

## CHAPTER 6

### Sample Answers for Chapter Discussion Questions

#### **Question #1**

High energy phosphate system:

- \* used in high power output activities (e.g., powerlifting)
- \* uses CP and ATP as the energy fuel
- \* produces a large amount of energy over a short period of time

Lactic acid system:

- \* used for medium power output activities (e.g., 800-m run)
- \* involves glycogen breakdown into pyruvate and ATP
- \* produces a medium amount of energy over a medium period of time

Oxygen system:

- \* used in low-power, long-duration activities (e.g., marathon)
- \* involves breakdown of fuels in the presence of oxygen to produce large amounts of ATP
- \* produces a large amount of energy over a long period of time

#### **Question #2**

High energy phosphate system:

Advantages: fast recovery, immediate energy production, produces a large amount of energy in a short amount of time

Disadvantages: short in duration, small energy production overall (not with respect to time)

Lactic acid system:

Advantages: not limited by oxygen delivery, medium ATP yield

Disadvantages: limited by lactic acid accumulation, long recovery

Oxygen system:

Advantages: high ATP yield, long duration

Disadvantages: slow energy production, limited by oxygen delivery

#### **Question #3**

The high energy phosphate system is used in the 100-m sprint, the lactic acid system is used in the 800-m run, and the oxygen system is used in the 5,000-m run.

#### **Question #4**

The most important source of fuel in the body is ATP (adenosine triphosphate).

#### **Question #5**

ATP resynthesis is the amount of ATP replenished/produced by a given metabolic pathway regardless of the amount of ATP used by that pathway. ATP turnover is the amount of ATP replenished/produced minus the amount of ATP used in a given metabolic pathway (i.e., the amount of ATP left for physical work at the end of a given metabolic pathway).

***Question #6***

Weight training (short-term sets and high force production) and power training should be used to train the high energy phosphate system. High-intensity training of 15-45 seconds in duration, as well as endurance training (to raise the anaerobic threshold), should be used to train the lactic acid system. Endurance training of long duration should be used to train the oxygen system.

## Question Bank for Written Student Assessment and Evaluation

### *Quiz: How Much Do You Know About Energy for Muscular Activity?*

1. Which of the following statements regarding the chemistry of energy production is **false**:
- A) ATP provides energy for all biochemical processes.
  - B) Energy is liberated when the chemical bond between ATP and its phosphate subgroup is formed.
  - C) The end product of the breakdown of complex nutrients is ATP.
  - D) Hydrosynthesis describes the chemical reaction during which energy is generated.
  - E) Two of the above.

**Answer:** *E (B and D)*

2. \_\_\_\_\_ is the energy currency of the body. **Answer:** *ATP*

3. All energy in the human body is derived from the breakdown of complex nutrients like carbohydrates, fats, and proteins. **Answer:** *true*

4. Which of the following statements regarding the energy systems is **true**:

- A) Aerobic and anaerobic distinction is made depending on whether carbon dioxide is produced in the production of energy.
- B) Two anaerobic systems can be separated on the basis of whether or not pyruvic acid is produced.
- C) The production of ATP involves two energy systems.
- D) The energy systems differ from each other with respect to the rate and the duration of energy production.
- E) Lactic acid is produced during energy production by the high energy phosphate system.

**Answer:** *D*

5. The process of forming glycogen from glucose is termed \_\_\_\_\_. **Answer:** *glycogenesis*

6. The average sedentary, healthy, 20-year-old male will have a  $\text{VO}_2\text{max}$  of 50-55 ml/kg/min.

**Answer:** *false (Correct: 40-44 ml/kg/min)*

7. The high energy phosphate system:

- A) uses high energy phosphate groups including creatine and ADP
- B) is limited by the small muscle stores of high energy phosphate groups
- C) is required for low-intensity muscle activity that is done over a short time interval
- D) produces energy at a very slow rate
- E) none of the above

**Answer:** *B*

8. The \_\_\_\_\_ is a metabolic process of aerobic energy production where pyruvic acid is metabolized, as are other fuel sources including glucose, fat, and protein. **Answer:** *Kreb's cycle*

9. The aerobic system is the primary source of energy for a narrow range of activities. **Answer:** *false* (Correct: *broad*)

10. Which of the following statements regarding the lactic acid system is **false**:

- A) Energy production occurs in the absence of oxygen.
- B) It involves a step-wise breakdown of glycogen and/or blood glucose into pyruvic acid and ATP.
- C) A specific enzyme is involved in the breakdown of glycogen or glucose in the presence of oxygen.
- D) Lactic acid is produced when the rate of work is high.
- E) Energy production is limited by lactic acid accumulation.

