

## Cell and Molecular Biology

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**1.** Life on Earth originated

- A. 4.5 billion years ago.
- B. between 3.5 and 4.0 billion years ago.
- C. 2.5 billion years ago.
- D. between 1.7 and 1.9 billion years ago.
- E. between 3.0 and 4.0 million years ago.

**(B)** The Earth formed approximately 4.5 billion years ago (A), with life originating between 3.5 and 4.0 billion years ago (B). The production of oxygen by early photosynthetic prokaryotes created an aerobic atmosphere approximately 2.5 billion years ago (C). The first eukaryotic organisms originated between 1.7 and 1.9 billion years ago (D), while the first hominids (ancestors of modern-day humans) are thought to have originated between 3.0 and 4.0 million years ago (E).

**2.** The earliest forms of life on Earth are thought to be primitive forms of

- A. paramecia.
- B. amoeba.
- C. bacteria.
- D. fungi.
- E. worms.

**(C)** Fossil and biochemical evidence suggest that the earliest forms of life were prokaryotic in nature, having a simple cellular structure without a defined nucleus or other organelles. Prokaryotes are represented by various genera of bacteria (C). All other organisms are classified as eukaryotes, having their DNA confined to an organized nucleus and containing various other membrane-bound organelles.

**3.** The cells of eukaryotic organisms contain a variety of organelles that allow for the compartmentalization of specific functions within the cell. The membranes surrounding the various organelles are composed of

- A. a double layer of proteins, within which lipids are embedded.
- B. a double layer of lipids, within which proteins are embedded.
- C. a single layer of proteins, within which lipids are embedded.
- D. a single layer of lipids, within which proteins are embedded.
- E. a triple layer of lipids, within which proteins are embedded.

**(B)** The cellular membranes of eukaryotic organisms are composed of a double layer of lipids (specifically, phospholipids) with a diverse array of proteins embedded within the bi-layer or attached to the surface. The membranes of different organelles differ in their composition of lipids and proteins, consisting of those most suited to the specific function(s) of the organelle. The lipid bi-layer structure, with embedded and attached proteins, functions to control the movement of substances into and out of the various organelles within the cell, as well as into and out of the cell as a whole.

**4.** In eukaryotic cells, protein synthesis takes place at the

- A. nucleus.
- B. mitochondria.
- C. chloroplasts.
- D. ribosomes.
- E. lysosomes.

**(D)** Protein synthesis takes place at the ribosomes of eukaryotic cells. The nucleus of eukaryotic cells (A) contains DNA, packaged into distinct chromosomes, which governs the physical and biochemical properties of the cell. Cellular respiration takes place in the mitochondria of eukaryotic cells (B), while photosynthesis takes place in the chloroplasts of plant cells and some bacterial cells (C). Lysosomes (E) use hydrolytic enzymes to breakdown macromolecules in the cells of some eukaryotic organisms.

**5.** Plant cells typically contain a large central vacuole. Which of the following is NOT a function of the central vacuole in plant cells?

- A. storage of organic compounds
- B. storage of inorganic ions, such as potassium and chloride
- C. disposal of metabolic by-products
- D. maintenance of water balance within the cell
- E. production of ATP

**(E)** The central vacuole found in most plant cells has a wide range of functions including the storage of both organic and inorganic compounds, the disposal of metabolic by-products (wastes), the maintenance of water balance and turgor pressure within the cell, and sometimes the storage of pigments, which give color to the cell (for example, the red and blue pigments found in the petals of flowers and the roots of beets). The production of ATP occurs through the process of cellular respiration, which takes place in the mitochondria of plant and animal cells.

**6.** The chemical interactions among molecules within the cell occur in an orderly array of intricately branched metabolic pathways, which manage the materials and energy resources within the cell. The transformation of energy from one form to another—for example, the conversion of potential energy to kinetic energy—is governed by the laws of thermodynamics. Which of the following is NOT consistent with the laws of thermodynamics governing energy transfer within a cell?

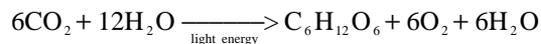
- A. Energy can neither be created nor destroyed within the cell.
- B. Energy transformations increase the degree of entropy within the cell.
- C. Organisms are considered “closed systems” and, therefore, cannot transfer energy between themselves and their environment.
- D. Chemical energy stored in cells is a form of potential energy.
- E. Heat is considered the lowest grade of energy within the cell.

**(C)** Organisms are considered “open systems” in which energy can be transferred between the individual and its surroundings. For example, plants can take in light energy and convert it into chemical energy in the form of glucose through the process of photosynthesis.

**7.** Which of the following best describes the process of photosynthesis, which occurs in the chloroplasts of plant cells?

- A. Glucose is broken down to produce oxygen and water.
- B. Glucose is broken down to produce carbon dioxide and water.
- C. Glucose is synthesized from oxygen and water.
- D. Glucose is synthesized from carbon dioxide and water.
- E. Glucose is synthesized from oxygen and carbon dioxide.

(D) In the process of photosynthesis, light energy is used to convert carbon dioxide from the atmosphere, and water is taken up by the plant from the soil to produce glucose, releasing oxygen to the atmosphere as a by-product, as shown in the equation below:



8. The most efficient wavelength(s) of light for photosynthesis is/are

- A. green.
- B. green and red.
- C. green and blue.
- D. red and blue.
- E. red and ultraviolet.

(D) Chlorophyll, the pigment involved in the process of photosynthesis and located in the chloroplasts of certain cells found in plants, algae, and some bacteria, absorbs light most efficiently in the red and blue wavelengths. Green wavelengths of light are reflected by chlorophyll, giving the pigment (and most plant leaves) a characteristic green color.

9. The breakdown of glucose in the presence of oxygen results in the production of carbon dioxide, water, and energy in the form of ATP. This process, which takes place in the mitochondria of both plant and animal cells, is referred to as

- A. cellular respiration.
- B. alcoholic fermentation.
- C. lactic acid fermentation.
- D. anaerobic respiration.
- E. photosynthesis.

(A) Organisms obtain energy (in the form of ATP) from the breakdown of organic molecules (primarily glucose), in the presence of oxygen, in the mitochondria of their cells through a process known as cellular respiration. (See the equation below). Fermentation involves the breakdown of glucose in the absence of oxygen (anaerobically). In some organisms, such as yeast, the breakdown product is ethanol, through a process known as alcoholic fermentation (B), while in other organisms, such as the muscle cells of humans, the breakdown product is lactic acid, through a process known as lactic acid fermentation (C). (Refer to equations below.) Both types of fermentation, which take place in the absence of oxygen, are often referred to as anaerobic respiration (D). Photosynthesis (E) involves the synthesis of glucose from carbon dioxide and water in the chloroplasts of certain cells found in plants, algae, and some bacteria.

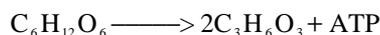
Cellular Respiration (Aerobic Respiration):



Alcoholic Fermentation (Anaerobic Respiration):



Lactic acid Fermentation (Anaerobic Respiration):



**10.** Which of the following statements regarding enzymes is INCORRECT?

- A. Enzymes are a type of protein.
- B. Enzymes are substrate-specific, meaning that a given enzyme will only act on a specific substrate and will not catalyze reactions involving similar substrates.
- C. Enzymes act as catalysts to speed up chemical reactions by increasing the amount of activation energy required to break the chemical bonds in the reactant molecules.
- D. Enzymes act as catalysts by changing the rate of chemical reactions without themselves being changed or consumed by the reaction.
- E. Enzyme activity can be affected (increased or decreased) by the physical and chemical environment of the cell in which it is found, with a given enzyme having an optimal temperature and pH range within which it is most efficient at catalyzing reactions.

(C) Enzymes act to *lower* the activation energy required for a chemical reaction to proceed, thereby speeding up the rate of the reaction.

**11.** Diffusion of molecules across a semi-permeable membrane, such as would occur if a salt water solution was separated from a distilled water solution by an artificial membrane, would ultimately result in which of the following?

- A. a dynamic equilibrium in which both solutions would have approximately equal concentrations of salt molecules
- B. all of the salt molecules moving to the distilled water solution
- C. all of the salt molecules remaining in the salt water
- D. all of the distilled water moving into the salt water container
- E. all of the salt water moving into the distilled water container

(A) Diffusion involves the movement of molecules from a region of higher concentration to a region of lower concentration, along what is known as a concentration gradient. After the concentration of molecules is similar on each side of the membrane, diffusion would occur at approximately equal rates in both directions across the membrane, resulting in a dynamic equilibrium between the two solutions, with no net movement of molecules in either direction.

**12.** What would most likely happen to a human red blood cell that was removed from the body and placed in a jar containing distilled water?

- A. The red blood cell would take up water and shrivel up.
- B. The red blood cell would take up water until it reached a point in which the cell wall would exert turgor pressure against the uptake of water, forcing excess water back out of the cell.
- C. The red blood cell would take up water until it swelled and burst.
- D. The red blood cell would lose water and shrivel up.
- E. The red blood cell would lose water and burst.

(C) A human red blood cell would have a higher concentration of solutes and, therefore, a lower concentration of water than the distilled water into which it was placed. As a result, the cell would take up water by osmosis (the movement of water across a semi-permeable membrane from a region of higher concentration to a region of lower concentration). Because animal cells do not have cell walls, the blood cell would continue to take up water and swell until it bursts (lyses). Plant cells, on the other hand, do have cell walls that exert an opposite pressure against the uptake of water (turgor pressure) forcing any excess water out of the cell and preventing the cell from *lysing*.

**13.** Metabolic pathways in which complex molecules are broken down into simpler compounds are referred to as

- A. energetic pathways.
- B. kinetic pathways.
- C. anabolic pathways
- D. catabolic pathways.
- E. catalytic pathways.

**(D)** Catabolic pathways involve the release of energy through the breakdown of complex molecules into simpler compounds, such as occurs during cellular respiration when glucose is broken down into carbon dioxide and water. Anabolic pathways (C) involve the consumption of energy as complex molecules are formed from simpler components, such as occurs during the formation of proteins from amino acids.

**14.** A molecule that binds to an enzyme somewhere other than its active site and results in an inhibition of enzyme activity is referred to as a

- A. competitive inhibitor.
- B. noncompetitive inhibitor.
- C. feedback inhibitor.
- D. coenzyme.
- E. cofactor.

**(B)** A noncompetitive inhibitor reduces enzyme activity by binding to the enzyme at a location other than the active site of the enzyme resulting in a change in the conformation of the enzyme so that the active site is no longer fully functional. A competitive inhibitor (A) reduces enzyme activity by binding to the active site of the enzyme and, thus, competing with the substrate for the binding site on the enzyme. Feedback inhibition (C) occurs when a metabolic pathway is switched off by the presence of its end product, which acts as an inhibitor of the enzyme catalyzing the reaction. A cofactor (E) is an inorganic compound that assists an enzyme with its catalytic activity. A coenzyme (D) is an organic compound that assists an enzyme with its catalytic activity.

**15.** Prior to cell division, cells go through a phase of the cell cycle known as DNA synthesis, which results in

- A. a doubling of the number of chromosomes within the cell.
- B. a doubling of the DNA content within each chromosome of the cell.
- C. a halving of the number of chromosomes within the cell.
- D. a halving of the amount of DNA within each chromosome of the cell.
- E. no change in the amount of DNA within the cell.

**(B)** During the synthesis phase of the cell cycle, in preparation for cell division, the DNA content of each chromosome doubles, such that each chromosome is represented by two sister chromatids; however, the number of chromosomes in the cell does not change.

**16.** During the process of meiosis, a single cell gives rise to

- A. two genetically identical daughter cells.
- B. two genetically unique daughter cells.
- C. four genetically identical daughter cells.
- D. four genetically unique daughter cells.
- E. four daughter cells, two of which are identical to the parent cell and two of which are genetically unique.

**(D)** Meiosis is the process of cell division that occurs in the germ cells and gives rise to gametes (for example, eggs and sperm in humans). Each cell that undergoes meiosis produces four genetically unique daughter cells. In contrast, somatic cells undergo a type of cell division referred to as mitosis, which produces two daughter cells that are identical to each other, as well as to the parent cell undergoing division. Mitosis allows for growth and repair of tissues.

## Diversity of Life

**17.** Which of the following represents the mode of reproduction that occurs in bacteria?

- A. transformation
- B. conjugation
- C. transduction
- D. binary fission
- E. budding

**(D)** Bacteria reproduce asexually only through a type of cell division known as binary fission, in which the single chromosome of the parent cell is duplicated, the cell grows in length to separate the two chromosomes, and the plasma membrane grows inward pinching the cell into two equal halves, each with a single copy of the chromosome. Although bacteria reproduce asexually only, genetic variation occurs through the exchange of genetic information by transformation (A), in which genes are taken up by the cell from the surrounding environment; conjugation (B), in which genes are transferred directly from one bacterial cell to another through the formation of a temporary conjugation tube connecting the two cells; and transduction (C), in which genes are transferred between cells by viruses. Budding (E) is a type of asexual reproduction in which outgrowths of the parent cell are pinched off to live independently (as in yeast and hydra) or remain attached to the parent organism to form an extensive colony (as in corals).

**18.** The Gram stain technique is used to determine the cell wall structure of various groups of bacteria. Not only is the Gram stain a useful taxonomic tool, but it is medically important because

- A. Gram-positive bacteria are typically more dangerous pathogens due to the toxins produced in their cell walls.
- B. Gram-negative bacteria tend to be more resistant to antibiotics than gram-positive bacteria.
- C. Gram-positive bacteria have more complex cell walls than gram-negative bacteria and, thus, are more difficult to treat.
- D. Gram-negative bacteria have much peptidoglycan in their cell walls, making them more toxic than Gram-positive bacteria.
- E. Gram-positive bacteria are not pathogenic.

