Name: ______________

Blk: ___ Date: ________

Marked by: ______________

Princeton Review: Enzymes

1. a) Another term for "enzyme": ________ ___________
   b) How many reactions does an enzyme catalyze? _______
   c) Therefore, how many types of enzyme must there be in a cell? ___________

2. What is the "energy of activation"?

3. a) What effect does the presence of enzymes have the energy of activation?

   b) What effect do they have on the speed at which reactants turn into products?

4. a) Define "biological catalyst":

   b) How do you know by the name that a molecule is an enzyme?
   c) Some examples: i) _________ acts on protein
      ii) __________ acts on lactose
      iii) Hydrolase catalyzes __________ ___________

5. Two facts about the active site:
   i)
   ii)

6. What is the term used for the reactant that matches a particular enzyme?

7. The steps involved in enzyme function:
   i) The reaction starts when the ___________ binds loosely to the active site.
   ii) This forms a (temporary) structure called the ________--_________ complex.
   iii) A _________ change occurs, forming two __________.
   iv) After they are formed, the products are released from the ________ _________.
   v) The enzyme, which is unchanged, is __________ for use in another reaction.

8. a) What occurs when an enzyme is denatured?
   b) What effect does this have on it?
   c) What two things can denature an enzyme? i) ii)

9. a) What is an inhibitor?

   b) How are they classified?
   c) In the diagram, where on the enzyme is the inhibitor binding?
   d) How does this stop the reaction?

ENZYMES

The chemical reactions that occur in the cells of living things take place in part because of the actions of biological catalysts called enzymes. Each type of enzyme catalyzes only one type of reaction, and since thousands of different kinds of reactions occur in cells, thousands of different enzymes exist. Almost all enzymes are proteins, so they are synthesized through the mechanism of protein synthesis discussed in Chapter 4. There are some RNA molecules with enzymatic activity; these are called **ribozymes.** The ribosome contains some ribozymes that help with peptide bond formation, and the process of gene splicing (where exons are kept and introns are deleted) also uses ribozymes. Both these processes will be reviewed in the plates on Protein Synthesis.

> In this plate we will examine the function of enzymes in chemical reactions. Our focus will initially be on how enzymes affect rates of reaction, and then we will turn to a study of enzyme activity. Take a look at the text below and color the appropriate structures.

Energy must be supplied in order for most cellular chemical reactions to proceed. The initial input of energy required to start a reaction is called the energy of activation. As is shown in the diagram entitled Enzyme Function, chemical **reactants (A)** can be converted into **products (B)** only after a substantial input of energy. Bold reds, greens, or blues should be used to color the arrows. Enzymes act to lower the activation energies of chemical reactions; in enzyme-catalyzed reactions, **reactants (C)** react more quickly to form **products (D)** because the activation energy of the reaction is far less. Dark colors should be used for these arrows.

> We will now discuss how enzymes lower the activation energy of chemical reactions.

An **enzyme (E)** is a biological catalyst that speeds up a chemical reaction without itself being consumed or altered. Enzymes' names can be easily recognized because they usually end in –ase. For example, the enzyme protease acts on protein, and lactase acts on lactose. Some enzymes are named specifically according to the type of reaction they catalyze. One example of this is synthetase, which catalyzes synthetic reactions; another is hydrolase, which catalyzes hydrolysis reactions.

