Name:____________________________________ Block:_____________ Date:________________________

PACKET #7

## Unit 3: Energy Transfer, Part I: Energy and Enzymes

***Reading***: *Chapter 2, section 3, Chapter 4, section 1*

### *Topic 1: Energy and ATP (4.1)*

1. Discuss why organisms need energy and how they obtain it.
2. Describe energy flow through an ecosystem.
3. Draw an ATP molecule and explain how ATP stores and releases energy.
4. Explain why ATP is referred to as the "Energy Currency" of the cell.
5. Summarize the importance of ATP in cellular energy transfer.

### *Topic 2: Chemical Reactions and Enzymes (2.3)*

6. Explain how chemical reactions affect chemical bonds in reactions.
7. Define and relate the terms: activation energy, catalyst, enzyme, substrate.
8. Describe how enzymes work affect how easily a chemical reaction will occur.
9. Explain how and why enzymes can be affected by factors such as temperature and pH.

***Vocabulary:***

| | | | | |
|---|---|---|---|---|
| Metabolism | Exergonic reaction | Catalysts | Substrate | ATP |
| Endergonic reaction | Activation energy | Enzymes | Active Site | Denaturation |
| Food Web | Trophic Level | | | |

# Chapter 2-8: Energy Flow in Living Things

The total amount of energy that exists in the universe remains constant, but energy can change from one form to another. For example, the chemical energy in gasoline can be released and transformed into heat energy and the energy of motion.

This type of transformation of energy occurs in many of the processes that take place in living things. In this plate, we will examine the flow of energy through living things and identify the molecule that serves as the main energy source in all life processes.

> This plate shows how energy exists in different forms at different times in living things. As you encounter the terms, color the appropriate structures in the diagram.

All of the energy on the Earth comes from the **sun (A)**; the **sun's energy ($A_1$)** is what drives chemical reactions and the processes of life. This solar energy is trapped in a photosynthesizing organelle of the plant called the **chloroplast (B)**; we discuss this organelle in detail later in the book.

A number of chemical reactions take place in the chloroplast to transform solar energy into chemical energy. **Carbon dioxide (C)** and **water (D)** are necessary for the process of **photosynthesis (E)**, and the products of photosynthesis include **carbohydrates (F)**, which are represented by a candy bar, and molecular **oxygen (G)**. The bonds of the carbohydrates now contain some of the sun's energy; photosynthesis has transformed the sun's energy into the chemical energy of the carbohydrate. Oxygen is given off as a waste product of photosynthesis, and it is expelled from the plant cell into the atmosphere.

> Having explained how the sun's energy is converted to the chemical energy found in carbohydrates, we will now discuss another transformation of energy. Continue your reading below, and focus on the right side of the diagram as we continue to study energy flow in living things.

Plants, humans, and many other living things use carbohydrates as their essential source of energy. Carbohydrates are transported to an organelle called the **mitochondrion (H)**, where they are combined with oxygen molecules in the process of **respiration (I)**, illustrated by the arrow. During chemical reactions in the mitochondrion, the energy from carbohydrates is released and used to form the energy-rich molecule **adenosine triphosphate (J)**. (Adenosine triphosphate is commonly abbreviated as ATP.) Carbon dioxide and water are byproducts of respiration; notice that they are both essential for photosynthesis. To summarize, the energy of the sun is first transformed into the energy of carbohydrates and then into the energy in the ATP molecule.

> We will conclude with a brief examination of the ATP molecule. Recall that the energy of the ATP molecule comes from the sun. As you read, color the appropriate structures in the diagram.

