

CELL METABOLISM

The study of metabolism is the study of cell reactions. In Chapter 6: Cell Metabolism you will read about the structure and function of enzymes and how enzymes control cell reactions. We are also going to look at the process called "Cell Respiration".

General Metabolism

(pp. 104), Glossary end of text)

1. Define the following terms and give a specific example of each.

a. metabolism

b. enzyme

c. substrate

d. coenzyme

2. Below is a diagram illustrating a metabolic pathway where a substance like glucose is being broken down in a series of steps, with each step being controlled by a specific enzyme. The purpose in this metabolic pathway is to release the chemical energy within the bonds so that the cell can use the energy.



Answer the following questions using the above diagram:

a. Where in the body might these reactions occur?

b. What does the reaction start with?

c. What does it end with?

d. What is required at each step?

e. The compounds in the middle of the reaction are referred to as:

Enzymes: Structure and Function

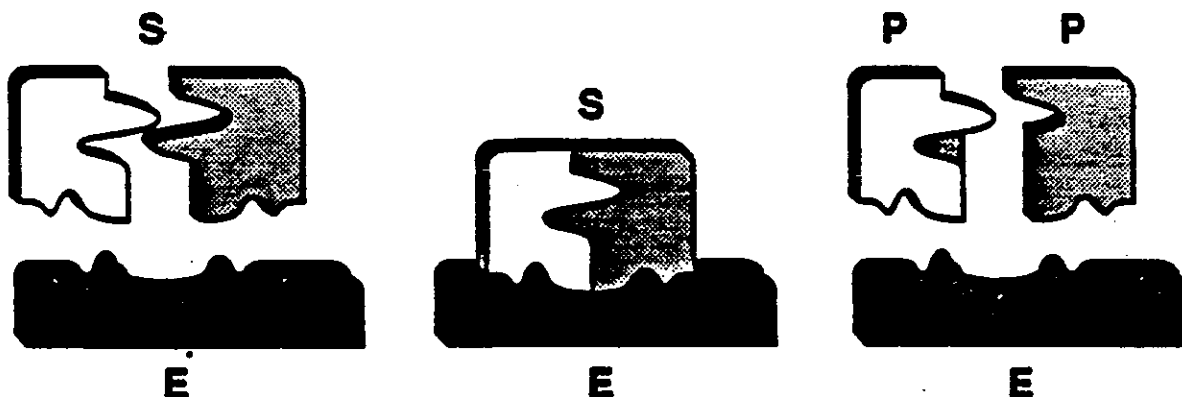
(pp. 106-9)

1. Explain why enzymes are called *catalysts*.
2. Enzymes are made up of what chemical components?
3. From your knowledge of protein structure, predict what would affect the functioning of enzymes.
4. How do the three different levels of protein structure help us understand more about their function?
5. Fig. 6.6 p. 107 illustrates an enzyme reacting with a substrate. The substance that the enzyme works upon is called the *substrate*. The substrate could be any carbohydrate like glucose, maltose, or sucrose. It could also be a fat, or a protein. Enzymes can break substrates down into simpler products (maltose \rightarrow glucose + glucose), or synthesize larger molecules (glucose + glucose \rightarrow maltose). The reactions can go in both directions.

Define the term *substrate*:

6. Look again at fig. 6.6 p. 107 which shows a working model of how enzymes interact with substrates. This model is called the *Lock and Key Theory*.

Lock & Key theory of enzymatic action



7. In the diagram above:

a. E is the _____

- b. S is the _____
- c. ES is the _____
- d. P is the _____

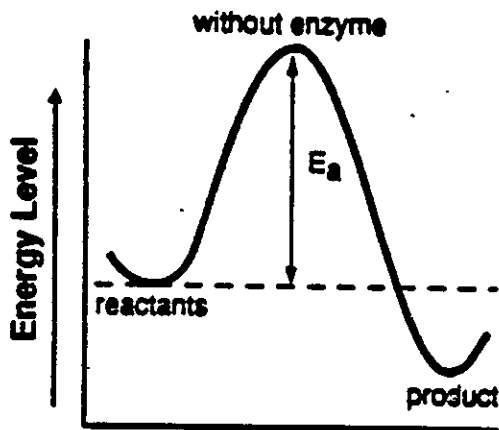


8. As illustrated above, every enzyme has a "groove" within its structure called the active site. What is the function of the active site?
9. Explain how enzymes are named.
10. Define the term *Enzyme-Substrate Complex*.

