Essentials of Sports Nutrition Study Guide

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Preface

The *Essentials of Sports Nutrition Study Guide* serves as a resource companion to *Essentials of Sports Nutrition and Supplements* (2008), the official textbook for the International Society of Sports Nutrition's (ISSN) certification in sports nutrition. The *Study Guide* is designed to assist you in understanding and mastering the text content that is necessary to achieve certification. Materials covered focus on terms, key words, concepts, and other associated topics. To accomplish the goals of this text, each chapter follows the official text closely, allowing students to work through specific content areas. At the end of each chapter, there are sample quizzes. Answers to all sample quizzes are presented in the Appendix of the *Study Guide*.

The *Study Guide* is designed to allow the student to work through major content areas as they read the *Essentials of Sports Nutrition and Supplements* text. Education-based research suggests that material is best learned when students first read material and then write or work through exercises that require them to apply the material they have just covered. The *Study Guide* is designed to facilitate this by engaging students with materials that relate to the information presented in the *Essentials of Sports Nutrition and Supplements* text. Students are strongly encouraged to use the two texts concurrently, thus engaging in the process of active reading and active learning.

The *Study Guide* was created as a learning tool to help students prepare for the International Society of Sports Nutrition's certification in sports nutrition. I have been truly honored to be associated with the creation of a study guide that will help prepare students for the rigors of the ISSN's certification. I wish you the best of luck as you prepare and eventually move into the profession.

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Acknowledgments

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How to Use This Text

As you prepare for the International Society of Sports Nutrition's certification in sports nutrition, this study guide can serve as a valuable tool to help you understand and master the material presented in the *Essentials of Sports Nutrition and Supplements*. The best approach is to first read a specific chapter in the *Essentials* text. After completely reading a chapter, open the corresponding chapter in the *Study Guide*. Read the chapter objectives so that you can focus on the major areas of emphasis. You can then begin working through the learning exercises. Two approaches can be used: 1) you can use the *Study Guide* to test your knowledge of what you have read in the *Essentials* text, or 2) you can work through each learning exercise in conjunction with rereading the individual sections of the corresponding chapter in the *Essentials* text. The second approach allows for the student to do two things: 1) read the material, and 2) reread the material while actively working through specific exercises. After completing the learning exercises, look at the Review of Terminology and Important Abbreviations sections to make sure you understand each of the terms and abbreviations. Finally, there are 20 practice questions associated with each chapter that you can use as practice exams to test how well you have mastered the material in each chapter.

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Contents

Part I
Basic Exercise Physiology

1
Thermodynamics, Biochemistry, and Metabolism

Objectives

On the completion of this chapter, you will be able to:
1. Understand the different energy systems used for physical activity.
2. Know how to apply your knowledge of exercise bioenergetics to athletic training programs.
3. Understand how the principle of training specificity relates to exercise bioenergetics.

Learning Exercises

Exercise 1: Basic Introductory Definitions

_____ is often considered to be the capacity to do work or to cause change.

Define and give an example of energy transfer:

Bioenergetics is the _____.

What three things are related to the study of bioenergetics?

1.

2.

3.

Exercise 2: Understanding Thermodynamics

What are the two components of the 2nd Law of Thermodynamics?

1.

2.

The transfer of high energy content to low energy content is an example of a _____.

Explain what happens during combustion. In this explanation, discuss the major players.

The greater the content of e^- and H^+ within a fuel the _____ the energy content present in that fuel source.

What are the two low energy end products of combustion?

1.

2.

The biologic equivalent of combustion is termed _____.

When examining the transfer of heat to mechanical motion, define the following terms:

Heat:

Temperature:

Efficiency:

Give examples of the efficiency of energy transfer for the following engines:

Steam engine:

Gasoline powered engine:

Diesel engine:

Human pedaling a bicycle:

Define the 1st Law of Thermodynamics:

Exercise 3: Energy Transfer

Define and describe the three types of systems:

1.

2.

3.

Match the term with the appropriate abbreviations:

Enthalpy:_____	A: *S*
Entropy:_____	B: G
Gibbs Constant:_____	C: H

Define the following terms:

1. Enthalpy:

2. Entropy:

Taking enthalpy, entropy, and the Gibbs' constant, write a basic equation that explains energy transfer:

= +

In the grand scheme of energy transfer, what does entropy represent?

The total amount of energy that is available for use is termed _____, which is dependent on the total energy within a system and its immediate environment, which is represented by _____, and how much energy is unavailable or _____.

