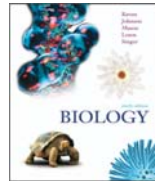


(C) Enzymes



AICE BIOLOGY

Jones ch 3, Raven ch 6



A few definitions

- Metabolism:
 - the totality of an organism's chemical reactions that manage the material and energy resources of an organism.
- Catabolism:
 - catabolic pathway that releases energy by breaking down complex molecules into simpler ones.
- Anabolism:
 - anabolic pathway that consumes energy to synthesize a complex molecule from simpler compounds.
- Catalyst:
 - chemical agent that increases the rate of a reaction without being changed or consumed by the reaction

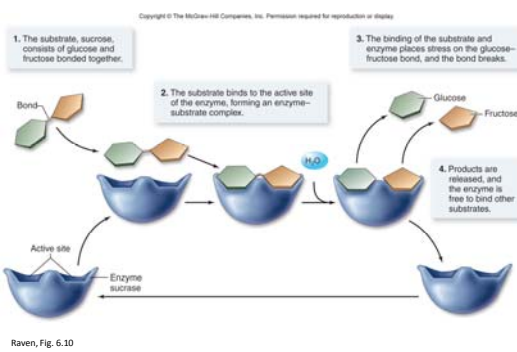
Enzymes

- Enzymes are proteins that act as a biological catalyst
 - Speed up rxn without perm. changing enzyme
 - Substance present at the start of the enzyme-catalyzed rxn is called the **substrate**
 - The **product** is the new substance or substances formed

Enzymes as catalysts

- Substrate is specific for enzyme and will be split into two or more molecules
- May catalyze the joining of two molecules such as a dipeptide from two amino acids.
 - Final molecule is called a product
- Enzymes are unchanged at the end of a process, so once the substrate is either broken down or built up, they are free to continue working more

Example of an enzyme-catalyzed reaction: Hydrolysis of sucrose



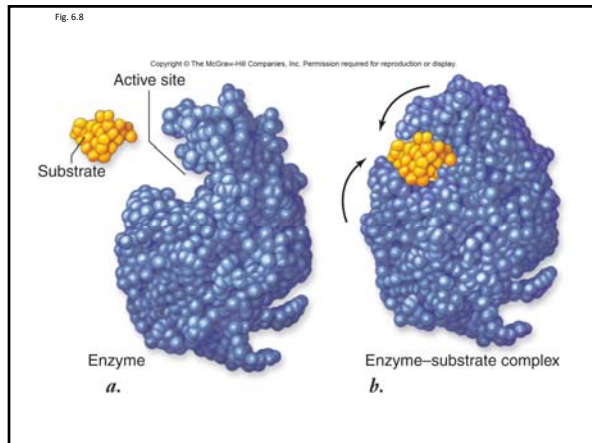
- All biological material contains catalase.
 - potatoes and celery
 - Experiments with catalase and hydrogen peroxide

Following the course of rxn

- You can follow what happen over time in a rxn catalyzed by an enzyme by
 - Measuring the rate of formation of the product
 - Measuring the rate of disappearance of the substrate
- Ex: Measuring the rate of formation of oxygen
 - Hydrogen peroxide $\xrightarrow{\text{catalase}}$ oxygen + water
 - Releases these products at the rate of 10^7 molecules per second

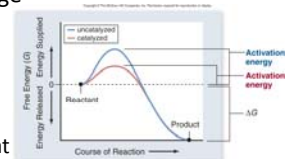
Active Sites

- Enzymes are globular proteins
 - In one part of the molecule there is an area called the active site where the substrate molecule can bind, producing a enzyme-substrate complex
 - 3D shape of the active site fits the substrate perfectly; *enzyme is specific for substrate*



