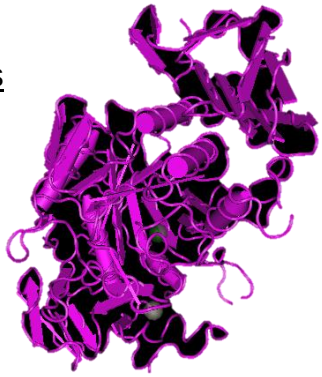
Enzymes are biological catalysts made up of proteins used to speed up rate of chemical reactions. They lower activation energy by providing an alternative pathway and remains chemically unchanged at the end of the chemical reaction.

Characteristics of enzymes:

- three dimensional shape held by weak hydrogen bonds
- specific in nature
- affected by temperature and pH
- can catalyse reversible reactions

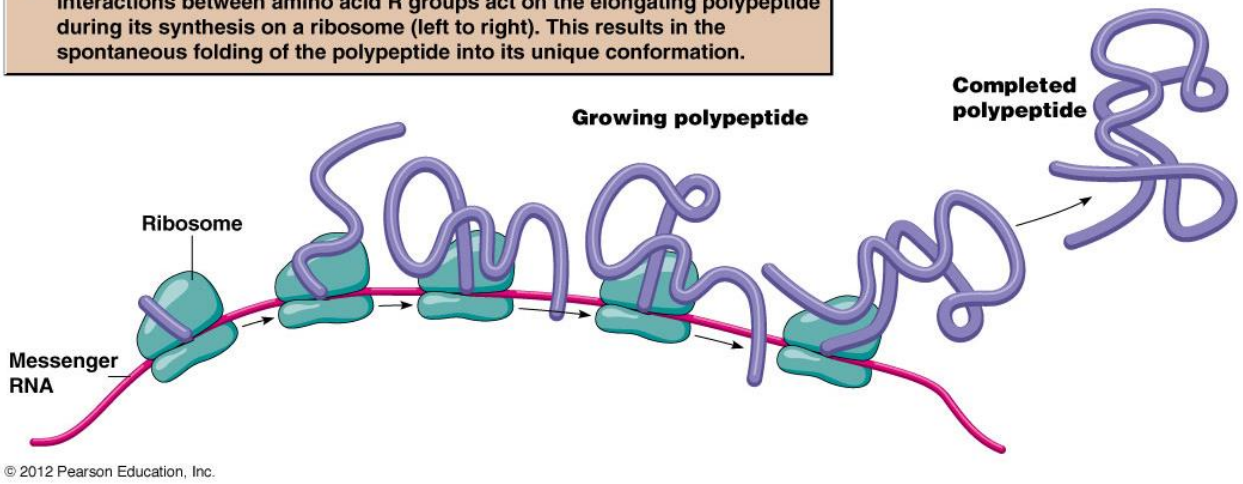


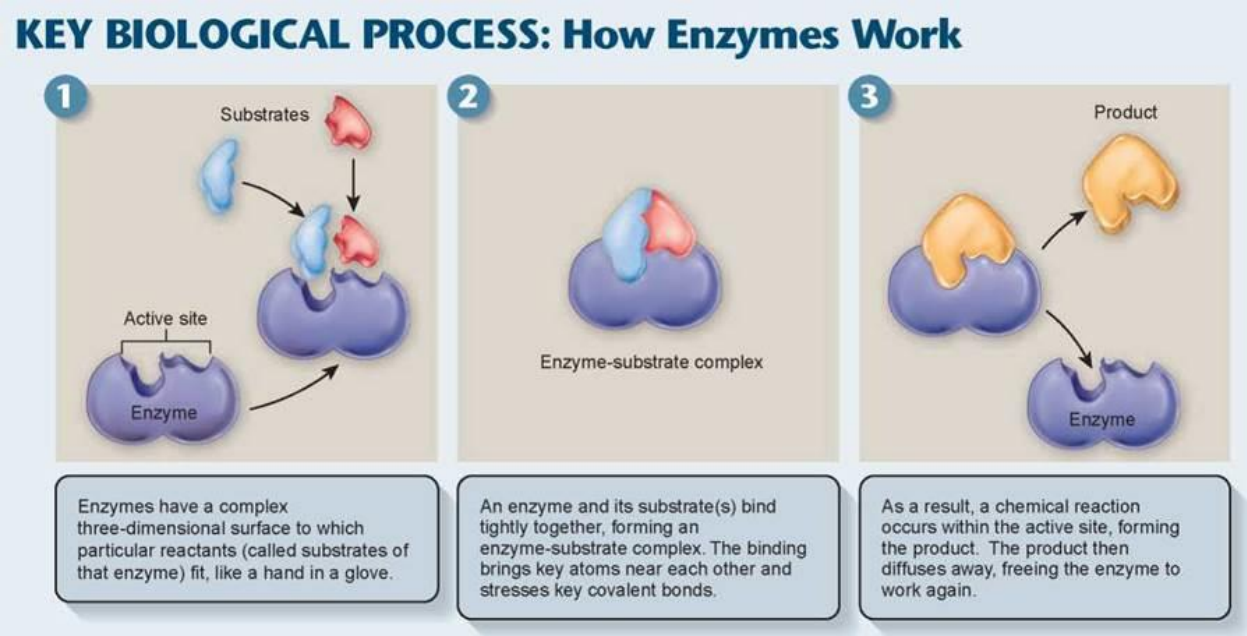
Human salivary amylase

Types of enzymes

- **Hydrolases** are hydrolytic enzymes that use water to cleave chemical bonds, usually dividing a large molecule into two smaller molecules. Examples of common **hydrolases** include esterases, proteases, glycosidases, nucleosidases, and lipases.
- **Synthases** are enzymes that catalase the synthesis of a substance without the use of a high-energy source such as cleavage of a phosphate bond in ATP.
