3 Cells: The Living Units

Student Objectives

When you have completed the exercises in this chapter, you will have accomplished the following objectives:

The Cellular Basis of Life

1. Define cell.
2. List the three major regions of a generalized cell and their functions.

The Plasma Membrane: Structure

3. Describe the chemical composition of the plasma membrane and relate it to membrane functions.
4. Compare the structure and function of tight junctions, desmosomes, and gap junctions.

The Plasma Membrane: Membrane Transport

5. Relate plasma membrane structure to active and passive transport processes.
6. Compare and contrast simple diffusion, facilitated diffusion, and osmosis relative to substances transported, direction, and mechanism.
7. Differentiate between primary and secondary active transport.
8. Compare and contrast endocytosis and exocytosis in terms of function and direction.
9. Compare and contrast pinocytosis, phagocytosis, and receptor-mediated endocytosis.

The Plasma Membrane: Generation of a Resting Membrane Potential

10. Define membrane potential and explain how the resting membrane potential is established and maintained.

The Plasma Membrane: Cell-Environment Interactions

11. Describe the role of the glycocalyx when cells interact with their environment.
12. List several roles of membrane receptors and that of voltage-gated membrane channel proteins.

The Cytoplasm

13. Describe the composition of the cytosol.
14. Discuss the structure and function of mitochondria.
15. Discuss the structure and function of ribosomes, the endoplasmic reticulum, and the Golgi apparatus, including functional interrelationships among these organelles.
16. Compare the functions of lysosomes and peroxisomes.
17. Name and describe the structure and function of cytoskeletal elements.
18. Describe the roles of centrioles in cell division and in formation of cilia and flagella.
19. Describe how the two main types of cell extensions, cilia and microvilli, differ in structure and function.

The Nucleus

20. Outline the structure and function of the nuclear envelope, nucleolus, and chromatin.

Cell Growth and Reproduction

21. List the phases of the cell cycle and describe the key events of each phase.
22. Describe the process of DNA replication.
23. Define gene and genetic code and explain the function of genes.
24. Name the two phases of protein synthesis and describe the roles of DNA, mRNA, tRNA, and rRNA in each phase.
25. Contrast triplets, codons, and anticodons.
26. Define autophagy and indicate its major cellular function.
27. Describe the importance of ubiquitin-dependent degradation of soluble proteins.

Extracellular Materials

28. Name and describe the composition of extracellular materials.

Developmental Aspects of Cells

29. Discuss some theories of cell differentiation and aging.
30. Indicate the value of apoptosis to the body.

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, reproduce, move, and respond to stimuli. The cells of the body differ in shape, size, and specific roles in the body. Cells that are similar in structure and function form tissues that, in turn, form the various body organs.

Activities in this chapter include questions relating to the structure and functional abilities of the generalized animal cell.

BUILDING THE FRAMEWORK

The Cellular Basis of Life

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

1. List the four concepts of the cell theory. _____

_____

_____

_____

2. Describe three different cell shapes. _____

_____

3. Name the three major parts of any cell. _____

_____

4. Define *generalized* or *composite cell.* _____

_____

_____

_____

The Plasma Membrane: Structure and Functions

1. Figure 3.1 is a diagram of a portion of a plasma membrane. Select four different colors, and color the coding circles and the corresponding structures in the diagram. Then, respond to the questions that follow, referring to Figure 3.1 and inserting your answers in the answer blanks.

◯ Phospholipid molecules ◯ Carbohydrate molecules

◯ Protein molecules ◯ Cholesterol molecules

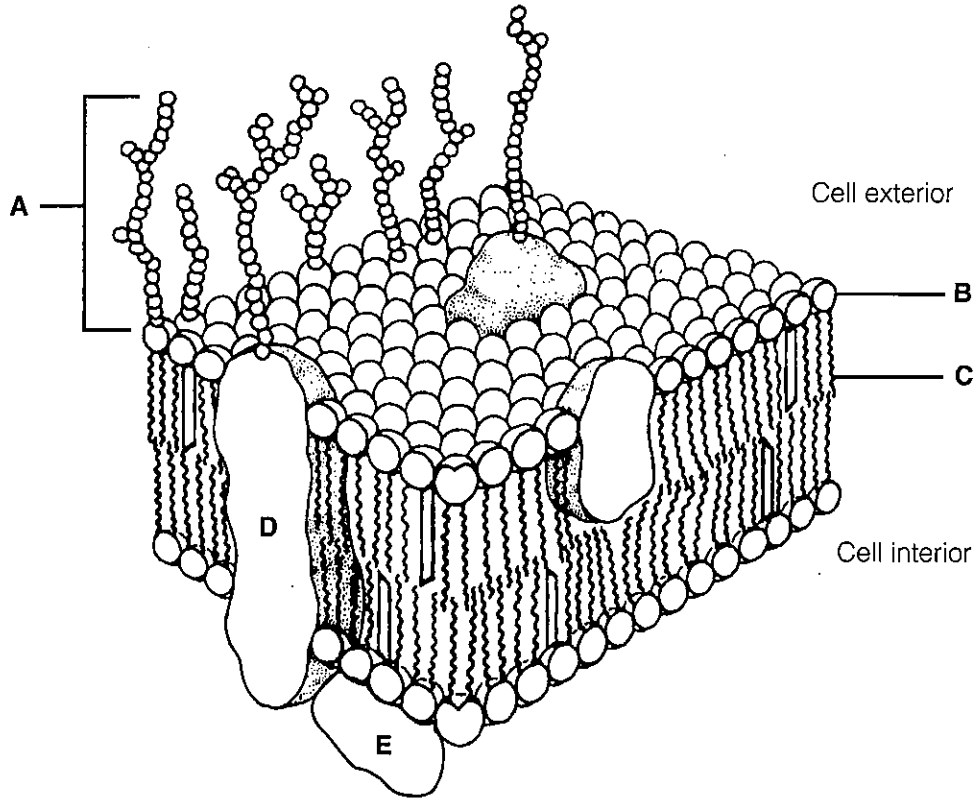


Figure 3.1

1. What name is given to this model of membrane structure? _____
2. What is the function of cholesterol molecules in the plasma membrane? _____

_____

3. Name the carbohydrate-rich area at the cell surface (indicated by bracket A). _____
4. Which label, B or C, indicates the nonpolar region of a phospholipid molecule? _____
5. Does nonpolar mean hydrophobic or hydrophilic? _____
6. Which label, D or E, indicates an integral protein, and which is a peripheral protein? _____

_____

2. Label the specializations of the plasma membrane, shown in Figure 3.2, and color the diagram as you wish. Then, answer the questions provided that refer to this figure.