Activation Energy

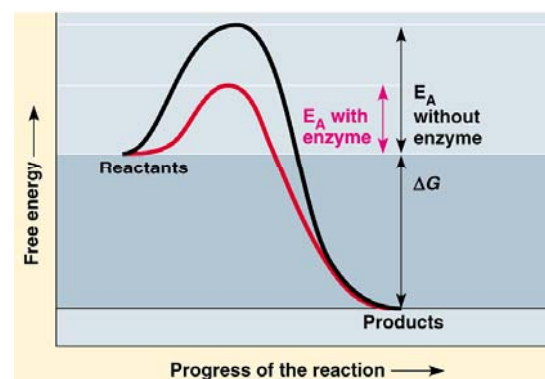
- Substrates generally need to be supplied with energy to cause them to change into products
 - Activation energy
 - Heat- causes rxn
 - Enzymes – work even at low temps, reducing activation energy needed

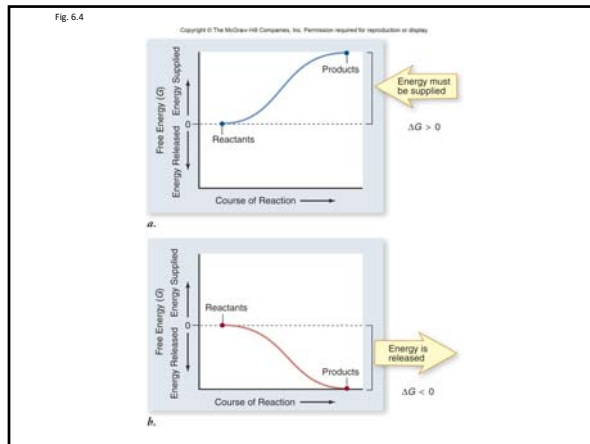


Enzymes reduce activation energy

- Most reactions in living cells could occur without an enzyme, but it would be too slow for life to continue (hydrogen peroxide \rightarrow water and oxygen), or they would never happen at all (breakdown of sugars).
- First, there must be some activation energy, the energy of the substrate must be raised in order for a reaction (hydrogen peroxide in sunshine or a clear bottle). Usually heat.
- Keeping your body heat maintained at 37°C
- Enzymes reduce the amount of activation energy needed

Enzymes lower the barrier of activation energy





Factors affecting rate of enzyme-catalyzed rxn

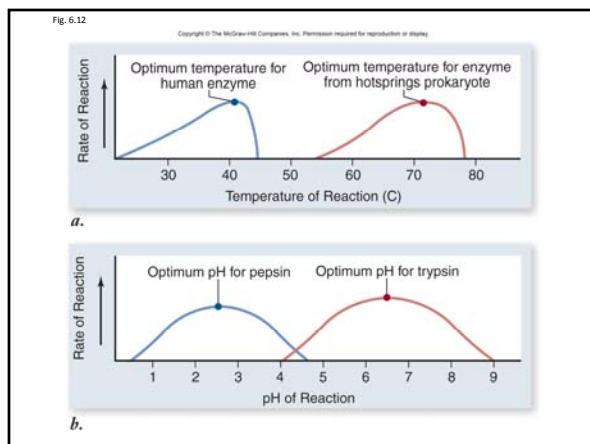
- Temperature
- pH
- Enzyme concentration
- Substrate concentration
- Inhibitors

Temperature and enzyme activity

- By raising the temperature, the kinetic motion of the enzyme increases and will increase the chance that a substrate will find an enzyme
- If the temp becomes too high, denaturation will occur and the enzyme will self destruct and lose its shape (form determines function)
- Optimum temp is the maximum rate of reaction

pH and enzyme activity

- Figure 3.9 shows most enzymes work in a neutral pH of 7.
- Protease, breaks down proteins, is in the very acidic environment of the stomach



Effect of enzyme concentration

- Figure 3.5
- Take five test tubes and fill them each with the same amount of hydrogen peroxide= end products should be the same for each
- Now use five different concentration of catalase and test the rate of reaction
- Initial rate of reaction is only fair comparison since by the end, all will eventually have the same byproducts
- Initial rates of reaction should increase linearly. Reaction rate is directly proportional to the enzyme concentration
- The more enzyme, the more active sites for the substrate

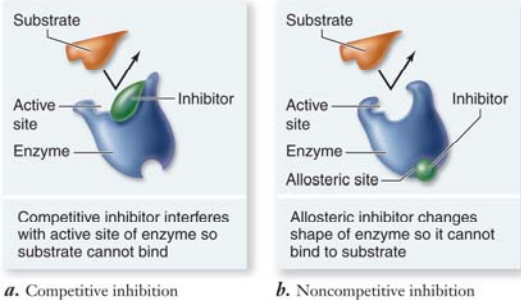
The effect of substrate concentration

- The enzyme working at its maximum possible rate is called the V_{max} .
- Increasing a substrate to the point when all the enzymes are being used and the substrate is now waiting for the enzyme.

