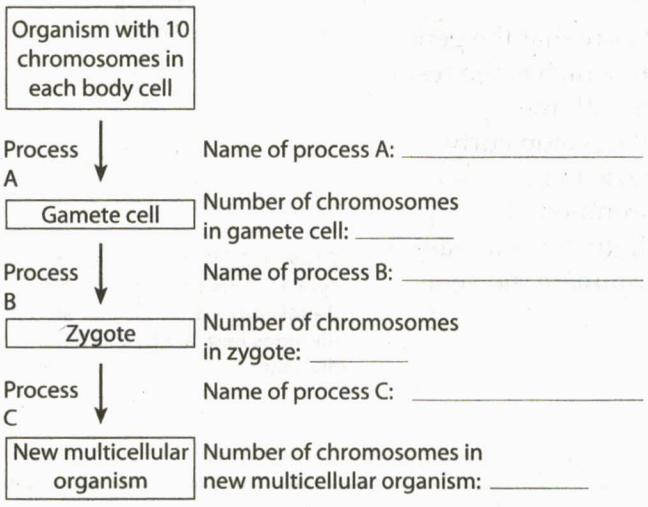
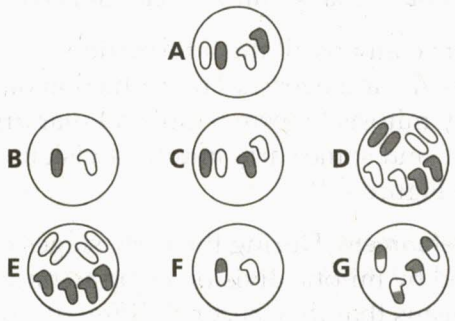
25. When organisms reproduce sexually, the species number of chromosomes is maintained. This can be demonstrated with a diagram like the one below. Complete the diagram by filling in the blanks with the appropriate information.



Base your answers to questions 26 through 29 on the diagrams below and on your knowledge of biology.

Diagram A represents the chromosomes in the nucleus of the body cell of a worm. Diagrams B through G represent chromosomal arrangements that may occur in other cells produced by this worm.



26. If meiosis failed to occur in both male and female worms, the zygote nucleus would resemble diagram

(1) E (2) G (3) C (4) D

27. If genes were exchanged between a single pair of chromosomes during gamete formation, the gamete nucleus would most closely resemble diagram

(1) F (2) B (3) C (4) G

28. The nucleus of a normal zygote formed when fertilization occurs in this species would most likely resemble diagram

(1) E (2) F (3) C (4) D

29. The nucleus of a mature gamete from a female worm would most likely resemble diagram

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

---

30. In human females, gametes are produced in the

(1) uterus (3) ovaries
(2) testes (4) estrogen

31. Complex organisms produce sex cells that unite during fertilization forming a single cell known as

(1) an embryo (3) a clone
(2) a gamete (4) a zygote

Human Reproduction and Development

Human reproduction and development are carried out by specialized organs. The function of these organs is regulated by hormones from the endocrine system. In humans, as in nearly all mammals, fertilization and development occur internally—within the mother's body. Reproductive organs in other mammals are similar in appearance and function.

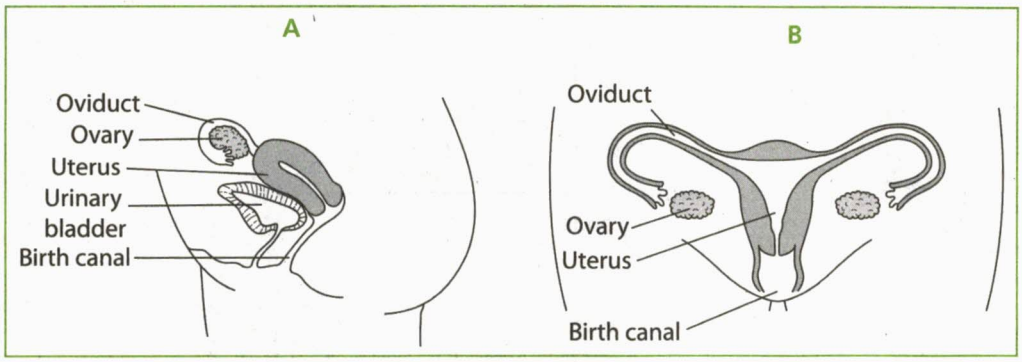


Figure 4-11. Two views of essential parts of the human female reproductive system and other structures: View A is from the side; View B is from the front.

Female Reproductive System The human female reproductive system is organized to produce gametes, to support internal fertilization and development, to exchange materials through the placenta, and to provide milk to the offspring.

