

## 5 Metabolism: Energy and Enzymes

### I. Chapter Outline

- A. Energy
  - 1. Two Laws of Thermodynamics
  - 2. ATP: Energy for Cells
- B. Metabolic Pathways
  - 1. Enzymes: Speed Reactions
  - 2. What Affects Enzyme Productivity
  - 3. Coenzymes: Helpers of Enzymes

### II. Chapter Review

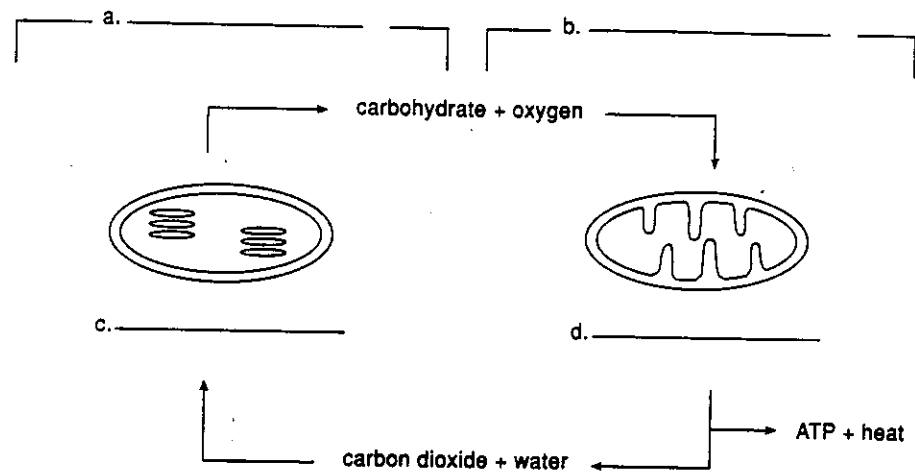
Page	Questions
74	<ol style="list-style-type: none"><li>1. List the 2 cellular organelles that transform one form of energy into another form.</li><li>2. Name the 2 processes that permit a flow of energy from the sun through all living things.</li><li>3. Define energy. Do chemicals, energy, or both cycle through living things?</li><li>4. Define the First Law of Thermodynamics. Can energy be converted from one form to another form?</li><li>5. Why must a cell perpetually take in energy in order to continue living?</li></ol>
75	<ol style="list-style-type: none"><li>6. What is meant by the Second Law of Thermodynamics? What form of energy is lost to the surroundings?</li><li>7. Name the molecule that is the immediate source of energy in cells. What is it composed of? Where are the high-energy bonds found?</li></ol>
76	<ol style="list-style-type: none"><li>8. Define metabolism. What are the advantages of having metabolic pathways in a cell?</li><li>9. What are enzymes? Why are they important? Are they specific? How are they named?</li><li>10. Why are enzymes absolutely necessary to the continued existence of a cell?</li></ol>
77	<ol style="list-style-type: none"><li>11. Do enzymes increase or lower the energy of activation of a reaction?</li><li>12. Describe what happens when an enzyme reacts with a substrate?</li><li>13. Where does the substrate fit onto the enzyme? Is the enzyme altered or used up after the reaction?</li><li>14. Describe the difference between the lock and key theory and the induced-fit model.</li></ol>
78	<ol style="list-style-type: none"><li>15. What is the difference between enzymatic reactions that bring about synthesis and degradation?</li><li>16. Why will an increase in the substrate concentration cause an increase in the enzyme's activity only up to a certain point?</li><li>17. What happens to an enzyme as the temperature continues to increase? if the pH continues to increase?</li></ol>
79	<ol style="list-style-type: none"><li>18. Define competitive inhibition. What is the difference between irreversible and reversible inhibition?</li><li>19. Define noncompetitive inhibition. What is the normal way by which metabolic pathways are regulated?</li><li>20. What are coenzymes? List 3 vitamins that are used in coenzymes.</li><li>21. What vitamin is present in the coenzyme NAD? What type of enzyme will often incorporate NAD? How are these coenzymes used? Is NADH<sub>2</sub> reduced or oxidized?</li><li>22. Name the coenzyme that brings about substrate reduction in plants. Define reduction.</li></ol>

### III. Objective Chapter Test

#### *Completion and Short Answer Questions*

1. \_\_\_\_\_ and \_\_\_\_\_ are two cellular organelles that transform one form of energy into another form of energy.

