Topic 2 Molecular Biology

Topic 2.5 Enzymes

Essential idea: Enzymes control the metabolism of the cell

Understandings:

- 2.5.U1 Enzymes have an active site to which specific substrates bind.
- 2.5.U2 Enzyme catalysis involve molecular motion and the collision of substrates with the active site.
- 2.5.U3 Temperature, pH and substrate concentration affect the rate of activity of enzymes.
- 2.5.U4 Enzymes can be denatured.
- 2.5.U5 Immobilized enzymes are widely used in industry.

Applications:

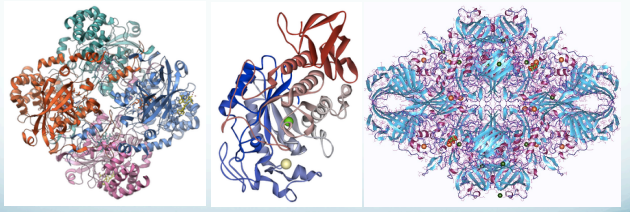
- 2.5.A1 Methods of production of lactose-free milk and its advantages

Skills

- 2.5.S1 Design of experiments to test the effect of temperature, pH and substrate concentration on the activity of enzymes.
- 2.5.S2 Experimental investigation of a factor affecting enzyme activity (Practical 3).

I. Active Sites and Enzymes

A. Enzymes have an active site to which specific substrates bind.
   1. Enzymes are globular proteins that increase the rate of biochemical reaction by lowering the activation energy threshold (i.e. biological catalyst).



Catalase | Amylase | Lactase

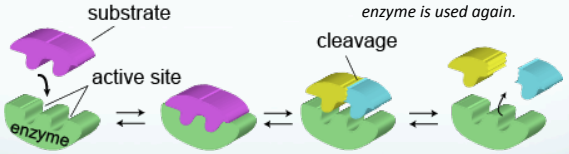
www.ebi.ac.uk; PBD; Astrojan

I. Active Sites and Enzymes

2. Substrate – reactant in a biochemical reaction.
3. Active site – region on the surface of an enzyme to which substrates bind and which catalyzes the reaction.

Polar regions of active site provided by the R groups of amino acids attract the substrate to the enzyme.

The products are released and the enzyme is used again.

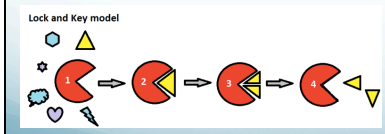


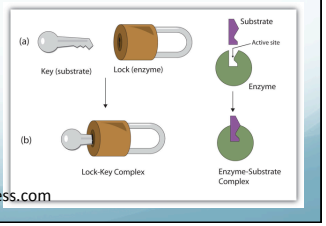
Once a substrate has been locked into the active site, the reaction is catalyzed.

shmoop.com

I. Active Sites and Enzymes

B. Enzymes are specific to their substrates
   1. The Lock-and-Key Model
      The substrate and active site match each other in two ways:
      - Structurally – The 3D structure of the active site is specific to the substrate. If it don't fit, it won't work!
      - Chemically – Substrates that are not chemically attracted to the active site won't be able to react.

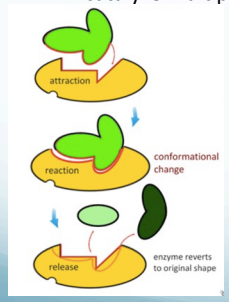




Pearson Education; katysstudynotes.wordpress.com

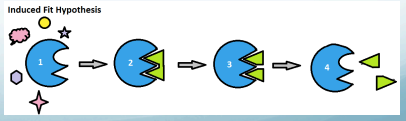
I. Active Sites and Enzymes

2. The Induced-Fit Model
   If the lock-and-key model were true, one enzyme would catalyze only one reaction. In reality, some enzymes can catalyze multiple reactions.



As the substrate approaches the enzyme it induces a conformational change in the active site, it changes to fit the substrate.

This stresses the substrate, reducing the activation energy of the reaction.



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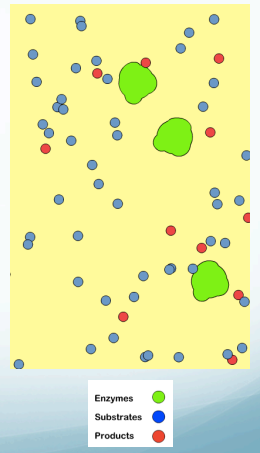
II. Enzyme Activity

A. Enzymes catalysis involves molecular motion and the collision of substrates with the active site
   - *Most reactions occur with the substrate dissolved in water*
   - *All molecules are in random motion (kinetic energy from the environment creates molecular motion).*
   - *If not immobilized, the enzyme will also move but more slowly*
   - *The coming together of a substrate molecule and an active site is known as a collision and is due to random movement*
   - *Successful collisions occur when the substrate and active site to be correctly aligned*



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III. Types of Enzymes

Enzyme Class	Reaction Catalyzed	Example
Hydrolase	Hydrolysis (catabolic)	Lipase, protease
Isomerase	Rearrangement of atoms within a molecule	Phosphohexoisomerase
Lyase	Splitting chemicals into smaller parts without using water (catabolic)	Decarboxylases, aldolases
Oxidoreductase	Transfers electrons or hydrogen atoms from one molecule to another	Dehydrogenases, oxidases
Synthetases	Joining of two molecules by the formation of new bonds (anabolic)	DNA ligase, DNA polymerase
Transferase	Moving a functional group from one molecule to another	Kinases, transaminase

