

### **Chapter 03—Carbohydrates**

1. The majority of energy in the typical American diet comes from \_\_\_\_\_.

- a. fat
- b. protein
- c. carbohydrate
- d. vitamins

ANSWER: c

2. A ketopentose is a carbohydrate containing \_\_\_\_\_.

- a. five carbons and a ketone group
- b. six carbons and an aldehyde group
- c. three carbons and an aldehyde group
- d. seven carbons and a ketone group

ANSWER: a

3. What type of bond holds two monosaccharides together?

- a. ionic
- b. hydrogen
- c. covalent
- d. peptide

ANSWER: c

4. When compounds with one or more chiral carbon atoms and the same formula are arranged as mirror images they are said to be \_\_\_\_\_.

- a. symmetrical
- b. enantiomers
- c. rotated
- d. linear

ANSWER: b

5. Name the model that depicts cyclized monosaccharides as lying in a horizontal plane with the hydroxyl groups pointing down or up from the plane.

- a. Haworth
- b. Fischer projection
- c. cyclized Fischer projection
- d. stereoisomer

ANSWER: a

6. What are the major dietary energy sources that are composed of two simple sugars?

- a. disaccharides
- b. polysaccharides
- c. monosaccharides
- d. trioses

ANSWER: a

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7. What is the most common digestible homopolysaccharide existing as both amylose and amylopectin?

- a. glycogen
- b. cellulose
- c. hemicellulose
- d. starch

ANSWER: d

8. Which of the following homopolysaccharides made of glucose contributes the most energy to the ordinary diet?

- a. amylose
- b. amylopectin
- c. glycogen
- d. cellulose

ANSWER: b

9. A homopolysaccharide that is important in human diets is \_\_\_\_ and the end product formed from the complete digestion of this homopolysaccharide is \_\_\_\_.

- a. cellulose; glucose
- b. lactose; galactose
- c. glycogen; glucose
- d. starch; glucose

ANSWER: d

10. Which disaccharide is commonly found in mushrooms?

- a. glucose
- b. fructose
- c. trehalose
- d. galactose

ANSWER: c

11. What is the key enzyme in digestion of polysaccharides?

- a. starch amylopectin
- b.  $\beta$ -amylase
- c.  $\alpha$ -dextranase
- d.  $\alpha$ -amylase

ANSWER: d

12. Cellulose is a polymer of glucose where the monomers are connected by  $\beta$ -linkages. Humans cannot digest this substance because \_\_\_\_.

- a. they only produce  $\alpha$ -amylase
- b. they produce insufficient quantities of  $\beta$ -amylase
- c. cellulose is resistant to the human form of  $\beta$ -amylase
- d. the  $\beta$ -linkages are too strong to be hydrolyzed

ANSWER: a

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13. Chiral carbon atoms have \_\_\_\_.
- a. four hydrogens attached to them
  - b. two methyl groups and two hydrogens attached to them
  - c. three hydrogen atoms and one methyl group attached to them
  - d. four different atoms or groups attached to them

ANSWER: d

14. The enzyme needed to hydrolyze the  $\alpha$  (1,6) bond of amylopectin is \_\_\_\_, which is secreted by the \_\_\_\_.
- a. amylase; enterocyte
  - b. sucrose; pancreas
  - c. lactase; enterocyte
  - d. isomaltase; enterocyte

ANSWER: d

15. The disaccharidases are synthesized by the \_\_\_\_.
- a. pancreas
  - b. liver
  - c. enterocyte
  - d. chief cell

ANSWER: c

16. Sucrose digestion is initiated in the \_\_\_\_.
- a. pylorus
  - b. fundus
  - c. duodenum
  - d. mouth

ANSWER: c

17. Starches in the duodenum and jejunum are acted upon by \_\_\_\_.
- a.  $\beta$ -amylase
  - b. lipase
  - c. sucrase
  - d.  $\alpha$ -amylase

ANSWER: d

18.  $\alpha$ -dextrinase is also called \_\_\_\_.
- a.  $\beta$ -amylase
  - b. isomaltase
  - c.  $\alpha$ -amylase
  - d. lactase