In human females, the **ovaries** produce egg cells (female gametes) and the hormones **estrogen** and **progesterone.** These hormones are associated with sexual development and the reproductive process. The ovaries are located near the open ends of tubes called oviducts (egg ducts). The egg cell can be fertilized in the oviduct if sperm are present. The oviducts lead to the **uterus,** where the embryo develops into a fetus. The main parts of the female reproductive system are illustrated in Figure 4-11.

After the fertilized egg sinks into the thickened wall of the uterus, a placenta begins to form. The **placenta** is the organ responsible for the passage (by diffusion) of nutrients and oxygen from the mother's blood to the fetus. Wastes from the fetus also diffuse to the mother's blood through the placenta. During birth, the muscular uterus undergoes a series of contractions that eventually push the baby out of the mother's body. The early events of pregnancy are shown in Figure 4-12.

Male Reproductive System The **testes** of the male reproductive system are the organs that produce sperm cells. The testes also produce the hormone **testosterone,** which is associated with male sexual development and reproduction. Other structures associated with the male reproductive system produce the fluids and nutrients that are needed for the proper function and delivery of the male gametes to the female reproductive system. The essential parts of the human male reproductive system are shown in Figure 4-13.

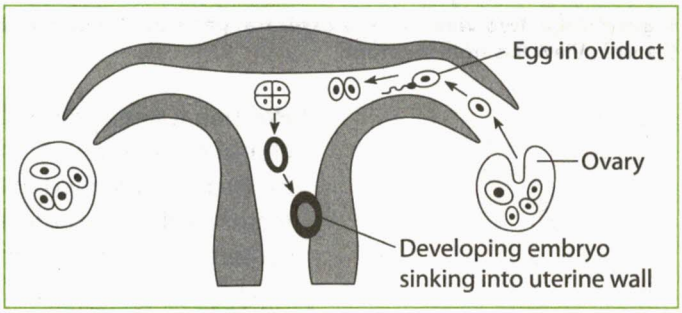


Figure 4-12. Early events of pregnancy: The egg released by the ovary travels down the oviduct where fertilization occurs. Mitotic divisions of the zygote begin as it continues to the uterus, where the developing embryo sinks into the uterine wall, and the placenta forms. The placenta will supply essential materials and remove wastes throughout the rest of the pregnancy.

Table 4-2. The Functions of the Parts of the Human Female Reproductive System

Structure	Function
Ovary	Produces egg cells; releases the hormones estrogen and progesterone
Oviduct	Site of fertilization; carries egg to uterus
Uterus	Site where embryo and fetus develop in association with placenta
Birth canal (vagina)	Site where sperm enter and swim to egg in oviduct; passageway for the birth of baby

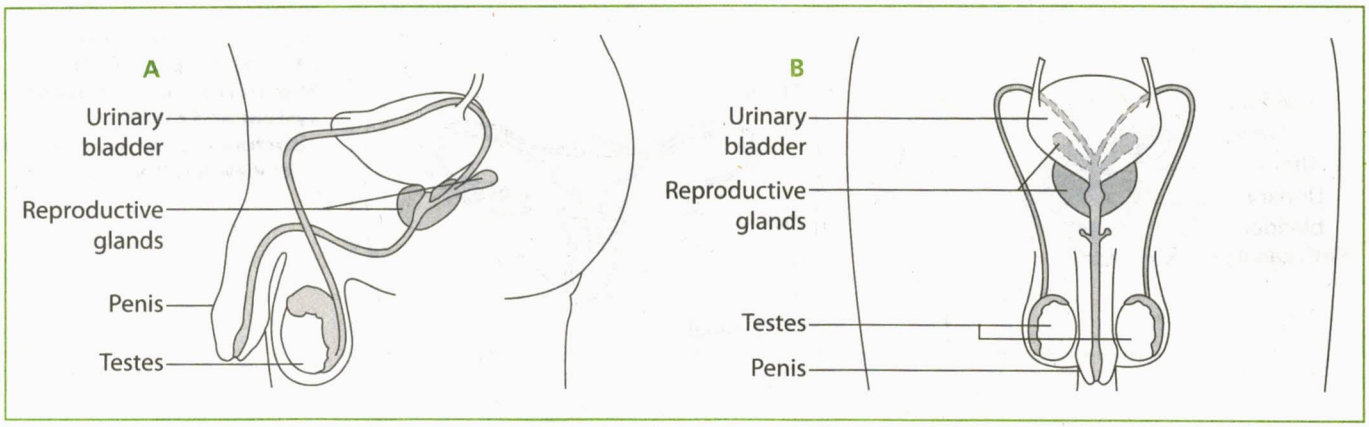


Figure 4-13. Two views of the essential parts of the human male reproductive system and other structures: View A is from the side; View B is from the front.