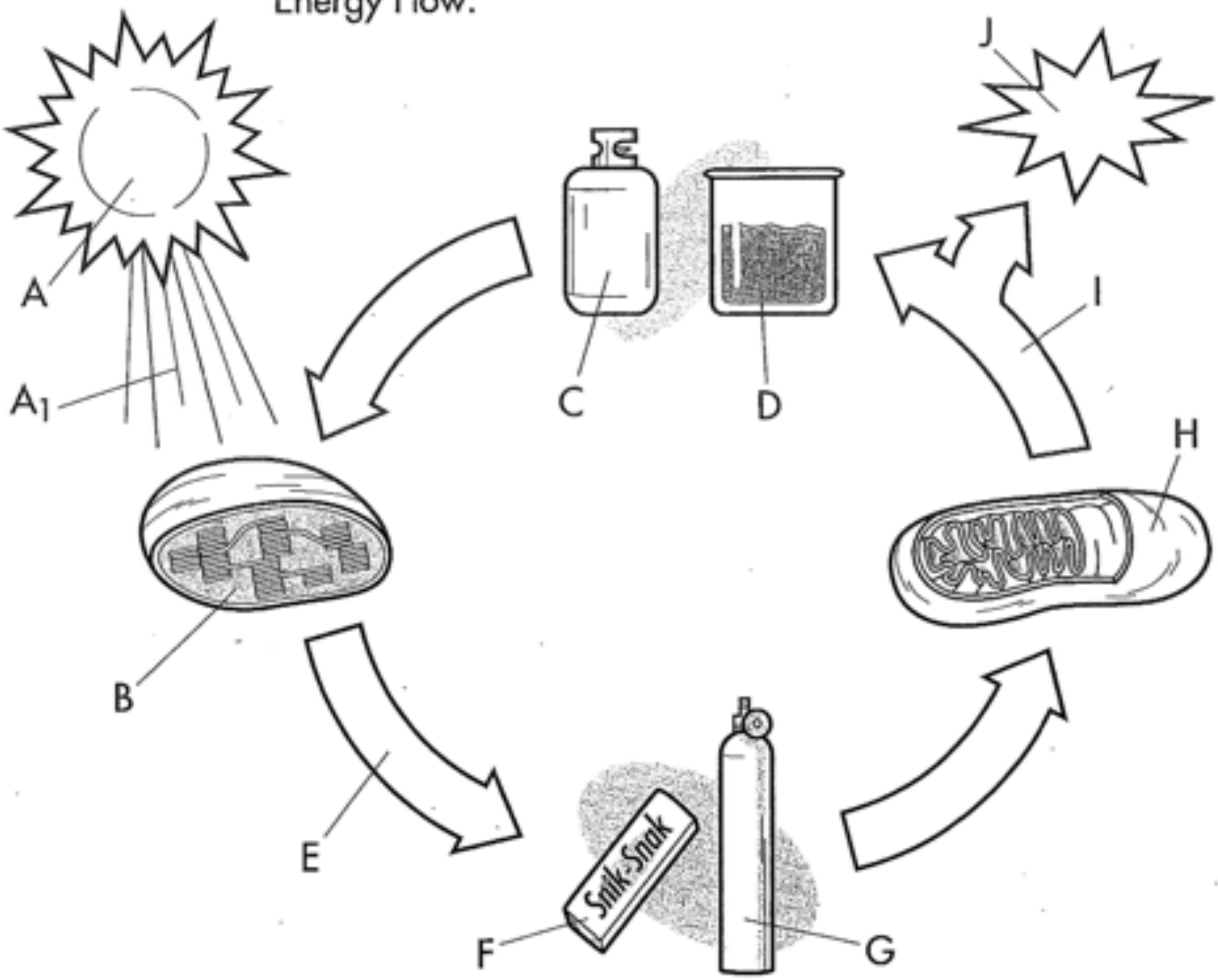
The adenosine triphosphate (ATP) molecule (J) is shown at the bottom of the plate. You should use a light shade to color the interior of the box, and darker colors should be used for the components of ATP. These components include an **adenine molecule ($J_1$)** and a **ribose molecule ($J_2$)**. Adenine is one of the four nitrogenous bases found in DNA and RNA, and ribose is a five-carbon carbohydrate. Attached to the ribose molecule are three **phosphate groups ($J_3$)**.

Living things use energy in the form of ATP, breaking it down into **adenosine diphosphate (K)** and an inorganic phosphate group. Adenosine diphosphate (ADP) contains adenine ($J_1$) and a ribose molecule ($J_2$), but only two phosphate groups ($J_3$). During this breakdown, seven kilocalories of energy are given off for use by the cell.

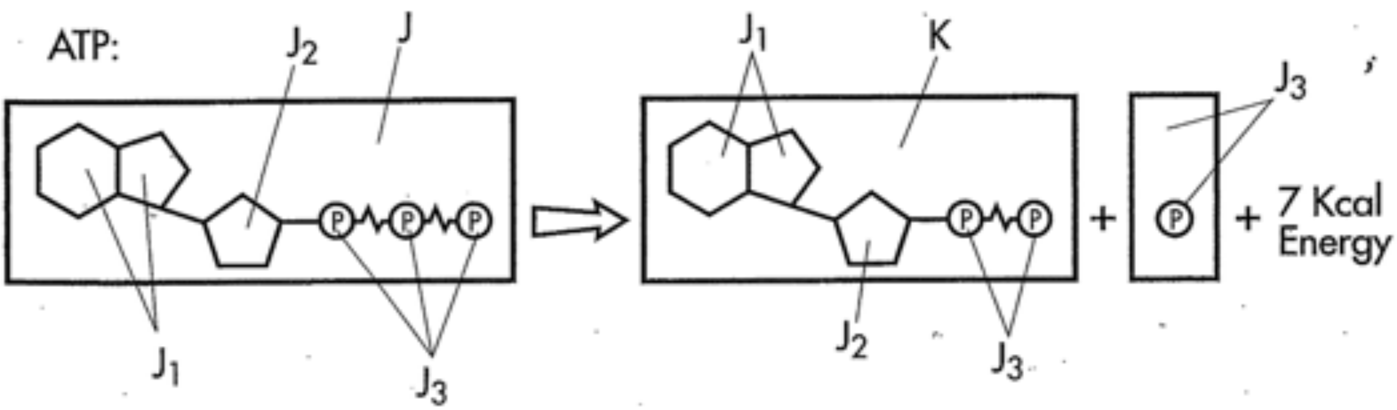
In the following plates, we will study the processes by which ATP is created, such as glycolysis, the Krebs cycle, electron transport, and chemiosmosis.