ANSWER: b

19. Choose the best description of the main method of glucose absorption.
- a. passive diffusion down a concentration gradient

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- b. active transport with fructose
- c. facilitated transport
- d. active transport with sodium

ANSWER: d

20. Which sugar is not present in the systemic circulation due to efficient removal by the liver?

- a. glucose
- b. fructose
- c. galactose
- d. sucrose

ANSWER: b

21. The glucose transporter that is sensitive to insulin is \_\_\_\_\_.

- a. GLUT1
- b. GLUT2
- c. GLUT4
- d. SGLT1

ANSWER: b

22. Which hormonal changes occur in response to a fall in blood glucose concentration?

- a. increased insulin, decreased glucagon
- b. decreased insulin, increased glucagon
- c. decreased insulin, decreased glucocorticoids
- d. increased insulin, increased glucagon

ANSWER: b

23. Glycemic load considers the \_\_\_\_\_ in the food.

- a. protein and carbohydrate content
- b. fat and carbohydrate content
- c. fat to carbohydrate ratio
- d. quantity and quality of carbohydrate

ANSWER: d

24. People with type 1 diabetes have \_\_\_\_\_.

- a. slow translocation of GLUT4 receptors from the Golgi body
- b. lack of mRNA synthesis for GLUT4 receptors in adipocytes or myocytes
- c. increased glycogenesis in myocytes after a meal
- d. below-normal glucokinase activity because of low insulin levels

ANSWER: d

25. Insulin is an anabolic hormone. Which process does insulin stimulate?

- a. lipolysis
- b. gluconeogenesis
- c. glycogenesis

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d. ketogenesis

ANSWER: c

26. Glucose phosphorylation in the liver is catalyzed by \_\_\_\_.

- a. glucokinase
- b. hexokinase
- c. insulin
- d. glucagon

ANSWER: a

27. Due to a lack of the enzyme glucose-6-phosphatase, which tissue capable of glycogenesis cannot contribute to blood glucose levels between meals?

- a. liver
- b. muscle
- c. brain
- d. kidney

ANSWER: b

28. Glycolysis is a process involving \_\_\_\_.

- a. synthesis of fatty acids
- b. reactions that convert glucose to glycogen
- c. reactions that convert glucose to pyruvate
- d. reactions that convert glycogen to protein

ANSWER: c

29. Conversion of phosphorylase b to the active phosphorylase a is carried out by \_\_\_\_.

- a. ADP
- b. AMP
- c. ATP
- d. cAMP

ANSWER: b

30. In what part of the cell does glycolysis occur?

- a. mitochondrion
- b. cytosol
- c. nucleus
- d. endoplasmic reticulum

ANSWER: b

31. In which cellular site is most of the energy released when carbohydrates are oxidized to carbon dioxide and water?

- a. cytoplasm
- b. endothelium
- c. Golgi body
- d. mitochondrion

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ANSWER: d

32. Two hormones that stimulate glycogenolysis in the muscle and liver, respectively, are \_\_\_\_.
- a. cortisol and epinephrine
  - b. epinephrine and glucagon
  - c. insulin and epinephrine
  - d. glucagon and insulin

ANSWER: b

33. Where are the enzymes that catalyze the citric acid cycle located?
- a. cytoplasmic matrix
  - b. endoplasmic reticulum
  - c. mitochondrial matrix
  - d. lysosome

ANSWER: c

34. In the \_\_\_\_, galactose is eventually converted to \_\_\_\_.
- a. liver; glucose
  - b. Kupffer cell; fructose
  - c. small intestine; glucose
  - d. chylomicron; glucose

ANSWER: a

35. Which substance is converted into glycogen in the process of glycogenesis?
- a. 2-phosphoglycerate
  - b. glucose-1-phosphate
  - c. fructose-1-phosphate
  - d. phosphoglyceraldehyde

ANSWER: b

36. In the complete oxidation of 1 mol of glucose, how many ATPs are formed?
- a. 4–6
  - b. 8–12
  - c. 18–24
  - d. 30–32

ANSWER: d

37. The poison, sodium cyanide, inhibits the enzyme cytochrome c oxidase. Why is ingestion of this poison usually fatal?
- a. It blocks the production of ATP in the cells.
  - b. It causes cells to rupture.
  - c. It changes membrane permeability allowing important molecules to leave the cell.
  - d. It causes changes in the acetyl-coenzyme A molecule.

