Part I. Clinical Applications

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

2. Your friend tells you that he is taking the antibiotic streptomycin for an infection. He wants to know how this particular antibiotic can kill bacterial cells but not kill his own cells. What is your explanation?

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

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

5. You overhear a group of teenagers betting each other as to who could drink the most water within a 30 minute time span. Being the excellent medical student that you are you interrupt them and explain the dangers of drinking seemingly harmless liquid (water) in such a short period of time. What is your explanation?
6. Some pediatricians recommend the use of a 10% salt solution to relieve congestion for infants with stuffy noses. What effect would such a solution have on the cell lining the nasal cavity, and why?

7. An instructor at the fitness center tells you that bodybuilders have the potential for increased supplies of energy and improved muscular performance because of increased numbers of mitochondria in their muscle cells. Is this correct? Why or why not?

8. One remedy for constipation is a saline laxative such as Epsom salts (MgSO4). Why do such salts have a laxative effect?

9. In a hospital, a nurse gave a patient recovering from surgery a transfusion of 5% salt solution by mistake instead of a transfusion of physiological saline (0.9% salt). The patient quickly went into shock and soon after died. What caused the patient to enter into a state of shock and die?

10. A smart student of anatomy was preparing a tossed salad in the afternoon for the evening meal. The vegetables to be used were placed in a bowl of cold water in order to keep these vegetables crisp. Osmotically speaking, explain why the vegetables remain crisp.
Test your understanding of the movement of materials across a plasma membrane.

6. ___________ is a passive process in which there is a net movement of molecules or ions from a region of their higher concentration to a region of their lower concentration. 

7. The process involving the movement of solvents, such as water, and dissolved substances across a selectively permeable membrane by gravity or mechanical pressure describes ___________.

8. This passive process is accomplished with the assistance of integral proteins in the membrane that serve as carriers: ___________ ___________.

9. ___________ is the net movement of water molecules through a selectively permeable membrane from an area of high water concentration to an area of low water concentration.

10. Active transport is a process by which substances are transported across a plasma membrane from an area of their ___________ concentration to an area of their ___________ concentration.

11. The source of energy used for active transport is ___________.

12. Name the three basic kinds of endocytosis: ___________ ___________ ___________.

13. A ___________ ___________ is a membrane sac that develops as pseudopodia surround and engulf a solid particle.

14. ___________ ___________ ___________ is similar to pinocytosis; however, it is a highly specific process in which cells can take up specific molecules or particles.
Part III

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

Answer (T) True or (F) False to the following questions.

15. ______ Tay-Sachs disease is a rare, inherited disease that causes rapid aging.
16. ______ Ribosomes are involved in protein synthesis.
17. ______ Pinocytosis is considered a passive process.
18. ______ The movement of mucus in the respiratory passageways is a function of the flagella.
19. ______ Nuclear pores in the envelope allow most ions and water-soluble molecules to shuttle between the nucleus and the cytoplasm.
20. ______ Interstitial fluid and intercellular fluid are two different fluids.
Match the following terms with their description (two answers apply to each).

<table>
<thead>
<tr>
<th>mitosis</th>
<th>reproductive division</th>
</tr>
</thead>
<tbody>
<tr>
<td>meiosis</td>
<td>somatic cell division</td>
</tr>
</tbody>
</table>

21. _______ Produce two daughter cells identical to the parent cell.

22. _______ Mechanism by which egg and sperm cells are produced.

Match the stage of mitosis with the corresponding activity.

<table>
<thead>
<tr>
<th>anaphase</th>
<th>cytokinesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>metaphase</td>
<td>prophase</td>
</tr>
<tr>
<td>telophase</td>
<td></td>
</tr>
</tbody>
</table>

23. _______ Cleavage furrow forms around center of cell, progresses inward, and separates cytoplasm into two separate and usually equal portions.

24. _______ Centromeres divide and identical sets of chromosomes move to opposite poles of cell.

25. _______ Chromatin shortens and coils into chromosomes, nucleoli and nuclear envelope disappear, a centrosome and its centrioles move to opposite poles, and mitotic spindles form.