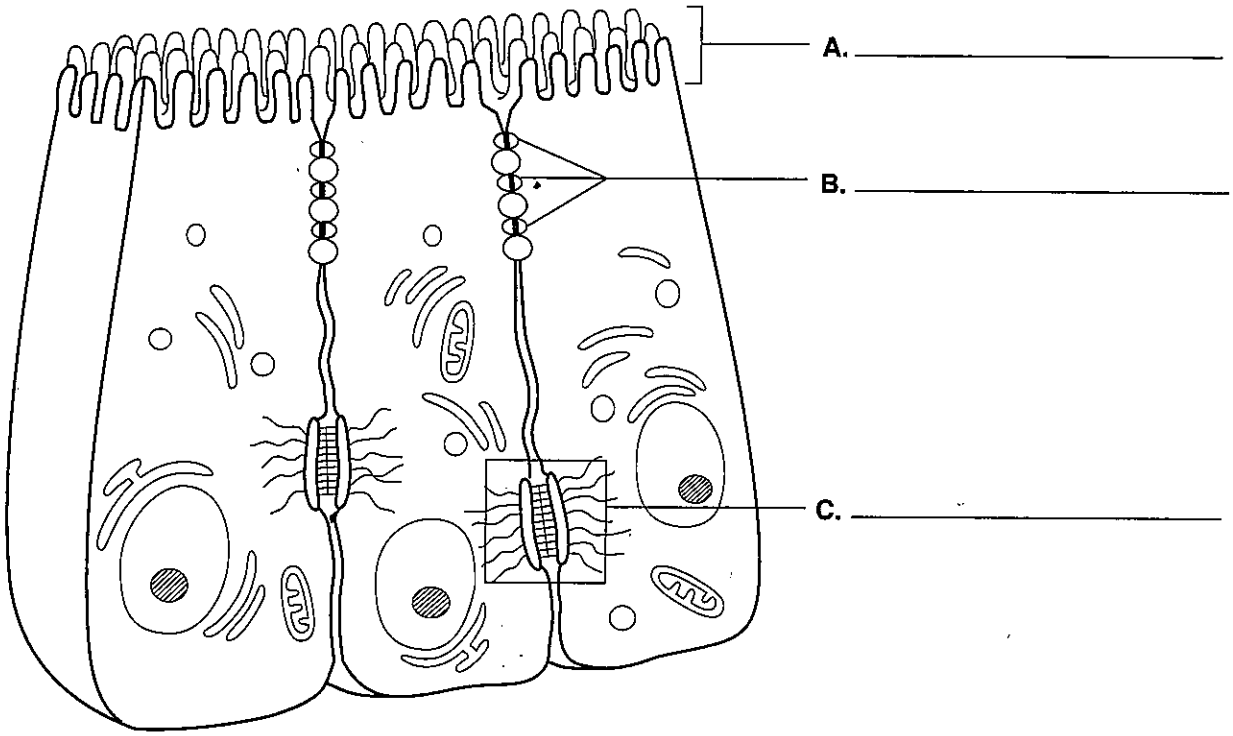


Figure 3.2

1. What is the structural significance of microvilli? _____

_____

2. What type of cell function(s) does the presence of microvilli typically indicate?

_____

3. What protein acts as a microvilli "stiffener"? _____

4. Name two factors in addition to special membrane junctions that help hold cells together.

_____

5. Which cell junction forms an impermeable barrier? _____

6. Which cell junction is a buttonlike adhesion? _____

7. Which junction has linker proteins spanning the intercellular space? _____

8. Which cell junction (not shown) allows direct passage from one cell's cytoplasm to the next?

_____

9. What name is given to the transmembrane proteins that allow this direct passage?

_____

3. Figure 3.3 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.

◯ Pore ◯ Solute pump ◯ Passive transport pump ◯ Phospholipids

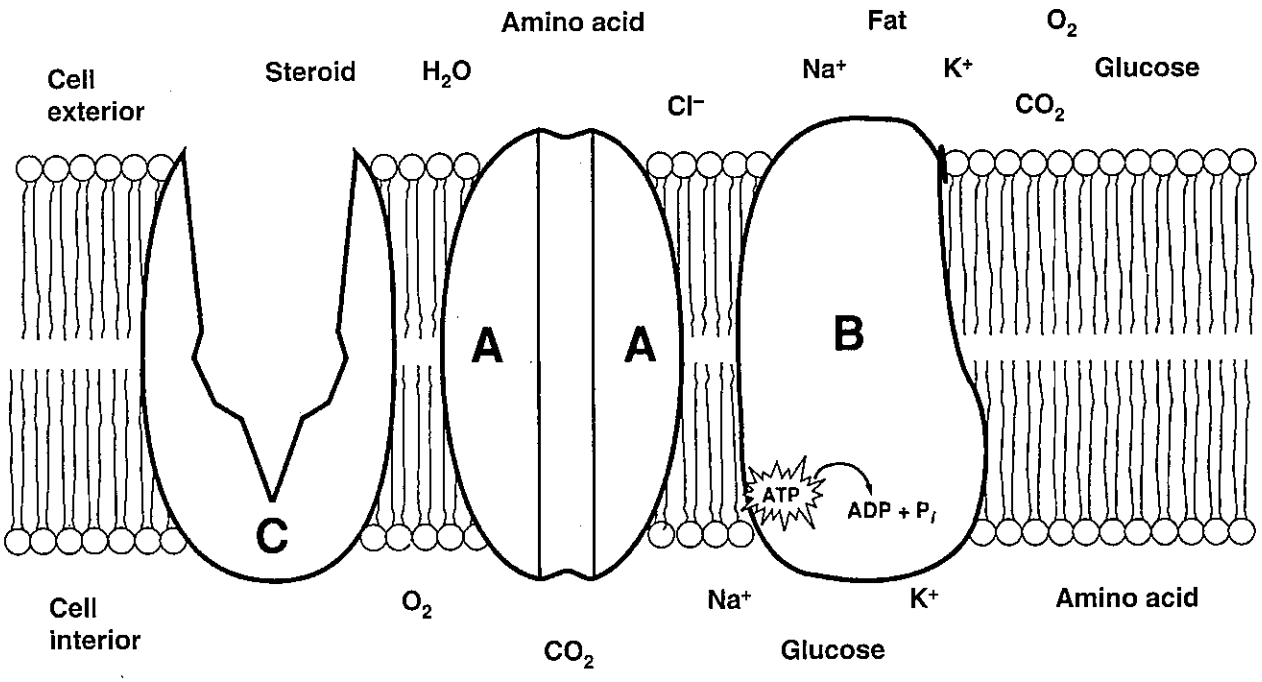


Figure 3.3

Now add arrows to Figure 3.3 as follows: 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 3.3:

1. Which of the substances shown move passively *through the lipid* part of the membrane?

_____

2. Which of the substances shown enter 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? _____

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

Key Choices

A. Protein-coated pit
B. Diffusion, simple
C. Diffusion, osmosis
D. Exocytosis
E. Phagocytosis
F. Pinocytosis
G. Receptor-mediated endocytosis
H. Solute pumping

_____ 1. Engulfment processes that require ATP

_____ 2. Driven by molecular energy

_____ 3. May provide signaling platforms

_____ 4. Moves down (with) a concentration gradient

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

_____ 6. Uses a clathrin-coated vesicle ("pit")

_____ 7. Typically involves *coupled systems*; that is, symports or antiports

_____ 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

5. Figure 3.4 shows three microscope fields containing red blood cells. Arrows indicate the direction of net osmosis. Select three different colors, and use them to color the coding circles and the corresponding cells in the diagrams. Then, respond to the questions below, referring to Figure 3.4 and inserting your answers in the spaces provided.