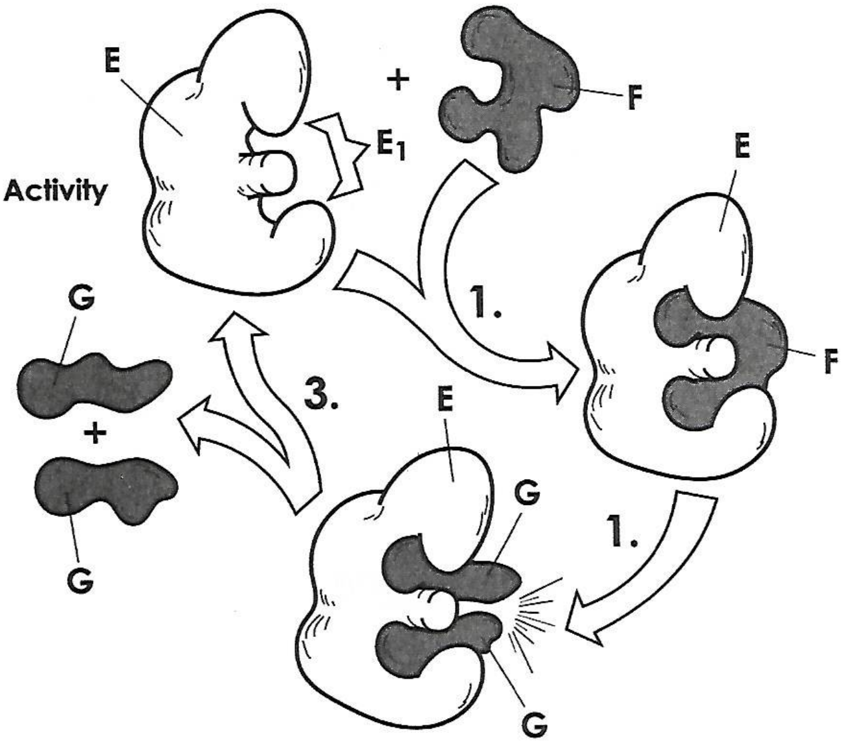
The key portion of the enzyme is the **active site (E_1).** The active site is the region in which reactants bind and, essentially, the region where the chemical reaction takes place. We will now describe one way that enzymes operate—enzymes can operate in several different ways to speed reactions. In this process, the reactant that binds loosely to the active site at the start of the reaction is called the **substrate (F).** In reaction 1, we see the enzyme and substrate combine at the active site. This reaction forms what is known as an enzyme-substrate complex. In reaction 2, a chemical change takes place at the active site and the result is the formation of two **products (G).** In reaction 3, the products are released from the active site and the enzyme is recycled for use in another reaction. For reactions in which there are two or more substrates, both bind loosely to the enzyme, which brings them close together. This allows them to react more quickly than they would otherwise, after which they are released.

> One way to remove an enzyme from a chemical system is to inhibit it. How inhibition takes place is the subject of the third diagram of the plate. Color the appropriate structures as you complete the plate.

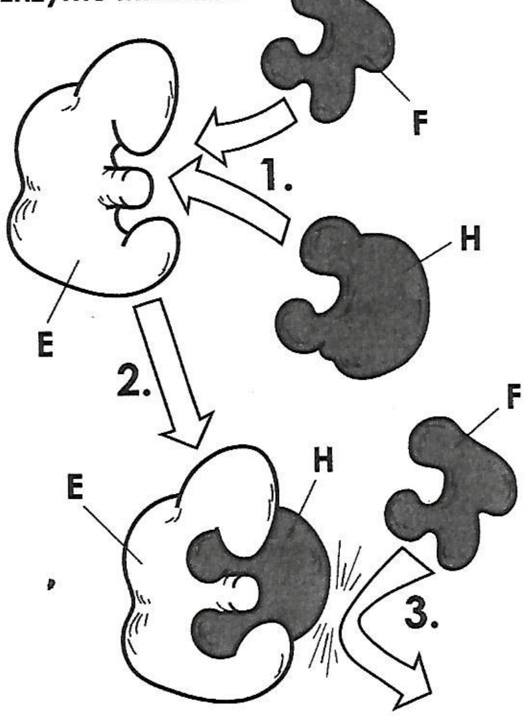
There are numerous ways in which enzymes can be inhibited. For example, heat can denature an enzyme, or change its structure, making it unable to bind to a substrate. Enzymes can also be denatured by acidic environments.

Many chemical substances interfere with the activity of enzymes by binding to them, and these are referred to as inhibitors. Inhibitors are classified by the way in which they bind to an enzyme. Notice that the enzyme (E) can react with the substrate (F) as well as with an **inhibitor (H).** In these cases, there is competition for the enzyme's active site. When large amounts of the inhibitor are present, it is more likely that the inhibitor, and not the substrate, will bind at the active site, as shown in chemical reaction 2. Once the inhibitor is blocking the active site, the substrate molecule cannot bind, as you can see in reaction 3, and no chemical reaction will occur.

