3

Cell organization

LEARNING OBJECTIVES

After studying this chapter, you should be able to:

- Describe cell structures and their functions.
- Discuss cellular energy production.
- Identify how substances move across a cell membrane.
- Describe cell division.
- Understand the phases of mitosis and meiosis.

CHAPTER OVERVIEW

Although the cellular level is the second level of structural organization, it's the first level for living matter. Learning about cell organization and function can help the nurse better understand certain disease processes, drug actions, and laboratory tests. This chapter reviews cellular components and energy production. It also explains substance movement across the cell membrane as well as cell division, including the phases of mitosis and meiosis.

CELLULAR COMPONENTS

Key concepts

- Cells are structural and functional units of all living matter
- Smallest body structures that can perform all the fundamental activities of life (such as movement, ingestion, excretion, and reproduction)
- Consist of three major components: protoplasm, a cell membrane, and a nucleus (see *Inside the cell,* page 28)

Protoplasm

- Viscous, translucent material containing a large percentage of water, inorganic ions (such as potassium, calcium, magnesium, and sodium), and naturally occurring organic compounds (such as proteins, lipids, and carbohydrates)
- *Nucleoplasm* is the protoplasm of the cell's nucleus; it plays a role in reproduction
- *Cytoplasm* is the protoplasm of the cell body that surrounds the nucleus (all the cell's contents from the cell membrane to the nucleus); it contains cytosol, organelles, and inclusions
  - *Cytosol* is the semifluid medium in the cytoplasm that makes up intracellular fluid; it contains proteins, enzymes, nutrients, and ions
  - *Organelles* are metabolic units that perform a specific function to maintain the life of the cell; they include mitochondria, ribosomes, the endoplasmic reticulum, Golgi apparatus (or complex), lysosomes, centrosomes, peroxisomes, and cytoskeletal elements
    - *Mitochondria* are the energy-producing cellular structures containing enzymes that oxidize food nutrients; this oxidation produces *adenosine triphosphate* (ATP), which provides energy for many cellular activities
    - *Ribosomes* are nucleoprotein particles attached to the endoplasmic reticulum and the site of protein synthesis
    - *Endoplasmic reticulum,* a system of interconnecting, fluid-filled, tubular channels, connects all parts of the cytoplasm
      - Rough (granular) endoplasmic reticulum is covered with ribosomes
      - Smooth endoplasmic reticulum contains enzymes to synthesize lipids
    - *Golgi apparatus* synthesizes carbohydrate molecules, which combine with protein produced by rough endoplasmic reticulum to form secretory products (such as lipoproteins)

Key facts about protoplasm

- Viscous, translucent material containing water, inorganic ions, and organic compounds
- Nucleoplasm: protoplasm of the cell's nucleus
- Cytoplasm: protoplasm of the cell body; contains cytosol, organelles, and inclusions

Types of organelles

- Mitochondria: produce energy through the production of ATP
- Ribosomes: site of protein synthesis
- Endoplasmic reticulum: channels connecting all parts of the cytoplasm
- Golgi apparatus: synthesize carbohydrate molecules
- Lysosomes: responsible for digestion within the cell
- Centrosomes: contain centrioles, which move to opposite poles of a cell during division
- Peroxisomes: contain oxidases, which reduce oxygen to hydrogen peroxide and hydrogen peroxide to water
- Cytoskeletal elements: form protein structure network