Taking the concept that Gibbs' recognized that enthalpy and entropy are the driving force behind energy transfer, write an equation that represents this.

= –

When looking at an open system, what two things should be considered?

1.

2.

As the rate of energy transfer increases, the efficiency of energy transfer _____.

Open systems are better explained in regards to a particular status in between beginning and end points. In this context, explain the following:

1. What is the symbol for the rate of energy exchange? _____
2. What is the symbol for the extent of metabolic product formation from reactants? _____
3. What is the symbol for Gibbs energy? _____

Write an equation that explains the relationship between Gibbs energy, the rate of energy exchange, and the extent of metabolic production formation from biochemical reactants.

*

What about an open system makes heat and entropy inevitable and continuous? What does this result in?

When looking at life, explain the relationship between the food we eat and the energy available to us and the heat we produce. In this example, relate entropy, enthalpy, and Gibbs energy to your discussion.

Exercise 4: Biochemistry

The flow of _____ and _____ is often termed oxidation-reduction reactions by scientists.

Define the two parts of an oxidation-reduction reaction:

1. Oxidation:
2. Reduction:

Define and describe the role of enzymes in the biochemistry of bioenergetics:

Explain what allosteric regulation is and how it affects enzyme activity.

Define the following terms:

1. Catabolic:
2. Anabolic:
3. Anaerobic:
4. Aerobic:

ATP: The High-Energy Phosphate and More High-Energy Phosphates

Define the following abbreviations:

1. ATP:
2. ADP:
3. AMP:
4. Pi:
5. CP:
6. C:

What is the ratio of ATP to ADP kept at? Why is this significant?

What two things does ATP turnover consist of?

1.
2.

What does the rate of ATP hydrolysis dictate?

What are the three single enzyme reactions that contribute to energy transfer in anaerobic metabolism?

1. Enzyme = _____

\+ → + + + + +

2. Enzyme = _____

\+ + → + +

3. Enzyme = _____

→ + +

When creatine phosphate stores are significantly depleted, the rate at which physical work is performed is significantly _____.

What does a high concentration of lactate in the muscle and blood indicate?

Explain why an athlete might consider ingesting baking soda and why this might not be the best idea.

The mitochondria degrade glucose to _____ and _____.

What are the two distinct parts of aerobic metabolism?

1.

2.

What are the three alternative names for aerobic metabolism?

1.

2.

3.

What coenzyme must be linked to a substrate for it to enter into the Krebs cycle?

What are the names of the two special carrier molecules that e^- and H^+ are attached to and are used to link the first part of aerobic metabolism to the second part?

Explain what a joule is and how it relates to a unit of heat (energy).

Explain the difference between direct and indirect calorimetry.

1. Direct calorimetry:
2. Indirect calorimetry:

Explain what the respiratory exchange ratio is.

1. What would the RER be if the amount of CO_2 produced equally matched the amount of O_2 consumed?
2. What would the RER be if you were primarily metabolizing fat?
3. Explain the relationship between intensity of exercise and the RER.

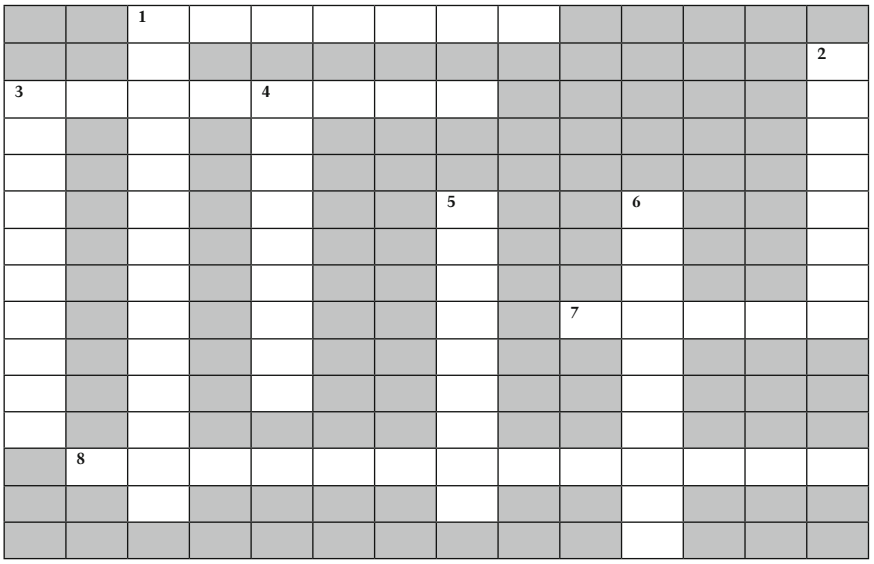
Explain the difference in the rate of ATP resynthesis between anaerobic and aerobic mechanisms.

