OCR (A) Biology A-level

Topic 2.4: Enzymes

Notes

Enzymes increase the **rate of reaction** by lowering the **activation energy** of the reaction they catalyse. **Active site** is the area of the enzyme where the reaction with the **substrate** takes place. Enzymes are **specific to substrates** they bind to meaning that only one type of substrate fits into the active site of the enzyme. When the enzyme and substrate form a **complex**, the structure of the enzyme is altered so that the active site of the enzyme fits around the substrate. This is called the **induced fit model**.

Factors affecting the rate of enzyme-controlled reactions:

- **Enzyme concentration** – the rate of reaction increases as enzyme concentration increases as there are more active sites for substrates to bind to, however increasing the enzyme concentration beyond a certain point has no effect on the rate of reaction as there are more active sites than substrates so substrate concentration becomes the limiting factor

- **Substrate concentration** – as concentration of substrate increases, rate of reaction increases as more enzyme-substrate complexes are formed. However, beyond a certain point the rate of reaction no longer increases as enzyme concentration becomes the limiting factor

- **Temperature** – rate of reaction increases up to the optimum temperature, which is the temperature at which enzymes work at their maximum rate. Rate of reaction decreases above the optimum temperature

Inhibitors

An **inhibitor** is a substance which slows down or stops a reaction by affecting the **binding of substrate to the enzymes**. Inhibitors can either be **re**versible and **irreversible**.

Examples of **irreversible inhibitors** include **heavy metal ions such** as **mercury and silver** which cause **disulphide bonds** within the protein structure to break, as a result causing the **shape of the active site** to change, thus affecting protein activity. Other examples include **cyanide** which is a nerve gas that covalently binds to the active site, therefore preventing the binding of the substrate.

Reversible inhibitors bind to the active site through **hydrogen bonds and weak ionic interactions** therefore they do not bind permanently. Reversible inhibitors can either be **competitive or non-competitive.**

Competitive inhibitors are similar in structure to the substrate molecule therefore they **bind to the active site of the enzyme**, decreasing its activity as they compete with substrate for the enzyme. The **amount of product formed remains the same**, however the rate at which product formation occurs decreases. The higher the concentration of competitive inhibitor the lower the reaction rate. Increasing the substrate reverses the effect of competitive inhibitors by outcompeting them.

Non-competitive inhibitor does not bind to the active site; it **binds at another site on the enzyme known as the allosteric site.** Binding of the non-competitive inhibitors **changes the shape of the active site therefore preventing the binding of the substrate**. Increasing the concentration of substrate has no effect on non-competitive inhibition.

Many **drugs** are inhibitors. Examples include **penicillin** which is used to fight bacterial infections, it is an inhibitor of enzyme **transpeptidase** which plays an important role in cell wall formation. Other examples include Ritonavir which is an antiretroviral drug used to treat HIV which inhibits HIV protease which is responsible for assembly of new viral particles and spread of infection.

Coenzymes

A **cofactor** is a **non-protein compound** required for the enzyme's activity to occur. There are three types of cofactors: **coenzymes, activators and prosthetic groups**.

Coenzymes are organic cofactors which do not bind permanently. They **facilitate the binding of substrate to enzyme.** Many coenzymes are **vitamin derived**, examples include **NAD derived from niacin**, which acts as a **hydrogen acceptor**.

Activators are **inorganic metal ions** which temporarily binds to the enzyme and alters its active site, making the reaction more feasible. For instance, **magnesium ion** is an important activator which is involved in processes such as **shielding negative charge**.

Prosthetic groups are permanently attached to the enzyme. For instance, **haemoglobin contains a prosthetic haem group** which contains iron, permanently bound to the molecule, which serves as a means of binding oxygen.