Hormonal Regulation The male reproductive system and other male characteristics, such as facial hair and a deep voice, that develop as sexual maturity is reached are influenced by several hormones, including testosterone from the testes. The development of the female reproductive system and female features, such as breast development and widening of the hips, also involves several important hormones, such as estrogen and progesterone.

Once sexual maturity is reached, females begin a regular cycle of about 28 days, during which an egg is released on about day 14. The timing of the events of this cycle is regulated by two hormones from the ovaries, along with several others from an endocrine gland in the brain. Figure 4-14 illustrates the changes in the level of several hormones associated with regulating this monthly cycle. The cycle varies slightly from individual to individual.

Although the interactions of the hormones are quite complex, estrogen and progesterone play important roles in the female reproductive cycle. Estrogen from the ovaries influences the sexual development of females. Together, estrogen and progesterone influence the preparation of the lining of the uterus so that a fertilized egg that embeds itself there can develop normally. Progesterone also maintains the uterine lining throughout pregnancy. For this reason, progesterone is often called the hormone of pregnancy. At the end of the cycle, if an egg is not fertilized, the levels of estrogen and progesterone decrease, and the lining of the uterus breaks down. Then the cycle begins again.

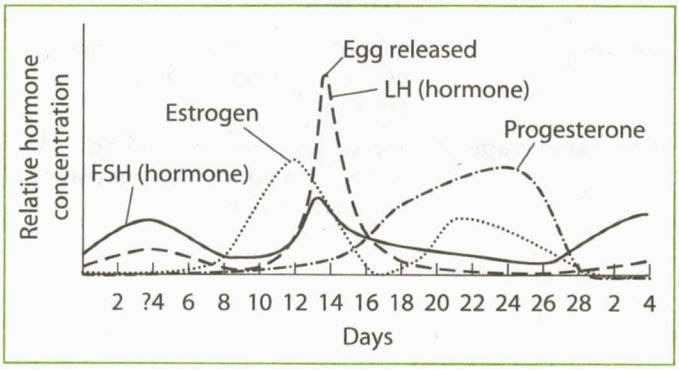


Figure 4-14. Hormones and events associated with the monthly reproductive cycle in human females: Notice the rise and fall in hormone levels at various times. These changes influence such events as the release of the egg from the ovary, the preparation of the uterus for a possible pregnancy, and the breakdown of the uterine lining if no pregnancy occurs. Remember that the timing of this cycle is NOT the same for everyone.

Human Development As with most other mammals, embryonic development continues in the uterus. Figure 4-15 shows some of the features of the uterus during pregnancy.

During the first part of pregnancy, cells continue to divide by mitotic division and begin to differentiate, forming tissues and organs. The placenta and a fluid-filled sac that cushions and

protects the developing embryo both form at this time, too. After about two months, when all the major organs have begun to form, the embryo is called a **fetus.**

During the first few months, when essential organs are forming in the embryo, things can go wrong. Problems associated with either the embryo's inherited genes or the mother's exposure to various harmful environmental factors can affect the embryo. Harmful environmental factors that a woman should avoid at any time during pregnancy include alcohol, drugs, and tobacco. Use of these can lead to the birth of a baby with brain damage, drug addiction, and/or low birth weight and the problems associated with it. An embryo or fetus may also be harmed if the mother has a poor diet, is exposed to certain toxic substances, or gets certain infections, such as German measles or AIDS.

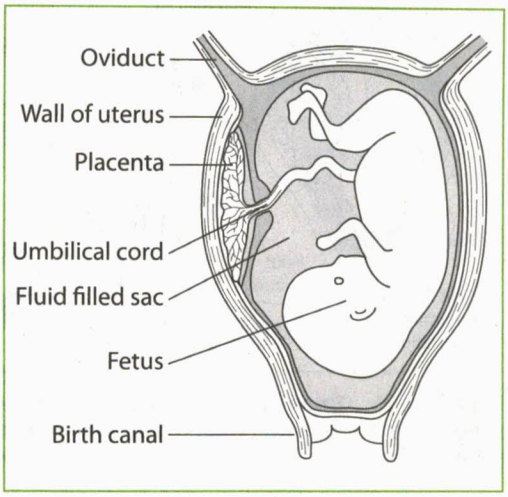


Figure 4-15. The uterus during pregnancy

After birth, cell differentiation and body growth continue until adulthood. During adulthood, the structures of the body slowly begin to age. Eventually, the organism weakens and dies. This process of birth, growth, development, aging, and death is a predictable pattern that applies not just to humans, but to all organisms.