# Energy Flow in Living Things

Energy Flow:




ATP:

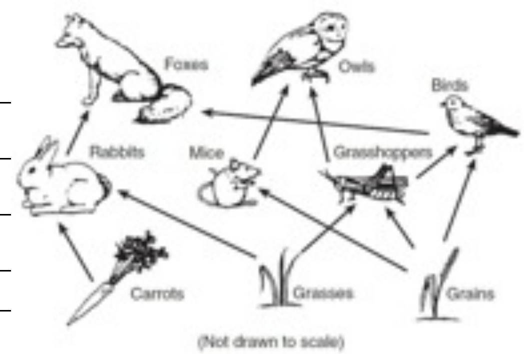



**Energy Flow in Living Things**

- ○ Sun .................A
- ○ Sun's Energy.........$A_1$
- ○ Chloroplast .........B
- ○ Carbon Dioxide.......C
- ○ Water ...............D
- ○ Photosynthesis........E
- ○ Carbohydrates ........F
- ○ Oxygen ...............G
- ○ Mitochondrion ........H
- ○ Respiration .........I
- ○ Adenosine Triphosphate..........J
  - ○ Adenine .........$J_1$
  - ○ Ribose ...........$J_2$
  - ○ Phosphate Groups ..$J_3$
- ○ Adenosine Diphosphate .........K

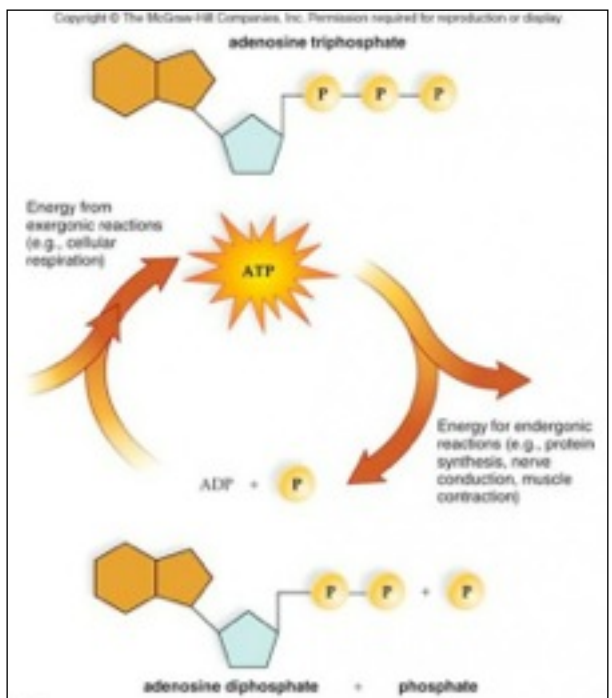
**Objective 1:** Discuss why organisms need energy and how they obtain it.