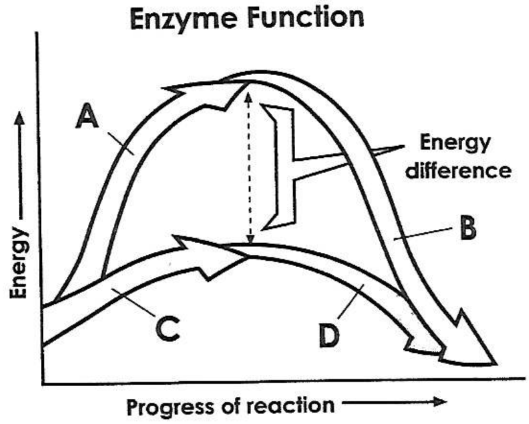
Enzyme Activity



Enzyme Inhibition



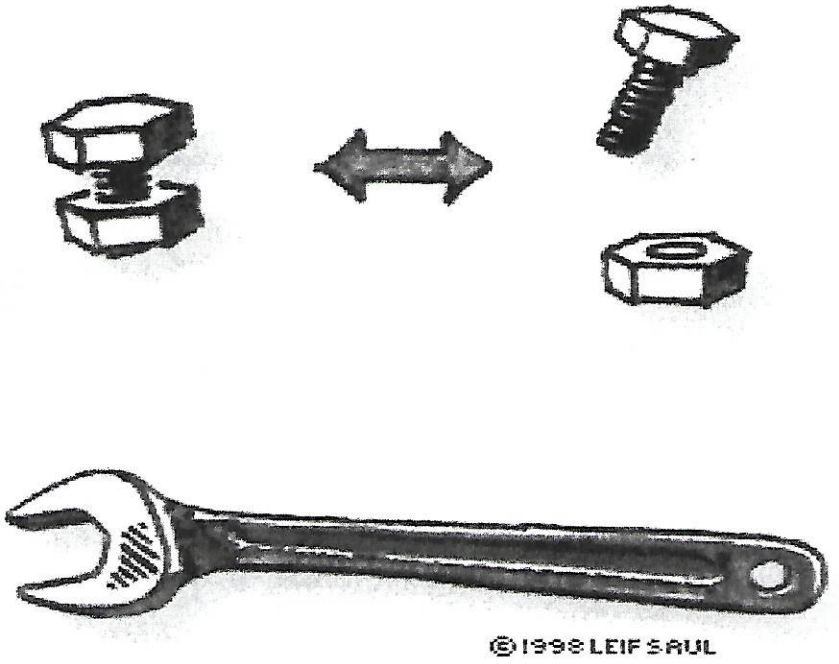
Enzyme Function



Reaction Without Enzyme
- Reactants A O
- Products B O

Reaction With Enzyme
- Reactants C O
- Products D O

- Enzyme E O
- Active Site E_1 O
- Substrate F O
- Products G O
- Inhibitor H O



Characteristics of Enzymes

Enzymes are proteins that speed up chemical reactions. Without enzymes, most chemical reactions would still occur, but they would happen much too slowly to sustain life. Because the body is essentially a "chemical processing plant," enzymes are crucial in every aspect of physiology. All enzymes have certain characteristics in common, which enable them to be effective. To illustrate these features, a fixed-size wrench is a useful metaphor.

First, enzymes are highly specific. Like a wrench that will only fit a 5/16-inch bolt, each enzyme generally works with only a particular kind of molecule.

Second, enzymes can speed up the same chemical reaction going in opposite directions. A wrench can either take things apart or put them together, depending on whether we begin with the parts already assembled or not. Similarly, an enzyme may ordinarily break a molecule into two pieces, but will put it back together again if it is provided only with the pieces.

Third, enzymes are unaffected by the reactions that they speed up. Just as a wrench remains the same after it has unscrewed thousands of bolts, so does an enzyme keep working for us after it completes a chemical reaction. This characteristic greatly increases the efficiency of enzymes, because they can be reused over and over again.