Lab Manual to accompany McKinley's Anatomy & Physiology 2025 Release 1st edition McKinley Solutions Manual

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McKinley/O'Loughlin/Bidle
***Anatomy and Physiology: An Integrative Approach*, 4/e**
Instructor Answer Key to In-chapter and End-of-chapter Questions

Chapter 1
Answers to "What Did You Learn?"

1. Anatomy is the study of structure and form, while physiology is the study of function.

2. If a health-care worker must perform CPR, the worker uses surface anatomy to palpate and locate the xiphoid process of the sternum, and then move the hands slightly superiorly to start CPR chest compressions.

3. Cardiovascular physiology examines how the heart, blood vessels and blood function.

4. Anatomists focus on the form and structure of the small intestine. They examine the cells and tissues that form the small intestine, and describe the layers of the small intestinal wall. Physiologists focus on the function of the small intestine. They examine how the muscle of the smooth intestine propels food through the digestive tract and describe the process by which nutrients are broken down and absorbed. Both anatomists and physiologists know that form and function of the small intestine are interrelated.

5. When you study with a partner, you each can help the other identify gaps in your knowledge, keep study sessions focused and on track, and serve as a sounding board when explaining a concept.

6. The ability of organisms to respond to stimuli such as changes in either their external or internal environment provides them with a mechanism for maintaining a constant internal environment, even as the environment around them changes.

7.

Level of organization	Structural Unit	Example in the body	Simple or complex?
Chemical	Atoms and molecules	DNA	Most simple
Cellular	cell	Skeletal muscle cell	More complex that chemical
Tissue	Tissues	Epithelial tissue	More complex than cellular
Organ	Organ	stomach	More complex than tissue
Organ system	Multiple organs	Digestive system	More complex than organ
Organismal	Organism	Human	Most complex

8. The urinary system is responsible for filtering and removing waste products from the blood.

9. A transverse plane, also called a horizontal or cross-sectional plane, would divide the mouth into superior and inferior sections.

10. Proximal.

11. A student's drawing and labeling should look similar to figure 1.7.

12. The lungs are located within the thoracic cavity. The serous membranes surrounding them consist of the parietal pleura, lining the inside of the body wall, and the visceral pleura, lining the individual lungs.

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13. Epigastric

14. A homeostatic system consists of a receptor, such as a sensory neuron in the skin or a stretch receptor within a muscle, that detects either an internal or external stimulus; a control system that integrates the input from the receptor, such as the brain or an endocrine gland; and an effector, such as a muscle or a gland, that causes changes in response to the stimulus.

15. Receptors in the skin, and the hypothalamus, both act as receptors to detect changes in body temperature. (The skin receptors detect skin temperature changes, while the hypothalamus detects temperature changes in the blood). The hypothalamus also acts as the control center, as it signals the effectors to respond to bring the body temperature back to a set point. The effectors are blood vessels, skeletal muscle, and smooth muscle (when the body is trying to conserve heat), whereas the effectors are blood vessels and sweat glands (when the body is trying to release heat).

16. Negative feedback systems involve responses that are in opposition to the stimulus, thereby maintaining the environment near the set point or normal level. Conversely, positive feedback systems entail a series of responses, each increasing in intensity, until a climax event is reached, at which point the system will return to homeostasis.

17. Diabetes, an inability of the body to maintain blood sugar levels, may result in damage to anatomical structures throughout the body due to high levels of glucose.

Answers to "Do You Know the Basics?"

1. B
Feedback: *Surface anatomy* correlates superficial markings on the surface of the body and skin to deeper anatomical features.

2. C
Feedback: *Organs* are often composed of several tissue types working in concert to perform a common function.

3. A
Feedback: An organism's *metabolism* is the sum of all of its biochemical reactions.

4. C
Feedback: A midsagittal or median plane separates the body into equal *right and left halves* as compared to simply a sagittal section, which separates the body into unequal right and left portions. There can be numerous sagittal planes but only one possible midsagittal section along the midline of the body.

5. D
Feedback: The term *proximal* is used to describe the position of a structure on an appendage closest to the point of attachment to the trunk. Although in standard anatomical position a structure that is proximal is often also superior, proximal is the correct term for describing the position along an appendage. The term superior may be used to describe positions along the axis of the body, closer to the head.

6. A
Feedback: The *patellar* region is the anterior portion of the knee. The popliteal region is the posterior portion of the knee.

7. A
Feedback: The diaphragm comprises the barrier between the superior thoracic cavity and the inferior *abdominal cavity*. The pelvic cavity is located inferior to the superior edges of the pelvic bones.

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8. D
Feedback: The pleural cavity surrounding the lungs consists of the parietal pleura, lining the internal walls of the thoracic cavity, and the *visceral pleura,* lining the surface of the lungs.

9. B
Feedback: *Homeostasis* is an automated process for maintaining a constant internal environment.

10. D
Feedback: The *effector* increasing the stimulus is an example of positive feedback. In a negative feedback system, the response moves the system in opposition to the stimulus, back toward the set point.

11. Anatomy is the study of structure and form, whereas physiology is the study of how the structures function. It is important to understand the anatomy of a structure in order to understand how it performs its function. Conversely, understanding the function of an anatomical feature helps to put into perspective the significance of its arrangement.

12. The simplest level of organization within an organism is found at the chemical level and is composed of atoms and molecules. At the cellular level of organization, molecules are organized into cells and subcellular components, forming the basic units of life. Groupings of similar cells performing similar functions are referred to as tissues, and groups of tissues may be found working in concert, forming organs at the organ level of organization. Related groups of organs working together in order to coordinate activities within the organism are called organ systems.

13. A hierarchical organization, metabolism, growth and development, responsiveness, regulation, and reproduction are characteristics common to all living organisms. All living things are arranged in a hierarchical manner with increasing levels of complexity from molecules to cells. They are capable of metabolism, growth and development, and responsiveness to stimuli. They are also able to regulate their internal environment in order to maintain homeostasis, ultimately surviving long enough to reproduce.

14. The human body consists of eleven organ systems. They are the integumentary, skeletal, muscular, nervous, endocrine, cardiovascular, lymphatic, respiratory, urinary, digestive, and reproductive systems.

15. A body in anatomical position is standing upright with the feet flat on the floor. The upper limbs are at the side of the body with palms facing anteriorly. The head is level and the eyes are looking forward. The anatomic position is the point of common reference used by anatomists and physiologists for accuracy and clarity. It provides an initial point of reference, from which all anatomic parts are described.

16. The forearm is the antebrachial region, the wrist is the carpal region, the chest is the thoracic region, the armpit is the axillary region, the thigh is the femoral region, and the entire foot is the pes.

17. The cranial cavity and vertebral canal are located within the posterior aspect of the body. The cranial cavity houses the brain and the vertebral canal contains the spinal cord.

18. The serous membranes are found lining the compartments of the ventral cavity of the body. They consist of a parietal layer lining the inside of the body wall and a visceral layer covering internal organs. In between the two membranes is a potential space, the serous cavity, which contains serous fluid.

19. A homeostatic system consists of a receptor that detects an internal or external stimulus, a control system that integrates the input from the receptor, and an effector, such as a muscle or a gland, that causes changes in response to the stimulus.

20. Negative feedback systems involve responses that are in opposition to the stimulus, thereby maintaining the environment near the set point or normal level. Conversely, positive feedback systems entail a series of responses, each increasing in intensity until a climax event is reached, at which point the system will return to homeostasis.

Answers to "Can You Apply What You've Learned?"

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1. B
Feedback: The pain is coming from a region below the umbilicus, hence it is in the lower portion of the abdomen and it is located on the right side. It is therefore in the *right lower quadrant*.

2. D
Feedback: The *right iliac region* is located just medial to the pelvic bones.

3. B
Feedback: X-rays are not absorbed by soft tissue such as the appendix. They are usually used to visualize dense structures.

4. B
Feedback: Sweat glands release sweat at the surface of the skin.

5. B
Feedback: Serotonin is a neurotransmitter responsible for regulating both pathways associated with depression in the brain and gastric motility in the stomach. Drugs such as SSRIs are used to treat depression in individuals with low levels of serotonin in the brain by inhibiting its reuptake by neurons. Because the SSRI drugs cannot specifically target the brain, they also have an effect within the digestive system, causing nausea and diarrhea.

Answers to "Can You Synthesize What You've Learned?"

1. Lynn has broken the bones within her forearm, the radius and ulna. She has an abrasion on her chin as well as bruising on her buttocks and thigh.

2. The epinephrine counteracted the effect of the bee sting, acting in opposition to the stimulus; it was therefore an example of negative feedback.

