Grade 10 NTI Day #8 Biology

Assignment: Please read the excerpt below as an independent reading assignment. Then read and answer the questions below the excerpt.

LESSON 2.4

Chemical Reactions and Enzymes

KEY QUESTIONS

- *What happens to chemical bonds during chemical reactions?*
- *How do energy changes affect whether a chemical reaction will occur?*
- *What role do enzymes play in living things, and what affects their function?*

HS-LS1-6: Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.

VOCABULARY

chemical reaction
reactant
product
activation energy
catalyst
enzyme
substrate

READING TOOL

As you read the lesson, complete the concept map in your **Biology Foundations Workbook** that shows the relationship between vocabulary terms.

Living things are made up of chemical compounds—some simple and some complex. But chemistry isn't just what life is made of—chemistry is also what life does. Everything that happens in an organism—its growth, its interaction with the environment, its reproduction, and even its movement—is based on chemical reactions. Even the twinkle of a firefly's body comes from a chemical reaction.

Chemical Reactions

A **chemical reaction** is a process that changes, or transforms, one set of compounds into another. An important scientific principle is that mass and energy are conserved during chemical transformations. This is also true for chemical reactions that occur in living organisms. Some chemical reactions occur slowly, such as the combination of iron and oxygen to form an iron oxide called rust. Other reactions occur quickly. The elements or compounds that engage in a chemical reaction are known as **reactants**. The elements or compounds produced by a chemical reaction are known as **products**. ***Chemical reactions involve changes in the chemical bonds that join atoms in compounds.***

Energy in Reactions

Energy is released or absorbed whenever chemical bonds are formed or broken. This means that chemical reactions also involve changes in energy. Some chemical reactions release energy, and other reactions absorb energy. Energy changes are one of the most important factors in determining whether a chemical reaction will occur. ***Chemical reactions that release energy often occur on their own, or spontaneously. Chemical reactions that absorb energy require a source of energy.***

An example of an energy-releasing reaction is the burning of hydrogen gas, in which hydrogen reacts with oxygen to produce water vapor.

$$2H_2 + O_2 \rightarrow 2H_2O$$

The energy is released in the form of heat, and sometimes—when hydrogen gas explodes—as light and sound.

The reverse reaction, in which water is changed into hydrogen and oxygen gas, absorbs so much energy that it generally doesn't occur by itself. In fact, the only practical way to reverse the reaction is to pass an electrical current through water. Thus, in one direction the reaction releases energy, and in the other direction the reaction requires energy.

Figure 2-21
Chemical Reactions

Burning is a type of chemical reaction that releases energy. When wood burns it releases energy in the form of heat and light.

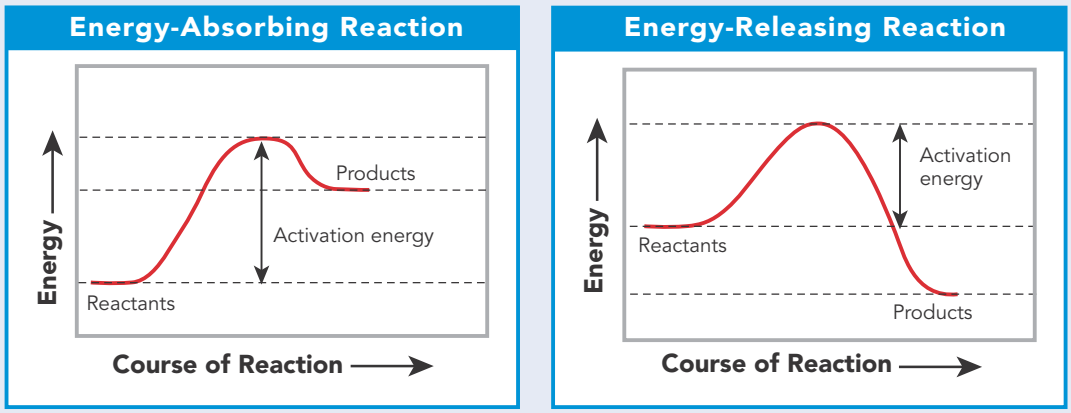
Energy Sources In order to stay alive, organisms need to carry out reactions that require energy. Because matter and energy are conserved in chemical reactions, every organism must have a source of energy to carry out chemical reactions. Plants get that energy by trapping and storing the energy from sunlight in energy-rich compounds. Animals consume plants or other animals for food. Then chemical reactions break apart the food and capture its energy.

Activation Energy Chemical reactions that release energy do not always occur spontaneously. Otherwise, the pages of a book might burst into flames without warning. The cellulose in paper burns only if you light it with a flame, which supplies enough energy to get the reaction started. The energy that is needed to get a reaction started is called its **activation energy**. As **Figure 2-22** shows, activation energy is involved in chemical reactions regardless of whether the overall chemical reaction releases energy or absorbs energy.