What is the oxygen deficit and what does it represent?

What is EPOC and what factors contribute to it?

What three measures are needed for the interpretation of total energy expenditure during exercise and recovery?

1.
2.
3.



Across:

1. Serves as an electron and hydrogen donor in glycolysis
3. Storage form of carbohydrates in the body
7. A unit of measurement used to represent work
8. Is the site of aerobic respiration, often called the powerhouse of the cell

Down:

1. The breakdown of glycogen in the body
2. Accepts an electron and a hydrogen during glycolysis
3. The breakdown of glucose in the body
4. The loss of electrons and protons
5. The gain of electrons and protons
6. An intricate and highly modifiable internal arrangement of protein fibers

Review Test

1. The two most important hydrogen (electron) carriers in bioenergetic chemical reactions are:
   a. NAD^+ and ATP
   b. FAD^+ and ATP
   c. NAD^+ and FAD^+
   d. NAD^+ and LDH

2. A respiratory quotient (RQ) of 0.95 during steady-state exercise is suggestive of a(n):
   a. High rate of carbohydrate metabolism
   b. High rate of fat metabolism
   c. Equal rate of fat/carbohydrate metabolism
   d. High rate of protein metabolism

3. A respiratory quotient (RQ) of 0.75 during steady-state exercise is suggestive of a(n):
   a. High rate of carbohydrate metabolism
   b. High rate of fat metabolism
   c. Equal rate of fat/carbohydrate metabolism
   d. High rate of protein metabolism

4. The breakdown of glucose occurs in a process termed:
   a. Glycogenolysis
   b. Oxidative phosphorylation
   c. Glycolysis
   d. None of the above

5. The first law of thermodynamics states that energy transfer operates at an efficiency.
   a. True
   b. False

6. A reduction reaction involves the:
   a. Gain of electrons
   b. Loss of hydrogen molecules
   c. Loss of electrons
   d. Gain of hydrogen molecules
   e. b and c
   f. a and d
   g. c and d

7. An enzyme functions as catalysts which increase the rate of spontaneous reactions.
   a. True
   b. False

8. The myokinase reaction results in the production of _____ and _____.
   a. ADP and Pi
   b. ATP and AMP
   c. ATP and ADP
   d. ADP and AMP

9. Direct calorimetry measures:
   a. Metabolic rate through oxygen consumption
   b. Metabolic rate through heat production
   c. Oxygen consumption with open circuit spirometry
   d. Oxygen consumption with closed circuit spirometry

10. ATP hydrolysis and resynthesis both contribute to ATP turnover.
    a. True
    b. False

11. The simplest and most rapid method to produce ATP during exercise is through:
    a. The glycolytic system
    b. The high-energy phosphate system
    c. Aerobic metabolism
    d. Glycogenolysis

12. The effect of heavy/severe exercise on substrate-level phosphorylation:
    a. Increase
    b. Decrease
    c. No effect

13. Blood lactate is an excellent indicator of glycolytic ATP turnover.
    a. True
    b. False

14. During EPOC, the principle nutrients used with oxidative means are lactate and fat.
    a. True
    b. False

15. The primary energy system utilized during an 800-meter run receives its energy from?
    a. High-energy phosphates
    b. Oxidative mechanisms
    c. Glycolytic mechanism
    d. None of the above

16. Enthalpy can be defined as the initial or total energy content within or available to a system.
    a. True
    b. False

17. The potential influence of substances on the activity of enzymes is termed allosteric regulation.
    a. True
    b. False

18. All of the following are true about ATP turnover except:
    a. ATP hydrolysis fuels cellular work
    b. ATP resynthesis occurs via energetic pathways
    c. The rate of ATP resynthesis dictates the rate of ATP hydrolysis
    d. a and b
    e. a and c

19. What is the effect of a drop off of creatine phosphate on the rate at which physical activity can be performed?
    a. Increased performance
    b. Decreased performance
    c. No effect on performance