3. X-rays and CT scans are optimal for visualizing dense tissues, such as tumors. An MRI or ultrasound would be better suited for examining soft tissues.

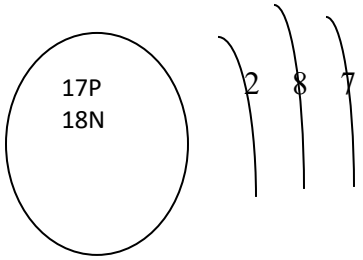
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Chapter 2
Answers to "What Did You Learn?"

1. The mass of an atom is determined by the combined number of protons and neutrons within its nucleus. The charge of an atom is determined by the number of positively charged protons and negatively charged electrons.

2. The nucleus of a chlorine atom consists of 17 protons and 18 neutrons. The electrons are arranged into three separate shells; the first shell closest to the nucleus contains two electrons, the second shell contains eight electrons, and the third outer shell contains seven electrons, for a total of 17 electrons.



3. Isotopes are atoms of the same element. They only differ in their number of neutrons, thus they differ in their atomic mass. A radioisotope is unstable because of extra neutrons. Stability can ultimately be reached through the loss of nuclear components in the form of high-energy radiation (e.g., alpha particles, beta particles). Thus, the radioisotope will decay as radiation is released.

4. The octet rule is the tendency for atoms to lose, gain, or share electrons to obtain a complete outer shell and thus become chemically stable.

5. Common cations (positively charged ions) of the human body include: sodium ions (Na^+), potassium ions (K^+), calcium ions (Ca^{2+}), magnesium ions (Mg^{2+}), and hydrogen ions (H^+). Common anions (negatively charged ions) include: chloride ions (Cl^-), bicarbonate ions (HCO_3^-), and phosphate ions (PO_4^{3-}).

6. Sodium (atomic number 11), potassium (atomic number 19), calcium (atomic number 20), magnesium (atomic number 12), hydrogen (atomic number 1), and chlorine (atomic number 17) should be highlighted.

7. In order to satisfy the octet rule, atoms may either lose or gain electrons to become chemically stable (have a complete outer shell of electrons). However, a charge is developed because the number of positively charged protons is no longer equal to the number of negatively charged electrons. For example, atoms with only one electron in their outer shell may give up the electron, resulting in a positive cation, now with a full outer shell. Conversely, atoms with seven electrons in their outer shell may accept an electron from another atom, becoming a negative anion, but now with a full outer shell.

8. Ionic bonds are formed due to an attraction between ions with different charges. Therefore, an ionic bond cannot be formed between two cations, nor can it be formed between two anions.

9. The structural formula exhibits the type and number of atoms in a molecule, and their arrangement within the molecule. In comparison, the molecular formula provides information only for the type and number of atoms in a molecule (but not how the atoms are arranged within the molecule).

10. Isomers are molecules composed of the same type and number of elements, but are arranged differently (i.e., they have the same molecular formula, but a different structural formula).

11. A covalent bond is formed when atoms share electrons in their outer orbitals in order to satisfy the octet rule.

12. Nitrogen is more electronegative that hydrogen, thus it is designated with a partial negative charge, whereas hydrogen is less electronegative than nitrogen and is designated with a partial positive charge.

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13. A covalent bond between atoms of the same element (with both atoms equally electronegative) will result in electrons being shared equally between the two atoms. Thus, the resulting bond is a nonpolar bond. A covalent bond formed between two different atoms (with one atom more electronegative than the other) will result in electrons being shared unequally between the two atoms. Thus, the resulting bond is a polar bond. The more electronegative atom will have a slightly negative charge and the less electronegative atom will have a slightly positive charge. Note: Because carbon and hydrogen atoms are nearly equal in terms of electronegativity, atoms of these two different elements essentially share electrons equally and form a nonpolar covalent bond between them.

14. Both O_2 and CO_2 are nonpolar molecules. O_2 is nonpolar because it is composed of the same type of atoms (elements) and CO_2 is a nonpolar molecules because the oxygen atoms with their partial negative charge are positioned in opposing direction and cancel one another. (Note that both respiratory gases, both O_2 and CO_2 are nonpolar molecules.

15. A hydrogen bond is a weak attraction between a partially positive hydrogen atom within a polar molecule and a partially negative atom within a polar molecule (usually oxygen, but sometimes nitrogen).

16. A student's drawing of hydrogen bonding between water molecules should look similar to figure 2.12b.

17. Surfactant is required to decrease surface tension (the cohesive attraction between water molecules) in the alveoli of the lungs. Body temperature is regulated through sweating because of water's high heat of vaporization. Sweating is less effective on a humid day because of the increased water in the environment that impedes additional water evaporating from the skin.

18. Nonelectrolyte molecules such as glucose dissolve but do not dissociate in water. Electrolytes such as sodium chloride (NaCl) both dissolve and disassociate into constituent ions in water, forming a solution capable of conducting electricity.

19. A student's drawing of hydrogen bonding between water molecules should look similar to figure 2.13c upper right image of phospholipid bilayer

20. Each water molecule can disassociate into one positively charged hydrogen ion and one negatively charged hydroxyl ion. It is considered neutral since it has an equal distribution of positive and negative charges.

21. An acid dissociates in water and releases hydrogen ions.

22. pH is a measure of the relative amounts of H^+ in a solution. The relationship between $[H^+]$ and pH is inverse. As $[H^+]$ increases, pH decreases, whereas as $[H^+]$ decreases, pH increases.

23. A buffer helps prevent pH changes if either excess acid or base is added. It acts either to accept H^+ from excess acid or donate H^+ to neutralize excess base. (Buffers act as H^+ sponges, absorbing H^+ if acid is added and releasing H^+ if base is added.)

24. Blood would be characterized as a suspension because blood cells settle to the bottom of a tube when left standing.

25. Blood is a **suspension** of formed elements that includes erythrocytes (red blood cells), leukocytes (white blood cells), and platelets within plasma. If blood is withdrawn from the body, the formed elements will settle out from the plasma. Blood is also a **colloid** of proteins dissolved in plasma, and it is a **solution** of ions and molecules dissolved in plasma.

26. The concentration of a solution may be expressed as (1) mass of solute per volume of solution [mass/volume], (2) grams of solute per 100 milliliters (mL) of solution [mass/volume percent], (3) moles of solute per liter of solution [molarity], and (4) moles of solute per kilogram of solvent [molality].

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27. The six common elements that form biological macromolecules include: carbon (C), hydrogen (H), and oxygen (O), and in some cases may also contain nitrogen (N), phosphorus (P), and sulfur (S). Hydrogen is the element that both (a) forms a common ion and (b) is a common element in biomolecules.

28. Carboxylic acids and phosphates are capable of acting as acids.

29. A polymer is composed of repeating monomer subunits. Proteins are composed of amino acid monomers, carbohydrates contain sugar monomers, and nucleic acids have nucleotide monomers.

30. Lipids are fatty, water-insoluble, hydrophobic molecules and do not typically dissolve in water.

31. Phospholipids are amphipathic molecules that form chemical barriers of cell membranes. They contain both a hydrophilic head group (that dissolves in water) and a pair of hydrophobic fatty acid tails (that do not dissolve in water), making them ideally suited for forming cellular membranes.

32. Glycogen is composed of repeating glucose monomers or subunits and is stored by animals within the liver and skeletal muscle cells.

33. Fructose, galactose, and glucose are monosaccharides. Sucrose, maltose, and lactose are disaccharides. Glycogen and starch are polysaccharides.

34. Nucleic acids store and transfer genetic information within cells. They ultimately determine the types of proteins synthesized within cells.

35. RNA molecules contain a ribose sugar in their nucleotides rather than the deoxyribose sugar that is within the nucleotides of DNA. The nucleotides of both RNA and DNA may contain the nitrogenous bases of adenine, guanine, and cytosine. The base uracil is present within nucleotides of RNA. In comparison, the base thymine is present in the nucleotides composing DNA. RNA is a single strand, whereas DNA is a double strand (double helix).

36. Amino acids are the monomers of a protein and they are covalently linked by peptide bonds.

37. A dipeptide consists of 2 amino acids, an oligopeptide contains 3 to 20 amino acids, a polypeptide contains 21 to 199 amino acids, and a protein consists of 200 or more amino acids. The term *protein* is generally used to refer to oligopeptide, polypeptide, and protein.

38. The R group of leucine is a nonpolar hydrocarbon, making it a nonpolar amino acid.

39. The tertiary structure refers to the three-dimensional shape exhibited by *one* completed polypeptide chain. The quaternary structure refers to the three-dimensional shape of *two or more* polypeptide chains that form the functional protein.

