3

Cell Structures and Their Functions

FOCUS: The basic unit of the human body is the cell. The cell membrane regulates the movement of materials into and out of the cell by diffusion, facilitated diffusion, active transport, endocytosis, and exocytosis. Chromosomes in the nucleus contain DNA which regulates the activities of the cell by controlling protein synthesis. The cytoplasm contains organelles which are specialized to perform specific functions such as protein synthesis (ribosomes) and ATP production (mitochondria).

CONTENT LEARNING ACTIVITY

Cell Structure

"*Each cell is a highly organized unit.*"

Match these terms with the correct statement or definition:

Cell membrane
Cytoplasm
Organelle
Nucleus

_____ 1. General term for specialized structure within cells which performs specific functions.

_____ 2. Contains the cell's genetic material and controls the cell.

_____ 3. Living material surrounding the nucleus of a cell; contains organelles.

_____ 4. Encloses the cytoplasm.

Cell Membrane

"*The cell membrane, or plasma membrane, is the outermost component of a cell.*"

A. Match these terms with the correct statement or definition:

Extracellular
Intracellular

_____ 1. Substances outside the cell.

_____ 2. Substances inside the cell.

B. Using the terms provided, complete these statements:

Cholesterol
Nonpolar
Phospholipid
Polar
Protein

The cell membrane consists of a double layer of (1) molecules. The (2) ends of these molecules are exposed to water inside and outside the cell, and the (3) ends form a lipid barrier between the inside and outside of the cell. Other lipids, such as (4), are interspersed among the phospholipids. According to the fluid mosaic model, (5) molecules float in the phospholipids and function as membrane channels, carrier molecules, receptor molecules, enzymes, or structural supports in the membrane.

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

C. Match these terms with the the correct plasma membrane: parts labeled in figure 3.1:

Carbohydrate chains
Cholesterol
Glycolipid
Membrane channel protein
Nonpolar region of phospholipid
Phospholipid bilayer
Polar region of phospholipid
Protein

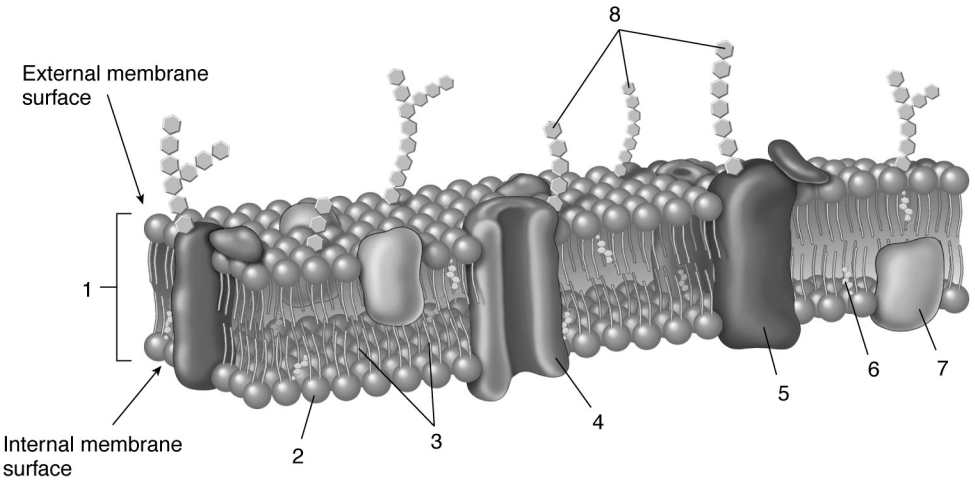


Figure 3.1

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

Organelles and Cell Functions

"*Organelles are specialized structures within cells that perform specific functions.*"

A. Match these terms with the correct statement or definition:

Nucleus, Nucleolus, Ribosome, Rough ER, Smooth ER

_____ 1. Large, membrane-bounded structure usually located near the center of the cell.

_____ 2. Contains chromosomes (DNA) which determine the structure and function of the cell.

_____ 3. Site of ribosomal subunit production.

_____ 4. Site of protein synthesis.

_____ 5. Membrane without ribosomes; site of lipid synthesis.

Ribosomal subunits leave the nucleus through nuclear pores.

