This response should show thorough knowledge of the processes of the structure of phospholipids, cell membrane structure and components, and movement across membranes. A satisfactory answer would show that in part (d) you followed the direction to explain the role of a protein selected in part (c). Be sure you underline important instructions like this, and follow them!

A strong response to this item requires an understanding of topics from Units 1 and 2 of the textbook. Your response could contain information about other protein functions, including specific examples of cell-cell signaling or enzymatic function.

Topic 2: The Cell

ANSWERS AND EXPLANATIONS

Level 1: Knowledge/Comprehension Questions

1. **(B) is correct.** This question is centered around proteins for export, which would require large numbers of ribosomes, rough ER, and many Golgi bodies.
2. **(C) is correct.** Linear chromosomes are the only cell structure on this list not found in both prokaryotes and eukaryotes. Eukaryotic cells have a true nucleus, which is surrounded by a double membrane called a nuclear envelope, and contain linear chromosomes, with their DNA wrapped around histone proteins. The genetic material of prokaryotes is localized in a clump in one particular region of the cell called the nucleoid region, and the main chromosome is a single molecule of circular DNA without associated histone proteins.
3. **(D) is correct.** The smooth ER proliferates in cells that detoxify poisons.
4. **(B) is correct.** The Golgi apparatus is the organelle that has a *cis* and *trans* face, and it acts as the packaging and secreting center of the cell. It consists of a series of flattened sacs of membranes called *cisternae*.
5. **(A) is correct.** Cellular respiration takes place in the mitochondria, forming ATP, the cell's energy currency. Mitochondria are bound by double membranes, and the proteins involved in ATP production are embedded in the inner membranes of the mitochondria. Red blood cells lack mitochondria as well as nuclei, making them well adapted to their function of oxygen transport.
6. **(C) is correct.** Lysosomes are characteristic of animal cells but not most plant cells. They are large membrane-bound structures that contain hydrolytic enzymes, and they are responsible for the breakdown of proteins, polysaccharides, fats, and nucleic acids. They function best at a low pH (around 5), so they pump hydrogen ions from the cytosol into their lumen to achieve this acidic pH.
7. **(D) is correct.** The radioactive tracking starts with the formation of the protein, which occurs on the ER. The protein then moves to the Golgi and out of the cell via vesicles that will fuse with the membrane. Choice C is the proper pathway, but the radioactive amino acids will not be used in the nucleus and would therefore not be tracked with this system.

8. (A) is correct. Surface proteins bind to signaling molecules (ligands), and this binding activates a signal transduction pathway, resulting in intracellular responses.

9. (D) is correct. The only substance listed that can passively diffuse through the cell membrane unaided by proteins is carbon dioxide. Remember that passive diffusion occurs without the cell doing any work. The other choices all need the processes of facilitated diffusion and transport proteins to cross the membrane. This is a question a student could answer at the end of the course (we hope), but not if you are covering cell biology at the beginning of your course.

10. (B) is correct. Large molecules are moved out of the cell by exocytosis. In exocytosis, vesicles that are to be exported from the cell (often coming from the Golgi apparatus) fuse with the plasma membrane, and their contents are expelled into the extracellular matrix. Vesicles are involved in exocytosis, but vesicles are a structure—not a process, as the question requires.

11. (A) is correct. When a signal molecule binds to the receptor protein, the gate of the ion channel opens or closes, allowing or blocking the flow of specific ions.

12. (A) is correct. Because the substance is being moved against the concentration gradient, energy is required. Requiring energy to move a substance against its concentration gradient is a characteristic of active transport. All the other choices are modes of passive transport and require no energy, but they can move a substance down its concentration gradient only.

13. (B) is correct. Choice A is a reference to a G-protein-coupled receptor, not the G protein. Choice A can be a quick but incorrect pick if the question is not read carefully. The G protein is activated by the G-protein-coupled receptor, which is a protein and eliminates D as a possible answer.

14. (D) is correct. Kinase enzymes are involved with ATP. Protein kinase enzymes are used to amplify the signal during the transduction phase of cell signaling by activating cell proteins with a phosphate from ATP. Protein phosphatases remove phosphates from proteins and in the process turn off the signal transduction pathway.