ANSWER: a

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38. The conversion of pyruvate to oxaloacetate in gluconeogenesis allows which molecules to enter the gluconeogenic pathway?

- a. alcohols
- b. amino acids
- c. monosaccharides
- d. polysaccharides

ANSWER: b

39. Alcohol in beverages is degraded mainly in the liver cytosol with the production of one NADH for each ethanol molecule. Predict what effect consumption of alcohol would have on the activity of the liver malate-aspartate shuttle.

- a. no change
- b. increased
- c. decreased
- d. reversed

ANSWER: b

40. Which process produces glucose-6-phosphate from noncarbohydrate sources?

- a. glycolysis
- b. glycogenolysis
- c. glycogenesis
- d. gluconeogenesis

ANSWER: d

41. During the end reaction of the electron transport chain, molecular oxygen becomes \_\_\_\_.

- a. oxidized to carbon dioxide
- b. reduced to water
- c.  $\text{NADH} + \text{H}^+$
- d.  $\text{FADH}_2$

ANSWER: b

42. Glucagon, epinephrine, and norepinephrine enhance the regulation of \_\_\_\_.

- a. glucose-1-phosphate
- b. phosphorylase
- c. coenzyme Q
- d. phosphofructokinase

ANSWER: b

43. The occurrence of a molecule in different spatial configurations is \_\_\_\_.

- a. isotopism
- b. isomerism
- c. stereoisomerism
- d. rotationalism

ANSWER: c

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44. The enzyme ATP synthase is believed to catalyze the formation of ATP, as described by the \_\_\_\_ theory.
- a. leakage
  - b. hydrogen pump
  - c. protein channel
  - d. chemiosmotic

ANSWER: d

45. The purpose of the hexose monophosphate shunt is to produce \_\_\_\_.
- a. pentose phosphates and NADPH
  - b. DNA and RNA
  - c. fatty acids
  - d. reducing substrates

ANSWER: a

46. Which tissue has the least activity of the pentose phosphate pathway?
- a. liver
  - b. adrenal cortex
  - c. mammary gland
  - d. skeletal muscle

ANSWER: d

47. Gluconeogenesis is essentially the reversal of which pathway?
- a. glycogenesis
  - b. glycolysis
  - c. TCA cycle
  - d. glycogenolysis

ANSWER: b

48. All of the following are substrates for gluconeogenesis EXCEPT \_\_\_\_.
- a. fatty acids
  - b. lactate
  - c. glycerol
  - d. glucogenic amino acids

ANSWER: a

49. Enterocytes absorb only one form of carbohydrate. This form is \_\_\_\_.
- a. disaccharides
  - b. polysaccharides
  - c. monosaccharides
  - d. trisaccharides

ANSWER: c

50. If an individual with no blood sugar abnormalities when eating regularly presented with severe hypoglycemia after 30 hours of fasting, which enzyme would you suspect might be malfunctioning?

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- a. phosphofructokinase
- b. pyruvate kinase
- c. fructose-1,6-bisphosphatase
- d. glucose-6-phosphatase

ANSWER: c

51. In skeletal muscle, hypercortisolism may lead to \_\_\_\_.

- a. enlargement of muscle fibers
- b. reduction in the size of muscle fibers
- c. increased contractile strength of muscle fibers
- d. increased healing capability

ANSWER: b

52. The abundance of GLUT4 is increased by induction in response to a high-CHO meal.

- a. True
- b. False

ANSWER: False

53. The purpose of the pentose phosphate pathway is to generate ribose, for nucleic acid synthesis, and NAD, for oxidizing power.