B. Match these terms with the correct statement or definition:

Golgi apparatus, Mitochondria, Lysosome, Secretory vesicle

_____ 1. Closely packed stacks of membranes; collects, modifies, packages, and distributes protein and lipid molecules.

_____ 2. Membrane-bounded sac that pinches off from the Golgi apparatus and releases its contents to the cell's exterior.

_____ 3. Membrane-bounded sac containing digestive enzymes.

_____ 4. Rod-shaped organelles with inner and outer membranes; major site of ATP production.

C. Match these terms with the correct statement or definition:

Cytoskeleton, Intermediate filaments, Microfilaments, Microtubules

_____ 1. General term for proteins that support the cell and make possible cell movements.

_____ 2. Hollow protein tubules; assist in cell division and help to form cilia and flagella.

_____ 3. Protein fibrils that enable muscles cells to contract.

_____ 4. Protein fibrils that are smaller than microtubules and larger than microfilaments; provide mechanical support.

D. Match these terms with the correct statement or definition:

Cilia
Flagellum
Microvilli

_____ 1. Projections that move materials embedded in mucus.

_____ 2. A long projection that functions to move a sperm cell.

_____ 3. Specialized extensions of the cell membrane that increase the surface area of cells; important in absorption of materials.

Cell Diagram

Match these terms with the cell parts labeled in figure 3.2:

Cell membrane
Centrioles
Cilia
Golgi apparatus
Lysosomes
Microvilli
Mitochondrion
Nuclear envelope
Nucleus
Nucleolus
Phagocytic vesicle
Cell membrane
Ribosome
Rough endoplasmic reticulum
Secretory vesicle
Smooth endoplasmic reticulum
Vesicles

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

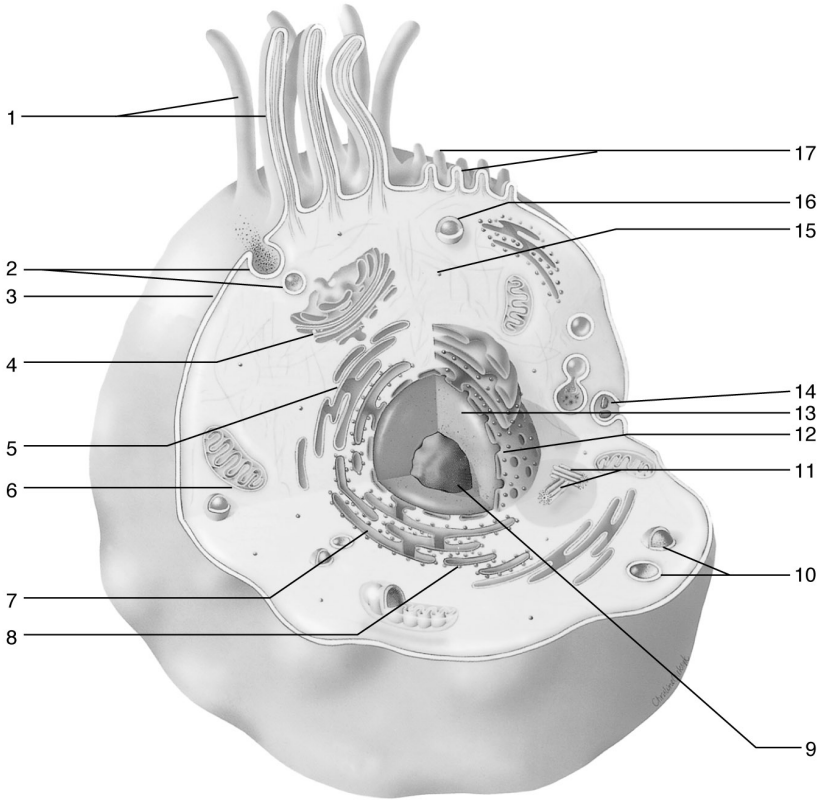


Figure 3.2

Movement Through the Cell Membrane

"*The cell membrane is selectively permeable, allowing some substances to pass through it, but not others.*"