**(B)** The Gram stain identifies bacterial groups based on differential staining of their cell walls. Gram-positive bacteria have relatively simple cell walls containing much peptidoglycan, while Gram-negative bacteria have more complex cell walls containing less peptidoglycan and much lipopolysaccharide. Although pathogenic bacteria can be found among both Gram-positive and Gram-negative groups, Gram-negative bacteria tend to be more resistant to antibiotics due to the complex structure of their cell walls. Also, Gram-negative bacteria tend to be more dangerous due to the production of toxins from the lipopolysaccharide layer.

**19.** The first photosynthetic organisms that used water and carbon dioxide to make organic compounds, producing oxygen as a by-product and allowing for the eventual development of aerobic cellular respiration among the Earth's organisms, are classified as

- A. plants.
- B. algae.
- C. bacteria.
- D. mosses.
- E. lichens.

**(C)** Between 2.5 and 3.5 billion years ago, strains of photosynthetic bacteria (cyanobacteria) evolved that were able to utilize water (instead of hydrogen sulfide) and carbon dioxide to make organic compounds, such as glucose. Oxygen was released as a by-product of the reactions.

**20.** Which of the following organisms is NOT classified as a protist?

- A. chlamydia
- B. amoeba
- C. paramecium
- D. green alga
- E. slime mold

(A) Chlamydia are bacteria and, thus, are prokaryotic organisms classified as Monera in the five-kingdom system of classification. Amoebas (B) and paramecia (C) are animal-like protists, green algae (D) are plant-like protists, and slime molds (E) are fungal-like protists.

**21.** Which of the following statements regarding protists is correct?

- A. All protists are single-celled.
- B. All protists are photosynthetic.
- C. All protists have cilia.
- D. All protists are eukaryotic.
- E. All protists move by pseudopodia.

(D) Kingdom Protista includes a diverse array of organisms that do not fit into any of the other kingdoms of the Five-Kingdom system of classification of organisms. The one characteristic shared by all protists is that they are eukaryotic organisms. Prokaryotic organisms (bacteria) are classified as Monera in the Five-Kingdom system.

**22.** Which of the following phenomena is explained by the endosymbiont theory?

- A. The presence of a nucleus in eukaryotic cells.
- B. The presence of chloroplasts and mitochondria in eukaryotic cells.
- C. The presence of cell walls in plant cells.
- D. The presence of a plasma membrane surrounding eukaryotic cells.
- E. The presence of a large central vacuole in plant cells.

(B) According to the endosymbiont theory, mitochondria and chloroplasts originated as small prokaryotes living as endosymbionts within larger cells. The proposed ancestors of mitochondria are aerobic, heterotrophic prokaryotes, while the proposed ancestors of chloroplasts are photosynthetic prokaryotes.

**23.** Fungi acquire nutrients by

- A. photosynthesis.
- B. chemitrophism.
- C. ingestion.
- D. diffusion.
- E. absorption.

(E) Fungi are heterotrophic organisms that acquire nutrients by absorption. Fungi secrete enzymes that breakdown complex organic molecules into smaller compounds that can be absorbed and used by the organism.

- 24.** There are numerous examples of both helpful and harmful species of fungi. Which of the following organisms is NOT considered a beneficial member of the Kingdom Fungi?
- A. *Rhizobium* sp.
  - B. *Penicillium roquefortii*
  - C. morel
  - D. *Saccharomyces cerevisiae* (bread / beer yeast)
  - E. puffball

(A) *Rhizobium* species are bacteria that form symbiotic relationships with the roots of plants in the legume family. Through a process known as nitrogen fixation, *Rhizobium* take nitrogen from the atmosphere and convert it into a form usable by the plant, enhancing the uptake of usable forms of nitrogen. *Penicillium roquefortii* (B) is a fungus that provides the color and flavor of roquefort cheese (a type of blue cheese). Morels (C) are a type of fungus that is edible and considered a delicacy by many people. *Saccharomyces cerevisiae* (D) is a yeast (single-celled fungal organism) used in the brewing and baking industries. Puffballs (E) are edible fungi.

- 25.** What part of the fungal life cycle is represented by the common mushrooms we purchase at the grocery?
- A. asexual reproductive structures
  - B. sexual reproductive structures
  - C. the main vegetative (non-reproductive) part of the body
  - D. the absorptive structures through which the organisms take up nutrients
  - E. the photosynthetic portion of the body

(B) The mushroom portion of a fungus represents the “fruiting body” or sexual reproductive structure of certain groups of fungi (Ascomycota and Basidiomycota). The asexual reproductive structures (A) of most fungi are small and borne on the vegetative part of the body (C), which consists of long, filamentous thread-like structures referred to as mycelia. There are no photosynthetic parts to the fungal body (E).

- 26.** Which of the following statements best describes the movement of water and dissolved sugars in plants?
- A. Water moves downward through the plant in phloem tissue, while dissolved sugars move upward through the plant in xylem tissues.
  - B. Water moves upward through the plant in the xylem tissue, while dissolved sugars move downward through the plant in the phloem.
  - C. Water moves downward through the plant in the xylem, while dissolved sugars move upward in the plant through the phloem.
  - D. Water moves upward through the plant in the phloem, while dissolved sugars move downward through the plant in the xylem.
  - E. Water moves upward through the plant in the xylem, while dissolved sugars move both upward and downward through the plant in the phloem.

(E) Water is taken up by the roots and transported upward through the plant in the xylem in response to tension created by evapotranspiration of water from the leaves of the plant. Dissolved sugars, made in the photosynthetic tissues of the plant (primarily the leaves), move throughout the plant in the phloem. The direction of movement is from a “source” (where the sugars are made or stored) to a “sink” (areas that need sugars for growth or metabolism). Thus, dissolved sugars may move downward through the plant (for example, from the leaves where it is being made to the roots for root growth or for storage) or upward through the plant (for example, from where it is stored in the roots to new growth occurring at the tips of young branches).

**27.** The vascular, nonseed-bearing (spore-producing) plants include

- A. pines and firs.
- B. mosses and liverworts.
- C. ferns and horsetails.
- D. mosses and ferns.
- E. ferns and pines.

(C) Ferns and horsetails, along with lycophytes, have vascular tissue (xylem and phloem) and sexually reproduce through spores (as opposed to seeds). Mosses and liverworts are non-vascular, meaning they do not contain xylem or phloem tissue (although some have primitive water-conducting cells) and reproduce sexually via spores. Pines and firs have well-developed vascular tissue and reproduce sexually by seed.

**28.** Flowering plants undergo a special type of fertilization referred to as double fertilization, which is considered a significant evolutionary advantage over nonflowering plants. In double fertilization,

- A. two sperm cells unite with the egg to produce a more robust triploid zygote.
- B. one sperm cell unites with the egg to form a zygote and one sperm cell unites with the endosperm (nutritive tissue) to form the fruit.
- C. two sperm cells unite with the egg cell to form a fruit.
- D. one sperm cell unites with the egg to form a zygote and one sperm cell unites with two polar nuclei to form the endosperm (nutritive tissue).
- E. two sperm cells and two egg cells all fuse to form a more robust tetraploid zygote.

(D) In double fertilization, which occurs in flowering plants, one sperm cell unites with an egg cell to form a diploid zygote, while a second sperm cell unites with two polar nuclei in the embryo sac (female gametophyte) to form triploid endosperm tissue. Triploid endosperm tissue is more robust and has a higher nutritive value than the haploid endosperm tissue of maternal origin found in nonflowering seed plants (gymnosperms).

**29.** A fruit is most commonly

- A. a mature embryo sac.
- B. a mature ovary.
- C. a fertilized ovule.
- D. a mature female gametophyte.
- E. endosperm tissue.

(B) In flowering plants, after fertilization, the ovule becomes the seed, and mature ovary tissue develops into the fruit, surrounding and protecting the seed. In some fruits, such as apples and strawberries, additional tissue (hypanthium or receptacle tissue) may also become part of the mature fruit.

**30.** Which of the following animal phyla is mismatched with its description and examples?

- |                    |                                |
|--------------------|--------------------------------|
| A. Platyhelminthes | no body cavity; flatworms      |
| B. Porifera        | lacking true tissues; sponges  |
| C. Cnidaria        | bilateral symmetry; hydra      |
| D. Mollusca        | determinate cleavage; clams    |
| E. Chordata        | indeterminate cleavage; humans |

(C) Members of phylum Cnidaria have a body plan with radial symmetry.

- 31.** Which animal phylum is mismatched with its primary characteristics of classification?
- A. Platyhelminthes      dorsoventrally-flattened; acoelomates
  - B. Nematoda              segmented; cylindrical
  - C. Mollusca              major body parts include a muscular foot, visceral mass, and a mantle
  - D. Arthropoda           regional segmentation; jointed appendages; exoskeleton
  - E. Chordata                notochord; dorsal hollow nerve cord

(B) Members of phylum Nematoda are unsegmented, cylindrical roundworms.

- 32.** The class of chordates whose members are endothermic and nourish their young from mammary glands is the
- A. Amphibia.
  - B. Osteichthyes.
  - C. Aves.
  - D. Reptilia.
  - E. Mammalia.

(E) Mammals are endothermic animals that nourish their young from the mammary glands of the female.

- 33.** Which of the following organisms is NOT considered a member of the class Reptilia?
- A. toad
  - B. snake
  - C. lizard
  - D. turtle
  - E. crocodile

(A) Toads are members of the class Amphibia.

## Vertebrate Anatomy and Physiology

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- 34.** Which of the following is NOT part of the excretory system in vertebrates?
- A. ureters
  - B. urethra
  - C. kidneys
  - D. small intestine
  - E. bladder

(D) The small intestine is part of the vertebrate digestive system, which functions in the ingestion, digestion, absorption, and elimination of food. The function of the vertebrate excretory system, which includes the ureters (A), urethra (B), kidneys (C), and bladder (E), is to rid the body of metabolic waste products and regulate the osmotic balance of the blood.

**35.** Which of the following statements regarding thermoregulation in vertebrates is true?

- A. Reptiles and amphibians are considered ectotherms because they derive body heat primarily from their surroundings and must rely on behavioral adaptations to regulate their body heat, while birds and mammals can regulate their body heat through internal metabolic changes and, thus, are considered endotherms.
- B. All vertebrates are ectotherms, having the ability to regulate their body heat through internal metabolic changes, while invertebrates are endotherms and must rely on adaptations to their surroundings to regulate body temperature.
- C. Birds and mammals have the ability to regulate their body heat through metabolism and are, thus considered ectotherms, while amphibians and reptiles must adapt to their surrounding by behavioral changes to adjust their body temperature and, thus are considered endotherms.
- D. The internal body temperature of an endothermic organism fluctuates according to the temperature of the individual's surroundings, while the internal body temperature of an ectothermic organism remains relatively constant regardless of the temperature of the individual's surroundings.
- E. All vertebrates are endotherms, having the ability to regulate their body heat through internal metabolic changes, while invertebrates are ectotherms and must rely on adaptations to their surroundings to regulate body temperature.

(A) Ectothermic organisms, which include amphibians, reptiles, and fish, must derive body heat from their surroundings and, therefore, must rely on behavioral adaptations to regulate body heat (for example, moving to a sunny spot from a shady spot to increase body temperature). As such, the internal body temperature of an ectothermic organism fluctuates according to the surrounding temperature. Endothermic organisms, which include birds and mammals, control their body heat by internal metabolic changes; therefore, their internal body temperature remains relatively constant regardless of the temperature of their surroundings.

**36.** Groups of cells with a common structure and function are referred to as

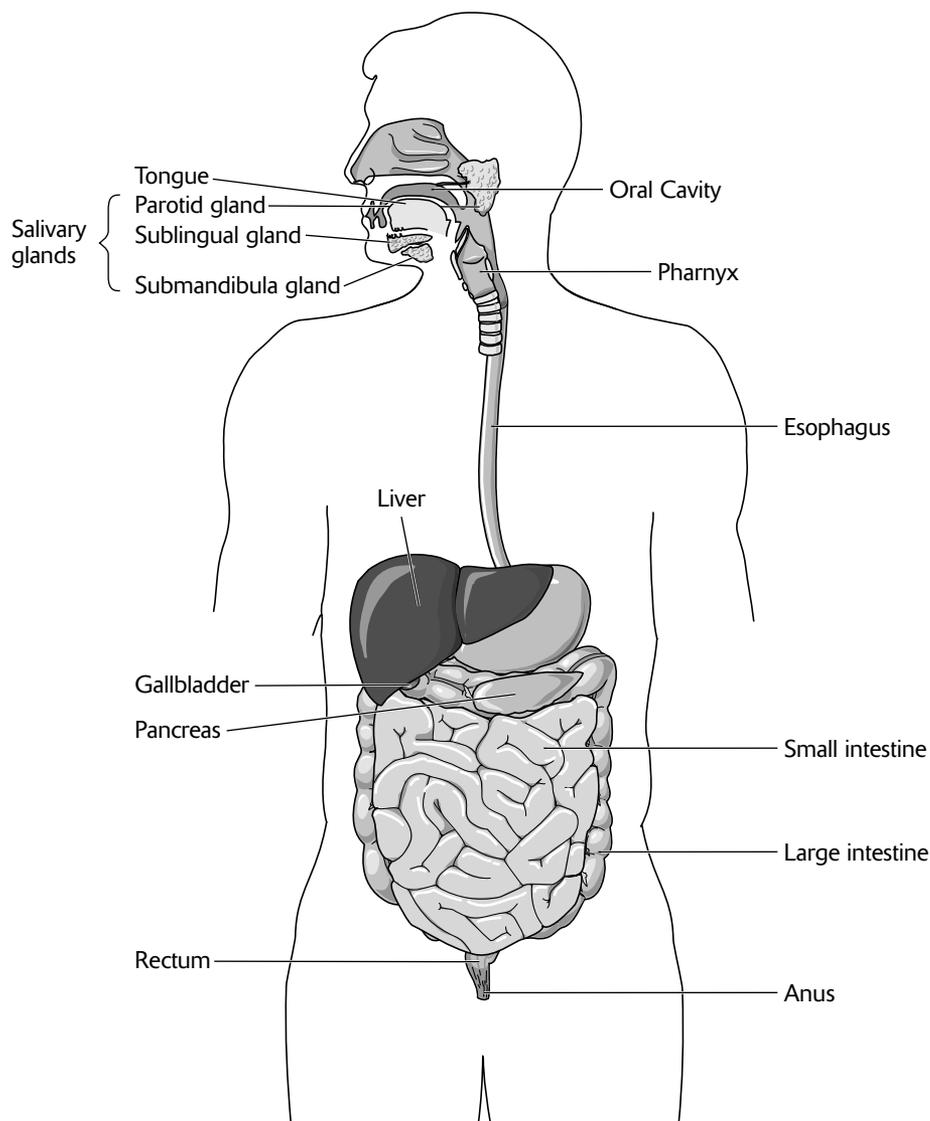
- A. organelles.
- B. organs.
- C. tissues.
- D. systems.
- E. fibers.