Key components of a cell

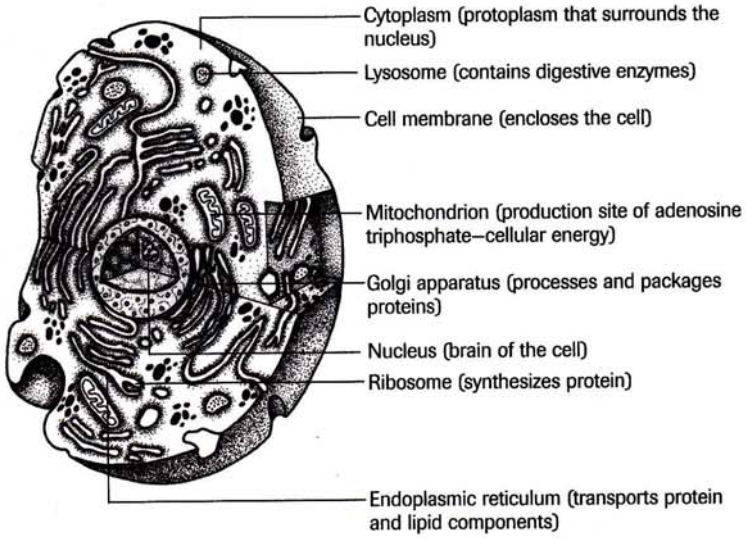
- Cytoplasm
- Lysosome
- Cell membrane
- Mitochondrion
- Golgi apparatus
- Nucleus
- Ribosome
- Endoplasmic reticulum

Key facts about the nucleus

- Control center of the cell
- Contains genetic material
- Contains one or more nucleoli
- Nuclear membrane separates the nucleus from the cytoplasm

Inside the cell

This cross section shows the components and structures of a cell.



- *Lysosomes* are digestive bodies that break down damaged or foreign material in the cells (see *Lysosomes at work*)
- Centrosomes contain *centrioles,* short cylinders adjacent to the nucleus; during cell division, they move to opposite poles of the cell and form the mitotic spindle
- Peroxisomes contain *oxidases,* enzymes capable of reducing oxygen to hydrogen peroxide and hydrogen peroxide to water
- Cytoskeletal elements form a network of protein structures

– *Inclusions* are chemicals produced by the cell (such as melanin, glycogen, and triglycerides) that aren't contained by a membrane but some have particular shape

Cell (plasma) membrane

- Semipermeable structure that surrounds the cell
- Regulates passage of certain materials in and out of the cell
- Separates the cell's internal environment from its external one

Nucleus

- Control center of the cell that directs the activities of the cytoplasmic structures
- Contains genetic material of the cell
- Also contains one or more *nucleoli,* spherical structures that synthesize ribonucleic acid (RNA)

Lysosomes at work

Lysosomes are the organelles responsible for digestion within a cell. Phagocytes assist in this process. Here's how lysosomes work.

FUNCTION OF LYSOSOMES

Lysosomes are digestive bodies that break down foreign or damaged material in cells. A membrane surrounds each lysosome and separates its digestive enzymes from the rest of the cytoplasm.

BREAKING IT DOWN

The lysosomal enzymes digest matter brought into the cell by *phagocytes*, special cells that surround and engulf matter outside the cell and then transport it through the cell membrane. The membrane of the lysosome fuses with the membrane of the cytoplasmic spaces surrounding the phagocytized material; this fusion allows the lysosomal enzymes to digest the engulfed material.

Key processes of lysosomes

- Enzymes digest matter brought into the cell by phagocytes
- Lysosome membrane fuses with the membrane of the cytoplasmic spaces (surrounds phagocytized material)
- Fusion allows enzymes to digest the engulfed matter

- Has a *nuclear membrane,* which separates the nucleus from the cytoplasm; pores in this membrane allow certain substances to pass through

CELLULAR ENERGY PRODUCTION

Key concepts

- Cellular activities require energy
- Mitochondria are the cellular power stations
  - – Contain enzymes that oxidize food nutrients
  - – Oxidation produces *ATP,* a chemical fuel for cellular processes
    - ATP is composed of a nitrogen-containing compound (adenine) joined to a five-carbon sugar (ribose) to form adenosine
      - Adenosine is joined to three phosphate groups
      - Chemical bonds between the first and second and the second and third phosphate groups contain a large amount of energy
    - ATP must be converted to adenosine diphosphate (ADP) to produce energy (remember the three R's)
      - *Rupture*—when the terminal high-energy phosphate bond ruptures, ATP is converted to ADP
      - *Release*—liberation of the third phosphate releases the energy stored in the chemical bond
      - *Recycle*—mitochondrial enzymes use the energy obtained by oxidizing food nutrients to reconvert ADP and the liberated phosphate back into ATP (the ATP is then available again for energy production)

