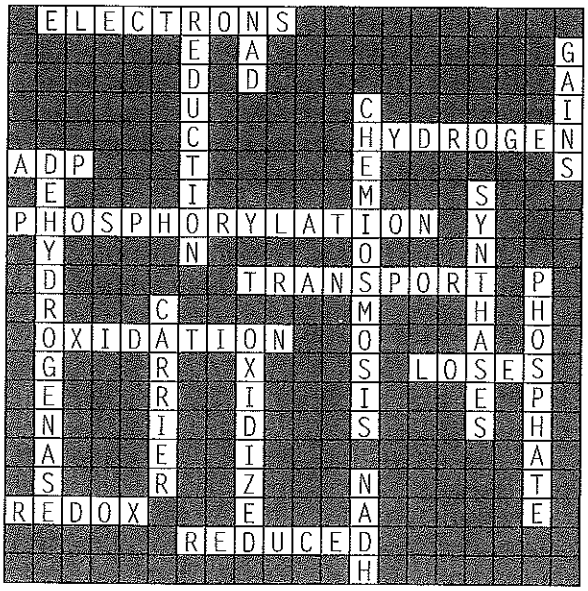
Exercise 2:



Exercise 3: 1. electrons carried by NADH 2. electrons carried by NADH and $FADH_2$ 3. glycolysis 4. glucose 5. pyruvate 6. Citric acid cycle 7. oxidative phosphorylation 8. cytoplasm 9. CO_2 10. CO_2 11. mitochondrion 12. ATP 13. ATP 14. ATP

Exercise 4: 1. I 2. K 3. E 4. C 5. C 6. D 7. B 8. J 9. F 10. A 11. L 12. G 13. H

Exercise 5: 1. NAD^+ 2. NADH 3. pyruvic acid 4. acetyl CoA 5. CO_2 6. coenzyme A 7. CO_2 8. NADH 9. ATP 10. $FADH_2$

Exercise 6: 1. final 2. ATP 3. oxidative phosphorylation 4. electron 5. inner 6. NADH 7. the citric acid cycle 8. O_2 9. H_2O 10. H^+ ions 11. active transport 12. potential 13. ATP 14. inner compartment of the mitochondrion 15. ATP synthases 16. ADP 17. ATP

Exercise 7: See Figures 6.10 and 6.11 in the text.

Exercise 8: 1. OP 2. G 3. G 4. G 5. OP 6. CA 7. OP 8. OP 9. CA 10. OP 11. OP 12. CA

Exercise 9: 1. facultative 2. yeasts 3. pyruvate 4. muscle 5. oxygen 6. NADH 7. ethanol 8. lactic 9. ATP 10. glycolysis 11. CO_2 12. anaerobes 13. anaerobic 14. less 15. glycolysis 16. lactate

Exercise 10: 1. carbohydrates 2. fats 3. proteins 4. sugars 5. glycerol 6. fatty acids 7. amino acids 8. glucose

Exercise 11: See Figure 6.16 in the text.

Test Your Knowledge

Multiple Choice: 1. b 2. e 3. c 4. b 5. d 6. c 7. c 8. a 9. b 10. e 11. e 12. a

Essay: 1. Breathing allows our lungs to supply cells with the oxygen used in cellular respiration and expel the carbon dioxide produced by cellular respiration.

2. Aerobic cellular respiration is more efficient (it produces more ATP per molecule of glucose consumed), but it must take place in an oxygen-containing (aerobic) environment. Fermentation requires no oxygen, but it is much less efficient (it produces much less ATP per glucose).

3. Oxidative phosphorylation occurs in the third (electron transport–chemiosmosis) stage of cellular respiration. Substrate-level phosphorylation occurs in glycolysis and the citric acid cycle. In oxidative phosphorylation, ATP synthase harnesses the flow of H^+ ions down their concentration gradient to make ATP. In substrate-level phosphorylation, an enzyme transfers a phosphate group from an organic molecule to ADP to make ATP. Oxidative phosphorylation makes the most ATP under aerobic conditions. Substrate-level phosphorylation makes the most ATP under anaerobic conditions.