(C) There is a hierarchical level of structure in living organisms. The lowest level of organization that can exist independently is the cell. Within the cells of eukaryotic organisms are specialized, membrane-bound structures, called organelles (A), that carry out specific functions. Groups of cells that share a common structure and function are organized into tissues (C). Various tissues are organized into specialized centers of function called organs (B), and groups of organs work together in an organized manner to form organ systems (D). For example, the human digestive system is composed of several organs, including the stomach, small intestine, large intestine, and gall bladder, among others, with each organ composed of different tissue types. Fibers (E) are specialized structures found in many different tissue types of living organisms.

**37.** In the human digestive system, the primary site of digestion and absorption is the

- A. stomach.
- B. liver.
- C. gall bladder.
- D. small intestine.
- E. large intestine.

(D) When food is ingested and begins to make its way down the human digestive system, it is first processed into small pieces in the mouth and the limited digestion of carbohydrates begins through the action of salivary amylase produced in saliva. With the aid of the tongue, the food is shaped into a ball, called a bolus, and pushed into the pharynx, which leads to both the esophagus and the trachea (windpipe). The act of swallowing pushes the trachea upward so that its opening, the glottis, is blocked by a cartilaginous flap called the epiglottis, thus ensuring that the bolus moves down into the esophagus instead of the windpipe. Muscular contractions, referred to as peristalsis, moves the bolus down the esophagus and into the stomach (A), where food is stored and preliminary digestion begins. As the bolus is mixed and processed by enzymes and acids produced in the stomach, it turns into a broth-like substance called chyme, which moves through the pyloric sphincter connecting the stomach to the small intestine (D). The small intestine is the site at which most digestion occurs and most nutrients are absorbed into the body. The pancreas, liver (B), and gall bladder (C) participate in digestion by producing enzymes that are secreted into the top portion of the small intestine (the duodenum) that help break down the chyme. When digestion is complete, unabsorbed fluids and waste products pass into the large intestine (E) and are eliminated as feces. See diagram below.



**38.** An individual whose diet is missing one or more essential nutrients is said to be

- A. undernourished.
- B. malnourished.
- C. anemic.
- D. heterotrophic.
- E. homeostatic.

**(B)** A malnourished individual is one whose diet is lacking one or more essential nutrients. An individual who is undernourished (A) has a diet that is deficient in caloric intake. An individual who is anemic (C) has insufficient hemoglobin or red blood cells. A heterotrophic individual (D) is one that obtains organic food molecules by consuming other organisms. An individual whose body is in a steady-state physiological condition is said to be in a homeostatic state (E).

**39.** When taking your pulse, you are actually measuring your

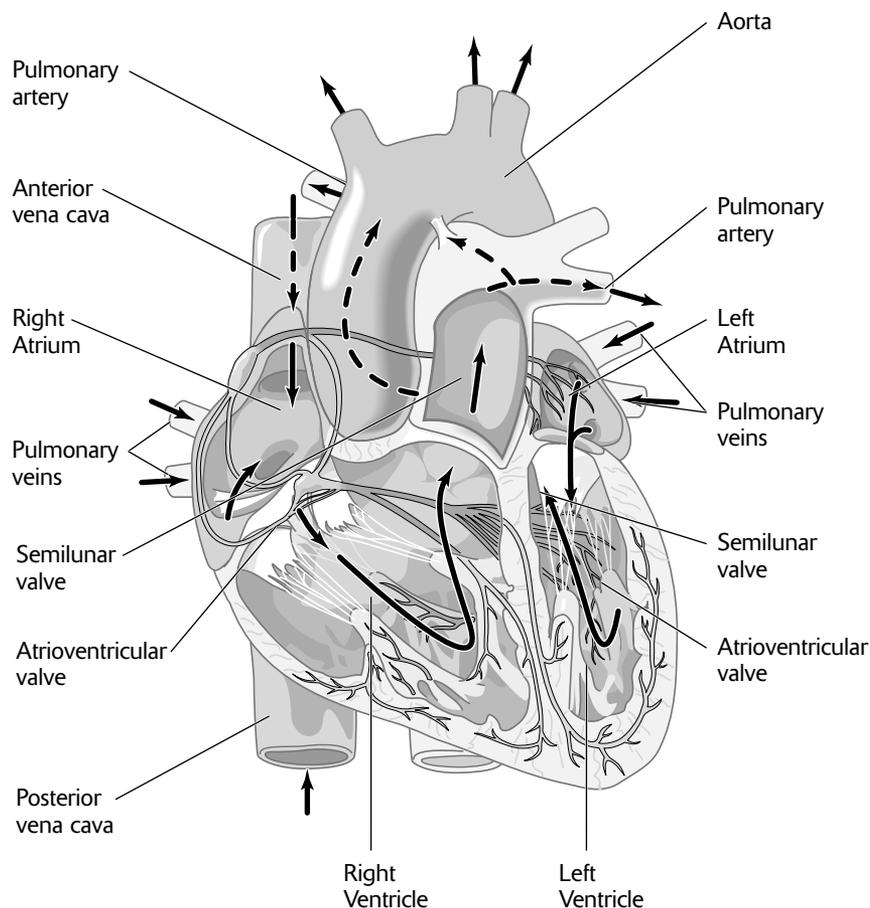
- A. diastolic blood pressure.
- B. systolic blood pressure.
- C. heart rate.
- D. basal metabolic rate.
- E. standard metabolic rate.

**(C)** By taking your pulse, you can measure your heart rate, or the number of times your heart beats per minute. The diastole (A), the relaxation phase of the cardiac cycle, and systole (B), the contraction phase of the cardiac cycle, must be measured with a sphygmomanometer and a stethoscope. Basal metabolic rate (D), the minimal number of calories an endothermic individual needs when at rest, is determined by the individual's weight and relative level of fitness. Standard metabolic rate (E), the minimal number of calories an ectothermic individual needs when at rest, depends on environmental conditions, such as temperature and relative humidity, as well as the weight of the individual.

**40.** Which of the following statements regarding blood flow through the human heart is INCORRECT?

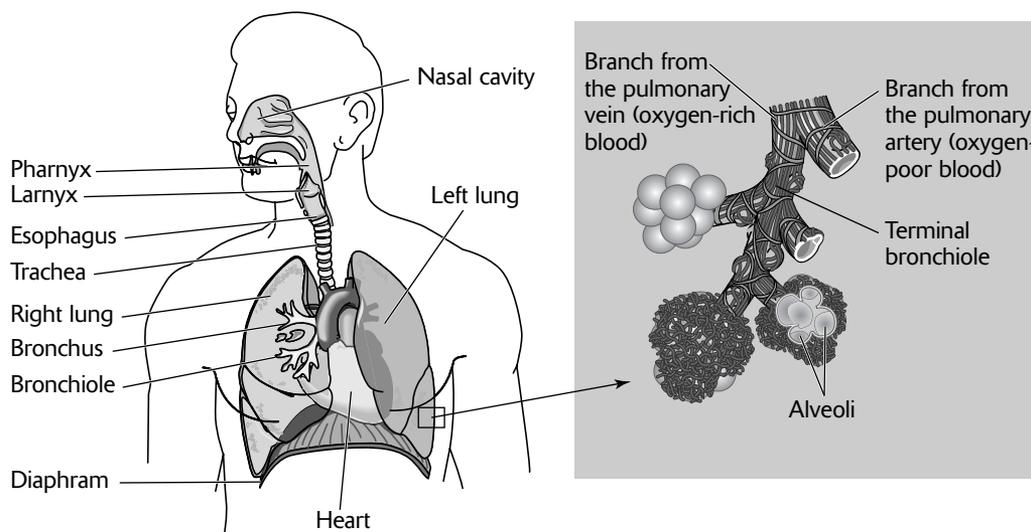
- A. Blood that is relatively low in oxygen enters the right atrium of the heart through the vena cava.
- B. The right ventricle of the heart forces oxygen-poor blood to the lungs.
- C. The left ventricle of the heart forces oxygen-rich blood throughout the body.
- D. Blood is supplied to the tissues of the heart by the pulmonary artery.
- E. Oxygen-poor blood from the head, neck, and limbs is emptied into the vena cava.

**(D)** Blood is supplied to the tissues of the heart by the first two branches of the aorta, referred to as the right and left coronary arteries. The pulmonary artery carries oxygen-poor blood from the heart to the lungs, while the pulmonary veins return oxygen-rich blood from the lungs to the heart. See diagram on the following page.



- 41.** In humans, the exchange of gases (oxygen and carbon dioxide) occurs primarily across the epithelium of the
- A. alveoli.
  - B. bronchioles.
  - C. bronchi.
  - D. trachea.
  - E. windpipe.

(A) When air is inhaled into the human respiratory system, it passes from the nasal cavity into the larynx. From the larynx, air moves into the trachea (D), also called the windpipe (E). The trachea branches into two bronchi (C), one leading to each lung. Within the lung, the bronchi branch into finer and finer tubes called bronchioles (B). The smallest bronchioles terminate into air sacs referred to as alveoli (A), the surface of which serves as the primary site for gas exchange in the human respiratory system. Oxygen in the air inhaled diffuses across the epithelial surfaces of the alveoli into surrounding capillaries. Carbon dioxide diffuses from the capillaries, across the epithelial surfaces of the alveoli and into the air space. See diagram on the following page.



**42.** In vertebrate organisms, oxygen and carbon dioxide are transported throughout the body by binding to

- A. water molecules in the blood.
- B. hemoglobin in white blood cells.
- C. hemoglobin in red blood cells.
- D. lymph in white blood cells.
- E. lymph in red blood cells.

**(C)** Hemoglobin is a blood pigment that gives red blood cells their characteristic color. Hemoglobin consists of four subunits, each of which contains an iron molecule that can bind to oxygen for transport throughout the body. Hemoglobin also binds and transports carbon dioxide and serves to buffer the blood, preventing harmful fluctuations in blood pH.

**43.** The human tissue system that functions to produce an outer covering for the body, serves as a sense organ and serves as a barrier against pathogens is the

- A. connective tissue system.
- B. adipose tissue system.
- C. muscle tissue system.
- D. dermal tissue system.
- E. fibrous tissue system.

**(D)** The dermal tissue system, the “skin,” serves as an outer covering for the body, as well as a barrier to entry for pathogens. It is also an important sensory organ. Connective tissue (A) functions to bind and support other tissues. Adipose tissue (B) is a specialized type of connective tissue that stores fat. Muscle tissue (C) is composed of long cells (fibers) that contract and relax, allowing for movement of various body parts. Fibrous tissue (E) is a dense connective tissue found in tendons and ligaments.

**44.** Which of the following does NOT represent a type of muscle tissue found in vertebrates?

- A. skeletal
- B. striated
- C. smooth
- D. cardiac
- E. squamous

(E) Squamous tissue is a type of dermal (epithelial) tissue. Skeletal muscle (A) is attached to bones by tendons and is responsible for voluntary movements of the body. Skeletal muscle is also referred to as striated muscle (B) because of the arrangement of overlapping filaments in the tissue, which give it a striped appearance. Smooth muscle (C) lacks striations; it is found in the walls of most of the internal organs including the digestive tract, bladder, and arteries. Cardiac muscle (D) forms the contractile wall of the heart.

- 45.** In vertebrate organisms, the axial skeleton provides an axis of support for the body and includes the skull, backbone, and rib cage, while the arms and legs are supported by the
- A. appendicular skeleton.
  - B. endoskeleton.
  - C. joints.
  - D. skeletal muscles.
  - E. exoskeleton.

(A) The appendicular skeleton provides support for the limbs (arms and legs) of vertebrate organisms. An endoskeleton (B) consists of hard supporting structures (bone and/or cartilage) contained within soft tissues of the body. The appendicular skeleton and the axial skeleton (which provides support for the trunk of the body—the head, backbone, and rib cage) together make up the endoskeleton of vertebrate organisms. Joints (C) allow for flexibility in body movement. Skeletal muscles (D) are attached to the bones and allow them to move through contraction and relaxation of the muscle tissues. An exoskeleton (E) is a hard structure deposited on the surface of an organism, such as is found in mollusks and arthropods.

- 46.** In the vertebrate immune system, all of the following are examples of nonspecific defense mechanisms EXCEPT
- A. secretions of the skin and mucous membranes.
  - B. phagocytic white blood cells.
  - C. antibodies.
  - D. antimicrobial proteins.
  - E. inflammatory response.

(C) Antibodies are produced in response to a specific foreign invader (antigen). Each antibody produced by the body works only against a specific antigen. Therefore, the production of antibodies is considered a “specific defense mechanism” or a “specific immune response”. Lymphocytes also respond to some specific foreign invaders and, therefore, are also considered a specific defense mechanism. Non-specific defense mechanisms (non-specific immune responses) operate against any foreign invader. Non-specific defense mechanisms include the skin (barrier), mucous membranes, and secretions of the skin (B), phagocytic white blood cells (C), antimicrobial proteins (D), and the inflammatory response (E).