- **Synthetases** are enzymes that catalyses the linking together of two molecules especially by using the energy derived from the concurrent splitting off of a pyrophosphate group from a triphosphate (as ATP).

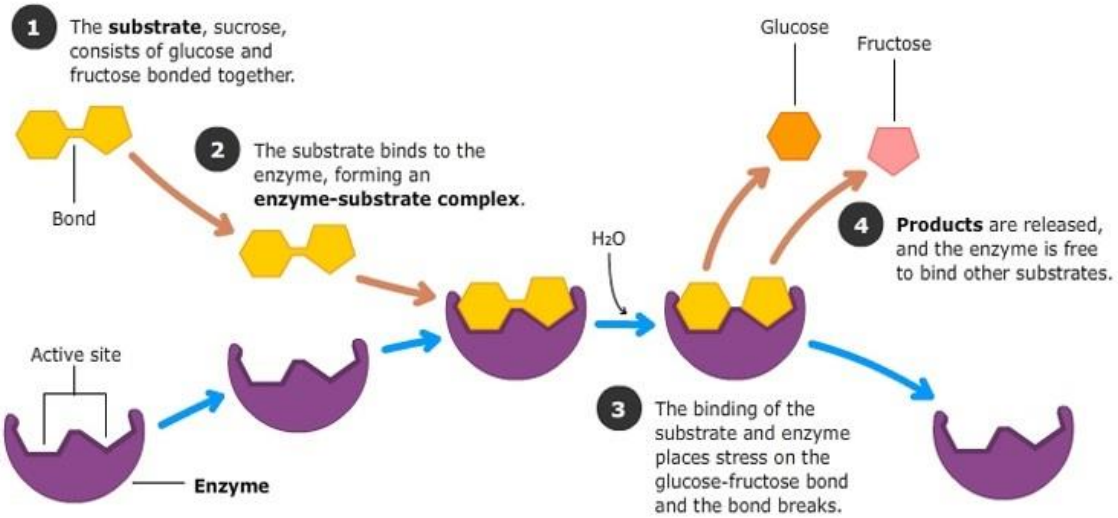
(b) Spontaneous folding of ribonuclease during synthesis. The same interactions between amino acid R groups act on the elongating polypeptide during its synthesis on a ribosome (left to right). This results in the spontaneous folding of the polypeptide into its unique conformation.





LO: Explain enzyme action in terms of the 'lock and key' hypothesis

- Enzyme is the "lock"
- Substrate is the "key"
- Specific substrate fits into active site of the enzyme. The three dimensional shape of the substrate is complementary to the shape of the active site of the enzyme
- Formation of enzyme-substrate complex
- Reaction takes place then the enzyme and substrate separates.
- Enzymes remain chemically unchanged at the end of the chemical reaction.