4. Rotenone prevents electrons from passing from an electron carrier molecule to the next. Cyanide and carbon dioxide block the passage of electrons to oxygen. In either case, the energy of moving electrons cannot be captured. Oligomycin blocks the passage of H^+ ions through ATP synthase, so ATP cannot be made. DNP makes the membrane of the mitochondrion leaky to H^+ ions, thus abolishing the H^+ concentration gradient whose energy is harnessed to make ATP.

5. These processes provide small organic molecules that the cell can use in the synthesis of organic molecules not obtained in food.

Apply the Concepts

Multiple Choice: 1. b 2. a 3. c 4. c 5. d 6. d 7. c 8. d 9. b 10. d 11. d 12. a 13. c

Essay: 1. Organisms that rely on aerobic cellular respiration are limited to environments where oxygen is available. Fermenters are able to live in anaerobic environments such as mud, manure piles, and sealed wine vats, free from competition with aerobic organisms.

2. Oxygen picks up electrons at the end of the electron transport chain. When oxygen runs out, there is no place for electrons to go. They "pile up," and electron transport stops. When electron transport stops, NADH and $FADH_2$ pile up, and NAD^+ and FAD are not regenerated. Without NAD^+ and FAD to pick up electrons and hydrogens, the Krebs cycle must stop.

3. Because FAD and NAD^+ are constantly recycled, the cell requires only a small supply of them.

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Without NAD^+ and FAD to pick up electrons and hydrogens from glycolysis and the citric acid cycle and deliver them to the electron transport chain, cellular respiration would stop.

4. If the victim had suffocated, the lack of oxygen would have caused electrons to pile up, and all the electron carriers would have held electrons. They would have been in the reduced state. Because the carriers were in the oxidized state—lacking electrons—Zyme knew that oxygen had been available in the cells to pick them up, so the victim did not suffocate.

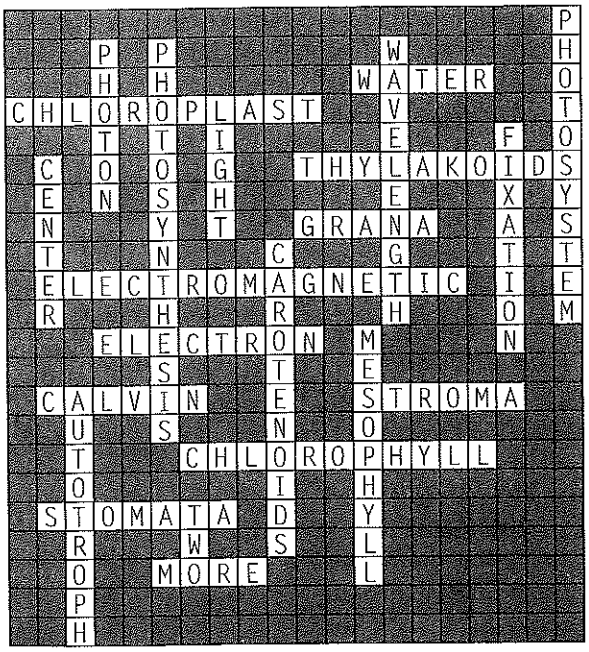
5. At first the yeasts in the flask were able to produce sufficient ATP via aerobic cellular respiration. As the yeast population grew, the oxygen in the flask was used up, and they turned to fermentation to produce ATP. Because fermentation is less efficient than aerobic respiration, the yeasts had to consume glucose at a faster rate to maintain their supply of ATP. Ethanol is a waste product of fermentation.