- 47.** Which of the following statements regarding vaccines is INCORRECT?
- A. Vaccines made from killed microorganisms may cause the disease they are designed to prevent.
  - B. Vaccines act like antigens to stimulate an immune response.
  - C. Vaccines stimulate immunological memory.
  - D. Vaccines are considered an active form of immunity.
  - E. Vaccines are considered an artificial form of immunity.

(A) Vaccines, whether made from bacterial toxins, parts of microorganisms, viable but weakened microorganisms, or killed microorganisms, are not capable of causing disease; however, they are capable of acting as antigens stimulating both a direct immune response (B) and immunological memory (C). Vaccines are considered an active form of immunity (D) because the immunity depends on a response from the vaccinated (“infected”) person’s immune system. Vaccines are considered an artificial form of immunity (E) because the immune response is not stimulated directly by the infectious agent.

**48.** Which of the following glands and hormones produced by the gland is MISmatched?

- |    |                 |                |
|----|-----------------|----------------|
| A. | pituitary gland | growth hormone |
| B. | adrenal glands  | oxytocin       |
| C. | thyroid gland   | thyroxine      |
| D. | ovaries         | progesterone   |
| E. | pineal gland    | melatonin      |

**(B)** Oxytocin, which stimulates uterine contractions, is produced by the pituitary gland. Other hormones produced by the pituitary gland include growth hormone (A), which stimulates growth; prolactin, which stimulates milk production and secretion; antidiuretic hormone, which promotes water retention by the kidneys; follicle-stimulating hormone, which stimulates production of eggs in females; luteinizing hormone, which stimulates ovaries and testes; thyroid-stimulating hormone, which stimulates the thyroid gland; and the adrenocorticotropic hormone, which stimulates the adrenal cortex to secrete glucocorticoids. The thyroid gland produces thyroxine (C), which stimulates and maintains metabolism; and calcitonin, which lowers blood calcium levels. The parathyroid glands produce parathyroid hormone, which raises blood calcium levels. The pancreas produces insulin, which lowers blood glucose levels; and glucagon, which raises blood glucose levels. The adrenal glands (B) produce epinephrine and norepinephrine, which raise blood glucose levels, increase metabolism, and constrict certain blood vessels; glucocorticoids, which raise blood glucose levels; and mineralocorticoids, which promote reabsorption of sodium and elimination of potassium in the kidneys. The testes produce androgens, which support sperm formation and promote the development of male secondary sex characteristics. The ovaries produce estrogens, which stimulate growth of the uterine lining and promote the development of female secondary sex characteristics; and progesterone (D), which promotes growth of the uterine lining. The pineal gland produces melatonin (E), which assists with the maintenance of biological rhythms. The thymus produces thymosin, which stimulates T-lymphocytes.

**49.** The junction where one neuron communicates with another neuron within a neural pathway in the human nervous system is referred to as a(n)

- A. neurotransmitter.
- B. membrane potential.
- C. synapse.
- D. axon.
- E. dendrite.

**(C)** A synapse is the junction where one neuron communicates with another neuron within a neural pathway. It is represented by a narrow gap between a synaptic terminal of an axon and a signal-receiving portion (dendrite) of another neuron or effector cell. A neurotransmitter (A) is an intercellular chemical messenger released at a synapse. The membrane potential (B) is a measure of the voltage across the plasma membrane, which is the result of differences in electrical charges on each side of the membrane (the cytoplasm and the extracellular fluid). An axon (D) is a long extension from a neuron that carries nerve impulses away from the cell body toward target cells. A dendrite (E) is a short highly branched extension of a neuron that carries nerve impulses toward the cell body.

**50.** In vertebrate organisms, the brain and spinal cord make up the

- A. parasympathetic nervous system.
- B. somatic nervous system.
- C. autonomic nervous system.
- D. peripheral nervous system.
- E. central nervous system.

(E) The brain and spinal cord make up the central nervous system of vertebrate organisms. The peripheral nervous system (D) is composed of the nerves and ganglia leading from the central nervous system to the rest of the body. The somatic nervous system (B) carries signals to skeletal muscles, usually in response to an external stimulus. The autonomic nervous system (C) conveys signals that regulate involuntary control of the cardiac muscles and the smooth muscles of the digestive, cardiovascular, excretory, and endocrine systems. The autonomic nervous system is divided into two divisions: the parasympathetic division controls activities that conserve energy, such as digestion and a slowing of the heart rate; the sympathetic division controls activities that consume energy, such as increasing heart rate or metabolic function, preparing the body for action.

**51.** Which of the following organs in human males is shared by both the reproductive system and the excretory system?

- A. prostate
- B. testes
- C. urethra
- D. ureter
- E. seminal vesicles

(C) The urethra serves as a conduit for the release of semen from the reproductive system and the release of urine from the excretory system. The prostate (A) is the largest of the glands that secretes semen, secreting it directly into the urethra. The testes (B) are the male gonads (male sex organs, where sperm are produced). The ureter (D) is a duct leading from the kidney to the bladder. The seminal vesicles (E) are a pair of glands that secrete about 60% of the semen produced.

## Developmental Biology

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**52.** During development of the human fetus, most organ development occurs

- A. during the last trimester.
- B. during the last month of development.
- C. during the first month of development.
- D. during the first trimester.
- E. during the last two weeks of development.

(D) The majority of organ development (organogenesis) occurs during the first trimester of pregnancy in humans. Because of the rapid rate of organ development during this period, the fetus is especially vulnerable to radiation, chemicals, and drugs that can cause birth defects.

**53.** Following fertilization (uniting of an egg and sperm), a special type of cell division referred to as cleavage takes place. Cleavage results in

- A. a three-layered embryo.
- B. the development of rudimentary organs.
- C. an eight-fold enlargement of the zygote.
- D. a partitioning of the zygote from one large cell into several smaller cells.
- E. the development of polarity in the zygote.

(D) After fertilization, a special form of cell division referred to as cleavage occurs. Cleavage involves a rapid succession of cell divisions in which the cells undergo DNA synthesis and mitosis, but not the two growth stages of the cell cycle. The result is a partitioning of the zygote (a single large cell) into several smaller cells, called blastomeres, without an overall increase in the size of the developing embryo. This multi-cellular embryo is called a blastula. Different parts of the cytoplasm are partitioned into different blastomeres during cleavage, setting up the cells for future developmental events. Following cleavage, gastrulation occurs, resulting in the formation of a three-layered embryo called a gastrula (A). The next stage of development, organogenesis, results in the production of rudimentary organs in the embryo (B).

- 54.** Gastrulation results in a rearrangement of the cells in the blastula to form an embryo composed of three layers of tissue referred to as germ layers. The three germ layers produced in gastrulation are the
- A. gastrula, animal pole, and vegetal pole.
  - B. ectoderm, endoderm, and mesoderm.
  - C. blastula, gastrula, and morula.
  - D. protoderm, procambium, and ground meristem.
  - E. blastocoel, blastopore, and archenteron.

**(B)** The three germ layers in vertebrate embryos are the ectoderm (which gives rise to the epidermis of the skin, the lining of the mouth and rectum, the cornea and lens of the eye, the nervous system, tooth enamel, and the epithelium of the pineal and pituitary glands); the endoderm (which gives rise to the lining of the digestive tract, reproductive system, respiratory system, bladder, and urethra, as well as giving rise to the liver, pancreas, thyroid, parathyroid glands, and thymus); and the mesoderm (which gives rise to the notochord, the skeletal system, the muscular system, the circulatory system, the lymphatic system, the excretory system, the reproductive system, the dermis of the skin, the lining of the body cavity, and the adrenal cortex). The protoderm, procambium, and ground meristem (D) are the primary meristems that give rise to the tissue systems of plants. Other than mammals, most animals have a polarity to their eggs, the animal and vegetal poles (A), which are defined by the distribution of substances within the egg. The blastula, gastrula, and morula (C) represent stages of embryo development in animals: the blastula refers to the multicellular embryo resulting from cleavage of the zygote; the gastrula refers to the three-layered embryo produced by gastrulation of the blastula; the morula refers to the solid ball of cells that results from a series of cleavages of the zygote in some animal embryos, such as frogs and sea urchins. The blastocoel (E) is a fluid-filled cavity that forms in the morula creating a hollow ball stage of development; the blastopore (E) is the open end of the archenteron (E), which is the primitive gut of developing frog and sea urchin embryos.

- 55.** Which of the following statements regarding embryo development in mammals is INCORRECT?
- A. Mammalian eggs have considerable yolk content, which serves as a food reserve.
  - B. Mammal eggs do not have cytoplasmic determinants that establish polarity in the egg.
  - C. The process of gastrulation in mammal eggs is similar to that found in birds and reptiles.
  - D. Organogenesis follows a similar pattern in bird, reptile, and mammal eggs.
  - E. Cleavage of mammal eggs occurs at a relatively slow rate, and the cleavage planes are random.

**(A)** Unlike the eggs of birds and reptiles, which are large and contain a large amount of yolk, mammal eggs are relatively small and contain very little stored food.

- 56.** During the early development of vertebrate embryos, cells with different developmental potential can influence the development of neighboring groups of cells through a process known as
- A. polarity.
  - B. organization.
  - C. induction.
  - D. potency.
  - E. determination.

**(C)** As vertebrate embryos develop, cell division creates groups of cells in different regions. The cells in one region can influence the development of groups of cells in nearby regions through responses to inductive signals (induction). Induction usually involves the switching on of a specific set of genes that causes the cells receiving the inductive signal to differentiate into a specific tissue type. Inductive signals play an important role in the arrangement of organs and tissues (pattern formation) in the developing embryo.

- 57.** Using modern technology, many genetic and congenital disorders can be detected in a developing human fetus while it is in the uterus. Which of the following procedures is NOT used to test the fetus while in the uterus?
- A. amniocentesis
  - B. chorionic villus sampling
  - C. ultrasound imaging
  - D. testing of a blood sample from the mother
  - E. in vitro fertilization

**(E)** In vitro fertilization refers to the uniting of an egg and a sperm outside the mother's body. Typically, an egg is surgically removed from the mother or a donor and fertilized with a sperm sample in a culture dish in the laboratory. When the embryo has reached the eight-celled stage, it is placed in the uterus and allowed to implant in the uterine lining. Technologies that can be used to test for genetic diseases and congenital disorders include amniocentesis (A), an invasive procedure that collects a sample of amniotic fluid for analysis; chorionic villus sampling (B), an invasive procedure that collects a sample of fetal tissue for testing; ultrasound imaging (C), a noninvasive procedure that uses high frequency sound waves to produce an image of the fetus on a computer screen; and testing a sample of the mother's blood (D). The mother's blood contains sufficient fetal cells for testing. The fetal cells, which can be identified using specific antibodies, are separated from the maternal cells and tested for genetic disorders.

- 58.** The ability of embryonic cells to retain the potential to develop into any part of the organism is referred to as
- A. cell fate.
  - B. pattern formation.
  - C. polarity.
  - D. totipotency.
  - E. determination.

**(D)** Totipotency refers to the ability of some embryonic cells to develop into any part of the organism. In some organisms, only the zygote is totipotent. In mammals, the embryonic cells (blastomeres) remain totipotent through the eight-celled stage.

- 59.** Factors that may result in congenital deformities by affecting the embryo during growth and development are referred to as
- A. disrupters.
  - B. teratogens.
  - C. carcinogens.
  - D. deformers.
  - E. morphogens.

**(B)** Many substances (drugs, chemicals, and alcohol) ingested by the mother can pass through the placental membrane into the blood supply of the fetus affecting organ formation, growth patterns, and brain development. Such substances, which affect growth and development of the embryo or fetus, are referred to as teratogens.

## Genetics

- 60.** The expression of genetic traits in an individual (that is, the physical appearance of the individual) is referred to as the individual's
- A. genome.
  - B. genotype.
  - C. phenotype.
  - D. genetic make-up.
  - E. allelic make-up.

(C) The physical appearance of an individual, which is an expression of their genetic make-up, is referred to as their phenotype, while the actual genetic make-up of the organism (D) is referred to as their genotype (B). The genome (A) refers to the entire genetic complement of an organism. The allelic make-up (E) of an individual is part of their genetic make-up. For example, if the “P” allele codes for pink flower color and is dominant to the “p” allele, which codes for white flower color, then an individual with a “pink” phenotype could have one of two genotypes: PP (homozygous dominant for pink flower color) or Pp (heterozygous for pink flower color). Homozygous recessive individuals (pp) would have white flowers.

- 61.** An individual that is heterozygous for a given trait will
- A. produce gametes containing one of two different types of alleles for that trait.
  - B. produce gametes containing one of three different types of alleles for that trait.
  - C. only give rise to offspring that have the same genotype as itself when crossed with a homozygous recessive individual.
  - D. only give rise to offspring that have the same phenotype as itself when crossed with a homozygous recessive individual.
  - E. only give rise to offspring that have the same phenotype as itself when crossed with another heterozygous individual.

(A) An individual that is heterozygous for a trait (for example, Aa) will produce gametes that carry either the “A” allele or the “a” allele. When a heterozygous individual (Aa) is crossed with a homozygous recessive individual (aa), half of the offspring will be heterozygous (Aa) and half will be homozygous recessive (aa); thus, some of the offspring will have a different genotype and a different phenotype from the heterozygous parent. If two heterozygous individuals are crossed (Aa × Aa), one quarter of the offspring will be homozygous dominant (AA); one half of the offspring will be heterozygous, like the parents (Aa); and one quarter of the offspring will be homozygous recessive (aa).