**Objective 2:** Describe energy flow through an ecosystem.




**Objective 3:** Label an ATP molecule and explain how ATP stores and releases energy.

**Figure 1: ATP-ADP Cycle**



**Objective 4:** Explain why ATP is referred to "the energy currency" of the cell.

**Objective 5:** Summarize the importance of ATP in cellular energy transfer.

**ATP-ADP Cycle Questions:**

1. What is the structural difference between ATP and ADP?

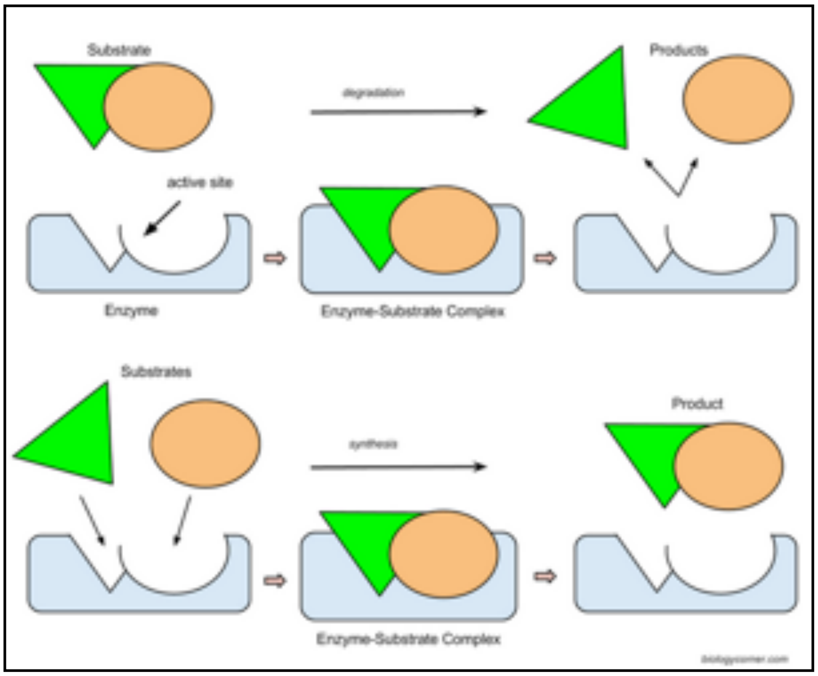
2. Which molecules are contained in both ATP and ADP?

3. In which structure, ATP or ADP, is more energy stored? Where is the energy stored?

4. Why is this considered a cycle?

**Objective 6:** Explain how chemical bonds are affected by chemical reactions.

**Figure 2:** Bonds are stressed or encouraged by enzymes

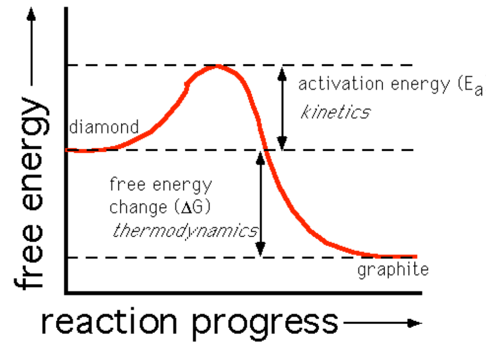



**Objective 7:** Define and relate the terms: activation energy, catalyst, enzyme, substrate.

**Enzyme Notes**

Reactions in the body (Objective 6)

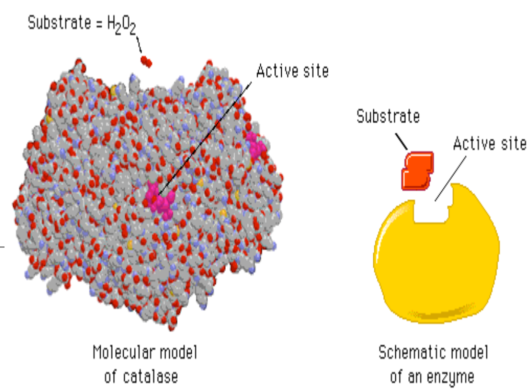
Catabolic (usually exergonic)




Anabolic (usually endergonic)

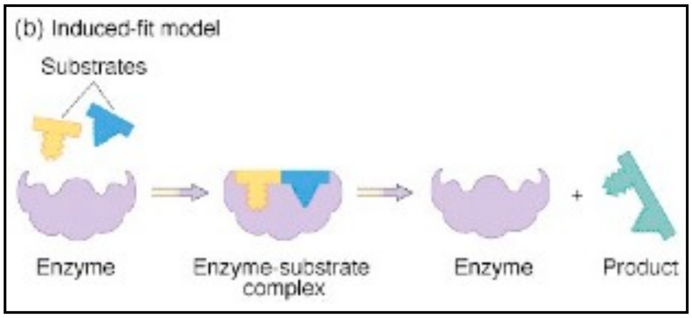
What are enzymes? (Objective 7)

What do enzymes do?




What do enzymes look like?

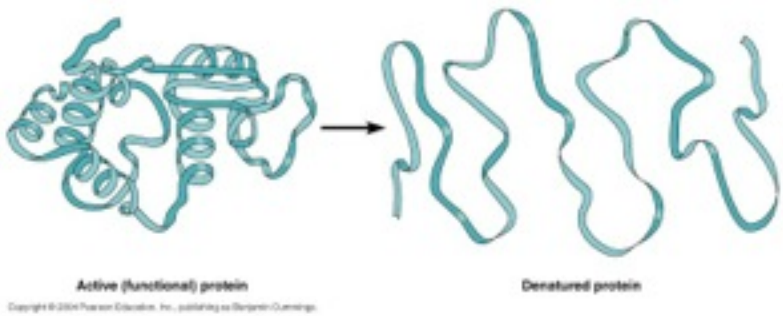
How do enzymes work? (Induced Fit Model) (Objective 8)




Enzyme/Substrate specificity:

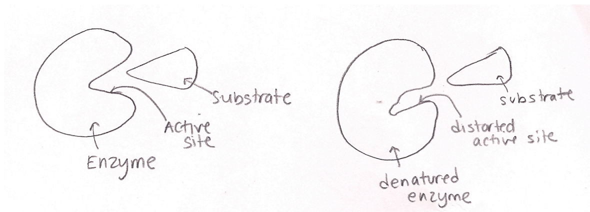
What affects enzyme function? (Objective 9)

Denaturation:

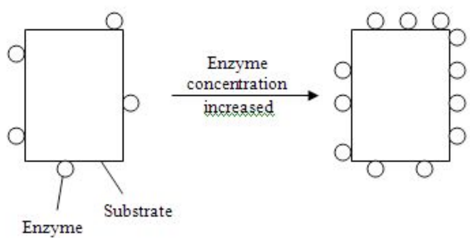



Temperature

pH




Enzyme concentration




Before you begin the activity, answer the following questions.

1. In the following equation, label the reactant(s), product(s), and enzyme(s):

$$\text{hydrogen peroxide} \xrightarrow{\text{catalase}} \text{water + oxygen}$$

2. Enzymes belong to which category of organic molecule?

3. What is the function of an enzyme?

4. What is activation energy?

5. What is a substrate?

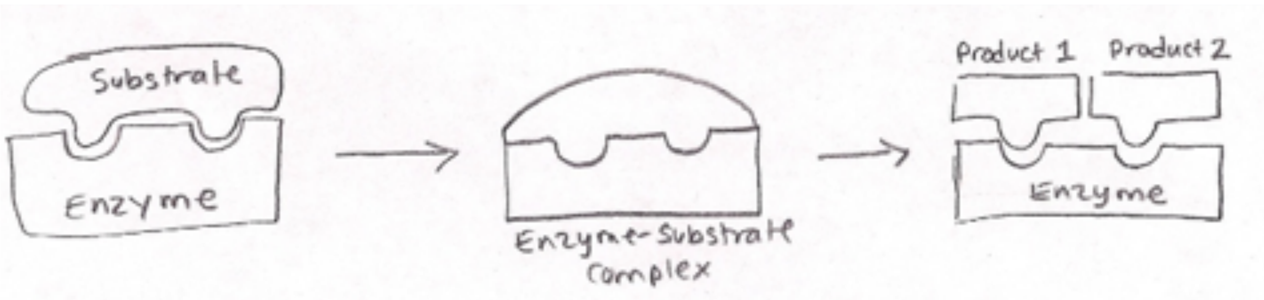
6. Where is the active site located?

7. What happens to the substrate during the induced fit process?

Part 2: Enzyme Investigation

In this activity, you will focus on modeling an example of a catabolic reaction where one substrate is broken down into two products. The general reaction for all reactions catalyzed by an enzyme is:

Enzyme + Substrate(s) → Enzyme-Substrate(s) Complex → Enzyme + Product(s)




This activity is designed to help you better understand how enzymes work. You will be working with a reaction that you have some experience with (from Journal 3-1), the hydrolysis of sucrose into glucose and fructose. The enzyme that catalyzes this reaction is sucrase. The enzyme reaction looks like this:

$$\text{Sucrose} \xrightarrow{\text{Sucrase}} \text{Glucose} + \text{Fructose}$$

(In reality, water is a necessary input, too. To simplify for this activity, we did not include it.)

Your job is to:

1. Label sucrose, sucrase, glucose, and fructose. (You have all the information you need to figure out what the reactant(s), product(s), and enzyme(s) are – either in the paragraphs above, or in your notes on the previous page ) Make sure that EVERY piece is properly labeled – for example, all "Enzyme" pieces should be labeled as the same thing – the enzyme doesn't change during the reaction.
2. Color or decorate the pieces so that all of the enzyme pieces look the same, all of the substrate pieces look the same, all of product 1 pieces look the same, and all of product 2 pieces look the same.
3. Cut out all the pieces from the attached page.
4. Arrange the pieces in a comic strip format on a piece of construction paper so that the above reaction is seen step-by-step. (HINT: There will be four steps total – refer to your notes on how enzymes work )
5. Before you glue down your pieces, get the teacher's approval
6. Number your steps or draw arrows to show how the reaction proceeds in your drawings.

**"Toothpickase" Enzyme Model**

The Object:
1. Try to break as many toothpicks in half as possible in two minutes.
2. Develop a model for enzyme activity.

The Rules:
1. Break toothpicks only one at a time.
2. Break toothpicks with two hands.
3. Break toothpicks completely in half.