◯ Water moves into the cells

◯ Water enters and exits the cells at the same rate

◯ Water moves out of the cells

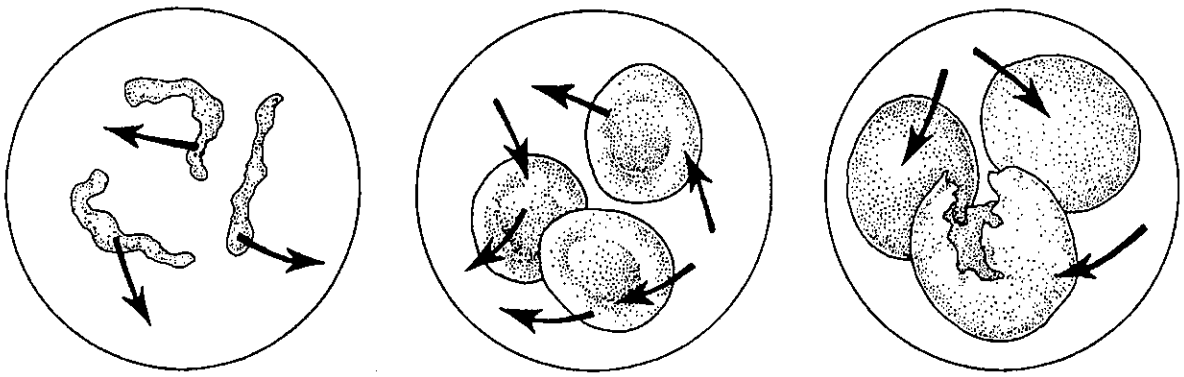


Figure 3.4

1. Name the type of tonicity illustrated in diagrams A, B, and C.

   A. _____ B. _____ C. _____

2. Name the terms that describe the cellular shapes in diagrams A, B, and C.

   A. _____ B. _____ C. _____

3. What does *isotonic* mean? _____

4. Why are the cells in diagram C bursting? _____

   _____

5. What is the difference between tonicity and osmolarity? _____

   _____

6. The differential permeability of the plasma membrane to sodium (Na^+) and potassium (K^+) ions results in the development of a voltage (resting membrane potential) of about –70 mV across the membrane as indicated in the simple diagram in Figure 3.5.

First, draw in some Na^+ and K^+ ions in the cytoplasm and extracellular fluid, taking care to indicate their *relative* abundance in the two sites.

Second, add positive and negative signs to the inner and outer surfaces of the "see-through" cell's plasma membrane to indicate its electrical polarity.

Third, draw in arrows and color them to match each of the coding circles associated with the conditions noted just below.

◯ Potassium electrical gradient ◯ Sodium electrical gradient

◯ Potassium concentration gradient ◯ Sodium concentration gradient

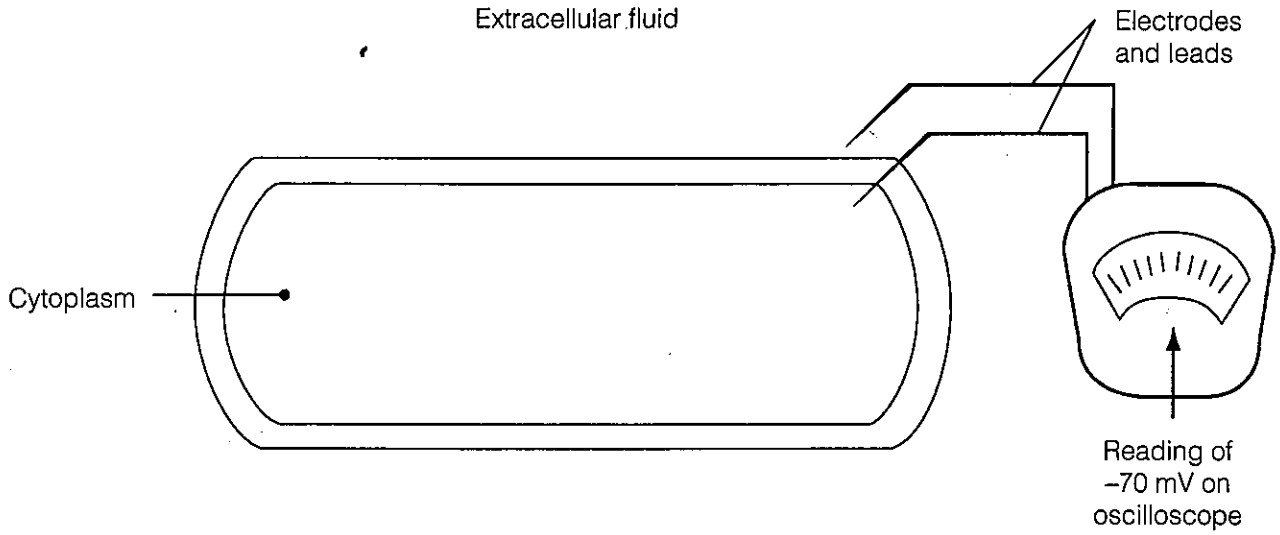


Figure 3.5

Which ion—Na^+ or K^+—is more important in determining the resting membrane potential?

_____

7. Referring to plasma membranes, circle the term or phrase that does *not* belong in each of the following groupings.

1. Fused protein molecules of adjacent cells Tight junction Lining of digestive tract

   Communication between adjacent cells No intercellular space

2. Lipoprotein filaments Binding of tissue layers Heart muscle

   Impermeable junction Desmosomes

3. Impermeable intercellular space Molecular communication Embryonic cells
   Gap junction Protein channel
4. Resting membrane potential High extracellular potassium ion (K^+) concentration
   High extracellular sodium ion (Na^+) concentration Nondiffusible protein anions
5. −50 to −100 millivolts Electrochemical gradient Inside membrane negatively charged
   K^+ diffuses across membrane more rapidly than Na^+ Protein anions move out of cell
6. Active transport Sodium-potassium pump Polarized membrane
   More K^+ pumped out than Na^+ carried in ATP required
7. Carbohydrate chains on cytoplasmic side of membrane Cell adhesion
   Glycocalyx Recognition sites Antigen receptors
8. Facilitated diffusion Nonselective Glucose saturation Carrier molecule
9. Clathrin-coated pit Exocytosis Receptor-mediated High specificity
10. CAMs Membrane receptors G proteins Channel-linked proteins
11. Second messenger NO Ca^{2+} Cyclic AMP
12. Cadherins Glycoproteins Phospholipids Integrins

The Cytoplasm

1. Define *cytosol.* _____

_____

2. Differentiate clearly between *organelles* and *inclusions.* _____

_____

_____

_____

3. Using the following terms, correctly label all cell parts indicated by leader lines in Figure 3.6. Then, select different colors for each structure and use them to color the coding circles and the corresponding structures in the illustration.