- 62.** If curly tails are dominant to straight tails in pigs, which of the following represents the correct phenotypic ratio of offspring that would be produced from a monohybrid cross between two pigs that were both heterozygous for curly tails?
- A. all offspring would have curly tails
  - B. all offspring would have straight tails
  - C. 3:1 with 3 curly-tailed : 1 straight-tailed
  - D. 3:1 with 3 straight-tailed : 1 curly-tailed
  - E. 1:1 with 1 curly-tailed : 1 straight-tailed

(C) A monohybrid cross is one in which the inheritance of a single gene (trait) is followed. If we assign “T” to represent tail shape in pigs, with “T” representing the dominant condition of curly tails and “t” representing the recessive condition of straight tails, then a cross between two pigs, both heterozygous for tail shape (Tt × Tt) would produce  $\frac{1}{4}$  homozygous dominant (TT),  $\frac{1}{2}$  heterozygous (Tt), and  $\frac{1}{4}$  homozygous recessive (tt) individuals. If curly tails (T) is

dominant to straight tails (t), then both the homozygous dominant offspring and the heterozygous offspring will have curly tails; thus,  $\frac{3}{4}$  of the offspring will have curly tails and  $\frac{1}{4}$  will have straight tails, for a 3 curly-tailed : 1 straight-tailed ratio among the offspring, as illustrated by the Punnett square below.

The heterozygous parents would each produce two types of gametes, in roughly equal proportions:  $\frac{1}{2}$  T and  $\frac{1}{2}$  t

	$\frac{1}{2}$ T	$\frac{1}{2}$ t
$\frac{1}{2}$ T	$\frac{1}{4}$ TT	$\frac{1}{4}$ Tt
$\frac{1}{2}$ T	$\frac{1}{4}$ Tt	$\frac{1}{4}$ tt

Thus, the genotypic ratio among the offspring is 1:2:1 (1 TT : 2Tt : 1 tt), and the phenotypic ratio among the offspring is 3:1 (3 curly-tailed : 1 straight-tailed).

- 63.** Which of the following represents the correct ratio of offspring that would be produced from a dihybrid cross between a brown, long-tailed mouse that is heterozygous for both body color and tail length and a white, short-tailed mouse that is homozygous recessive for both traits?
- A. 9:3:3:1 with 9 brown, long-tailed : 3 brown, short-tailed : 3 white, long-tailed : 1 white, short-tailed
  - B. 9:3:3:1 with 9 brown, long-tailed : 3 white, short-tailed : 3 brown, short-tailed : 1 white, long-tailed
  - C. 9:3:3:1 with 9 brown, short-tailed : 3 brown, long-tailed : 3 white, short-tailed : 1 white, long-tailed
  - D. 1:1:1:1 with 1 brown, long-tailed : 1 brown, short-tailed : 1 white, long-tailed : 1 white, short-tailed
  - E. All offspring would be brown with long tails.

**(D)** A dihybrid cross is one in which the inheritance of two genes (traits) is followed simultaneously. If we assign “B” to represent body color, with “B” representing the dominant allele for brown and “b” representing the recessive allele for white, and we assign “T” to represent tail length, with “T” representing the dominant allele for long tails and “t” representing the recessive allele for short tails, then a cross between a mouse that is heterozygous for both traits (BbTt) and a mouse that is homozygous recessive for both traits (bbtt) would result in a 1:1:1:1 ratio of brown, long-tailed : brown, short-tailed : white long-tailed : white, short-tailed, as illustrated by the Punnett square below.

The heterozygous individual would produce four types of gametes, with approximately equal frequency ( $\frac{1}{4}$  BT,  $\frac{1}{4}$  Bt,  $\frac{1}{4}$  bT,  $\frac{1}{4}$  bt), and the homozygous recessive individual would produce only one type of gamete (bt), resulting in a  $4 \times 1$  Punnett square:

	$\frac{1}{4}$ BT	$\frac{1}{4}$ Bt	$\frac{1}{4}$ bT	$\frac{1}{4}$ bt
bt	$\frac{1}{4}$ BbTt	$\frac{1}{4}$ Bbtt	$\frac{1}{4}$ bbTt	$\frac{1}{4}$ bbtt

The genotypic ratio among the offspring is 1:1:1:1 (1 BbTt : 1 Bbtt : 1 bbTt : 1 bbtt), and the phenotypic ratio among the offspring would be 1:1:1:1 (1 brown, long-tailed : 1 brown, short-tailed : 1 white, long-tailed : 1 white, short-tailed).

- 64.** If the offspring from a cross between a red-flowered snapdragon and a white-flowered snapdragon are all pink, the most likely explanation is that
- A. the allele for red flower color is completely dominant to the allele for white flower color.
  - B. the allele for white flower color is completely dominant to the allele for red flower color.
  - C. there are epistatic interactions occurring between the alleles for red and white flower color.
  - D. there are pleiotropic interactions between the alleles for red and white flower color.
  - E. the allele for red flower color shows incomplete dominance over the allele for white flower color.

(E) When the phenotypes of the offspring are intermediate between the phenotypes of the two parents, the most likely cause is that the dominant allele does not completely mask the recessive allele. In the case of the snapdragons in this example, if the dominant allele (for example, “R”) produces red pigment, and the recessive allele (for example, “r”) produces no pigment, the heterozygous offspring (Rr) may produce less pigment than the red parents (RR), because they have only one copy of the dominant allele that produces the pigment and, therefore, appear pink.

- 65.** A trait that is controlled by two or more genes, such as yield in agricultural crops and height in humans, resulting in a continuous array of phenotypes, is referred to as a(n)
- A. epistatic trait.
  - B. pleiotropic trait.
  - C. polygenic trait.
  - D. multi-allelic trait.
  - E. discrete trait.

(C) A polygenic trait is one whose inheritance is governed by two or more genes. These quantitative traits, which typically show a continuous array of phenotypes, are usually also highly influenced by environmental factors. Discrete traits (E) are those that are controlled by a single gene, with or without environmental influence, and show a limited number of specific phenotypes. A multi-allelic trait (D) is a type of discrete trait that has more than two possible alleles (for example, the A, B, O blood groups in humans). Epistasis (A) occurs when a gene at one locus alters the phenotypic expression of a gene at another locus (for example the inheritance of coat color in horses). Pleiotropy (B) refers to the condition in which one gene controls the expression of more than one trait (for example, the gene responsible for sickle cell anemia in humans results in the expression of numerous physical symptoms).

- 66.** A family tree that shows the genetic make-up of individuals in an extended (human) family, and the relationships among those individuals, is referred to as a
- A. flow chart.
  - B. pedigree.
  - C. Punnett square.
  - D. template.
  - E. fingerprint.

(B) The genetic basis of human traits is relatively difficult to study (as compared to fruit flies, plants, mice, and so on) because humans have a relatively long life cycle, typically have relatively small numbers of offspring, and “controlled matings” for which genetic studies cannot be conducted. As a result, geneticists rely on several techniques to study human genes, including the use of pedigree analysis. A pedigree is a family tree that shows the genetic make-up of individuals in an extended family and the relationships among those individuals. Geneticists can use the information contained in a pedigree to determine the mode of inheritance of various traits, determine the genotype of individuals whose genotype (that is, homozygous dominant or heterozygous) is unknown, and predict the probabilities of genotypes and phenotypes of future offspring.

- 67.** Sex-linked traits are those traits that are carried on the sex chromosomes. In humans, most sex-linked traits are carried on the X chromosome; very few traits are carried on the Y chromosome. Which of the following statements regarding X-linked traits in humans is INCORRECT?
- A. Females cannot show sex-linked recessive traits.
  - B. All daughters born to a father with a sex-linked dominant disorder will show the disorder.
  - C. Sons cannot inherit a sex-linked trait from their father.
  - D. Males cannot be heterozygous for sex-linked traits.
  - E. All sons born to a mother who is homozygous dominant for a sex-linked dominant trait will show the disorder.

(A) The sex chromosome complement of human females is XX, and the sex chromosome complement of human males is XY. Daughters receive one X chromosome from their mother and one X chromosome from their father. With two X chromosomes, sex-linked recessive disorders are less common among females than males, as there is a chance that a female will carry at least one unaffected X chromosome (with the dominant allele), masking the presence of the recessive allele. However, it is possible for a daughter to inherit the recessive allele from both parents and show the homozygous recessive trait. Sons inherit their X chromosome from their mother and their Y chromosome from their father. Thus, even an unaffected, heterozygous mother has a 50-50 chance of producing an affected son.

**68.** Aneuploidy (the condition of having extra copies or missing copies of individual chromosomes) results from errors that take place during meiosis. This type of error is referred to as a

- A. linkage.
- B. translocation.
- C. crossover.
- D. non-disjunction.
- E. transition.

(D) Mistakes that occur during meiosis often result in non-disjunction, in which the members of a pair of homologous chromosomes fail to separate in meiosis I and move to the same pole of the cell, or sister chromatids fail to separate in meiosis II and move to the same pole of the cell. The result in either case is one or more gametes with an incorrect complement of chromosomes, containing either too much genetic information (having two copies of the same chromosome) or missing genetic information (missing a chromosome).

**69.** Some human genetic disorders are due to chromosomal aberrations resulting from the breakage of chromosomes leading to changes in the normal structure of the chromosome. Which of the following is NOT the result of chromosome breakage and altered chromosome structure?

- A. deletion.
- B. duplication.
- C. inversion.
- D. translocation.
- E. polyploidy.

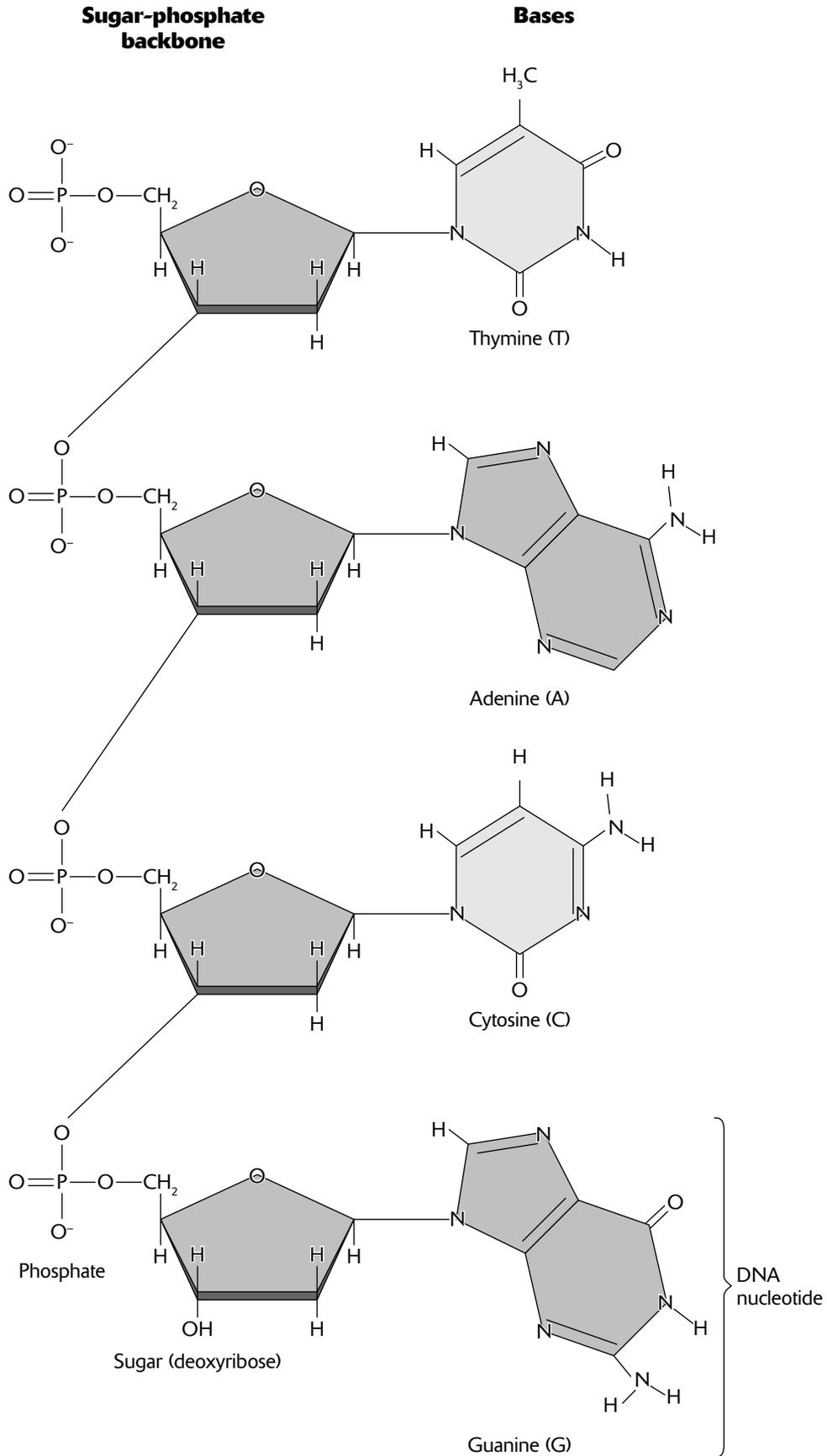
(E) Polyploidy results from mistakes that take place during meiosis that result in non-disjunction of entire sets of chromosomes, such that the resulting gamete (egg or sperm) is diploid instead of haploid. A deletion (A) occurs when a piece of a chromosome that does not include the centromere is broken off and lost during cell division. A duplication (B) occurs when a piece that was broken off of one chromosome attaches to the homologous chromosome, resulting in a duplication of the information contained on the chromosome fragment. An inversion occurs when a fragment broken off of a chromosome reattaches to the same chromosome, but in the opposite orientation, which results in the inability for the genes to be read properly during transcription and protein synthesis. A translocation (D) occurs when the fragment from a broken chromosome attaches to a non-homologous chromosome.

- 70.** Genes present in the mitochondria of both plants and animals, and in the chloroplasts of plants, are inherited independently of the nuclear genes and are inherited in a non-Mendelian manner. Inheritance of traits carried on genes present in the mitochondria or chloroplasts is referred to as
- A.** embryonic inheritance
  - B.** paternal inheritance
  - C.** maternal inheritance
  - D.** zygotic inheritance
  - E.** genomic inheritance

**(C)** The genes present in the mitochondria and chloroplasts are inherited through the cytoplasm during cell division. Because the egg cells of both plants and animals have a considerable amount of cytoplasm, and the male gametes (pollen or sperm) have a negligible amount of cytoplasm, most of the genes in the mitochondria and chloroplasts are inherited through the maternal parent and, therefore, the inheritance of mitochondrial and chloroplast genes is referred to as maternal inheritance.

- 71.** DNA is composed of chains of nucleotides. Each nucleotide consists of
- A.** a ribose sugar, a nitrogenous base, and a phosphate group.
  - B.** a deoxyribose sugar, a nitrogenous base, and a phosphate group.
  - C.** a ribose sugar, a nitrogenous base, and a sulfur group.
  - D.** a deoxyribose sugar, a nitrogenous base, and a sulfur group.
  - E.** a ribose sugar, a phosphorus base, and a mitogenous group.

**(B)** DNA (deoxyribonucleic acid) is a polynucleotide composed of a chain of nucleotide units. Each nucleotide unit consists of the sugar deoxyribose, a phosphate group, and one of four nitrogenous bases (adenine, thymine, cytosine, guanine). The phosphate group of one nucleotide is attached to the sugar of the next nucleotide, forming a backbone of alternating sugar and phosphate molecules with the nitrogenous bases projecting inward and held together by hydrogen bonds, as depicted in the diagram on the following page.

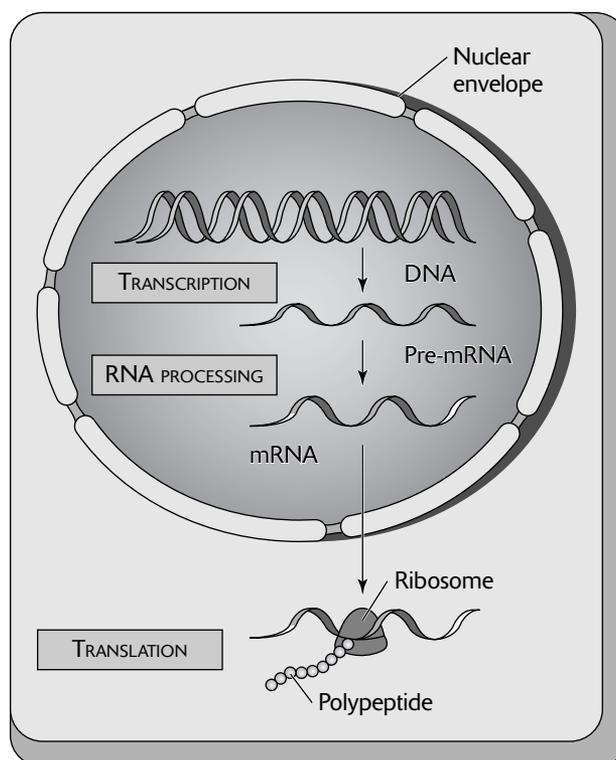


- 72.** Adenine makes up approximately 30% of the nitrogenous bases found in human DNA. Thus, the percentages of the other bases in human DNA are
- 20% guanine, 30% thymine, and 20% cytosine
  - 30% guanine, 20% thymine, and 20% cytosine
  - 20% guanine, 20% thymine, and 30% cytosine
  - 15% guanine, 30% thymine, and 25% cytosine
  - The percentages of the other bases cannot be determined from the information given.

(A) In DNA, the sugar—phosphate backbone is held together by paired nitrogenous bases that project inward from the backbone. The bases are held together by hydrogen bonds, and the molecular structure of the bases is such that adenine only pairs with thymine and guanine only pairs with cytosine. Thus, the percentages of adenine and thymine in a DNA molecule will be equal, as will the percentages of guanine and cytosine. **Note:** There is no thymine in RNA; adenine pairs with uracil in RNA molecules. The pairing rules (Chargaff's rules) ensure that DNA is replicated properly prior to cell division, and that DNA is transcribed properly onto mRNA prior to protein synthesis.

- 73.** The synthesis of a polypeptide is accomplished through the process of
- DNA replication.
  - RNA processing.
  - transcription.
  - splicing.
  - translation.

(E) Each gene on a molecule of DNA codes for one polypeptide, a component of proteins. DNA in the nucleus is read and copied onto a complementary mRNA (messenger RNA) molecule through the process of transcription (C). Following transcription, the non-coding regions of the mRNA molecule (introns), which lie between the coding regions (exons), are excised and the exons are spliced together through RNA processing (B). The processed mRNA molecule moves out of the nucleus into the cytoplasm and attaches to a ribosome, where the synthesis of polypeptides takes place through the process of translation (E). DNA replication (A) is the process by which DNA molecules are duplicated prior to cell division. Refer to the diagram below.



- 74.** The genetic code refers to
- A. the genetic make-up of an organism.
  - B. the genetic make-up of a population.
  - C. nucleotide triplets that code for amino acids.
  - D. the specificity of base pairing that holds the DNA molecule together.
  - E. the DNA template strand.

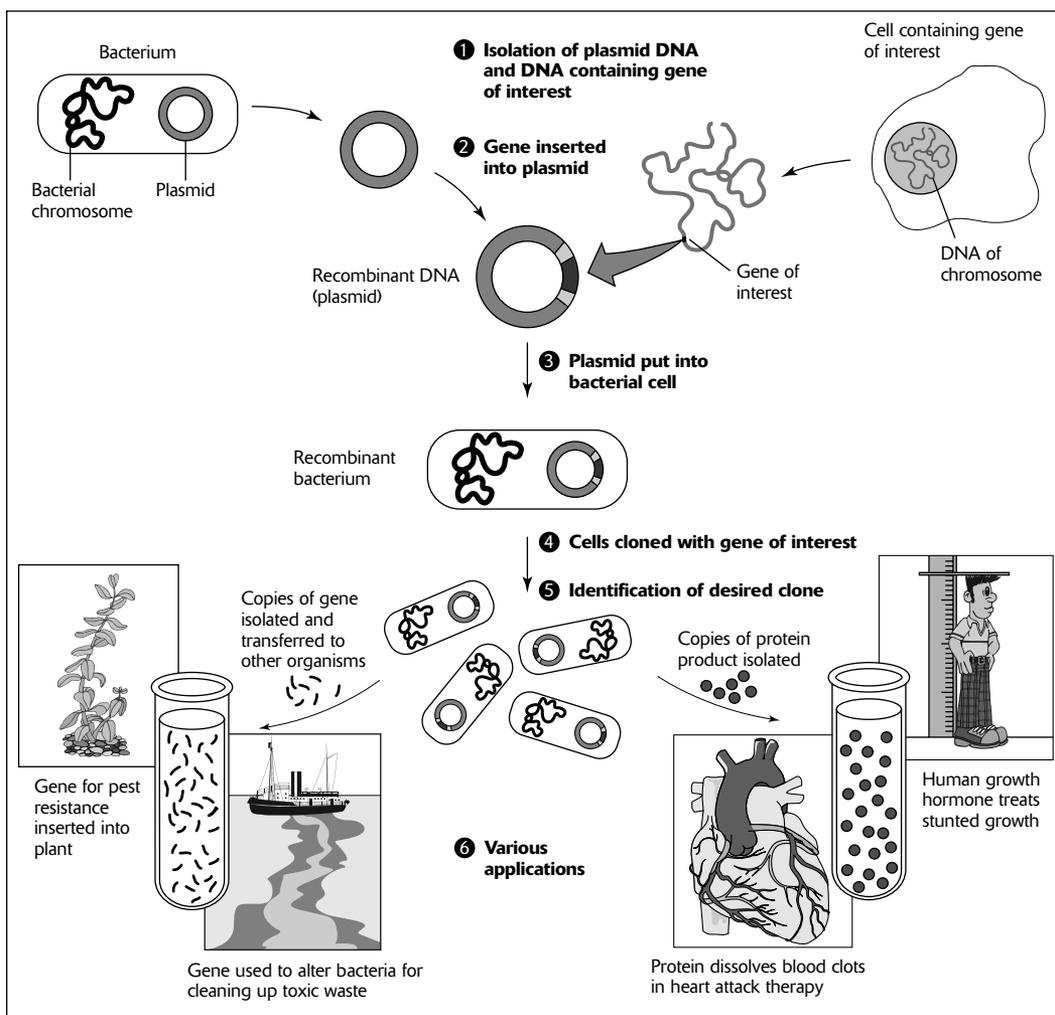
(C) Series of three nucleotides (triplets) on the DNA molecule are transcribed onto a mRNA molecule, where they are read by a transfer RNA (tRNA) molecule during translation. Each triplet of bases on the DNA molecule codes for a specific amino acid. When these triplets are transcribed onto a mRNA molecule, specific tRNA molecules, carrying amino acids, read the triplet code on the mRNA molecule and insert the appropriate amino acid into the growing polypeptide chain.

- 75.** Most cells in the human body contain proto-oncogenes that can be stimulated to become cancerous (oncogenes) through mutations. The normal function of proto-oncogenes in human cells is to
- A. stimulate protein synthesis.
  - B. repair damaged regions of DNA.
  - C. produce antibodies against invading pathogens.
  - D. control normal cell growth and division.
  - E. splice introns from mRNA during RNA processing.

(D) Proto-oncogenes are normal genes present in the human genome that code for proteins that regulate cell growth and cell division. Mutations (either spontaneous mutations, or those caused by exposure to radiation, cancer-causing chemicals, and certain viruses) occurring in the proto-oncogenes may cause them to no longer regulate normal cell growth and division. Uncontrolled cell growth and division may lead to cancer.

- 76.** DNA molecules, made in vitro in the laboratory, that contain DNA from two or more organisms are referred to as
- A. DNA clones.
  - B. recombinant DNA.
  - C. plasmids.
  - D. vectors.
  - E. phages.

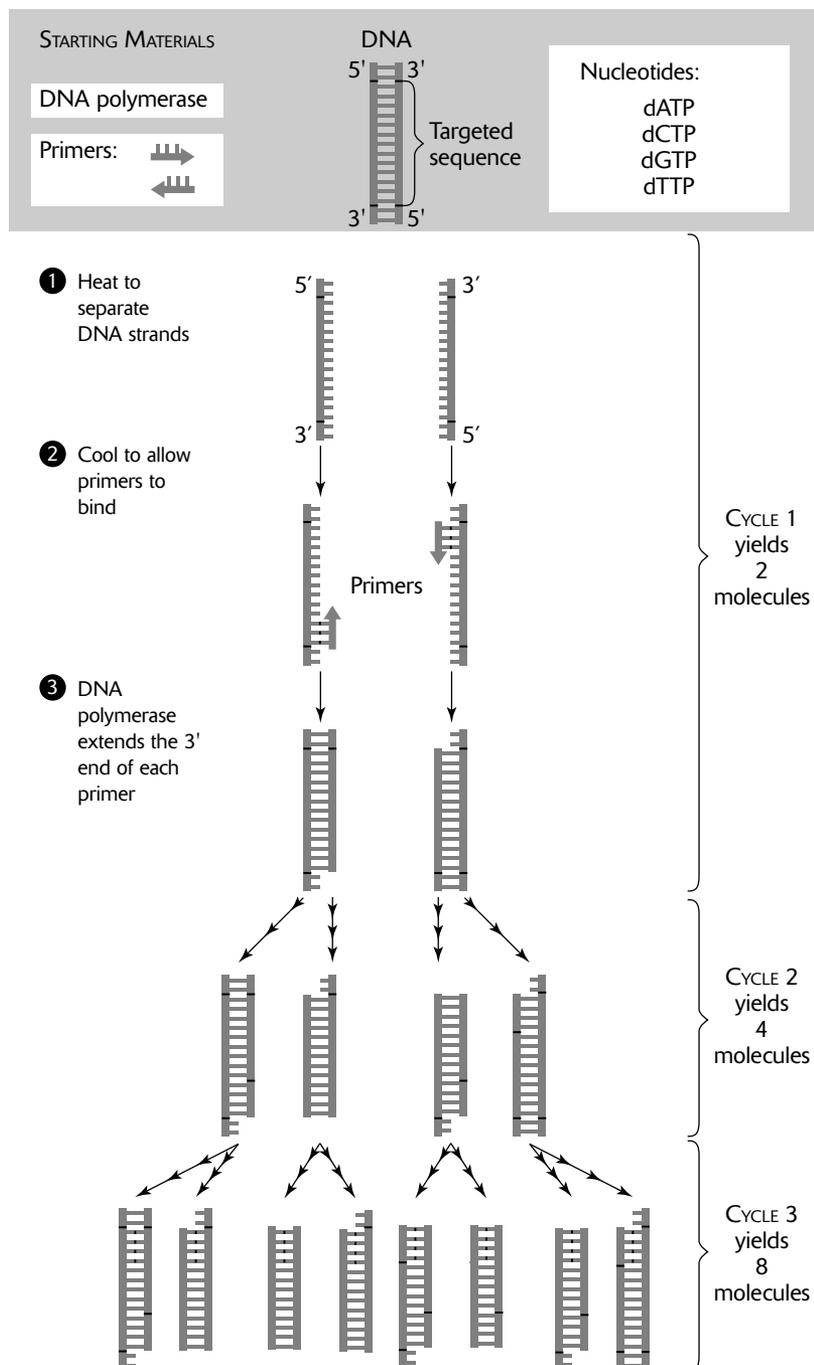
(B) DNA molecules that contain segments from different sources / organisms can be manufactured in vitro in the laboratory. This is usually done by cutting two sources of DNA with restriction enzymes and putting them together in solution. Restriction enzymes are isolated from various bacterial strains where they function to destroy foreign DNA or bacterial viruses (bacteriophages) entering the bacterial cell. Restriction enzymes cut DNA molecules at specific locations, with each restriction enzyme recognizing a unique base sequence where it cuts the DNA molecule. The restricted DNA molecules are double-stranded with at least one single-stranded end, called a *sticky end*. These single-stranded ends will form hydrogen bonds with strands containing complementary sticky ends, even if the complementary strand is from a DNA molecule from a different organism. The fused DNA molecules are sealed together with the enzyme DNA ligase, creating a recombinant DNA molecule that has been spliced together from DNA of different organisms. (Refer to the diagram on the following page.) DNA from one organism, for example a human DNA segment containing the gene coding for human growth hormone, may be spliced into a plasmid using restriction enzymes and recombinant DNA technology. (**Note:** Plasmids are small, circular pieces of DNA that reside in most bacterial cells and replicate themselves independently of the bacterial cell.) Recombinant plasmids can then be inserted into bacterial cells through transformation, the uptake of DNA (in this case, in the form of a plasmid) from the surrounding culture medium. As the bacterial cells reproduce, the recombinant plasmids, containing the gene for the production of human growth hormone, are replicated along with the bacterial cells. After sufficient reproduction, the human growth hormone proteins can be isolated from the cell colony. (See diagram on the following page.) This procedure is one method by which DNA can be cloned.



