Section 5.3 Review Answers

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1. In cellular respiration, glucose is oxidized in the mitochondria to produce carbon dioxide, water, and ATP molecules. In photosynthesis, carbon dioxide molecules are reduced, resulting in the formation of glucose and oxygen.

2. Aerobic respiration occurs in the mitochondria of eukaryotic organisms. It is the complete oxidation of glucose in the presence of oxygen resulting in the production of carbon dioxide, water and ATP.

Anaerobic cellular respiration is used by some organisms (prokaryotes) in anoxic environments to obtain energy. Like aerobic respiration it includes an electron transport chain and a concentration gradient to produce ATP. However, this process is not as efficient in ATP production as aerobic respiration is. In addition, since oxygen is not available to act as the final electron acceptor, other molecules (sulfate, nitrate, carbon dioxide) serve as the electron acceptor.

Fermentation is an anaerobic process. In some organisms and in animal cells temporarily without oxygen, lactate fermentation occurs, resulting in the formation of lactic acid and considerably less energy than aerobic respiration. Yeast can undergo ethanol fermentation, whereby glucose is converted to carbon dioxide, ethanol, and ATP.

3. The three energy-releasing metabolic pathways associated with aerobic cellular respiration are glycolysis, the Krebs cycle, and the electron transport chain.

4. Students may choose to generate a graphic indicating the reactants and products; if so, it should be similar to Figure 5.19. Also indicated should be that glycolysis takes place outside of the mitochondria in the cytoplasm, that oxygen is not required, and that the product, pyruvate, is then converted to acetyl CoA in the mitochondrial matrix.

5. Students may choose to generate a graphic indicating the reactants and products; if so, it should be similar to Figure 5.20. Also indicated should be that the Krebs cycle takes place in the mitochondrial matrix, the $FADH_2$ and NADH produced contribute electrons to the electron transport chain, and that oxygen is required for these reactions to occur—although not used directly in the reactions. (If oxygen is not present, pyruvate from glycolysis is reduced by fermentation.)

6. The electron transport system involves the passing along of high-energy electrons from NADH and $FADH_2$ using electron-carrying molecules that are attached to the inner membrane of the mitochondria. As electrons are passed along, energy is released in discreet amounts. The energy released is used to pump hydrogen ions across the mitochondrial intermembrane space to produce a hydrogen ion concentration gradient for ATP synthesis via chemiosmosis. Oxygen is the final acceptor of the electrons and combines with hydrogen to form water.

7. Chemiosmosis refers to use of the potential energy associated with a hydrogen ion concentration gradient across a membrane to synthesize ATP by binding a phosphate group to ADP.

8. The final electron acceptor in aerobic respiration is oxygen. If this molecule is not present, then the pyruvate that is generated from glycolysis begins to build up. When this occurs, the cell starts to break down pyruvate by fermentation, which also involves the oxidation of NADH to NAD^+.

9. Anaerobic cellular respiration is not as efficient as aerobic respiration, so fewer ATP are synthesized.

Note: If you want to ask a more challenging question, change the term "anaerobic cellular respiration" to "fermentation." The answer would then be:

Aerobic cellular respiration produces much more ATP than fermentation does because fermentation relies solely on glycolysis to generate ATP, whereas aerobic respiration also generates ATP via the Krebs cycle and the electron transport system.

10. Fermentation is a metabolic pathway that uses glycolysis to break down glucose to pyruvate, and then, in association with the oxidation of NADH to NAD^+, reduces pyruvate to various compounds. Compounds that are synthesized by fermentation include ethanol and lactate. This metabolic pathway is considered to be anaerobic because it does not require the presence of oxygen. In fact, in many cases, it occurs as a result of the lack of oxygen.

11. Both lactate and ethanol fermentations involve the reduction of pyruvate (from glycolysis) with associated oxidation of NADH to NAD^+ and result in the synthesis of the same amount of ATP (from gylcolysis). However, the products of these two pathways differ. Lactate fermentation results in the production of lactate, while ethanol fermentation results in the production of carbon dioxide and ethanol.