Benchmark Test Review

3 Cells

Use the information below to review the correct answers on the Chapter Test.

1. As described by cell theory, all new cells arise from preexisting cells. In a tree or any other multicellular organism, new cells arise from preexisting cells as they divide by mitosis and pass through the cell cycle.

2. All cells are contained inside a cell membrane, which consists of a lipid bilayer and proteins. In plant cells, a tough cell wall surrounds the cell membrane. Fungi and many bacteria also have cell walls, although of different chemical composition than the cell walls of plants.

3. If materials could not enter or leave the cell, then the cell would die quickly. Gases such as carbon dioxide and oxygen can diffuse directly across the lipid bilayer. Larger molecules, however, must travel through the proteins embedded in the lipid bilayer. Water also travels through these proteins.

4. The two types of cells are prokaryotic cells, such as bacteria, and eukaryotic cells, which include the cells of all multicellular organisms. Prokaryotic cells lack a nucleus, while eukaryotic cells have a nucleus. The nucleus contains DNA, which is the molecule that controls cell activity.

5. Prokaryotes are always unicellular, and the cells are generally smaller and simpler than eukaryotic cells. A prokaryotic cell lacks a nucleus and other membrane-bound organelles. Both prokaryotic and eukaryotic cells are surrounded by a cell membrane, and, in some cases, a cell wall.

6. All cells use ribosomes to synthesize proteins. Only eukaryotic cells, however, have membrane-bound proteins such as the endoplasmic reticulum. Many ribosomes are located on the endoplasmic reticulum.

7. Osmosis is the diffusion of water across a selectively permeable membrane, such as the cell membrane. Like other forms of diffusion, osmosis involves movement of water from a region of high concentration to a region of low concentration. When red blood cells are placed in pure water, the water diffuses into the cells, eventually causing the cells to burst apart.

8. Nearly all eukaryotic cells gain energy from mitochondria, which are the organelles where cellular respiration is completed. In plants, leaf cells have mitochondria as well as chloroplasts, which are the organelles where photosynthesis occurs.

9. Many cell structures are made of a mixture of different macromolecules. However, the cell wall of a plant cell is made almost entirely of a tough, sturdy

carbohydrate called cellulose. The cell membrane is made mostly of a phospholipid bilayer, but many proteins are embedded in the bilayer.

10. ATP acts like a chemical battery for the cell. When it breaks apart to form ADP and a phosphate group, it releases energy that can be immediately transferred to the components of another chemical reaction. Many chemical processes, such as the synthesis of sugars during photosynthesis, require an energy input from ATP.

11. Photosynthesis involves two interdependent processes: the light-dependent reactions and the light-independent reactions. In the light-dependent reactions, the cell converts the energy of light into chemical energy in the form of ATP and NADPH. These compounds are transferred to the light-independent reactions, in which molecules of carbon dioxide are assembled into sugars.

12. The light-dependent reactions and the light-independent reactions are both essential for photosynthesis. Each process depends on the other process, and neither process could occur individually. The light-dependent reactions involve the conversion of light energy into chemical energy in the form of ATP and NADPH. In the light-independent reactions, the chemical energy is used to assemble molecules of sugar.

13. Photosynthesis acts to remove carbon dioxide from the atmosphere and convert its carbon to sugars, which the plant may then convert to other compounds that make up the plant. Although plants also perform cellular respiration, which releases carbon dioxide, the effect of photosynthesis on the atmosphere is much greater.

14. Photosynthesis involves many individual chemical reactions. However, when considered as a single process, the reactions have only two reactants, which are carbon dioxide and water, and only two products, which are sugars and oxygen.

15. ATP and NADPH are the energy-carrying molecules of photosynthesis. They cycle between the light-dependent reactions, where they are produced, and the light-independent reactions, where they provide the energy for the synthesis of sugars.

16. During the light-dependent reactions of photosynthesis, the energy of light is used to remove the hydrogen atoms from water molecules. The oxygen atoms that remain are released as part of molecular oxygen (O_2), which is the byproduct of photosynthesis.