- The processes of \_\_\_\_\_ and \_\_\_\_\_ permit a flow of energy from the sun through all living things.
- \_\_\_\_\_ is defined as the capacity to bring about change or do work.
- Chemicals, but not \_\_\_\_\_, can cycle through living things.
- When cells require energy for synthetic reactions, they "spend" \_\_\_\_\_.
- In the diagram below, list the two cellular processes that allow for energy transformations on lines a and b. On lines c and d, list the organelles responsible for each cellular process.



- The First Law of Thermodynamics states that energy can neither be (a) \_\_\_\_\_ nor (b) \_\_\_\_\_. However, it can be (c) \_\_\_\_\_ from one form to another.
- According to the Second Law of Thermodynamics, one usable form of energy \_\_\_\_\_ (can / cannot) be completely converted into another usable form.
- \_\_\_\_\_ is the nonusable form of energy that is easily lost to the surroundings.
- Every ATP molecule is composed of the base (a) \_\_\_\_\_, the sugar (b) \_\_\_\_\_, and three (c) \_\_\_\_\_ groups. The wavy lines in the formula for ATP indicate (d) \_\_\_\_\_ phosphate bonds.
- The equation  $ADP + \textcircled{P} \longrightarrow ATP$  is energy \_\_\_\_\_ (requiring / releasing).
- $$A \xrightarrow{E_1} B \xrightarrow{E_2} C \xrightarrow{E_3} D$$

In this metabolic pathway, the letter B stands for the (a) \_\_\_\_\_ as the result of the action of Enzyme 1. However, as a result of the action of Enzyme 2, B represents a (b) \_\_\_\_\_. Each and every reaction in a cell requires a specific (c) \_\_\_\_\_.

13. The generalized equation for enzymatic action is \_\_\_\_\_  
 This equation shows that the enzyme and the substrate form a temporary \_\_\_\_\_ complex.

14. \_\_\_\_\_ is an enzyme that removes hydrogen atoms from a substrate.

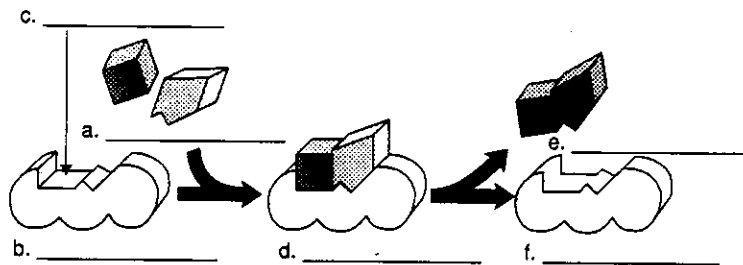
15. In the list below, give the name of the enzyme for each specific substrate.

Substrate	Enzyme
a. Lipid	a.
b. Urea	b.
c. Maltose	c.
d. Ribonucleic acid	d.

16. Less heat is needed to bring about a chemical reaction within a cell because enzymes will \_\_\_\_\_  
 (*increase / decrease*) the energy of activation of a reaction.

17. The \_\_\_\_\_ site is the place where the substrate fits onto the enzyme for orientation so that the reaction takes place.