The Game:
1. Spread toothpicks on table surface randomly.
2. When teacher instructs, begin breaking toothpicks.

| Time (seconds) | # of broken toothpicks | Class average |
|---|---|---|
| 0 | 0 | 0 |
| 10 | | |
| 30 | | |
| 60 | | |
| 120 | | |

3. You will stop and count the number of broken toothpicks at:
   - 10 seconds
   - 30 seconds
   - 60 seconds
   - 120 seconds

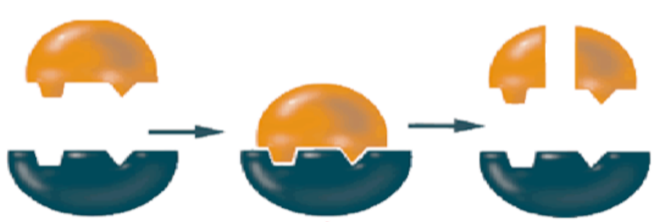
The Analysis: Answer the following questions with your lab group.
1. In this model, how did we represent the:
   A. Enzyme

   B. Substrate

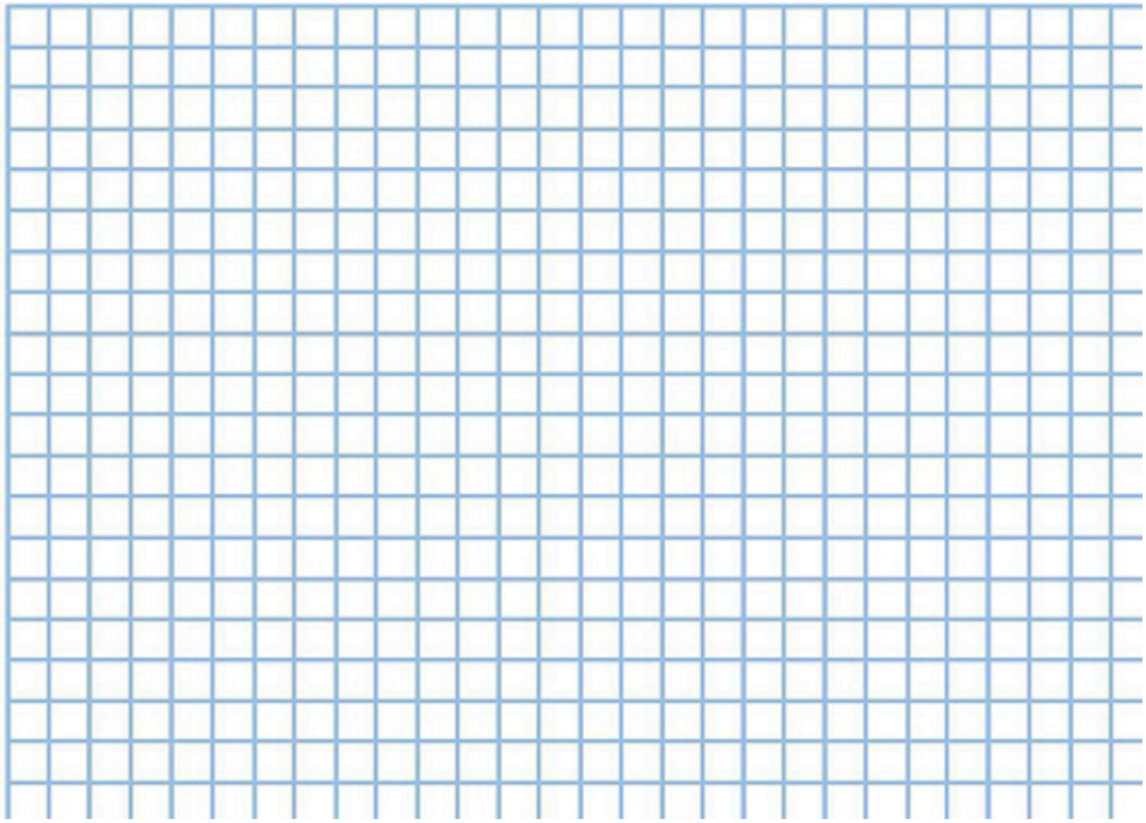
   C. Active Site

   D. Induced Fit Model

2. What changed during the reaction: enzyme, substrate, or both? Explain.



3. Create a graph of the class data.



4. Calculate the rate of this reaction. (#toothpicks/time)

A. From 0 – 30 seconds:

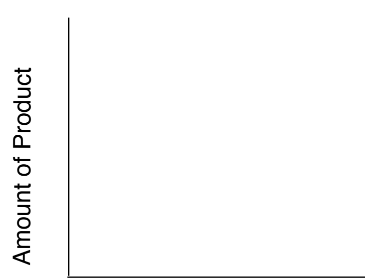
B. From 0 – 60 seconds:

C. From 60 – 120 seconds:

5. Did the rate of reaction remain constant? Why do you think this happened?

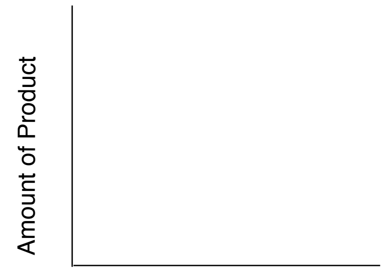
6. How could we use our "toothpickase" model to represent **doubling the substrate concentration** in an enzyme-catalyzed reaction?