**77.** A method for cloning DNA segments without using recombinant plasmids and bacterial colonies is referred to as

- A. transformation.
- B. transduction.
- C. conjugation.
- D. genetic engineering.
- E. polymerase chain reaction.

(E) The polymerase chain reaction (PCR) allows for the amplification (making of hundreds or thousands of copies) of a DNA segment without using plasmids and bacterial cells. This technique is especially useful when small quantities of DNA are available to work with, such as the case with evidence (for example, blood or semen) found at a crime scene. The amplification of the DNA allows for the production of a large quantity of DNA from a small sample relatively quickly. The PCR procedure is outlined in the diagram on the following page. Transformation (A) refers to the uptake of DNA from the surrounding environment. Transduction (B) refers to the uptake of DNA by bacterial cells through infection of the cells with a bacteriophage (bacterial virus). Conjugation (C) refers to the transfer of DNA between two bacterial cells through the formation of a temporary connection (conjugation tube) between the cells. Genetic engineering (D) refers to any direct manipulation of genes for research or practical purposes.



**78.** Genetic engineering and DNA technology have already been used for many practical applications. Which of the following applications is NOT currently being used?

- A. insertion of genetically engineered genes into human gametes (eggs and sperm)
- B. insertion of genetically engineered genes for disease resistance into agriculturally important crop species
- C. production of large quantities of human growth hormone and insulin
- D. prenatal detection of genetic disorders
- E. the production of DNA fingerprints for use in criminal cases

(A) To date, genetic engineering and gene technology have not been used to insert genetically engineered genes into human eggs and sperm. Such a use of the available DNA technology is still highly controversial.

## Evolution, Ecology, and Behavior

- 79.** Which of the following is NOT one of the principle observations used by Charles Darwin in the development of the theory of evolution by natural selection?
- A. Most species have such a great potential for reproduction that population sizes would increase exponentially if all individuals that were born successfully reproduced.
  - B. Environmental resources are limited.
  - C. Populations sizes naturally tend to fluctuate significantly from year to year.
  - D. Individuals within a population show a high level of variability for physical characteristics.
  - E. Much of the variation seen among individuals in a population is heritable (can be passed on to their offspring).

(C) Despite the great reproductive potential of most species (A), their population sizes do NOT fluctuate significantly from year to year. These observations, combined with the observation that environmental resources are limited (B), led Darwin to infer that the production of more individuals than the environment can support, led to a struggle for survival among the individuals of a population such that only a small percentage survive and reproduce. From the observation that there is quite a bit of variability among individuals in a population for most characteristics (D) and the observation that much of the variability was heritable (passed on from parent to offspring) (E), Darwin inferred that the struggle for survival was not random, but rather due at least in part to inherited characteristics—those individuals who inherited characteristics that made them best adapted to their environment were the most likely to survive and produce offspring. Darwin also inferred that the ability of the best-adapted individuals to survive and reproduce would lead to a gradual change in the genetic make-up of the population, with favorable traits increasing in frequency in the population over time. These inferences led Darwin to the development of the Theory of Evolution by Means of Natural Selection.

- 80.** Natural selection can best be defined as
- A. an interaction between the environment and the genetic make-up of an individual.
  - B. the adaptation of organisms to their environment.
  - C. descent with modification.
  - D. differential success in reproduction (different abilities of individuals to survive and reproduce).
  - E. heritable variation.

(D) The differential success in reproduction among individuals in a population, in which the “most fit” or “best adapted” individuals are most likely to survive and reproduce is, by definition, the process of natural selection. The process of natural selection is *influenced* by an interaction between the genetic make-up of an individual and environmental conditions (A) and is based in part on the presence of heritable variation (E). Natural selection allows for the adaptation of populations of organisms to their environment (B). The process of evolution is often defined as “descent with modification” (C).

- 81.** Which of the following fields of evidence in support of evolution is MISmatched with its description?
- A. Fossil Record—the study of the succession of fossil forms discovered around the globe.
  - B. Biogeography—the study of the geographical distribution of species.
  - C. Comparative Anatomy—the study of anatomical similarities among species grouped together in the same taxonomic category.
  - D. Comparative Embryology—the study of the process by which human embryos go through a fish stage, an amphibian stage, and a reptile stage before reaching a mammalian stage during development.
  - E. Molecular Biology—the study of DNA and proteins to determine relationships among species.

(D) The field of Comparative Embryology studies the similarities and differences in embryo development among different species. The research in this field shows that closely related organisms go through similar stages of embryonic development. For example, embryos of all vertebrates go through a stage in which they have gill pouches. As development continues, these structures diverge greatly in the different taxonomic groups. For example, in fish the gill pouches develop into gills, while in humans, the gill pouches develop into the Eustachian tubes that connect the middle ear with the throat. Although humans and fish both go through a stage during embryo development in which gill pouches are present, humans do NOT go through a fish stage during embryo development. Humans also do not go through an amphibian stage or a reptile stage during embryo development.

- 82.** A group of individuals of the same species that live within the same geographic area is referred to as a(n)
- A. population.
  - B. community.
  - C. gene pool.
  - D. evolutionary unit.
  - E. geographic unit.

(A) A population refers to a group of individuals of the same species that share a common geographic area. A community (B) refers to all of the populations of different species that share a common geographic area and have the potential to interact with each other. A gene pool (C) refers to the total complement of genes in a population at any given time.

- 83.** Which of the following is NOT one of the conditions required for a population to maintain Hardy-Weinberg equilibrium?
- A. large population size
  - B. no gene flow into or out of the population from other populations (for example, by migration into or out of the population)
  - C. no net mutations
  - D. no natural selection
  - E. no random mating

(E) For Hardy-Weinberg equilibrium to be maintained, mating must occur randomly. If individuals seek mates with certain characteristics, then the random mixing of gametes (necessary to maintain Hardy-Weinberg equilibrium) will not take place. A population in Hardy-Weinberg equilibrium will not undergo evolution. Although most populations fail to meet one or more of the conditions required to maintain Hardy-Weinberg equilibrium, the principles underlying Hardy-Weinberg equilibrium provide a basis for understanding the processes controlling microevolution. For each of the five conditions required for maintaining Hardy-Weinberg equilibrium, there is a corresponding force allowing for microevolution to occur:

- (1) **Large population size:** If a population is very small, its gene pool might not reflect the gene pool represented in the entire species. In addition, the existing gene pool of a small population may not be accurately represented in the next generation, due to random chance or sampling error, if all of the alleles are not passed on. This force of microevolution is referred to as genetic drift—changes to the gene pool of a small population due to random chance.
- (2) **No gene flow into or out of the population:** Certain alleles may be lost from a population, or their frequencies may be changed, if a high proportion of individuals with those alleles migrate out of the population. On the other hand, the frequency of certain alleles may be increased, or new alleles may be introduced into the gene pool, if individuals from another population (with different allelic and genotypic frequencies in the gene pool) migrate into the population.
- (3) **No net mutations:** Random mutations that are transmitted in gametes will alter the allelic composition of the gene pool. If there are more mutations in one direction (for example  $A \rightarrow a$ ) than the reverse direction ( $a \rightarrow A$ ), then the allelic frequency of the gene pool may be altered.

- (4) **No natural selection:** Natural selection for or against specific alleles will alter their frequency in the gene pool. Mutations combined with natural selection for or against the mutations provides the strongest driving force for evolution. Natural selection results in alleles being passed on to the next generation disproportionately to their frequency in the current gene pool, and it is the only evolutionary force that allows a population to become more adapted to its environment.
- (5) **Random mating:** Most organisms select mates based on certain phenotypic characteristics. In addition, individuals often mate with other individuals that are physically close by. These types of non-random mating patterns often favor specific alleles over others, leading to changes in the allelic frequencies in a population over time.

**84.** In a population that is in Hardy-Weinberg equilibrium, if 9% of the individuals show the recessive trait and there are only two possible alleles for the trait, what is the frequency of the dominant allele in the population?

- A. .09
- B. 0.3
- C. 0.7
- D. 0.49
- E. 0.42

(C) According to the Hardy-Weinberg theorem, the allelic and genotypic frequencies of a population in Hardy-Weinberg equilibrium will remain constant from generation to generation (that is, the population will not evolve). Population geneticists have developed an equation to determine the allelic and genotypic frequencies in a population, and have defined  $p$  to represent the frequency of the dominant allele and  $q$  to represent the frequency of the recessive allele. If there are only two allelic possibilities for the trait, then the frequencies of the dominant and recessive alleles must equal 100%. Thus,  $p + q = 1$ . A homozygous dominant individual would inherit a dominant allele from each parent; the odds of two dominant alleles being present in an individual would be  $p \times p = p^2$ . Thus, the frequency of the homozygous dominant genotype would be  $p^2$ . Similarly, the frequency of the homozygous recessive genotype would be  $q^2$ . The frequency of heterozygotes would be  $p \times q$ ; however, since there are two ways a heterozygote can occur (inheriting the dominant allele from the mother and the recessive allele from the father or inheriting the dominant allele from the father and the recessive allele from the mother), the overall frequency of heterozygotes would be  $2pq$ . Because the genotypic frequencies must equal 100%, the equation representing genotypic frequencies can be written as  $p^2 + 2pq + q^2 = 1$ . From these Hardy-Weinberg equations, we can determine the allelic and genotypic frequencies present in a population by observing phenotypic frequencies. We typically use the recessive phenotype, because we know that the individual must be homozygous recessive for the trait, so we can easily determine the frequency of the recessive allele from the frequency of the recessive phenotype. Conversely, with complete dominance, the homozygous dominant and heterozygous individuals will have the same phenotype, so their genotype cannot be determined by observing their phenotype.

In our example, we observed that 9% of the population shows the recessive phenotype. Thus, the frequency of the homozygous recessive individuals ( $q^2$ ) would be  $.09$ , and the frequency of the recessive allele would be  $q = \sqrt{.09} = 0.3$ . Because  $p + q = 1$ , then  $1 - q = p$ . In our example,  $p = 1 - 0.3 = 0.7$ . From these allelic frequencies, we can determine the frequencies of the genotypes in the population. We already know the frequency of the homozygous recessive genotype is  $q^2 = .09$ . The frequency of the homozygous dominant genotype is  $p^2 = 0.7^2 = .49$ , and the frequency of the heterozygous genotype is  $2pq = 2(0.7)(0.3) = .42$ .

**85.** There are several different acceptable scientific definitions of what constitutes a species. Which of the following species concepts is MISmatched with its description?

- A. Biological species concept—emphasizes reproductive isolation between species.
- B. Morphological species concept—emphasizes anatomical differences between species.
- C. Recognition species concept—emphasizes recognition of potential mates within a species.
- D. Evolutionary species concept—emphasizes evolutionary lineages and relationships between species.
- E. Ecological species concept—emphasizes the genetic mechanisms that maintain a species as a distinct phenotype.

(E) The ecological species concept emphasizes a species niche or role within the ecosystem.

- 86.** The evolutionary history of a species, or groups of related species, is referred to as
- A. phylogeny.
  - B. speciation.
  - C. the fossil record.
  - D. paleontology.
  - E. pedigree analysis.

(A) Phylogeny traces the evolutionary history of species or related groups of species. Reconstructive phylogeny is part of the discipline of systematics, the study of biological diversity on a global evolutionary scale.

- 87.** If two organisms belong to the same class, they must also belong to the same
- A. family.
  - B. phylum.
  - C. order.
  - D. genus.
  - E. species.

(B) Classification of organisms follows a hierarchical approach, with the highest level being the domain and the lowest level being the species. The hierarchical classification proceeds as follows: domain, kingdom, phylum (or division, for plants), subphylum, class, order, family, genus, species.

- 88.** All of the organisms existing in a particular location, along with all of the abiotic factors with which they interact is referred to as a(n)
- A. ecological niche.
  - B. population.
  - C. ecosystem.
  - D. biome.
  - E. community.

(C) An ecosystem includes a local community and the physical surroundings (abiotic factors) with which the organisms interact. A community (E) includes all the organisms living in a given area, which have the potential to interact with each other. A population (B) refers to a group of individuals of the same species living in a defined geographic location. A biome (D) refers to one of the major global ecosystems, which are typically defined by the predominant vegetation found in the region. An ecological niche (A) can be defined as the biotic and abiotic resources used by an organism in a given environment, or the functional role of an organism in its environment.

- 89.** Interactions between species occur on several levels. One type of interspecific interaction, in which one species benefits from the relationship while the other species is neither hurt nor harmed by the relationship, is referred to as
- A. competition.
  - B. predation.
  - C. mutualism.
  - D. parasitism.
  - E. commensalism.