40. Denaturing a protein changes its conformation and affects its activity. Exposure of a protein to higher than normal concentration of hydrogen ions (a decrease in pH) results in the positively charged H^+ binding with negatively charged structures that were participating in electrostatic interactions that were holding the protein in its final shape. The loss of these electrostatic interactions between the amino acids that compose the protein results in its unfolding (or denaturation).

Answers to "Do You Know the Basics?"

1. C

Feedback: *Isotopes* are atoms of the same element that have the same number of protons and electrons, but differ in the number of neutrons.

2. A

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Feedback: *Lipids* are hydrophobic molecules and are not soluble (do not dissolve) in water.

3. C
Feedback: Water has a high *specific heat,* allowing it to absorb and release energy without changing temperature. In addition, the high *heat of vaporization* for water allows it to dissipate a large amount of energy during evaporative cooling of the skin.

4. D
Feedback: A pH less than 7.0 is acidic and a pH greater than 7.0 is basic.

5. D
Feedback: The formed elements of blood act as a suspension. Dissolved proteins in the plasma act as a colloid. The numerous dissolved solutes also make blood a solution.

6. A
Feedback: *Triglycerides* are not considered polymers because they are not composed of repeating monomer subunits.

7. C
Feedback: Glucose is stored in animal tissues as *glycogen*.

8. B
Feedback: Although phosphates which contain phosphorus are common ions in the body, phosphorus itself is not a common ion.

9. B
Feedback: A *hydrogen bond* is an intermolecular attraction between a slightly positive hydrogen atom within a polar molecule and a slightly negative atom (e.g., oxygen, nitrogen) in a polar molecule.

10. B
Feedback: *Denaturing* a protein changes its conformation. Excessive denaturation can permanently affect protein structure and possibly its function as well.

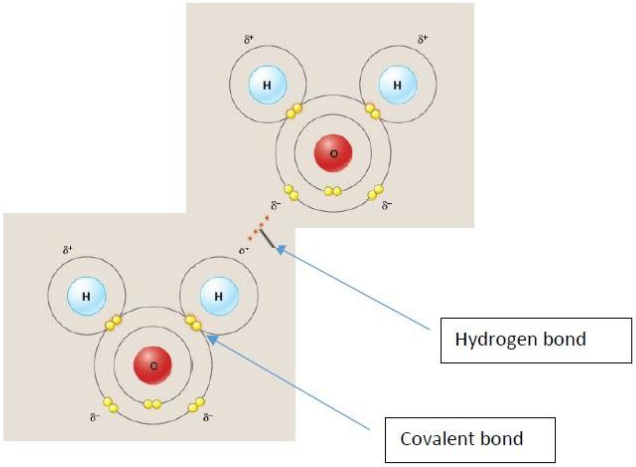
11. Common cations of the human body include sodium ions (Na^+), potassium ions (K^+), calcium ions (Ca^{2+}), magnesium ions (Mg^{2+}), and hydrogen ions (H^+). Common anions include chloride ions (Cl^-), bicarbonate ions (HCO^{3-}), and phosphate ions (PO_4^{3-}).

12. Polar bonds have varying degrees of unequal electron sharing between two different atoms, except for C-H, an oxygen atom bonded to a hydrogen atom. Oxygen, the more electronegative of the atoms, will have a stronger pull on the electrons and will thus have a slightly more negative charge around it, while the hydrogen atom will be relatively more positive (or less negative). A polar molecule is a molecule that contains a prevalence of polar bonds between the atoms that compose it. For example, water is a polar molecule composed of two polar covalent bonds between the oxygen atom and each hydrogen atom.

13.

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14. Polar molecules (e.g., glucose) will dissolve in water because hydrogen bonds are formed between the water and the polar molecules. The polar molecule does not dissociate, remaining intact as in this example of a glucose molecule. In comparison, ionic compounds both dissolve and dissociate. Ionic compounds such as sodium chloride (NaCl) will disassociate in water because the polar water molecules will disrupt the electrostatic interactions between sodium and chloride ions, thereby separating them.

15. An acid contributes hydrogen ions to a solution, making it more acidic (having a lower pH). A base binds hydrogen ions from a solution, making it more basic (having a higher pH). pH is the measure of hydrogen ions in a solution. A buffer is capable of either absorbing or releasing hydrogen ions, thereby helping to prevent pH changes when acids or bases are added.

16. The concentration of a solution may be expressed as either the ratio of the mass of solute compared to the volume of the solution (mass/volume), as the percent of mass of solute in 100 milliliters of solution (mass/volume %), as the number of moles of solute per liter of solution (molarity), or the number of moles of solute per kilogram of solvent (molality).

17. Proteins are composed of amino acids (repeating units); carbohydrates are composed of simple sugars (repeating units); nucleic acids are composed of nucleotides (repeating units); but lipids are **not** composed of repeating units. There are four primary types of lipids: *triglycerides* (composed of glycerol and fatty acids); *phospholipids* (composed of glycerol, two fatty acids, a phosphate, and various organic groups); *steroids* (cholesterol, steroid hormones, and bile salts—composed predominantly of hydrocarbons that differ in the side chains extending from the rings); and *eicosanoids* (prostaglandins, thromboxanes, and leukotrienes—composed of modified 20-carbon fatty acids synthesized from arachidonic acid).

18. Nucleotides (composed of a sugar, phosphate, and a nitrogenous) that compose DNA and RNA contain nitrogen that forms a nitrogenous waste called uric acid. Amino acids contain an amine functional group, —NH_2, that is converted to a nitrogenous waste called urea. Both uric acid and urea must be effectively eliminated by the kidney for an individual to remain healthy.

19. In an aqueous environment, amphipathic molecules such as phospholipids will orient themselves so that their hydrophobic domains face each other while the hydrophilic domains are exposed to water. This is the basis behind the arrangement of phospholipids within a phospholipid bilayer of the plasma membrane of a cell.

20. A protein's function is dependent upon the retention of its normal 3-dimensional shape. Denaturation is a change in the conformation of a protein that changes/affects its activity. Exposure of a protein to either an increase in temperature or a pH outside of its normal environment can denature the protein by disrupting electrostatic interactions such as ionic bonds within the molecule.

An increase in temperature can weaken the intramolecular attractions between the amino acids in the primary structure of the protein strand, causing the protein to unfold or denature such that it can no longer function normally.

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Changes in H^+ concentration that are associated with changes in pH interfere with the electrostatic interactions within the protein that hold it in its 3-dimensional shape. Exposure of a protein to higher than normal concentration of hydrogen ions (a decrease in pH) results in the positively charged H^+ binding with negatively charged structures that were participating in electrostatic interactions that were holding the protein in its final shape. Exposure of a protein to lower than normal concentration of hydrogen ions (an increase in pH) results in the positively charged H^+ that were participating in electrostatic interactions and holding the protein in its final shape being removed. The loss of these electrostatic interactions between the amino acids that compose the protein results in its unfolding (or denaturation).

Answers to "Can You Apply What You've Learned?"

1. C
Feedback: Surface tension is high within the air sacs in the lungs of premature infants that are not producing sufficient surfactant. Surfactant is a detergent-like substance that prevents hydrostatic interactions between water molecules, thereby preventing the lungs from collapsing and the alveolar walls from sticking together. Premature babies often lack the ability to produce surfactant and are at risk for respiratory problems.

2. D
Feedback: Electrolytes such as sodium ions, potassium ions, and chloride ions are capable of conducting electricity.

3. B
Feedback: Radioisotopes emit high-energy radiation.

4. D
Feedback: Calcium (Ca^{2+}) ions are an important structural component of bone tissue.

5. C
Feedback: *Proteins* consist of covalently bonded amino acids held together by peptide bonds. If insulin is administered orally, the peptide bonds are broken by enzymes of the digestive system (to form individual amino acids).

Answers to "Can You Synthesize What You've Learned?"

1. High-energy radiation can cause mutations within DNA.

2. The number of hydrogen ions in the blood increases, resulting in a lower pH (a condition called acidosis). The increasing number of hydrogen ions may interfere with the hydrostatic interactions holding proteins together, thus denaturing the proteins.

3. The drug would regulate the levels of the monosaccharide glucose within the blood.

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Chapter 3
Answers to "What Did You Learn?"

1. Kinetic energy is the energy of motion. Movement of sodium ions along a concentration gradient or the movement of electrons from a higher to lower energy state are both examples of kinetic energy.

2. The movement of muscle is an example of mechanical energy, a form of kinetic energy that involves the movement of an object due to an applied force.

