35. An enzyme works best at a body temperature of 37°C. With a fever and an increase in temperature, this will cause a decrease in enzyme activity. The high temperature will denature the enzyme and alter the shape of the enzyme. Substrates will no longer be able to bind to the active site and the enzyme will not be able to do its job. The function of the enzyme is dependent on its shape, therefore a denatured enzyme will not be able to carry out any chemical reactions in the body. Death may result.
36. Cyanide prevents the transfer of electrons to oxygen. Cytochrome oxidase will not be able to accept electrons and therefore not be able to produce enough ATP for the cells.
37. Iodine would move into the thyroid gland by active transport.
38. The modified cellulose will start to dissolve at a specific pH in the small intestine. It is not affected by the low pH of the stomach.
39. Graph
40. 37°C
41. Trypsin denatured and therefore could not function properly. Without trypsin, proteins could not be digested into peptides.
42. hydrolytic enzyme
43. proteins
44. peptides
45. hydrolysis
46. water
47. Trypsin is very specific to its substrate and will only act on proteins, not sucrose.
48. Design an experiment.

Chapter 6 Diagnostic Questions

1. **b.** step 2 only
2. **a.** ATP
3. **d.** in the phosphate bonds
4. **c.** animal and plant cells
5. **d.** cellular respiration
6. **d.** carbon dioxide
7. **a.** the absence of oxygen.
8. **b.** viruses
9. **a.** to produce ATP
10. **c.** so that it is in a form that cells can use the energy
11. **c.** active transport of potassium ions
12. **a.** Cellular respiration does not consist of just one step as the equation implies. It consists of many phases.

    b. Photosynthesis is the opposite of cellular respiration. The reactants of photosynthesis are the products of cellular respiration. The products of photosynthesis are the reactants of cellular respiration.

    c. Plants carry out both photosynthesis and cellular respiration.

    d. Some of the energy is lost as heat.
13. **1.** cristae (inner membrane); **2.** outer membrane; **3.** intermembrane space; **4.** matrix
14. Diagram
15. respiration is the exchange of gases; it is a process that provides blood cells with oxygen
16. to get energy; process in which the oxygen is necessary to convert the energy stored in carbon containing molecules into ATP
17. to provide a constant supply of oxygen for our cells and to produce ATP for metabolic activities
18. When the muscle cells in your body work vigorously during a run or heavy exercise, they carry out fermentation. Fermentation supplies the body with ATP when oxygen is scarce.
19. The runners do not have enough oxygen for their cells to produce ATP. Heavy breathing occurs to get as much oxygen into the body as possible because the cells are not getting enough oxygen.

Chapter 6 Review Questions

1. **a.** is transformed into heat.
2. **c.** under anaerobic conditions.
3. **c.** C.
4. **d.** Acetyl CoA goes through a series of reactions that extract electrons and hydrogen ions
5. **a.** A and B
6. **c.** C.
7. **a** It reduces 2 NAD^+ for every glucose molecule.
8. **c.** 20 ATP.
9. **c.** FAD – is a reducing agent in the citric acid cycle
10. **a.** They are coenzymes that accept electrons.
11. **c.** II and III only
12. **a.** O_2
13. **c** produces a large quantity of reducing power in the form of NADH and $FADH_2$
14. **c.** to aerobically degrade pyruvate to carbon dioxide and water with the generation of 2 ATP molecules
15. **d.** They occur in the matrix of the mitochondrion and produce carbon dioxide.
16. **a.** the hydrogen ion gradient across the inner mitochondrial membrane.
17. **d.** NADH
18. **d.** I, II and III
19. **c.** to convert ADP to ATP.
20. **c.** II and III only
21. **c.** II and III only
22. **d.** NADH will donate high-energy electrons to the electron transport chain
23. **a.** preparatory reaction, citric acid cycle, electron transport chain

    b. glycolysis and fermentation

    c. glycolysis, citric acid cycle, fermentation

    d. preparatory reaction, citric acid cycle

    e. glycolysis

f. electron transport chain
g. electron transport chain
h. preparatory reaction, citric acid cycle
i. glycolysis, citric acid cycle
j. citric acid cycle
k. electron transport chain
l. citric acid cycle
m. electron transport chain
n. preparatory reaction
o. fermentation
p. electron transport chain
q. electron transport chain
r. electron transport chain
s. glycolyis
t. fermentation
u. electron transport chain
v. electron transport chain
w. electron transport chain
x. citric acid cycle
y. electron transport chain

24.