Key facts about cellular energy production

- Mitochondria are the cellular power stations
- Mitochondria contain enzymes that oxidize food nutrients
- Oxidation produces ATP
- Energy is produced when ATP is converted to ADP

Key ATP processes

- Rupture: ATP is converted to ADP
- Release: Energy stored in the chemical bond is released
- Recycle: ADP is reconverted to ATP for further energy production

SUBSTANCE MOVEMENT ACROSS THE CELL MEMBRANE

Key concepts

- Each cell interacts with body fluids through the interchange of substances across the cell membrane
- Substances move between cells and body fluids by one of four main mechanisms: diffusion, osmosis, active transport, or endocytosis
- Transport of fluids and dissolved substances across capillaries into *interstitial fluid* (fluid surrounding the cells) is facilitated by filtration

Diffusion

- Passive transport method that doesn't require cellular energy
- Dissolved particles (solute) move from an area of higher concentration to one of lower concentration
- Several factors influence the diffusion rate
  - *Concentration gradient* (difference in particle concentration on either side of the plasma membrane) affects diffusion (the greater the concentration gradient, the faster diffusion occurs)
  - Small particles diffuse more rapidly than large particles
  - Lipid-soluble particles diffuse more rapidly than other particles through the lipid layers of the cell membrane
  - *Electrical charge* of particles can speed or slow diffusion
    - If electrically charged particles (ions) on either side of the cell membrane have opposite charges, diffusion occurs more rapidly (ions with opposite charges attract each other)
    - If ions on either side of the membrane have the same charge, diffusion occurs more slowly (ions with the same charge repel each other)
- *Facilitated diffusion* occurs when a carrier molecule in the cell membrane picks up the diffusing substance on one side of the membrane and deposits it on the other side

Osmosis

- Passive transport method that involves molecule movement from a solution of higher concentration to one of lower concentration (see *Understanding osmosis*)
- Movement of water (solvent) molecules across the cell membrane differentiates osmosis from diffusion; water moves from a dilute solution (with a higher concentration of water molecules) to a concentrated solution (with a lower concentration of water molecules)
- Mechanism depends on the *osmotic pressure* of a solution
  - Osmotic pressure measures the "water-attracting" property of a solution (determined by the number of dissolved particles in a

Key facts about diffusion

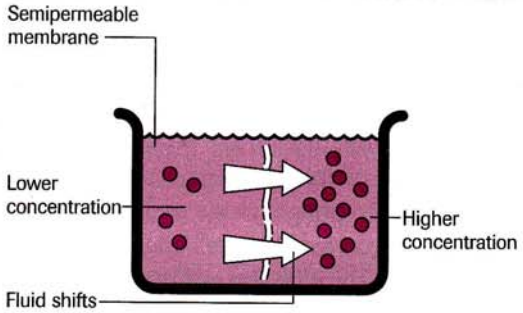
- Passive transport method that doesn't require energy
- Dissolved particles move from an area of higher to lower concentration
- Concentration gradient, particle size, and particle type affect diffusion rate
- Facilitated diffusion: the diffusing substance is picked up on one side of the membrane and deposited on the other side

Key facts about osmosis

- Passive transport method in which molecules move from a solution of higher to lower concentration
- Water molecules move from an area of dilute solution (with a higher concentration of water molecules) to concentrated solution (with a lower concentration of water molecules)
- Depends on osmotic pressure

Understanding osmosis

This illustration shows the movement of fluid from an area of lower solute concentration to an area of higher solute concentration until the concentration is equal in both areas. This movement is known as *osmosis*.



given volume of solution, not by their size or electrical charge); for example, a calcium chloride molecule ($CaCl_2$) dissociates (ionizes) in solution into three particles: a calcium ion and two chloride ions (its osmotic pressure is higher than that of a larger glucose molecule, which doesn't dissociate into ions when dissolved in solution)

- Water movement in and out of cells by osmosis depends on the osmotic pressure differences between intracellular and extracellular fluids (normally, intracellular osmotic pressure equals extracellular osmotic pressure; consequently, water content of cells doesn't change)
- Osmotic pressure changes in body fluids cause water to shift between cells and extracellular fluids, impairing or disrupting cell functions
  - When osmotic pressure of extracellular fluid is lower than that of intracellular fluid, water enters cells, causing them to swell and, possibly, rupture
  - Conversely, when osmotic pressure of extracellular fluid is higher than that of intracellular fluid, water moves into extracellular fluid, causing cells to shrink

- **Active transport**
  - Transport method that moves a substance across the cell membrane (a *carrier molecule* in the cell membrane combines with the substance, transports it through the membrane, and deposits it on the other side of the membrane)
    - Usually, a substance moves from an area of lower concentration to an area of higher concentration (against the concentration gradient)
    - A substance may move from an area of higher concentration to an area of lower concentration (with the concentration gradient)

Key facts about osmotic pressure

- Measures the "water-attracting" property of a solution (determined by the number of dissolved particles in a solution)
- Osmotic pressure differences between intracellular and extracellular fluids cause osmosis
- A change in the osmotic pressure of body fluids triggers a water shift between cells and extracellular fluids

Key facts about active transport

- Moves a substance across the cell membrane using a carrier molecule
- Usually moves from an area of lower to higher concentration
- Requires energy from ATP breakdown

- Requires energy from ATP breakdown to transport a substance across a cell membrane

Endocytosis

- Active transport method in which a substance is engulfed by the cell rather than passing through the cell membrane
  - Cell surrounds the substance with part of its membrane
  - Part of the membrane separates, forming a vacuole that moves to the cell interior
- Divided into phagocytosis and pinocytosis
  - In *phagocytosis*, the cell engulfs and ingests particles too large to pass through the cell membrane
  - In *pinocytosis*, the cell engulfs substances in solution or very small particles in suspension

Filtration

- Pressure applied to a solution on one side of the cell membrane forces fluid and dissolved particles through the membrane; the filtration rate depends on the amount of pressure
- Filtration serves two main purposes
  - It promotes transfer of fluids and dissolved materials from blood across capillaries into interstitial fluid (pressure of capillary blood provides filtration force)
  - Filtration from blood flowing through capillaries in the kidneys results in urine formation

Key facts about endocytosis

- Active transport method in which a substance is engulfed by the cell
- Divided into phagocytosis and pinocytosis
- Phagocytosis: the cell ingests particles too large to pass through the cell membrane
- Pinocytosis: the cell engulfs substances in solution

Key facts about filtration

- Pressure forces fluid and dissolved particles through a membrane
- Amount of pressure determines the filtration rate

CELL DIVISION

Key concepts

- Each cell must replicate itself for life to continue
- Before a cell divides, its chromosomes duplicate
- In duplication, deoxyribonucleic acid (DNA) chains separate
  - Double helix separates into two DNA chains (serves as the template for constructing a new chain)
  - Individual DNA nucleotides link into new strands, with bases complementary to those in the originals
  - Two identical double helices (duplicates of the original DNA chain) form, each containing one of the original strands and a newly formed complementary strand (see *DNA duplication*)
- Uncontrolled cell division may cause excess tissue to form (may develop into a tumor, growth, or neoplasm)
- Continuous cell division occurs in phases
- Cells normally divide by mitosis or meiosis

Mitosis

- Form of cell division that all cells undergo (except gametes)
  - Parent cell with 46 chromosomes (diploid) undergoes division and gives rise to two daughter cells

Key facts about cell division

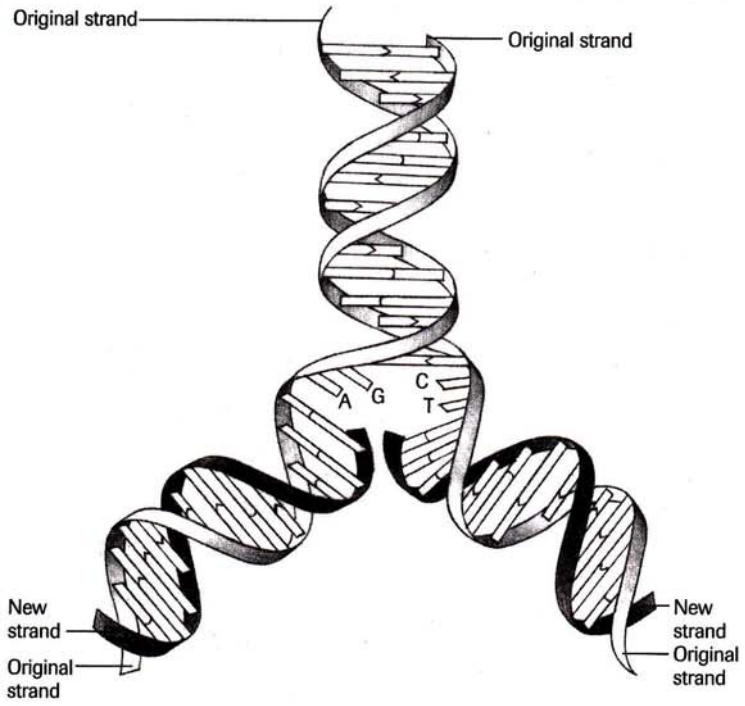
- Chromosomes duplicate before a cell divides
- In duplication, DNA chains separate
- Uncontrolled cell division can cause excess tissue formation
- Cells normally divide by mitosis or meiosis

Key facts about mitosis

- Form of cell division for all cells except gametes
- Parent cell divides to produce two identical daughter cells
- Occurs in one inactive phase and four active phases

DNA duplication

The basic structural unit of deoxyribonucleic acid (DNA) is the nucleotide, which is composed of a phosphate group, deoxyribose, and a nitrogen base made of adenine (A), guanine (G), thymine (T), or cytosine (C). Many nucleotide strands become twisted to form a double helix of a DNA molecule. During duplication, linked DNA chains separate. Then new complementary chains form and link to the originals (parents). This results in two identical double helices, consisting of parent and daughter, as shown.



Key facts about DNA duplication

- Double helix separates into two DNA chains
- DNA nucleotides link into new strands
- Two identical double helices form, each with one original strand and one newly formed strand

  – Both daughter cells are identical to each other and to the parent cell
- Cell division occurs in five phases: *interphase* (inactive phase), *prophase, metaphase, anaphase,* and *telophase* (all active phases) (see *Five phases of mitosis,* page 34)

- **Meiosis**
  - Form of cell division that only gametes (ova and spermatozoa) undergo
  - Genetic material mixes between homologous chromosomes (number of chromosomes in four daughter cells reduces by half)
    – Each cell has only 23 chromosomes (haploid)
    – Each cell contains genetic material from both parents due to crossover and because the chromosomes of each parent don't all move to one side of the cell during anaphase

Key facts about meiosis

- Form of cell division exclusive to gametes
- Has two divisions separated by a resting phase
- First division has six phases: producing two daughter cells, each containing 23 chromosomes
- Second division has four phases: the daughter cells divide, resulting in four daughter cells containing the haploid number of chromosomes

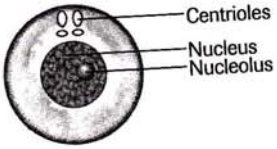
- Cell division occurs in two major steps
  - First division has six phases
  - Second division has four phases; at the end, each parent cell has produced four daughter cells genetically different from the parent cell (see *Meiosis: Step-by-step*)

Five phases of mitosis

Through the process of mitosis, the nuclear content of all body cells (except gametes) reproduces and divides. The result is the formation of two new daughter cells, each containing the diploid (46) number of chromosomes.

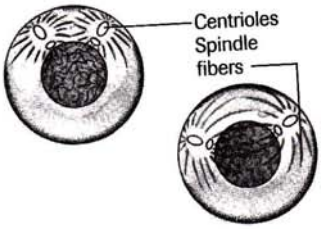
INTERPHASE

During *interphase*, the nucleus and nuclear membrane are well defined and the nucleolus is visible. As chromosomes replicate, each forms a double strand that remains attached at the center by a centromere.