- ◯ Plasma membrane
- ◯ Mitochondrion
- ◯ Nuclear membrane
- ◯ Centrioles
- ◯ Chromatin threads
- ◯ Nucleolus
- ◯ Golgi apparatus
- ◯ Microvilli
- ◯ Rough endoplasmic reticulum (rough ER)
- ◯ Smooth endoplasmic reticulum (smooth ER)

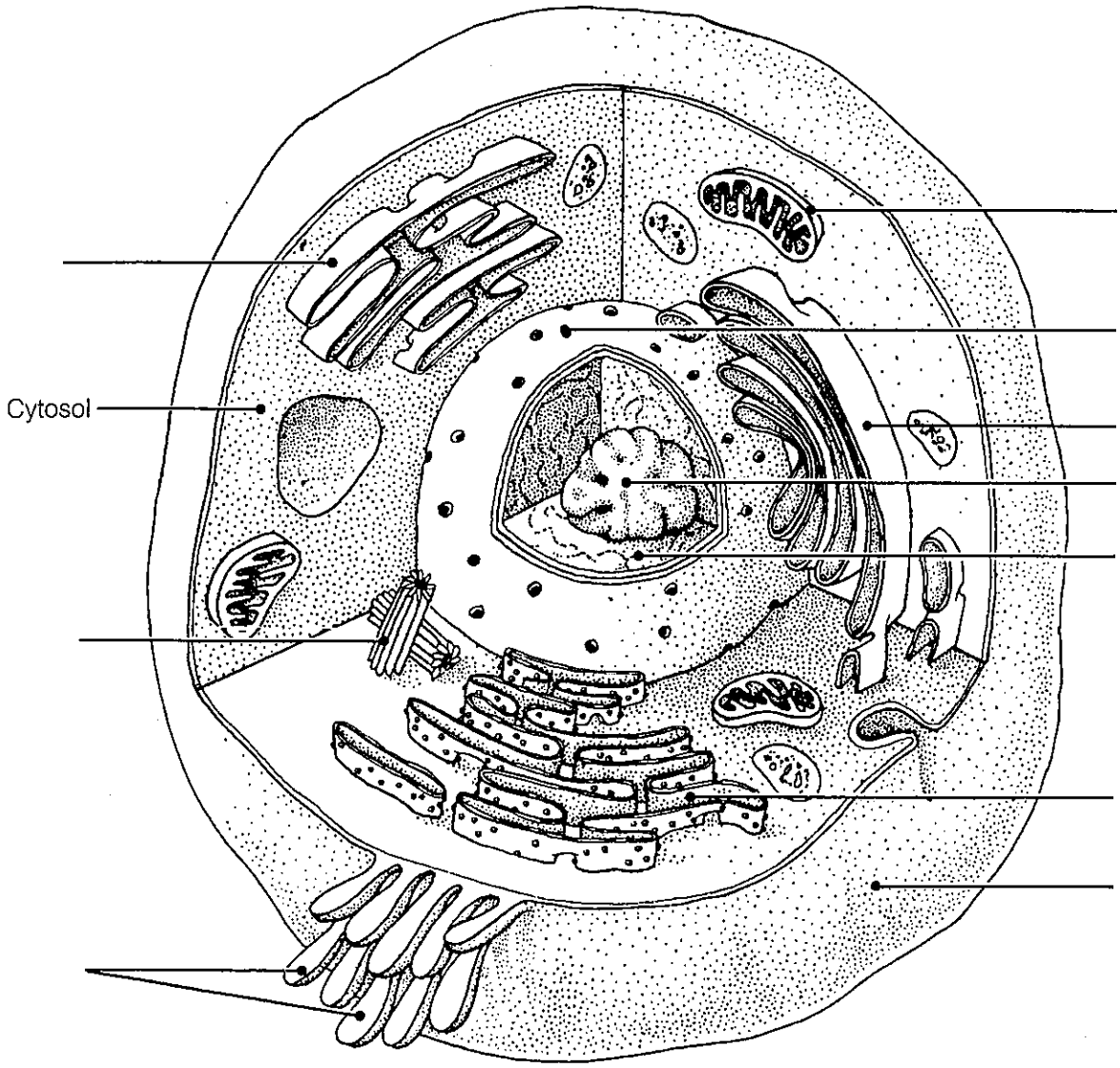


Figure 3.6

4. Complete the following table to fully describe the various cell parts. Insert your responses in the spaces provided under each heading.

Cell structure	Location	Function
	External boundary of the cell	Confines cell contents; regulates entry and exit of materials
Lysosome		
	Scattered throughout the cell	Controls the release of energy from foods; forms ATP
	Projections of the plasma membrane	Increase the membrane surface area
Golgi apparatus		
	Two rod-shaped bodies near the nucleus	"Spin" the mitotic spindle
Smooth ER		
Rough ER		
	Attached to membranes or scattered in the cytoplasm	Synthesize proteins
		Act collectively to move substances across cell surface in one direction
	Internal structure of centrioles; part of the cytoskeleton	
Peroxisomes		
		Contractile protein (actin); moves cell or cell parts; core of microvilli
Intermediate filaments	Part of cytoskeleton	
Inclusions		

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 Self-replicating Vitamin A storage
5. Centrioles Basal bodies Mitochondria Cilia Flagella
6. ER Endomembrane system Ribosomes Secretory vesicles
7. Nucleus DNA Lysosomes Mitochondria

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. interact with myosin to produce contractile force

_____ 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 cells (make and use large amounts of ATP)

8. Describe the components and importance of the endomembrane system.

The Nucleus

1. Complete the following brief table to describe the nucleus and its parts. Insert your responses in the spaces provided.

Nuclear structure	General location/appearance	Function
Nucleus		
Nucleolus		
Chromatin		
Nuclear membrane		

2. Figure 3.7 shows a portion of the proposed model of a chromatin fiber. Select two different colors for the coding circles and the corresponding structures on the figure. Then, respond to the two questions that follow.

◯ DNA helix ◯ Nucleosome

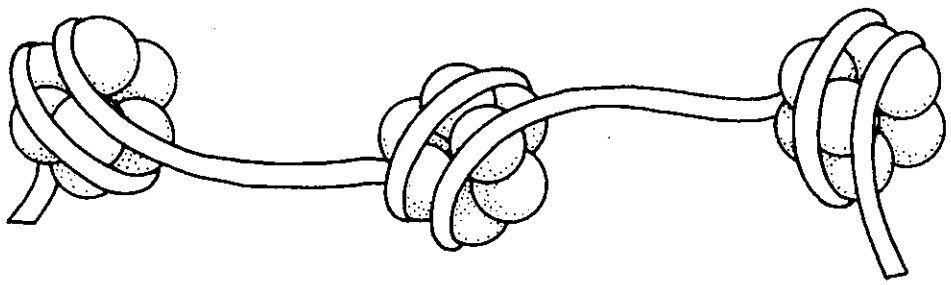


Figure 3.7

1. What is the chemical composition of a nucleosome? (Be specific.) _____

_____

2. What is the function of the nucleosome components named above? _____

_____

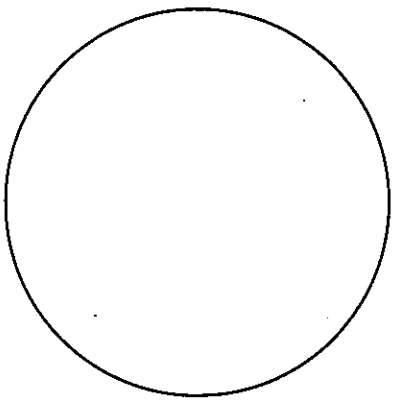
Cell Growth and Reproduction

1. The cell life cycle consists of interphase and _____, during which the cell _____. Name the three phases of interphase in order, and indicate the important events of each phase.