6a. Sketch the graph you would expect to see:



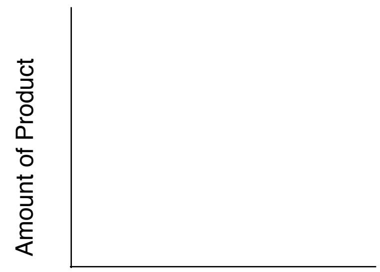
7. How could we use our “toothpickase” model to represent **doubling the enzyme concentration** in an enzyme-catalyzed reaction?

7a. Sketch the graph you would expect to see:

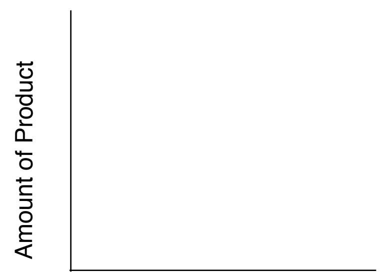



8. How could we use our “toothpickase” model to represent **decreasing the temperature** of an enzyme-catalyzed reaction?

8a. Sketch the graph you would expect to see:



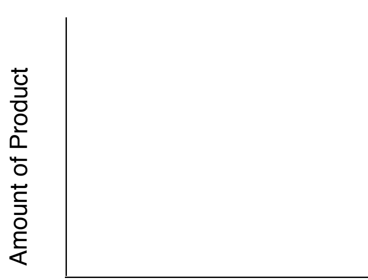

9. How could we use our “toothpickase” model to represent **denaturing the enzyme** in an enzyme-catalyzed reaction?

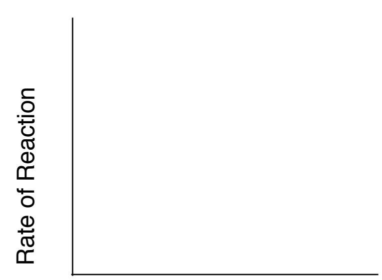



9a. Sketch the graph you would expect to see:

10. How could we use our “toothpickase” model to represent **enzymes saturated with substrate** in an enzyme-catalyzed reaction?

10a. Sketch the graphs you would expect to see:



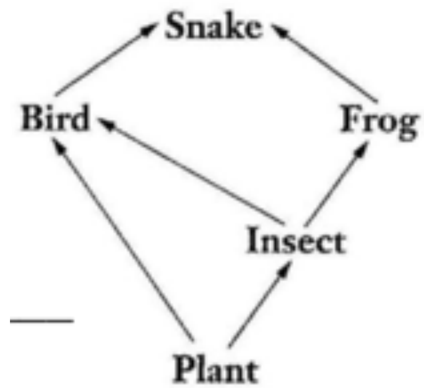
**Energy Practice problems**

Energy Transfer in an Ecosystem

**Part A –** Answer the questions using the diagram to the right.

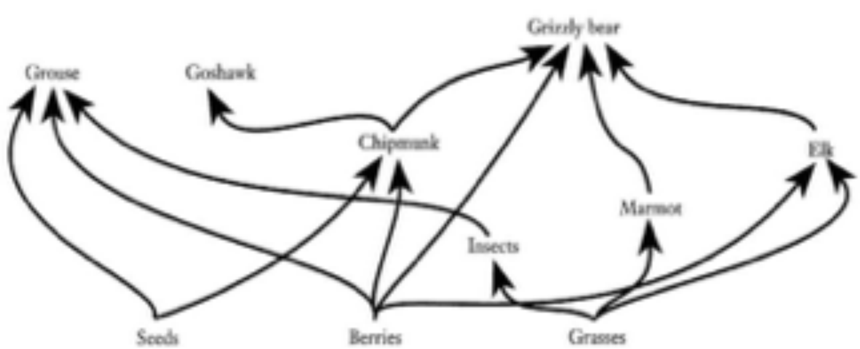
1. How many food chains make up the food web?
2. Which organism is an herbivore?

3. Which organism is an autotroph?
4. Which organism is an omnivore?
5. Which organism is a tertiary consumer?
6. Finish the web: Draw in arrows showing how the organisms on the diagram relate to the decomposer. Summarize your answer.




**Decomposer**

**Part B -** Use the food web below to fill in the table. List all organisms as autotrophs or heterotrophs in the first two columns. In the third columns, state whether each heterotroph is a primary, secondary, or tertiary consumer. (Note: If an organism fits into more than one category, list only the highest order.