15. (C) is correct. Many signaling pathways involve small, nonprotein water-soluble molecules or ions called *second messengers*. Calcium ions and cyclic AMP are two common second messengers. Once activated, the second messengers can initiate a phosphorylation cascade, resulting in a cellular response.

16. (D) is correct. Intracellular receptors work with signal molecules that are hydrophobic compounds and are therefore able to cross the plasma membrane. Testosterone, as indicated in the question, is a steroid hormone and thus is hydrophobic. Once activated, intracellular receptors often act as transcription factors.

17. (C) is correct. Cytokinesis is the division of the cytoplasm to form two separate daughter cells.

18. (A) is correct. In eukaryotic cells, DNA is replicated during S phase, a subphase of interphase. The important thing is to recognize that before identical cells can be produced by mitosis, the amount of DNA must be doubled by replication.

19. (B) is correct. Interphase is a busy time in the cell as growth and cell functions are occurring. Interphase is divided into Gap 1, S phase, and G2. In G1 the cell has just completed mitosis and is growing and performing its specific cell functions. Because the cell has not passed the G1 checkpoint, no energy is being used for preparations for cell division.

20. (A) is correct. During S phase, the DNA is replicated. If S phase were attempted and failed, mitosis would be halted and apoptosis would occur.

21. (D) is correct. The fluid mosaic model is a reference to a membrane with a mosaic of various proteins embedded or attached to a double layer of phospholipids.

22. (A) is correct. Because membranes are hydrophobic, hydrophobic molecules easily pass across the membrane. Remember: Hydrophilic dissolves hydrophilic; hydrophobic dissolves hydrophobic.

23. (D) is correct. The important parts of this question are the three correct statements in choices A, B, and C. Think about how these big picture ideas are incorporated into the cell signalling sequence of reception, transduction, and cellular response.

Level 2: Application/Analysis/Synthesis Questions

1. (A) is correct. Water moves in a hypotonic-to-hypertonic direction. Cells A, B, and C are all animal cells (red blood cells) and lack a cell wall. Cell D is a plant cell with a cell wall. Cell A is in a hypotonic solution, cell B is in an isotonic solution, and cell C is in a hypertonic solution. When answering this type of question, pay close attention to whether the solution or the cell is referenced as being hypertonic or hypotonic. In A, the solution is hypotonic but the cell is hypertonic.

2. (C) is correct. In plant cells, the relatively inelastic cell wall exerts a back pressure on the cells, called turgor pressure. In cell D, the plant cell is immersed in a hypotonic solution, causing the cell to uptake water, thus creating the highest levels of turgor pressure. Animal cell A lyses ("pops") because it has only a thin, flexible membrane.

3. (C) is correct. The solution in Tank A started with more solutes; then, as the water is purified, its concentration of solutes increases through the process of reverse osmosis. Tank A becomes increasingly hypertonic over the course of the purification treatment.

4. (B) is correct. Tank A, with the tap water, is hypertonic to the purified water. Because water flows from hypotonic to hypertonic, water would move from Tank B into Tank A.

5. (C) is correct. Epinephrine is the ligand that activates the G protein-coupled receptor responsible for glycogen breakdown. Epinephrine does not enter the cell, suggesting a second messenger. Only in intact cells could the first messenger (epinephrine) be translated to a cellular response–glycogen breakdown.

6. (D) is correct. Substances will move down their concentration gradient until their concentration is equal on both sides of the membrane. The concentration of glucose on side B is 2.0 *M*, whereas the concentration of glucose on side A is 1.0 *M*; therefore, glucose will move from side B to side A. Solutes

move down their own concentration gradients, not the combined gradients as answer A would indicate.