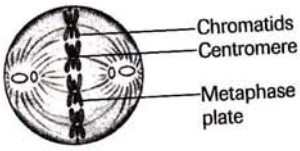
PROPHASE

In *prophase*, the nucleolus disappears and the chromosomes become distinct. *Chromatids*, halves of each duplicated chromosome, remain attached by the centromere. Centrioles move to opposite sides of the cell and radiate spindle fibers.



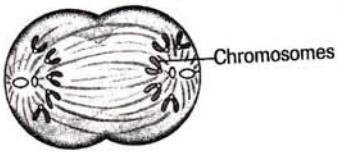
METAPHASE

Metaphase occurs when chromosomes line up randomly in the center of the cell between the spindles, along the metaphase plate. The centromere of each chromosome then replicates.



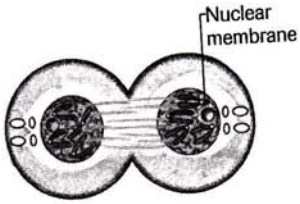
ANAPHASE

Anaphase is characterized by centromeres moving apart, pulling the separate chromatids (now called *chromosomes*) to opposite ends of the cell. The number of chromosomes at each end of the cell equals the original number.



TELOPHASE

During *telophase*, the final stage of mitosis, a nuclear membrane forms around each nucleus and spindle fibers disappear. The cytoplasm compresses and divides the cell in half. Each new cell contains the diploid (46) number of chromosomes.



Five phases of mitosis

- Interphase: nucleus and nuclear membrane are well defined
- Prophase: nucleolus disappears and chromosomes are distinct
- Metaphase: chromosomes line up in the cell's center
- Anaphase: centromeres move apart and chromosomes move to opposite ends
- Telophase: nuclear membrane forms around each nucleus and the cell is divided in half

Meiosis: Step-by-step

Meiosis has two divisions separated by a resting phase. By the end of the first division, two daughter cells exist, each containing the haploid (23) number of chromosomes. When the second division ends, each of the two daughter cells from the first division divides, resulting in four daughter cells, each containing the haploid number of chromosomes.

FIRST DIVISION

The first division has six phases. Here's what happens during each one.

Interphase

1. Chromosomes replicate, forming a double strand attached at the center by a centromere.
2. Chromosomes appear as an indistinguishable matrix within the nucleus.
3. Centrioles appear outside the nucleus.

Prophase I

1. The nucleolus and nuclear membrane disappear.
2. Chromosomes are distinct, with chromatids attached by the centromere.
3. Homologous chromosomes move close together and intertwine; exchange of genetic information (genetic recombination) may occur.
4. Centrioles separate and spindle fibers appear.

Metaphase I

1. Pairs of synaptic chromosomes line up randomly along the metaphase plate.
2. Spindle fibers attach to each chromosome pair.

Anaphase I

1. Synaptic pairs separate.
2. Spindle fibers pull homologous, double-stranded chromosomes to opposite ends of the cell.
3. Chromatids remain attached.

Telophase I

1. The nuclear membrane forms.
2. Spindle fibers and chromosomes disappear.
3. Cytoplasm compresses and divides the cell in half.
4. Each new cell contains the haploid (23) number of chromosomes.

Interkinesis

1. The nucleus and nuclear membrane are well defined.
2. The nucleolus is prominent and each chromosome has two chromatids that don't replicate.

SECOND DIVISION

The second division closely resembles mitosis and is characterized by these four phases.

Prophase II

1. The nuclear membrane disappears.
2. Spindle fibers form.
3. Double-stranded chromosomes appear as thin threads.

Metaphase II

1. Chromosomes line up along the metaphase plate.
2. Centromeres replicate.

Anaphase II

1. Chromatids separate (now a single-stranded chromosome).
2. Chromosomes move away from each other to the opposite ends of the cell.

Telophase II

1. The nuclear membrane forms.
2. Chromosomes and spindle fibers disappear.
3. Cytoplasm compresses, dividing the cell in half.
4. Four daughter cells are created, each containing the haploid (23) number of chromosomes.