18. Use the following terms to label this diagram: substrate, enzyme, active site, product, enzyme-substrate complex.

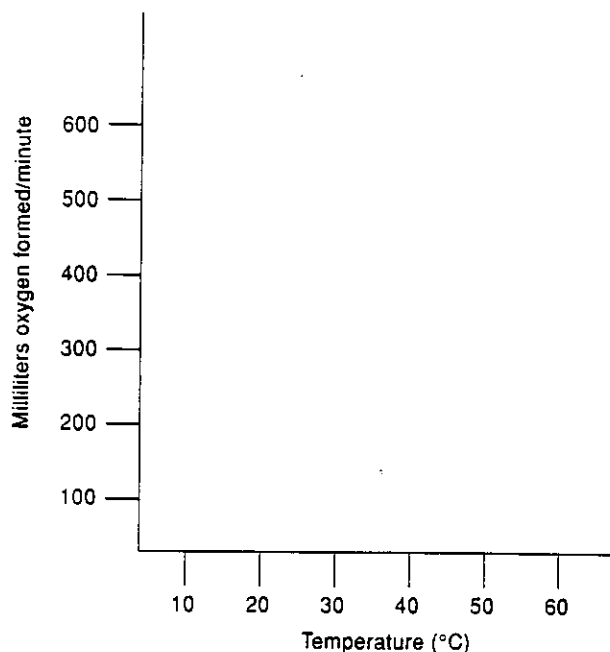


19. When the substrate binds to the enzyme, the enzyme undergoes a slight change in shape to achieve maximum fit.  
 This concept is termed the \_\_\_\_\_ model.

20. Suppose two amino acids join together to form a dipeptide. This type of reaction is considered a  
 \_\_\_\_\_ (*synthetic / degradation*) reaction.

21. Catalase is an enzyme that breaks down hydrogen peroxide into water and oxygen. Plot the results of the data below in the accompanying graph.

<u>Milliliters of Oxygen Formed per Minute</u>	<u>Temperature (°C)</u>
100	10
200	20
300	30
600	40
300	50
100	60



22. On the basis of the above graph, at which temperature did the catalase exhibit the greatest activity? \_\_\_\_\_
23. Why did the activity of catalase decrease as the temperature continued to increase above 40 °C? \_\_\_\_\_
24. Explain why hydrogen peroxide can be broken down by the enzyme catalase but another substrate, such as maltose, cannot be broken down by catalase. \_\_\_\_\_

<u>Substrate Concentration (Milligrams/milliliter)</u>	<u>Amount of Product Formed (Milligrams/milliliter)</u>
0	0
10	100
20	200
30	400
40	400
50	400

25. Study the table given above.
- Which substrate concentration will initially yield the maximum amount of product formed? (a) \_\_\_\_\_
- Explain why the amount of product formed does not increase as the substrate concentration goes beyond 30 milligrams/ml. (b) \_\_\_\_\_

26. On the basis of the two tables presented below, which table shows irreversible inhibition? \_\_\_\_\_

Table A

Substrate Concentration (Milligrams/milliliter)	Inhibitor Concentration (Milligrams/milliliter)	Amount of Product Formed (Milligrams/milliliter)
20	0	200
20	10	100
20	20	50
20	40	0
100	40	400

Table B

Substrate Concentration (Milligrams/milliliter)	Inhibitor Concentration (Milligrams/milliliter)	Amount of Product Formed (Milligrams/milliliter)
20	0	200
20	10	0
20	20	0
20	40	0
100	40	0

27. In \_\_\_\_\_ inhibition, an inhibitor binds to an enzyme at a site other than the active site.
28. Organic molecules that bind to enzymes and serve as carriers for electrons are called \_\_\_\_\_.
29. When NAD accepts hydrogens from a substrate, it is (a) \_\_\_\_\_, while the substrate is (b) \_\_\_\_\_.
30. Two environmental factors that can change the shape of an enzyme are (a) \_\_\_\_\_ and (b) \_\_\_\_\_.
31. Enzymes may have a nonprotein helper called a(n) (a) \_\_\_\_\_ or an organic molecule called a(n) (b) \_\_\_\_\_.
32. \_\_\_\_\_ is the loss of electrons or the removal of hydrogen atoms.

