Enzyme NOTES

WHAT is an enzyme? HOW do they work?

THE BIG IDEA: An **ENZYME** is a **PROTEIN** that functions as a **catalyst** to **SPEED UP a CHEMICAL REACTION** in the body; it is NOT used up in the chemical reaction, rather it is recycled and used over and over again

All enzymes are **proteins**.

Enzymes are **biological catalyst.**

- Catalyst speed up reactions.
- These reactions would take place anyway… the enzymes just speed them up!

CHARACTERISTICS of Enzymes –

1. Enzymes do not make anything happen that couldn't happen on its own, just makes it happen faster.
2. Enzymes are **not used up** in reactions. They can be used over and over again!
3. Enzymes are only needed in **small amounts**.
4. Each enzyme is **highly selective** about its substrate.
5. Enzymes chemically recognize, bind and **modify substrates**.

HOW is an enzymes SHAPE related to its FUNCTION??

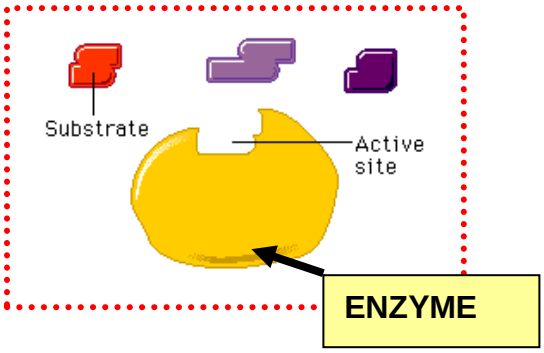
THE BIG IDEA: An **enzyme's STRUCTURE DETERMINES** its **FUNCTION**!!!!

1. Enzymes are **highly specific:** they catalyze only one chemical reaction, having a specific **substrate**. This specificity results from an enzyme's **specific 3-dimensional shape.**
2. The part of the enzyme that binds to the substrate is called the **active site**. The active site has a 3-dimensional shape that precisely **matches** the 3-dimensional shape of the molecule to be reacted, called the **substrate**.
3. When the substrate and enzyme bind temporarily, an **enzyme-substrate complex** is formed.
4. The activation **energy** needed for the reaction to occur is **reduced**.
5. After the reaction is complete, the substrate has formed a **new product or products** and the **enzyme** is released to be **reused.**
6. Enzyme specificity is often described using the "**lock-and-key**" model of enzyme action: The shape of the active site (the "lock") determines which substrate (which "key") will "fit" into the enzyme. If the substrate ("key") can't fit into the active site ("lock"), the enzyme cannot catalyze the chemical reaction
7. Remember these **key ideas**…
   a. The **SUBSTRATE** is the REACTANT in the chemical reaction that is catalyzed by the enzyme, the substance that is CHANGED
   b. The **ACTIVE SITE** is the region on the enzyme where the substrate attaches; the shape of the active site determines which substrates the enzyme can bind.
   c. **Imagine a KEY (the SUBSTRATE) fitting a LOCK (the ACTIVE SITE).**
   d. The **PRODUCT** is what you end up with after the chemical reaction has occurred.

ENZYME ACTION – can occur two ways:

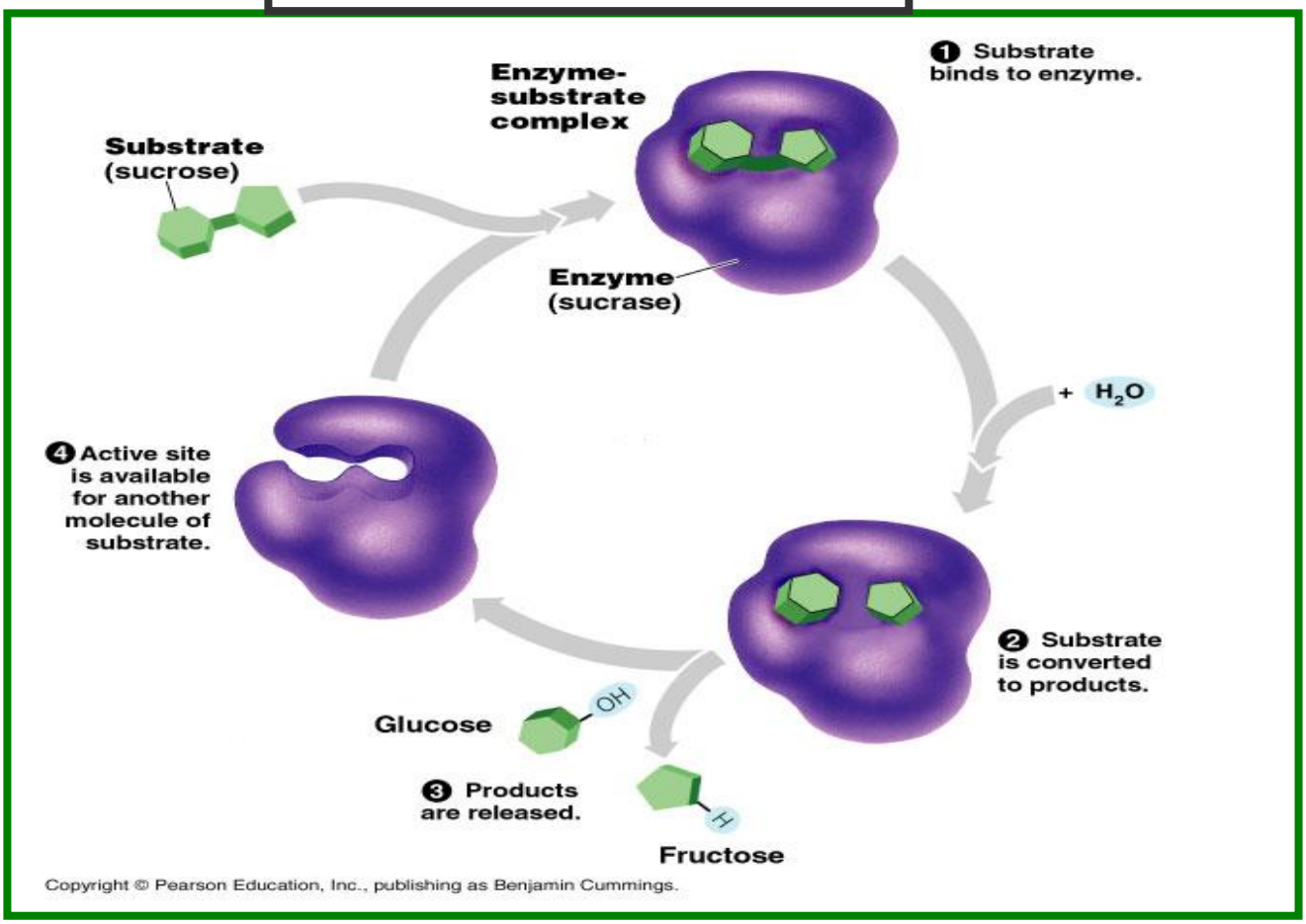
1. Lock and Key model – the substrate molecule has a specific 3-dimensional shape that allows it to fit into the specific 3-dimensional shape of an enzyme's active site. Both enzyme and substrate already exist in these specific 3-dimensional shapes.

2. Induced Fit model – An interaction between the enzyme and substrate induces or changes the shape of the molecules to produce a suitable fit.



Summary of a typical enzyme catalyzed chemical reaction:

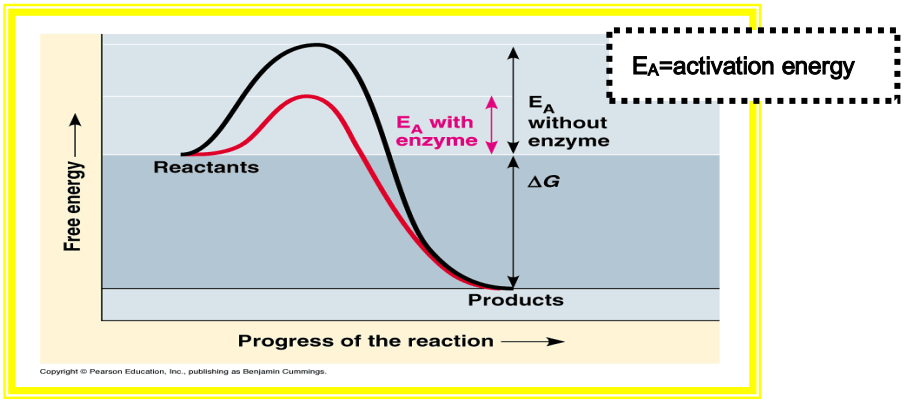
REACTANTS → PRODUCTS



HOW do enzymes CATALYZE chemical reactions??

Enzymes **speed up** the rate of chemical reactions by **lowering the activation energy** (the amount of energy needed to start the reaction).

