IB CHEMISTRY:
OPTION B BIOCHEMISTRY NOTES

B.1 Introduction to biochemistry

Biochemistry

- Biochemistry: The study of chemical process in living matter
- Biochemical processes are known as metabolism
- Metabolism: The sum of the chemical reactions occurring in an organism
- Metabolic reactions take place in highly controlled aqueous environments
- Metabolic reactions can classified be anabolic or catabolic

Definitions
Anabolism – The synthesis of complex molecules from simpler units, it requires energy (endothermic)
Catabolism – The breakdown of complex molecules into simpler units, it releases energy (exothermic)

Formation of polymers

- The functions of biological molecules depend on their shapes and structures.
- Biopolymers are commonly made of smaller, recurring sub units called monomers
- Biological polymers form by condensation reactions in which monomers react to form a polymer. This releases water
- Biological polymers are broken down by hydrolysis reactions in which a polymer breaks up into separate monomers. This requires water

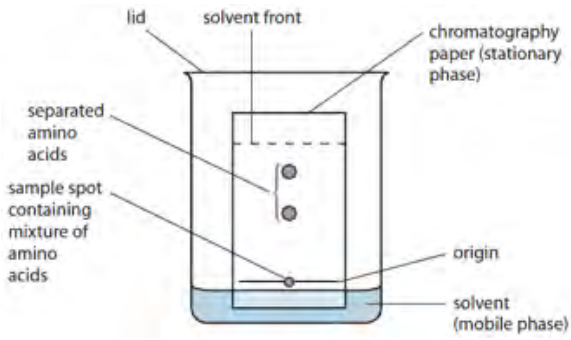
Photosynthesis and Respiration

- **Photosynthesis: The synthesis of energy rich molecules (like glucose) from carbon dioxide and water using light energy**
- Photosynthesis Equation: $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

- The amino acids all differ in their ability to dissolve in the solvent (the mobile phase) and also in their ability to bind to the stationary phase. Therefore, they will move up at different rates and reach different heights. **Ninhydrin** is often used as locating agent to make the spots visible
- The amino acids can now be identified by comparing the R_f values or to pure samples run under the same conditions
- **The R_f values can be determined with the formula**:

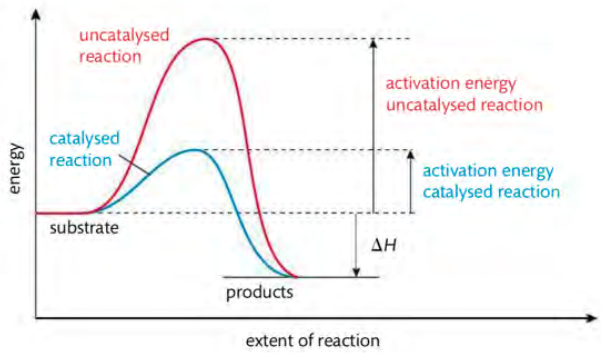
$$R_f = \frac{distance\ moved\ from\ origin\ by\ amino\ acid}{distance\ moved\ by\ solvent\ from\ origin}$$

- R_f is always less than or equal to 1 and has no units

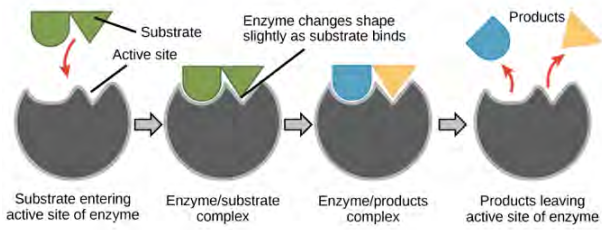


Enzymes

- **Enzymes are globular proteins that act as biological catalysts, increasing reaction rates of biological processes without being used up in the process**
- Enzymes control the manufacture of complex substances, such as skin and blood as well as the breaking down of chemicals to provide energy
- Compared with inorganic catalysts enzymes:
    - Produce much faster reaction rates
    - Operate under much milder conditions
    - More sensitive and selective
    - Can become denatured at high temperatures (affecting tertiary structure)

