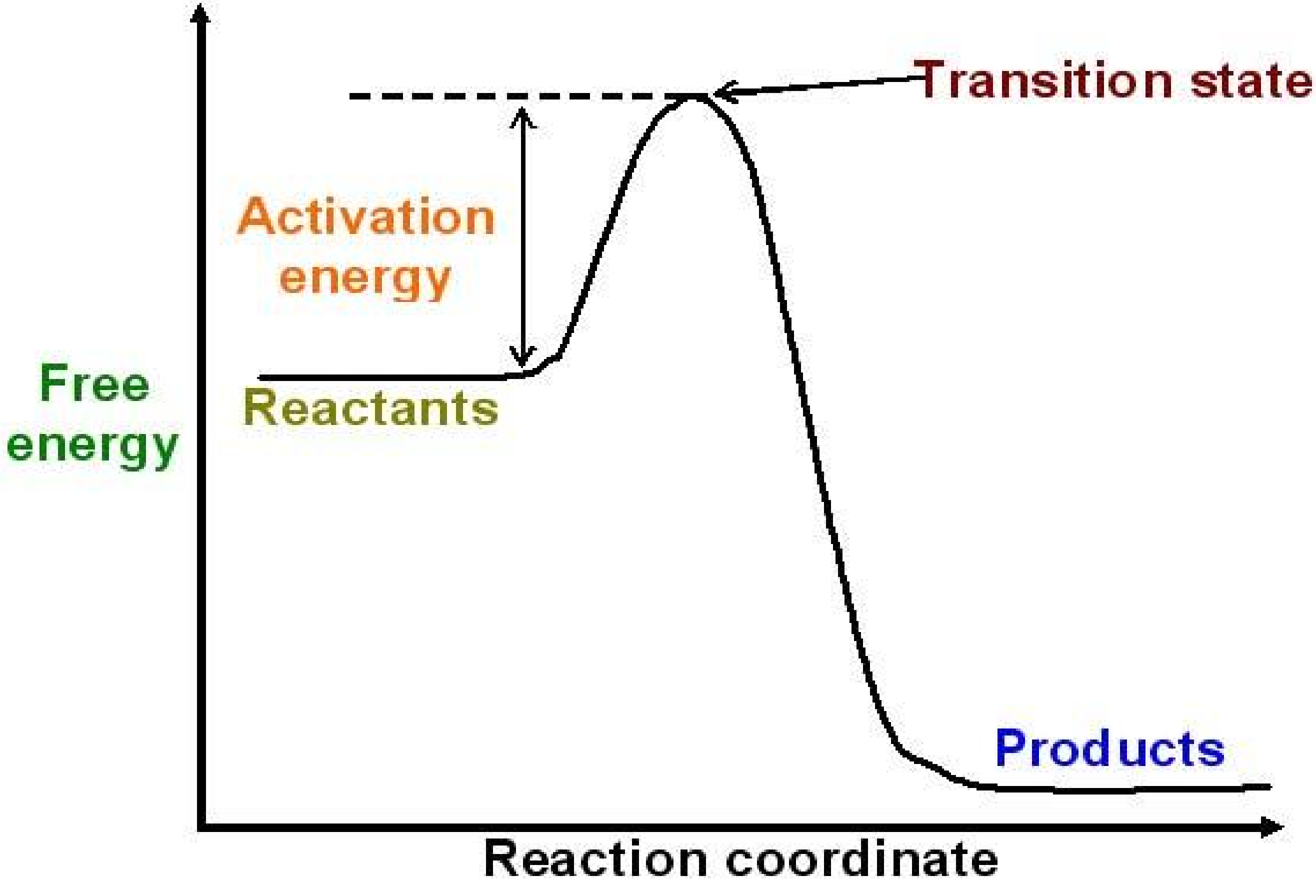
ENZYMES

A protein with catalytic properties due to its power of specific activation

Chemical reactions

- Chemical reactions need an initial input of energy = **THE ACTIVATION ENERGY**
- During this part of the reaction the molecules are said to be in a **transition state**.