3. Even though energy can neither be created nor destroyed, it can be transformed or converted from one form to another. Such transformations are not completely efficient, always resulting in the release of some of the energy as heat, which is not available to do work.

4. Reactants are the substrates or substances that are present prior to a chemical reaction. The reactants are converted to products during the reaction.

5. Formation of a complex molecule from simpler chemical structures would be classified as: (a) a synthesis reaction, (b) an endergonic reaction, and (c) a form of anabolism.

6. ATP is formed from glucose oxidation and used as the energy currency for energy-requiring processes within the cell.

7. When equilibrium is disturbed in a reversible reaction, the system will adjust and the reaction is driven toward either the reactants or the products until equilibrium is reestablished. For example, an increase in substrates drives the chemical reaction to the right (making more product) until a new equilibrium is reached.

8. Initially, the effect of a fever (elevation in temperature) increases the kinetic energy of the molecules, providing enough energy to break chemical bonds. The consequence of high fever may result in the denaturing of proteins and potentially cause the death of the cell (and possibly the death of the individual).

9. Enzymes are catalysts that decrease the energy of activation required for a chemical reaction to proceed.

10. The active site is a region in the enzyme that is the temporary binding site for the substrate to the enzyme.

11. Enzymes are proteins that catalyze metabolic reaction by lowering the activation energy necessary for the reaction. The structure of the protein directly affects its affinity for its specific substrate. (1) Substrate enters the enzyme's active site and temporarily binds to it, forming an enzyme-substrate complex. (2) Binding of substrate into the active site induces conformational changes in the enzyme; this response is referred to as the induced-fit model of enzyme function. (3) Chemical bonds in the substrate are stressed by changes in the enzyme shape. This lowers the E_a, (activation energy) so that bonds in the substrate(s) are more easily broken and new chemical bonds may be formed. (4) A new molecule (called [a] product[s]) is released from the enzyme. Inorganic cofactors are attached to enzymes and may be required for the normal function of some enzymes.

12. The name of an enzyme is usually based upon the name of the substrate or the product involved in the chemical reaction, or sometimes the name of the enzyme subclass. The suffix -ase is added to the final word of the name.

13. The rate of an enzyme-catalyzed reaction may be increased as the concentration of substrate is increased, until all of the enzyme molecules are saturated. Enzymes function most efficiently at their optimal temperature. Decreasing temperature from an enzyme's optimum range will decrease its activity. Increasing temperature increases the rate of the reaction until enzymes denature. Changing pH in either direction (increase or decrease) from its optimal pH will readily denature the protein as the change in hydrogen ion concentration interferes with electrostatic interactions within the enzyme, denaturing it.

14. Inhibitors prevent an enzyme from converting substrate to product. Competitive inhibitors affect enzyme activity by competing with substrates at the active site of the enzyme. Noncompetitive inhibitors do not resemble the

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substrate, but they inhibit an enzyme by binding to a site on the enzyme other than the active site (a site called the allosteric site). This modulates the shape of the enzyme altering the shape of its active site.

15. A metabolic pathway is formed by numerous enzymes. Each enzyme catalyzes one progressive change to its specific substrate molecule and then releases the product. Thus, the product of one enzyme becomes the substrate of the next enzyme. Negative feedback is a means to regulate the activity of metabolic pathways. The product from a metabolic pathway acts as an allosteric inhibitor to turn off an enzyme early in the pathway and regulate enzyme activity.

16. Phosphorylation (the adding of a phosphate group) and dephosphorylation (the removal of a phosphate group) are processes that regulate enzymes by turning on some enzymes and turning off other enzymes.

17. The overall chemical reaction for cellular respiration of glucose is: $C_6H_{12}O_2 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$. The oxidation of glucose, an exergonic reaction, results in a step-by-step enzymatic breakdown of glucose with the accompanying release of energy to synthesize ATP. If oxygen is available, glucose is completely broken down and carbon dioxide and water are formed.

18. The four stages of cellular respiration for glucose oxidation include: (1) glycolysis (which occurs within the cytosol of the cell), and the (2) intermediate stage, (3) citric acid cycle (or Krebs cycle), and (4) electron transport system. (Stages 2, 3, and 4 occur within the mitochondria).

19. Glycolysis is a process that occurs within the cytosol and does not require oxygen. The net reaction entails the breakdown of glucose (a 6-carbon molecule) into two pyruvate molecules (each a 3-carbon molecule). The reaction involves the initial input of two molecules of ATP and yields four molecules of ATP, for a net yield of two molecules of ATP. Two molecules of NAD^+ are also reduced to form NADH (and H^+) from energy released during the oxidation of glucose.

20. Pyruvate may either enter a mitochondrion (if sufficient oxygen is available) to be completely oxidized to carbon dioxide (with the energy released in its chemical bonds) or (if oxygen is lacking) be converted to lactate (a process described in detail in a later section).

21. The intermediate stage of cellular respiration is an aerobic process (requires oxygen) that occurs within mitochondria, which "links" the metabolic pathway of glycolysis (that occurs in the cytosol) with the metabolic pathway of the citric acid cycle. During this process CO_2 is released from pyruvate (through decarboxylation) and two electrons and a hydrogen ion are transferred to NAD^+ to form. (NOTE: this process would occur twice for each glucose molecule).

22. The citric acid cycle is an aerobic process that occurs within the matrix of mitochondria. It uses acetyl CoA as the initial substrate and forms two CO_2 molecules and one CoA molecule as the products. The oxidation of acetyl CoA yields: one molecule of ATP, three molecules of NADH, and one molecule of $FADH_2$. (NOTE: this process would occur twice for each glucose molecule).

23. Cellular respiration of one molecule of glucose yields: two molecules of ATP and two molecules of NADH during glycolysis; two molecules of NADH during the intermediate stage (per original glucose molecule); and two molecules of ATP, six molecules of NADH, and two molecules of $FADH_2$ during the citric acid cycle (per original glucose molecule).

24. NADH and $FADH_2$ serve as coenzymes to temporarily hold energy by binding electrons and hydrogen released during the breakdown of glucose during glycolysis, the intermediate stage, and the citric acid cycle. These coenzymes hold the electrons until the electrons are transferred to the electron transport chain, which allows the formation of ATP through oxidative phosphorylation.

25. The three primary steps of the electron transport system are the following: (1) Electrons are transferred from coenzymes to O_2, (2) Proton gradient is established, and (3) Proton gradient is harnessed to form ATP.

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CHAPTER 1: The Sciences of Anatomy and Physiology

CHAPTER OVERVIEW

This chapter provides students with an initial introduction to the disciplines of human anatomy and physiology. The chapter focuses on anatomy and physiology equally—showing the confluent interrelationship between the two. It shows that form and function are inseparable, with function dictating form.

In an exciting way, Chapter 1 introduces students to new terminology and new concepts concerning the wonderful human organism. Students will gain knowledge on the levels of organization, homeostasis, introductory physiological principles, and anatomical terms, along with some cursory understandings of human diseases.

KEY POINTS TO EMPHASIZE WHEN TEACHING HUMAN ANATOMY AND PHYSIOLOGY

An instructional understanding: An instructor must keep three important facts in mind when teaching an introductory human anatomy and physiology course. One is that many students do not have any significant biological/chemical background prior to taking the course. Second, the great majority of students taking A&P courses are already in or applying to clinical programs. Third, physiology is generally the most difficult for students to understand. Considering these facts, it is best for an instructor to relate A&P concepts to everyday life situations. Clinically relevant scenarios should be interwoven in order to show the student that the concepts discussed do clinically apply. Difficult physiological concepts should be initially explained using simple everyday terms until the student has begun to master scientific terminology.

1. Start the course by explaining to the student that an introductory course in anatomy and physiology is not easy. However, the text is written in an easy reading manner that maximally facilitates students learning. Explain that your instruction will attempt to use real-life situations along with clinically relevant scenarios. Let the student know that they will be exposed to an entirely new vocabulary that must be understood and utilized in the various clinical professions.
2. Define anatomy and physiology and compare and contrast the two.
   a. As often as possible, show word origins along with Latin and Greek prefixes and suffixes. This helps clinical students on standardized entrance and licensure examinations. Refer students to the inside back cover of this textbook for a listing of the most common roots, prefixes, and suffixes in anatomy and physiology.
   b. Discuss how anatomy integrates with physiology. Give examples of how function dictates form, like the megaphone's similarity to the human ear.
   c. Discuss the importance of composite courses in both anatomy and physiology, in contrast to independent courses in each discipline.
3. Discuss the scientific method as it relates to explaining and understanding the workings of the body. When discussing the scientific method, explain the process.
   a. Explain that the first step in examining natural events is through observation.
   b. Discuss the second step: the development of a hypothesis.
   c. Discuss why and how data are collected to support, reject, or modify the hypothesis.