20. Aerobic metabolism is also known as:
    a. Krebs cycle
    b. Glycolysis
    c. Tricarboxylic acid cycle
    d. All of the above
    e. a and b
    f. b and c

Review of Terminology

Introduction	**Energy Transfer**	**Adenosine Triphosphate: The "High-Energy" Phosphate**
Bioenergetics	Closed System	Adenosine Diphosphate
Energy	Enthalpy	Adenosine Monophosphate
	Entropy	Adenosine Triphosphate
Thermodynamics	Isolated System	Chemo-Mechanical
Combustion	Open System	Hydrolysis
Efficiency	Closed System	
Gradient		**More "High-Energy" Phosphates**
Heat	**Biochemistry**	Alkalosis
Metabolism	Aerobic	ATP/ADP Ratio
Temperature	Allosteric Regulation	Creatine Kinase
	Anabolic	Creatine Monohydrate
Glycolysis	Anaerobic	Creatine Phosphate
Glycogen	Catabolic	Myokinase
Glycogenolysis	Enzymes	
Glycolysis	Feed-Backward	**Respiration**
Lactate	Feed-Forward	Acetyl-CoA
Pyruvate	Oxidation	Citric Acid Cycle
	Reduction	Flavin-Adenine Dehydrogenase
Energy Expenditure		Krebs Cycle
Calories	**Sidebar 1.1**	Macronutrients
Direct Calorimetry	Convection	Mitochondria
Excess Postexercise Oxygen Consumption	Cytomatrix	Nicotinamide Adenine Dehydrogenase
Indirect Calorimetry	Lactate Dehydrogenase	Respiration
Joule		Tricarboxylic Acid Cycle
Oxygen Deficit	**Sidebar 1.3**	
Respiratory Exchange Ratio	Maximal Oxygen Uptake	**Practical Applications**
Steady State		Electrocardiogram
Total Energy Expenditure		Slow O_2 Component
Work		

Important Abbreviations

∂	FAD^+
ζ	G
ΔG	H
ΔH	H^+
Δ*S*	H_2O
ADP	LDH
AMP	Mol
ATP	NAD^+
C	O_2
CO_2	Pi
CoA	Red-Ox
e^-	RER
EKG	S
EPOC	TEE
ETC	VO_2 max

2
Skeletal Muscle Plasticity

Objectives

On the completion of this chapter, you will be able to:

1. Define the basic definitions associated with bioenergetics.
2. Understand the basic principles behind thermogynamics.
3. Develop an understanding of the concept of energy transfer.
4. Describe the biochemical reactions associated with various energy-transfer pathways in the body.
5. Explain the basics of energy expenditure, the methods for measuring energy expenditure, and the relationship of energy expenditure to exercise.

Learning Exercises

Exercise 1: Defining Layers of Connective Tissue in Skeletal Muscle

List the three major connective tissue layers found in skeletal muscle:

1. _____

2. _____

3. _____

The _____ surrounds the bundles of muscle fibers which are called _____.

The _____ surrounds each muscle fiber and separates it from adjacent fibers.

The deep fascia or _____ surrounds the entire muscle.

Exercise 2: Describing and Defining the Muscle Fibers and Architecture

Explain the characteristic of skeletal muscle fibers that allows more myofibers to be packed into a given volume of muscle.

Explain the difference between fusiform and pennate muscles.

List the three types of pennate muscle seen in the body:

1. _____

2. _____

3. _____

Define and describe the following terms:

1. Inscriptions:

2. Serially Arranged Fibers:

3. Pennate Fiber Arrangements:

Exercise 3: Understanding the Skeletal Muscle Fiber

The Sarcolemma

Define the function and structure of the sarcolemma.

What are the primary structures involved in the development of the difference in electrical potential across the sarcolemma?

The Neuromuscular Junction

Describe the structures that comprise the neuromuscular junction.

The neurotransmitter _____ is released from the vesicles in the synaptic knobs.

The _____ is the very small space that separates the muscle fiber from the motor neuron.

List the three major structures associated with the neuromuscular junction:

1. _____
2. _____
3. _____

The Transverse Tubules and Sarcoplasmic Reticulum

List the two structures that are part of the elaborate system of channels that are needed in order to activate the myofiber:

1. _____
2. _____

The _____ allow the action potential to be propagated deep into the core of the muscle fiber.

The _____ which are voltage sensing proteins lie in the _____ membrane and trigger the release of calcium from the _____ through the _____ receptors.