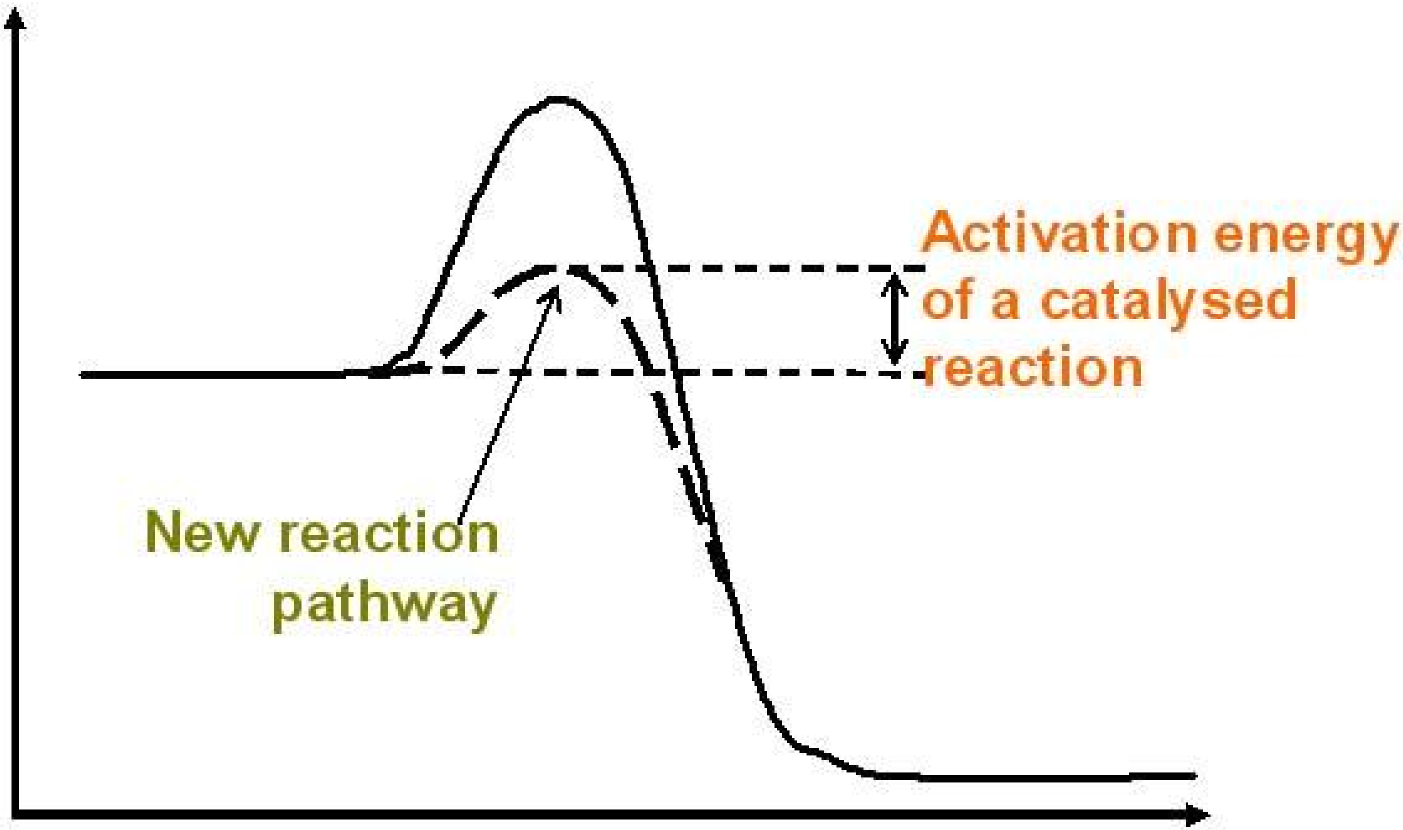
Reaction pathway



Making reactions go faster

- Increasing the temperature make molecules move faster
- Biological systems are very sensitive to temperature changes.
- Enzymes can increase the rate of reactions without increasing the temperature.
- They do this by lowering the activation energy.
- They create **a new reaction pathway** “a short cut”