26. _______ Centromeres of chromatid pairs line up on metaphase plate of cell.

27. _______ Nuclear envelope reappears and encloses chromosomes, chromosomes resume chromatin form, nucleoli reappear, and mitotic spindle disappears.

Match the tumor type to its definition.

<table>
<thead>
<tr>
<th>carcinoma</th>
<th>melanoma</th>
</tr>
</thead>
<tbody>
<tr>
<td>leukemia</td>
<td>osteogenic sarcoma</td>
</tr>
<tr>
<td>lymphoma</td>
<td>sarcoma</td>
</tr>
</tbody>
</table>

28. _______ Cancer of blood-forming organs characterized by rapid white blood cell growth with distorted development.

29. _______ Cancer arising in connective tissues or muscle cells.

30. _______ Malignant disease of lymphatic tissue.

31. _______ Cancer of the bone.

32. _______ Cancerous growth of melanocytes.

33. _______ A malignant tumor arising from epithelial cells.

34. A term that means tumor or abnormal growth is _______. A cancerous growth is a (benign? malignant?) neoplasm, whereas a noncancerous tumor is a (benign? malignant?) neoplasm.

35. Which type of growth is more likely to spread and to possibly cause death? (Benign? Malignant?) A term that means the spread of cancer cells is _______.

36. In the formation of mature sperm and egg cells, nuclear division is known as _______. In the formation of all other body cells, that is, somatic cells, nuclear division is called _______.

37. Cytoplasmic division in both somatic and reproductive division is known as _______. In (meiosis? mitosis?) the two newly formed cells have the same hereditary material and genetic potential as the parent cell.
Identify organelles in the box that fit descriptions below. One answer will be used twice, all others, once.

<table>
<thead>
<tr>
<th>Centrioles</th>
<th>Golgi complex</th>
<th>Mitochondria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cilia</td>
<td>Lysosomes</td>
<td>RER, Rought endoplasmic reticulum</td>
</tr>
<tr>
<td>Flagella</td>
<td>Microfilaments</td>
<td>SER, Smooth endoplasmic reticulum</td>
</tr>
</tbody>
</table>

1. Site of synthesis and brief storage of proteins
2. Site of synthesis of fatty acids, phospholipids, and steroids
3. Site of enzymes that detoxify alcohol and other harmful chemicals
4. Stacks of cisterns with vesicular ends, involved in packaging and secretion of proteins and lipids
5. Release enzymes that lead to autolysis of the cell
6. Cristae-containing structures, called “powerhouses of the cell” because ATP production occurs here
7. Form part of cytoskeleton, involved with cell movement and contraction
8. Part of cytoskeleton, provide support and give shape to cell; form flagella, cilia, centrioles, and spindle fibers; made of protein tubulin
9. Help organize mitotic spindle used in cell division
10. Long, hairlike structures that help move entire cell, as in sperm cells
11. Short, hairlike structures that move particles over cell surfaces

For extra review. Considering the functions of organelles listed in the above exercise, choose the answers (organelles) that fit the following descriptions. Answers in that list may be used more than once.

12. Abundant in liver cells that detoxify Phenobarbital and other drugs that enter the liver.
13. Present in large numbers of muscle and liver cells, which require much energy.
14. Located on surface of cells of the respiratory tract; help to move mucus.
15. Extensive in pancreatic cells that secrete insulin.
16. The inherited condition, Tay-Sachs disease, involves absence of an enzyme within these organelles in nerve cells.

Select from the following list of terms to identify passive transport processes described below.