Ten phases of meiosis

- Interphase: Chromosomes replicate and form a double strand
- Prophase I: Chromosomes are distinct; homologous chromosomes intertwine
- Metaphase I: Synaptic chromosomes line up
- Anaphase I: Synaptic pairs separate
- Telophase I: Nuclear membrane forms; cell divides in half
- Interkinesis: Nucleus and nuclear membrane are well defined; nucleolus is prominent
- Prophase II: Nuclear membrane disappears
- Metaphase II: Chromosomes line up
- Anaphase II: Chromosomes move to opposite ends of the cell
- Telophase II: Nuclear membrane forms; cell divides in half

Items to study for your next test on cell organization

1. Cellular components and their functions
2. Breakdown of ATP by mitochondria
3. Types of movement across cell membranes
4. Chromosome and DNA duplication
5. The processes of mitosis and meiosis

NCLEX CHECKS

It's never too soon to begin your NCLEX preparation. Now that you've reviewed this chapter, carefully read each of the following questions and choose the best answer. Then compare your responses with the correct answers.

1. The nurse knows that which cellular component is the control center of a cell?

- ☐ **1.** Nucleus
- ☐ **2.** Golgi apparatus
- ☐ **3.** Ribosome
- ☐ **4.** Mitochondrion

2. While explaining meiosis to a client, the nurse explains that meiosis ends during which phase?

- ☐ **1.** When two new daughter cells form, each with the haploid number of chromosomes
- ☐ **2.** When one daughter cell forms and is an exact copy of the original cell
- ☐ **3.** When four new daughter cells form, each with the haploid number of chromosomes
- ☐ **4.** When four new daughter cells form, each with the diploid number of chromosomes

3. The nurse knows that centromeres move apart and pull the separate chromosomes to opposite ends of the cell in which phase of mitosis?

- ☐ **1.** Interphase
- ☐ **2.** Prophase
- ☐ **3.** Metaphase
- ☐ **4.** Anaphase

4. The nurse knows that which type of movement requires no energy?

- ☐ **1.** Active transport
- ☐ **2.** Diffusion
- ☐ **3.** Phagocytosis
- ☐ **4.** Pinocytosis

5. While explaining cellular structures to a client, the nurse knows that which cellular structure connects all parts of the cytoplasm?

- ☐ **1.** Endoplasmic reticulum
- ☐ **2.** Lysosome
- ☐ **3.** Centriole
- ☐ **4.** Nucleolus

6. The nurse keeps in mind that which factor influences diffusion?

- ☐ **1.** Smaller particles diffuse more slowly than larger particles.
- ☐ **2.** Lipid-soluble particles diffuse more rapidly through the lipid layers of the cell membrane.
- ☐ **3.** Ions on one side of the membrane diffuse more slowly when ions on the other side of the membrane have the opposite electrical charge.
- ☐ **4.** Ions with the same electrical charge attract each other, which speeds up diffusion.

7. The nurse knows that which statement describes osmosis?

- ☐ **1.** Osmosis involves active transport.
- ☐ **2.** Water molecules move from a dilute solution to a concentrated solution.
- ☐ **3.** Dissolved particles move from an area of higher concentration to one of lower concentration.
- ☐ **4.** The size and electrical charge of the particles determine the rate of movement.

8. In the first meiotic division, the gametes undergo six phases of cell division. Place all the phases listed below in ascending chronological order. Use all the options.

1. Metaphase	
2. Anaphase	
3. Telophase	
4. Prophase	
5. Interphase	
6. Interkinesis	

9. The nurse knows that which organelle breaks down foreign or damaged material in a cell?

- ☐ **1.** Ribosomes
- ☐ **2.** Lysosomes
- ☐ **3.** Peroxisomes
- ☐ **4.** Centrosomes

10. The nurse understands that which cell structure synthesizes RNA?

- ☐ **1.** Plasma membrane
- ☐ **2.** Cytoplasm
- ☐ **3.** Nucleoli
- ☐ **4.** Nucleus

ANSWERS AND RATIONALES

1. CORRECT ANSWER: 1

Serving as the cell's control center, the nucleus plays a role in cell growth, metabolism, and reproduction. The Golgi apparatus synthesizes carbohydrate molecules, ribosomes synthesize proteins, and mitochondria are energy-producing cellular structures.