Phase of interphase	Important events

2. Diagram in Figure 3.8 (by making a pie-shaped graph) the relative lengths of time of the G_1, S, G_2, and M phases for the cell types listed:

A. Rapidly dividing cell type



B. Slowly dividing cell type

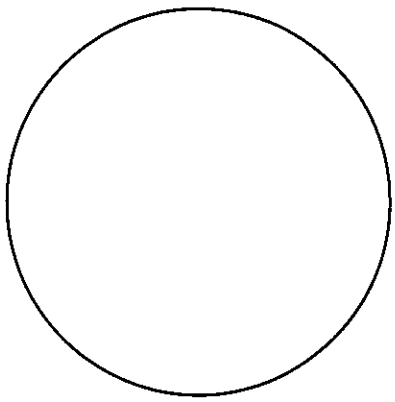


Figure 3.8

3. Complete the following statements concerning the control of cell division.

_____ 1.
_____ 2.
_____ 3.

A complex of two proteins called __(1)__ gives the "OK" signal for a cell to begin mitosis. One of these proteins, called __(2)__, is always present. The other, a regulatory protein called __(3)__, is regenerated anew with each cycle.

4. The following statements describe events that occur during the different phases of mitosis. Identify the phase by choosing the correct responses from the key choices and inserting the answers in the answer blanks.

Key Choices

A. Anaphase B. Metaphase C. Prophase D. Telophase E. None of these

_____ 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. Chromosomes cease their poleward movement.

_____ 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. DNA replication occurs.

_____ 9. Chromosomes obviously are duplex structures.

_____ 10. Chromosomes attach to the spindle fibers.

_____ 11. Cytokinesis occurs.

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

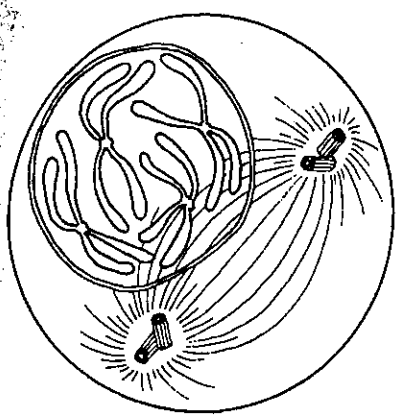
_____ 13. This is the period during which a cell is not in the M phase.

_____ 14. Chromosomes (chromatids) are V shaped.

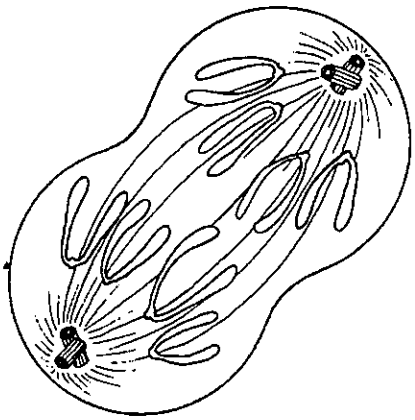
5. Identify the phases of mitosis depicted in Figure 3.9 by inserting the correct terms in the blanks under each diagram. Then, select different colors to represent the structures below, and use them to color the coding circles and the corresponding structures in the illustration. When you have completed the work on Figure 3.9, identify all of the mitotic stages provided with leader lines in the photomicrograph of an onion root tip in Figure 3.10.

◯ Nuclear membranes, if present ◯ Centrioles ◯ Chromosomes

◯ Nucleoli, if present ◯ Spindle fibers, if present

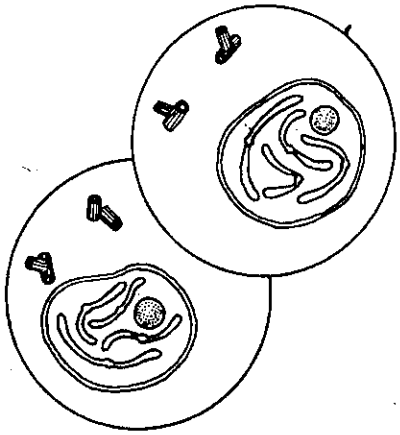


A. _____

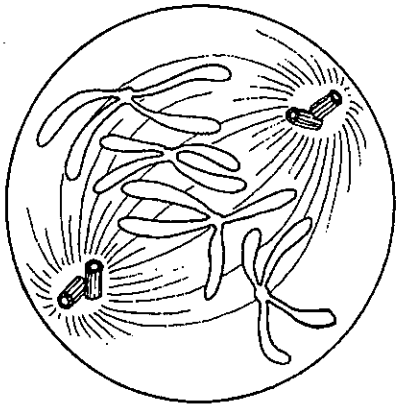


B. _____

Figure 3.9



C. _____



D. _____

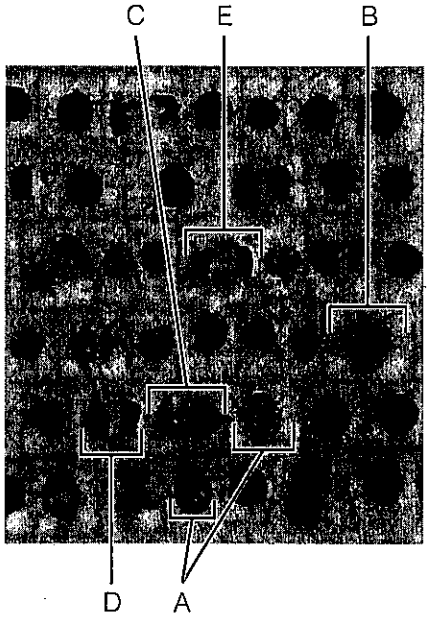


Figure 3.10

A. _____

B. _____

C. _____

D. _____

E. _____

6. The following statements provide an overview of the structure of DNA (the 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.
_____ 9.
_____ 10.
_____ 11.
_____ 12.
_____ 13.
_____ 14.
_____ 15.
_____ 16.
_____ 17.
_____ 18.

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)__.

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 of 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.

7. Figure 3.11 is a diagram illustrating protein synthesis.

First, select four different colors and use them to color the coding circles and the corresponding structures in the diagram.

