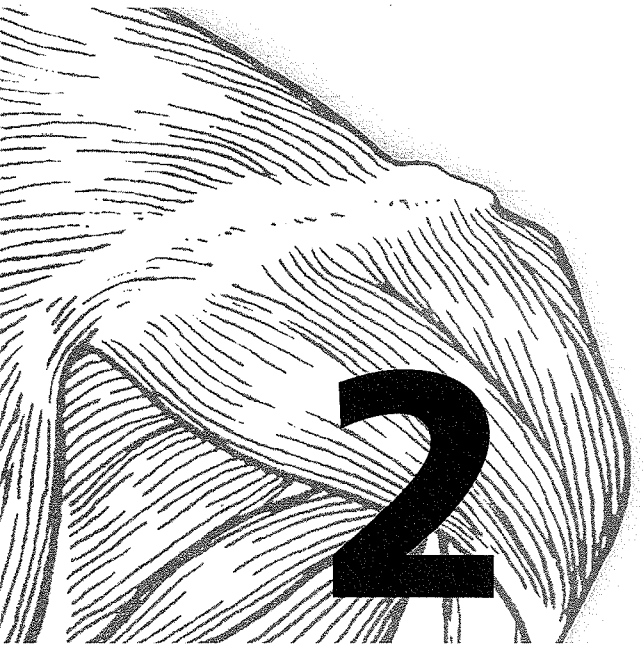


2 BASIC CHEMISTRY

Everything in the universe is composed of one or more elements, the unique building blocks of all matter. Although over 100 elemental substances exist, only four of these (carbon, hydrogen, oxygen, and nitrogen) make up more than 96% of all living material.

The student activities in this chapter consider basic concepts of both inorganic and organic chemistry. Chemistry is the science that studies the composition of matter. Inorganic chemistry studies the chemical composition of nonliving substances that (generally) do not contain carbon. Organic chemistry studies the carbon-based chemistry (or biochemistry) of living organisms, whether they are maple trees, fish, or humans.

Understanding of atomic structure, bonding behavior of elements, and the structure and activities of the most abundant biologic molecules (proteins, fats, carbohydrates, and nucleic acids) is tested in various ways. Mastering these concepts is necessary to understand how the body functions.

CONCEPTS OF MATTER AND ENERGY

1. Select *all* phrases that apply to each of the following statements and insert the letters in the answer blanks.

_____ 1. The energy located in the bonds of food molecules:
- A. is called thermal energy
- B. is a form of potential energy
- C. causes molecular movement
- D. can be transformed to the bonds of ATP

_____ 2. Heat is:
- A. thermal energy
- B. infrared radiation
- C. kinetic energy
- D. molecular movement

_____ 3. Whenever energy is transformed:
- A. the amount of useful energy decreases
- B. some energy is lost as heat
- C. some energy is created
- D. some energy is destroyed

2. Use choices from the key to identify the energy *form* in use in each of the following examples.

Key Choices

A. Chemical B. Electrical C. Mechanical D. Radiant

_____ 1. Chewing food

_____ 2. Vision (two types, please—think!)

_____ 3. Bending your fingers to make a fist

_____ 4. Breaking the bonds of ATP molecules to energize your muscle cells to make that fist

_____ 5. Lying under a sunlamp

COMPOSITION OF MATTER

3. Complete the following table by inserting the missing words.

Particle	Location	Electrical charge	Mass
		+ 1	
Neutron			
	Orbitals		

4. Insert the *chemical symbol* (the chemist's shorthand) in the answer blank for each of the following elements.

_____ 1. Oxygen _____ 4. Iodine _____ 7. Calcium _____ 10. Magnesium

_____ 2. Carbon _____ 5. Hydrogen _____ 8. Sodium _____ 11. Chlorine

_____ 3. Potassium _____ 6. Nitrogen _____ 9. Phosphorus _____ 12. Iron

5. Using the key choices, select the correct responses to the following descriptive statements. Insert the appropriate answers in the answer blanks.

Key Choices

A. Atom C. Element E. Ion G. Molecule I. Protons

B. Electrons D. Energy F. Matter H. Neutrons J. Valence

_____ 1. An electrically charged atom or group of atoms

_____ 2. Anything that takes up space and has mass (weight)

_____ 3. A unique substance composed of atoms having the same atomic number

_____ 4. Negatively charged particles, forming part of an atom

_____ 5. Subatomic particles that determine an atom's chemical behavior, or bonding ability

_____ 6. The ability to do work

_____ 7. The smallest particle of an element that retains the properties of the element

_____ 8. The smallest particle of a compound, formed when atoms combine chemically

_____ 9. Positively charged particles forming part of an atom

_____ 10. Name given to the electron shell that contains the most reactive electrons

_____ 11. _____ 12. Subatomic particles responsible for most of an atom's mass

6. For each of the following statements that is true, insert *T* in the answer blank. If any of the statements are false, correct the underlined term by inserting your correction in the answer blank.

_____ 1. Na^+ and K^+ are needed for nerve cells to conduct electrical impulses.

_____ 2. The atomic number of oxygen is 8. Therefore, oxygen atoms always contain 8 neutrons.

_____ 3. The greater the distance of an electron from the nucleus, the less energy it has.

_____ 4. Electrons are located in more or less designated areas of space around the nucleus called orbitals.

_____ 5. An unstable atom that decomposes and emits energy is called retroactive.

_____ 6. Iron is necessary for oxygen transport in red blood cells.

_____ 7. The most abundant negative ion in extracellular fluid is calcium.

_____ 8. The element essential for the production of thyroid hormones is magnesium.

_____ 9. Calcium is found as a salt in bones and teeth.

MOLECULES, CHEMICAL BONDS, AND CHEMICAL REACTIONS

7. Match the terms in Column B to the chemical equations listed in Column A. Enter the correct letter or term in the answer blanks.

	Column A	Column B
_____	1. $A + B \rightarrow AB$	A. Decomposition
_____	2. $AB + CD \rightarrow AD + CB$	B. Exchange
_____	3. $XY \rightarrow X + Y$	C. Synthesis

8. Figure 2–1 is a diagram of an atom. Select two different colors and use them to color the coding circles and corresponding structures on the figure. Complete this exercise by responding to the questions that follow, referring to the atom in this figure. Insert your answers in the answer blanks provided.

◯ Nucleus

◯ Electrons

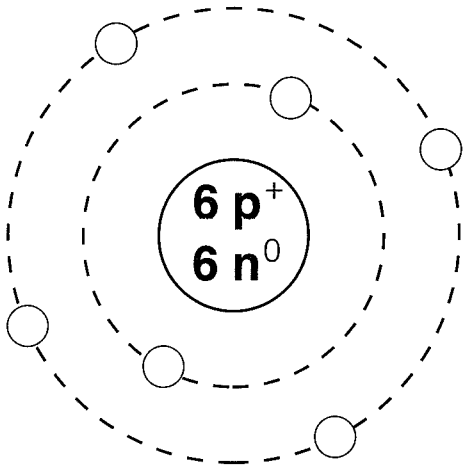


Figure 2–1

1. What is the atomic number of this atom? _____
2. What is its atomic mass? _____
3. What atom is this? _____
4. If this atom had one additional neutron but the other subatomic particles remained the same as shown, this slightly different atom (of the same element) would be called a(n) _____
5. Is this atom chemically active or inert? _____
6. How many electrons would be needed to fill its outer (valence) shell? _____

7. Would this atom most likely take part in forming ionic or covalent bonds? _____ Why? _____

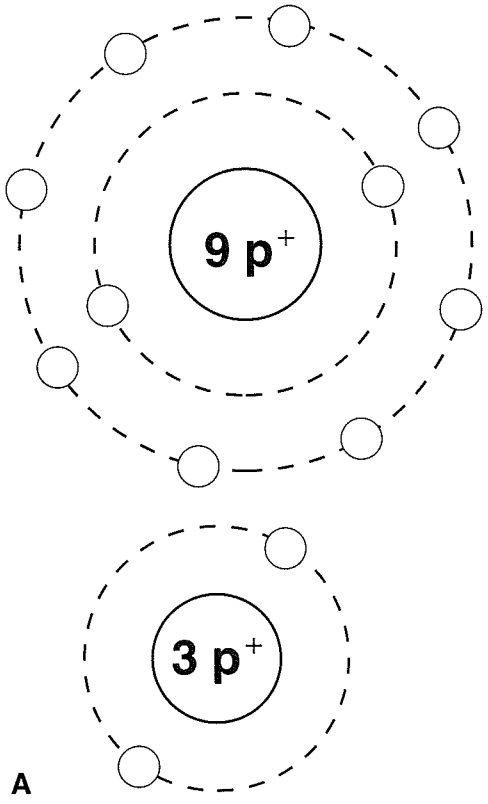
_____

9. Both H_2O_2 and $2OH^-$ are chemical species with two hydrogen atoms and two oxygen atoms. Briefly explain how these species are different:

_____

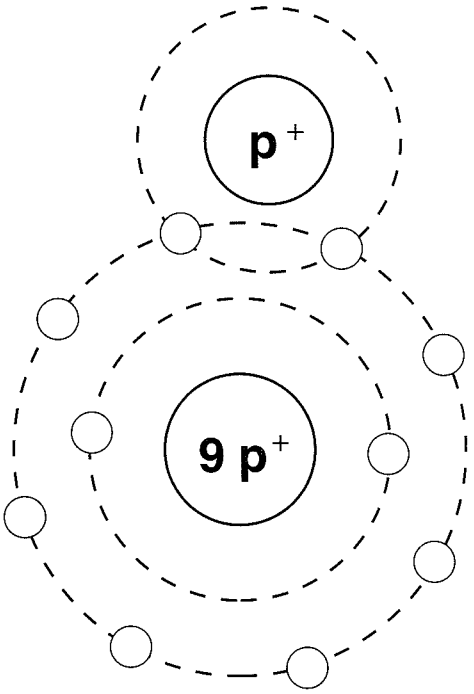
_____

10. Two types of chemical bonding are shown in Figure 2–2. In the figure, identify each type as a(n) *ionic* or *covalent* bond. In the case of the ionic bond, indicate which atom has lost an electron by adding a colored arrow to show the direction of electron transfer. For the covalent bond, indicate the shared electrons.