17. Carbon dioxide gas (CO_2) from the atmosphere is one of two reactants of the process of photosynthesis. It provides the carbon for glucose and other sugars, which are the main products of photosynthesis. Half of the oxygen atoms of carbon dioxide are also incorporated into the sugars.

18. The reactants, or inputs of a chemical reaction, are generally written on the left side of a chemical equation. A forward arrow shows that the reactants

are converted into the products, which are written on the right side of the equation. Glucose and oxygen are the reactants of cellular respiration, and carbon dioxide, water, and energy in the form of ATP are the products.

19. The overall processes of cellular respiration and photosynthesis are described by a chemical equation that looks the same except for the arrows, which point in opposite directions. The reactants of one of the two processes are the products of the other process. Note that cellular respiration releases energy, while photosynthesis takes up energy that is provided by light.

20. ATP acts like a rechargeable battery for the cell. It releases energy for chemical reactions when it breaks apart to form ADP and a phosphate group. Then an input of energy can reverse the reaction and re-form ATP again. The main benefit to the cell of performing cellular respiration is to regenerate its supply of ATP. Glucose is the source of the energy that is captured and stored in ATP.

21. The role of oxygen in cellular respiration is to accept hydrogen atoms at the end of the electron transport chain, which changes oxygen into water. Glycolysis may occur when oxygen is not present, or in cells that lack mitochondria, where the Krebs cycle and electron transport occur.

22. Note that glycolysis involves the initial use of two ATP molecules followed by the generation of four ATP molecules, for a net gain of two ATP molecules per molecule of glucose. The formation of ATP takes energy, and the chemical bonds of glucose are the source of this energy. So, the products of glycolysis, which are two molecules of pyruvic acid, have less energy than the glucose molecule that formed them.

23. Cellular respiration involves three separate processes: glycolysis, the Krebs cycle, and electron transport. The second two processes depend on oxygen, but glycolysis may occur when oxygen is absent. Much less ATP is produced, and waste products build up. Muscle cells can function temporarily with this less efficient pathway, but eventually they must rest.

24. Cellular respiration and photosynthesis are related because the reactants of one process are the products of another. On early Earth, oxygen began accumulating in the atmosphere because of the actions of cyanobacteria, which perform photosynthesis and release oxygen. Today, the relative stability of oxygen levels is an indication that global photosynthesis and cellular respiration, along with other processes that alter oxygen levels, are balanced with one another.

25. During the S phase of the cell cycle, DNA is replicated to double the amount of chromosomes of the cell. Note that DNA and chromosomes are not replicated during either mitosis or cytokinesis, which together make up the M phase of the cell cycle.

26. The diagram shows cytokinesis, or the division of the cytoplasm of a cell into two daughter cells. Cytokinesis occurs just after mitosis, which is the division of the cell nucleus. Taken together, mitosis and cytokinesis change a

single cell into two genetically identical daughter cells. Multicellular organisms grow larger by this process.

27. Before mitosis occurs, the chromosomes of the cell exist as two identical chromatids, joined together at their center by a structure called the centromere. During metaphase of mitosis, all the chromosomes are moved into a line along the center of the cell. Then, in anaphase, the chromosomes are pulled apart, with identical chromatids pulled to opposite sides of the cell.

28. The cell cycle depends on precise timing of a series of events, including the growth of the cell, the duplication of chromatids, and mitosis. Cyclins are a set of compounds that control the timing of these events. Scientists continue to investigate how cyclins function.

29. Mitosis may occur at different rates in different types of cells, and it may not occur at all in some cells. However, when mitosis does occur, it occurs in the same way in all cells of the organism. The end result of mitosis and other events of the cell cycle is the duplication of all chromosomes and the maintenance of the chromosome number in all cells. Cell differentiation occurs because of difference in gene expression, and not the presence or absence of genes.