Match these terms with the correct statement or definition:

Carrier molecules
Lipid bilayer
Membrane channels
Vesicles

_____ 1. Molecules that are soluble in lipids dissolve in this.

_____ 2. Allow molecules of only a certain size range to pass through.

_____ 3. Large molecules that are not lipid-soluble are transported by these proteins.

_____ 4. Membrane-bound sacs that transport large nonlipid-soluble molecules, small pieces of matter, and even whole cells.

_____ 5. Sodium and potassium ions are transported through these.

_____ 6. Glucose and amino acids are transported by these.

Because of the membrane's permeability characteristics and its ability to transport certain molecules, cells are able to maintain proper intracellular concentrations of molecules.

Diffusion

"*Diffusion is an important means by which substances move through the extracellular and intracellular fluids in the body.*"

Match these terms with the correct statement or definition:

Diffusion
Solute
Solvent

_____ 1. Predominant liquid or gas in a solution.

_____ 2. Substance dissolved in the solvent.

_____ 3. Tendency for solute ions or molecules to move from an area of higher concentration to an area of lower concentration in solution.

_____ 4. Process involving the constant random movement of solutes in a solution.

A concentration gradient is a measure of the difference in concentration of a solute in a solvent between two points.

Osmosis and Filtration

"*Osmosis is important to cells because large volume changes caused by water movement can disrupt normal cell functions.*"

Match these terms with the correct statement or definition:

Crenation, Filtration, Hypotonic, Hypertonic, Isotonic, Lysis, Osmosis, Osmotic pressure

_____ 1. Diffusion of water across a selectively permeable membrane.

_____ 2. The force required to prevent the movement of water across a selectively permeable membrane.

_____ 3. When a cell is placed in this type of solution it shrinks.

_____ 4. Rupture of a cell placed in hypotonic solution.

_____ 5. Movement of a solution through a membrane in response to a pressure difference; some substances pass through the membrane but others don't.

Mediated Transport Mechanisms

"*Mediated transport mechanisms involve carrier molecules that move large, water soluble or electrically charged molecules across the cell membrane.*"

Match these terms with the correct statement or definition:

Active transport, Facilitated diffusion, Secondary active transport

_____ 1. Only moves substances from a higher to a lower concentration; does not require metabolic energy (ATP).

_____ 2. Moves substances against their concentration gradient; requires ATP; the sodium-potassium exchange pump is an example.

_____ 3. Establishes an ion concentration gradient; diffusion of the ions provides the energy necessary to transport other substances.

Endocytosis and Exocytosis

"*Endocytosis and exocytosis use vesicles to move substances across the cell membrane.*"

Match these terms with the correct statement or definition:

Endocytosis, Exocytosis, Phagocytosis, Pinocytosis

_____ 1. Includes both phagocytosis and pinocytosis.

_____ 2. Means cell eating and is the ingestion of solid particles.

_____ 3. Secretory vesicles fuse with the cell membrane, and the contents of the vesicle are eliminated from the cell.

Cell Metabolism

"*Cell metabolism is the sum of all the chemical reactions in the cell.*"

Match these terms with the correct statement or definition:

Aerobic respiration
Anaerobic respiration
Glycolysis

_____ 1. The chemical process that breaks down glucose to pyruvic acid.

_____ 2. Can only occur when oxygen is available.

_____ 3. Through the citric acid cycle and the electron transport chain, pyruvic acid is converted to carbon dioxide and water.