A

Type of bond: _____



B

Type of bond: _____

Figure 2–2

11. Figure 2–3 illustrates five water molecules held together by hydrogen bonds. First, correctly identify the oxygen and hydrogen atoms both by color and by inserting their atomic symbols on the appropriate circles (atoms). Then label the following structures in the figure:

- ◯ Oxygen
- ◯ Hydrogen
- ◯ Positive pole (end)
- ◯ Negative pole (end)
- ◯ Hydrogen bonds

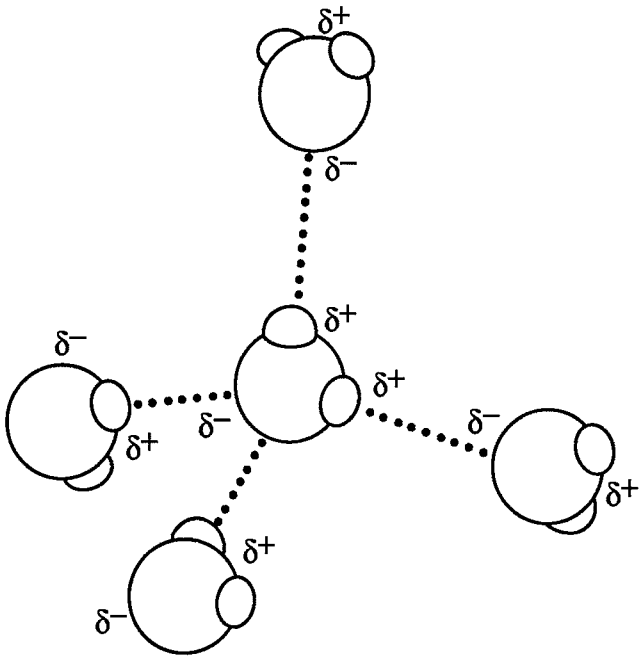
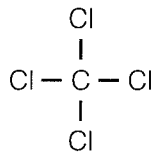


Figure 2–3

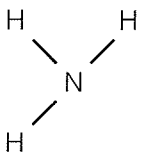
12. Circle each structural formula that is *likely* to be a polar covalent compound.

A



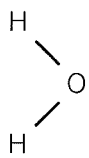
B H — Cl

C



D Cl — Cl

E



13. Respond to the instructions following the equation:

$$H_2CO_3 \longrightarrow H^+ + HCO_3^-$$

1. In the space provided, list the chemical formula(s) of compounds. _____
2. In the space provided, list the chemical formula(s) of ions. _____
3. Circle the product(s) of the reaction.
4. Modify the equation by adding a colored arrow in the proper place to indicate that the reaction is reversible.

BIOCHEMISTRY: THE COMPOSITION OF LIVING MATTER

14. Use the key choices to identify the substances described in the following statements. Insert the appropriate letter(s) or corresponding term(s) in the answer blanks.

Key Choices

A. Acid(s) B. Base(s) C. Buffer D. Salt(s)

_____ 1. _____ 2. _____ 3. Substances that ionize in water; good electrolytes

_____ 4. Proton (H^+) acceptor

_____ 5. Ionize in water to release hydrogen ions and a negative ion other than hydroxide (OH^-)

_____ 6. Ionize in water to release ions other than H^+ and OH^-

_____ 7. Formed when an acid and a base are combined

_____ 8. Substances such as lemon juice and vinegar

_____ 9. Prevents rapid/large swings in pH

15. Complete the following statements concerning the properties and biological importance of water.

_____ 1.
_____ 2.
_____ 3.
_____ 4.
_____ 5.
_____ 6.
_____ 7.
_____ 8.

The ability of water to maintain a relatively constant temperature and thus prevent sudden changes is because of its high __(1)__. Biochemical reactions in the body must occur in __(2)__. About __(3)__ % of the volume of a living cell is water. Water molecules are bonded to other water molecules because of the presence of __(4)__ bonds. Water, as H^+ and OH^- ions, is essential in biochemical reactions such as __(5)__ and __(6)__ reactions. Because of its __(7)__, water is an excellent solvent and forms the basis of mucus and other body __(8)__.

16. Use an *X* to designate which of the following are organic compounds.

_____ Carbon dioxide _____ Fats _____ Proteins _____ H_2O

_____ Oxygen _____ KCl _____ Glucose _____ DNA

17. Using the key choices, fully characterize weak and strong acids.

Key Choices

A. Ionize completely in water

B. Ionize incompletely in water

C. Act as part of a buffer system

D. When placed in water, always act to change the pH

E. Ionize at high pH

F. Ionize at low pH

G. Ionize at pH 7

Weak acid: _____ Strong acid: _____

18. Match the terms in Column B to the descriptions provided in Column A. Enter the correct letter(s) or term(s) in the answer blanks.

Column A

_____ 1. Building blocks of carbohydrates

_____ 2. Building blocks of fat

_____ 3. Building blocks of protein

_____ 4. Building blocks of nucleic acids

_____ 5. Cellular cytoplasm is primarily composed of this substance

_____ 6. The single most important fuel source for body cells

_____ 7. Not soluble in water

_____ 8. Contain C, H, and O in the ratio CH_2O

_____ 9. Contain C, H, and O, but have relatively small amounts of oxygen

_____ 10. _____ 11. These building blocks contain N in addition to C, H, and O

_____ 12. Contain P in addition to C, H, O, and N

_____ 13. Used to insulate the body and found in all cell membranes

_____ 14. Primary components of meat and cheese

_____ 15. Primary components of bread and lollipops

_____ 16. Primary components of egg yolk and peanut oil

_____ 17. Include collagen and hemoglobin

_____ 18. Class that usually includes cholesterol

Column B

A. Amino acids

B. Carbohydrates

C. Lipids (fats)

D. Fatty acids

E. Glycerol

F. Nucleotides

G. Monosaccharides

H. Proteins

19. Using the key choices, correctly select *all* terms that correspond to the following descriptions. Insert the correct letter(s) or their corresponding term(s) in the answer blanks.

Key Choices

A. Cholesterol	D. Enzyme	G. Hormones	J. Maltose
B. Collagen	E. Glycogen	H. Keratin	K. RNA
C. DNA	F. Hemoglobin	I. Lactose	L. Starch

_____ 1. Example(s) of fibrous (structural) proteins

_____ 2. Example(s) of globular (functional) proteins

_____ 3. Biologic catalyst

_____ 4. Plant storage carbohydrate

_____ 5. Animal storage carbohydrate

_____ 6. The "stuff" of the genes

_____ 7. A steroid

_____ 8. Double sugars, or disaccharides

20. Five simplified diagrams of biological molecules are depicted in Figure 2–4. First, identify the molecules and insert the correct names in the answer blanks on the figure. Then select a different color for each molecule listed below and use them to color the coding circles and the corresponding molecules on the illustration.

◯ Fat ◯ Nucleotide ◯ Monosaccharide

◯ Functional protein ◯ Polysaccharide

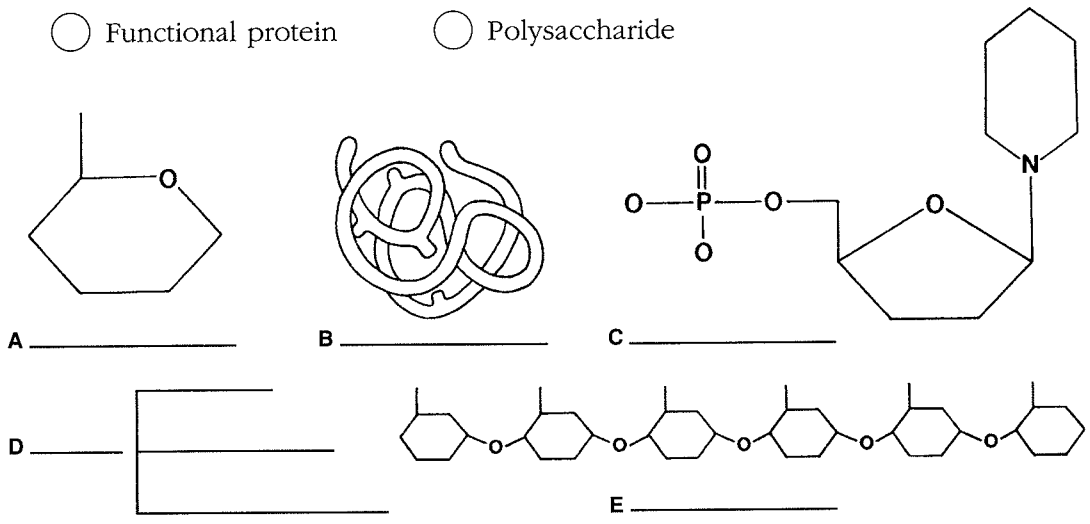


Figure 2–4

21. Circle the term that does not belong in each of the following groupings.

1. Adenine Guanine Glucose Thymine
2. DNA Ribose Phosphate Deoxyribose
3. Galactose Glycogen Fructose Glucose
4. Amino acid Polypeptide Glycerol Protein
5. Glucose Sucrose Lactose Maltose

22. For each true statement, insert *T* in the answer blank. If any are false, correct the underlined term and insert your correction in the answer blank.

_____ 1. Phospholipids are polarized molecules.

_____ 2. Steroids are the major form in which body fat is stored.

_____ 3. Water is the most abundant compound in the body.

_____ 4. Nonpolar molecules are generally soluble in water.

_____ 5. The bases of RNA are A, G, C, and U.

_____ 6. The universal energy currency of living cells is RNA.

_____ 7. RNA is single stranded.

_____ 8. The four elements that make up more than 90% of living matter are C, H, N, and Na.

23. Figure 2–5 shows the molecular structure of DNA, a nucleic acid.

A. First, identify the two unnamed nitrogen (N) bases and insert their correct names and symbols in the two blanks beside the color-coding circles.

B. Complete the identification of the bases on the diagram by inserting the correct symbols in the appropriate spaces on the right side of the diagram.

C. Select different colors and color the coding circles and the corresponding parts of the diagram.

D. Label one deoxyribose (d-R) sugar unit and one phosphate (P) unit of the "backbones" of the DNA structure by inserting leader lines and labels on the diagram.

E. Circle the associated nucleotide.

◯ Deoxyribose sugar (d-R) ◯ Adenine (A) ◯ _____ ( )

◯ Phosphate (P) ◯ Cytosine (C) ◯ _____ ( )

Then answer the questions following Figure 2–5 by writing your answers in the answer blanks.