- a. True
- b. False

ANSWER: False

54. Pentose sugars provide more dietary energy than hexose sugars.

- a. True
- b. False

ANSWER: False

55. Glucose is transported from the lumen into the enterocyte by active transport using SGLT1 protein, which also requires Na as a co-transporter.

- a. True
- b. False

ANSWER: True

56. The process of gluconeogenesis occurs mainly in the liver and, in cases of starvation, in the kidneys as well.

- a. True
- b. False

ANSWER: True

57. The muscle is an important tissue in gluconeogenesis because it can use amino acids from protein breakdown and convert them to glucose, which it then secretes into the circulation for other tissues.

- a. True
- b. False

ANSWER: False

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58. Glycogenolysis in muscle cells provides glucose that can be transported through the bloodstream.

- a. True
- b. False

ANSWER: False

59. Glucose phosphorylation in the liver is catalyzed by glucokinase.

- a. True
- b. False

ANSWER: True

60. The Cori cycle would be active under anaerobic conditions, such as excessive muscle exertion.

- a. True
- b. False

ANSWER: True

61. Maintenance of normal blood glucose concentration is controlled by the small intestine, the liver, the kidneys, skeletal muscle, and adipose tissue.

- a. True
- b. False

ANSWER: True

62. Because they do not have mitochondria, red blood cells generate a lot of lactate from glycolysis, which they in turn must convert into glucose to meet their energy needs.

- a. True
- b. False

ANSWER: False

63. All cells have mitochondria, which act as the main site for ATP production.

- a. True
- b. False

ANSWER: False

64. Active transport requires energy for the Na-K pump to transport Na out of the cell, thereby driving the transport of another substance (e.g., glucose) when the Na re-enters the cell down its concentration gradient.

- a. True
- b. False

ANSWER: True

65. Fructose transport into the enterocyte relies on the facilitative transporter GLUT5.

- a. True
- b. False

ANSWER: True

66. After hydrolysis of triacylglycerols stored in adipose tissue, free glycerol in the blood is converted in the liver to glucose via glycogenolysis.

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- a. True
- b. False

ANSWER: False

**Enzymes:** Match the enzymes with the pathway in which they function in carbohydrate metabolism.

- a. glycogenesis
- b. glycolysis
- c. gluconeogenesis
- d. glycogenolysis
- e. pentose phosphate pathway

67. phosphofructokinase

ANSWER: b

68. pyruvate carboxylase

ANSWER: c

69. glycogen phosphorylase

ANSWER: d

70. glucose-6-phosphate dehydrogenase

ANSWER: e

71. branching enzyme

ANSWER: a

**Transporter Proteins:** Match the transporter proteins with their major site of expression.

- a. erythrocytes, CNS
- b. liver,  $\beta$ -cells, kidney
- c. brain, sperm, placenta
- d. muscle, heart, adipocytes
- e. intestine, kidney, brain, skeletal muscle, adipose

72. GLUT1

ANSWER: c

73. GLUT2

ANSWER: d

74. GLUT3

ANSWER: a

75. GLUT4

ANSWER: b

76. GLUT5

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ANSWER: e

77. Often you will hear the statement, “Insulin is important for the uptake of blood glucose by all tissues.” What is wrong with this statement? Be specific.

ANSWER: This is really a GLUT4 question—all tissues can take up glucose because they have transporters (even when there isn't any insulin). Insulin stimulates increased uptake in muscle and adipose because it binds to the insulin receptor on these cells and causes the GLUT4 to translocate from the cytosol to the membrane. Note that insulin still binds to the insulin receptor on all the other cells—they all have changes in glycolytic enzymes, etc.—they just don't have the right type of GLUT to translocate in response to insulin. Also note that insulin does not enter cells—it (like glucagon) binds to its receptor and various signals are transmitted into the cell (i.e., signal transduction), which results in various responses (induction of genes; stimulation of enzymes; translocation of GLUT4); some of these responses occur in all cells, some in only specific cells.