2. CORRECT ANSWER: 3

Meiosis comes to completion with the end of telophase II. The result is four daughter cells, each containing the haploid (23) number of chromosomes.

3. CORRECT ANSWER: 4

Anaphase is characterized by centromeres moving apart and pulling the separate chromatids (now called *chromosomes*) to opposite ends of the cell. The number of chromosomes at either end of the cell is the same as the original number. In interphase, the nucleus and nuclear membrane are well defined and the nucleolus is visible. The replicating chromosomes form double strands attached at the middle by a centromere. During prophase, the nucleolus disappears and the chromosomes become distinct. Chromatids are still attached by the centromere. In metaphase, the chromosomes line up in the center of the cell between the spindles, and the centromere of each chromosome replicates.

4. CORRECT ANSWER: 2

Diffusion is a form of passive transport that doesn't require cellular energy to move dissolved particles from an area of higher concentration to an area of lower concentration. Active transport uses energy from the breakdown of ATP to transport a substance across a cell membrane. Phagocytosis requires energy to engulf and ingest particles that are too large to pass through cell membranes. Pinocytosis uses energy to engulf substances in solution or very small particles in suspension.

5. CORRECT ANSWER: 1

The endoplasmic reticulum is a system of interconnecting tubular channels that connects all parts of the cytoplasm. Lysosomes are digestive bodies that break down damaged or foreign material in the cells. Centrioles are short cylinders adjacent to the nucleus that move to opposite

ends of the cell and form the mitotic spindle during cell division. Nucleoli are spherical structures in the nucleus that synthesize RNA.

6. CORRECT ANSWER: 2

Lipid-soluble particles diffuse more quickly through the lipid layers of the cell membrane. Particle size does affect diffusion, but smaller particles diffuse more quickly than larger particles. Ions move more rapidly through a membrane when the ions on either side have opposite electrical charges. Ions with the same electrical charge repel each other, slowing diffusion.

7. CORRECT ANSWER: 2

In osmosis, water molecules move across the cell membrane from a dilute solution (with a higher concentration of water molecules) to a concentrated solution (with a lower concentration of water molecules). Osmosis uses passive transport to move molecules from a solution of higher molecular concentration to a solution of lower molecular concentration. Dissolved particles move from an area of higher concentration to one of lower concentration as a result of diffusion, not osmosis. Particle size and electrical charge affect the rate of movement in diffusion, with small particles diffusing faster than large ones and ions of unlike charges attracting each other.

8. CORRECT ANSWER:

5. Interphase
4. Prophase
1. Metaphase
2. Anaphase
3. Telophase
6. Interkinesis

In meiosis, the first phase is interphase, during which chromosomes replicate and are attached at the center by a centromere. Next, during prophase, chromosomes align so that matching genes are side by side. The third phase is metaphase, during which the chromosomes move to the center of the cell; the two chromatids of each chromosome begin to separate but remain joined at the centromere, where spindle fibers are attached. Then, during anaphase, the homologous chromosomes (not the chromatids) of each pair separate and move to opposite poles of the cell. The fifth phase is telophase, during which nuclear membranes form around the chromosomes and the cytoplasm divides, forming two new daughter cells. Lastly, during interkinesis, the nucleus and nuclear mem-

brane are well defined and the nucleolus is prominent. Each chromosome has two chromatids that don't replicate.

9. CORRECT ANSWER: 2
Lysosomes are digestive bodies that break down foreign or damaged materials in cells. Ribosomes are the sites of protein synthesis. Peroxisomes contain oxidases, enzymes capable of reducing oxygen to hydrogen peroxide and hydrogen peroxide to water. Centrosomes contain centrioles, short cylinders adjacent to the nucleus that take part in cell division.

10. CORRECT ANSWER: 3
Nucleoli are found in the nucleus and synthesize RNA.The nucleus is the control center of the cell, directing the activities of the structures in the cytoplasm. The plasma membrane regulates the passage of certain materials in and out of the cell. Cytoplasm includes the cell's contents from the cell membrane to the nucleus.