The induced fit model

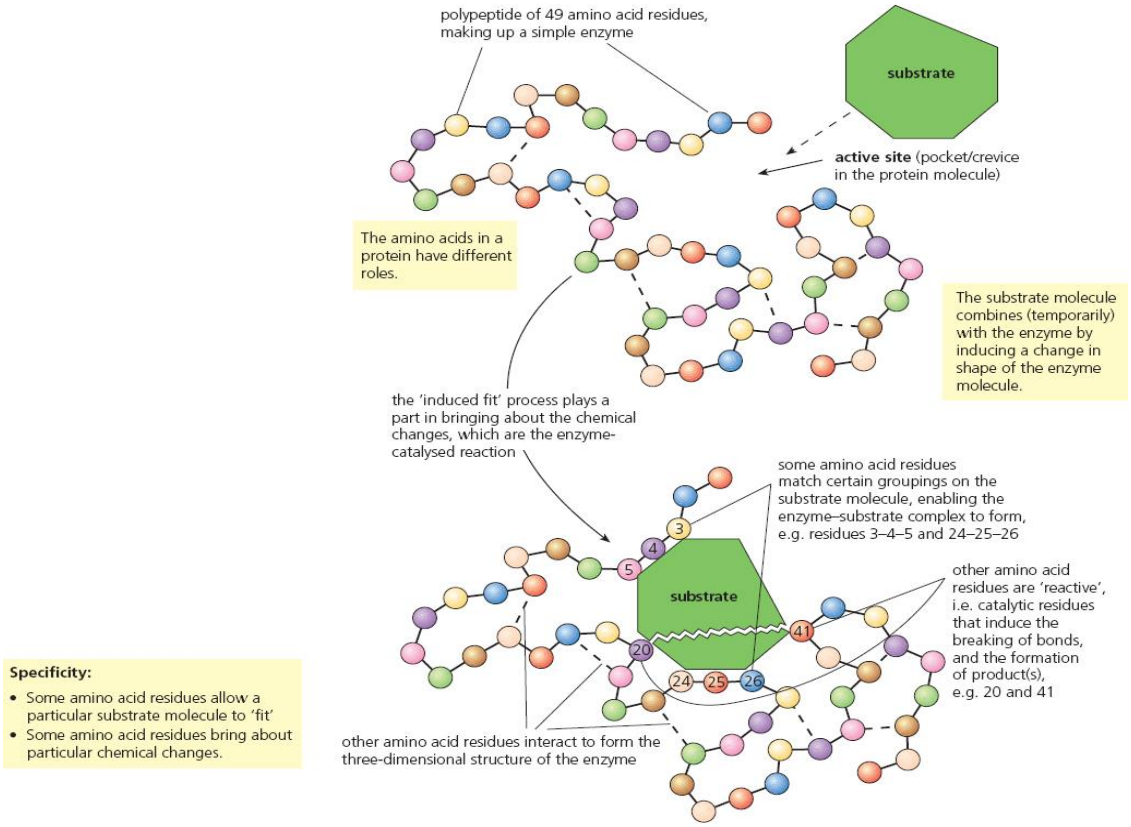
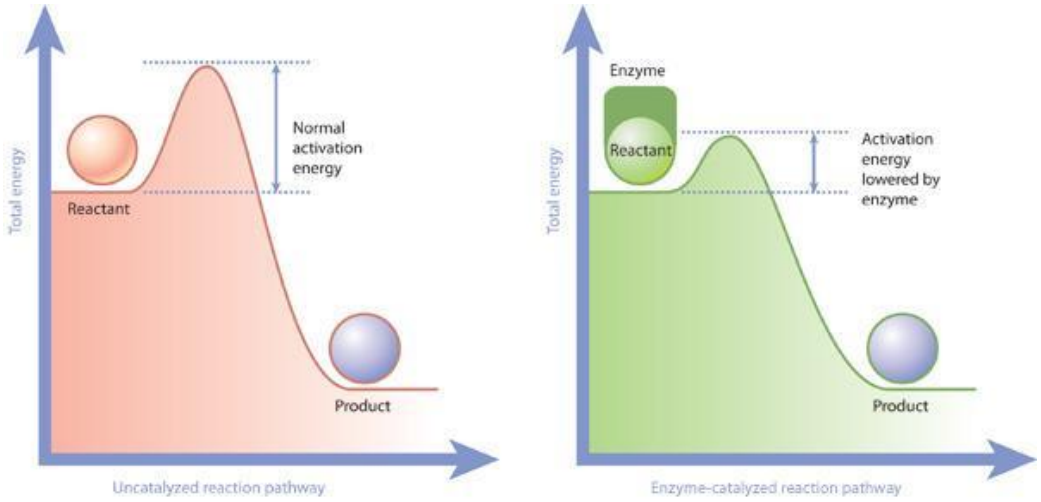