78. A number of metabolic pathways have a problem in that certain components required for them to function are found in either the cytosol or the mitochondria, and some intermediates cannot cross the membrane. This requires that certain compounds be shuttled from one compartment to the other. Explain this shuttling process for either: (a) glycolysis/TCA cycle OR (b) gluconeogenesis. Your answer should include what needs to be shuttled, why it needs to be shuttled, and how this is accomplished.

ANSWER: **a) Glycolysis/TCA Cycle:** The NADH generated by glycolysis needs to get in the mitochondrion for the electron transport chain (NADH from TCA cycle is already there). The malate-aspartate shuttle is used. Electrons ( $H^+$ ) from NADH are used to generate malate (from oxaloacetate), which crosses the membrane and gives them back to NAD to generate NADH (and oxaloacetate). Oxaloacetate is converted into aspartate, which crosses back to the cytosol and is metabolized to oxaloacetate to begin the process all over again. [Students may get this confused or mixed with the malate-oxaloacetate shuttle involved in gluconeogenesis.] **(b) Gluconeogenesis:** The problem is the need to get oxaloacetate out of the mitochondrion into the cytosol where the final conversion to glucose (via PEP) occurs. The amino acid alanine as well as glycerol and lactate enter gluconeogenesis as pyruvate, whereas other AAs feed into the TCA cycle at points dependent on the length of their carbon skeleton. In any case, we convert pyruvate to oxaloacetate (via pyruvate carboxylase) or any other TCA cycle keto acid to oxaloacetate. Oxaloacetate can't cross the membrane, so it is converted into malate (or aspartate); malate (or aspartate) crosses the membrane, and it is converted back to oxaloacetate. Now, oxaloacetate can be converted into PEP by PEPCK and continue to be metabolized to glucose.

79. Glycogenesis, glycogenolysis, gluconeogenesis, and glycolysis are tissue-specific—that is, either the pathway or certain aspects of the pathway are different for different tissues. Pick ONE metabolic process and describe what occurs, including what tissues are involved and any tissue-specific differences. Make sure to indicate any and all signals involved in this process.

ANSWER:

**Glycogenesis** occurs in muscle and the liver [the student should choose one tissue]. For either tissue, the signal is high blood glucose, which results in the release of insulin. For liver tissue, insulin induces glucokinase to increase glucose uptake by the liver. Insulin also stimulates (NOT induces) the dephosphorylation of glycogen synthase, resulting in its activation and the synthesis of glycogen. Note that insulin stimulates the enzyme (glycogen synthase phosphatase, which carries out the dephosphorylation of glycogen synthase, an example of covalent modification). Glycogen synthase and glycogen synthase phosphatase (or glycogen synthase kinase for that matter) are separate enzymes. Except for hexokinase (not induced by insulin) instead of glucokinase, the same mechanism occurs in muscle.

**Glycogenolysis** obviously also occurs in muscle and the liver. The signal is low blood glucose, resulting in the release of glucagon and epinephrine. For the liver, glucagon stimulates glycogen phosphatase b to a (same enzyme, a is just the phosphorylated form); it does this by stimulating the activity of a different enzyme, glycogen phosphatase kinase. In muscle, the signal is epinephrine, rather than glucagon. The result in both tissues is the breakdown of glycogen ultimately to glucose-6-phosphate. In liver tissue, glucagon also induces glucose-6-phosphatase, the enzyme that converts glucose-6-phosphate to glucose, which is then released into

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the blood. For muscle, there is no induction of glucose-6-phosphatase; thus, it simply proceeds through glycolysis/TCA to generate energy. So, liver glycogen results in glucose for the entire body; muscle glycogen only supplies energy for the muscle.

**Gluconeogenesis** occurs primarily in the liver and to some extent in the kidney. It involves the conversion of non-CHO precursors (AAs, lactate, glycerol) into glucose, which is then released by the liver into the bloodstream. This pathway is stimulated in response to low blood glucose and the subsequent action of glucagon, released by the pancreas due to low blood glucose. Glucagon induces many of the key enzymes (pyruvate carboxylase, PEPCK, fructose biphosphatase, and glucose-6-phosphatase). Amino acids are converted into their corresponding keto acid and ultimately oxaloacetate, which must leave the mitochondria and be converted to PEP, etc.