An enzyme controlled pathway



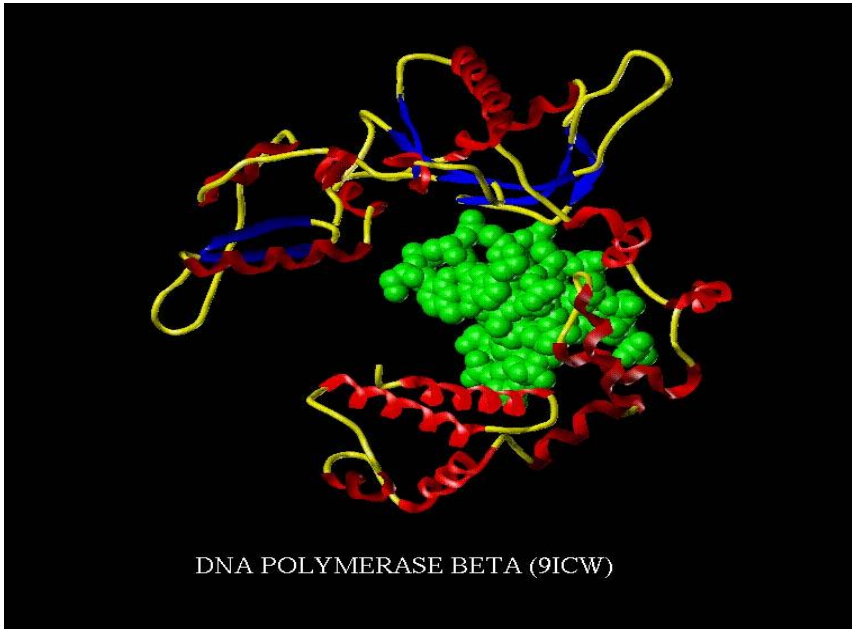
- Enzyme controlled reactions proceed 108 to 1011 times faster than corresponding non-enzymic reactions.

Enzyme structure

- Enzymes are **proteins**
- They have a **globular** shape
- A complex **3-D** structure

Human pancreatic amylase

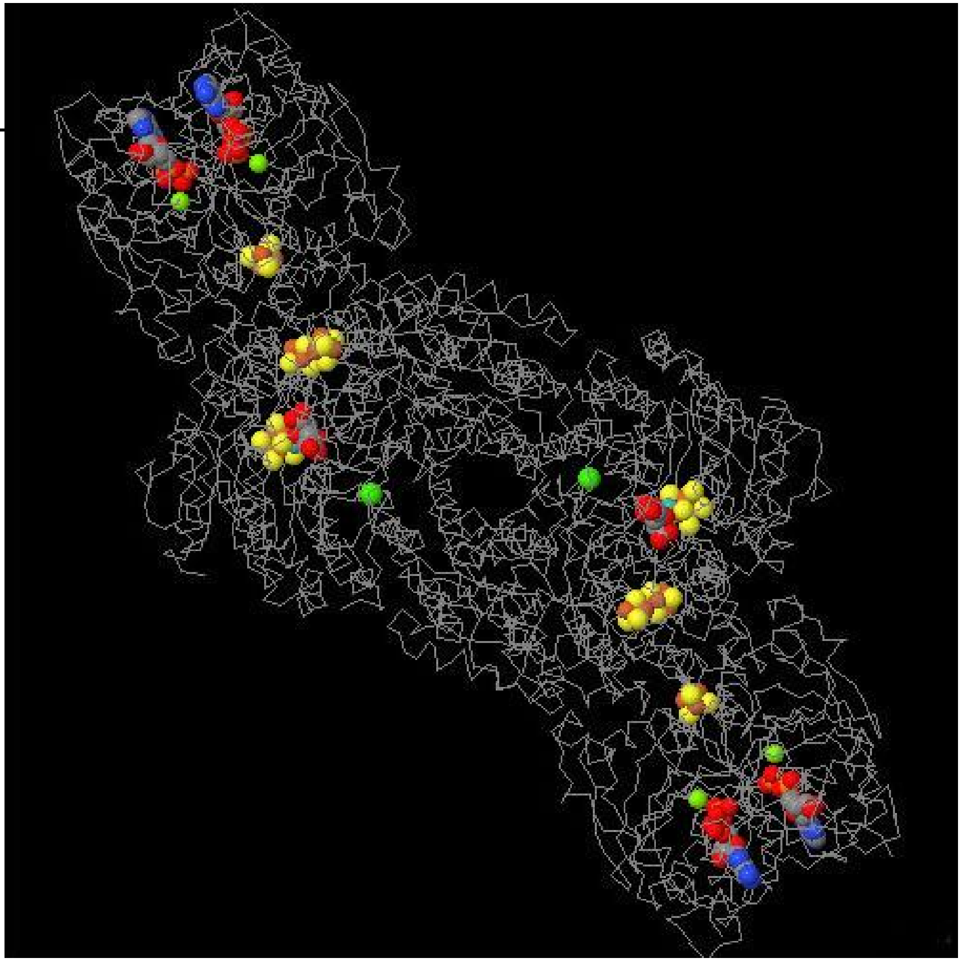
The active site



- One part of an enzyme, the active site, is particularly important
- The **shape** and the **chemical environment** inside the active site permits a chemical reaction to proceed more easily