7. **(B) is correct.** First, you must note that glucose is the smaller molecule and focus only on where it is in higher concentration. Because its highest concentration is on side B, it will move to side A.
8. **(A) is correct.** As glucose moves into side A, the total amount of solute on that side increases, becoming hypertonic, causing water to follow.
9. **(A) is correct.** Notice that the H^+ ions in the diagram are moving against their concentration gradient. Movement of solutes against their concentration gradient requires energy and, therefore, active transport.
10. **(B) is correct.** Recall that decreasing the extracellular pH (for example, going from pH 7 to pH 6) would increase the H^+ ion concentration, providing more H^+ ions for cotransport as well as a steeper gradient into the cell.
11. **(C) is correct.** Cell A in the figure for question 1 demonstrates what happens when red blood cells are placed in a hypotonic solution. With the RBCs destroyed, the WBCs will be easier to observe.
12. **(C) is correct.** The clue is given in the stem of the question, where melanin is identified as a protein for export. With that information, you would expect an increase in ribosomes, rough ER, Golgi bodies, and vesicles.
13. **(B) is correct.** When the DNA is damaged beyond the ability of the cell to repair it, apoptosis pathways are initiated. Damaged cells may become cancerous, so it is better for the organism to destroy the cell than to take a chance on a cancerous cell.
14. **(B) is correct.** Because both prokaryotes and eukaryotes use ATP, choice B does not provide evidence for the endosymbiotic hypothesis. Notice that the other three choices do provide evidence and would be the key points in developing an answer to essay questions about the evidence for endosymbiosis.
15. **(A) is correct.** The hypothesis being tested is tied directly to the ΔFus3 gene. Option B is a testable hypothesis, but it is not involved with the ΔFus3 gene. When determining the proper hypothesis, do not stray to the big picture of the experiment; be precise about the specific experiment being conducted.
16. **(D) is correct.** Wild-type yeast cells act as a control for observation of shmoo formation because wild-type cells have both Fus3 and formin present under the experimental conditions.
17. **(C) is correct.** If Fus3 kinase is critical to shmoo formation, cells that don't produce Fus3 kinase should not be able to form shmoos. Don't be intimidated by long, complicated-looking questions. This question may look hard, but the underlying concept is straightforward: If the Fus3 gene does not function, shmoos do not form.
18. **(A) is correct.** Because the mating factor is diffusing from the direction of the other mating-type yeast, it is the G protein-coupled receptors on that side of the cell that bind the mating factor, become activated, and start the phosphorylation cascade that activates Fus3, which activates formin, which leads to localized shmoo formation.
19. **(C) is correct.** If the G protein could not bind GTP, it would not become activated, and so it would not start the phosphorylation cascade. Be aware

that the questions do not necessarily get harder as you progress through the set. All the multiple-choice questions count the same, and there is no penalty for guessing. If you try a hard question, do not just assume that all of the remaining questions will be hard. Try each question and be aware that sometimes the last question is the easiest.

Grid-In Questions

1. **The correct answer is 8,000 (μm^3).**
2. **The correct answer is 8.**
3. **The correct answer is −10.40 (bars).** The formula of solute potential is −iCRT. In this case the values are −(1.0) (0.42) (0.0831) (298) = −10.40. Sucrose does not ionize, which makes the value of *i* in the formula 1. If you find these problems difficult, go to the lab section of this book to Investigation 4, Diffusion and Osmosis, where you can find an explanation of water potential and how to work water potential problems.

Free-Response Questions

(a) Eukaryotic cells might have evolved by taking in free-living prokaryotes. One piece of evidence is that prokaryotic cells are much smaller than eukaryotic cells. Mitochondria and chloroplasts are comparable in size to prokaryotic cells.

A second piece of evidence is that mitochondria and chloroplasts both consist of a double membrane exterior, which would be a possible result of a prokaryotic cell being engulfed by another cell.

Mitochondria and chloroplasts also contain their own DNA and are capable of dividing on their own. The presence of DNA could be evidence that they were independent organisms at some time.

(b) To trace the path of proteins in the cell from their creation to their expulsion, we must start in the nucleus. In the nucleus, mRNA is transcribed from DNA. The mRNA travels out of the nucleus through a nuclear pore to the cytoplasm, ending up at ribosomes, which are associated with the endoplasmic reticulum (called rough endoplasmic reticulum because of this association). As the mRNA is translated into protein, the amino acid chain is threaded into the lumen of the ER, where it undergoes folding to assume its final shape, or conformation.

Secretory proteins travel in vesicles from the endoplasmic reticulum to the series of flattened membranous sacs known as the Golgi apparatus. They enter at the *cis* face and eventually bud from the *trans* face after undergoing a series of modifications to prepare them for secretion. The vesicles may then fuse with the cell membrane, and the contents are released from the cell in a process called exocytosis.

The student response in (a) might have used the presence of ribosomes in mitochondria and chloroplasts that translate genes unique to the organelles as one of the arguments for endosymbiosis. However, the question asked for three explanations, so this would be substituted for one of the others. Specific