Figure 3.5 The induced fit hypothesis of enzyme action

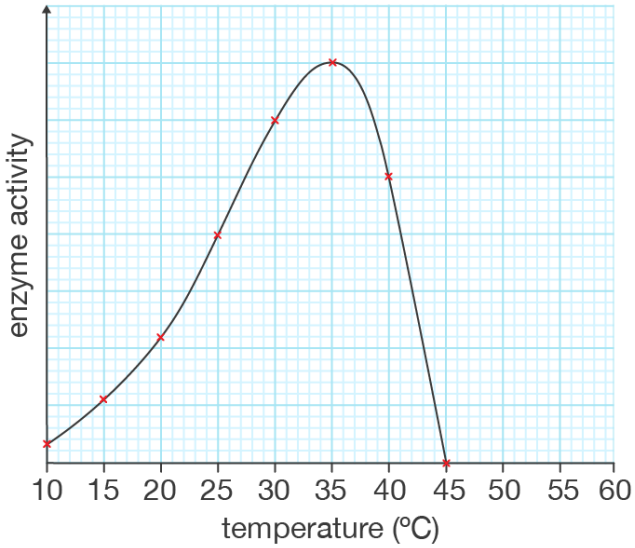
LO: Explain the mode of action of enzymes in terms of an active site, enzyme-substrate complex, lowering of activation energy and enzyme specificity

- Enzyme binds to the substrate at the active site on the enzyme molecule.
- Results in the formation of an enzyme-substrate complex.
- Enzymes reduce the activation energy needed for the reaction to occur, so the reaction occurs more readily. Activation energy is the energy needed to start a chemical reaction.
- Enzyme specificity due to the three dimensional shape of the enzyme held by weak hydrogen bonds. The active site of the enzyme is complementary to the three dimensional shape of the substrate.



LO: Investigate and explain the effects of temperature and pH on the rate of enzyme catalysed reactions

Temperature



Low temperature

- Kinetic energy of particles is low, enzyme is inactive.
- Enzyme substrate complex formation is slow and rate of reaction is low.

Increasing temperature to optimum temperature

- Kinetic energy of particles increases, increasing the frequency of collision of the substrate and enzyme molecules.
- Rate of formation of enzyme substrate complex increases and rate of reaction increases.
- Note: Rate of reaction usually doubles for every 10°C increase.

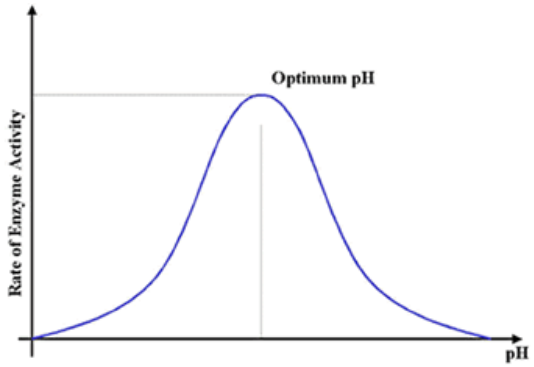
Optimum temperature

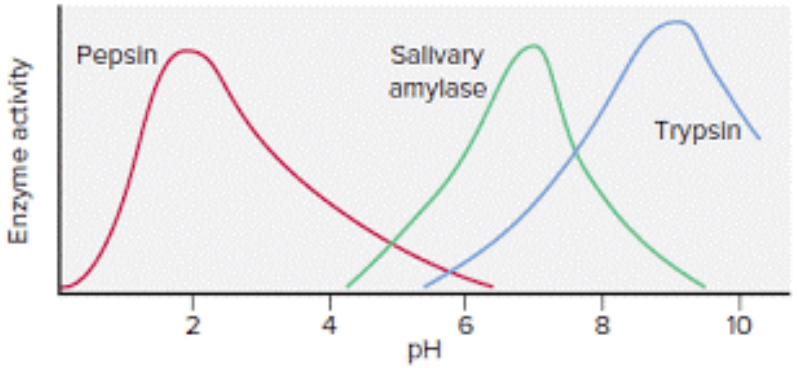
- Enzyme is most active.
- Rate of formation of enzyme substrate complex is at its maximum and rate of reaction is the highest.