**Glycolysis**

is the oxidation of glucose to pyruvate, is cytosolic, and is anaerobic. Glycolysis occurs in all tissues/cells and is stimulated under fed conditions. High blood glucose leads to insulin secretion by the pancreas, which in turn induces glucokinase, PFK, and pyruvate kinase. Glucokinase is for liver tissue only—other tissues have hexokinase, which is not induced by insulin (but they still have PFK, etc.).

80. Enzymes are regulated by induction, covalent regulation (a form of posttranslational modification), and allosteric modification. Pick out any THREE (3) enzymes from the enzymes involved in glycolysis, the TCA cycle, gluconeogenesis, glycogenesis, or glycogenolysis. Then, indicate: the reaction that the enzyme catalyzes; what tissue(s) this occurs in; how it is regulated (via one of the mechanisms listed above); and what signals are involved in its regulation. NOTE: Long answers are unnecessary—this can be done in a relatively short single sentence.

ANSWER: [There are many examples, so just a few are listed below, but they are probably the most common.]

Allosteric – all of the ones associated with ATP, ADP, NAD, and NADH are allosteric; ADP positively regulating PFK and ATP inhibiting it is an example. There are also isocitrate dehydrogenase,  $\alpha$ -ketoglutarate dehydrogenase, and pyruvate dehydrogenase.

Covalent regulation – insulin stimulating the enzyme phosphatase, which dephosphorylates glycogen synthase (that's the covalent regulation part), thereby promoting glycogen synthesis. The opposite reaction is glucagon (or epinephrine) stimulating the kinase that phosphorylates the enzyme phosphorylase b to generate phosphorylase a, the active form that breaks down glycogen to glucose-1-phosphate. Note – the hormones do not directly carry out covalent regulation; they stimulate (note the word *stimulate*, not *induce*) the enzyme that post-translationally modifies a second enzyme by phosphorylation or dephosphorylation to make it active or inactive.

Induction – many, many examples. Most common: insulin induces glucokinase (not hexokinase); PFK. Glucagon induces glucose-6-phosphatase; PEPCK.

81. Discuss why sucrose, ordinarily an easily digested carbohydrate, might present problems of flatulence and diarrhea in individuals with severe inflammatory bowel disease.

ANSWER: Grading rubric – answer should include the following items:

Sucrose is digested by the disaccharidase sucrase in the brush border of the small intestine. In inflammatory bowel disease the mucosal cells do not produce sufficient sucrase; thus, undigested molecules draw water by osmosis, causing diarrhea, and gut bacteria ferment some sucrose with production of gases (flatulence).

82. Following a meal containing carbohydrates, glucose enters the bloodstream and increases the circulating blood glucose concentration. Describe the changes in the levels of hormonal regulators (insulin, glucagon, and cortisol) in response to this high glucose concentration and their major functions in lowering glucose levels in the bloodstream back to normal.

ANSWER: Grading rubric – answer should include the following items:

Following a meal, circulating blood glucose increases, triggering insulin release from the beta cells of the pancreas. Insulin then interacts with the insulin receptors on the muscle cells and adipocytes to start an

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intracellular cascade that moves GLUT4 transporters to the cell membrane and allows blood glucose to enter the largest tissues in the body (muscle and fat). Other tissues also take up glucose via GLUT transporters that do not require the influence of insulin. Blood glucose quickly returns to normal levels. As the next meal approaches, blood glucose begins to decrease, which triggers release of glucagon from the alpha cells of the pancreas. Glucagon acts on liver cells to stimulate glycogenolysis and the liver releases stored glucose to keep blood glucose levels normal. Similarly, low blood glucose levels stimulate the release of cortisol from the adrenal cortex and cortisol supports the stimulation of gluconeogenesis, which also contributes to raising low blood glucose levels toward normal.