_____ 4. Produces 36 to 38 ATP molecules from each glucose molecule.

_____ 5. Occurs without oxygen and converts pyruvic acid to lactic acid.

_____ 6. Produces two ATP molecules for each glucose molecule.

_____ 7. Allows cells to function when oxygen levels are low, for example, during intense exercise.

Protein Synthesis

"*Events that lead to protein synthesis begin in the nucleus and end in the cytoplasm.*"

Match these terms with the correct statement or definition:

mRNA
rRNA
tRNA
Transcription
Translation

_____ 1. This process occurs when the double strands of a DNA segment separate, and RNA nucleotides pair with DNA nucleotides.

_____ 2. RNA that carries information in groups of three nucleotides called codons, and each codon codes for a specific amino acid.

_____ 3. RNA that has an anticodon and binds to a specific amino acid.

_____ 4. This process involves the synthesis of polypeptide chains at the ribosome in response to the information contained in mRNA molecules.

The proteins produced in a cell function as enzymes or structural components inside and outside the cell.

Mitosis

"Nearly all cell divisions in the body occur by mitosis, and the resultant "daughter" cells have the same amount and type of DNA as the "parent" cell."

A. Match these terms with the correct statement or definition:

Autosomes
Diploid
XX
XY

_____ 1. The number of chromosomes in most body cells; 46 in humans.

_____ 2. The name of chromosomes other than the sex chromosomes.

_____ 3. The sex chromosomes found in a female.

B. Match these terms with the correct statement or definition:

Anaphase
Interphase
Metaphase
Prophase
Telophase

_____ 1. Time of DNA replication; not one of the four phases of mitosis.

_____ 2. Chromosomes become visible in this phase.

_____ 3. Chromosomes align along the center of the cell.

_____ 4. Chromosomes move toward the poles of the cell.

_____ 5. Chromosomes begin to unravel and resemble the genetic material during interphase.

C. Match these terms with the correct statement or definition:

Centriole
Centromere
Chromatids
Spindle fibers

_____ 1. The two strands that make up a chromosome after interphase.

_____ 2. The specialized region that links chromatids together.

_____ 3. Move the chromosomes toward the poles of the cell.

D. Match these terms with the phases of mitosis and the cell parts involved in mitosis labeled in figure 3.3:

Anaphase
Centriole
Centromere
Chromatid
Chromatin
Chromosome
Metaphase
Nucleoli
Nuclear membrane
Prophase
Spindle fiber
Telophase