Second, using the letters of the genetic code, label the nitrogen bases on the encoding strand (strand 2) of the DNA double helix, on the mRNA strands, and on the tRNA molecules.

Third, referring to Figure 3.11, answer the questions that follow, and insert your answers in the answer blanks.

◯ Backbones of the DNA double helix ◯ tRNA molecules

◯ Backbone of the mRNA strands ◯ Amino acid molecules

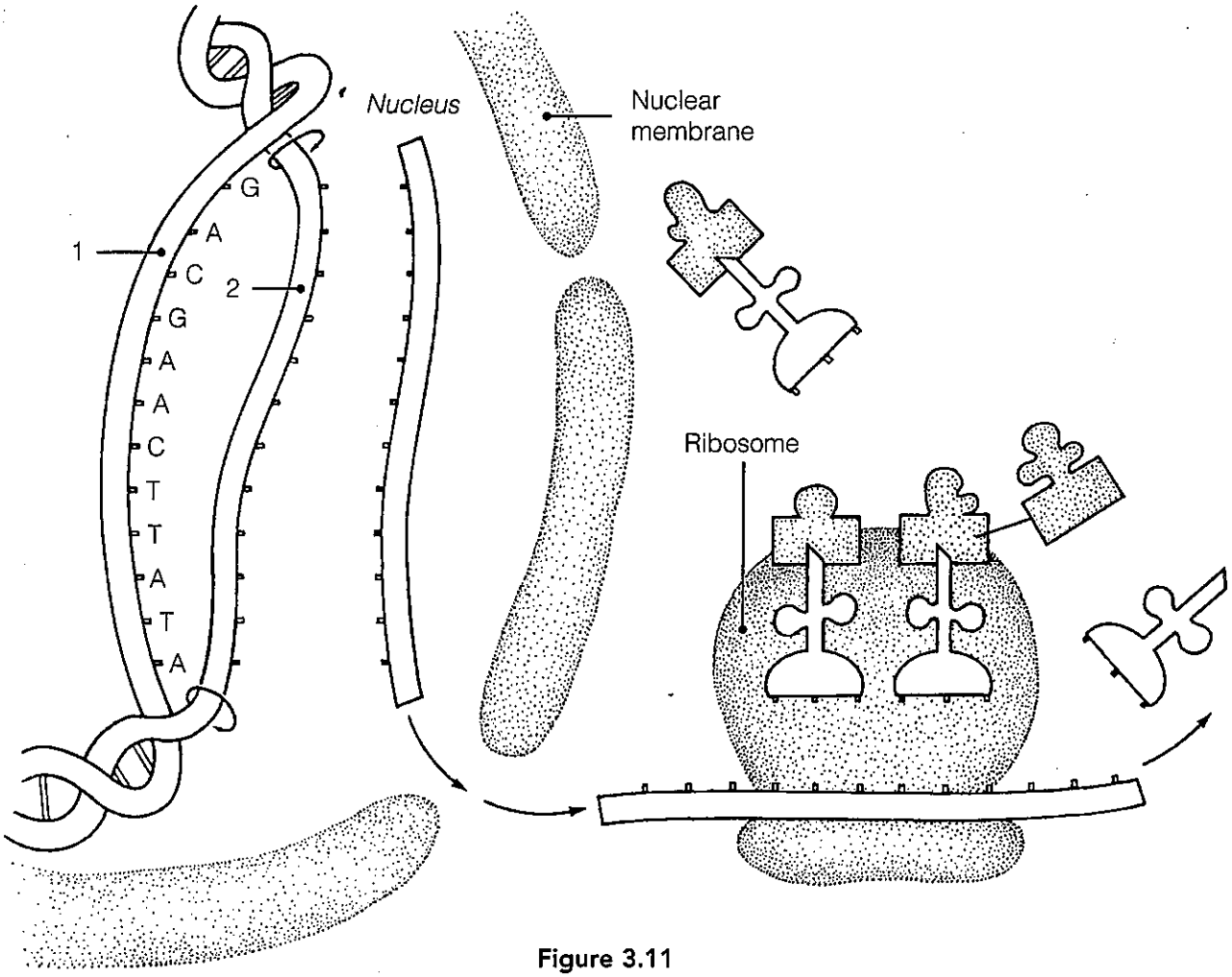


Figure 3.11

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. All types of RNA are made on the _____.

4. 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 _____.

5. Define *gene*. _____

_____

8. 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 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.

Extracellular Materials

1. Name the three major categories of extracellular materials in the body, provide examples of each class, and cite some of the important roles of these substances.

1. _____
2. _____
3. _____

Developmental Aspects of Cells

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

_____ 1.
_____ 2.
_____ 3.
_____ 4.

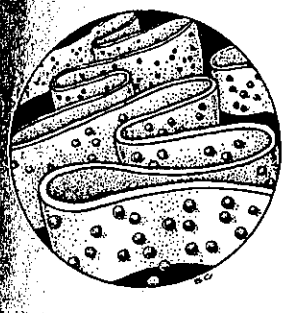
The fertilized egg, or __(1)__, divides thousands of times to form the multicellular embryo. Although the cells begin to specialize very early in development, all body cells have identical numbers and kinds of __(2)__. Specialization of particular cells is fostered by __(3)__ signals that activate or deactivate particular genes in neighboring cells. Consequently, the synthesis of only certain kinds of __(4)__ is directed by the activated genes in specialized cells.

5. After birth, cell divisions continue throughout childhood and adolescence until the body reaches adult size. Thereafter, cell
6. divisions occur only for __(5)__ and __(6)__. Under certain circumstances, as in anemia, __(7)__, or accelerated cell division,
7. occurs.

8. Cellular aging may be the result of continual insults over a long period of time by chemical toxins, such as __(8)__ and
9. __(9)__, and from high-energy radiation, such as __(10)__.

10.

12. The normal function of one tumor suppressor gene is to prevent cells with damaged chromosomes and DNA from "progressing from G_1 to S," whereas another tumor suppressor gene prevents "passage from G_2 to M." When these tumor suppressor genes fail to work, cancer can result. Explain what the phrases in quotations mean.



THE INCREDIBLE JOURNEY

A Visualization Exercise for the Cell

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

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

1. For this journey, you will be miniaturized to the size of a small protein molecule and will travel in a microsubmarine, specially
2. designed to enable you to pass easily through living membranes. You are injected into the intercellular space between two epithelial
3. cells, and you are instructed to observe one cell 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 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 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 on which molecules are in your immediate vicinity.

_____ 4.
_____ 5.
_____ 6.
_____ 7.
_____ 8.
_____ 9.
_____ 10.
_____ 11.
_____ 12.

As suspected, there is an abundance of energy-rich __(4)__ molecul 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 globul 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 tha from the inside the color of this structure is a result of dark, coiled, intertwined masses of __(8)__, which your analyzer confirms contai genetic materials, or __(9)__ molecules. Making your way through this tangled mass, you pass two round, dense structures that appear t be full of the same type of globules you saw outside. These two rou structures are __(10)__. All this information confirms your earlier identification of this cellular structure, so nov you move to its exterior to continue your observations.