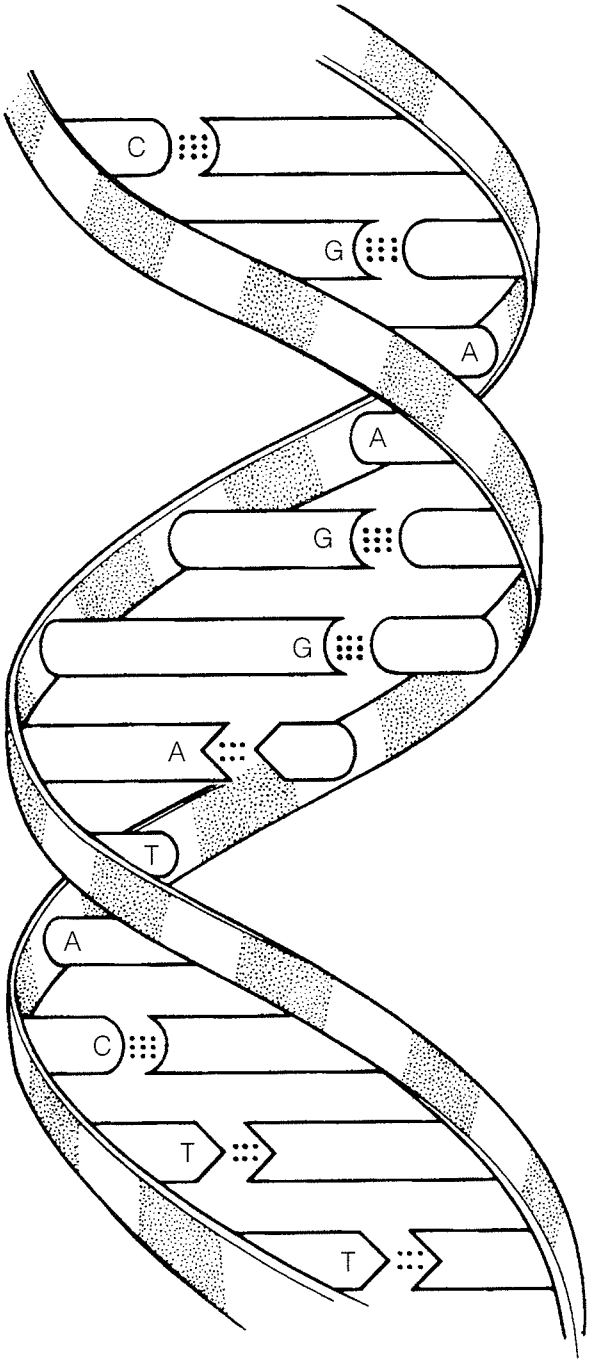


Figure 2–5

1. Name the bonds that help to hold the two DNA strands together. _____
2. Name the three-dimensional shape of the DNA molecule. _____
3. How many base pairs are present in this segment of a DNA model? _____
4. What is the term that means "base pairing"? _____

24. The biochemical reaction shown in Figure 2–6 represents the complete digestion of a polymer (a large molecule as consumed in food) down to its constituent monomers, or building blocks. Select two colors and color the coding circles and the structures. Then, select the one correct answer for each statement below and insert your answer in the answer blank.

◯ Monomer ◯ Polymer

Figure 2–6

_____ 1. If starch is the polymer, the monomer is:

A. glycogon B. amino acid C. glucose D. maltose

_____ 2. During polymer digestion, water as H^+ and OH^- ions would:

A. be a product of the reaction.

B. act as a catalyst.

C. enter between monomers, bond to them, and keep them separated.

D. not be involved in this reaction.

_____ 3. Another name for the chemical digestion of polymers is:

A. dehydration B. hydrolysis C. synthesis D. displacement

_____ 4. If the monomers are amino acids, they may differ from each other by their:

A. R group B. amino group C. acid group D. peptide bond

INCREDIBLE JOURNEY

A Visualization Exercise for Biochemistry

. . . you are suddenly upended and are carried along in a sea of water molecules at almost unbelievable speed.

25. Complete the narrative by inserting the missing words in the answer blanks.

For this journey, you are miniaturized to the size of a very small molecule by colleagues who will remain in contact with you by radio. Your instructions are to play the role of a water molecule and to record any reactions that involve water molecules. Considering water molecules are polar

_____ 1.
_____ 2.
_____ 3.
_____ 4.
_____ 5.
_____ 6.
_____ 7.
_____ 8.
_____ 9.
_____ 10.
_____ 11.
_____ 12.
_____ 13.
_____ 14.
_____ 15.

molecules, you are outfitted with an insulated rubber wet suit with one __(1)__ charge at your helmet and two __(2)__ charges, one at the end of each leg.

As soon as you are injected into your host's bloodstream, you feel as though you are being pulled apart. Some large, attractive forces are pulling at your legs from different directions! You look about but can see only water molecules. After a moment's thought, you remember the polar nature of your wet suit. You record that these forces must be the __(3)__ that are easily formed and easily broken in water.

After this initial surprise, you are suddenly upended and carried along in a sea of water molecules at almost unbelievable speed. You have just begun to observe some huge, red, disk-shaped structures (probably __(4)__) taking up O_2 molecules when you are swept into a very turbulent environment. Your colleagues radio that you are in the small intestine. With difficulty, because of numerous collisions with other molecules, you begin to record the various types of molecules you see.

In particular, you notice a very long helical molecule made of units with distinctive R-groups. You identify and record this type of molecule as a __(5)__, made of units called __(6)__ that are joined together by __(7)__ bonds. As you move too close to the helix during your observations, you are nearly pulled apart to form two ions, __(8)__, but you breathe a sigh of relief as two ions of another water molecule take your place. You watch as these two ions move between two units of the long helical molecule. Then, in a fraction of a second, the bond between the two units is broken. As you record the occurrence of this chemical reaction, called __(9)__, you are jolted into another direction by an enormous globular protein, the very same __(10)__ that controls and speeds up this chemical reaction.

Once again you find yourself in the bloodstream, heading into an organ identified by your colleagues as the liver. Inside a liver cell, you observe many small monomers, made up only of C, H, and O atoms. You identify these units as __(11)__ molecules because the liver cells are bonding them together to form very long, branched polymers called __(12)__. You record that this type of chemical reaction is called __(13)__, and you happily note that this reaction also produces __(14)__ molecules like you!

After another speedy journey through the bloodstream, you reach the skin. You move deep into the skin and finally gain access to a sweat gland. In the sweat gland, you collide with millions of water molecules and some ionized salt molecules that are continually attracted to your positive and negative charges. Suddenly, the internal temperature rises, and molecular collisions __(15)__ at an alarming rate, propelling you through the pore of the sweat gland onto the surface of the skin. So that you will be saved from the fate of evaporating into thin air, you contact your colleagues and are speedily rescued.

AT THE CLINIC

26. It is determined that a patient is in acidosis. What does this mean, and would you treat the condition with a chemical that would *raise* or *lower* the pH?

27. A newborn is diagnosed with sickle cell anemia, a genetic disease in which substitution of one amino acid results in abnormal hemoglobin. Explain to the parents how the substitution can have such a drastic effect on the structure of the protein.

28. Johnny's body temperature is spiking upward. When it reaches 104°F, his mother puts in a call to the pediatrician. She is advised to give Johnny children's acetaminophen or ibuprofen and sponge his body with cool to tepid water to prevent a further rise in temperature. How might a fever (excessively high body temperature) be detrimental to Johnny's welfare?

29. Mrs. Gallo's physician suspects that she is showing the initial signs of multiple sclerosis, a disease characterized by the formation of hardened plaques in the insulating sheaths surrounding nerve fibers. What medical imaging technique will the physician probably order to determine if such plaques are present?

30. Stanley has indigestion and is doubled over with pain. How could an antacid reduce his stomach discomfort?

31. Explain why the formation of ATP from ADP and P_i requires more energy than the amount released for cellular use when ATP is broken down.

THE FINALE: MULTIPLE CHOICE

32. Select the best answer or answers from the choices given.

1. Which of the following is (are) true concerning the atomic nucleus?
   A. Contains the mass of the atom
   B. The negatively charged particles are here
   C. Particles can be ejected
   D. Contains particles that determine atomic number
   E. Contains particles that interact with other atoms

2. Organic compounds include:
   A. water
   B. carbon dioxide
   C. oxygen
   D. carbonic acid
   E. glycerol

3. Important functions of water include:
   A. cushioning
   B. transport medium
   C. participation in chemical reactions
   D. solvent for sugars, salts, and other solutes
   E. reducing temperature fluctuations

4. Which of the elements listed is the most abundant extracellular anion?
   A. Phosphorus
   B. Sulfur
   C. Potassium
   D. Chloride
   E. Calcium

5. The element essential for normal thyroid function is:
   A. iodine
   B. iron
   C. copper
   D. selenium
   E. zinc

6. Alkaline substances include:
   A. gastric juice
   B. water
   C. blood
   D. orange juice
   E. ammonia

7. Which of the following is (are) not a monosaccharide?
   A. Glucose
   B. Fructose
   C. Sucrose
   D. Glycogen
   E. Deoxyribose

8. Which is a building block of neutral fats?
   A. Ribose
   B. Guanine
   C. Glycerol
   D. Glycine
   E. Glucose

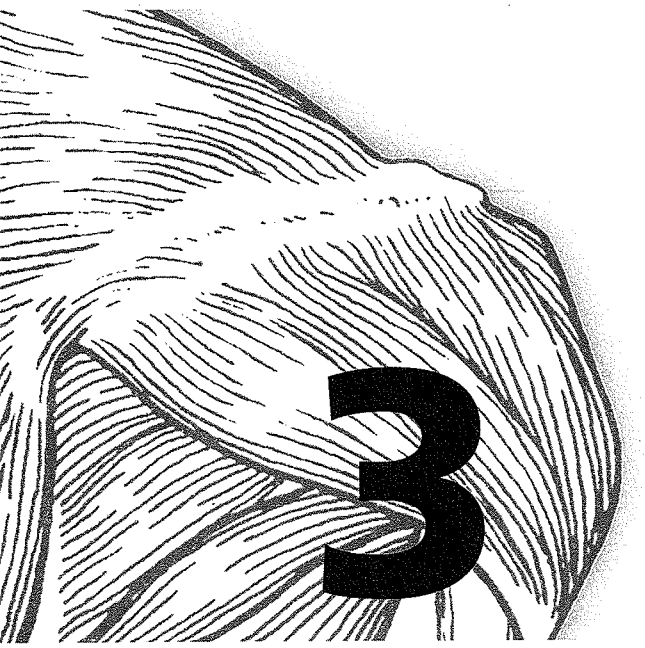
9. Which of the following is primarily responsible for the helical structure of a polypeptide chain?
   A. Hydrogen bonding
   B. Tertiary folding
   C. Peptide bonding
   D. Quaternary associations
   E. Complementary base pairing

10. Which of the following is (are) not true of RNA?
    A. Double-stranded
    B. Contains cytosine
    C. Directs protein synthesis
    D. Found primarily in the nucleus
    E. Can act as an enzyme

11. DNA:
    A. contains uracil
    B. is a helix
    C. is the "genes"
    D. contains ribose

12. Glucose is to starch as:
    A. a steroid is to a lipid
    B. a nucleotide is to nucleic acid
    C. an amino acid is to a protein
    D. a polypeptide is to an amino acid

13. Energy contained in molecular bonds is:
    A. electrical
    B. mechanical
    C. chemical
    D. radiant
    E. kinetic



3 CELLS AND TISSUES

The basic unit of structure and function in the human body is the cell. Each of a cell's parts, or organelles, as well as the entire cell, is organized to perform a specific function. Cells have the ability to metabolize, grow and reproduce, move, and respond to stimuli. The cells of the body differ in shape, size, and in specific roles in the body. Cells that are similar in structure and function form tissues, which, in turn, construct the various body organs.