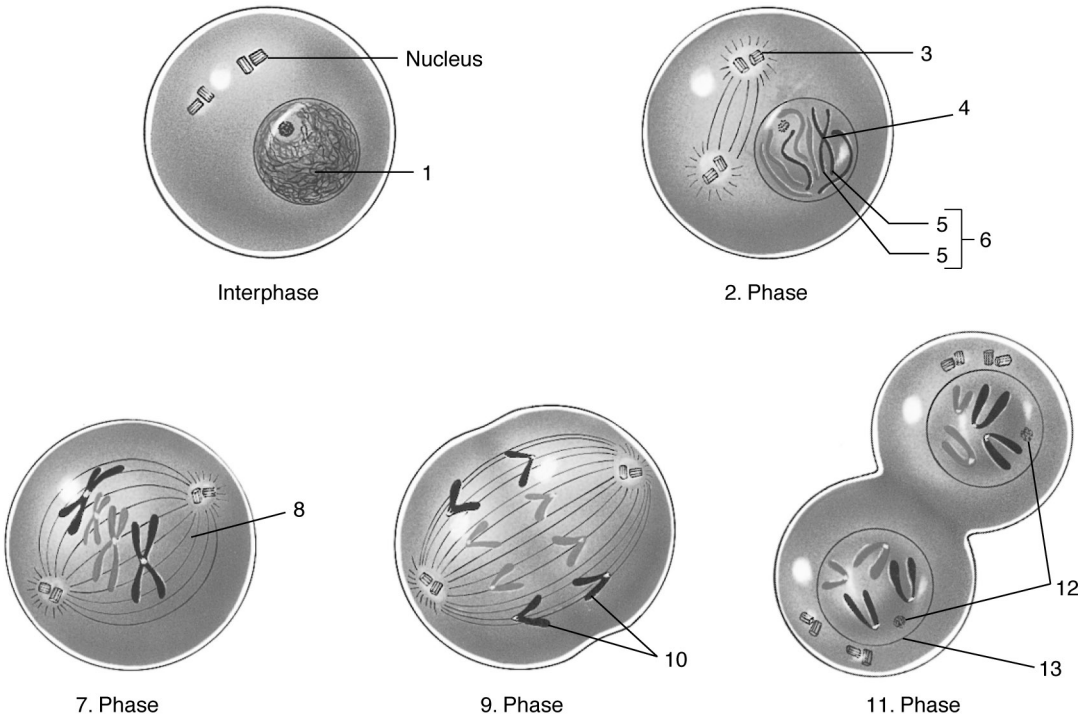


Figure 3.3

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

Meiosis

"*Meiosis is the formation of sex cells.*"

Match these terms with the correct statement or definition:

Crossing over
Haploid
Interkinesis
Gametes
Random distribution
Tetrad

_____ 1. Sex cells such as sperm cells or oocytes.

_____ 2. The number of chromosomes in a sex cell; 23 in humans.

_____ 3. Four chromatids of a pair of chromosomes.

_____ 4. Time between the first and second meiotic division.

_____ 5. Two things responsible for genetic diversity.

_____

_____

Differentiation

"*The human body is composed of many different kinds of cells.*"

Using the terms provided, complete these statements:

The same
Different
Differentiation

All the cells in the body arise from a single fertilized egg. The DNA in these cells is (1). The process by which cells develop specialized structures and functions is called (2). One type of specialized cell (e.g., bone cell) has (3) DNA as another type of specialized cell (e.g., fat cell). The reason specialized cell types are different from each other is because they have (4) parts of their DNA active.

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

QUICK RECALL

Complete the following chart by writing in the organelle described by the structures and functions listed.

	ORGANELLE	STRUCTURE	FUNCTION
1.	_____	Membrane-bound sac pinched off from the Golgi apparatus	Contents released to the exterior of the cell by exocytosis
2.	_____	Series of membranes that extend from the outer nuclear membrane; no ribosomes attached	Lipid synthesis
3.	_____	Surrounded by double-layered envelope with pores	Contains DNA in the form of chromatin (chromosomes) which produces RNA
4.	_____	Composed of hollow protein tubules	Support for the cytoplasm of the cell; involved in cell division; essential component of cilia and flagella
5.	_____	Small extensions of the cell membrane supported by microfilaments	Increase cell surface area for absorption
6.	_____	Closely packed stacks of curved membrane-bound sacs	Modifies, packages, and distributes proteins and lipids
7.	_____	Two subunits composed of ribosomal RNA and protein	Site where mRNA and tRNA come together to assemble amino acids into proteins
8.	_____	Membrane-bound vesicle containing intracellular digestive enzymes	Breakdown of phagocytized particles
9.	_____	Small, bean-shaped or rod-shaped organelle; double membrane with infoldings of the inner membrane called cristae	Most ATP synthesis in the cell
10.	_____	Small organelles that divide and migrate to each pole of the cell during cell division.	Chromosomes move toward them during cell division.
11.	_____	Series of membranes that extend from the outer nuclear membrane; ribosomes attached	Synthesis of proteins

12. _____	One to four rounded, dense, well-defined nuclear bodies	Production of ribosomal subunits
13. _____	Appendages from the surface of the cell; contain microtubules	Movement of materials over the surface of the cells
14. _____	Similar to cilia but much longer; usually one per cell	Propels sperm cells
15. _____	Small protein fibrils	Provide structure to cytoplasm and mechanical support to microvilli; responsible for muscle's ability to contract
16. _____	Protein fibrils, intermediate in size between microtubules and microfilaments	Provide mechanical support to the cell

17. List six functions of the cell.

18. List the two major types of molecules found in the cell membrane and give their functions.

19. List eight ways materials (including water) can cross a membrane.

20. List three terms used to describe the tendency of cells to shrink or swell when placed in a solution.

21. Name the two steps that occur during protein synthesis.

WORD PARTS

Give an example of a new vocabulary word that contains each word part.