Just ahead, you see what appears to be a mountain of flattened sacs with hundreds of small vesicles at its edges. The vesicles appear 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-bounded 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—Danger—Danger." There is little doubt that this apparently innocent structure is actually a __(12)__.

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

CHALLENGING YOURSELF

At the Clinic

1. An infant is brought in with chronic diarrhea, which her mother says occurs whenever the baby drinks milk. The doctor diagnoses lactose intolerance. She explains to the parents that their baby is unable to digest milk sugar and suggests adding lactase to the baby's milk. How would lactose intolerance lead to diarrhea? How does adding lactase prevent diarrhea?

2. Anaphylaxis is a systemic (bodywide) allergic reaction in which capillaries become excessively permeable. This results in increased filtration and fluid accumulation in the tissues, leading to edema. Why is this condition life-threatening even if no apparent bleeding occurs?

3. Some people have too few receptors for the cholesterol-carrying low-density lipoprotein (LDL). As a result, cholesterol builds up in blood vessel walls, restricting blood flow and leading to high blood pressure. By what cellular transport process is cholesterol taken up from the blood in a person with normal numbers of LDL receptors?

4. Sugar (glucose) can appear in the urine in nondiabetics if sugar intake is exceptionally high (when you pig out on sweets!). What functional aspect of carrier-mediated transport does this phenomenon demonstrate?

5. Plasma proteins, such as albumin, have an osmotic effect. In normally circulating blood, the 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 (IF). Explain why this leads to edema.

6. Hydrocortisone is an anti-inflammatory drug that acts to stabilize lysosomal membranes. Explain how this effect reduces cell damage and inflammation. Why is this steroid hormone marketed in a cream (oil) base and used topically (applied to the skin)?

7. 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 bacterial mRNA and the breakup of polysomes. What process is being affected, and how does this kill the bacterial cells?

8. Phagocytes gather in the air sacs of the lungs, especially in the lungs of smokers. What is the connection?

Stop and Think

1. Think *carefully* about the chemistry of the plasma membrane, then answer this question: Why is minor damage to the membrane usually not a problem?

2. Knowing that diffusion rate is inversely proportional to molecular weight, predict the results of the following experiment: Cotton balls are simultaneously inserted in opposite ends of a one-meter-long glass tube. One cotton ball is saturated with ammonium hydroxide (NH_4OH), the other with sulfuric acid (H_2SO_4). The two gases diffuse until they meet, at which point a white precipitate of ammonium chloride is formed. At what relative point along the tube does the precipitate form?

3. The upper layers of the skin constantly slough off. Predict the changes in the integrity of desmosomes as skin cells age (and move closer to the skin's surface).

4. Some cells produce lipid-soluble products. Can you deduce how such products are stored, that is, prevented from exiting the cell?

5. List three examples of folding of cellular membranes to increase membrane surface area.

6. Should the existence of mitochondrial ribosomes come as a complete surprise? Explain your response.

7. If a structure (such as the lens and cornea of the eye) contains no blood vessels (that is, is *avascular*), is it likely to be very thick? Why or why not?

8. Examine the organelles of the cells depicted in Figure 3.12 A and B. Predict the product of each cell, and state your reasons.

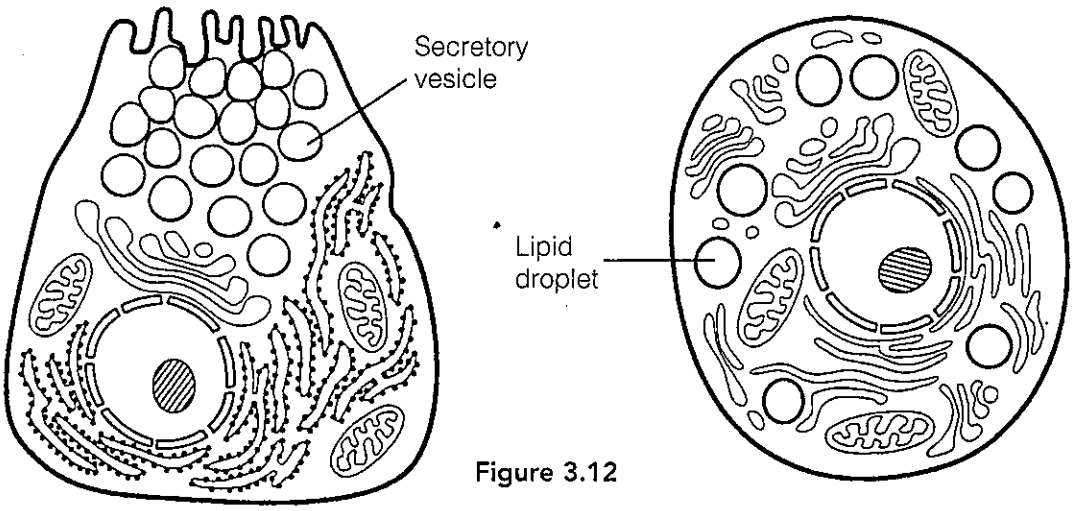


Figure 3.12

A. Acinar cell from pancreas

B. Interstitial endocrine cell from testis

9. In Figure 3.13, an artificial cell with an aqueous solution enclosed in a selectively permeable membrane has just been immersed in a beaker containing a different solution. The membrane is permeable to water and to the simple sugars glucose and fructose, but is completely impermeable to the disaccharide sucrose. Answer the following questions pertaining to this situation.

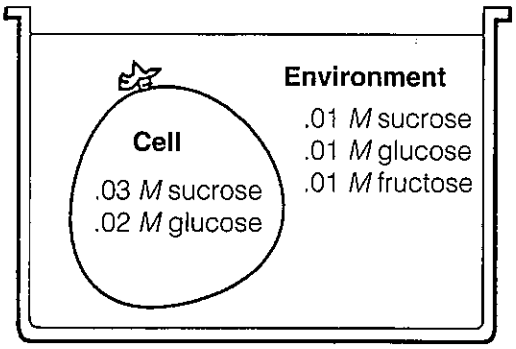


Figure 3.13

1. Which solute(s) will exhibit net diffusion into the cell?
2. Which solute(s) will exhibit net diffusion out of the cell?
3. In which direction will there be net osmotic movement of water?
4. Will the cell crenate or swell?

10. Using the information provided:

mRNA codon:	AUG	AAC	CGU	GAA	AGU	UAG
amino acid:	Met	Asn	Arg	Glu	Ser	Stop

and given the DNA sequence TACGCATCACTTTTGATC:

1. What is the amino acid sequence encoded?
2. If the nucleotides that are underlined were deleted by mutation, what would the resulting amino acid sequence be?

COVERING ALL YOUR BASES

Multiple Choice

Select the best answer or answers from the choices given.

1. Which of the following is not a basic concept of the cell theory?
   A. All cells come from preexisting cells.
   B. Cellular properties define the properties of life.
   C. Organismic activity is based on individual and collective cellular activity.
   D. Cell structure determines and is determined by biochemical function.
   E. Organisms can exhibit properties that cannot be explained at the cellular level.