*Matching Questions.* Use the following answers to match with the words below.

a. inhibitor b. ATP c. reduction d. enzyme e. extreme temperature

33. denatured \_\_\_\_\_
34. substance that can compete with a substrate \_\_\_\_\_
35.  $\text{NAD} \rightarrow \text{NADH}_2$  \_\_\_\_\_
36. energy currency of the cell \_\_\_\_\_
37. substance that can speed up one particular reaction \_\_\_\_\_

*True (T) or False (F) Questions.* If you believe the statement to be false, then rewrite the statement as a true one.

38. The removal of hydrogen atoms by ATP releases energy that can be used to build up NAD.

Answer: \_\_\_\_\_ Restatement: \_\_\_\_\_

39. Enzymes, being molecules that speed up chemical reactions, are required in photosynthesis and cellular metabolism.

Answer: \_\_\_\_\_ Restatement: \_\_\_\_\_

40. The shape of an inhibitor molecule is very similar to the shape of the enzyme's substrate.

Answer: \_\_\_\_\_ Restatement: \_\_\_\_\_

41. High temperatures and extreme pH can cause an enzyme to denature.

Answer: \_\_\_\_\_ Restatement: \_\_\_\_\_

42. All enzymes function at the same pH.

Answer: \_\_\_\_\_ Restatement: \_\_\_\_\_

43. The First Law of Thermodynamics states that one usable form of energy cannot be completely converted into another usable form.

Answer: \_\_\_\_\_ Restatement: \_\_\_\_\_

#### *Multiple Choice Questions*

44. ATP is the energy currency of cells because it

- a. is easily oxidized.
- b. contains high energy phosphate bonds.
- c. combines very well with other substrates.
- d. can be synthesized from inorganic components.

45. In a metabolic pathway,

- a. the product of one reaction becomes the substrate of the next reaction.
- b. the same enzyme is used for all reactions.
- c. the end product is never formed.
- d. ATP is released all the time.
- e. nonprotein enzymes are used.

46. Initially, as the substrate concentration is increased, the reaction rate

- a. slows down.
- b. speeds up.
- c. stays the same.
- d. speeds up and then decreases.

47. In photosynthesis, the coenzyme used for reduction is \_\_\_\_\_.

- a. ATP
- b. NAD
- c. NADP
- d. niacin
- e. Mg ions

48. In cells, oxidation is accomplished by the

- a. addition of oxygen.
- b. addition of electrons.
- c. removal of carbon atoms.
- d. removal of hydrogen atoms.

49. The vitamin found within the coenzyme NAD is \_\_\_\_\_.

- a. phosphate
- b. thiamine
- c. niacin
- d. biotin
- e. riboflavin

50. Which statement is NOT correct about enzymes?
- They usually end in the suffix "-ase".
  - They catalyze only one reaction.
  - They increase the energy of activation.
  - They bind temporarily with the substrate.
  - They speed up a chemical reaction.

51. The specificity of an enzyme to a particular substrate is accounted for by its \_\_\_\_.
- protein portion
  - coenzymes
  - cofactors
  - vitamins
  - pH

52. An example of reversible inhibition is \_\_\_\_.
- alcohol dehydrogenase with alcohol or ethylene glycol
  - penicillin inhibition of bacterial cell wall synthesis
  - cytochrome oxidase and hydrogen cyanide
  - inhibition by the end product of a metabolic pathway on the first enzyme

53. Which of the following is NOT an enzyme?
- lactase
  - maltose
  - lipase
  - urease
  - ribonuclease

#### IV. Subjective Chapter Test

54. According to the First Law of Thermodynamics, energy can never be created nor destroyed. If that is the case, how can living things ever grow and reproduce if they cannot create energy?

55. Why are enzymes absolutely necessary to the continued existence of a cell?