**Answer:** *C*

11. The resynthesis of ATP by the aerobic system takes place in cell organelles called \_\_\_\_\_. **Answer:** *mitochondria*

12. Anaerobic threshold is the point during exercise when you begin to feel discomfort and a burning sensation in the muscles. **Answer:** *true*

13. Which of the following statements regarding the oxygen system is **false**:

- A) Exercise performed at an intensity below the anaerobic threshold relies exclusively on the aerobic system.
- B) The use of this system results in high blood lactate levels.
- C) Energy fuel used by this system includes pyruvic acid.
- D) As the duration of the activity increases, the relative contribution of this system to the total energy requirement increases.
- E) None of the above.

**Answer:** *B*

14. The abbreviation used to describe maximum aerobic power is \_\_\_\_\_. **Answer:** *VO<sub>2</sub>max*

15. The aerobic system is 12 times more efficient than the other energy systems. **Answer:** *true*

16. What is endurance training? What are the four major effects of endurance training on aerobic metabolism? **Answer:** *Endurance training consists of repeated, sustained efforts of long duration several times per week. Examples of endurance exercise include running, swimming, or biking for 40 minutes or more at a heart rate of 130-140 beats per minute. Endurance training (1) increases vascularization within the muscles so there is an enhanced delivery of nutrients and oxygen to the muscle; (2) increases the number and size of mitochondria within the muscle fibers; (3) increases the activity of the enzymes involved in the aerobic metabolic pathways; and (4) results in the preferential use of fats over glycogen during exercise, which saves the muscles' rather limited store of glycogen.*

### Multiple Choice Questions

1. Which of the following statements regarding ATP is **true**:

- A) ATP muscle stores are high enough to maintain muscular activity for long durations.
- B) The amount of energy generated by the breakdown of ATP into ADP is 90-100 kcal.
- C) ATP cannot be regenerated in the human body.
- D) The ATP for muscular contraction is needed for the formation of cross bridges.
- E) The process of ATP regeneration is extremely slow.

**Answer: D**

2. The energy systems in the human body are:

- i. anaerobic lactic system
- ii. aerobic lactic system
- iii. aerobic system
- iv. anaerobic pyruvic system
- v. anaerobic alactic system

- A) i, ii, v
- B) iii, iv, v
- C) i, iii, v
- D) ii, iv, v
- E) i, iii, iv

**Answer: C**

3. The advantages of the high energy phosphate system include:

- A) It produces energy at a slow rate but for a long duration.
- B) Its rate of recovery is relatively rapid.
- C) It can produce large amounts of energy in a short amount of time.
- D) Both A and B.
- E) Both B and C.

**Answer: E**

4. The limiting factors of the high energy phosphate system include:

- A) high lactic acid concentrations in the muscle
- B) intra-muscular ADP stores
- C) initial concentrations of high energy phosphates
- D) local supply of creatine
- E) low intra-muscular oxygen availability

**Answer: C**

5. Which of the following statements regarding the main fuel of the lactic acid system is **false**:

- A) Glycogen is the circulating form of carbohydrate in the body.
- B) The main fuel source is carbohydrate.
- C) Carbohydrate is the primary energy fuel for the brain.
- D) Carbohydrates are the primary dietary sources of glucose.
- E) Glycogen consists of hundreds of glucose molecules linked together.