WORD PART	MEANING	EXAMPLE
intra-	within	1. _____
inter-	between	2. _____
iso-	equal	3. _____
hypo-	under; less than	4. _____
hyper-	over; above	5. _____
-some	body	6. _____

MASTERY LEARNING ACTIVITY

Place the letter corresponding to the correct answer in the space provided.

_____ 1. Cytoplasm is
a. called the control center of the cell.
b. found surrounding the nucleus.
c. responsible for regulating what materials enter or exit the cell.
d. assembled within the nucleolus.

_____ 2. Which of the following are functions of the proteins found in cell membranes?
a. membrane channels
b. carrier molecules
c. enzymes
d. receptor molecules
e. all of the above

_____ 3. A large structure normally visible in the nucleus of a cell?
a. endoplasmic reticulum
b. mitochondrion
c. nucleolus
d. lysosome

_____ 4. Which of the following organelles would one expect to be present in a cell responsible for producing lipids?
a. rough endoplasmic reticulum
b. smooth endoplasmic reticulum
c. lysosomes
d. centrioles

_____ 5. The cell organelle that modifies and packages material to be secreted is the
a. nucleolus.
b. ribosome.
c. mitochondria.
d. Golgi apparatus.

_____ 6. Which of the following organelles produces large amounts of ATP?
a. nucleus
b. mitochondria
c. ribosomes
d. endoplasmic reticulum

_____ 7. Lipid-soluble molecules diffuse through the _____; water soluble molecules diffuse through the _____.
a. membrane channels; membrane channels
b. membrane channels; cell membrane
c. cell membrane; membrane channels
d. cell membrane; cell membrane

_____ 8. Container A contains a 10% salt solution and container B a 20% salt solution. If the two solutions were connected, the net movement of water by diffusion would be from _____ to _____, and the net movement of the salt by diffusion would be from _____ to _____.
a. A, B, A, B
b. A, B, B, A
c. B, A, A, B
d. B, A, B, A

_____ 9. Which of the following statements is true about facilitated diffusion?
a. Net movement is with the concentration gradient.
b. It requires the expenditure of energy (ATP).
c. It does not require a carrier molecule.
d. It moves materials through membrane channels.

_____ 10. Which of the following statements concerning the secondary active transport of glucose into cells is true?
a. The sodium-potassium exchange pump moves Na^+ ions out of cells.
b. The concentration of Na^+ ions outside cells is greater than inside cells.
c. A carrier molecule moves Na^+ ions and glucose into cells.
d. all of the above

_____ 11. A process that uses vesicles to move liquid (not particulate matter) into cells is
a. diffusion.
b. pinocytosis.
c. phagocytosis.
d. exocytosis.

_____ 12. As a result of cell metabolism
a. ATP molecules are produced by aerobic or anaerobic respiration.
b. the oxygen we breathe in is used to form water.
c. the carbon atoms of food molecules are used to produce carbon dioxide.
d. all of the above

_____ 13. Transcription occurs when the sequence of
a. nucleotides in DNA (a gene) determines the sequence of nucleotides in mRNA.
b. nucleotides in mRNA determines the sequence of amino acids in mRNA.
c. amino acids in tRNA determines the sequence of nucleotides in DNA
d. amino acids in proteins determines the sequence of nucleotides in DNA

_____ 14. A portion of a mRNA molecule that determines one amino acid in a polypeptide chain is called a
a. anticodon.
b. codon.
c. nucleotide.
d. translator.