READING CHECK **Interpret Graphs** Look at **Figure 2-22**. How does the energy of the reactants and products differ between an energy-absorbing reaction and an energy-releasing reaction?

Figure 2-22
Activation Energy

The peak of each graph represents the energy needed for the reaction to go forward. The difference between this required energy and the energy of the reactants is the activation energy.



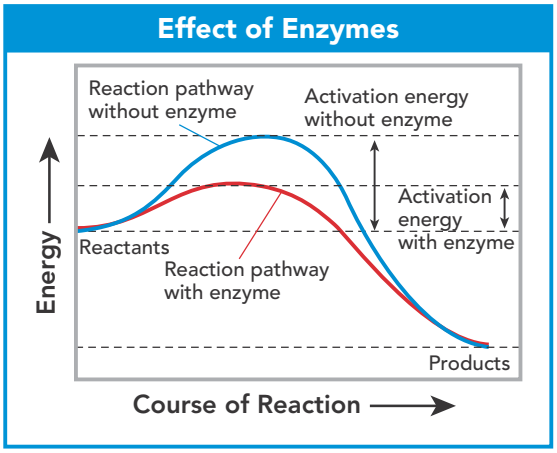
INTERACTIVITY

Investigate the changes to matter and energy in an enzyme-catalyzed reaction.

Figure 2-23

Effect of Enzymes

Notice how the addition of an enzyme lowers the activation energy in this reaction. The enzyme speeds up the reaction.

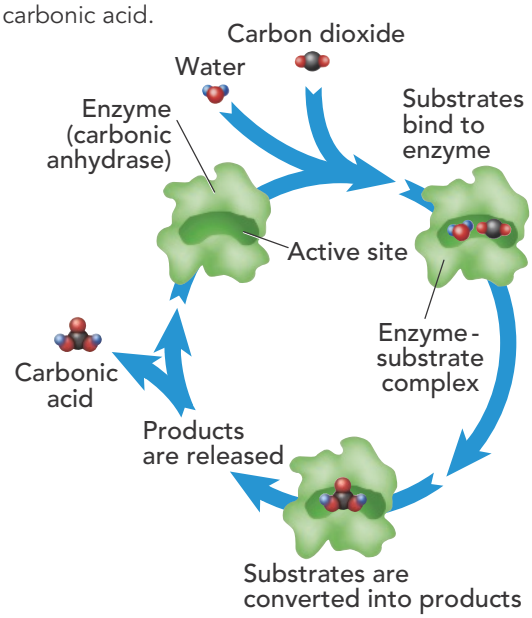


ANIMATION

Figure 2-24

An Enzyme-Catalyzed Reaction

Carbonic anhydrase binds both substrates: carbon dioxide and water. The substrates react to form carbonic acid.



Enzymes

Some chemical reactions that are essential to life would happen so slowly or require such high activation energies that they could never take place on their own. These chemical reactions are made possible by a process that would make any chemist proud—by catalysts made by living cells. A **catalyst** is a substance that speeds up the rate of a chemical reaction without being consumed by the reaction. Catalysts work by lowering a reaction's activation energy.

Nature's Catalysts **Enzymes** are biological catalysts, and most enzymes are proteins. ***The role of enzymes is to speed up chemical reactions that take place in cells.*** Like other catalysts, enzymes act by lowering activation energies, as illustrated by the graph in **Figure 2-23**. Lowering the activation energy has a dramatic effect on how quickly the reaction is completed. How big an effect does it have? Consider the reaction in which carbon dioxide combines with water to produce carbonic acid, as shown in **Figure 2-24**.

Left to itself, this reaction is so slow that carbon dioxide might build up in the body faster than the bloodstream could remove it. Fortunately, the bloodstream contains an enzyme called carbonic anhydrase that speeds up the reaction by a factor of 10 million. With carbonic anhydrase, the reaction takes place immediately and carbon dioxide is removed from the blood quickly.

Enzymes are very specific, generally catalyzing only one chemical reaction. For this reason, part of an enzyme's name is usually derived from the reaction it catalyzes. Carbonic anhydrase gets its name because it also catalyzes the reverse reaction, which removes water from carbonic acid.

The Enzyme-Substrate Complex How do enzymes do their jobs? For a chemical reaction to occur, the reactants must collide with each other with sufficient energy that existing bonds will be broken and new bonds will be formed. If the reactants do not have enough energy, they will be unchanged after the collision.

Enzymes provide a site where reactants can be brought together, reducing the energy needed for the reaction. The reactants of enzyme-catalyzed reactions are known as **substrates**. In the reaction catalyzed by carbonic anhydrase, the substrates are water and carbon dioxide.

HS-LS1-6

Exploration Lab Open-Ended Inquiry

Temperature and Enzymes

Problem How does temperature affect the rate of an enzyme-catalyzed reaction?