**Answer: A**

6. Lactic acid accumulation:

- A) increases hydrogen ion concentration
- B) impedes cross bridge formation
- C) inhibits proper enzyme function during glycolysis
- D) hampers transmission of the electrical signal at the neuromuscular junction
- E) all of the above

**Answer: E**

7. "Handling" lactic acid refers to the body's ability to:

- A) slow down muscle glycolysis
- B) remove lactic acid from the muscles
- C) use more oxygen
- D) produce lactic acid in the muscles
- E) two of the above

**Answer: B**

8. Major factors that can affect the rate of lactate removal from the muscle include:

- A) metabolism of lactic acid
- B) rate of lactic acid diffusion from the muscles
- C) muscle blood flow
- D) all of the above
- E) two of the above

**Answer: D**

9. The limiting factors of the aerobic system include:

- A) intra-muscular oxygen supply
- B) intra-muscular mitochondria concentration
- C) Krebs's cycle enzyme activity
- D) intermediate product formation
- E) both A and B

**Answer: E**

10. Which of the following statements regarding the aerobic system is **true**:

- A) Fats are the most efficient energy fuel used by this system.
- B) Water and carbon monoxide are given off as the metabolic by-products.
- C) It is well suited for low- to moderate-intensity activities.
- D) All of the above.
- E) Two of the above.

**Answer: E (A and C)**

11. The major characteristics of the oxygen system include:

- A) high ATP production
- B) fast ATP production
- C) ability to remove lactic acid
- D) all of the above

E) two of the above

**Answer: E (A and C)**

12.  $\dot{V}O_2$ max:

A) is most often expressed in L/min

B) is determined by measuring the maximal volume of oxygen that can be consumed in a given amount of time during submaximal effort

C) is lower in trained individuals than in nontrained individuals

D) is used to evaluate the power of the anaerobic system

E) none of the above

**Answer: E**

13. In the Cori cycle:

A) lactic acid is metabolized in the liver into glycogen and then pyruvic acid

B) lactic acid is metabolized in the muscle fiber into pyruvic acid and then glucose

C) lactic acid is metabolized in the liver into pyruvic acid and then glucose

D) lactic acid is metabolized in the muscle fiber into glucose and then pyruvic acid

E) lactic acid is metabolized in the liver into pyruvic acid and then glycogen

**Answer: C**

14. Which of the following factors does **not** contribute to a high aerobic power:

A) a high level of blood glucose

B) a high arterial oxygen content

C) a larger tissue oxygen extraction

D) an increased amount of blood that the heart can pump

E) none of the above

**Answer: A**

15. Which of the following statements regarding the effects of training on the oxygen system is **false**:

A) Endurance exercise is the most effective method of training.

B) Older individuals adapt their aerobic system more slowly than younger people.

C) Training should include repeated, sustained efforts of long duration several times per week.

D) Genetics does not play a significant role in determining the rate of adaptation.

E) None of the above.

**Answer: D**

### *Fill in the Blank Questions*

1. Energy for muscular contraction is generated through \_\_\_\_\_, a chemical reaction during which \_\_\_\_\_ is broken down into \_\_\_\_\_ and \_\_\_\_\_. **Answer: hydrolysis; ATP; ADP; a free phosphate group**

2. The metabolic process of ATP regeneration is termed \_\_\_\_\_. During this chemical reaction \_\_\_\_\_ is recombined with \_\_\_\_\_ to produce \_\_\_\_\_. **Answer:** *ATP resynthesis; ADP; a free phosphate group; ATP*
3. Another high-energy compound in the muscle cell known as \_\_\_\_\_ can be broken down to produce \_\_\_\_\_ and creatine. The \_\_\_\_\_ then bonds with \_\_\_\_\_ to reform ATP. **Answer:** *creatine phosphate; a free phosphate group; free phosphate group; ADP*
4. The lactic acid system uses a complex biochemical process called \_\_\_\_\_ to release energy in the form of ATP. **Answer:** *anaerobic glycolysis*
5. The last product of the 10-step breakdown of carbohydrate is known as \_\_\_\_\_. **Answer:** *pyruvate or pyruvic acid*
6. The exercise intensity at which lactic acid begins to accumulate within the blood is known as the \_\_\_\_\_. **Answer:** *anaerobic threshold*
7. Increasing the effectiveness of the \_\_\_\_\_ energy system will decrease lactic acid production. **Answer:** *aerobic*
8. Most daily activities use energy provided by the \_\_\_\_\_ system. **Answer:** *aerobic or oxygen or long-term*
9. As the duration of the activity increases, the relative contribution of the \_\_\_\_\_ system to the total energy requirement decreases. **Answer:** *anaerobic*
10. In the aerobic system, a complex biochemical process known as \_\_\_\_\_ is used to resynthesize ATP. **Answer:** *oxidative phosphorylation*
11. \_\_\_\_\_ are an important energy source for athletic events that require large outputs of energy over a long period of time as they provide nearly limitless energy supplies to the human body. **Answer:** *Fats*
12. Endurance training increases the number and size of \_\_\_\_\_ within the muscle fibers. **Answer:** *mitochondria*