Chapter 7

Review the Concepts

Exercise 1: pine tree, green bacterium, rosebush, seaweed, moss, alga, grass

Exercise 2:



Exercise 3: $6\,CO_2 + 12\,H_2O \rightarrow C_6H_{12}O_6 + 6\,H_2O + 6\,O_2$. The C and O in $C_6H_{12}O_6$ come from CO_2. The H in $C_6H_{12}O_6$ comes from H_2O. The O in O_2 comes from H_2O. The H in H_2O comes from H_2O and the O comes from CO_2. H_2O is oxidized, and CO_2 is reduced.

Exercise 4: 1. light 2. H_2O 3. outer membrane of chloroplast 4. CO_2 5. light reactions 6. $NADP^+$ 7. Calvin cycle 8. ADP + P 9. stroma 10. granum 11. thylakoids 12. electrons 13. ATP 14. NADPH 15. O_2 16. sugar

Exercise 5: 1. B 2. A 3. H 4. C 5. B 6. A 7. D 8. H 9. G 10. F 11. C 12. E 13. I 14. D 15. A 16. A 17. H 18. G

Exercise 6: a. 5 b. 9 c. 2 d. 6 e. 3 f. 7 g. 8 h. 4 i. 1 Gamma waves have the most energy. Blue and red light are used in photosynthesis.

Exercise 7: 1. photosynthesis 2. chloroplasts 3. mesophyll 4. light 5. chlorophyll 6. thylakoids 7. Calvin 8. stroma 9. sugar (or glucose or G3P) 10. photons 11. blue 12. red 13. green 14. carotenoids 15. reaction center complex 16. electron 17. H^+ 18. stroma 19. thylakoids 20. gradient 21. ATP synthase 22. ATP 23. photophosphorylation 24. water 25. water 26. oxygen 27. oxygen 28. light 29. chlorophyll 30. acceptor 31. NADPH 32. Calvin 33. photosynthesis 34. stroma 35. carbon dioxide 36. ATP 37. NADPH 38. G3P 39. glucose 40. fixation 41. respiration 42. ATP

Exercise 8: 1. C_3 2. C_4 3. C_4 4. CAM 5. C_3 6. C_3 7. C_4 or CAM 8. C_4 or CAM 9. CAM 10. C_3

Exercise 9: 1. warm 2. cool 3. cool 4. cool 5. warm 6. cool 7. cool 8. warm 9. cool 10. cool 11. warm 12. warm

Exercise 10: For example, "CFCs, used as refrigerants and propellants, are changed by the sun into reactive free radicals, which destroy the ozone that protects life from UV radiation."

Test Your Knowledge

Multiple Choice: 1. b 2. a 3. a 4. c 5. e 6. b 7. b 8. d 9. b 10. e 11. b 12. a 13. d

Essay: 1. If a plant is given carbon dioxide containing radioactive ^{18}O, no labeled oxygen atoms appear in the O_2 produced by the plants, showing that the oxygen in O_2 does not come from CO_2. If the plants are given water containing ^{18}O, the O_2 gas they produce does contain labeled O, showing that the oxygen in O_2 comes from H_2O.

2. See Figure 7.5 in the text.

3. Photosynthesis allows producers to manufacture organic food molecules from inorganic reactants. This process produces virtually all the organic matter required as food by plants and all other living things on Earth.

4. Increased burning of fossil fuels (such as oil and gas) releases CO_2 into the atmosphere. Deforestation reduces global photosynthesis,

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reducing removal of CO_2 from the atmosphere by plants. Both of these activities contribute to an increased greenhouse effect, because more CO_2 in the atmosphere could trap more heat. A temperature increase of just a few degrees could melt polar ice, flooding coastal regions. Storms could intensity and droughts become more common. We could reduce our contribution to the greenhouse effect by using fossil fuels more efficiently, recycling forest products, and replanting trees on deforested land.

Apply the Concepts

Multiple Choice: 1. a 2. d 3. e 4. c 5. a 6. c 7. c 8. a 9. c 10. e 11. d

Essay: 1. Plants would grow most slowly under green lights, because green light is not absorbed well by photosynthetic pigments. Green is reflected, which is why plants are green.