2. The dimension outside the observed range for human cells is:
   A. 10 micrometers
   B. 30 centimeters long
   C. 2 nanometers
   D. 1 meter long

3. A cell's plasma membrane would not contain:
   A. phospholipid
   B. nucleic acid
   C. protein
   D. cholesterol
   E. glycolipid

4. Which of the following would you expect to find in or on cells whose main function is absorption?
   A. Microvilli
   B. Cilia
   C. Desmosomes
   D. Gap junctions
   E. Secretory vesicles

5. Adult cell types expected to have gap junctions include:
   A. skeletal muscle
   B. bone
   C. heart muscle
   D. smooth muscle

6. For diffusion to occur, there must be:
   A. a selectively permeable membrane
   B. equal amounts of solute
   C. a concentration difference
   D. some sort of carrier system
   E. all of these

7. Fluid moves out of capillaries by filtration. If the plasma glucose concentration is 100 mg/dl, what will be the concentration of glucose in the filtered fluid?
   A. Less than 100 mg/dl
   B. 100 mg/dl
   C. More than 100 mg/dl
   D. The concentration cannot be determined.

8. Lack of cholesterol in the plasma membrane would result in the membrane's:
   A. excessive fluidity
   B. instability
   C. increased protein content
   D. excessive fragility
   E. reduced protein content

9. Which of the following membrane components i involved in glucose transport?
   A. Phospholipid bilayer
   B. Transmembrane protein
   C. Cholesterol
   D. Peripheral protein
   E. Glycocalyx

10. If a 10% sucrose solution within a semipermeabl sac causes the fluid volume in the sac to increas a given amount when the sac is immersed in water, what would be the effect of replacing the sac solution with a 20% sucrose solution?
    A. The sac would lose fluid.
    B. The sac would gain the same amount of fluic
    C. The sac would gain more fluid.
    D. There would be no effect.

11. Cyanide binds to at least one molecule that is involved with ATP synthesis. In cells exposed to cyanide, most of the cyanide would be found in:
    A. mitochondria
    B. lysosomes
    C. ribosomes
    D. ER

12. Intestinal cells absorb glucose, galactose, and fructose by carrier-mediated transport. Poisoning the cells' mitochondria inhibits the absorption of glucose and galactose but not that of fructose. By what processes are these sugars absorbed?
    A. All are absorbed by facilitated diffusion.
    B. All are absorbed by active transport.
    C. Glucose and galactose are actively transported, but fructose is moved by facilitated diffusion.
    D. Fructose is actively transported, but glucose and galactose are moved by facilitated diffusion.

13. In a polarized cell:
    A. sodium is being pumped out of the cell
    B. potassium is being pumped out of the cell
    C. sodium is being pumped into the cell
    D. potassium is being pumped into the cell

14. Which of the following are possible functions of the glycocalyx?
    A. Determination of blood groups
    B. Binding sites for toxins
    C. Aiding the binding of sperm to egg
    D. Guiding embryonic development
    E. Increasing the efficiency of absorption

15. A cell stimulated to increase steroid production will have abundant:
    A. ribosomes
    B. rough ER
    C. smooth ER
    D. Golgi apparatus
    E. secretory vesicles

16. A cell's ability to replenish its ATP stores has been diminished by a metabolic poison. What organelle is most likely to be affected?
    A. Nucleus
    B. Plasma membrane
    C. Centriole
    D. Microtubule
    E. Mitochondrion

17. Steroid hormones increase protein synthesis in their target cells. How would this stimulus be signified in a bone-forming cell that secretes the protein collagen?
    A. Increase in heterochromatin
    B. Increase in endocytosis
    C. Increase in lysosome formation
    D. Increase in formation of secretory vesicles
    E. Increase in amount of rough ER

18. In certain nerve cells that sustain damage, the rough ER disbands and most ribosomes are free. What does this indicate?
    A. Decrease in protein synthesis
    B. Increase in protein synthesis
    C. Increase in synthesis of intracellular proteins
    D. Increase in synthesis of secreted proteins

19. What cellular inclusions increase in number in a light-skinned human after increased exposure to sunlight?
    A. Melanin granules
    B. Lipid droplets
    C. Glycogen granules
    D. Mucus
    E. Zymogen granules

20. A cell with abundant peroxisomes would most likely be involved in:
    A. secretion
    B. storage of glycogen
    C. ATP manufacture
    D. movement
    E. detoxification activities

21. Biochemical tests show a cell with replicated DNA, but incomplete synthesis of proteins needed for cell division. In what stage of the cell cycle is this cell most likely to be?

A. M
C. S
B. G_2
D. G_1

22–24. Consider the following information for Questions 22–24:

A DNA segment has this nucleotide sequence:

A A G C T C T T A C G A A T A T T C

22. Which mRNA matches or is complementary?

A. A A G C T C T T A C G A A T A T T C
B. T T C G A G A A T G C T T A T A A G
C. A A G C U C U U A C G A A U A U U C
D. U U C G A G A A U G C U U A U A A G

23. How many amino acids are coded in this segment?

A. 18
C. 6
B. 9
D. 3

24. What is the tRNA anticodon sequence for the fourth codon from the left?

A. G
C. GCU
B. GC
D. CGA

25. The organelle that consists of a stack of 3–10 membranous discs associated with vesicles is:

A. mitochondrion
C. Golgi apparatus
B. smooth ER
D. lysosome

26. Which statement concerning lysosomes is false?

A. They have the same structure and function as peroxisomes.
B. They form by budding off the Golgi apparatus.
C. They are abundant in phagocytes.
D. They contain their digestive enzymes to prevent general cytoplasmic damage.

27. The fundamental structure of the plasma membra is determined almost exclusively by:

A. phospholipid molecules
B. peripheral proteins
C. cholesterol molecules
D. integral proteins

28. Centrioles:

A. start to duplicate in G_1
B. reside in the centrosome
C. are made of microtubules
D. lie parallel to each other

29. The *trans* face of the Golgi apparatus:

A. is where products are dispatched in vesicles
B. is its convex face
C. receives transport vesicles from the rough ER
D. is in the center of the Golgi stack

30. The protein that tags cytoplasmic proteins for destruction is:

A. ubiquitin
B. cyclin
C. proteosome
D. histone

31. It is impossible to see chromosomes in an interphase cell because:

A. they must be moved to the center of the spindle before they become visible
B. they are an extended threadlike form called chromatin
C. they have left the nucleus
D. DNA synthesis has not occurred yet

Word Dissection

For each of the following word roots, fill in the literal meaning and give an example, using a word found in this chapter.

Word root	Translation	Example
1. chondri		
2. chrom		
3. crist		
4. cyto		
5. desm		
6. dia		
7. dys		
8. flagell		
9. meta		
10. mito		
11. nucle		
12. onco		
13. osmo		
14. permea		
15. phag		
16. philo		
17. phobo		
18. pin		
19. plasm		
20. telo		
21. tono		
22. troph		
23. villus		