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4. When discussing various methods of studying anatomy, give some clinically relevant reasoning.
    a. Use, for example, that systemic anatomy is used in medical fields. The cardiovascular system is shared by the cardiologist (subspecialty of internal medicine) and the cardiothoracic surgeon (subspecialty of surgery). The gastrointestinal system is shared by the gastroenterologist (internal medicine) and the general or colorectal surgeon. Surgeons can operate, and internal medicine specialists use nonsurgical treatments.
    b. Discuss that gross anatomy is a course in itself. The dissection method used in the course is generally a regional approach rather than a systemic approach. A systemic approach dissection requires several specimens to be used by the same group of students.
    c. Discuss that cytology, histology, and embryology are complete courses by themselves. Inform the student that this course presents an in-depth yet introductory-type presentation of these topics. For some students, this introductory presentation sparks interest to take additional courses.
    d. Define and discuss embryology. Define the embryonic period in a human.
    e. Discuss that in the clinical setting, topical anatomy terms are important. For example, a nurse or medical doctor would not say, “Put the IV on the inside surface of the elbow.” Instead he/she would say, “Place it in the antecubital fossa.”
5. When discussing various methods of studying physiology, give some clinically relevant reasoning.
    a. It is important to mention that physiology will be discussed mainly using a systemic approach, such as cardiovascular physiology and neurophysiology. However, though it will be discussed on the systemic approach, much of modern-day physiology is discussed on the cellular and chemical level basis. It is important for the student to know that diagnosis and treatment is fast moving to the cellular level.
    b. Students sometimes have difficulty comparing physiology to pathophysiology. It is best to use homeostatic imbalance as an explanatory method. For example, if resting heart rate is in the 60–100 beats per minute range, the discussion is physiologic, but in most cases when it deviates outside this range, it is pathologic.
    c. Some students have difficulty understanding the difference between pathology and pathophysiology. One is more anatomical and the other more physiological.
6. Discuss the living processes (properties) and levels of organization, using several examples.
    a. Students have difficulty understanding life processes and how they interrelate with one another.
    b. Define metabolism and its subsumed components of anabolism and catabolism.
    c. Discuss the dynamic cycle of anabolism and catabolism in terms of biochemical compounds.
    d. Discuss growth. Use related media to compare and contrast growth by hyperplasia (increase in the number of cells) versus hypertrophy (increase in the size of cells).
    e. Use supportive resources to discuss why most growth is by hyperplasia rather than hypertrophy as a result of the surface-to-volume relationship of cells.
    f. Discuss development in terms of differentiation. Use related media to discuss that though human cells undergo differentiation (cell specialization), those with a nucleus have the same genetic information (genomic equivalence).

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g. Define responsiveness and how it interrelates with homeostasis. One must be able to perceive a stimulus in order to react to it.
h. Discuss body regulation in terms of homeostasis. Use good examples that are clinically relevant.
i. Give a cursory explanation of mitosis versus meiosis as it relates to somatic cells and gametes, respectively.
j. Explain that the reproductive process attributed to the sex cells (development of a new living organism) is the least vitally important homeostatic process in a stressful situation. Use the example that a female's menstrual period is discontinued during extreme times of stress and/or severe weight loss.
k. Show how the levels of organization integrate with one another.
l. Explain how the whole is greater than the sum of its parts in a living organism.
m. Explain how, though the levels of organization have defined levels such as the chemical and cellular levels, some emphasis must be placed on describing the in-between structures like organelles.
n. Since most students are seeking clinical careers, one may emphasize that an organism is an individual entity. However, humans interact with the living and nonliving, and all of this impacts our wellness. Thus, mention and define population, biological community, and ecosystem. Use related resources to explain this.

7. Most students who have taken a chemistry or physics course have been presented with the term "system" as defined in those disciplines.
   a. Note the difference between a system in chemistry and physics and that of an organ system.
   b. Describe all of the organ systems.
8. Describe the anatomical position and how it relates to the various body planes.
   a. Define a body plane.
   b. Give examples of all the body planes using examples of cutting the body along those planes.
   c. Explain the importance of the anatomical position in terms of relative anatomical terminology. However, the person does not have to actually be positioned that way to discuss the anatomical terminology. For example, if an individual is removed by paramedics from the interior of their vehicle in a car accident, the paramedics will use anatomical terms to describe the various injured body areas. However, they obviously would not rearrange the accident victim into the anatomical position to describe the injuries. They would imagine the person is in that position for point of reference.
   d. Explain why a sagittal plane utilizes two descriptive terms, "midsagittal" and "sagittal" (some use the term "parasagittal" instead of "sagittal"). The other anatomical planes have only one descriptive term. The reason is that the human body is intended to be bilaterally symmetrical.
   e. Explain that some synonymous anatomic terms in a human (two-legged organism) differ in their synonymous meaning in a four-legged organism. For example, in a two-legged organism, anterior and ventral are the same and posterior and dorsal are the same. However, in a dog, his head (cephalic) is anterior and his caudal region is posterior.
   f. Explain that anatomical directional terms are relative (need at least two terms for comparison). Thus "medial" means a structure closer to the midline, not necessarily at the

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midline. But in order to use it, reference must be made to something further out from the midline ('lateral').

9. Describe all the body cavities.
    a. Discuss the lines of demarcation that delineate the various body cavities.
    b. Discuss the fact that there are really no freely open spaces in the human body, due to the surface tension of water closing the spaces. However, the space can be easily opened without trauma to a delineating surface. Body cavities are therefore potential spaces.
    c. Discuss the lack of body cavities in the arms and legs.
    d. Discuss the false and true pelvic body cavities. Use outside resources to do this.
    e. Use the visceral and parietal serous membranes to describe the body cavities.
    f. Define and describe a serous membrane, along with the type of fluid it produces and the membrane's purpose.
    g. Discuss the contents of some body cavities.
10. Describe the abdominopelvic regions and quadrants.
    a. Present the terms used in the nine-region description.
    b. Present the terms used in the quadrant system.
    c. Inform the students that the quadrant system is used in the clinical professions. The nine-region system is too confining when making a diagnosis using the physical exam. The quadrant system provides more diagnostic latitude. More of an organ is in a quadrant than a nine-section region.
    d. Use a clinical scenario in describing the quadrant system as it relates to diagnosis. For example, have the students state what possible structures could be injured if one had a stab wound injury to a certain quadrant.
11. Students have difficulty understanding homeostasis in terms of (a) its dynamic fluctuating nature, (b) the internal environment, and (c) its normal homeostatic range, and the set point within the range.
    a. Define homeostasis explaining its dynamic nature.
    b. Describe the body fluids considered to comprise the internal environment.
    c. Discuss that all body processes and chemicals have a normal range. The range was determined by examining a statistically significant population of healthy individuals.
    d. Discuss that the dynamic nature of homeostatic actions involves oscillating fluctuations around a central value in the homeostatic range, known as the "set point." The set point is the optimal point for homeostatic control, with the rest of the range being a buffer zone.
    e. Discuss that when an individual moves out of the homeostatic range, particularly in an unexplained manner, it generally is no longer a discussion of physiology but rather pathophysiology. For example, if a person's resting heart rate is above 100 beats per minute, it could point to a pathological condition.
    f. Discuss the major mechanism used in homeostasis: feedback.
    g. Define feedback and the two types (negative and positive). Use good examples to compare and contrast both types.
    h. Discuss how negative feedback is the most common mechanism used in homeostasis and why.
    i. Discuss that positive feedback is occasionally used as a control method in homeostasis. Describe when and why it is used.
    j. Discuss each component of the feedback loop and how they integrate.

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k. Use specific examples of feedback loop operation.
l. Give an example of a disease state that occurred when the feedback loop malfunctioned.