	Glycolysis	Preparatory Reaction	Citric Acid Cycle	Electron Transport Chain
Location in the Cell	cytoplasm	matrix of mitochondria	matrix of mitochondria	cristae of the mitochondria
Net ATP yield	2 ATP		2 ATP	26-28 ATP
Products	2 ATP 2 pyruvate 2 NADH + H^+	2 NADH + H^+ 2 CO_2 2 Acetyl CoA	2ATP 4 CO_2 6 NADH + H^+ 2 $FADH_2$	26-28 ATP H_2O
Aerobic or Anaerobic	anaerobic	aerobic	aerobic	aerobic

25. ATP (adenosine triphosphate) consists of the nitrogenous base adenine, a ribose sugar and three phosphate groups. Energy is stored in the high-energy bonds between the phosphate groups. When ATP breaks down to ADP (adenosine diphosphate) and a molecule of inorganic phosphate, stored energy is released. This energy is used for biological functions such as protein synthesis and nerve conduction.

26. Most of the chemical energy is lost to heat.

27. Organisms use oxidation and reduction reactions to produce energy.

28. Oxidation of glucose to carbon dioxide: The carbon atom in glucose loses hydrogen atoms but gains oxygen atoms. By gaining oxygen atoms, the carbon is oxidized. Reduction of oxygen to water: The oxygen molecule (O_2) loses an oxygen atom but gains hydrogen atoms. By losing oxygen atoms, the O_2 molecule is reduced.

29. Aerobic exercise requires oxygen in order to produce ATP through cellular respiration. Oxygen is needed for this process.

30. The cristae of the mitochondrion have the electron transport chain. The cristae increase the internal surface area of the mitochondrion to increase the area for ATP production.

31. glycolysis = 2 ATP; citric acid cycle = 2 ATP; electron transport chain = 26–28 ATP

32. **a.** Glycolysis is the breakdown of glucose to 2 pyruvates. It produces 2 NADH and 2 ATP. ATP is made by substrate-level ATP synthesis.

b. The citric acid cycle involves the acetyl group attached to CoA breaking down to 2 CO_2 molecules. It produces 2ATP, 4 CO_2, 6 NADH + H^+ and 2 $FADH_2$. ATP is made by substrate-level ATP synthesis.

c. The electron transport chain oxidizes NADH or FADH2 and creates a H^+ gradient. The enzyme ATP synthase uses this H^+ gradient to produce ATP via chemiosmosis.

d. In anaerobic conditions, cells use glycolysis to produce 2 ATP in a process called fermentation. In lactate fermentation, pyruvate is converted into lactate and oxidizes NADH to NAD^+. In alcoholic fermentation, pyruvate is converted into alcohol (ethanol) and carbon dioxide is produced. This reaction regenerates NAD^+.

33. Aerobic cellular respiration has oxygen as a final electron acceptor in the electron transport chain. The electron transport chain produces more ATP (26–28 ATP) compared to fermentation (2 ATP).

34. NAD^+ is the oxidized form and acts as an electron acceptor. NADH + H^+ is the reduced form and is a major carrier of hydrogen atoms and free energy in the cell.

35. Substrate-level ATP synthesis uses an enzyme to add a phosphate group to ADP to produce ATP. Chemiosmosis uses a hydrogen ion gradient to produce ATP. Substrate-level ATP synthesis occurs in glycolysis and the citric acid cycle, while chemiosmosis occurs during the electron transport chain.

36. NADH is formed from NAD^+, while $FADH_2$ is formed from FAD. Both have gained electrons and are reduced compounds. For every two electrons that NADH donates, 2-3 ATP are produced. For every two electrons that $FADH_2$ donates, 1-2 ATP are produced.

37. It takes 2 ATP molecules to activate glucose at the beginning of glycolysis and then produces 4 ATP molecules by the end of the reaction. This gives a net gain of 2 ATP.

38. Coenzyme A, FAD and NAD^+ are important components of cellular respiration. They are needed for the production of ATP. Without these coenzymes, there would be minimum production of ATP and the person would show signs of fatigue.

39. Flow Chart

40. The purpose of fermentation is to regenerate NAD^+ so that it returns to glycolysis to pick up more electrons to keep glycolysis going.