Enzyme inhibitors

- A competitor for the active site will interfere with the substrate's ability to bind with an enzyme
- Reaction rate will vary if there is more substrate or inhibitor
- A competitive inhibitor will bind at the active site, a non-competitive inhibitor will bind elsewhere, but will distort the shape of the enzyme.
- Most are reversible when competitor leaves
- End product inhibition is an example of non-competitive reversible inhibition
- Irreversible inhibition is when the enzyme is permanently changed and will no longer work.

Inhibitors



The course of a reaction

- Getting to know catalase and how it breaks down hydrogen peroxide
- H_2O_2 is a toxic by-product from your metabolism
- Catalase exists in all living tissues
- Reaction is swift, marked by bubbles of O_2
- Will eventually slow down and stop (nothing left but water)
- Steep curve at the beginning is initial rate of reaction, lots of substrate to hit the enzymes
- Easy to graph

Fig. 6.14

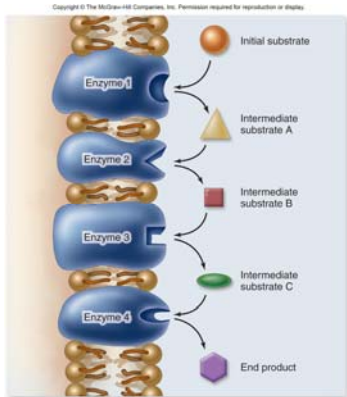
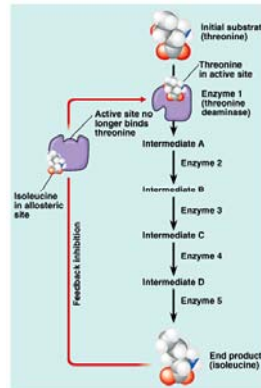
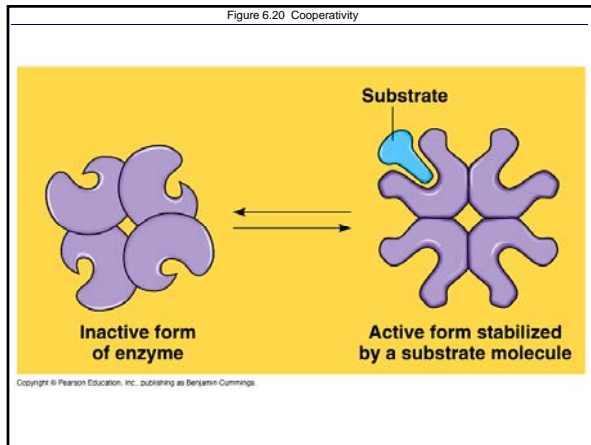
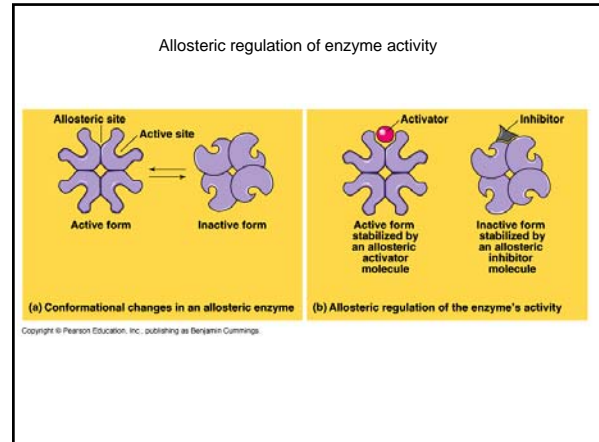
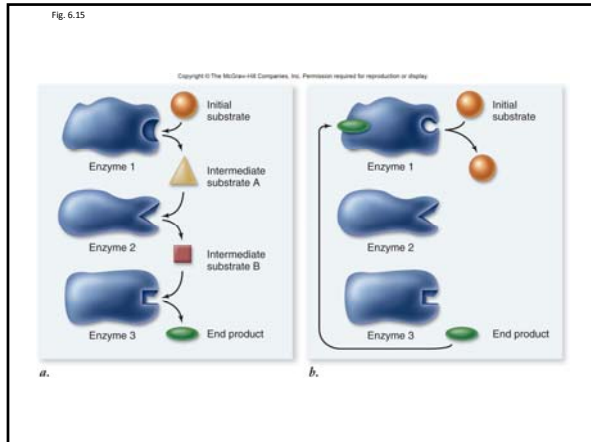


Figure 6.19 Feedback inhibition





ENZYMES

- follow the time course of an enzyme-catalysed reaction by measuring rates of formation of products (for example, using catalase) or rates of disappearance of substrate (for example, using amylase)

- ### Measuring reaction rate
- More difficult to measure how amylase breaks down starch (amylose and amylopectin) into maltose
 - Instead, measure how fast starch disappears from the reaction mixture
 - Take samples at known time and add iodine
 - Can also mix starch, iodine in potassium iodide solution and amylase in a tube and take regular readings of the color, however, iodine interferes with the rate of reaction and slows it down.

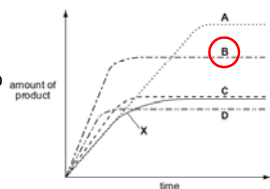
- ### Enzyme rules: form determines function of the enzyme - substrate complex
- Specificity: one enzyme to one substrate
 - Names often end in -ase and will correlate with substrate: lipase \leftrightarrow lipose, amylase \leftrightarrow amylose, etc.
 - Globular proteins with 3-D shape
 - Hydrophilic R-groups on the outside to ensure that they are water soluble.
 - All possess an active site specific for that substrate, must be a perfect fit and will be helped in place by some of the R-groups amino acids

ENZYMES

(d) investigate and explain the effects of temperature, pH, enzyme concentration and substrate concentration on the rate of enzyme-catalysed reactions, and explain these effects;

Practice Question 1:

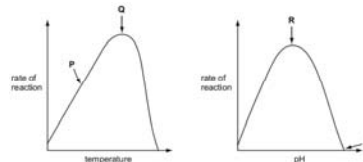
The curve X shows the activity of an enzyme at 20°C. Curves A to D show the effect of different conditions on the activity of the enzyme.



Which curve shows the effect of increasing the temperature by 10° C and adding extra substrate?

Enzymes Practice Question 2

The graphs show the effects of temperature and pH on enzyme activity.

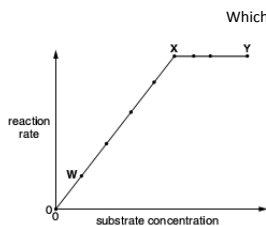


Which statement explains the enzyme activity at the point shown?

- A. At P, hydrogen bonds are formed between enzyme & substrate.
- B. At Q, the kinetic energy of enzyme and substrate is highest.
- C. At R, peptide bonds in the enzyme begin to break.
- D. At S, the substrate is completely denatured.

Enzymes Practice Question 3

The graph shows the effect of substrate concentration on the rate of an enzyme-controlled reaction. The enzyme concentration is constant.



Which statement about the graph is correct?

- A. Between W and X, the number of enzyme molecules is limiting.
- B. Between X and Y, the number of enzyme molecules is limiting.
- C. Between X and Y, the number of substrate molecules is limiting.
- D. Between X and Y, the product concentration remains the same.

Resources

Jones, M. (2010). Cambridge International A/AS- Level Revision Guide. London, NW1. Hodder Education.

Jones, M., Fosbery, R., Taylor, D., & Gregory, J. (2007). AS Level and A Level *Biology, 2nd ed.* Cambridge, UK: Cambridge University Press.

Raven, P., et al. (2011). *Biology, 9th ed.* McGraw-Hill Companies Inc.