Beyond optimum temperature

- Weak hydrogen bonds in three dimensional enzyme structure is broken.
- Three-dimensional shape of enzyme is lost and shape of active site is altered.
- Substrate can no longer bind to active site of enzyme and no enzyme-substrate complexes are formed.
- Enzyme is denatured and rate of reaction decreases to zero.

pH





Below optimum pH

- Weak hydrogen bonds in three dimensional enzyme structure is broken.
- Three-dimensional shape of enzyme is lost and shape of active site is altered.
- Substrate can no longer bind to active site of enzyme and no enzyme-substrate complexes are formed.
- Enzyme is denatured and rate of reaction decreases to zero.

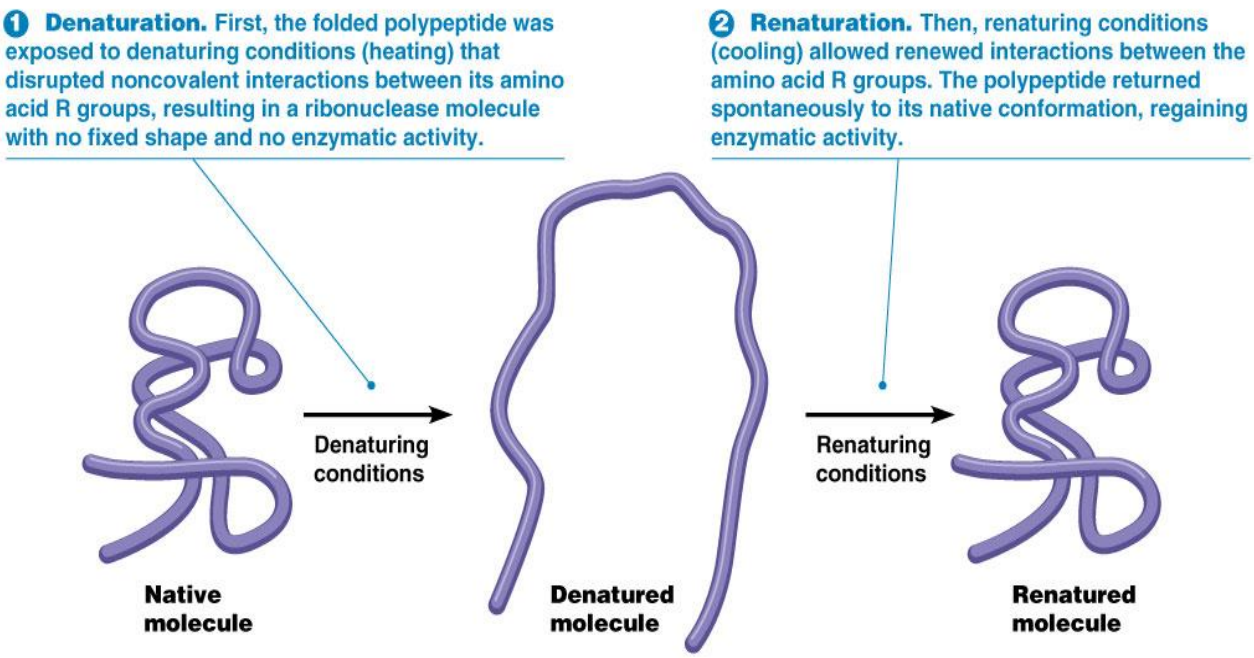
Optimum pH

- Enzyme is most active.
- Rate of formation of enzyme substrate complex is at its maximum and rate of reaction is the highest.

Above optimum pH

- Weak hydrogen bonds in three dimensional enzyme structure is broken.
- Three-dimensional shape of enzyme is lost and shape of active site is altered.
- Substrate can no longer bind to active site of enzyme and no enzyme-substrate complexes are formed.
- Enzyme is denatured and rate of reaction decreases to zero.

(a) Spontaneous refolding of ribonuclease following denaturation. Anfinsen's experiment showed that all the information needed for the proper folding of a ribonuclease polypeptide into its native three-dimensional conformation is present in its amino acid sequence.



Industrial uses of enzymes