83. In anaerobic conditions the NADH produced in glycolysis is not reoxidized by oxygen in the mitochondria but is oxidized to NAD in the cytoplasm by an enzyme. What is the enzyme and what is the importance of this reaction for conditions of low oxygen level?

**ANSWER:** Grading rubric – answer should include the following items:

The enzyme is lactate dehydrogenase, which, under anaerobic conditions, catalyzes the transfer of two  $H^+$  from  $NADH + H$  to pyruvate to create lactate. This is important to regenerate NAD so that it can be used again in glycolysis. Glycolysis needs to be ongoing in conditions of low oxygen in order to generate ATP because oxidative production of ATP is compromised in conditions of low oxygen.

84. Discuss the chemiosmotic hypothesis of the mechanism by which the energy from electron transport is used to synthesize ATP.

**ANSWER:** Grading rubric – answer should include the following items:

Electron transport and ATP synthesis are said to be coupled because the energy used to pump protons from the mitochondrial matrix into the intermembrane space (called translocation of the protons) creates potential energy that can be harnessed by the enzyme complex ATP synthase to make ATP from ADP. As electrons pass through Complexes I, III, and IV of electron transport, sufficient energy is released to pump protons into the intermembrane space. This creates both a proton gradient and an electrical gradient across the inner mitochondrial membrane. When these gradients are sufficiently large, protons enter the channels provided by the ATP synthase molecule imbedded in the mitochondrial membrane, the  $F_0$  portion. As the protons travel through the  $F_1$  portion of ATP synthase, which extends into the matrix and rotates as the protons pass through back into the matrix, the energy that causes the rotational movement drives the phosphorylation of ADP to create ATP.

85. Describe the process by which high levels of muscle lactate, produced by oxygen debt from exercise, are controlled/diminished by gluconeogenic action of the liver.

**ANSWER:** Grading rubric – answer should include the following items:

Lactate from muscles is released into the blood, from which it is removed by the liver. In the liver, lactate is converted to pyruvate, which then enters the gluconeogenic pathway to be converted to glucose and returned to the blood for use by other tissues. This process is called the Cori cycle.

86. Describe the symport mechanism involving glucose and the  $Na^+/K^+$ -ATPase pump.

**ANSWER:** Grading rubric – answer should include the following items:

- Glucose is absorbed by active transport requiring the  $Na^+/K^+$ -ATPase pump.
- Transport protein SGLT1 is located on the enterocyte luminal surface (apical side of the enterocyte).
- SGLT1 simultaneously transports sodium and glucose (or galactose) into the enterocyte.
- The sugar can only bind if the sodium is already bound, thus exposing the sugar-binding site.

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- Sodium moves down a concentration gradient and is released inside the cell, which then releases glucose inside the cell.

The sodium is pumped out against a concentration gradient into the extracellular fluid via the  $\text{Na}^+/\text{K}^+$ -ATPase pump on the basolateral membrane of the enterocyte and potassium is pumped into the cell against a concentration gradient in exchange.

Use of ATP to make the exchange of sodium for potassium is a major energy demand of a body at rest (basal metabolic rate).

87. According to the USDA data for the years 1970-2010, which food source is the most abundant macronutrient (by weight) in the American diet?
- carbohydrates
  - fats
  - proteins
  - nucleic acids

ANSWER: a

88. According to the USDA data for the year 2010, most of the carbohydrates in the American diet came from \_\_\_\_.
- disaccharides
  - monosaccharides
  - grain products
  - soft drinks

ANSWER: c

89. In order to be absorbed by the body, all digestible carbohydrates must be broken down into \_\_\_\_.
- disaccharides
  - monosaccharides
  - trisaccharides
  - oligosaccharides

ANSWER: b

90. Upon digestion, food carbohydrates yield four times more glucose than \_\_\_\_.
- fructose
  - galactose
  - sucrose
  - trehalose

ANSWER: a

91. The second most abundant food sources of carbohydrates are \_\_\_\_.
- complex carbohydrates
  - sugars and sweeteners
  - fruits and vegetables
  - digested proteins

ANSWER: b

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

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