2. Carotenoids absorb all colors except yellow and orange. Because carotenoids absorb green light, they are able to capture some light energy not absorbed by chlorophyll and channel this energy to chlorophyll for use in photosynthesis.

3. Energy from the movement of excited electrons along a chain of electron carriers is used to pump H^+ through the membrane into the thylakoid space. This buildup of H^+ lowers the pH of the solution in the thylakoid space.

4. In photosynthesis, high-energy electrons come from chlorophyll whose electrons are excited by light. These electrons are replaced by splitting water. In cellular respiration, glucose is the source of high-energy electrons. In both processes, movement of the electrons through electron carriers is harnessed to move H^+ through a membrane; this energy is ultimately used by ATP synthase to make ATP. In photosynthesis, the high-energy electrons are also used to make glucose. In cellular respiration, the electrons combine with O_2 and H^+ to form water. Photophosphorylation takes place in the thylakoid membranes of the chloroplast; oxidative phosphorylation takes place along the inner membrane of the mitochondrion. In both processes, ATP synthase harnesses flow of H^+ through the membrane to make ATP.

5. In the light reactions of photosynthesis, sunlight excites chlorophyll in a leaf, causing it to give up excited electrons. High-energy electrons move through electron carriers, which generate an H^+ gradient, which in turn is harnessed to make ATP. The electrons and hydrogen are picked up by $NADP^+$, forming NADPH. In the Calvin cycle, energy from the ATP and hydrogen and electrons from NADPH are used to reduce CO_2, forming sugar. When you consume the plant, the sugar is "burned" in cellular respiration. The glucose is oxidized, and its hydrogen and electrons are transferred to NAD^+ and FAD, forming NADH and $FADH_2$. These molecules deliver the high-energy electrons to the electron transport system in the mitochondrion. The electrons move through electron carriers, which generate an H^+ gradient, which in turn is harnessed by ATP synthase to make ATP. The ATP is then hydrolyzed to ADP and P to power muscle movement.

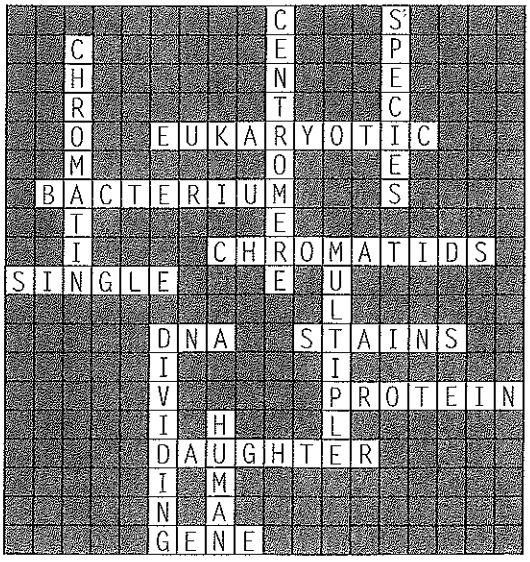
6. Van Helmont was correct in concluding that the soil did not contribute much material to the growth of the tree, but he was wrong in thinking that the weight gain must have come from the water. What van Helmont couldn't know (but we do) is that water supplies only the hydrogen atoms used in photosynthesis to build the carbohydrates that make up most of a plant. The bulk of the atoms in carbohydrate molecules—all the carbon and oxygen—come from CO_2 that the plant gets from the air!

Chapter 8

Review the Concepts

Exercise 1: 1. like 2. asexual 3. DNA 4. DNA 5. chromosomes 6. identical 7. mother 8. binary fission 9. circular 10. smaller 11. duplicates or replicates 12. plasma membrane 13. wall 14. genomes 15. egg 16. sperm 17. fertilization 18. variation

Exercise 2:



Exercise 3: 1. interphase, activity between divisions 2. G_1, cell growth following division 3. S, growth and DNA synthesis 4. G_2, growth and activity between DNA replication and division