Enzymes II: How Enzymes Work

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The Basics of Life

Understanding Enzymes

To better understand enzymes, we will explore several questions:

1) How do enzymes affect substrate molecules?
2) What factors affect how well enzymes work?
3) What other types of molecules may be required for an enzyme to work?

Substrate Binding

Substrates are typically affected in one of three ways when they bind the active site of an enzyme:

1) proper orientation
2) charge transfer between substrate and enzyme
3) physical strain on substrate
Many factors can have an effect on how efficiently enzymes work, such as:
- pH
- temperature
- substrate/enzyme concentration
- allosteric interactions
- inhibitors
- presence of required molecular groups

Hemoglobin, which carries oxygen in your blood, is affected by all of the factors mentioned on the right.

Changes in pH can affect the charge characteristics of the enzyme or substrate:
- substrates may not be able to bind active site due to chemical changes in substrate or active site
- enzyme tertiary structure may be disrupted*, rendering enzyme inactive

*Recall that tertiary structure is determined by relatively weak interactions between the R-groups of an enzyme's amino acids.

Enzyme activity generally increase with increasing temperature.

However, when temperatures increase too much beyond an enzyme's optimal temperature, the enzyme may denature, resulting in a loss of activity.
Enzyme activity tends to increase with increasing substrate concentration.

Allosteric enzymes have multiple binding sites, often on multiple subunits:
- binding of one substrate molecule makes it easier to bind a second substrate molecule
- binding of a regulatory molecule makes it easier to bind a second regulatory molecule, and more difficult to bind substrate

Due to their sensitivity to changes in substrate concentration, allosteric enzymes are often used to regulate metabolic pathways.
Inhibition of Enzymes

Certain molecules bind enzymes and decrease their activity, either by blocking the active site directly or by changing the shape of the active site:

1) irreversible inhibition
   - inhibitors bound permanently to enzyme
2) reversible inhibition
   - competitive inhibition
     - inhibitors compete with substrate to bind active site
   - non-competitive inhibition
     - inhibitors bind alternative site, results change in active site so substrate cannot bind.

Required Molecular Groups

Many enzymes require binding of other molecules in order to work.

Three main types:

1) cofactors
   - inorganic ions (Fe^{2+}, Fe^{3+}, Zn^{2+}) bound at active site
2) coenzymes
   - small carbon molecules that interact with enzymes (examples: NAD, FAD)
3) prosthetic groups
   - small carbon molecules covalently bound to enzyme (examples: heme of hemoglobin, retinal of rhodopsin)