Cofactors

- An additional non-protein molecule that is needed by some enzymes to help the reaction
- Tightly bound cofactors are called prosthetic groups
- Cofactors that are bound and released easily are called coenzymes
- Many vitamins are coenzymes



Nitrogenase enzyme with Fe, Mo and ADP cofactors

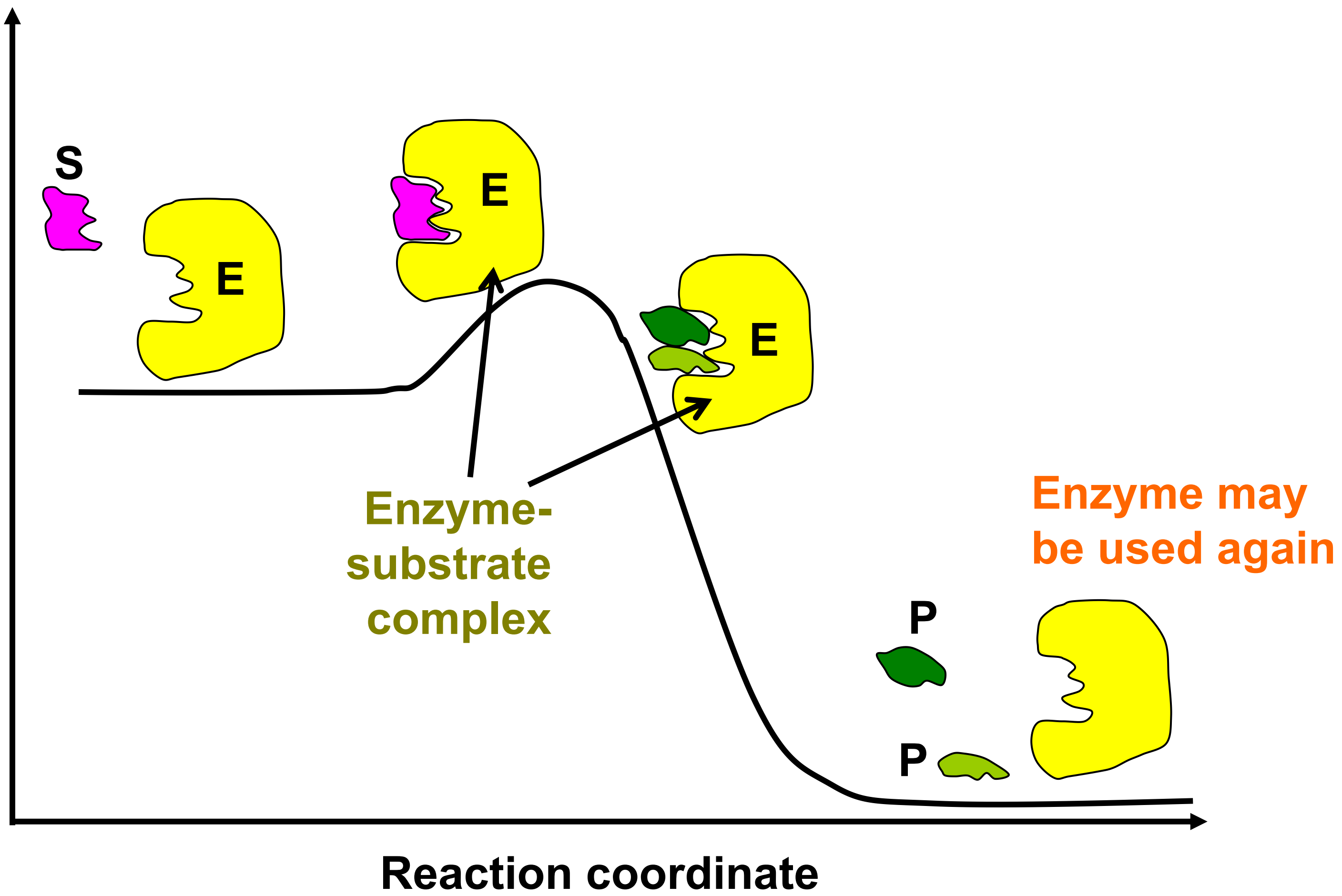
The substrate

- The substrate of an enzyme are the **reactants** that are activated by the enzyme
- Enzymes are **specific** to their substrates
- The specificity is determined by the **active site**

The Lock and Key Hypothesis

- Fit between the substrate and the active site of the enzyme is exact
- Like a key fits into a lock very precisely
- The key is analogous to the enzyme and the substrate analogous to the lock.
- Temporary structure called the enzyme-substrate complex formed
- Products have a different shape from the substrate
- Once formed, they are released from the active site
- Leaving it free to become attached to another substrate