Student activities in this chapter include questions relating to the structure and function of the generalized animal cell and to the general arrangement of tissues and their contribution to the activities of the various body organs.

CELLS

Overview

1. Answer the following questions by inserting your responses in the answer blanks.

_____ 1.

_____ 2.

_____ 3.

_____ 4.

_____ 5.

_____ 6.

_____ 7.

_____ 8.

_____ 9.

_____ 10.

1–4. Name the four elements that make up the bulk of living matter.

5. Name the single most abundant material or substance in living matter.

6. Name the trace element most important for making bones hard.

7. Name the element, found in small amounts in the body, that is needed to make hemoglobin for oxygen transport.

8–12. Although there are many specific "jobs" that certain cells are able to do, name five functions common to all cells.

_____ 11.

_____ 12. →

_____13.

_____14.

_____15.

_____16.

_____17.

13–15. List three different cell shapes.

16. Name the fluid, similar to seawater, that surrounds and bathes all body cells.

17. Name the flattened cells, important in protection, that fit together like tiles. (This is just one example of the generalization that a cell's structure is very closely related to its function in the body.)

Anatomy of a Generalized Cell

2. Using the list of terms on the following page, correctly label all cell parts indicated by leader lines in Figure 3–1. Then select different colors for each structure and use them to color the coding circles and the corresponding structures in the illustration.

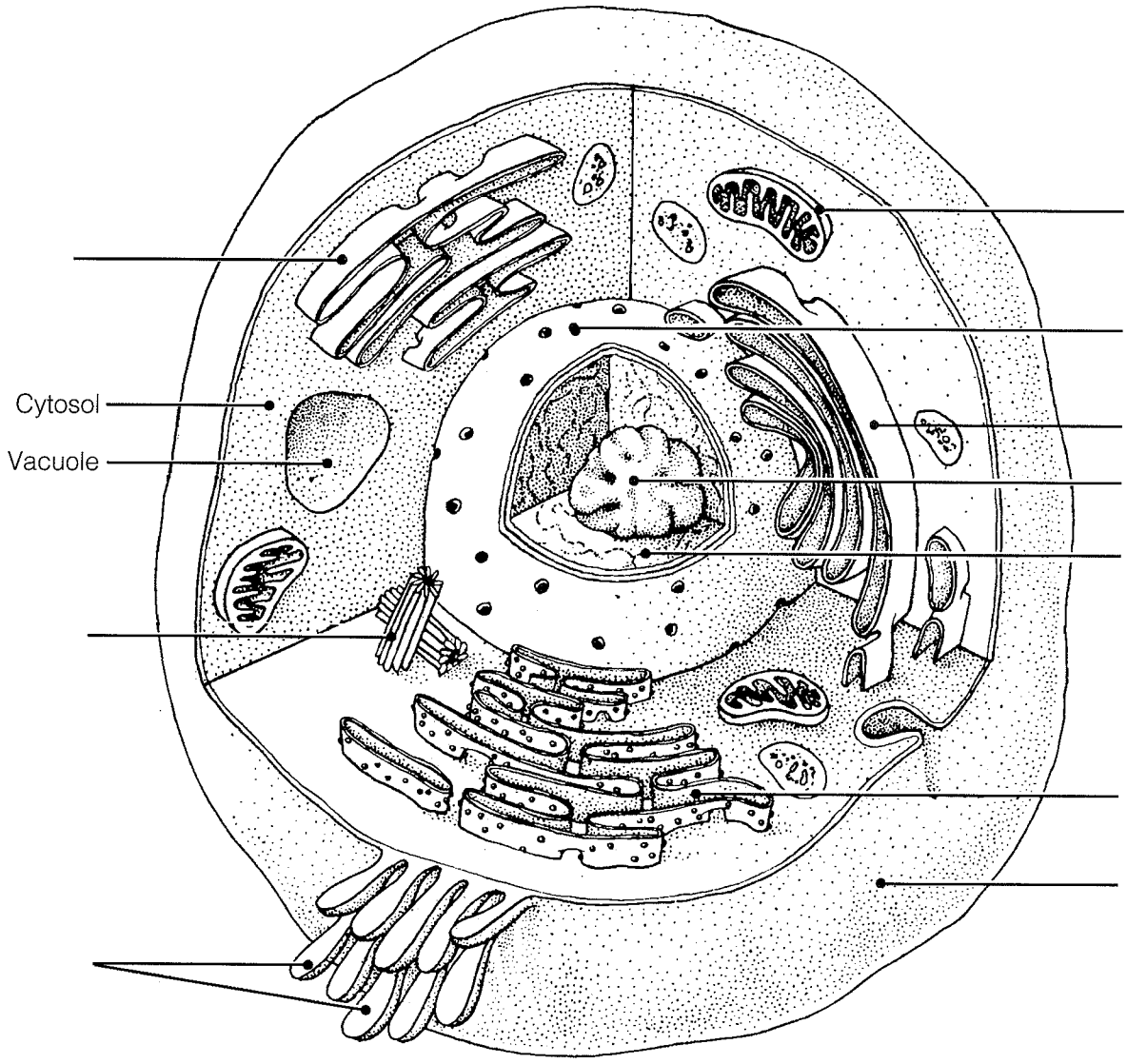


Figure 3–1

- ◯ Plasma membrane
- ◯ Centriole(s)
- ◯ Chromatin thread(s)
- ◯ Golgi apparatus
- ◯ Microvilli
- ◯ Mitochondrion
- ◯ Nuclear membrane
- ◯ Nucleolus
- ◯ Rough endoplasmic reticulum (ER)
- ◯ Smooth endoplasmic reticulum (ER)

3. Figure 3–2 is a diagram of a portion of a plasma membrane. Select three different colors and color the coding circles and the corresponding structures in the diagram. Then respond to the questions that follow, referring to Figure 3–2 and insert your answers in the answer blanks.

◯ Phospholipid molecules ◯ Carbohydrate molecules ◯ Protein molecules

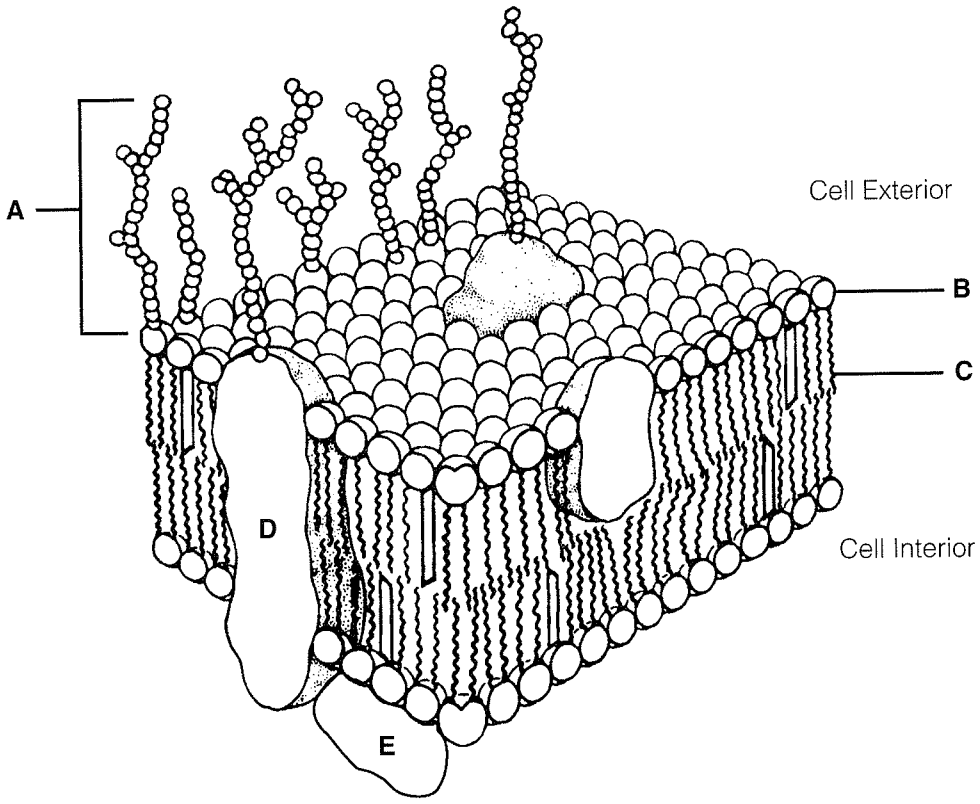


Figure 3–2

1. Name the carbohydrate-rich area at the cell surface (indicated by bracket A). _____
2. Which label, B or C, indicates the nonpolar region of a phospholipid molecule? _____
3. Does nonpolar mean hydrophobic or hydrophilic? _____
4. What are two roles of the membrane proteins? _____

   and _____

4. Label the specializations of the plasma membrane, shown in Figure 3–3, and color the diagram as you wish. Then, answer the questions provided below that refer to this figure.