Cells must regulate their content of hydrogen peroxide (H_2O_2), a chemical that helps fight infections but can be harmful in high concentrations. Catalase is the enzyme that catalyzes the breakup of hydrogen peroxide into water and oxygen. In this lab, you will investigate how temperature affects the function of catalase.

You can find this lab in your digital course.

The substrates bind to a site on the enzyme called the active site. The active site and the substrates have complementary shapes, and they may be held together by weak interactions such as hydrogen bonds and van der Waals forces. The fit is so precise that the active site and substrates are often compared to a lock and key. You can even think of the catalyst as being the key that turns on a chemical reaction machine, allowing products to be created much faster than they would be without the catalyst.

Regulation of Enzyme Activity Enzymes play essential roles in chemical pathways, making materials that cells need, releasing energy, and transferring information. Because the activity of an enzyme depends upon the structure of its active site, conditions that tend to change protein structure can affect enzyme activity. These conditions include high temperature and extreme pH, which may weaken hydrogen bonds, causing proteins to unfold and disrupting active site structure.

Not surprisingly, the enzymes produced by human cells generally work best at temperatures close to 37°C, the normal temperature of the human body. Similarly, the stomach enzyme pepsin, which acts on food in the stomach, works best under acidic conditions. In addition, the activities of most enzymes are regulated by molecules that carry chemical signals within cells, switching enzymes "on" or "off" as needed.

INTERACTIVITY

Explore enzymes and the variables that affect them.

Name _____ Class _____ Date _____

Lesson Quiz

2.4 Chemical Reactions and Enzymes

Directions

For multiple choice questions, write the letter that best answers the question or completes the statement on the line provided. For other question types, follow the directions provided.

1. Write the word or phrase from the word bank to complete the sentences.

activation energy	catalyst	enzymes	products	reactants

Chemical reactions convert _____ to _____. In nonliving systems, the presence of a(n) _____ allows the reaction to proceed very quickly and have a lower _____. In living systems, this function is carried out by proteins called _____.

_____ **2.** Mark argues that proteins within the body have two functions: structure and transport. Sara disagrees. Which significant function of proteins did Mark omit from his list?

a. Proteins increase the speed of reactions in the body.
b. Proteins store energy that can be released when the body needs it.
c. Proteins form waxy, waterproof coverings.
d. Proteins store genetic information within cells.

_____ **3.** Enzymes are able to increase the speed of a reaction because they accomplish which of these tasks?

a. They alter the net energy change of reaction.
b. They decrease the activation energy.
c. They absorb energy from the reactants.
d. They absorb energy from the products.

Name _____ Class _____ Date _____

_____ **4.** Your assignment in biology lab is to design an experiment that would detect whether the enzyme pepsin is breaking down a protein. In the human body, pepsin works in the stomach. Which of the following experimental designs would be your best choice?

a. Test tube A: Water and egg white
Test tube B: Water, egg white, and pepsin.
Procedure: Test the pH of both tubes at the same temperatures for consistency.

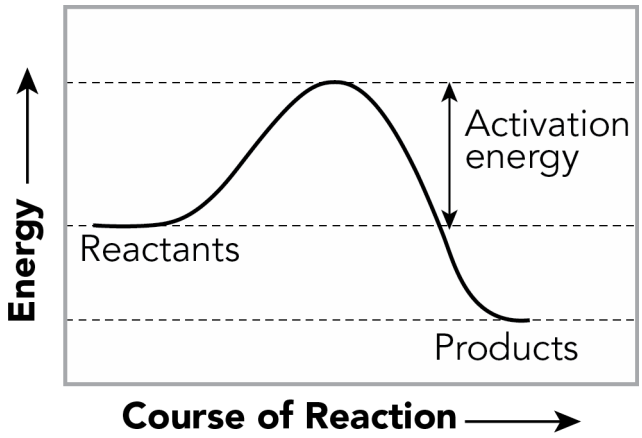
b. Test tube A: Water and soy protein
Test tube B: Water, egg white, and pepsin
Test tube C: Water, egg white, acid, pepsin
Procedure: Observe each test tube for changes in the protein every 15 minutes.

c. Test tube A: Water and egg white
Test tube B: Water, egg white, weak acid, and pepsin
Test tube C: Water, egg white, strong acid, and pepsin
Procedure: Record the mass of the egg white in each test tube before you begin. Measure the egg whites every 15 minutes.

d. Test tube A: Water and egg white
Test tube B: Water, egg white, weak base, and pepsin
Test tube C: Water, egg white, strong base, and pepsin
Procedure: Record the mass of the egg white in each test tube before you begin. Measure the egg whites every 15 minutes.

Name _____ Class _____ Date _____

_____ **5.** Study the graph.



Based on the information in the graph, choose the statement that best describes the reaction that the graph represents.

a. The reaction absorbs energy.
b. The reaction releases energy.
c. The reaction fails to proceed because of insufficient energy.
d. The reaction fails to proceed because it does not involve an energy change.