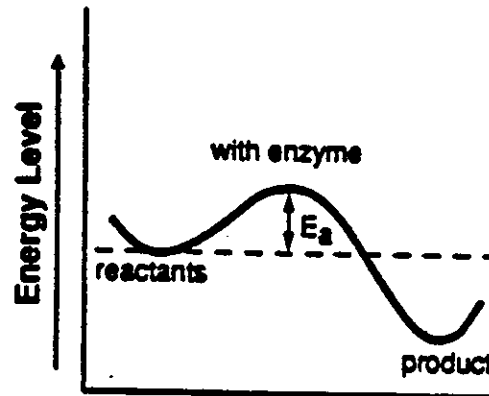
Enzyme-Energy Relationships

(p.106)

Enzymes are required to produce energy for cells. Without enzymes, the chemical energy stored within carbohydrates could not be released.



a. Progress of Reaction



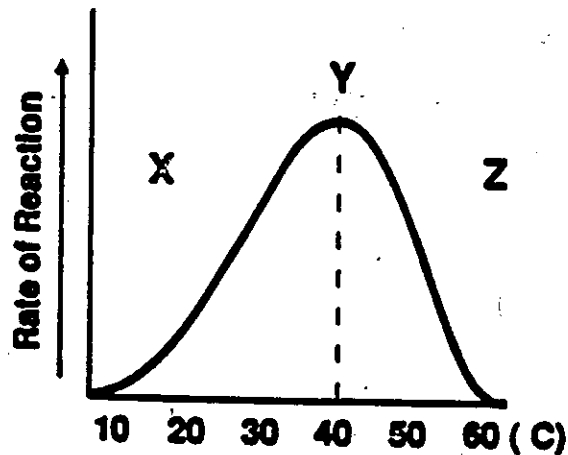
b. Progress of Reaction

1. The above graph illustrates how enzymes affect the amount of energy needed to carry out a metabolic reaction. Look at this graph, and answer the following questions:

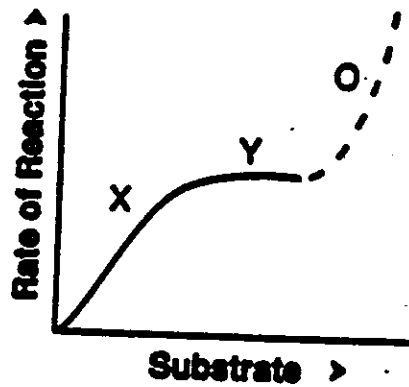
- a. From the graph it appears as if enzymes lower the energy of activation (E_a) in all chemical reactions. Explain what this means.
- b. An inorganic catalyst required 20,600 cal/mol to hydrolyze casein, a protein in milk. With an enzyme, 12,000 cal/mol of energy is required. Why is there such a difference?

Factors that affect enzymes

Enzymes are often affected by a variety of different factors. How well they operate can be affected by temperature, pH, and the concentration of substrate used in a specific reaction. The graphs below illustrate the effect. Look at each graph and answer the questions that follow.



1. Look at the graph above showing the effect of temperature on enzyme action. Explain what is occurring at:
 - a. X?
 - b. Y?
 - c. Z?

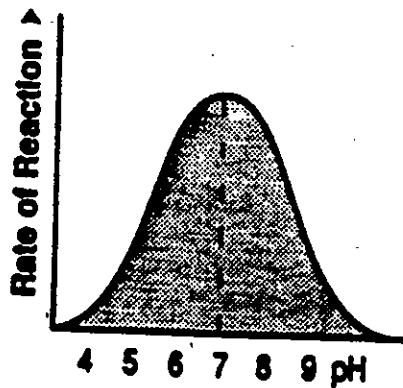


2. The graph above illustrates the affect of increasing the concentration of substrate while keeping the amount of enzyme at a fixed amount.