<table>
<thead>
<tr>
<th>Bulk-phase endocytosis</th>
<th>Osmosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exocytosis</td>
<td>Phagocytosis</td>
</tr>
<tr>
<td>Facilitated diffusion</td>
<td>Simple diffusion</td>
</tr>
</tbody>
</table>

17. Net movement of any substance (such as cocoa powder in hot milk) from region of higher concentration to region of lower concentration; membrane not required
18. Same as (a) except movement across a semipermeable membrane with help of a transporter; ATP not required
19. Net movement of water from region of high water concentration (such as 2 percent NaCl) to region of lower water concentration (such as 10 percent NaCl) across semipermeable membrane; important in maintenance of normal cell size and shape
20. “Cell drinking”
21. Process of cellular ingestion of food by endocytosis
22. Secretion of neurotransmitter from neurons, hormones from endocrine cells

The passive movement of glucose through a semipermeable membrane, with the help of an integral protein, is an example of
A. diffusion
B. osmosis
C. bulk flow
D. facilitated diffusion
B10. Complete the following exercise about osmosis in blood.

24. Human red blood cells (RBCs) contain intracellular fluid that is osmotically similar to ______ NaCl.
   A. 2.0 percent  B. 0.9 percent  C. 0 percent (pure water)

25. A solution that is hypertonic to RBCs contains (more? fewer?) solute particles and (more? fewer?) water molecules than blood.

26. Which of these solutions is hypertonic to RBCs?
   A. 2.0 percent NaCl  B. 0.9 percent NaCl  C. Pure water

27. If RBCs are surrounded by hypertonic solution, water will tend to move (into? out of?) them, so they will (crenate? hemolyze?).

28. A solution that is ___________ -tonic to RBCs will maintain the shape and size of the RBC.

29. Intravenous (IV) solutions are likely to be ___________ -tonic. Solutions given to persons who are dehydrated are likely to be ___________ -tonic. An example of such a solution is ___________ .

30. Which solution will cause RBCs to hemolyze?
   A. 2.0 percent NaCl  B. 0.9 percent NaCl  C. Pure water

31. Which solution has the highest osmotic pressure?
   A. 2.0 percent NaCl  B. 0.9 percent NaCl  C. Pure water

Part V

Select the key choices that characterize each of the following statements. Insert the appropriate answers in the answer blanks. **Can use choices more than once.**

**Key Choices**

- Active transport
- Diffusion, simple osmosis
- Facilitated diffusion
- Pinocytosis
- Exocytosis
- Filtration
- Phagocytosis
- Receptor-mediated endocytosis

1. Engulfment processes that require ATP
2. Driven by molecular energy
3. Driven by hydrostatic (fluid) pressure (typically blood pressure in the body)
4. Moves down a concentration gradient
5. Moves up (against) a concentration gradient; requires a carrier
6. Moves small or lipid-soluble solutes through the membrane
7. Transports amino acids and Na⁺ through the plasma membrane
8. Examples of vesicular transport
9. A means of bringing fairly large particles into the cell
10. Used to eject wastes and to secrete cell products
11. Membrane transport using channels or carrier proteins that does not require ATP
Using the following terms, fill in the circled, numbered, blank spaces to complete the concept map. Follow the numbers which comply with the organization of the concept map.

- Metaphase
- Somatic cells
- Telophase
- Cytokinesis
- DNA replication
- G₂ phase
- Mitosis
- G₁ phase

**Cell cycle**

1. Division of
2. 2 major stages

**Interphase**

13. G₂ phase
14. S phase

**G₂ phase**
- Time
- Indefinite time
- Activity
- "Resting cell"
- Cell manufactures cytosol & organelles

**S phase**
- Time
- 8 or more hours
- Activity
- Result
- Cell duplicates chromosomes

**Prophase**
- Time
- 2 - 5 hours
- Activity
- Chromatin to chromosomes
- Spindle fibers form
- Nuclear envelope disappears

**Anaphase**
- Events
- Chromatid pairs separate
- Daughter chromosomes move toward opposite ends of cells

**Telophase**
- Events
- Reverse of prophase
- End of mitosis

**Chromatids move to metaphase plate**

**Mitosis**
- Beginning of
15. Four stages

**Centromeres**
- Tangled mass containing DNA during interphase; condenses into chromosomes during prophase:

**Centrosomes**
- Holds chromatid pair together; these align on the metaphase plate:

**Chromatids**
- Form the mitotic spindle composed of microtubules:

**Chromatin**
- Name given to replicated chromosomes in prophase:

**Return to**

2 new cells
The following statements describe events that occur during the different phases of cell division. Identify the phase by choosing the correct response(s) from the key choices and inserting the term(s) in the answer blanks.