Increase rate
Decrease energy



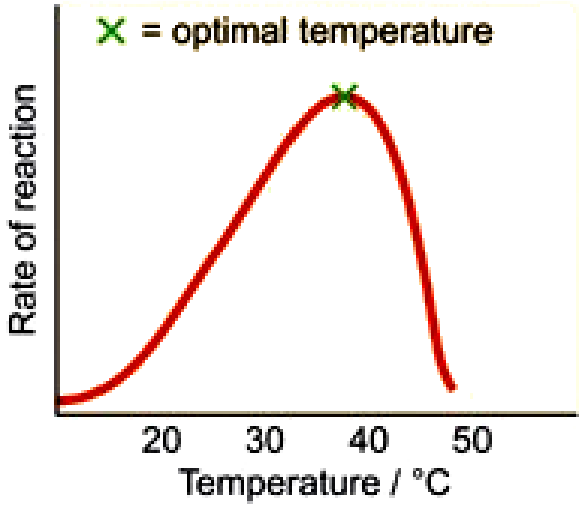
1. The binding of the **substrate** to the **active site** of the **enzyme**, applies a strain to the 3-dimensional shape of the substrate such that a specific chemical bond in the substrate is weakened.
2. Once this chemical bond is weakened, it is easier to break because it takes less work (less energy) to break the weakened bond.

What environmental FACTORS can affect an ENZYME'S FUNCTION?

1. **Temperature:**

THE BIG IDEA: Enzymes function optimally at certain temperatures.

a. As temperature increases, kinetic energy increases and molecules are moving more, increasing the likelihood that enzyme and substrate molecules will "bump into" each other, bind, and react. Therefore, initially enzyme reaction rate increases with an increase in temperature.



b. **BUT, if it gets TOO HOT, the enzyme becomes "DENATURED"** as the heat "cooks" the protein. Once it is denatured, the enzyme's 3-dimensional structure breaks down and it becomes misfolded. The enzyme's shape changes, therefore the 3-dimensional shape of its active site changes. Once the shape of the active site changes, it cannot bind to the substrate anymore and the enzyme cannot function anymore. Therefore, at higher temperatures the enzyme's reaction rate decreases sharply.

c. The **OPTIMAL TEMPERATURE** for an enzyme is the temperature at which the enzyme "works best," and the rate of chemical reaction is highest. The "optimal temperature" for most of the enzymes in YOUR body is ~98.6 degrees F (also known as ~37 degrees C).

d. **OVERALL TRENDS**
   - At extremely cold temperatures enzymes work slowly or not at all.
   - Warm temperatures generally increase relative rate (speed) of an enzyme.
   - Extremely high temperatures inactivate or "denature" the enzyme.

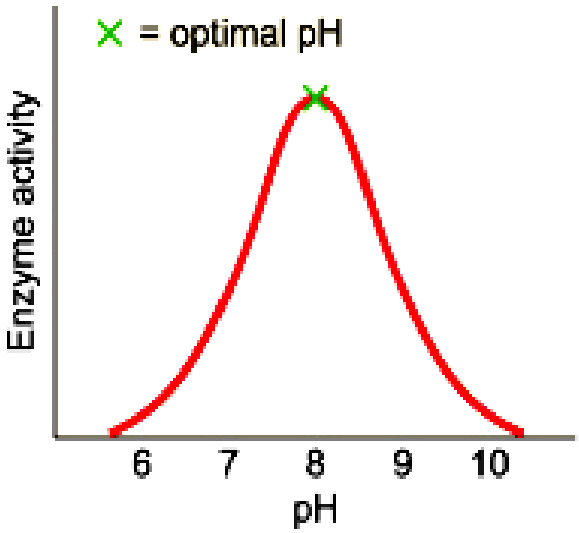
2. **pH (a measure of acidity)**

THE BIG IDEA: Enzymes function optimally at a certain pH.

a. Enzymes are extremely sensitive to changes in acidity.

b. Each enzyme works within quite a narrow pH range.

c. Changes in pH can make and break chemical bonds within the enzyme, changing the shape of the enzyme and, therefore, its effectiveness. **If the pH is too low (too acidic) or too high (too basic), the enzyme becomes "DENATURED":** The chemical bonds within the enzyme are rearranged and the enzyme becomes misfolded. As the enzyme's shape changes, the 3-dimensional shape of its active site changes, and the active site cannot bind to the substrate anymore. Thus, the enzyme cannot function anymore and the reaction rate decreases sharply.