12. Discuss homeostatic imbalance as it relates to disease states.
    a. Mention deviations from homeostatic ranges and diseases.
    b. Discuss signs versus symptoms of disease. Use outside resources to do this.
    c. Discuss the difference between a diagnostic maneuver versus a therapeutic one. Give good clinical examples of each. Use outside resources to do this.
    d. Use external sources to inform students of the techniques used in a physical exam (palpation, auscultation, percussion, and visualization). Use outside resources to do this.
    e. Discuss the role of some of the various laboratory tests in the clinical diagnostic process. Laboratory tests are ordered after a good history and physical exam has been performed. The specific laboratory tests to be ordered are determined by the findings from the history and physical examination.
13. Discuss the fact that not only anatomists and physiologists use the scientific method to gain an understanding of the normal workings of the human body, clinicians also use this method to explain the abnormal (disease) workings of the human body. Use examples of clinical scenarios to explain the process.
14. Students are very interested in the wide array of radiologic tests, particularly the newer fascinating ones. Use external-related media to show examples of the various radiographic techniques and images.
    a. Discuss the advantages and disadvantages of the standard X-ray.
    b. Discuss what a contrast media is and its advantages in radiographic imaging. Use outside resources to do this.
    c. Discuss the CT scan, noting its benefits and limitations.
    d. Discuss the MRI, noting its benefits and limitations.
    e. Discuss the reason to do a CT scan versus an MRI, and vice versa. MRI allows a better view of soft tissue since it avoids bone. Bone does not have much water. Water is a main factor in the operation of the MRI device.
    f. Discuss the ultrasound in terms of benefit.
    g. Briefly discuss the DSA and PET scan in terms of their advantages.

SUGGESTED CHAPTER OUTLINE

1.1 Anatomy and Physiology Compared: Anatomy is the study of structure and form. Physiology is the study of function of the body parts. (pp. 2–3)

A. Scientific Method (p. 2)
    1. A systematic and rigorous process that scientists use to study a problem.
    2. They use **observation** to examine natural events.
    3. Then develop a **hypothesis** or a possible explanation for their observations.
    4. They devise an **experiment** to test the validity of their hypothesis.
    5. The data are then closely examined to see whether the hypothesis is supported, rejected, or needs to be modified.

B. Anatomy: Details of Structure and Form (p. 2)
    1. **Microscopic anatomy** cannot be seen with the unaided eye. It includes cytology and histology.
    2. **Cytology** is the study of body cells and their internal structure.
    3. **Histology** is the study of tissues.

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4. **Neurophysiology** examines how nerve impulses are propagated throughout the nervous system.
5. **Gross anatomy,** also called **macroscopic anatomy,** investigates the structure and relationships of body parts that are visible to the unaided eye, such as the intestines, stomach, brain, heart, and kidneys. It includes systemic anatomy, regional anatomy, surface anatomy, comparative anatomy, and embryology.
6. **Systemic anatomy** studies the anatomy of each functional body system.
7. **Regional anatomy** examines all of the structures in a particular region of the body as a complete unit.
8. **Surface anatomy** focuses on both superficial anatomic markings and the internal body structures that relate to the skin covering them.
9. **Comparative anatomy** examines similarities and the differences in the anatomy of different species.
10. **Embryology** is the discipline concerned with the developmental changes occurring from conception until birth.
11. Specialized branches of anatomy focus on the diagnosis of medical conditions or the advancement of basic scientific research. These branches include pathologic anatomy and radiographic anatomy.
12. **Pathologic anatomy** examines all anatomic changes resulting from disease.
13. **Radiographic anatomy** investigates the relationships among internal structures that may be visualized by specific scanning procedures such as the ultrasound, magnetic resonance imaging (MRI), or X-ray.

C. Physiology: Details of Function (p. 3)
1. Physiologists examine the function of various organ systems and typically focus on the molecular or cellular level to gain a complete understanding of the system's workings.
2. The discipline parallels anatomy because it also is very broad and may be divided into smaller groups. These groups include cardiovascular physiology, neurophysiology, respiratory physiology, reproductive physiology, and pathophysiology.
3. **Cardiovascular physiology** examines the functioning of the heart, blood vessels, and blood.
4. **Neurophysiology** examines how nerve impulses are propagated throughout the nervous system.
5. **Respiratory physiology** studies how respiratory gases are transferred by gas exchange between the lungs and the blood vessels, supplying the lungs among other things.
6. **Reproductive physiology** explores how the regulation of reproductive hormones can drive the reproductive cycle and influence sex cell production and maturation.
7. **Pathophysiology** investigates the relationship between the functioning of an organ system and disease or injury to that organ system.

1.2 Anatomy and Physiology Integrated: Physiologic function dictates structure's anatomic form. (p. 3 and Figure. 1.1 on pp. 4–5)

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A. Anatomy and physiology initially may appear to be different sciences, but further reflection reveals that these two sciences are integrated, because form (anatomy) and function (physiology) are interrelated.
B. Structure (anatomy) determines the function (physiology) and the function dictates the structure.
C. Anatomists cannot gain a full appreciation of anatomic form without also understanding a structure's function.
D. Physiologists cannot fully appreciate body functions without learning the form of the structures involved.

1.3 How to Study Anatomy and Physiology Effectively (pp. 3–7)

A. Do not wait until the last minute to study.
B. Do not study for long periods of time without breaks.
C. Do not study with multiple distractions.
D. Do not simply passively read over your notes.
E. Do not study by yourself only.
F. Do schedule regular daily study sessions well before the upcoming exam.
G. Do study for multiple, short periods of time.
H. Do minimize your distractions.
I. Do utilize active learning methods when you study, which include making your own tables to organize materials, drawing and labeling anatomic structures, making flow charts, quizzing yourself repeatedly, and explaining/teaching a concept to a partner.
J. Study with a partner or group.
K. Utilize all the resources available in the textbook, which includes learning strategies boxes, concept connection boxes, concept overview figures, multiple assessments in each chapter, LearnSmart, and Anatomy and Physiology Revealed.

1.4 The Body's Levels of Organization: Scientists group the body's components into an organized hierarchy of form and function. (pp. 7–9)

A. Characteristics that Describe Living Things (pp. 7–8)
1. Several properties are common to all organisms, including organization, metabolism, growth, development, responsiveness, regulation, and reproduction.
2. **Organization** is the complex hierarchical structuring of the body.
3. **Metabolism** is the sum of all chemical reactions in the body. Metabolism is subsumed into two interrelated processes, anabolism and catabolism.
4. **Anabolism** is a biochemical building process where small molecules are joined to make larger ones.
5. **Catabolism** is a biochemical breaking down process where large molecules are broken down into smaller ones.
6. **Growth** is the enlargement in the size of an organism.
7. **Development** (differentiation) is the process whereby cells specialize to become more sophisticated for specific functioning, like nerve cells.
8. **Responsiveness** is the ability to sense and react to stimuli.
9. **Regulation** is based in homeostasis. The ability to maintain a constant internal environment in the face of a changing external environment.
10. **Reproduction** is a process that produces new cells for growth, maintenance, and repair. The sex cells are responsible for developing a new living organism.

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B. The View from Simplest to Most Complex (p. 8) and Figure 1.2 (p. 9)
   1. Anatomists and physiologists recognize several levels of increasing complex organization in humans. In increasing hierarchical order, these levels include the chemical level, cellular level, tissue level, organ level, organ system level, and organism level.
   2. The **chemical level** is the simplest level, involving atoms and molecules. Atoms are the smallest intact chemical units and molecules are combinations of atoms.
   3. The **cellular level** consists of cells, which are the smallest living structures and serve as the basic units of structure and function. Interfaced between the chemical level and cellular level are the biochemical macromolecules (carbohydrates, lipids, proteins, and nucleic acids) and the cellular substructures these macromolecules form, which are the organelles.
   4. The **tissue level** is comprised of groups of similar cells (similar embryonic origin) that collectively form common functions.
   5. The **organ level** is composed of human organs that are composed of two or more tissue types that perform specific, complex functions.
   6. The **organ system level** contains organs that work together to coordinate activities and achieve a common function.
   7. The **organism** is the highest level human structural organization, comprised of all of the organ systems working in an integrated functional manner.

C. Introduction to Organ Systems (p. 8); Figure 1.3 (pp. 10–12)
   1. Complex multicellular organisms, like the human, perform a myriad of complex metabolic processes.
   2. The complexity of these processes requires a sophisticated division of physiological labor. Each organ system is assigned a certain major physiological task; its name reflects that major task.
   3. Since a living entity is not merely the sum of its parts, each organ system multitasks. No organ system performs only one task. It is named in accordance with its major task, but its other tasks are also vital to life.
   4. Some tasks are shared by more than one organ system, as exemplified by the control of acid/base balance. This homeostatic control is shared by two organ systems, the respiratory system and the renal system. This sharing of tasks enhances physiological organization.
   5. Due to their primary and secondary functions, some organs are included in more than one organ system.

D. Clinical View: The Human Microbiome: Another Human Organ? (p. 9)
   1. The human microbiome is the total collection of microorganisms living on and within the body, which equals the number of human cells present in the body (about 30-40 trillion)
   2. These unique microorganisms with their own genes, metabolic pathways, and products are deeply woven into our physiology and can have profound effects on our health.
   3. The Human Microbiome Project has given us a great deal of information about the composition and range of this microbial world.