41. [VENN DIAGRAM: LEFT CIRCLE: FERMENTATION IN MUSCLES]: pyruvate is converted into lactic acid; occurs in bacteria and in human muscle cells; Lactic acid fermentation →

glucose → glycolysis (pyruvate) → lactic acid + 2 ATP. [RIGHT CIRCLE: FERMENATION IN YEAST]: pyruvate is converted into carbon dioxide and ethanol; occurs in yeast and other bacteria; Alcoholic fermentation → glucose → glycolysis (pyruvic acid) → carbon dioxide + alcohol + 2 ATP. [CentreCIRCLE]: both occur anaerobically (in the absence of oxygen); glucose is converted into cellular energy (ATP); reducing agent is NADH + H^+]

42. Flow Chart

43. The citric acid cycle turns twice because two acetyl CoA molecules enter the cycle per glucose molecule.

44. Pyruvate is converted to a C_2 acetyl group attached to coenzyme A.

45. The citric acid cycle produces carbon dioxide.

46. **a.** During substrate-level ATP synthesis, an enzyme passes a high-energy phosphate to ADP and ATP is formed.

b. As oxidation occurs, hydrogen atoms (H^+ and e^-) are removed and this forms NADH + H^+

c. As oxidation occurs, hydrogen atoms (H^+ and e^-) are removed and this forms $FADH_2$

d. Each acetyl group received from the preparatory reaction is oxidized to two carbon dioxide molecules.

47. Carbon monoxide will block electron transfer from NADH to oxygen. If the electron transport chain stops, then no ATP will be produced for cellular function. Absence of ATP will not allow metabolic activities to occur and cells will die as a result.

48. The electron transport chain consists of a series of protein complexes located in the cristae of the mitochondria. The protein carriers accept high-energy electrons and pass them along from one protein to another. As this occurs, hydrogen ions are pumped from the matrix to the intermembrane space. As hydrogen ions flow from the intermembrane space into the matrix down the concentration gradient, the ATP synthase complex produces ATP through chemiosmosis.

49. As the high-energy electrons are passed from one electron carrier to the next, energy is captured to produce ATP. Oxygen is the final electron acceptor and forms water.

50. The ATP synthase complex allows hydrogen ions to diffuse across the inner mitochondrial membrane. As a result of this, ATP synthase produces ATP from ADP and P by chemiosmosis.

51. They all carry out fermentation to produce ATP.

52. The carbohydrates will be stored as glycogen in the muscle cells. On the day of the race, glycogen will be converted to glucose. In the presence of oxygen, the mitochondria in the muscle cells break down the glucose to produce ATP for the muscle cells during the race.

53. During a sprint, the mitochondria are producing ATP for the body through aerobic respiration. During a marathon, where the muscle cells in the body are working vigorously, the muscle cells will tend to carry out fermentation when oxygen is scarce. Lactic acid can build up in the muscle cells. The liver then takes the lactic acid from the muscle cells and converts it back to pyruvic acid.

54. ATP will not be produced if the electron transport chain is inhibited.

55. The faster fatty acids are converted to acetyl CoA and enter the citric acid cycle, the greater the rate of respiration. These compounds may convert fatty acids to acetyl CoA more rapidly.

56. carbon dioxide

57. alcoholic fermentation

58. anaerobic

59. rate of bubble production would increase

60. They pick up electrons and carry the high energy electrons to the electron transport chain and drop them off.

61. Blocking ATP synthase results in oxygen not being consumed and no ATP will be produced. Oligomycin inhibits ATP synthase and the hydrogen ions from the intermembrane space will not be able to flow through the ATP synthase complex to produce ATP. The concentration of hydrogen ions will accumulate in the intermembrane and the electron transport chain will eventually stop working and the cell will die.

62. Graphic Organizer

63. ADP is like a battery low on energy and ATP is like a battery full of energy.

64. ATP is produced when a phosphate is added to ADP: ADP + P → ATP. ATP is broken down into ADP by removing a phosphate group: ATP → ADP + P

65. The electron transport chain is analogous to a flight of stairs. As the object bounces down the stairs, it loses potential energy. Similarly, in the electron transport chain, high-energy electrons give off a small amount of energy with each step as they pass electrons from one protein to the next. The energy released is used to produce ATP.

66. **a.** the investment of the two ATP molecules

b. energy is transferred to ATP, NADH and $FADH_2$

c. citric acid cycle

67. Chemiosmosis Analogy: When the gates (=ATP synthase) of a dam (=cristae) are opened, water (=H^+ ions) flows through the dam down the concentration gradient. The potential energy stored in the water is used to generate energy (=ATP).

68. Research

69. Skeletal muscle cells and liver cells have different net energy yield because they differ in: cellular conditions and the use of different electron acceptors – NAD^+ or FAD.

70. Graph

71. 35°C

Chapter 7 Diagnostic Questions

1. **a.** is reflected.

2. **c.** autotrophic.

3. **b.** to convert light energy into chemical energy

4. **c.** mitochondria and chloroplasts.

5. **c.** in plant cells and animal cells.

6. **a.** in plant cells only.

7. **b.** chlorophyll