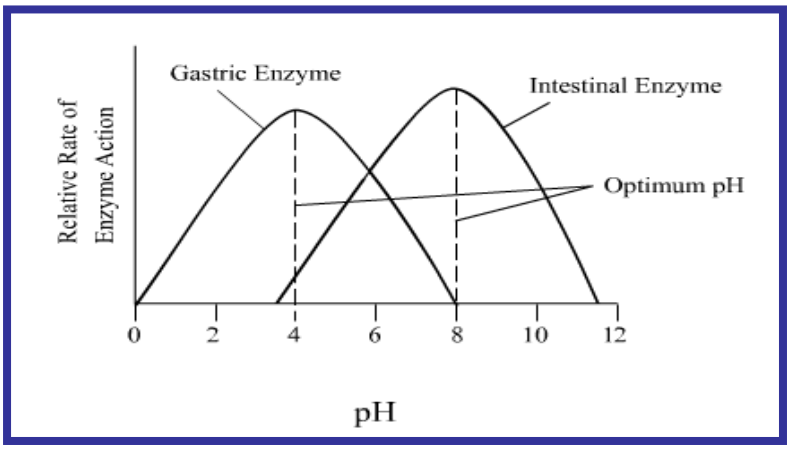


d. The **OPTIMAL pH** for an enzyme is the pH at which the enzyme "works best," and the rate of chemical reaction is highest.

e. The "optimal pH" for most of the enzymes in YOUR body is ~pH8.

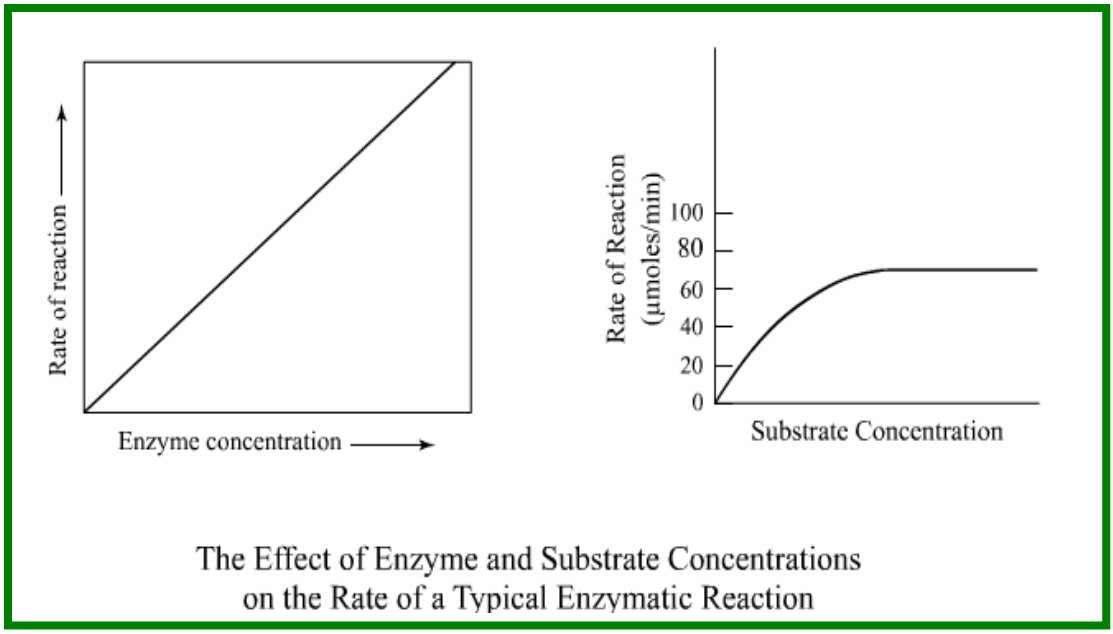
f. TRENDS:

- **Acidic pH:** <pH7
- **Neutral pH:** =pH7
- **Basic pH:** >pH7
- **OPTIMAL pH:** The pH at which the enzyme "works best," and the chemical reaction goes fastest
- The "optimal pH" for most of the enzymes in YOUR body is ~pH8
- **HOWEVER** there are exceptions, such as the digestive enzymes of your stomach, which function in an environment of **~pH3-4**!!!



3. **Concentration of Enzyme or Substrate**

THE BIG IDEAS: When enzyme concentration is low, the reaction is slower. As enzyme concentration increases, the reaction is faster **up to a point when the amount of substrate available becomes limiting**. Similarly, when substrate concentration is low, the reaction is slower. As substrate concentration increases, the reaction is faster **up to a point when the amount of enzyme available becomes limiting**.



The Effect of Enzyme and Substrate Concentrations on the Rate of a Typical Enzymatic Reaction