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4. These bacteria flourish in all parts of the body that are exposed to the external environment with some body areas more hospitable than others.
5. The large intestine contains 70% of the entire human microbiome.
6. The microbiome interacts with our body systems and can influence the nervous system; protect us from infection; assist with digestion, energy harvest, and energy utilization; and influence the development of the immune system.
7. Our microbiome is essential to our health and well-being as are the rest of our body organs.

1.5 The Precise Language of Anatomy and Physiology: Clinicians and researchers in anatomy and physiology require a precise language to ensure that they are discussing the same features and functions. (pp. 9–19)

A. Anatomic Position (p. 13); Figure 1.4 (p. 13)
1. **Anatomic position** is a common agreed upon point of reference used when describing the position of certain anatomical structures in the human body. It is very important when discussing relative anatomical terms.
2. In order to assume the position, the person stands erect and upright with their limbs at their sides, their palms facing anteriorly, and feet held together but positioned in a 45° angle from one another.

B. Sections and Planes (pp. 13−14); Figure 1.4 (p. 13); Figure 1.5 (p. 14)
1. The term **section** implies an actual cut or slice to expose the internal anatomy.
2. A **plane** is an imaginary flat surface passing through the body.
3. The planes of the body include the coronal, transverse, sagittal, and oblique planes.
4. A **coronal plane,** also termed a frontal plane, is a vertical plane that divides the body into front (anterior) and back (posterior) parts.
5. A **transverse plane,** also termed a horizontal plane, divides the body into top (superior) and bottom (inferior) parts.
6. A **sagittal plane** divides the body into right and left halves. Since the body is intended to be bilaterally symmetrical, a cut down the middle of the head continuing down through the midline of the trunk (through the umbilicus) will divide the body into equal right and left sections, thus termed a midsagittal plane. If the body is divided into unequal right and left parts, it is simply termed a sagittal plane.
7. The coronal, transverse, and sagittal planes are at perfect 90° angles from one another. If a plane is cut at another angle, it is termed an oblique plane.

C. Anatomic Directions (p. 14); Figure 1.6 (p. 15); Table 1.1 (p. 14)
1. Once the body is positioned in the anatomic position, the researcher or clinician can discuss anatomical structures in terms of relative directional terms. Examples of these terms are anterior, posterior, dorsal, ventral, proximal, and distal.
2. **Anterior** is toward the front surface.
3. **Posterior** is toward the back surface.
4. **Dorsal** is at the back side of the human body.
5. **Ventral** is at the belly side of the human body.
6. **Proximal** refers to a structure on the appendages. It is the structure closest to the point of attachment to the body trunk.
7. **Distal** refers to a structure on the appendages. It is the structure farthest away from the point of attachment to the body trunk.

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D. Regional Anatomy (p. 15) Figure 1.7 (p. 15); Table 1.2 (p. 16)
1. The human body is partitioned into two main regions, the axial and appendicular regions.
2. The **axial region** includes the head, neck, and trunk.
3. The **appendicular region** is composed of the upper and lower limbs, which attach to the axial region.
4. Several more specific regions are located within the two main regions, and they are identified by proper anatomic terminology as noted in Table 1.2: Human Body Regions (p. 16).

E. Body Cavities and Membranes (pp. 16–18); Figure 1.8 (p. 17); Figure 1.9 (p. 18)
1. Internal organs and organ systems are housed within enclosed spaces, or cavities. These body cavities are named either according to the bones that surround them or the organs they contain. The main two body cavities are the posterior cavity and ventral cavity. These two body cavities are subdivided into smaller body cavities according to certain anatomical structures.
2. The posterior body cavity is different from the ventral cavity in that the posterior aspect contains cavities that are completely encased in bone and are physically and developmentally different from the ventral cavity. It is subdivided into two enclosed cavities, the cranial and vertebral cavities.
3. The **cranial cavity** is formed by the bones of the cranium, and so it goes by the name endocranium.
4. The **vertebral cavity** is formed by the bones of the vertebral column and houses the spinal cord.
5. The **ventral cavity** is the large, anteriorly placed cavity in the body. Unlike the posterior cavity, the ventral cavity and its subdivisions do not completely encase their organs. This cavity contains the thoracic and **abdominopelvic cavities.**
6. Ventral body cavities are lined by serous membranes, unlike the posterior cavities.
7. A serous membrane is a continuous layer of cells, as compared to the plasma membrane, which surrounds a single cell.
8. **Serous membranes** are composed of two layers, a parietal layer and a visceral layer.
9. The **parietal layer** lines the internal surface of the body wall.
10. The **visceral layer** covers the external surface of the organ in the cavity.
11. Between the parietal layer and visceral layer of serous membranes is a potential space, called the serous cavity.
12. **Serous membranes** secrete a serous fluid that has an oily consistency. Its purpose is to serve as a lubricant that prevents friction when organs rub against one another in the ventral cavities.
13. The **thoracic cavity,** a subdivision of the ventral cavity, contains three cavities itself. These cavities are the mediastinum cavity, pericardial cavity, and the pleural cavity.
14. The **mediastinum cavity** is located in the median space in the thoracic cavity. It contains the heart, thymus, esophagus, trachea, and major blood vessels that connect to the heart.
15. The **pericardial cavity** is located within the mediastinum, and it encloses the heart in a two-layered serous membrane, called the pericardium.

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16. The **parietal pericardium** is the outermost layer of the serous membrane and forms the sac around the heart, while the visceral pericardium forms the heart's external surface.
17. The pericardial cavity is the potential space between the parietal and visceral pericardium.
18. The pleural cavities are located in the right and left sides of the thoracic cavity; they surround the two lungs.
19. Just like the pericardial cavity, the pleural cavities have two layers of serous membranes. One is the parietal layer and the other is the visceral layer.
20. The parietal layer is the outer layer that surrounds the internal surface of the thoracic wall and the visceral layer covers the external surface of the lungs.
21. The **abdominopelvic cavity** is a subdivision of the ventral body cavity and is separated from the thoracic cavity by a flat dome-shaped muscle, known as the diaphragm.
22. The abdominopelvic cavity is subdivided into two smaller cavities, the abdominal cavity and pelvic cavity, by a horizontal plane at the level of the superior aspects of the hip bones.
23. The abdominal cavity lies superior to this horizontal plane, at the level of the superior aspects of the hip bones. It contains most of the digestive organs along with the kidneys and most of the ureters.
24. The **pelvic cavity** lies inferior to the horizontal plane, at the level of the superior aspects of the hip bones. It contains the distal part of the large intestine, the remainder of the ureter, the urinary bladder, and the internal reproductive organs.
25. Just like the pericardial and pleural membranes, the peritoneum is a two-layered serous membrane that lines the abdominopelvic cavity. It also has a parietal layer and visceral layer.
26. The **parietal peritoneum** is the outermost layer of this serous membrane, lining the internal walls of the abdominopelvic cavity.
27. The **visceral peritoneum** is the inner layer of this serous membrane, covering the external surfaces of most of the abdominopelvic organs.
28. The **peritoneal cavity** is the potential space between the visceral and parietal peritoneum, containing a lubricating fluid: serous fluid.

F. Abdominopelvic Regions and Quadrants (pp. 18−19) Figure 1.10 (p. 19)

1. In order to accurately describe organ location, anatomists and clinicians commonly partition the large abdominopelvic cavity into smaller compartments. Two partitioning methods are used, the nine compartment method and the quadrant method.
2. The nine compartment method divides the abdominopelvic cavity into an **umbilical region, epigastric region, hypogastric region, right hypochondriac region, left hypochondriac region, right lumbar region, left lumbar region, right iliac region,** and **left iliac region.**
3. Some health care professionals prefer to partition the abdomen into four quadrants, using the umbilicus as the central point and having imaginary transverse and midsagittal planes pass through the umbilicus.