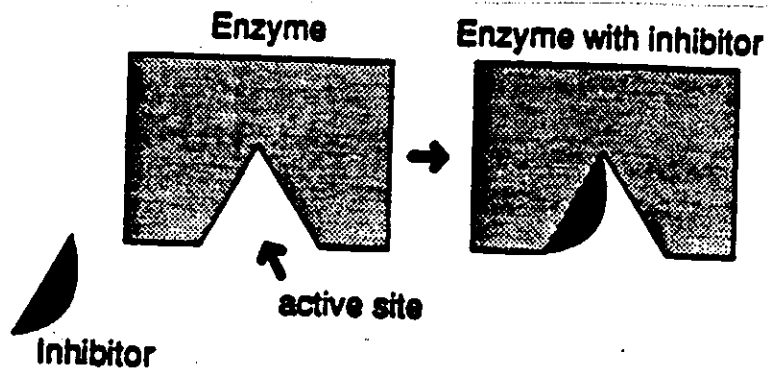
a. Account for the rise in the graph at X.

b. Account for the leveling off of the graph at Y.

c. What would you have to do to have the graph move upward at O?



3. The above graph illustrates the affect of pH on an enzyme. Do high or low pH levels increase or decrease the rate of reaction? What is the optimum pH level?



4. The diagram above illustrates the effect of an inhibitor on enzyme action. Look at the diagram and explain how an inhibitor affects enzyme activity.
5. Explain how the following factors affect enzyme action. Give reasons for your answer.
- heavy metals
 - temperature
 - pH

Coenzymes-Enzyme Activity

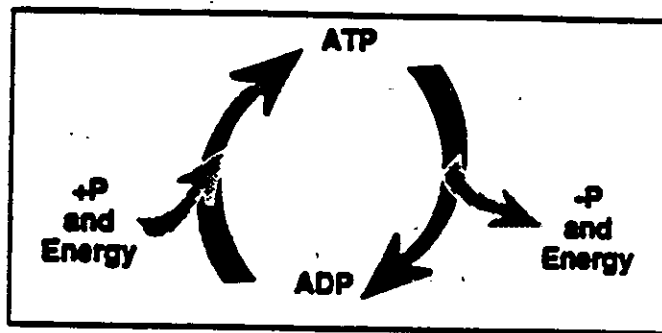
(pp. 109-110)

Coenzymes and apoenzymes play an important role in enzyme function.

- Explain how the following help enzymes to function and give a specific example.
 - apoenzymes
 - coenzymes
 - vitamins

Energy Transfer in Cells

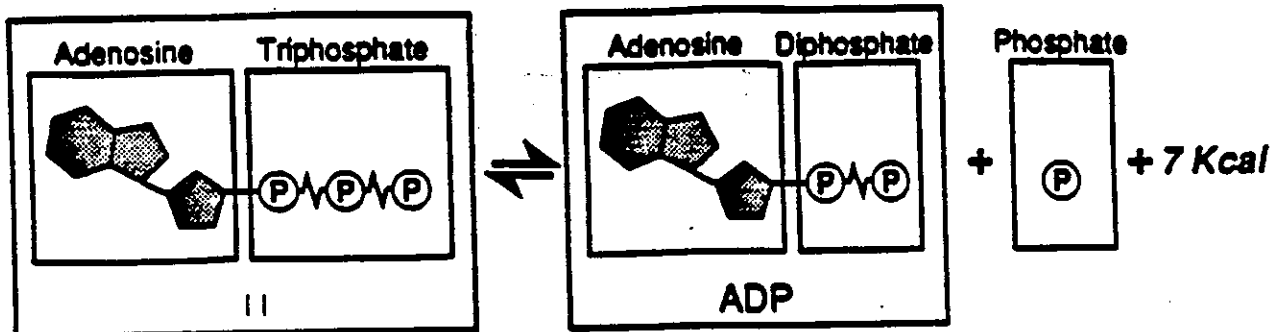
The energy "currency" of a cell is ATP. In order to follow the energy processes in cells, we need an understanding of ATP and NAD.



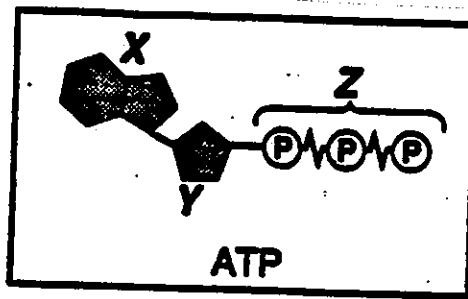
ATP

(p. 41.)

In cells, chemical energy is removed from carbohydrates like glucose and temporarily stored as high energy phosphates in a nucleotide called *adenosine triphosphate* or ATP. Above is a diagram illustrating how the cell mitochondria removes the chemical energy from glucose and transfers it temporarily to ATP. After reading about ATP in the textbook, look at the diagram of the ATP cycle above and answer the following questions:



1. Write the full name of ATP.
2. What type of compound is ATP?
3. What supplies ATP with its energy?
4. What is occurring when:
 - a. ADP is converted to ATP?
 - b. ATP is converted to ADP?