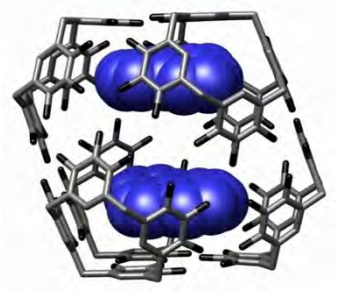


- The active site of an enzyme is usually a flexible hollow or cavity within the molecule
- **The induced-fit model is a theory that says the active site will change shape to enfold a substrate molecule**
- A reactant molecule, known as the substrate is maneuvered into the site and it is there at the surface of the enzyme that the reaction takes place
    1. The reactant (substrate) enters the active site
    2. Bonds formed between the enzyme and substrate weaken lowering the reaction's activation energy



• Broken down by bacteria or other organism • Reduces plastic waste • Reduce use of petrochemicals	• Increases use of fertilizes and pesticides • Might breakdown before end of use • Release of methane/greenhouse gas during degradation

Host-Guest chemistry



- Host-guest complexes are composed of two or more molecules or ions that are held together through non-covalent bonding
- Host–guest chemistry is very similar to enzymes as it uses host molecules (like enzymes) that bond with specific guest molecules (like substrates) to form host-guest complexes (like enzyme-substrate complexes)
- The difference between host-guest complexes and enzyme-substrate complexes is that in host-guest chemistry the host is a synthetic molecule specially developed to bond to a specific 'target' molecule (guest)
- Note that – as in enzyme-substrate complexes – the bonds that hold the host-guest complex together are all non-covalent attractions, e.g. hydrogen bonds and dipole-dipole, ionic and hydrophobic attractions
- Host-guest chemistry can be applied to the removal of xenobiotics in the environment
- The binding between a xenobiotic and a host produces a supramolecule

Biomagnification and Bioaccumulation

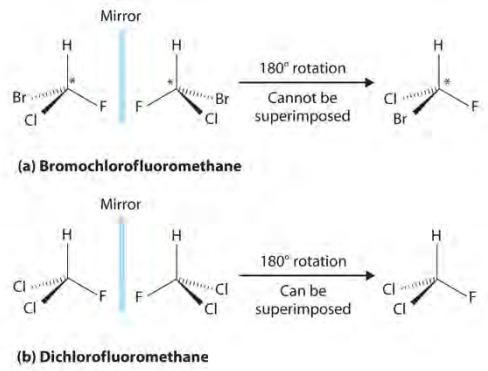
- Biomagnification: A process that leads to increasing concentrations of (unwanted) substances in animals as you go higher up the food chain
- Bioaccumulation: The accumulation (build up) of a substance within an organism over time
- An example includes DDT:
- DDT is an insecticide that was used to control mosquito populations that spread diseases such as malaria and typhus
- DDT is readily soluble in fat and does not break down therefore it accumulates in fatty tissue
- In the 1960s bird of prey such as ospreys suffered a decline in numbers which was due to the toxic effect of DDT
- The use of DDT as an insecticide was banned in many countries in the 1970s

- Anthocyanins are water soluble as they have polar hydroxyl groups which allow them to form hydrogen bonds
- Anthocyanins are very sensitive to pH which also means they can be used as pH indicators. Although with different pH they undergo different structures
- The color changes arise form transfer of H^+ from OH groups, which alters the conjugation and so the absorbance at the chromophore

B.10 Stereochemistry in biomolecules

Stereochemistry

- Stereoisomers represent different spatial arrangements of the atoms in a molecule
- Many biopolymers can exist as stereoisomers, each with distinct characteristics generally meaning that only one form of the isomer can be used
- A chiral molecule is non-superimposable on its mirror image so that the mirror image is actually a different molecule
- An achiral molecule is a molecule that is superimposable on its mirror image



Enantiomers

- Enantiomers are pairs of stereoisomers that are chiral
- They have exactly the same connectivity but opposite three-dimensional shapes
- However, enantiomers are not the same as each other, one enantiomer cannot be superimposed on the other but is a mirror image of the molecule
- Two enantiomers have identical physical properties, except for rotation

Proteins: Amino acids

- In amino acids, the carboxyl group, amino group, hydrogen atom and R group are all bonded to the same carbon
- Because there are four different groups all amino acids are chiral (except glycine) meaning that the amino acids are optically active and can exist as two different stereoisomers (known as enantiomers)
- The different stereoisomers of amino acids are most commonly known as L and D forms
- The L and D forms of amino acids have identical physical properties and chemical reactivity's
    - L: Laevorieterity