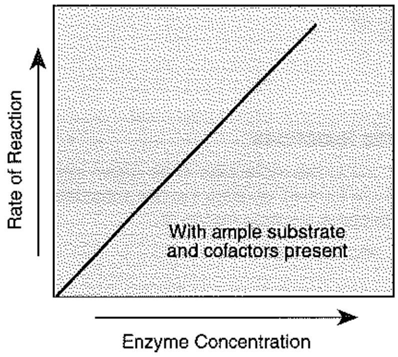
Enzyme Reaction Rates

Enzymes are sensitive molecules. They often have a narrow range of conditions under which they operate properly. At low temperatures there is little activity. As temperature is increased, so does the enzyme activity until the point is reached when the temperature is so high it damages the protein (**denaturation**). This causes the enzyme to stop working. Extremes in acidity can also cause the protein structure of enzymes to denature. Poisons often work by causing enzymes to cease functioning. Cofactors such as vitamins and trace elements are required for many enzymes to function.

In the four graphs below, the *rate of reaction* or degree of *enzyme activity* is plotted against each of four factors that affect enzyme performance. Answer the questions that relate to each graph:



1. **Enzyme Concentration**
   (a) Describe the change in the rate of reaction when the enzyme concentration is increased (assuming there is plenty of the substrate present):

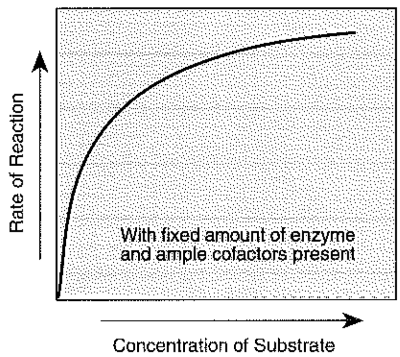
   ____

   ____

   (b) Suggest how a cell may vary the amount of enzyme present in a cell:

   ____

   ____



2. **Substrate Concentration**
   (a) Describe the change in the rate of reaction when the substrate concentration is **increased** (assuming a fixed amount of enzyme and ample cofactors):

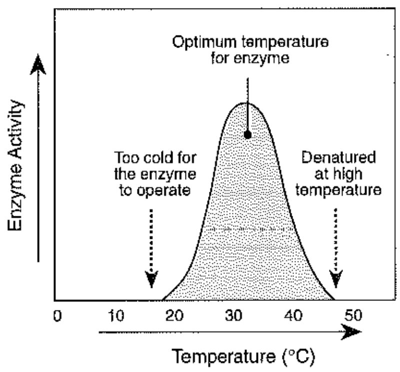
   ____

   ____

   (b) Explain why the rate changes the way it does:

   ____

   ____



3. **Temperature**
   Higher temperatures speed up all reactions, but few enzymes can tolerate temperatures higher than 50–60°C. The rate at which enzymes are **denatured** (change their shape and become inactive) increases with higher temperatures.
   (a) Describe what is meant by an *optimum temperature* for enzyme activity:

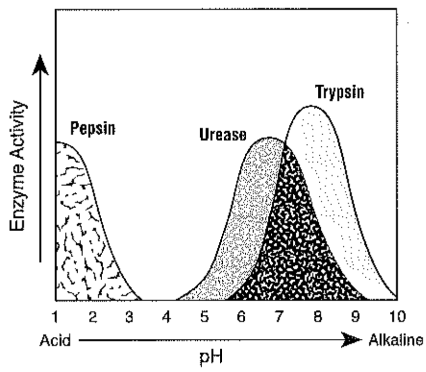
   ____

   ____

   (b) Explain why most enzymes perform poorly at low temperatures:

   ____

   ____



4. **Acidity (pH)**
   Like all proteins, enzymes are **denatured** by *extremes* of **pH** (very acid or alkaline). Within these extremes, most enzymes are still influenced by pH. Each enzyme has a preferred pH range for optimum activity.
   (a) State the optimum pH for each of the enzymes:

   Pepsin: ____________ Trypsin: ____________ Urease: ____________

   (b) Pepsin acts on proteins in the stomach. Explain how its optimum pH is suited to its working environment:

   ____

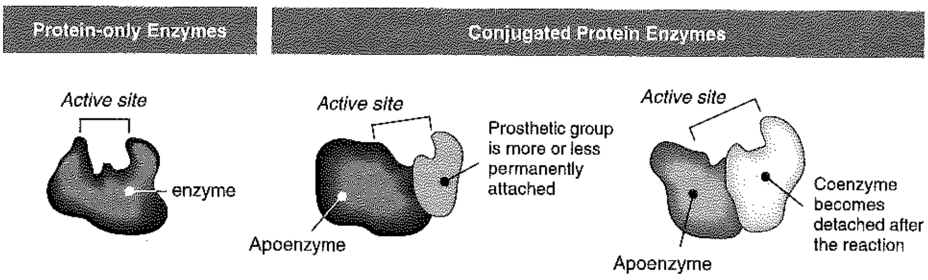
   ____

A 2 Enzyme Cofactors and Inhibitors

Enzyme activity is often influenced by the presence of other chemicals. Some of these can enhance an enzyme's activity. Called **cofactors**, they are a nonprotein component of an enzyme and may be organic molecules (called **coenzymes**) or inorganic ions (e.g. Ca^{2+}, Zn^{2+}). Enzymes may also be deactivated, temporarily or permanently, by enzyme **inhibitors.**

Types of Enzyme

Nearly all enzymes are made of protein, although RNA has been demonstrated to have enzymatic properties. Some enzymes consist of just protein, while others require the addition of extra components to complete their catalytic properties. These may be permanently attached parts called **prosthetic groups**, or temporarily attached pieces (**coenzymes**) that detach after a reaction, and may participate with another enzyme in other reactions.

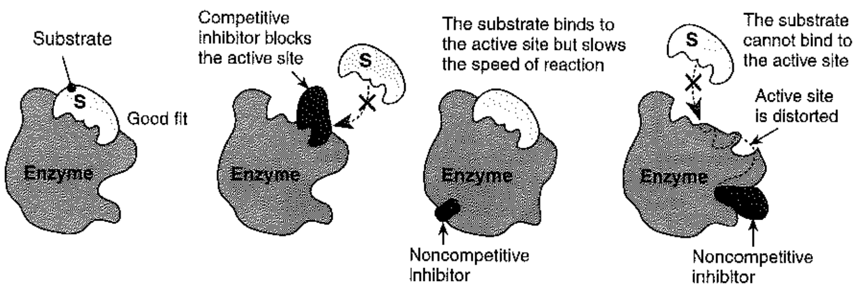


Enzyme comprised of just protein eg. Lysozyme

Prosthetic Group Required
Contains apoenzyme (protein) plus a prosthetic group e.g. Flavoprotein + FAD

Coenzyme Required
Contains apoenzyme (protein) plus a coenzyme (non-protein) e.g. Dehydrogenases + NAD

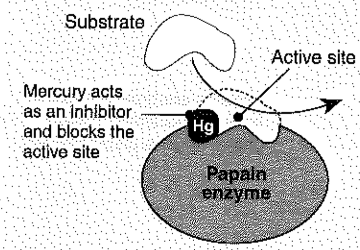
Reversible Enzyme Inhibitors



No inhibition | **Competitive inhibitor** | **Noncompetitive inhibitor** | **Allosteric Enzyme inhibitor**

Enzyme inhibitors may be of two kinds: *reversible* and *irreversible*. **Reversible inhibitors** are used to control enzyme activity. There is often an interaction between the substrate or end product and the enzyme controlling the reaction. Buildup of the end product or a lack of substrate may serve to deactivate the enzyme. This deactivation may take the form of **competitive** (competes for the active site) or **noncompetitive** inhibition. While noncompetitive inhibitors have the effect of slowing down the rate of reaction, **allosteric inhibitors** block the active site altogether and prevent its functioning.

Irreversible Inhibitors (Poisons)



Certain **heavy metals** bind tightly and permanently to the active sites of enzymes, destroying their catalytic properties. Examples of toxic heavy metals include: *mercury* (Hg), *cadmium* (Cd), *lead* (Pb), and *arsenic* (As). They are generally non-competitive inhibitors, although an exception is mercury that deactivates the enzyme papain. They are retained in the body, and lost slowly.

1. Describe the general role of **cofactors** in enzyme activity: ____________________

2. **Heavy metals** can be very toxic to life forms.
   (a) Name 4 heavy metals that are toxic to humans: ____________________
   (b) Explain in general terms why these heavy metals are toxic: ____________________

3. There are many enzyme inhibitors that are not heavy metals (eg. those found in some pesticides)
   (a) Name a **common poison** that is an enzyme inhibitor, but *not a heavy metal*: ____________________
   (b) Try to find out how this poison works in interfering with enzyme function. Briefly describe which enzyme it affects: ____________________

4. Explain the difference between **competitive** and **noncompetitive** inhibition: ____________________

5. Explain how **allosteric inhibitors** differ from other noncompetitive inhibitors: ____________________