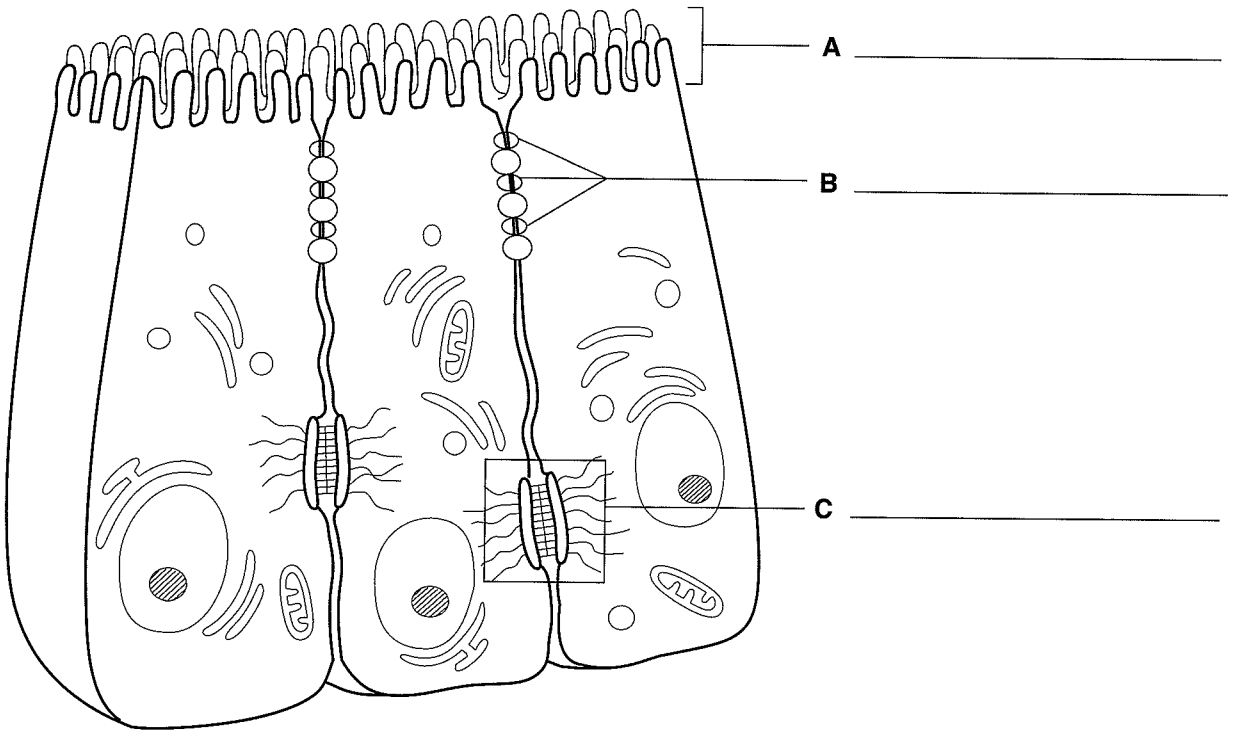


Figure 3–3

1. What type of cell function(s) does the presence of microvilli typically indicate? _____
2. Which cell junction forms an impermeable barrier? _____
3. Which cell junction is an anchoring junction? _____
4. Which junction has linker proteins spanning the intercellular space? _____
5. Which cell junction is not illustrated, and what is its function? _____

_____

5. Relative to cellular organelles, circle the term or phrase that does not belong in each of the following groupings.

1. Peroxisomes Enzymatic breakdown Centrioles Lysosomes
2. Microtubules Intermediate filaments Cytoskeleton Cilia
3. Ribosomes Smooth ER Rough ER Protein synthesis
4. Mitochondrion Cristae ATP production Vitamin A storage
5. Centrioles Mitochondria Cilia Flagella
6. ER Nuclear pores Ribosomes Transport vesicles Golgi apparatus
7. Nucleus DNA Lysosomes Chromatin Nucleolus

6. Name the cytoskeletal element (microtubules, microfilaments, or intermediate filaments) described by each of the following phrases.

_____ 1. Give the cell its shape

_____ 2. Resist tension placed on a cell

_____ 3. Radiate from the cell center

_____ 4. Involved in moving intracellular structures

_____ 5. Are the most stable

_____ 6. Have the thickest diameter

7. Different organelles are abundant in different cell types. Match the cell types with their abundant organelles by selecting a letter from the key choices.

Key Choices

A. Mitochondria C. Rough ER E. Microfilaments G. Intermediate filaments

B. Smooth ER D. Peroxisomes F. Lysosomes H. Golgi apparatus

_____ 1. Cell lining the small intestine (assembles fats)

_____ 2. White blood cell; a phagocyte

_____ 3. Liver cell that detoxifies carcinogens

_____ 4. Muscle cell (contractile cell)

_____ 5. Mucus–secreting cell (secretes a protein product)

_____ 6. Cell at external skin surface (withstands friction and tension)

_____ 7. Kidney tubule cell (makes and uses large amounts of ATP)

Cell Physiology

Membrane Transport

8. Figure 3–4 shows a semipermeable sac, containing 4% NaCl, 9% glucose, and 10% albumin, suspended in a solution with the following composition: 10% NaCl, 10% glucose, and 40% albumin. Assume the sac is permeable to all substances *except* albumin. Using the key choices, insert the letter indicating the correct event in the answer blanks.

Key Choices

A. Moves into the sac B. Moves out of the sac C. Does not move

_____ 1. Glucose _____ 3. Albumin

_____ 2. Water _____ 4. NaCl

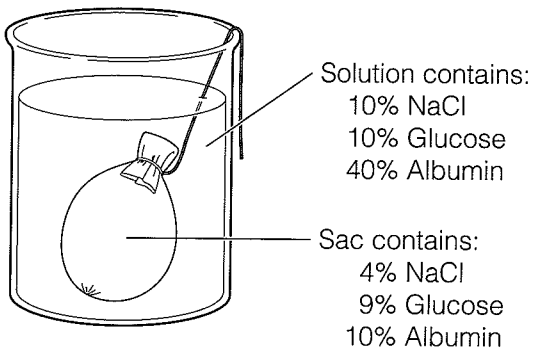


Figure 3–4

9. Figure 3–5 shows three microscopic fields (A–C) containing red blood cells. Arrows indicate the direction of net osmosis. Respond to the following questions, referring to Figure 3–5, by inserting your responses in the spaces provided.

1. Which microscopic field contains a *hypertonic* solution? _____

   The cells in this field are said to be _____

2. Which microscopic field contains an isotonic bathing solution? _____

   What does *isotonic* mean? _____

   _____

3. Which microscopic field contains a *hypotonic* solution? _____

   What is happening to the cells in this field and why? _____

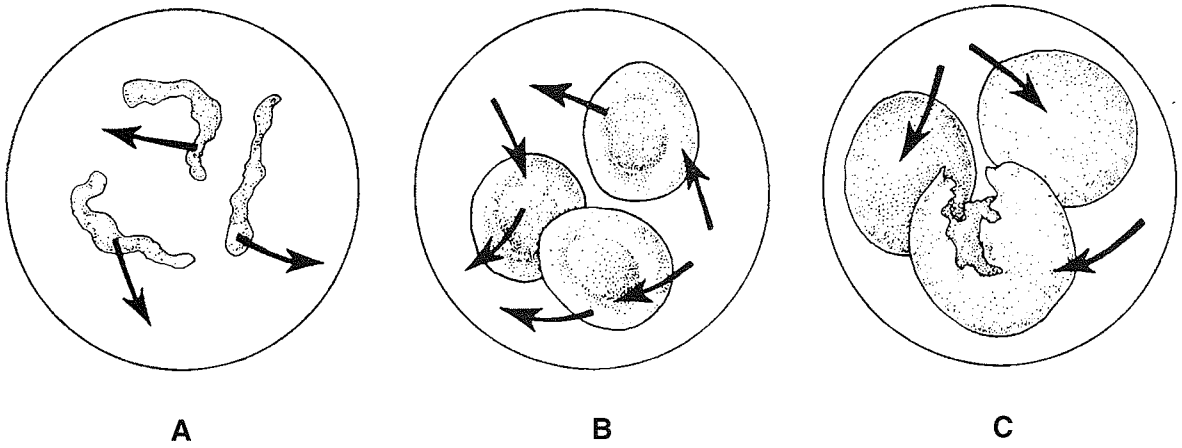


Figure 3–5

10. Figure 3–6 is a simplified diagram of the plasma membrane. Structure A represents channel proteins constructing a pore, structure B represents an ATP-energized solute pump, and structure C is a transport protein that does not depend on energy from ATP. Identify these structures and the membrane phospholipids by color before continuing.

◯ Channel ◯ Solute pump ◯ Passive transport protein carrier ◯ Phospholipids

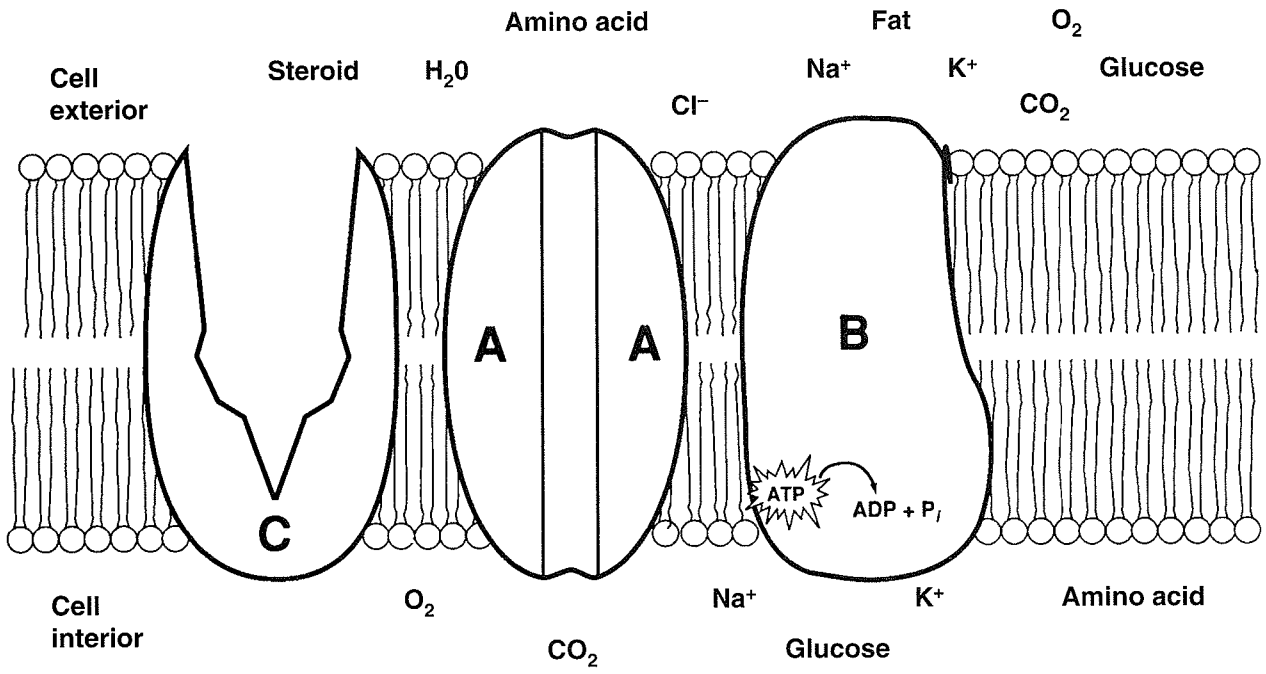


Figure 3–6

Now add arrows to Figure 3–6 as instructed next: For each substance that moves through the plasma membrane, draw an arrow indicating its (most likely) direction of movement (into or out of the cell). If it is moved actively, use a red arrow; if it is moved passively, use a blue arrow.

→

Finally, answer the following questions referring to Figure 3–6:

1. Which of the substances shown moves passively *through the lipid* part of the membrane? _____
2. Which of the substances shown enters the cell by attachment to a passive-transport protein carrier? _____
3. Which of the substances shown moves passively through the membrane by moving through its pores? _____
4. Which of the substances shown would have to use a solute pump to be transported through the membrane? _____

11. Select the key choices that characterize each of the following statements. Insert the appropriate answers in the answer blanks.