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4. The quadrant system divides the abdominal cavity into a **right upper quadrant, right lower quadrant, left upper quadrant,** and **left lower quadrant.**

1.6 Homeostasis: Keeping Internal Conditions Stable: Homeostasis refers to the body's ability to maintain a relatively stable internal environment in response to changing internal or external conditions. (pp. 19–24)

A. Components of Homeostatic Systems (pp. 19–21); Figure 1.11 (p. 20)

1. The body maintains homeostasis by utilizing homeostatic control systems. Three components are associated with each homeostatic system: receptor, control center, and effector.
2. The **receptor** is the body structure that detects changes in a variable, which is either the substance or process that is regulated.
3. The change in the variable is the **stimulus.**
4. The control center is the structure that interprets input from the receptor and initiates changes through the effector. It serves as the go between, integrating the other two components of the homeostatic system.
5. The **effector** is the structure that brings about the change to alter the stimulus. Its action attempts to bring the variable back into optimal homeostatic range, as dictated by the control unit.
6. The components of the homeostatic system form a dynamic control system, known as the feedback loop.
7. The **feedback loop** operates in the following manner: A stimulus is received by the receptor. The receptor information is sent to the control center. The control unit integrates the incoming input and dictates a change utilizing the effectors. The effectors receive input from the control unit, effecting return of the body to homeostasis.
8. Homeostatic control systems are separated into two broad categories based on whether the system maintains the variable within a normal range by moving the stimulus in the opposite direction, or amplifies the stimulus in the same direction.
9. Negative feedback moves the variable in the opposite direction.
10. Positive feedback moves the variable in the same direction.

B. Homeostatic Systems Regulated by Negative Feedback (pp. 21–23); Figure 1.12 (p. 21); Figure 1.13 (pp. 22–23)

1. Most body processes are controlled by **negative feedback.**
2. Negative feedback involves moving the stimulus in the opposite direction. The variable is maintained with a normal level, termed the "set point." Temperature regulation is one example of negative feedback homeostatic control.
3. Human body temperature is monitored by temperature receptors in the skin and by blood passing through a certain area of the brain, known as the hypothalamus.
4. The skin temperature receptors send a signal to the hypothalamus, which is the human body temperature control unit.
5. The hypothalamus sends a signal to the thermal effectors, which are blood vessels in the skin, sweat glands, skeletal muscles, and in some cases smooth muscles associated with hair follicles.
6. In a cold environment, surface blood vessels decrease lumen diameter, thus decreasing blood flow to the skin, leading to decreased heat loss from the body.

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Skeletal muscles increase motion: shivering. In some cases, smooth muscle associated with hair follicles increase contraction: goose bumps.

7. The opposite actions occur in a hot environment for the opposite reasons. Skin blood vessels increase lumen diameter, skeletal muscles decrease motion, and sweat glands increase action.

C. Homeostatic Systems Regulated by Positive Feedback (p. 24); Figure 1.14 (p. 24); Figure 1.15 (p. 24)

1. A homeostatic system may also be controlled by **positive feedback**. In such a case, the stimulus is reinforced to continue in the same direction until a climatic event occurs. Following the climatic event, the body returns to homeostasis.
2. One example of positive feedback, as used in homeostasis, is the breast-feeding process.
3. The baby's suckling of the breast is the initial stimulus, which is detected by the sensory receptors in the skin of the nipple. The receptors send a signal to the control center in the hypothalamus. A signal is sent from the hypothalamus to the anterior pituitary gland, where oxytocin, a hormone, is produced and secreted. The oxytocin travels in the bloodstream to the mammary glands, which are the effectors, causing them to secrete milk.
4. The intensity of suckling force governs the amount milk secretion; the stimulus intensifies the response in the same direction.
5. Once the baby stops suckling (and thus the initial stimulus is removed), then the cycle will stop.
6. Other homeostatic examples of positive feedback are blood coagulation and labor contractions, subsequently leading to childbirth.

1.7 Homeostasis, Health, and Disease: Disease is a result of homeostatic imbalance. (p. 25)

A. Disease occurs when the body is unable to maintain a relatively stable internal environment: homeostatic imbalance.

1. Homeostatic imbalance may sometimes occur due to a normal process, such as aging.
2. Normal homeostatic ranges may be altered as a result of aging.
3. In order to treat a patient, a diagnosis must be made.
4. A **diagnosis** is a finding of the specific cause of the homeostatic imbalance.
5. Some drugs are intended to produce a homeostatic imbalance in order to treat a certain disease, such as when a serotonin reuptake inhibitor (SSRI) is given to raise the level of serotonin out of homeostatic range in an attempt to treat human depression.
6. Some medications adversely alter body processes and chemical levels. These are known as drug side effects.
7. Clinical View: Medical Imaging (pp. 26–27)
    a. **Radiography** is the primary method of obtaining an image of a body part for diagnostic purposes.
    b. **Ultrasound** is an imaging method that transmits high-frequency ultrasonic waves into the body and then receives reflected signals in order to produce an image of internal organs.
    c. **Computerized Tomography,** CT scan, is a more sophisticated application of X-rays, producing multiple axial images of a body organ or region. The

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multiple images are processed and analyzed by a computer, thus producing a three-dimensional image of a thin slice of the body region.

d. **Digital Subtraction Angiography (DSA)** is a modified three-dimensional X-ray technique used primarily to observe blood vessels.
e. **Magnetic Resonance Imaging, MRI,** provides noninvasive images of soft body tissues, using a strong magnetic field and radio waves that alters the energy of protons in the nuclei of hydrogen atoms. Since hydrogen atoms are a main component of water molecules, soft tissues possessing higher water contents are viewed better than hard tissues, such as bone, having lower water contents.
f. **Positron Emission Tomography (PET scan)** uses radioactively labeled glucose molecules to analyze the metabolic state of a tissue at a given moment in time, thus determining which tissues are most metabolically active.

VISUALS, IN-CLASS DEMONSTRATIONS, AND DISCUSSIONS

1. Discuss some of the early discoveries that led to our current understanding of the human body.
2. Models of the early stages of human development (cleavage through gastrula) are good visuals and students can see the changes in sizes of cells and movements during the gastrula stage. Models of later stages of development (fetal) are useful for showing the orientation of the fetus in the female body.
3. Explain how anatomy and physiology are related to one another. Help students visualize the correlation between anatomy and physiology by showing models of the various organ systems and discuss how a structure determines function.
4. Using a SMART Board, discuss PowerPoint slides of the body cavities and internal structures to help students visualize regions of the body.
5. Charts of body cavities and their contents are useful for review.
6. Students enjoy dissectible mannequins and models of the adult body, and they are good visuals.
7. Discuss the differences between microscopic and macroscopic (gross) anatomy. It is important that students understand that dissections are aimed at helping us to understand the functions of each level of organization but that the body works as a whole and is more complex than the sum of its parts.
8. Have the students outline the ways in which the body compensates for the variations in temperature and identify these mechanisms as homeostasis at work when an individual is working outside on a 100°F day, and compare that to being outside on a day that is below freezing.
9. Discuss the thermostat in the classroom with students to demonstrate negative feedback. Students can easily understand the negative feedback system of the HVAC system at work.
10. Discuss the process of childbirth with students to demonstrate positive feedback. There are some childbirth models on the market.

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11. Using a human model, present directional terms as opposites. Discuss how the terms anterior/posterior and superior/inferior refer to different areas for bipeds and quadrupeds. Also, discuss that words are often combined to more accurately identify the relative position of a single structure.
12. Give definitions of word roots, prefixes, and suffixes to help students begin to build a language of biomedical terminology.
13. Using a balloon or plastic bag, show that body cavities lined by serous membranes are generally potential spaces. They are filled with a serous fluid that exhibits a surface tension, thus closing the space. Use water in the balloon or plastic bag to show that surface tension of the fluid creates a potential space that can be easily opened without destruction of the two layers of the balloon or paper bag.
14. Have students work in small groups to practice the human body regional terms with each other or with models.

Related Media

Insight Media. *The last Neanderthal: Competing theories of human origins*.
Winston, Robert M. L. *Interactive universe: The human body*.
Cambridge Educational (Firm). *The human body systems at work*.
Chantilly, VA Teaching Company. *Understanding the human body: An introduction to anatomy and physiology*.
Films for the Humanities and Sciences. *The virtual body*.
Warner Home Video. *The incredible human body*.
Cambridge Educational (Firm). *Human body systems at work*.
Cerebellum Corporation. *The anatomically correct world of anatomy*.
Films for the Humanities (Firm). *The new living body*.
HSTN. *Basic human anatomy*.
Macpherson, Peter. *The body atlas*.
Goldcrest Films and Television. *The living body*.
Interactive Physiology 9-system suite.
Cerebellum Corporation. *Anatomy*.
Karen Goodman. *The incredible human body*.
Marshall, E. G. *National geographic: The incredible human machine*.
www.you.tube for many short videos on the human body.

Related Animations Found in APR—Module 1—Body Orientation

Homeostasis: Thermoregulation

Related Animations Found Under Presentation Tools

Blood sugar regulation
Homeostasis: Introduction
Homeostasis: Digestion blood glucose
Homeostasis: Hypoglycemic condition
Homeostasis: Homeostasis of blood glucose
Positive and negative feedback

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