Applications of Reproductive Technology

Recent discoveries by scientists have greatly changed the way we can deal with many problems involving the reproduction of humans as well as plants and other organisms. The knowledge we have gained has a variety of agricultural, ecological, and medical applications.

In the field of agriculture, scientists have produced plants that are resistant to insects, weed killers, and even frost. Such altered plants can then be cloned to produce thousands of genetically identical offspring. Using artificial insemination, scientists can generate hundreds of offspring from one farm animal. They can also freeze the sperm or fertilized eggs of an animal and transport them to animals thousands of miles away, at far less cost than transporting the animals themselves.

In the field of ecology, reproductive technology is being used to help build up populations of endangered species. Embryos from the endangered species have been transplanted into related species, who later give birth to offspring that are no different than they would be if they developed in the bodies of the endangered animals themselves. Also, hormones of insects that regulate their reproduction and development have been studied in an attempt to find ways to control insects without using poisonous chemicals.

In the field of medicine, recent scientific discoveries have led to new ways of dealing with reproductive problems in humans, other animals, and plants. Some women cannot become pregnant because of problems with their hormones, ovaries, or other parts of their reproductive systems. Reproductive technologies have enabled doctors to help infertile women become pregnant by using hormone therapy to adjust their hormones to normal levels. Sometimes doctors can extract several eggs from a woman's ovaries and fertilize them with sperm in a laboratory dish. When these

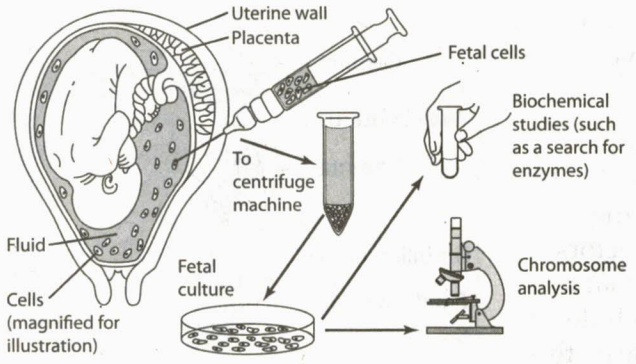


Figure 4-16. Obtaining fetal cells and fluids during pregnancy: Biochemical studies and chromosome analysis of the fetus can be done with cells and fluids removed during pregnancy.

fertilized eggs are implanted in the woman's uterus, a successful pregnancy may result.

Ultrasound and miniature video cameras allow doctors to view ovaries, oviducts, and other reproductive structures, or even a developing fetus, to determine if or where problems exist. Methods have also been developed to retrieve fetal cells that are present in the fluids around the developing fetus. (See Figure 4-16.) Doctors can then analyze the cells for chromosome abnormalities and the fluids for biochemical deficiencies that may threaten the health or development of the fetus.

Review Questions

32. What substances are involved in controlling the production of sperm and eggs in humans?

(1) vitamins (3) starches
(2) hormones (4) minerals

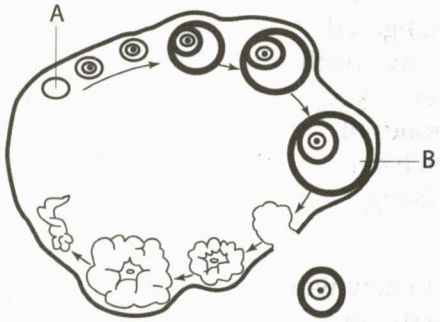
33. Which practice is essential to good prenatal care?

(1) increased egg production
(2) frequent dieting
(3) avoidance of drugs
(4) intake of antibiotics

34. Which part of the human male reproductive system produces hormones that influence the development of male sex characteristics?

(1) penis (3) gametes
(2) testes (4) ovaries

35. The diagram below represents a sequence of events in a human ovary.



The process that occurs between stage A and stage B is known as

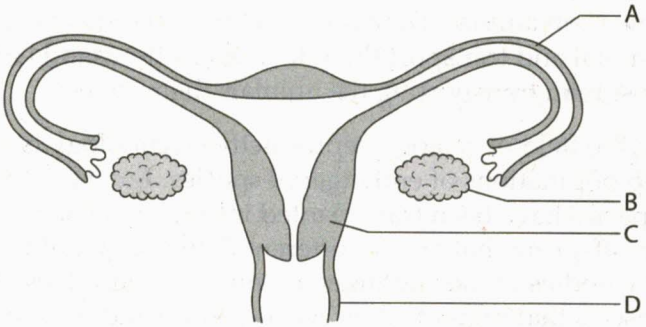
(1) egg formation (3) mitotic cell division
(2) sperm formation (4) cell recombination

36. The diagram below represents a series of events that takes place in the life cycle of humans.

Which term best describes the event taking place in the box labeled X?

(1) fertilization (3) meiosis
(2) immune response (4) protein synthesis

Base your answers to questions 37 through 41 on the diagram below and on your knowledge of biology. The diagram represents the human female reproductive system.



37. Fertilization usually occurs within structure

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

38. A placenta normally develops in structure

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

39. The structure that produces estrogen and progesterone is

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

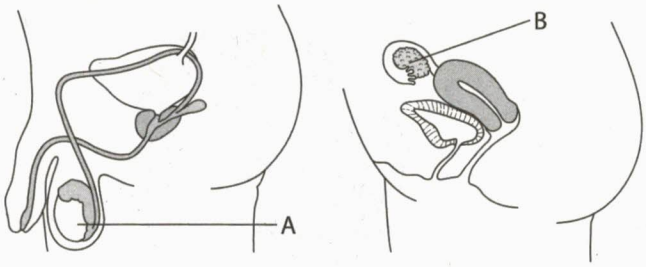
40. The structure that produces egg cells is

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

41. Shortly after implantation, tissue from the embryo normally grows into the wall of

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

Base your answers to questions 42 through 44 on the diagram below and on your knowledge of biology. The diagram represents the human male and female reproductive systems.



42. Gametes are produced in

(1) A, only
(2) B, only
(3) both A and B
(4) neither A nor B

43. Estrogen and progesterone are produced in

(1) A, only
(2) B, only
(3) both A and B
(4) neither A nor B

44. A substance is produced that influences both the reproductive cycle and the development of sex characteristics in

(1) A, only
(2) B, only
(3) both A and B
(4) neither A nor B

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45. In humans and other mammals, nutrients are transferred from the mother's bloodstream to the embryo's bloodstream across the

(1) placenta
(2) uterus
(3) ovary
(4) intestine

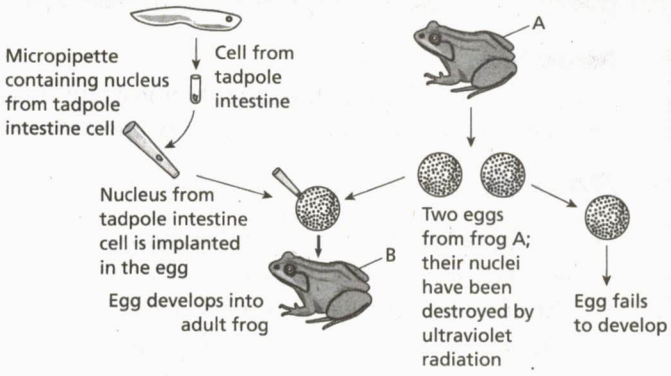
46. Which substance is a waste that would normally diffuse across the placenta from the embryo to the mother?

(1) glucose
(2) oxygen
(3) amino acid
(4) carbon dioxide

47. The egg of a mammal is smaller than that of a bird because the embryo of the mammal obtains its nutrients from the

(1) placenta through the process of diffusion
(2) mammary glands of the mother
(3) blood of the mother when it mixes with the blood of the embryo
(4) yolk stored in the uterus of the mother

Base your answers to questions 48 and 49 on the diagram below, which represents an experiment, and on your knowledge of biology.



48. An inference that can be made from this experiment is that

(1) adult frog B will have the same genetic traits as the tadpole
(2) adult frog A can develop only from an egg and a sperm
(3) fertilization must occur in order for frog eggs to develop into adult frogs
(4) the nucleus of a body cell fails to function when transferred to other cell types

49. Other scientists substituted a nucleus from a frog sperm cell and no adult frog developed. Explain why a sperm cell nucleus would not work in this procedure. [1]

Base your answers to questions 50 through 52 on the information below and on your knowledge of biology.

Some women have a blockage in that portion of their reproductive tract where fertilization of the egg cell would normally occur. *In vitro* fertilization is a technique that has been developed to make it possible for such women to bear their own children. This technique involves fertilizing an egg in a sterile petri dish and then implanting the developing embryo into the mother.

50. To ensure that the mother will have mature egg cells available for *in vitro* fertilization, she must be treated with chemicals that regulate her reproductive cycle. Identify these chemicals that regulate the female reproductive cycle. [1]

51. Egg cells for *in vitro* fertilization must be surgically removed from the mother. Identify the structure in the body of the mother that is the source for these egg cells. [1]

52. An embryo that developed from *in vitro* fertilization would be implanted in the mother's

(1) ovary (2) uterus (3) stomach (4) placenta

Practice Questions for the New York Regents Exam

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.

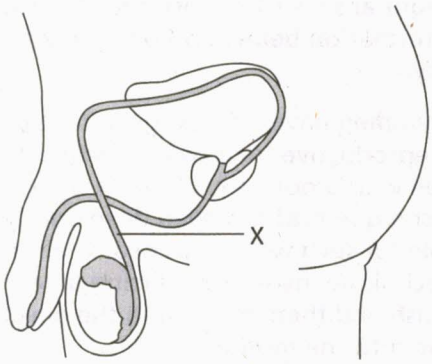
Part A

1 Compared to the number of chromosomes in a normal human body cell, the number of chromosomes in a normal sperm cell is
(1) the same
(2) twice as great
(3) half as great
(4) four times as great

2 Children born to the same parents are usually very different from each other. These differences result primarily from the process of
(1) mitotic division
(2) meiosis
(3) asexual reproduction
(4) cloning

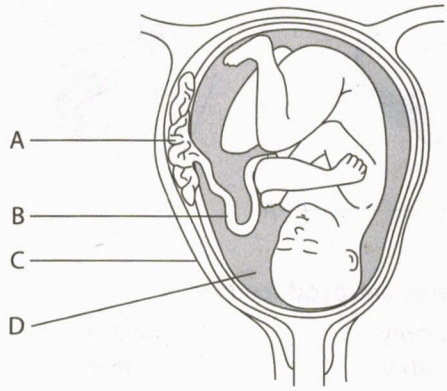
3 Human growth and sexual development are controlled by
(1) nerves
(2) hormones
(3) the digestive system
(4) the excretory system

4 The diagram below represents the human male reproductive system.



If structure X were cut and tied off at the line, which change would occur immediately?
(1) Hormones would no longer be produced.
(2) Sperm would no longer be produced.
(3) Sperm would be produced but no longer released from the body.
(4) Urine would be produced but no longer released from the bladder

Base your answers to question 5 through 7 on the diagram below, which represents a stage in human development.



5 The exchange of oxygen, food, and wastes between mother and fetus occurs at
(1) A
(2) B
(3) C
(4) D

6 What is the function of the fluid labeled D?
(1) nourishment
(2) protection
(3) excretion
(4) respiration

7 The structure labeled C, within which development occurs, is known as the
(1) birth canal
(2) uterus
(3) ovary
(4) placenta

---

8 Which is arranged in the correct sequence?
(1) fertilization → embryo development → meiosis → birth
(2) embryo development → meiosis → fertilization → birth
(3) meiosis → fertilization → embryo development → birth
(4) fertilization → meiosis → embryo development → birth

9 The diagram at the right represents a cell that will undergo mitosis.

Which of the diagrams best illustrates the daughter cells that result from a normal mitotic cell division of the parent cell shown?

(1) 

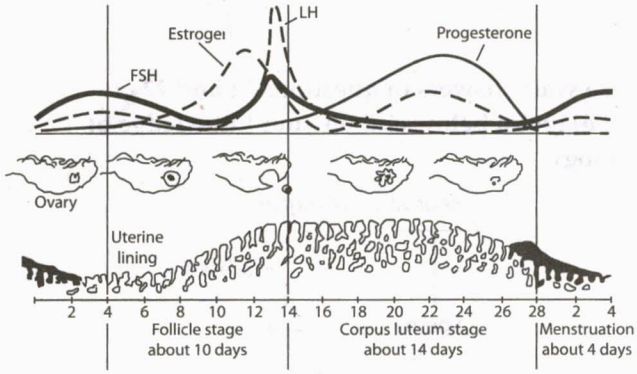
(2) 

(3) 

(4) 

Part B

Base your answers to questions 10 through 14 on the diagram below, which shows some events in the human female reproductive cycle, and on your knowledge of biology.



10 During which part of this cycle does the breakdown of the thickened uterine lining occur?
(1) ovulation
(2) corpus luteum stage
(3) menstruation
(4) follicle stage

11 On or about which day is the egg released from the ovary?
(1) day 8
(2) day 14
(3) day 20
(4) day 28

12 What is the average length of this reproductive cycle?
(1) 32 days
(2) 28 days
(3) 14 days
(4) 4 days

13 The hormone FSH stimulates the development of a follicle in the ovary of a human female. As the follicle develops, it secretes estrogen. A high level of estrogen decreases the secretion of FSH. This mechanism is an example of
(1) gamete development
(2) cell differentiation
(3) positive feedback
(4) negative feedback

14 Which hormones are secreted by the ovaries?
(1) progesterone and estrogen
(2) FSH and progesterone
(3) FSH and LH
(4) LH and estrogen

---

15 Compare the number of chromosomes present in the offspring with the number of chromosomes present in the parent organism in the process of cloning. [1]

Base your answers to questions 16 through 19 on the passage below and on your knowledge of biology.

Some researchers state that the level of a particular hormone present in the bloodstream of a pregnant woman may be used to predict whether birth will occur prematurely, on time, or late. During a study involving 485 pregnant women, the level of corticotropin-releasing hormone (CRH) was measured during weeks 16 through 20 of the usual 40-week gestation (development) period. A comparison of these hormone levels to times of birth indicated that women who delivered prematurely (less than 37 weeks) had an average of 3.6 times more CRH than those who gave birth on time.

CRH, a hormone produced by a hormone-secreting section of the brain called the hypothalamus, aids in regulating the secretion of hormones produced by the adrenal glands. CRH is also secreted by the placenta. Secretion of CRH by the placenta usually begins early in the second trimester of pregnancy. The level continues to increase dramatically as the delivery date approaches. For most of the pregnancy, another protein molecule binds to CRH, blocking its action. Researchers suggest that when CRH levels rise high enough to counteract the blocking protein, labor begins.

The placenta has a regulatory role over activities in the body of the mother during pregnancy. Secretions of placental estrogen and progesterone begin after the first few weeks. From the third to the ninth month, the placenta supplies these hormones at levels necessary to maintain pregnancy. Progesterone inhibits the uterine contractions necessary for delivery. It has been suggested that cortisol, an adrenal hormone released by the fetus, overcomes the inhibiting effects of progesterone as the level of progesterone drops toward the end of gestation. Also, at this time, oxytocin, a hormone synthesized by the hypothalamus of the mother, is released, stimulating uterine contractions and the onset of labor.

Although it is still not known whether CRH determines the length of pregnancy, researchers expect that experiments to lower CRH levels to prevent premature labor are not far off.

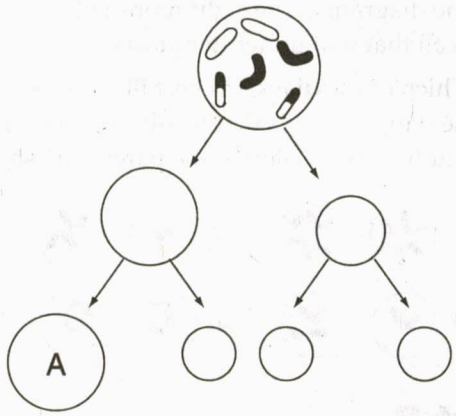
16 According to the passage, which structures play a role in initiating the birth process at the end of the gestation period?
(1) adrenal glands and ovaries
(2) uterus and ovaries
(3) hypothalamus and placenta
(4) placenta and zygote

17 In humans, the length of the period of gestation is usually
(1) 120 days
(2) 140 days
(3) 250 days
(4) 280 days

18 According to the passage, the release of cortisol by the adrenal gland of the fetus causes
(1) a decrease in CRH levels in the blood of the mother
(2) a decrease in the inhibiting effects of progesterone
(3) contractions of the ovaries
(4) the secretion of progesterone

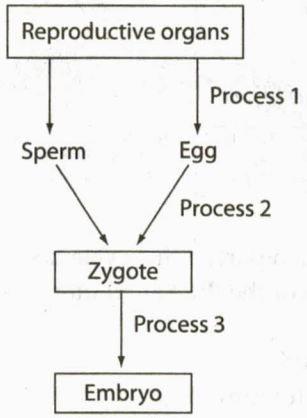
19 Explain how the placenta controls certain activities that occur during pregnancy. [1]

20 An incomplete diagram of meiosis in the ovary of an animal is shown below.



On the diagram below, draw in the chromosomes of cell *A*. Your drawing should show the usual result of the process of meiosis. [1]

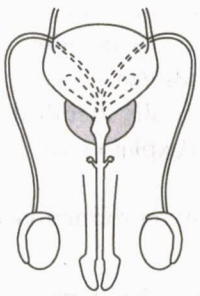
Base your answers to questions 21 and 22 on the diagram below and on your knowledge of biology.



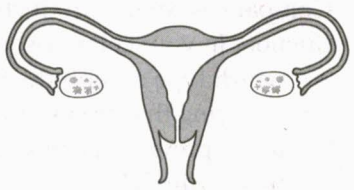
21 State why Process 2 is necessary in sexual reproduction. [1]

22 State *one* difference between the cells produced by Process 1 and the cells produced by Process 3. [1]

Directions (23–25): The diagrams below represent organs of two individuals. The diagrams are followed by a list of sentences. For each phrase in questions 23 through 25, select the sentence from the list below that best applies to that phrase and record its number.