Key Choices

A. Active transport	D. Exocytosis	G. Phagocytosis
B. Diffusion, simple	E. Facilitated diffusion	H. Pinocytosis
C. Diffusion, osmosis	F. Filtration	I. Receptor-mediated endocytosis

_____ 1. Engulfment processes that require ATP

_____ 2. Driven by molecular energy

_____ 3. Driven by hydrostatic (fluid) pressure (typically blood pressure in the body)

_____ 4. Moves down a concentration gradient

_____ 5. Moves up (against) a concentration gradient; requires a carrier

_____ 6. Moves small or lipid-soluble solutes through the membrane

_____ 7. Transports amino acids and Na^+ through the plasma membrane

_____ 8. Examples of vesicular transport

_____ 9. A means of bringing fairly large particles into the cell

_____ 10. Used to eject wastes and to secrete cell products

_____ 11. Membrane transport using channels or carrier proteins that does not require ATP

Cell Division

12. The following statements provide an overview of the structure of DNA (genetic material) and its role in the body. Choose responses from the key choices that complete the statements. Insert the appropriate answers in the answer blanks.

Key Choices

A. Adenine	G. Enzymes	M. Nucleotides	S. Ribosome
B. Amino acids	H. Genes	N. Old	T. Sugar (deoxyribose)
C. Bases	I. Growth	O. Phosphate	U. Template, or model
D. Codons	J. Guanine	P. Proteins	V. Thymine
E. Complementary	K. Helix	Q. Replication	W. Transcription
F. Cytosine	L. New	R. Repair	X. Uracil

_____ 1.
_____ 2.
_____ 3.
_____ 4.
_____ 5.
_____ 6.
_____ 7.
_____ 8.

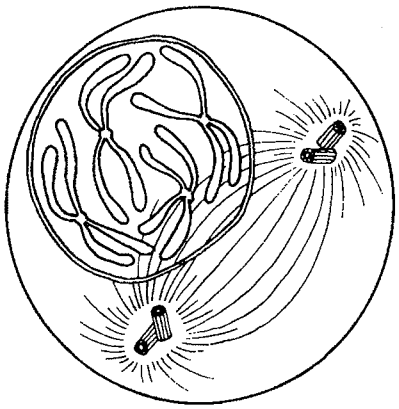
DNA molecules contain information for building specific __(1)__. In a three-dimensional view, a DNA molecule looks like a spiral staircase; this is correctly called a __(2)__. The constant parts of DNA molecules are the __(3)__ and __(4)__ molecules, forming the DNA-ladder uprights, or backbones. The information of DNA is actually coded in the sequence of nitrogen-containing __(5)__, which are bound together to form the "rungs" of the DNA ladder. When the four DNA bases are combined in different three-base sequences, called triplets, different __(6)__ of the protein are called for. It is said that the N-containing bases of DNA are __(7)__, which means that only certain bases can fit or interact together. Specifically, this means that __(8)__ can bind with guanine, and adenine binds with __(9)__.

_____ 9.
_____ 10.
_____ 11.
_____ 12.
_____ 13.
_____ 14.
_____ 15.
_____ 16.
_____ 17.
_____ 18.

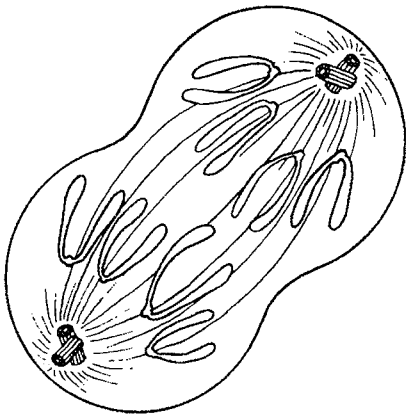
The production of proteins involves the cooperation of DNA and RNA. RNA is another type of nucleic acid that serves as a "molecular slave" to DNA. That is, it leaves the nucleus and carries out the instructions of the DNA for the building of a protein on a cytoplasmic structure called a __(10)__. When a cell is preparing to divide, in order for its daughter cells to have all its information, it must oversee the __(11)__ of its DNA so that a "double dose" of genes is present for a brief period. For DNA synthesis to occur, the DNA must uncoil, and the bonds between the N bases must be broken. Then the two single strands of __(12)__ each act as a __(13)__ for the building of a whole DNA molecule. When completed, each DNA molecule formed is half __(14)__ and half __(15)__. The fact that DNA replicates before a cell divides ensures that each daughter cell has a complete set of __(16)__. Cell division, which then follows, provides new cells so that __(17)__ and __(18)__ can occur.

13. Identify the phases of mitosis depicted in Figure 3–7 by inserting the correct name in the blank under the appropriate diagram. Then select different colors to represent the structures listed below and use them to color in the coding circles and the corresponding structures in the illustration.

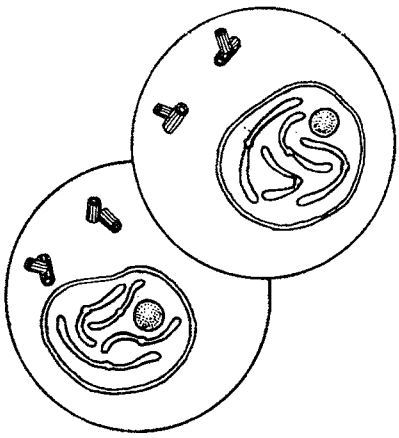
- ◯ Nuclear membrane(s), if present
- ◯ Nucleoli, if present
- ◯ Chromosomes
- ◯ Centrioles
- ◯ Spindle fibers



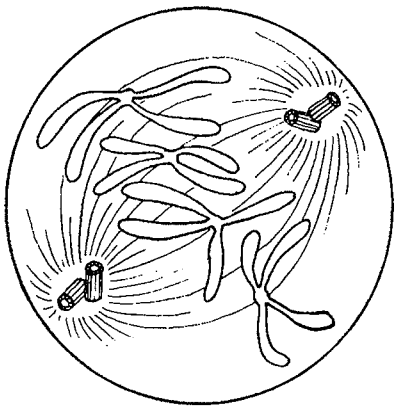
A _____



B _____



C _____



D _____

Figure 3–7

14. The following statements describe events that occur during the different phases of mitosis. Identify the phase by choosing the correct response(s) from the key choices and inserting the letter(s) or term(s) in the answer blanks.

Key Choices

A. Anaphase C. Prophase E. None of these

B. Metaphase D. Telophase

_____ 1. Chromatin coils and condenses to form deeply staining bodies.

_____ 2. Centromeres break, and chromosomes begin migration toward opposite poles of the cell.

_____ 3. The nuclear membrane and nucleoli reappear.

_____ 4. When chromosomes cease their poleward movement, this phase begins.

_____ 5. Chromosomes align on the equator of the spindle.

_____ 6. The nucleoli and nuclear membrane disappear.

_____ 7. The spindle forms through the migration of the centrioles.

_____ 8. Chromosomal material replicates.

_____ 9. Chromosomes first appear to be duplex structures.

_____ 10. Chromosomes attach to the spindle fibers.

_____ 11. A cleavage furrow forms during this phase.

_____ 12. The nuclear membrane is absent during the entire phase.

_____ 13. A cell carries out its *usual* metabolic activities.

15. Complete the following statements. Insert your answers in the answer blanks.

_____ 1.
_____ 2.
_____ 3.
_____ 4.
_____ 5.
_____ 6.
_____ 7.

Division of the __(1)__ is referred to as mitosis. Cytokinesis is the division of the __(2)__. The major structural difference between chromatin and chromosomes is that the latter are __(3)__. Chromosomes attach to the spindle fibers by undivided structures called __(4)__. If a cell undergoes nuclear division but not cytoplasmic division, the product is a __(5)__. The structure that acts as a scaffolding for chromosomal attachment and movement is called the __(6)__. __(7)__ is the period of cell life when the cell is not involved in division.

Protein Synthesis

16. Figure 3–8 is a diagram illustrating protein synthesis. Select four different colors, and use them to color the coding circles and the corresponding structures in the diagram. Next, using the letters of the genetic code, label the nitrogen bases on strand 2 of the DNA double helix, on the mRNA strands, and on the tRNA molecules. Then, answer the questions that follow referring to Figure 3–8, inserting your answers in the answer blanks.