**Key Choices**
- Anaphase
- Prophase
- Metaphase
- Telophase
- Cytokinesis

- **24.** Chromatin coils and condenses to form deeply staining bodies.
- **25.** Centromeres break, and chromosomes begin migration toward opposite poles of the cell.
- **26.** The nuclear membrane and nucleoli reappear.
- **27.** When chromosomes cease their poleward movement, this phase begins.
- **28.** Chromosomes align on the equator of the spindle.
- **29.** The nucleoli and nuclear membrane disappear.
- **30.** The spindle forms through the migration of the centrioles.
- **31.** Chromosomal material replicates.
- **32.** Chromosomes first appear to be duplex structures.
- **33.** Chromosomes attach to the spindle fibers.
- **34.** A cleavage furrow forms during this phase.
- **35.** The nuclear membrane is absent during the entire phase.
- **36.** A cell carries out its usual metabolic activities.

37. Which of the following is NOT found in the nucleus?
- A. nucleolus
- B. chromatin
- C. centrioles
- D. chromosomes

38. If a cell undergoing mitosis normally has 20 chromosomes, how many chromosomes will each daughter cell have?
- A. 10
- B. 20
- C. 40
- D. 80

39. Structurally, the cell membrane is best described as a:
- a. phospholipid layer integrated with peripheral proteins
- b. phospholipid bilayer interspersed with proteins
- c. protein bilayers interspersed with phospholipids
- d. protein layer interspersed with peripheral phospholipids

40. All transport through the cell membrane can be classified as either:
- a. active or passive
- b. diffusion or osmosis
- c. pinocytosis or phagocytosis
- d. permeable or impermeable

41. The four stages of mitosis in correct sequence are:
- a. prophase, anaphase, metaphase, telophase
- b. prophase, metaphase, telophase, anaphase
- c. prophase, metaphase, anaphase, telophase
- d. prophase, anaphase, telophase, metaphase

42. Epsom salts exert a laxative effect due to the process of:
- a. osmosis
- b. diffusion
- c. diarrhea
- d. phagocytosis
Using the terms below, fill in the blanks to complete the trek through the chemical organization in the human body.

- Integral proteins
- Cell membrane
- Intracellular fluid
- Phospholipid
- Cell division
- Mitochondrion
- Chromosomes
- Rough endoplasmic reticulum
- Ions
- Cytosol
- ATP
- Saccules
- Lysosomes
- Cristae
- Channels
- Nuclear
- Nonmembranous
- Extracellular fluid
- Peripheral proteins
- Protein synthesis
- Respiratory enzymes
- Golgi apparatus
- Cytoskeleton
- Nuclear envelope
- Matrix
- Cilia
- Proteins
- Organelles
- Nucleus
- Ribosomes
- Nucleoli
- Nucleoplasm
- Endoplasmic reticulum