The _____ has a network of cross-connections which are more complex in fast-twitch fibers.

The activation of a skeletal muscle during contractions causes a rapid diffusion of Ca^{2+} into the sarcoplasm by the _____.

Define and describe what SERCA is and its role during muscle relaxation.

Sarcoplasm and Cellular Organelles

Define and describe sarcoplasm.

What are some of the structures that are in the sarcoplasm?

1. _____
2. _____
3. _____
4. _____
5. _____

"The powerhouse of the cell" is where oxidative metabolism occurs within the myofiber. This structure is also called the _____.

Define and explain a myofibril.

Define and describe the structure and function of a sarcomere.

Describe the structure and function of the Z lines.

Exercise 4: Muscle Contractile and Regulatory Proteins

Name the two major contractile proteins that make up the sarcomere:

1. _____
2. _____

How many myosin heavy chain (MHC) molecules does myosin contain?

How many myosin light chain (MLC) molecules does myosin contain?

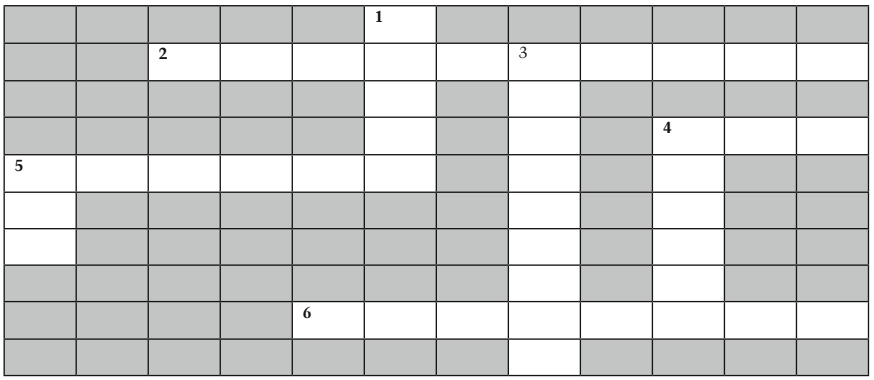
How many pairs of MHC molecules are intertwined to form the thick filament?

The globular head or the _____ projects outward toward the thin filament.

The _____ molecule is also known as the thin filament.

In complete detail, describe the organization of the thick filament.

Summarize the role of two regulatory and two essential myosin light chains.



Across:

2: The smallest functional unit of skeletal muscle
4: Compound broken by myosin ATPase
5: The thick filament
6: Serves as a skeleton or scaffold for the sarcomere

Down:

1: The thin filament
3: Long cylindrical filament that extends the length of the muscle fiber
4: Enzyme found as an intrinsic part of the globular head of myosin
5: Myosin contains two molecules of this structure

List and summarize the function of the three major components of a thin filament:

1. _____:

2. _____:

3. _____:

List and describe the two types of actin molecules:

1. _____:

2. _____:

List and describe the functions of the three subunits of troponin:

1. _____:

2. _____:

3. _____:

In detail, summarize the relationships and interactions of actin, tropomyosin, and troponin.

Diagram the basic structure of a muscle sarcomere including actin, myosin, Z lines, I band, A band, and H zone.

Exercise 5: Cytoskeleton Function and Structures

Describe and summarize the structure of titin and its relationship to myosin.

List the three functions that might be related to titin:

1.

2.

3.

Describe and summarize the structure and functions of nebulin.

The group of proteins that are termed intermediate fibers contains _____ which is a protein that links adjacent sarcomeres at their Z lines.

Summarize the role of dystrophin in stabilizing the sarcolemma during contraction. In this description, discuss how this protein relates to Duchenne muscular dystrophy.

Exercise 6: Skeletal Muscle Actions

Define the following terms:

Dynamic Muscle Action:

Concentric Muscle Action:

Eccentric Muscle Action:

Plyometric Muscle Action:

Isometric Muscle Action:

List the events/steps that lead from the excitation of the central nervous system to the propagation of the myofiber action potential on the sarcolemma.

List the events that lead from the propagation of the action potential on the sarcolemma until muscular contraction.

In detail, explain the process of cross-bridge cycling and the sliding filament theory.

Summarize the process by which a muscle relaxes:

Exercise 7: Classification of Muscle Fibers and Motor Unit Types

List and explain the characteristics of the three classifications of muscle fibers that are based on the contractile and metabolic properties of the myofibers:

1. _____:

2. _____:

3. _____: