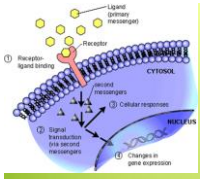
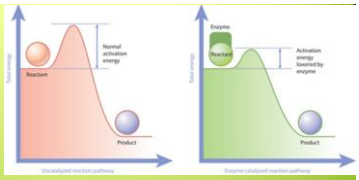
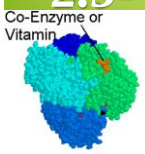
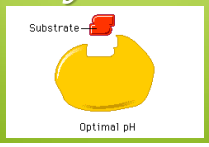
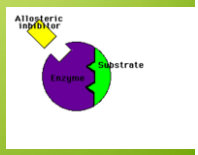




Molecular Biology
2.5- Enzymes

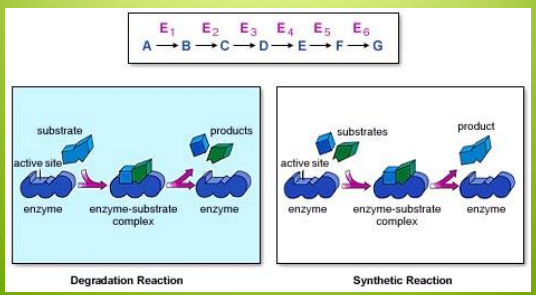






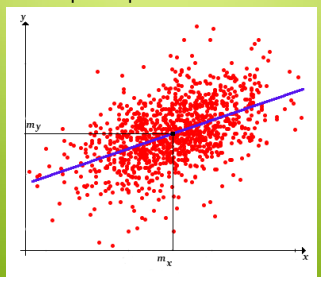
Essential idea:

- Enzymes control the metabolism of the cell.



Nature of science:

- Experimental design
  - accurate, quantitative measurements in enzyme experiments require replicates to ensure reliability. (3.2)

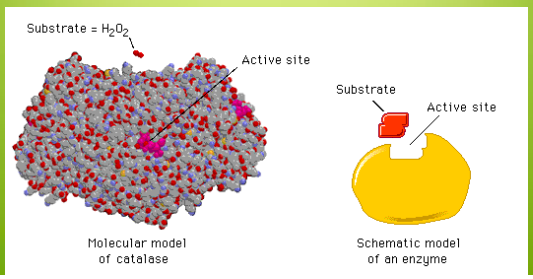


Theory of knowledge:

- Development of some techniques benefits particular human populations more than others.
  - Example: the development of lactose-free milk available in Europe and North America would have greater benefit in Africa/Asia where lactose intolerance is more prevalent. The development of techniques requires financial investment.
  - Should knowledge be shared when techniques developed in one part of the world are more applicable in another?

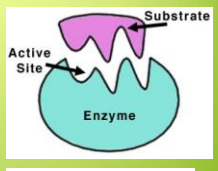
Enzymes

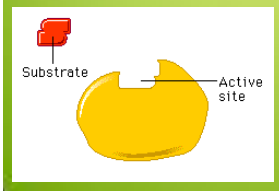
- Enzymes are globular proteins
- Enzymes have an active site to which specific substrates bind.

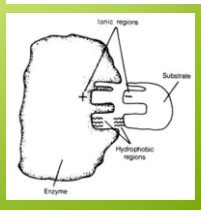


Enzyme-Substrate Complexes

- Substrates are reactants in an enzymatic reaction.
- The substrate must be complementary to the surface properties (shape and charge) of the active site.
- Active site is a microenvironment

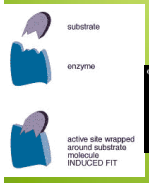


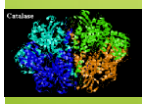


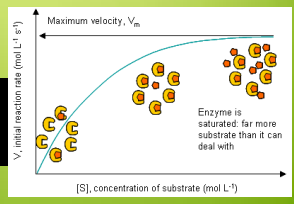


Enzyme-Substrate Complexes

- Induced-fit model
  - Slight change in enzyme shape when substrate binds
  - Facilitates the reaction
- When all enzymes are filled (saturated) reaction can't go faster
- Most enzymes named adding the ending "-ase."

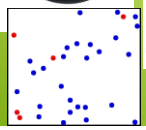


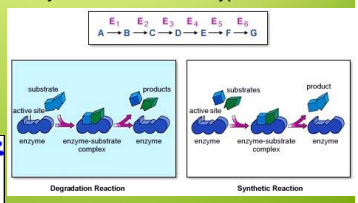




How Enzymes Work

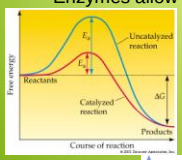
- Enzymes are **catalytic** proteins
- Speed chemical reactions without being changed
- Enzyme catalysis involves molecular motion and the collision of substrates with the active site.
- Every enzyme catalyzes only one reaction or one type of reaction.

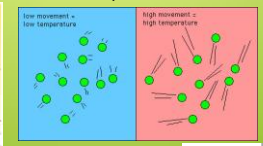


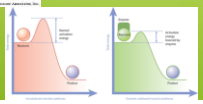


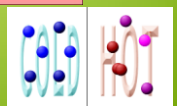
How Enzymes Work

- Enzymes lower the Energy of Activation
  - **Energy of activation (E_A)** is energy that must be added to cause molecules to react
  - Heat speeds a reaction, but denatures proteins
  - Enzymes allow reactions to proceed at moderate temps



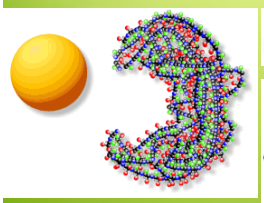


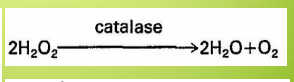


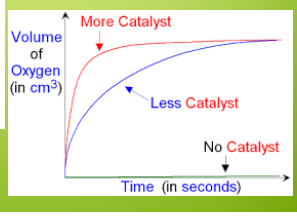


Enzyme Activity

- Enzymatic reactions are rapid
  - Most occur 1000 times/sec
  - $2H_2O_2 \rightarrow 2H_2O + O_2$ (600,000 times/sec with catalase).

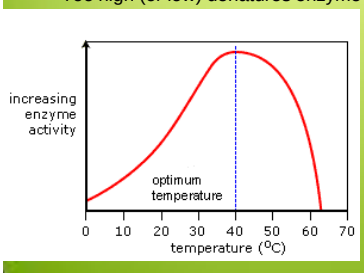


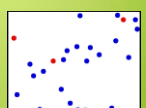


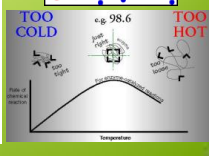


Enzyme Activity

- Temperature
  - Increase temp → increase molecular collisions → increase enzyme activity
  - Too high (or low) denatures enzyme

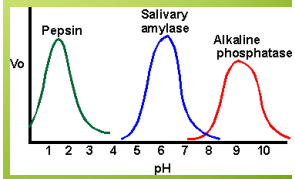






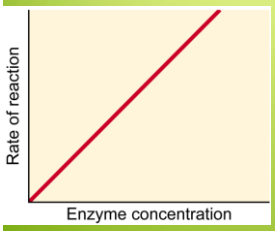
Enzyme Activity

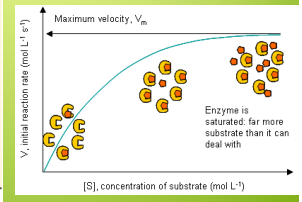
- pH
  - Each enzyme has optimal pH that maintains its normal configuration.
  - A change in pH alters ionization of side chains, eventually resulting in denaturation.
  - Optimal pH varies per enzyme



Enzyme Activity

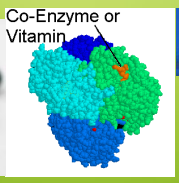
- Concentration
  - Enzyme- increases rate (to a point)
  - Substrate- increases rate till enzyme is saturated





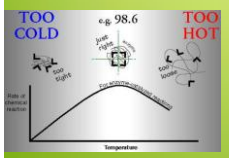
Cofactors and Coenzymes

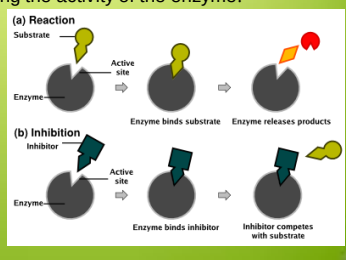
- Many enzymes require an inorganic ion or nonprotein cofactor to function
- The enzyme may only become active when all the appropriate cofactors or coenzymes are present and bind to the appropriate sites on the enzyme.
- Cofactors- inorganic ions (iron,zinc, copper)
- **Coenzymes**- Organic cofactors (vitamins)



Controlling Metabolism

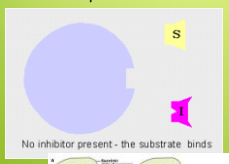
- Other molecules and the environment in which the enzyme acts can enhance or inhibit enzyme activity.
- Molecules can bind reversibly or irreversibly to the active or allosteric sites, changing the activity of the enzyme.

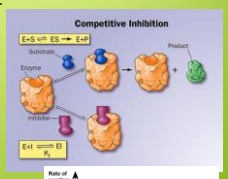


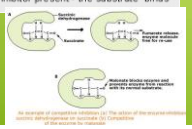


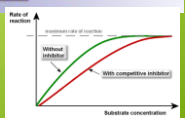
Controlling Metabolism

- Competitive Inhibition
  - Another molecule is similar to enzyme's substrate
  - **Competes** with substrate for enzyme's **active site**
  - Decreases product formation rate.



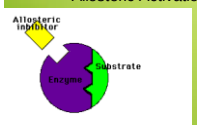


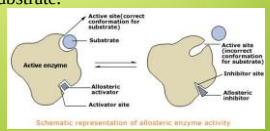


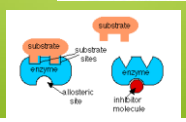


Controlling Metabolism

- Allosteric Interactions
  - Noncompetitive Inhibition
    - A molecule binds to an allosteric site (a site other than active site)
    - Changes the three-dimensional structure of the enzyme
    - Cannot bind to its substrate.
  - Allosteric Activation

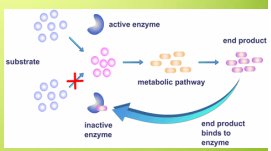


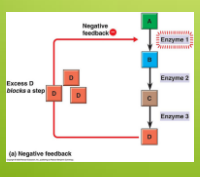




Controlling Metabolism

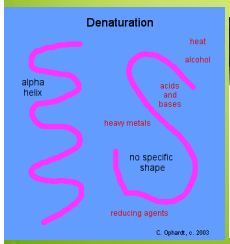
- Feedback Inhibition
  - Regulates activity of most enzymes
  - Product binds to enzyme's active or allosteric site
  - Concentrations of products can be kept within narrow ranges.

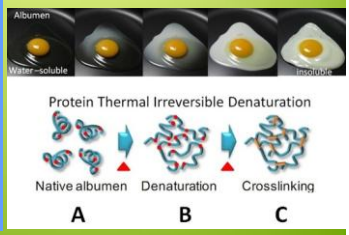




Denaturation of Enzymes

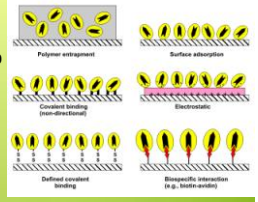
- Denaturation of proteins by heat or by deviation of pH from the optimum can immobilize proteins
  - Remember these slides? (from 2.4- Proteins)





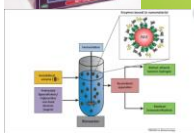
Immobilized Enzymes

- Enzymes used in industry are usually immobilized.
- They are attached to a material so that their movement is restricted.
- Common ways of doing this are:
  - Aggregations of enzymes bonded together
  - Attached to surfaces, e.g. glass
  - Entrapped in gels, e.g. alginate gel beads



Immobilized Enzymes

- Widely used in industry.
  - Detergents contain proteases and lipases to breakdown protein and fat stains.
  - Breakdown the starch or cellulose into biofuels that can be combusted.
  - In the textiles industry enzymes help in the processing of fibers and leather.
  - Paper production uses enzymes to helping in the pulping of wood

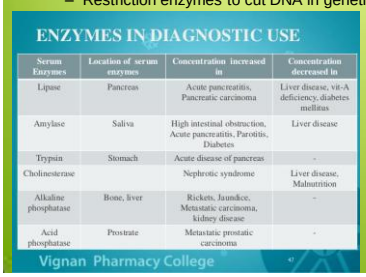


Immobilized Enzymes

- Widely used in the food industry
  - Pectin to increase the juice yield from fruit.
  - Rennin is used to help in cheese production.
  - Various enzymes used in clarification of beer.

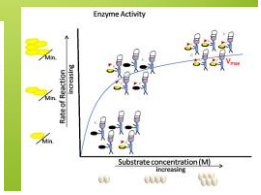
Immobilized Enzymes

- Medicine & Biotechnology
  - Diagnostic tests
  - Contact lens cleaners
  - Restriction enzymes to cut DNA in genetic engineering.



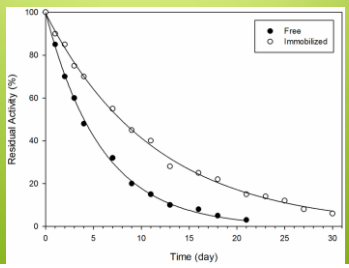
Advantages of Enzyme Immobilization

- Concentration of substrate can be increased as the enzyme is not dissolved
  - this increases the rate of reaction
- Recycled enzymes can be used many times
  - Easy to separate from the reaction mixture
  - Reaction can stopped at the correct time
  - Cost saving.



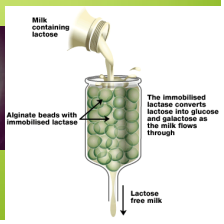
Advantages of Enzyme Immobilization

- Stability of the enzyme to changes in temperature and pH is increased
  - Reduces the rate of degradation
  - Cost saving.



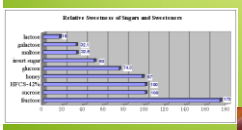
Production of Lactose-free Milk

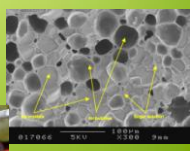
- Lactase obtained from commonly from yeast or bacteria.
- Lactase is bound to the surface of alginate beads.
- Milk is passed (repeatedly) over the beads.
- The lactose is broken down into glucose and galactose.
- The immobilized enzyme remains to be used again



Production of Lactose-free Milk

- Other uses of lactose free milk:
  - Increase the sweetness of milk (glucose and galactose are sweeter)
  - Reduce need for artificial sweeteners
  - Reducing the crystallization of ice-creams (glucose and galactose are more soluble than lactose)
  - Shorten the production time for yogurts or cheese (bacteria ferment glucose and galactose more readily than lactose)

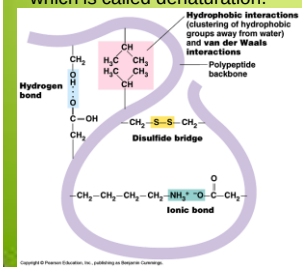


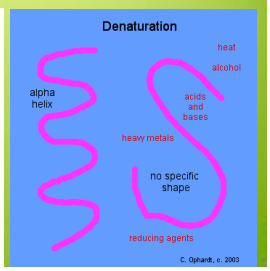


End

Altering Protein Structure

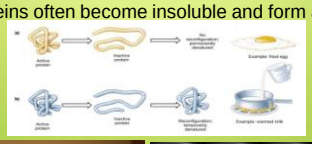
- Most bonds and interactions of protein structure are relatively weak can be disrupted or broken.
- This results in a change to the conformation of the protein, which is called denaturation.

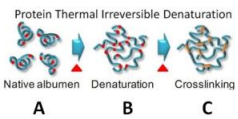




Altering Protein Structure

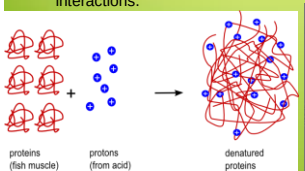
- Denaturation is permanent in most cases.
- Soluble proteins often become insoluble and form a precipitate.

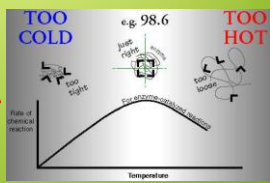




Altering Protein Structure

- Extremes of pH can cause denaturation
  - charges on R groups are changed
  - breaks ionic bonds within the protein or causes new ionic bonds to form.
- Heat can cause denaturation
  - vibrations within the molecule breaks intermolecular bonds or interactions.





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