◯ Backbones of the DNA double helix

◯ Backbone of the mRNA strands

◯ tRNA molecules

◯ Amino acid molecules

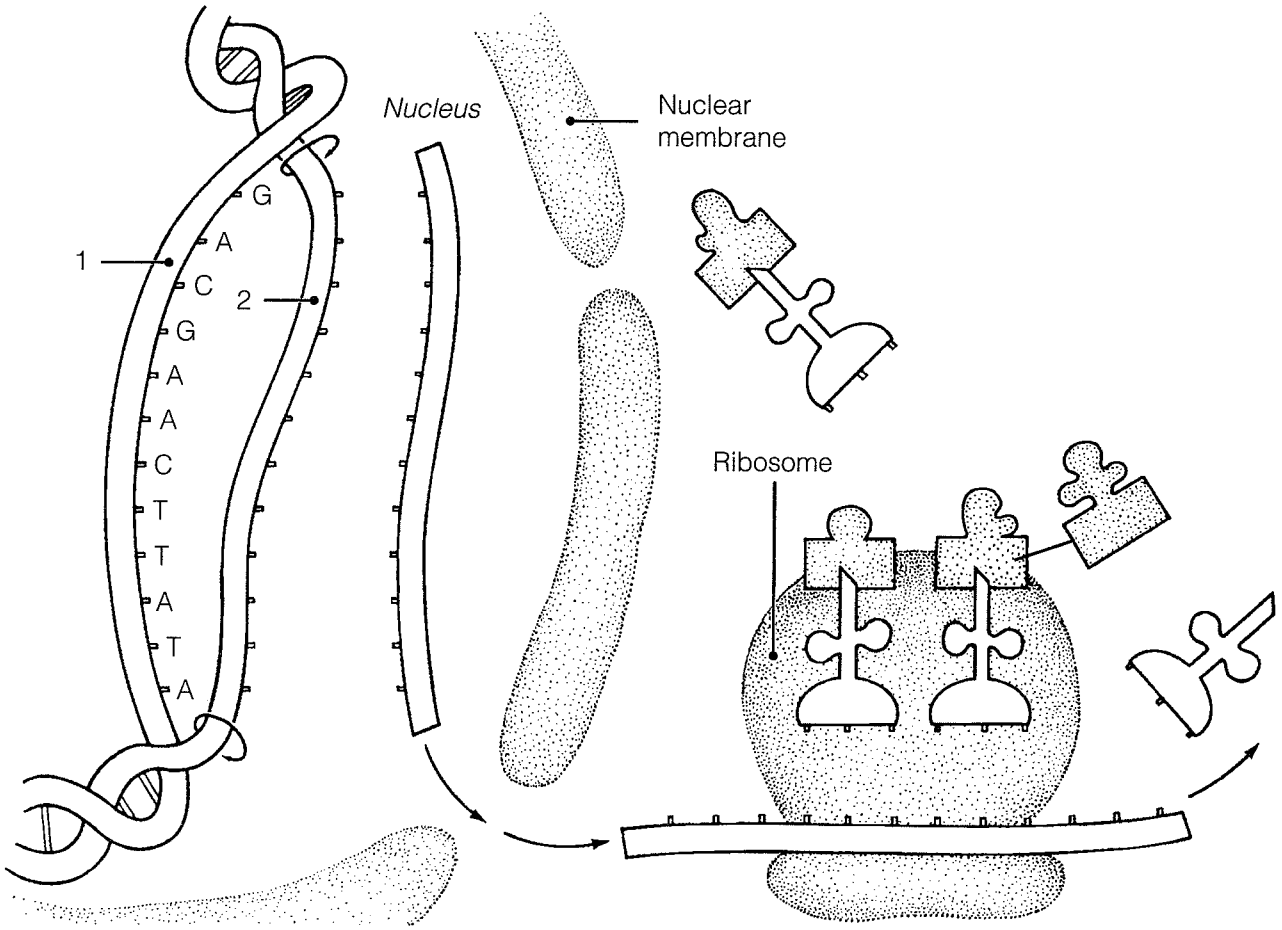


Figure 3–8

1. Transfer of the genetic message from DNA to mRNA is called _____.

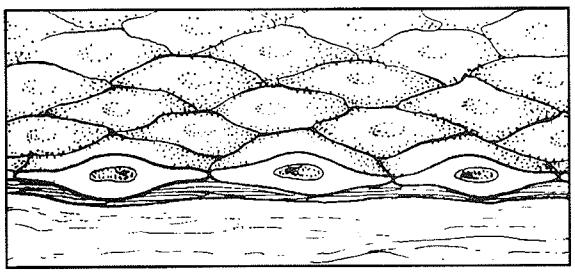
2. Assembly of amino acids according to the genetic information carried by mRNA is called _____.

3. The set of three nitrogen bases on tRNA that is complementary to an mRNA codon is called a _____. The complementary three-base sequence on DNA is called a _____.

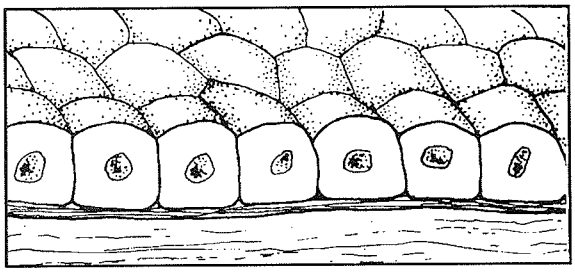
BODY TISSUES

17. Twelve tissue types are diagrammed in Figure 3–9. Identify each tissue type by inserting the correct name in the blank below it on the diagram. Select different colors for the following structures and use them to color the coding circles and corresponding structures in the diagrams.

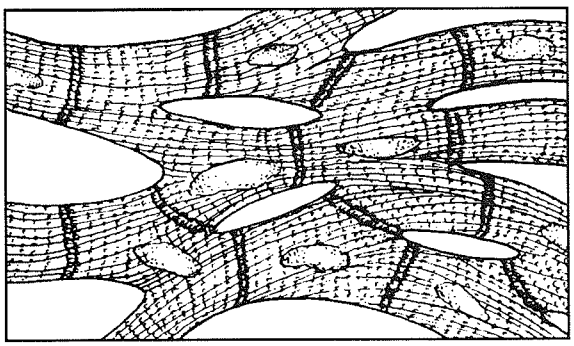
- ◯ Epithelial cells
- ◯ Nerve cells
- ◯ Muscle cells
- ◯ Matrix (Where found, matrix should be colored differently from the living cells of that tissue type. Be careful; this may not be as easy as it seems!)



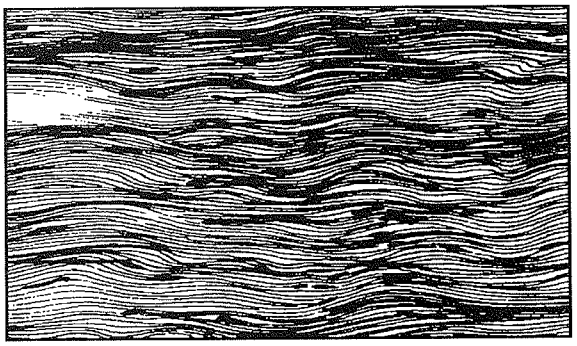
A _____



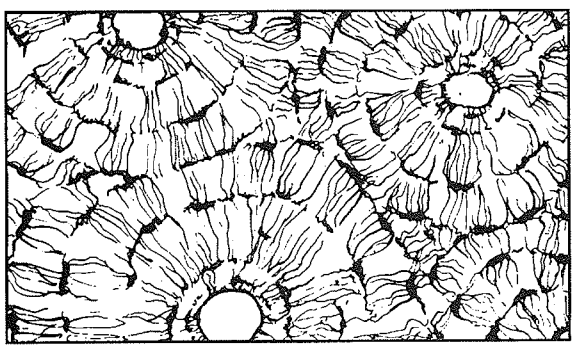
B _____



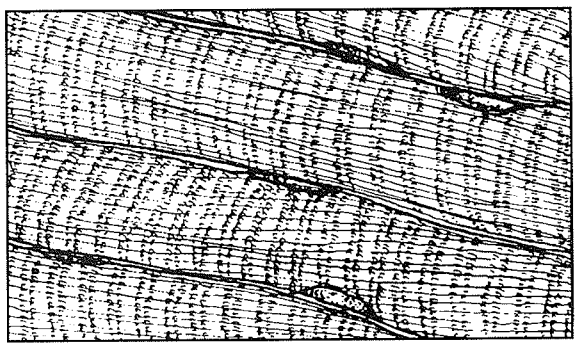
C _____



D _____



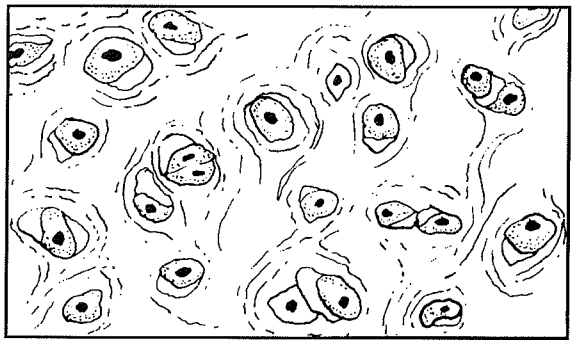
E _____



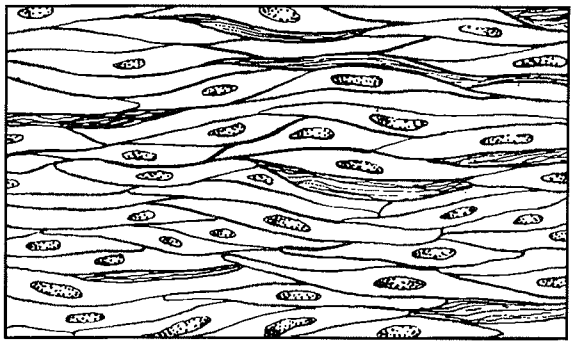
F _____

Figure 3–9, A–F

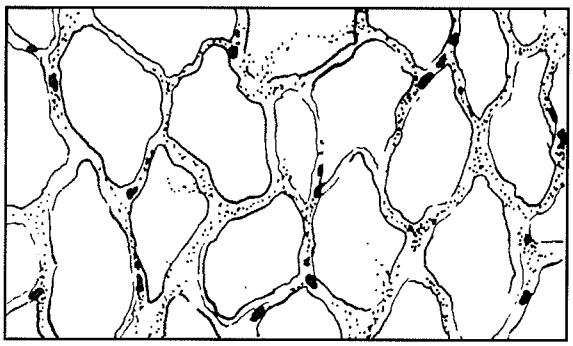
G _____



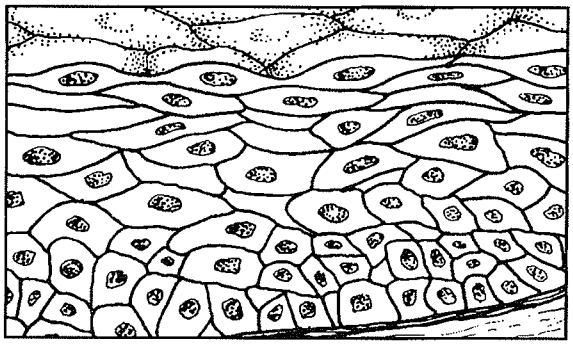
H _____



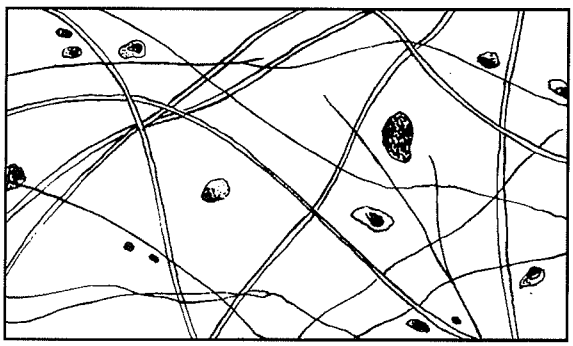
I _____



J _____



K _____



L _____

Figure 3–9, G–L

18. Describe briefly how the particular structure of a neuron relates to its function in the body. _____

_____

_____

19. Using the key choices, correctly identify the *major* tissue types described. Enter the appropriate letter or tissue type term in the answer blanks.

Key Choices

A. Connective B. Epithelium C. Muscle D. Nervous

_____ 1. Forms mucous, serous, and epidermal membranes

_____ 2. Allows for organ movements within the body

_____ 3. Transmits electrochemical impulses

_____ 4. Supports body organs

_____ 5. Cells of this tissue may absorb and/or secrete substances

_____ 6. Basis of the major controlling system of the body

_____ 7. The cells of this tissue shorten to exert force

_____ 8. Forms hormones

_____ 9. Packages and protects body organs

_____ 10. Characterized by having large amounts of nonliving matrix

_____ 11. Allows you to smile, grasp, swim, ski, and shoot an arrow

_____ 12. Most widely distributed tissue type in the body

_____ 13. Forms the brain and spinal cord

20. Using the key choices, identify the following specific type(s) of epithelial tissue. Enter the appropriate letter or classification term in the answer blanks.