_____ 15. In which of the following organelles is mRNA synthesized?
a. nucleus
b. ribosome
c. endoplasmic reticulum
d. lysosome

_____ 16. The organelle of the cell that serves as the site of protein synthesis?
a. ribosome
b. vesicle
c. Golgi apparatus
d. nucleolus

_____ 17. Transfer RNA
a. is used to produce mRNA.
b. binds to amino acids and has an anticodon.
c. duplicates itself during interphase.
d. is a type of enzyme.

_____ 18. Given the following events:
1. tRNA is released from the ribosome
2. mRNA binds to a ribosome
3. amino acids on adjacent tRNA bind together
4. the codon of mRNA binds to the anticodon of tRNA

Arrange the events in the order in which they occur during translation.
a. 2, 4, 3, 1
b. 2, 4, 1, 3
c. 4, 2, 3, 1
d. 4, 2, 1, 3

_____ 19. Choose the consequence that most specifically predicts the response of a cell to a substance that inhibits messenger RNA synthesis.
a. inhibits protein synthesis
b. inhibits DNA synthesis
c. stimulates protein synthesis
e. stimulates DNA synthesis

_____ 20. Given the following activities:
1. repair
2. growth
3. gamete production
4. differentiation

Which of the activities are the result of mitosis?
a. 2
b. 3
c. 1, 2
d. 3, 4
e. 1, 2, 4

_____ 21. Chromatids
a. are duplicated DNA molecules.
b. are joined at the centromere.
c. become chromosomes at anaphase.
d. all of the above

_____ 22. The stage of mitosis in which the chromosomes unravel and new nuclei are formed?
a. anaphase
b. metaphase
c. prophase
d. telophase

_____ 23. The major function of meiosis is to ensure that each of the resultant daughter cells
a. has the same number and kind of chromosomes as the parent cell.
b. has one half the number of chromosomes as the parent cell.
c. has only autosomal chromosomes
d. none of the above

_____ 24. Crossing over
a. occurs during mitosis.
b. is an exchange of genetic material between chromatids.
c. decreases genetic variability.
d. establishes the sex of the individual.

_____ 25. The sex of individuals is determined by their sex chromosomes. An individual is male if he has chromosomes
a. MM.
b. MF.
c. XX.
d. XY.

FINAL CHALLENGES

Use a separate sheet of paper to complete this section.

1. Given the following characteristics in an electron micrograph of a cell:
   1. many microvilli
   2. many mitochondria
   3. the cell lines a cavity
   4. little smooth endoplasmic reticulum
   5. little rough endoplasmic reticulum
   6. few vesicles

   On the basis of these observations, which of the following is likely to be a major function of the cell?
   a. secretion of a protein
   b. production of a lipid
   c. intracellular digestion
   d. active transport

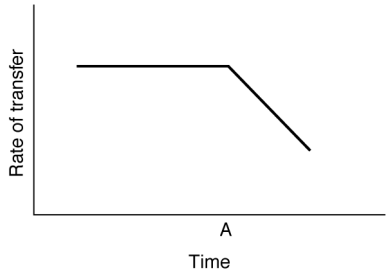
2. Mature red blood cells do not contain a nucleus, but they do have other cell organelles. Given the following activities:
   1. Produce ATP.
   2. Produce mRNA.
   3. Produce ribosomes.

   List the activities the red blood cell is able to perform.
   a. 1
   b. 3
   c. 1, 2
   d. 2, 3
   e. 1, 2, 3

3. Suppose that a woman was running a long distance race. During the race she lost a large amount of hypotonic sweat. You would expect her cells to
   a. shrink.
   b. swell.
   c. remain the same.

4. Suppose that a man is doing heavy exercise in the hot summer sun. He perspires profusely. He then drinks a large volume of distilled water. You would expect his cells to
   a. shrink.
   b. swell.
   c. remain the same.

5. In an experiment the rate of transfer of an amino acid into a cell was carefully monitored. Part way through the experiment, at time A, an inhibitor of ATP production was introduced. The results of this experiment are graphed below.



   On the basis of these data it can be concluded that the mechanism responsible for the movement of the amino acid was
   a. diffusion.
   b. facilitated diffusion.
   c. active transport.