30. In large, complex multicellular organisms, undifferentiated cells called stem cells divide to produce the specialized or differentiated cells that perform specific roles in the organism. Many specialized cells, such as muscle and nerve cells, might never undergo mitosis.

31. As shown by the diagram, cell division (or the M phase of the cell cycle) is only one portion of the cell cycle. The other portions are the G1 and G2 phases, which involve cell growth, and the S phase, or synthesis phase, in which single-stranded chromatids are duplicated to form double-stranded chromosomes. The four main phases always occur in the order shown in the diagram.

32. During metaphase of mitosis, the chromosomes are moved to form a straight line across the cell. Then during the next phase, which is anaphase, the chromosomes are pulled apart to form separated chromatids. Note that the chromosomes align in pairs, called tetrads, only during metaphase I of meiosis, and not during mitosis.

33. Mitosis is the division of the cell nucleus, and it occurs in all eukaryotic organisms. Prokaryotes, which do not have nuclei, reproduce by a process called binary fission. Binary fission is similar to the cytokinesis that occurs in the eukaryotic cell cycle.

34. Like other reactions in the cell, the reaction that forms ATP relies on an enzyme to catalyze it. This enzyme, called ATP synthase, depends on the diffusion of hydrogen ions to provide the energy for the reaction to occur. In photosynthesis, light is the ultimate source of the energy needed to generate a concentration difference of hydrogen ions across the thylakoid membrane.

35. Homeostasis is the maintenance of constant or near constant internal conditions. By itself, the movement of water into or out of the cell is not an especially strong example of homeostasis. The cell is disturbed from equilibrium, but homeostasis involves a process for restoring the equilibrium. In this case, the process after the cell swells with water is the cell's pumping out excess water.

36. All organisms are able to reproduce, grow, use energy, and respond to their environment. Organisms also store genetic information in DNA, and they use the same general process for translating the information in DNA. The two main classes of organisms are prokaryotes, which are single-celled organisms that lack nuclei, and eukaryotes, which can be either single-celled or multicellular, and which contain nuclei.

37. Active transport involves the movement of materials against a concentration gradient, from regions of low concentration to regions of high concentration. This movement always requires the use of energy, which generally is supplied by the molecule ATP. Nerve cells use a sodium/potassium ion pump to maintain a high concentration of potassium ions inside the cells. When the nerve cells "fire," or depolarize, the potassium ions rush out of the cells.

38. Sexual reproduction involves two parents, each of which donate genetic information to offspring through specialized reproductive cells. These reproductive cells, or gametes, are the result of meiosis, which is a specialized form of cell division.

39. Asexual reproduction involves a single parent that passes genes to offspring. All the offspring are alike, and each is as well adapted as its parent to life in its habitat. In contrast, the offspring of sexual reproduction are genetically varied, which provides an advantage when environmental conditions change.

40. Stem cells are undifferentiated cells, such as those in an animal embryo. These cells give rise to differentiated cells, such as the cells of nervous, muscular, or glandular tissues. Stem cell research could lead to techniques for regrowing or repairing damaged tissues, such as damaged nerves in the spinal cord or brain.

41. The potential benefits of iPS cells involve their ability to develop into all sorts of other cells, including nervous and muscular cells. The breakthrough in creating iPS cells has led to research in regenerative medicine.

42. Researchers hope that if stem cells are injected into a patient, they will act to replace damaged or missing healthy cells. However, the stem cells could behave in unexpected ways, such as by dividing too rapidly and causing a cancerous tumor, or by differentiating into unwanted cell types.

43. Stem cell research is controversial because it involves ethical issues of life and death. Many people object on ethical grounds to any deliberate process that damages a human embryo or prevents the embryo from

developing into a baby. While the methods of science and scientific knowledge can inform and help evaluate ethical arguments, science alone cannot decide them.

44. Meiosis is the process that creates gametes such as egg and sperm cells. They are haploid cells, and contain half of the chromosomes necessary to create a living organism. When an egg and a sperm meet, they have a full diploid set of chromosomes and can develop into a complete organism.