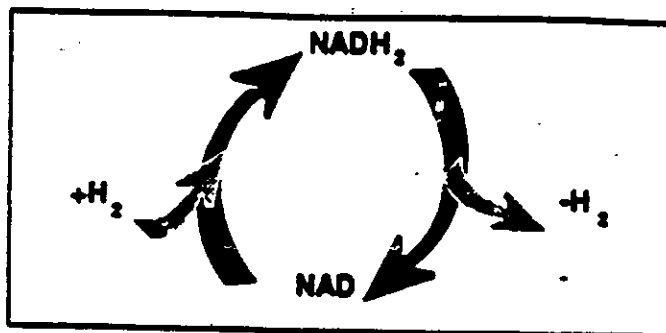
5. Look at the diagram of ATP above. Identify the labeled parts.

X _____

Y _____

Z _____

6. Explain the role that ATP plays in cell metabolism. List your main points.



NAD

1. When glucose is broken down in cell respiration to produce energy, hydrogen atoms are removed. These hydrogen atoms contain high energy electrons that are used by the mitochondria to generate ATP. The diagram above illustrates the removal of hydrogen atoms and the transfer of them to another compound, the process is called *oxidation-reduction*. (p. 110)

Define the following terms:

a. oxidation

b. reduction

2. Refer to the diagram above, illustrating the NAD cycle.

a. What is occurring at +H₂?

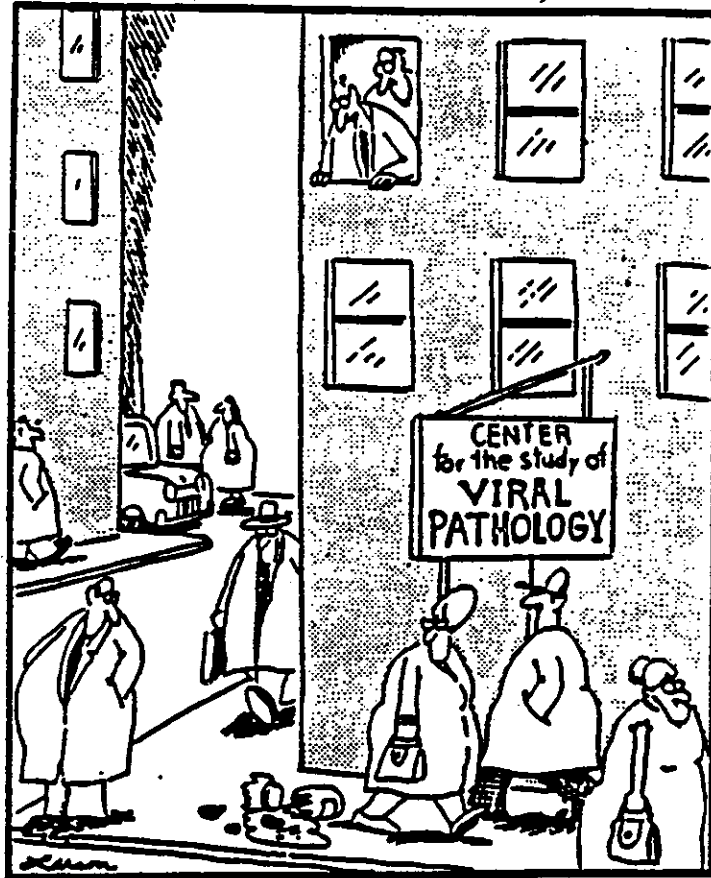
b. What is occurring at -H₂?

- c. What is the difference between NAD and NADH₂?
- d. What of compound is NAD?
- e. What is the role of NADH₂ in cell respiration?

Sample Exam Questions

1. Explain how the following factors affect enzyme catalyzed reactions:
 - a. temperature
 - b. pH
 - c. concentration of substrate
 - d. concentration of enzyme
2. Compare and contrast yeast and animal fermentation.
3. Explain the role of the following in cell respiration:
 - a. oxygen
 - b. ATP
 - c. NADH₂
 - d. FADH₂
 - e. oxaloacetic acid
 - f. citric acid
 - g. pyruvic acid
 - h. respiratory chain
4. Explain what would happen to cell respiration when an animal cell runs out of oxygen.

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"Uh-oh."