Robo is inhaled into the body via a deep inspiration while its human host is sleeping. The micro-robot immediately lodges in the trachea among a group of pseudostratified, ciliated, columnar epithelial cells. Robo's initial maneuver is to get into a position for entry into one of the cells. The robot radios control command, “ Might need a life jacket.” There appears to be a watery “moat” around each cell, most likely the (1) _______ _______. The robot’s location seems to be in jeopardy because of the presence of small “finger-like” projections, the (2) _______ ________, which are swaying back and forth and threatening to “wash” the robot farther down into the respiratory tract. The robot’s mechanical arm extends and grabs hold of the outer boundary of a cell, the (3) _______ _______. Robo is instructed to “look for” (4) _______ ________, which form (5) _______ ________ large enough for the robot to gain entry into the cell. As it passes through the opening, its chemical sensors pick up the presence of a (6) _______ ________ bilayer with integral proteins embedded in the membrane and (7) _______ ________ attached to the inner membrane surface. Once inside, the trek through the cytosol or (8) _______ ________ begins. Resistance to movement is greater inside the cell than outside because of the presence of dissolved nutrients, (9) _______ ________, soluble and insoluble (10) _______ ________, and waste products. The first “observation” inside the cell is what looks like a protein framework, the (11) _______ ________, which gives the cytoplasm strength and flexibility. Formed structures, the (12) _______ ________, are in abundance, some attached and others freely floating in the (13) _______ ________. Robo’s contact with some of the organelles is easy because they are (14) _______ ________ while others may be difficult to get into because of the presence of a membrane. Structures such as the ribosomes, which are involved in (15) _______ ________, and the centrioles, which direct strands of DNA during (16) _______ ________, are noted quite easily as Robo treks through the cytosol. A small “cucumber-shaped” structure, a(n) (17) _______ ________, is “sighted” however, the robot’s entry capabilities are fully taxed owing to the unusual double membrane. After penetrating the outer membrane, an inner membrane containing numerous folds called (18) _______ ________ blocks further entry. The inner membrane serves to increase the surface area exposed to the fluid contents or (19) _______ ________. The presence of (20) _______ ________ attached to the folds would indicate that this is where (21) _______ ________ is generated by the mitochondria. Robo senses the need for a quick “diffusion” through the outer membrane and back into the cytosol. The moving cytosol carries the micro-robot close to the center of the cell where it contacts the cell’s control center, the (22) _______ ________. Robo is small enough to pass through the double membrane, the (23) _______ ________, because it contains (24) _______ ________. Once inside, the environment is awesome! Nuclear organelles called (25) _______ ________ engage in activities which would indicate that they synthesize the components of the (26) _______ ________ since RNA and ribosomal proteins are in abundance. The fluid content of the nucleus, the (27) _______ ________, contains ions, enzymes, RNA, DNA, and their nucleotides. The DNA strands form complex structures called (28) _______ ________, which contain information to synthesize thousands of different proteins and control the synthesis of RNA. Robo leaves the nucleus by way of the ER or (29) _______ ________ where it senses the manufacture of proteins at specific sites along the membrane, the (30) _______ ________, or RER. Some of the synthesized molecules are stored, others will be transported along with the robot by transport vesicles that will deliver them to the (31) _______ ________. A system of flattened membrane discs called (32) _______ _________. Robo relays the message to control command, “Looks like a stack of dinner plates in which synthesis and packaging of secretions along with cell membrane renewal and modification are taking place.”

The trek ends with the robot’s entrance into the extracellular fluid and passage into the lumen of the trachea where it waits for a “cough” from its host to exit the respiratory tract and return to Mission Control.
Extra Credit Questions

1. In kidney dialysis, a person’s blood is passed through a bath that contains several ions and molecules. The blood is separated from the dialysis fluid by a membrane that allows water, small ions, and small molecules to pass, but does not allow large proteins or blood cells to pass. What should the composition of dialysis fluid be for it to remove urea (a small molecule) without changing the blood volume (removing water from the blood)?

2. Red blood cells are hemolyzed when the cells are placed in contact with:
   a. a hypotonic solution
   b. a hypertonic solution
   c. an isotonic solution
   d. a salt solution

3. The energy-producing process in the mitochondria involves a series of reactions in which ___________ is consumed and ___________ is generated.
   a. carbon dioxide; oxygen
   b. water; oxygen
   c. carbon dioxide; water
   d. oxygen; carbon dioxide

4. A solution that is hypotonic to cytoplasm has:
   a. a solute concentration lower than that of the cytoplasm
   b. a solute concentration higher than that of the cytoplasm
   c. a solute concentration that is equal to that of the cytoplasm
   d. an osmotic concentration higher than that of the intracellular fluid

5. An injection of a concentrated salt solution into the circulatory system would result in:
   a. little or no effect on the red blood cells
   b. hemolysis of the red blood cells
   c. a slight increase in cellular volume
   d. crenation of the red blood cells

6. Facilitated diffusion differs from ordinary diffusion in that:
   a. ATP is expended during facilitated diffusion
   b. molecules move against a concentration gradient
   c. carrier proteins are involved
   d. it is an active process utilizing carriers