The Lock and Key Hypothesis



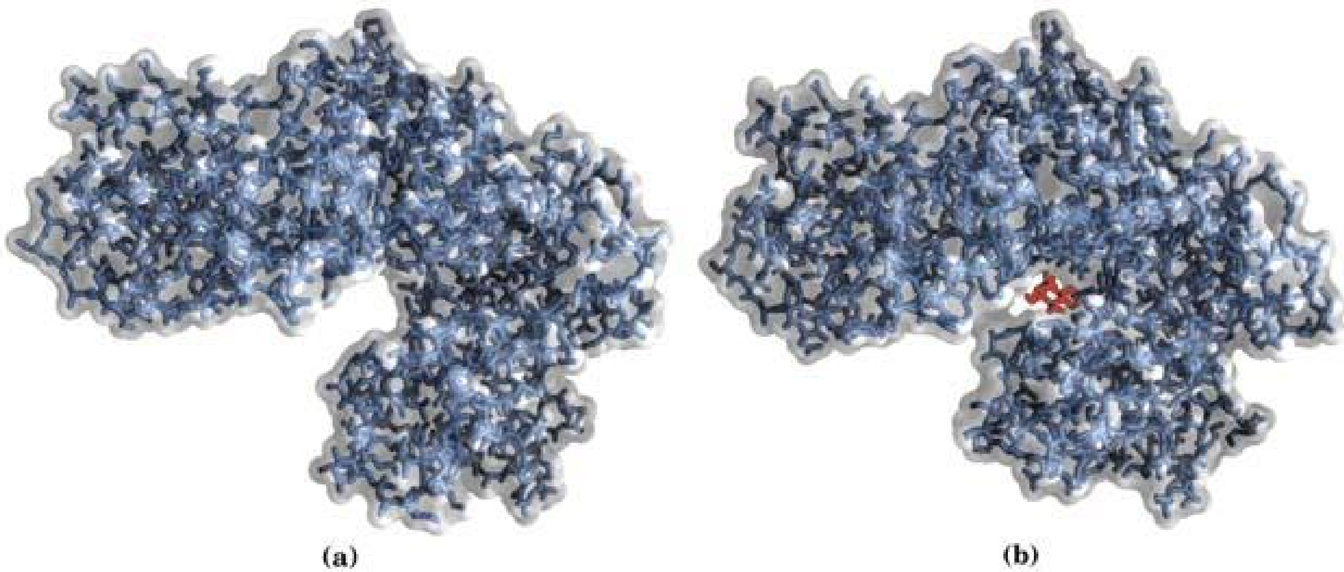
The Lock and Key Hypothesis

- This explains enzyme specificity
- This explains the loss of activity when enzymes denature

The Induced Fit Hypothesis

- Some proteins can change their shape (conformation)
- When a substrate combines with an enzyme, it induces a change in the enzyme's conformation
- The active site is then moulded into a precise conformation
- Making the chemical environment suitable for the reaction
- The bonds of the substrate are stretched to make the reaction easier (lowers activation energy)

The Induced Fit Hypothesis



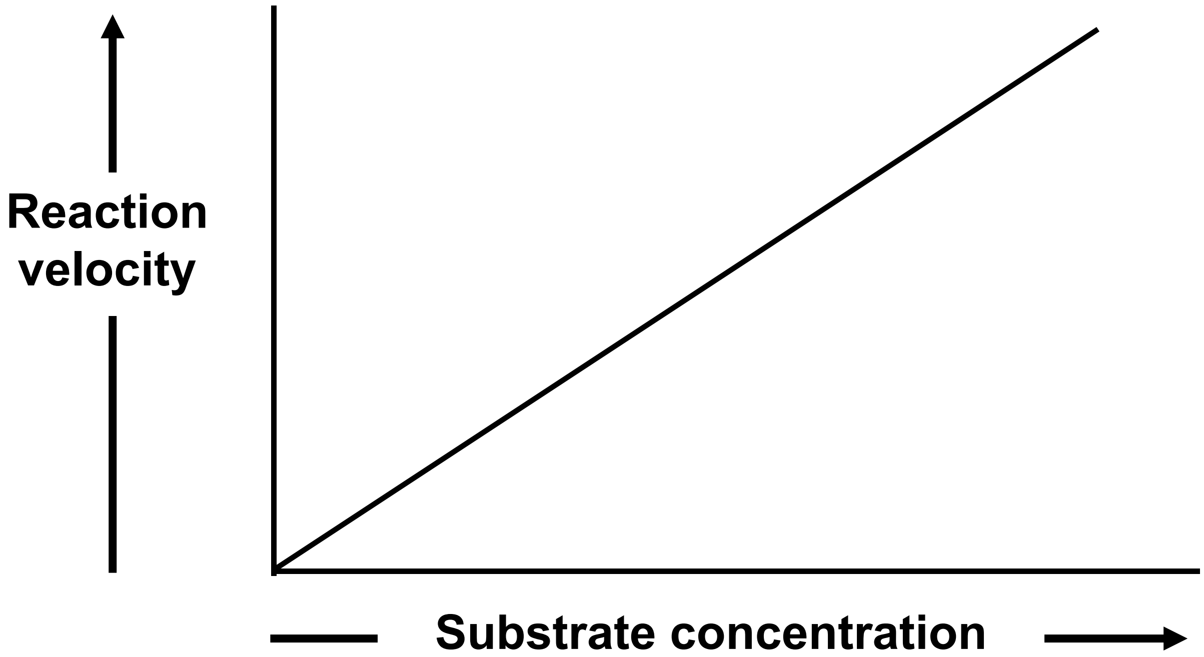
Hexokinase (a) without (b) with glucose substrate

- This explains the enzymes that can react with a range of substrates of similar types

Factors affecting Enzymes

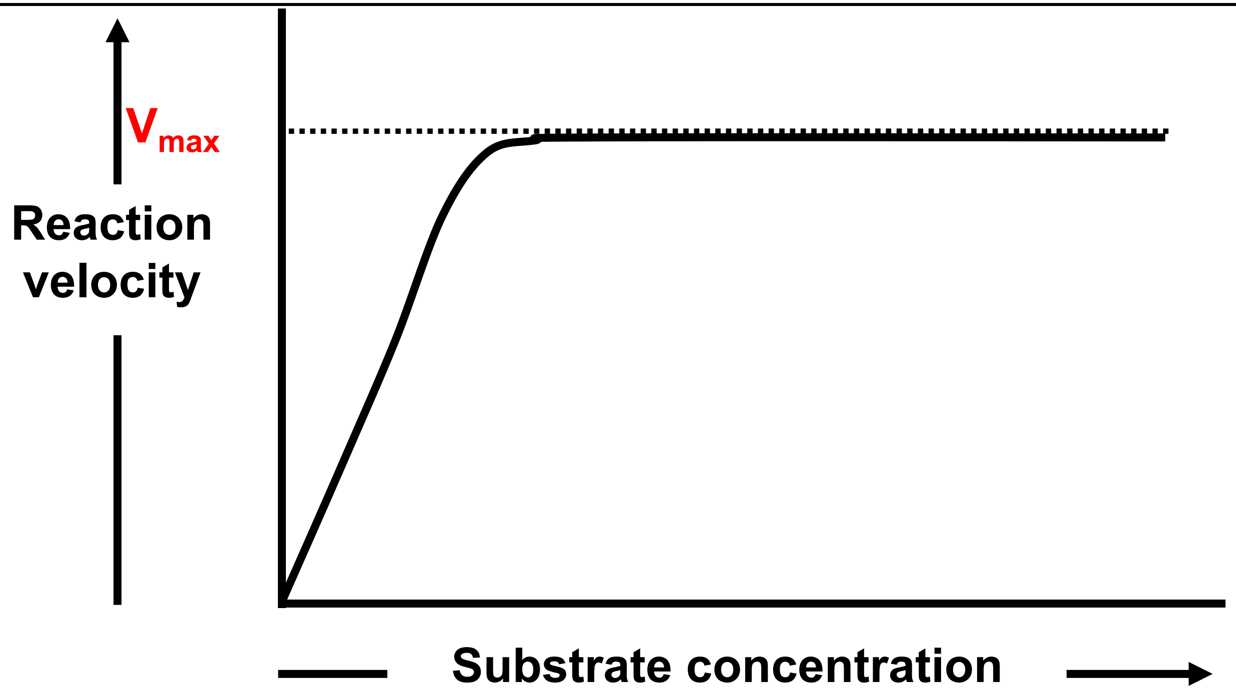
- substrate concentration
- pH
- temperature
- inhibitors

Substrate concentration: Non-enzymic reactions



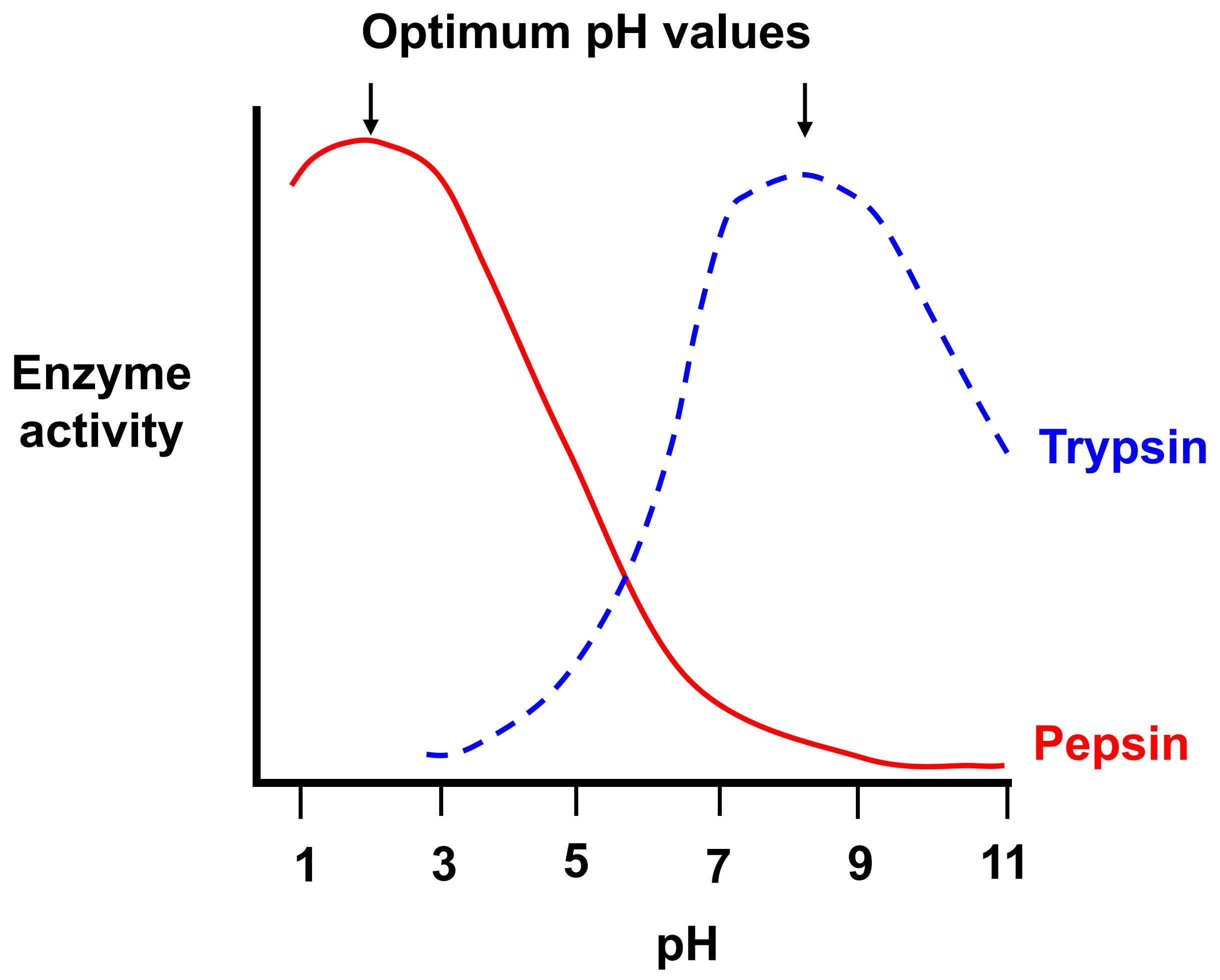
- The increase in velocity is proportional to the substrate concentration

Substrate concentration: Enzymic reactions



- Faster reaction but it reaches a saturation point when all the enzyme molecules are occupied.
- If you alter the concentration of the **enzyme** then $\mathbf{V_{max}}$ will change too.

The effect of pH



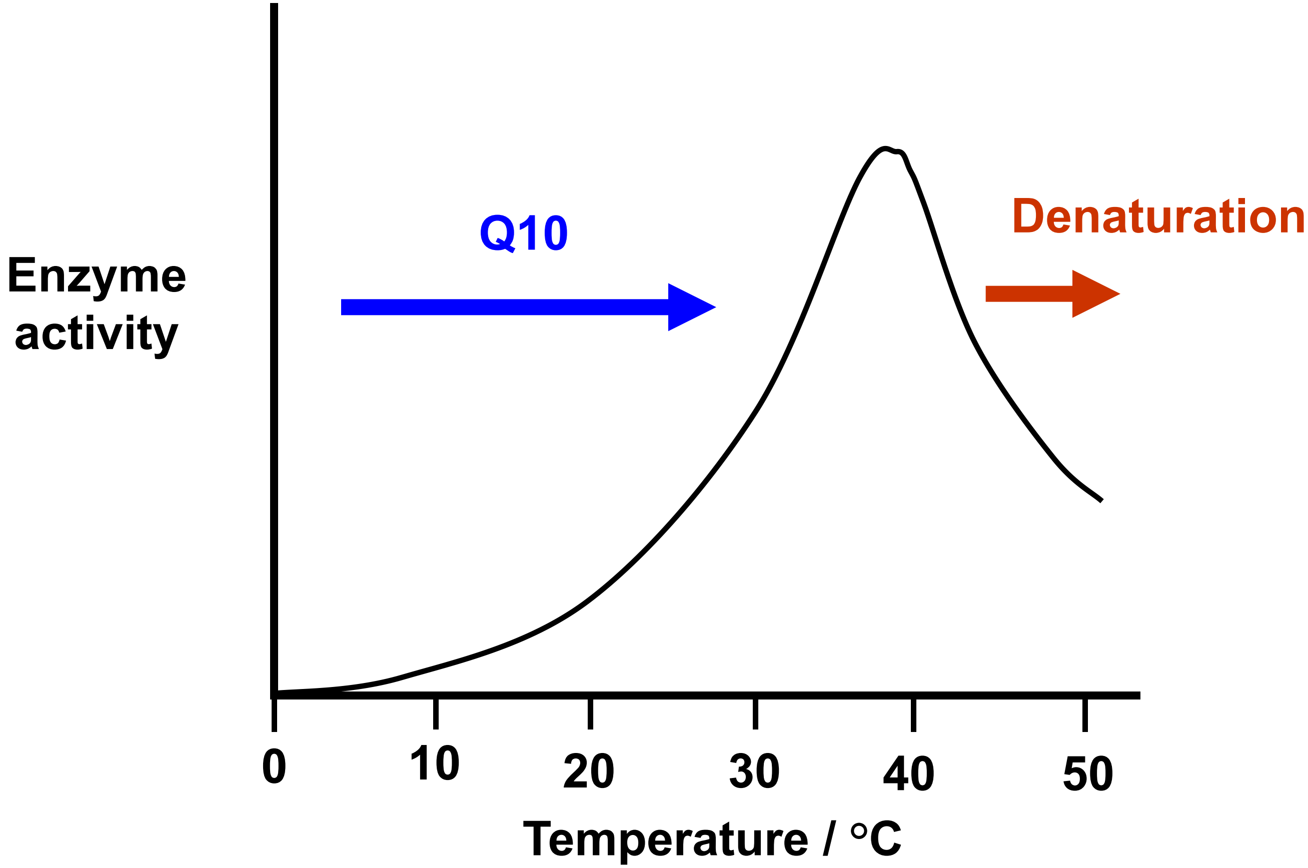
The effect of pH

- Extreme pH levels will produce **denaturation**
- The structure of the enzyme is changed
- The active site is distorted and the substrate molecules will no longer fit in it
- At pH values slightly different from the enzyme's optimum value, small changes in the charges of the enzyme and it's substrate molecules will occur
- This change in ionisation will affect the binding of the substrate with the active site.

The effect of temperature

- Q10 (**the temperature coefficient**) = the increase in reaction rate with a 10°C rise in temperature.
- For chemical reactions the Q10 = 2 to 3
(the rate of the reaction doubles or triples with every 10°C rise in temperature)
- Enzyme-controlled reactions follow this rule as they are chemical reactions
- BUT at high temperatures proteins **denature**
- The optimum temperature for an enzyme controlled reaction will be a balance between the Q10 and denaturation.

The effect of temperature



The effect of temperature

- For most enzymes the optimum temperature is about 30°C
- Many are a lot lower,
  cold water fish will die at 30°C because their enzymes denature
- A few bacteria have enzymes that can withstand very high temperatures up to 100°C
- Most enzymes however are fully denatured at 70°C

Inhibitors

- Inhibitors are chemicals that reduce the rate of enzymic reactions.
- The are usually specific and they work at low concentrations.
- They block the enzyme but they do not usually destroy it.
- Many drugs and poisons are inhibitors of enzymes in the nervous system.