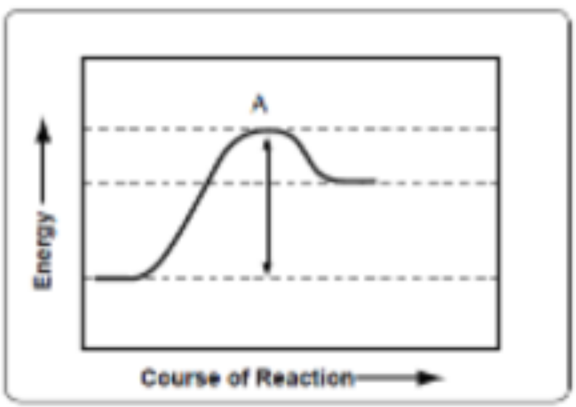

| Autotrophs | Heterotrophs | Type of Heterotroph |
|---|---|---|
| 10. | 13. | 20. |
| 11. | 14. | 21. |
| 12. | 15. | 22. |
| | 16. | 23. |
| | 17. | 24. |
| | 18. | 25. |
| | 19. | 26. |

1. During a chemical reaction, chemical bonds are _________________.
2. Biological catalysts, or enzymes, act by lowering the ____________________ required for a reaction.
3. The reactants of an enzyme-catalyzed reaction are known as ________________.
4. For (a) and (b), use the words to create a single sentence that describes their relationship:
   a. Catalyst, enzyme, activation energy

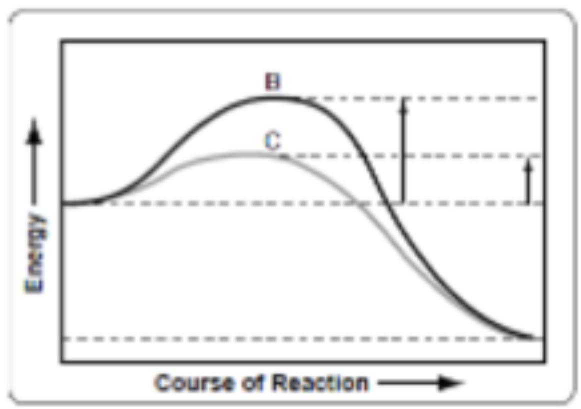
   b. Reactant, product, chemical reaction

Use the diagrams below to answer questions #5-7.

Graph I



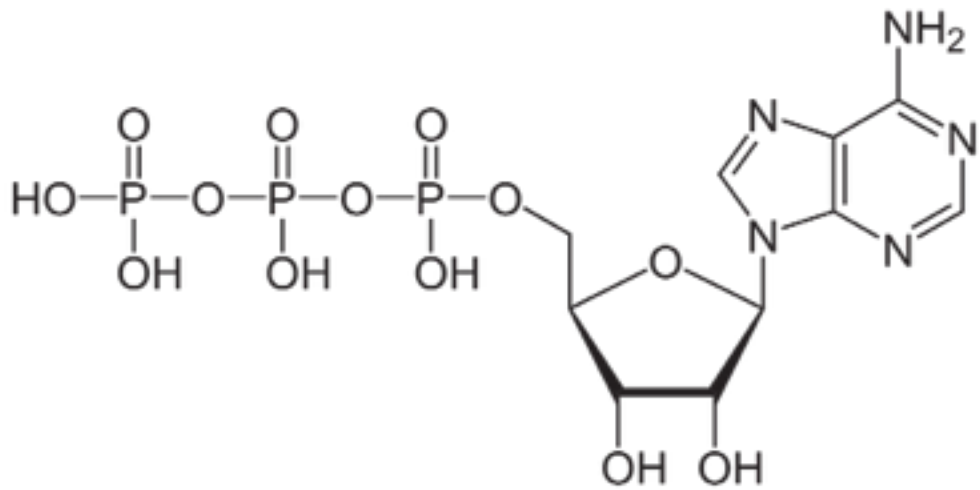

Graph II




5. Which pathway (A, B, or C) has the greatest activation energy? ______
6. Which graph (I or II) shows the reaction that absorbs energy? ______
7. Why are two pathways shows in the graph on the right? What does line C represent?

8. Challenge question: Most enzymes in the human body work best at 37°C. Imagine that scientists have discovered an enzyme in the body that works best at 39°C. What processes or functions might this enzyme be involved in?

9. The diagram below shows the structure of ATP.




a. Label the high-energy bonds.

b. Circle the portion of the molecule that makes up ADP.

c. ATP is a derivative of which type of monomer? ______________________

19. How does ATP enable the cell to store and transfer energy?

20. In which cellular organelle is ATP produced? _____________________

a. What is the name of the process by which ATP is produced? __________________