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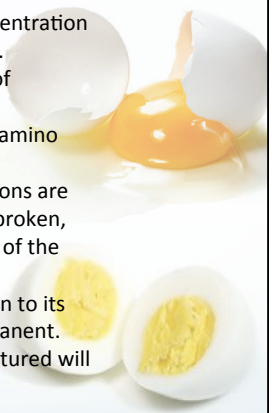
IV. Factors Affecting Enzyme Activity

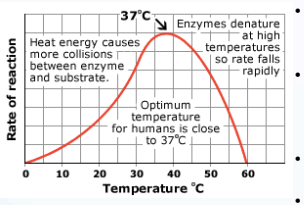
A. Temperature, pH and substrate concentration affect the rate of activity of enzymes.
   1. The 3 dimensional conformation of proteins is stabilized by bonds or interactions between R groups of amino acids within the molecule.
   2. Most of these bonds and interactions are relatively weak and can be easily broken, resulting in a change to the shape of the protein called denaturation.
   3. A denatured protein will not return to its normal shape, the change is permanent.
   4. Many soluble proteins when denatured will become insoluble.

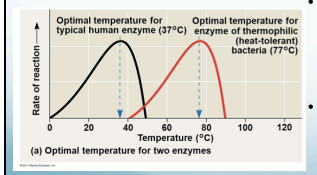


Natural Home Remedies for Life; recipetips.com

IV. Factors Affecting Enzyme Activity

B. Temperature



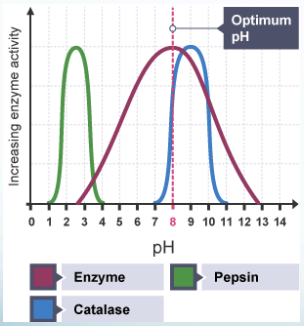


- *At low temperature there is little thermal/ kinetic energy for the activation of the enzyme catalyzed reaction to be successful.*
- *Increasing temperature increases thermal/ kinetic energy of both the enzyme and substrate, resulting a higher number of collisions, and increased enzyme activity.*
- *At an optimal temperature, the rate of enzyme activity will be at its peak.*
- *At higher than optimal temperatures, the enzyme will have reduced stability due to the increase in thermal/kinetic energy disrupting the hydrogen bonds holding the enzyme together.*
- *The enzyme, particularly the active site, loses its shape resulting in a loss of enzyme activity (denaturation).*

sachabiochem0001.wordpress.com; Peasron Education

IV. Factors Affecting Enzyme Activity

C. pH

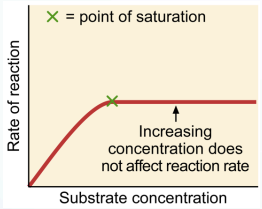


- *Changing the pH will alter the charge of the enzyme which in turn will alter the solubility of the protein and may change the shape of the enzyme.*
- *Changing the shape of the enzyme, particularly the active site, results in a loss of enzyme activity (denaturation).*
- *All enzymes have an optimal pH range. Outside this range, the rate of enzyme activity will be diminished.*

bbc.co.uk

IV. Factors Affecting Enzyme Activity

D. Concentration



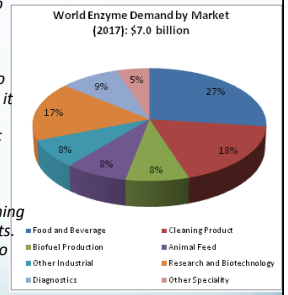
- *Increasing the substrate concentration increases the rate of reaction.*
- *At the optimum concentration of substrate molecules, all active sites of the enzymes are full and working at maximum efficiency.*
- *Any increase in substrate concentration beyond the optimum will have no added effect as there will not be any active sites free to catalyze reactions.*

rsc.org

V. Immobilized Enzymes

A. Common uses of enzymes in industry include:

- *Detergents contain proteases and lipases to help breakdown protein and fat stains.*
- *Biofuels are made from enzymes used to breakdown the starch in grains.*
- *Textiles are made with enzymes that help to process fibers (e.g. polishing cloth) to make it appear more shiny.*
- *Brewing naturally carbonated and alcoholic beverages use enzymes to help clarify the drink and for cleaning.*
- *Medicine and Biotechnology use enzymes widely, from to run diagnostic tests to cleaning contact lenses to cutting DNA into fragments.*
- *Food industry is dependent upon enzymes to increase fruit juice yield with pectin, and produce sweeteners through converting glucose to fructose with isomerase.*
- *Rennin is used in cheese production.*
- *Paper is produced using enzymes to pulp wood.*

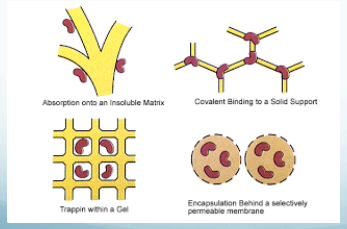


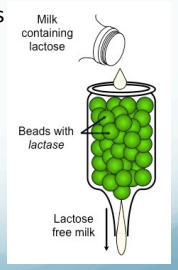
themoneyroller.com

V. Immobilized Enzymes

B. Enzymes are immobilized by in industry by attaching them to a material to restrict their movement. Common methods are:

1. Aggregations of enzymes bonded together
2. Attached to inert surfaces like glass
3. Entrapped in gels such as alginate beads





Bioninja.com.au; enzymetechnology.blogspot.com

V. Immobilized Enzymes

C. Advantages of immobilization are:

1. Easy separation of enzymes from the products.
2. The endpoint of the reaction can be better controlled if separation is easier.
3. The enzymes can be recollected and reused.
4. Increases stability of the enzyme increasing reaction rate and yield.
5. More enzyme – substrate collisions can occur.

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