(E) An example of commensalism would be the presence of an epiphytic orchid living on a tree. This relationship benefits the orchid because the tree branches provide a place for the orchid to rest while absorbing water and nutrients from the atmosphere, whereas, the tree is neither helped nor harmed by the orchid. Competition (A) involves two (or more) species competing for limited resources (food, water, shelter, and space) and usually results in detrimental effects to the populations of both species. Predation (B) involves one organism (the predator, such as a mountain lion) benefiting by

capturing and eating another organism (prey, such as a deer). Parasitism (D) involves one organism (the parasite) living on or in another organism (the host). Although the parasite usually doesn't kill its host outright, it usually weakens it, leading to a reduction in fitness and reproductive potential of the host. An example would be mistletoe living on a host tree. Unlike epiphytic plants (such as the orchid in the example on the previous page), mistletoe puts down root-like projections into the living tissue of its host tree, absorbing water and nutrients at the expense of the host. Mutualism (C) describes an interspecific interaction in which both species benefit from the relationship. An example of mutualism can be found in lichens, which are composed of a fungal organism and a green alga or cyanobacteria living symbiotically, in which the green alga or cyanobacteria provides energy (carbohydrates) to both organisms through photosynthesis, while the fungus provides the alga or cyanobacteria with shelter from the elements, as well as a source of water and dissolved nutrients through absorption of broken down organic matter from the soil.

**90.** The base (first trophic level) of most food chains is occupied by

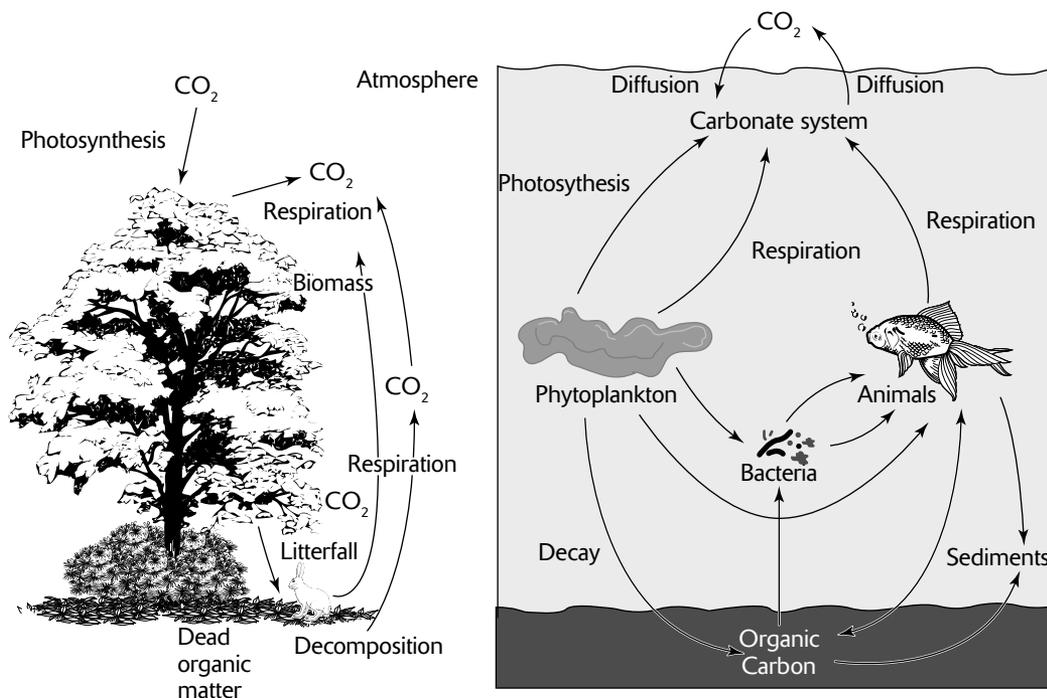
- A. grasses.
- B. algae.
- C. primary consumers.
- D. producers.
- E. herbivores.

**(D)** Producers are organisms that are capable of manufacturing their own food, usually through the process of photosynthesis. Producers in terrestrial ecosystems include any plant that is consumed by another organism. Producers in aquatic ecosystems are usually small, often single-celled forms, of algae and photosynthetic bacteria (phytoplankton). Organisms that feed on the producers are referred to as primary consumers. Because they eat plant material, the primary consumers are often referred to as herbivores. Organisms that feed upon the primary consumers are referred to as secondary consumers. The secondary consumers, which feed on other animals, are also referred to as carnivores. There may be several trophic levels of consumers present in a given food chain. Many organisms feed at several layers of the food chain—for example, a hawk might consume a mouse, or it might consume a snake that has consumed a mouse. Organisms that feed on both producers and consumers are referred to as omnivores. Decomposers, which include fungi, bacteria, and slime molds, break down dead and decaying material and recycle the nutrients back into the ecosystem. The decomposers are often depicted as being at the end of a food chain; however, they actually operate at all levels of the food chain, breaking down waste.

**91.** Water, nutrients, and carbon are cycled through an ecosystem, moving from non-living (abiotic) components to living (biotic) components, and back to non-living components. One of these biogeochemical cycles is the carbon cycle. Which of the following statements regarding the carbon cycle is INCORRECT?

- A. The processes of photosynthesis and cellular respiration account for the majority of transformations and movement of carbon through an ecosystem.
- B. Theoretically, on a global scale, the return of carbon dioxide to the atmosphere through cellular respiration should be approximately balanced by the removal of carbon dioxide from the atmosphere through photosynthesis.
- C. Globally, the amount of atmospheric carbon dioxide is steadily increasing due to the burning of wood and fossil fuels, which adds more carbon dioxide to the atmosphere than can be taken back out of the atmosphere through photosynthesis, disrupting the balance of the carbon cycle.
- D. During the winter months, there may be a seasonal spike of carbon dioxide in the atmosphere due to a lower rate of photosynthesis, especially among deciduous plants.
- E. Aquatic ecosystems do not include a carbon cycle among the biogeochemical cycles present.

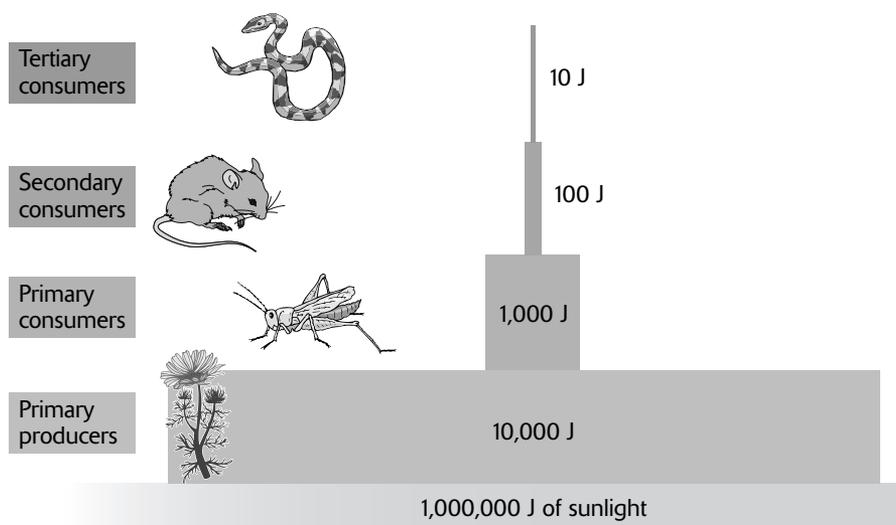
**(E)** The carbon cycle present in aquatic ecosystems is similar to the terrestrial system, except that it is more complicated due to the interaction of carbon dioxide with water and limestone, resulting in a series of intermediates including carbonic acid, bicarbonate, and carbonate. Terrestrial and aquatic carbon cycles are illustrated on the following page.



**92.** Movement of energy through an ecosystem occurs,

- A. in a cyclical fashion, similar to the water, carbon, and nutrient cycles.
- B. in one direction, with a gain of energy at each trophic level.
- C. in one direction, with a loss of energy at each trophic level.
- D. bidirectionally, with a gain of energy at each trophic level.
- E. bidirectionally, with a loss of energy at each trophic level.

(C) Unlike water, carbon, and nutrients (nitrogen, phosphorus, and so on), energy moves in one direction through an ecosystem, with a loss of energy at each trophic level. The producers usually constitute the largest biomass at a trophic level in a terrestrial food chain (see diagram on the following page). When consumers feed on the producers, not all of the energy contained in the producers' biomass is available as usable energy to the consumers. Some of the energy contained within the producers is used up by the producers themselves for metabolic activity, while additional energy is lost as heat. This loss of energy continues at each successive level of the food chain, with approximately 10% of the available energy converted to new biomass at each successive trophic level. The inefficiency of energy transfer through a food chain limits most terrestrial food chains to about four trophic levels. In some aquatic ecosystems, which have a large turnover of microscopic producers, the producers may not have the greatest biomass in the food chain; the herbivorous zooplankton typically have greater overall biomass than the phytoplankton (producers).



- 93.** Many chemicals, such as DDT, become more and more concentrated at each successive trophic level of a food chain. This phenomenon is known as
- biological control.
  - biological magnification.
  - eutrophication.
  - toxin accumulation.
  - biological synthesis.

**(B)** Biological magnification refers to the phenomenon in which many chemicals become more and more concentrated at each successive level of a food chain. The magnification occurs because the biomass at any given trophic level is produced from a much larger biomass at the trophic level below it. The top carnivores in a food chain are the most likely to show detrimental effects from the biological magnification of toxic substances. Such was the case with DDT, a chemical that accumulates in fatty tissues, which was in such high concentrations in raptors (often at or near the top of a food chain) that it interfered with calcium deposition in the birds' egg shells. As a result, the eggs' shells were weak, and the eggs often broke when the birds tried to incubate them in the nest.

- 94.** Runoff of animal waste from feedlots and stockyards, as well as runoff of excess fertilizer from agricultural and urban areas, has resulted in an excessive quantity of inorganic nutrients (especially nitrogen and phosphorus) entering many streams, rivers, and lakes. The excess nutrients disrupt the normal nutrient cycles and lead to excessive growth of photosynthetic organisms. The excessive nutrient enrichment of bodies of water is referred to as
- eutrophication.
  - biological magnification.
  - fertilization.
  - nutrient runoff.
  - biological runoff.

**(A)** Eutrophication, the accumulation of excessive quantities of nutrients in lakes, streams, and rivers, usually results in the excessive growth of photosynthetic organisms, especially algae and cyanobacteria. These *algal blooms* produce considerable oxygen during the day (as a byproduct of photosynthesis); however, at night, cellular respiration by these same organisms cause a significant reduction in oxygen content. In addition, as the photosynthetic organisms die, the organic material accumulates at the bottom of the water body. As decomposers breakdown the organic matter, they use up most of the available oxygen, potentially leading to the death of fish and other organisms.

**95.** A measure of the variety of organisms found within a given geographic area is referred to as

- A. genetic variation.
- B. polymorphism.
- C. conservation biology.
- D. biodiversity.
- E. carrying capacity.

**(D)** Biodiversity refers to the variety of different organisms found within a given region. Biodiversity is vital to the health of the Earth, including human welfare. In addition to aesthetic value, many species provide us with food, fiber, and medicine. As species go extinct, their potential value is lost.

**96.** The use of living organisms, particularly bacteria, fungi, and plants, to detoxify polluted ecosystems is referred to as

- A. biological restoration.
- B. sustainable detoxification.
- C. bioremediation.
- D. bioassimilation.
- E. habitat restoration.

**(C)** Bioremediation uses living organisms to detoxify polluted ecosystems. Certain bacterial and fungal species have the ability to break down toxic substances into inert, nontoxic substances. In addition, certain fungi, lichens, and plant species take up toxic chemicals and concentrate them in their tissues. The organisms can then be harvested, removing the toxic substances from the area as the organisms are removed. In some instances, the accumulated toxins (for example, accumulated heavy metals) can be extracted from the organisms and used commercially, preventing them from needing to be discarded as hazardous waste.

**97.** Behavior is controlled by

- A. the genetic make-up of the individual only.
- B. nature.
- C. both the genetic make-up of the individual and environmental influences.
- D. environmental influences only.
- E. nurture.

**(C)** There are still common myths being perpetuated in society that behavior is controlled either by the genetic make-up of the individual (nature) or environmental influences (nurture). Most scientists today agree that behavior is controlled by both the genetic make-up of an individual and by environmental influences. The degree of genetic versus environmental influence varies among individuals for different behaviors.

**98.** A method of learning that is limited to a certain period in an animal's life, and is generally irreversible, is referred to as

- A. imitation.
- B. habituation.
- C. maturation.
- D. conditioning.
- E. imprinting.

(E) Imprinting is a form of learning that is connected to innate behavior. Imprinting occurs at a specific stage in an organism's life and is usually irreversible. A well-known example is the imprinting of baby ducks and geese on their mother, or a substitute mother figure. In nature, baby ducks and geese imprint on their mother and follow her around until they are mature. They grow up to interact with others of the same species. The results of several experiments in which goose eggs were artificially incubated and hatched, and the baby geese spent their first few critical hours with the researchers, showed that these geese did not recognize other members of their species. Instead, they imprinted on the researchers, following them around, as other baby geese follow the mother goose. Even as adults, the experimental geese preferred to spend time with the researchers than with other geese.

**99.** Animals often learn by association, such as learning to associate one stimulus with another. Learning by trial-and-error, in which an animal learns to associate one of its behaviors with either a reward or a punishment, is referred to as

- A. operant conditioning.
- B. experimental conditioning.
- C. experiential conditioning.
- D. learned conditioning.
- E. classical conditioning.

(A) Operant conditioning is a type of associative learning that involves trial and error. An animal learns to associate a particular behavior with either a reward or punishment and then tends to either repeat the behavior or avoid the behavior accordingly. Another form of associative learning involves the association of an arbitrary stimulus with a reward or punishment. This type of learning is referred to as classical conditioning.

**100.** The discipline of sociobiology is primarily concerned with the study of

- A. competitive behaviors.
- B. mating behaviors.
- C. modes of communication among individuals within a species.
- D. modes of communication among individuals of different species.
- E. the evolution of social behavior.

(E) Sociobiology examines the evolution of social behavior, which includes competitive behaviors, mating behaviors, diverse modes of communication and social interactions within and between species.