Individual A



Individual B

Sentences

1. The phrase is correct for both Individual *A* and Individual *B*.
2. The phrase is not correct for either Individual *A* or Individual *B*.
3. The phrase is correct for Individual *A*, only.
4. The phrase is correct for Individual *B*, only.

23 Contains organs that produce gametes [1]

24 Contains organs involved in internal fertilization [1]

25 Contains a structure in which a zygote divides by mitosis [1]

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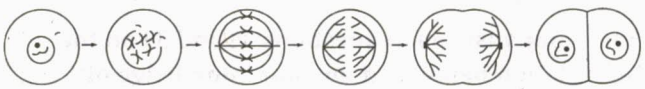
26 Which activity most directly involves the process represented in the diagram below?



(1) a gamete reproducing sexually
(2) a white blood cell engulfing bacteria
(3) a zygote being produced in an ovary
(4) an animal repairing damaged tissue

Part C

27 Early in the 1960s, many pregnant women took the drug thalidomide. Women who took thalidomide during their first three months of pregnancy gave birth to babies with severe birth defects. The babies typically had deformities of their arms and legs. Women who took thalidomide later in their pregnancies gave birth to normal babies.

Explain why the babies born to mothers taking thalidomide during their first few months of pregnancy suffered from birth defects while the others did not. [1]

28 Describe how the human fetus obtains food and oxygen during its development. In your explanation be sure to include:

- a description of how the food and oxygen move from the mother to the fetus [1]
- an explanation of the role of the placenta in this process [1]

29 The production of a normal baby involves protecting the developing embryo from harmful environmental factors. State three ways in which the pregnant woman could avoid exposing the developing embryo to environmental risks. [3]

30 The diagram below shows some steps involved in preparing tissue cultures in plants.

Compare the genetic makeup of the offspring plants that are transferred to the soil to that of the parent plant that provided the stem pieces. [1]

31 The process of meiosis followed by fertilization is necessary to maintain the species chromosome number of a sexually reproducing species. For instance, a species with 24 chromosomes in each body cell normally has offspring that also have 24 chromosomes in their body cells.

Explain the specific way that meiotic cell division and fertilization interact to help maintain the species chromosome number. [1]

Base your answers to questions 32 and 33 on the information below and on your knowledge of biology.

It is possible to collect human sperm and to use this sperm later to fertilize eggs in a process called artificial insemination. The collected sperm samples are frozen and stored in a sperm bank until needed. When a woman makes use of a sperm bank, she requests sperm from a donor with the physical features she wants. The name of the donor is not revealed. The artificial insemination process involves placing the sperm in the woman's body and allowing fertilization to occur in the normal manner.

32 A woman whose husband cannot produce sperm becomes pregnant through artificial insemination. Describe how the DNA of the baby will compare with the DNA of the woman and her husband. [1]

33 If the woman were given sperm from the same donor for three different pregnancies and she had three daughters, would the three girls look alike or would they be different? Support your answer with a biological explanation. [1]

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34 Scientists have successfully cloned sheep and cattle for several years. A farmer is considering the advantages and disadvantages of having a flock of sheep cloned from a single individual. Discuss the issues the farmer should take into account before making a decision. Your response should include:

- how a cloned flock would be different from a noncloned flock [1]
- one advantage of having a cloned flock [1]
- one disadvantage of having a cloned flock [1]
- one reason that the farmer could not mate these cloned sheep with each other to increase the size of his flock [1]
- one reason that the offspring resulting from breeding these sheep with an unrelated sheep would not all be the same [1]

35 Compare asexual reproduction to sexual reproduction. In your comparison, be sure to include:

- which type of reproduction results in offspring that are usually genetically identical to the previous generation and explain why this occurs [1]
- one other way these methods of reproduction differ [1]

36 A human is a complex organism that develops from a zygote. Briefly explain some of the steps in this developmental process. In your answer be sure to:

- explain how a zygote is formed [1]
- compare the genetic content of the zygote to that of a body cell of the parents [1]
- identify one developmental process involved in the change from a zygote into an embryo [1]
- identify the structure in which fetal development usually occurs [1]
- identify two factors that can affect fetal development and explain how each factor affects fetal development [1]

37 Define fertilization and describe the resulting development of a human embryo. In your answer, be sure to include a definition of fertilization and the functions of the ovary, uterus, and placenta. Circle the terms *fertilization*, *ovary*, *uterus*, and *placenta* in your description. [4]

Base your answers to questions 38 and 39 on the information below and on your knowledge of biology. The reproductive cycle in a human female is not functioning properly. An imbalance of hormones is diagnosed as the cause.

38 Identify one hormone directly involved in the human female reproductive system that could cause this problem. [1]

39 Explain why some cells in a female's body respond to reproductive hormones while other cells do not. [1]