### *True or False Questions*

1. A kilocalorie is the amount of energy needed to raise 1,000 grams of water by 1 degree Celsius. **Answer:** *true*
2. A speedskater competing in a 500-meter race uses an aerobic energy system. **Answer:** *false* (Correct: *anaerobic*)

3. The two anaerobic systems can be separated on the basis of whether or not lactic acid is produced during the energy production. **Answer:** *true*
4. The high energy phosphate system is also known as the anaerobic lactic system. **Answer:** *false (Correct: anaerobic alactic)*
5. With the short-term system, lactic acid is produced during energy production. **Answer:** *true*
6. The total muscle stores of ATP are depleted after only a few minutes of high-intensity work. **Answer:** *false (Correct: seconds)*
7. When the rate of work is low, pyruvate is converted into lactic acid. **Answer:** *false (Correct: high)*
8. The process of forming glycogen from glucose is termed glycolysis. **Answer:** *false (Correct: gluco-genesis)*
9. The rate of lactic acid production can be decreased by decreasing the intensity of the activity and by increasing the effectiveness of the anaerobic system. **Answer:** *true; false (Correct: aerobic)*
10. The most important energy system in the human body is the aerobic system. **Answer:** *true*
11. For intensive work of 2-3 minutes' duration, approximately two-thirds of the energy is supplied from anaerobic metabolism and one-third from aerobic metabolism. **Answer:** *false (Correct: half; half)*
12. The aerobic system contributes 70-95 percent of energy for exercise lasting longer than 10 minutes. **Answer:** *true*
13. The aerobic energy production system is called the Cori cycle. **Answer:** *false (Correct: Kreb's cycle)*
14. Fats cannot be broken down anaerobically. **Answer:** *true*
15. The average sedentary, healthy, 20-year-old female will have a VO<sub>2</sub>max of 36-40 ml/kg/min. **Answer:** *true*

### *Other Types of Questions*

1. What is the name of the process that breaks down ATP? What does this process yield?  
**Answer:**  
*ATP is broken down into adenosine phosphate (ADP) and a free phosphate group during a process known as hydrolysis. This process liberates energy for muscular work.*

2. Match the following energy systems with their corresponding characteristic. The systems can be matched with more than one answer.

| Energy System        | Answer    | Characteristic                                    |
|----------------------|-----------|---|
| 1. Immediate alactic | A, B, & D | A) Does not produce lactic acid                   |
| 2. Short-term lactic | C & F     | B) Primary source of energy is ATP and CP         |
| 3. Long-term oxygen  | A & E     | C) Primary source of energy for a 200-m sprint    |
|                      |           | D) Also known as the high energy phosphate system |
|                      |           | E) Primary source of energy for boxing            |
|                      |           | F) Also known as the glycolytic system            |

3. List two ways to decrease the rate of lactic acid production during high-intensity exercise.

**Answer:**

*Decrease the intensity of the activity.*

*Increase the body's ability to handle lactic acid.*

4. What is the most important energy system in the body? Why?

**Answer:**

*The oxygen or long-term energy system is the most important energy system in the human body, as it represents the primary source of energy for a broad range of activities. Most daily activities use energy provided by the aerobic system. Exercise performed at an intensity lower than that of the anaerobic threshold relies exclusively on the aerobic system for energy production.*

5. What happens in the Cori cycle?

**Answer:**

*In the Cori cycle, lactic acid produced by the muscles is taken to the liver to be metabolized back into pyruvic acid and then glucose.*

6. Name four major effects of endurance training on aerobic metabolism.

**Answer:**

*Increased intra-muscular vascularization*

*Increased number and size of mitochondria*

*Increased activity of enzymes*

*Preferential use of fats during exercise*