Key Choices

A. Pseudostratified columnar (ciliated) C. Simple cuboidal E. Stratified squamous

B. Simple columnar D. Simple squamous F. Transitional

_____ 1. Lines the esophagus and forms the skin epidermis

_____ 2. Forms the lining of the stomach and small intestine

_____ 3. Best suited for areas subjected to friction

_____ 4. Lines much of the respiratory tract

_____ 5. Propels substances (e.g., mucus) across its surface

_____ 6. Found in the bladder lining; peculiar cells that slide over one another

_____ 7. Forms thin serous membranes; a single layer of flattened cells

21. The three types of muscle tissue exhibit certain similarities and differences. Check (✓) the appropriate spaces in the following table to indicate which muscle types exhibit each characteristic.

Characteristic	Skeletal	Cardiac	Smooth
1. Voluntarily controlled			
2. Involuntarily controlled			
3. Banded appearance			
4. Single nucleus in each cell			
5. Multinucleate			
6. Found attached to bones			
7. Allows you to direct your eyeballs			
8. Found in the walls of stomach, uterus, and arteries			
9. Contains spindle-shaped cells			
10. Contains cylindrical cells with branching ends			
11. Contains long, nonbranching cylindrical cells			
12. Displays intercalated discs			
13. Concerned with locomotion of the body as a whole			
14. Changes the internal volume of an organ as it contracts			
15. Tissue of the circulatory pump			

22. Circle the term that does not belong in each of the following groupings.

1. Collagen Cell Matrix Cell product
2. Cilia Flagellum Microvilli Elastic fibers
3. Glands Bones Epidermis Mucosae
4. Adipose Hyaline Osseous Nervous
5. Blood Smooth Cardiac Skeletal

23. Using the key choices, identify the following connective tissue types. Insert the appropriate letter or corresponding term in the answer blanks.

Key Choices

A. Adipose connective tissue
B. Areolar connective tissue
C. Dense fibrous connective tissue
D. Osseous tissue
E. Reticular connective tissue
F. Hyaline cartilage

_____ 1. Provides great strength through parallel bundles of collagenic fibers; found in tendons

_____ 2. Acts as a storage depot for fat

_____ 3. Composes the dermis of the skin

_____ 4. Forms the bony skeleton

_____ 5. Composes the basement membrane and packages organs; includes a gel-like matrix with all categories of fibers and many cell types

_____ 6. Forms the embryonic skeleton and the surfaces of bones at the joints; reinforces the trachea

_____ 7. Provides insulation for the body

_____ 8. Structurally amorphous matrix, heavily invaded with fibers; appears glassy and smooth

_____ 9. Contains cells arranged concentrically around a nutrient canal; matrix is hard due to calcium salts

_____ 10. Forms the stroma or internal "skeleton" of lymph nodes, the spleen, and other lymphoid organs

Tissue Repair

24. For each of the following statements about tissue repair that is true, enter *T* in the answer blank. For each false statement, correct the underlined words by writing the correct words in the answer blank.

_____ 1. The nonspecific response of the body to injury is called regeneration.

_____ 2. Intact capillaries near an injury dilate, leaking plasma, blood cells, and antibodies, which cause the blood to clot. The clot at the surface dries to form a scab.

_____ 3. During the first phase of tissue repair, capillary buds invade the clot, forming a delicate pink tissue called endodermal tissue.

_____ 4. When damage is not too severe, the surface epithelium migrates beneath the dry scab and across the surface of the granulation tissue. This repair process is called proliferation.

→

_____ 5. If tissue damage is very severe, tissue repair is more likely to occur by fibrosis, or scarring.

_____ 6. During fibrosis, fibroblasts in the granulation tissue lay down keratin fibers, which form a strong, compact, but inflexible mass.

_____ 7. The repair of cardiac muscle and nervous tissue occurs only by fibrosis.

DEVELOPMENTAL ASPECTS OF CELLS AND TISSUES

25. Correctly complete each statement by inserting your responses in the answer blanks.

_____ 1.
_____ 2.
_____ 3.
_____ 4.
_____ 5.
_____ 6.
_____ 7.
_____ 8.
_____ 9.
_____ 10.
_____ 11.
_____ 12.
_____ 13.
_____ 14.
_____ 15.
_____ 16.
_____ 17.
_____ 18.
_____ 19.
_____ 20.

During embryonic development, cells specialize to form __(1)__. Mitotic cell division is very important for overall body __(2)__. All tissues except __(3)__ tissue continue to undergo cell division until the end of adolescence. After this time, __(4)__ tissue also becomes amitotic. When amitotic tissues are damaged, they are replaced by __(5)__ tissue, which does not function in the same way as the original tissue. This is a serious problem when heart cells are damaged.

Aging begins almost as soon as we are born. Three explanations of the aging process have been offered. One states that __(6)__ insults, such as the presence of toxic substances in the blood, are important. Another theory states that external __(7)__ factors, such as X rays, help to cause aging. A third theory suggests that aging is programmed in our __(8)__. Three examples of aging processes seen in all people are __(9)__, __(10)__, and __(11)__.

Neoplasms occur when cells "go wild" and the normal controls of cell __(12)__ are lost. The two types of neoplasms are __(13)__ and __(14)__. The __(15)__ type tends to stay localized and have a capsule. The __(16)__ type is likely to invade other body tissues and spread to other (distant) parts of the body. To correctly diagnose the type of neoplasm, a microscopic examination of the tissue called a __(17)__ is usually done. Whenever possible, __(18)__ is the treatment of choice for neoplasms.

An overgrowth of tissue that is not considered to be a neoplasm is referred to as __(19)__. Conversely, a decrease in the size of an organ or tissue, resulting from loss of normal stimulation, is called __(20)__.

INCREDIBLE JOURNEY

A Visualization Exercise for the Cell

A long, meandering membrane with dark globules clinging to its outer surface now comes into sight.

26. Where necessary, complete statements by inserting the missing words in the answer blanks.

_____ 1.
_____ 2.
_____ 3.
_____ 4.
_____ 5.
_____ 6.
_____ 7.
_____ 8.
_____ 9.
_____ 10.

For your second journey, you will be miniaturized to the size of a small protein molecule and will travel in a microsubmarine, specially designed to enable you to pass easily through living membranes. You are injected into the intercellular space between two epithelial cells, and you are instructed to observe one of these cells firsthand and to identify as many of its structures as possible.

You struggle briefly with the controls and then maneuver your microsub into one of these cells. Once inside the cell, you find yourself in a kind of "sea." This salty fluid that surrounds you is the __(1)__ of the cell.

Far below looms a large, dark, oval structure, much larger than anything else you can see. You conclude that it is the __(2)__. As you move downward, you pass a cigar-shaped structure with strange-looking folds on its inner surface. Although you have a pretty good idea that it must be a __(3)__, you decide to investigate more thoroughly. After passing through the external membrane of the structure, you are confronted with yet another membrane. Once past this membrane, you are inside the strange-looking structure. You activate the analyzer switch in your microsub for a readout indicating which molecules are in your immediate vicinity. As suspected, there is an abundance of energy-rich __(4)__ molecules. Having satisfied your curiosity, you leave this structure to continue the investigation.

A long, meandering membrane with dark globules clinging to its outer surface now comes into sight. You maneuver closer and sit back to watch the activity. As you watch, amino acids are joined together, and a long, threadlike protein molecule is built. The globules must be __(5)__, and the membrane, therefore, is the __(6)__. Once again, you head toward the large dark structure seen and tentatively identified earlier. On approach, you observe that this huge structure has very large openings in its outer wall; these openings must be the __(7)__. Passing through one of these openings, you discover that from the inside, the color of this structure is a result of dark, coiled, intertwined masses of __(8)__, which your analyzer confirms contain genetic material, or __(9)__ molecules. Making your way through this tangled mass, you pass two round, dense structures that appear to be full of the same type of globules you saw outside. These two round structures are __(10)__. All this information confirms your earlier identification of this cellular structure, so now you move to its exterior to continue observations.

→

_____ 11.
_____ 12.

Just ahead, you see what appears to be a mountain of flattened sacs with hundreds of small saclike vesicles at its edges. The vesicles seem to be migrating away from this area and heading toward the outer edges of the cell. The mountain of sacs must be the __(11)__. Eventually you come upon a rather simple-looking membrane-bound sac. Although it doesn't look too exciting and has few distinguishing marks, it does not resemble anything else you have seen so far. Deciding to obtain a chemical analysis before entering this sac, you activate the analyzer and on the screen you see "Enzymes — Enzymes — Hydrolases — Hydrolases — Danger — Danger." There is little doubt that this innocent-appearing structure is actually a __(12)__.

Completing your journey, you count the number of organelles identified so far. Satisfied that you have observed most of them, you request retrieval from the intercellular space.

AT THE CLINIC

27. Johnny lacerated his arm and rushed home to Mom so she could "fix it." His mother poured hydrogen peroxide over the area, and it bubbled vigorously where it came in contact with the wound. Because you can expect that cells were ruptured in the injured area, what do you *think* was happening here?

28. The epidermis (epithelium of the cutaneous membrane or skin) is a keratinized stratified squamous epithelium. Explain why that epithelium is much better suited for protecting the body's external surface than a mucosa consisting of a simple columnar epithelium would be.

29. Streptomycin (an antibiotic) binds to the small ribosomal subunit of bacteria (but not to the ribosomes of the host cells infected by bacteria). The result is the misreading of bacteria mRNA and the breakup of polysomes. What process is being affected, and how does this kill the bacterial cells?

30. Systemic lupus erythematosus (often simply called lupus) is a condition that sometimes affects young women. It is a chronic (persistent) inflammation that affects all or most of the connective tissue proper in the body. Suzy is told by her doctor that she has lupus, and she asks if it will have widespread or merely localized effects within the body. What would the physician answer?

31. Mrs. Linsey sees her gynecologist because she is unable to become pregnant. The doctor discovers granulation tissue in her vaginal canal and explains that sperm are susceptible to some of the same chemicals as bacteria. What is inhibiting the sperm?

32. Sarah, a trainee of the electron microscopist at the local hospital, is reviewing some micrographs of muscle cells and macrophages (phagocytic cells). She notices that the muscle cells are loaded with mitochondria while the macrophages have abundant lysosomes. Why is this so?

33. Bradley tripped and tore one of the tendons surrounding his ankle. In anguish with pain, he asked his doctor how quickly he could expect it to heal. What do you think the doctor's response was and why?

34. In normally circulating blood, the plasma proteins cannot leave the bloodstream easily and, thus, tend to remain in the blood. But if stasis (blood flow stoppage) occurs, the proteins will begin to leak out into the interstitial fluid. Explain why this leads to edema (water buildup in the tissues).