

# Biochemistry

Food is a good source of one or more of the following: protein, carbohydrate or lipid.  
Living organisms need food for energy, growth, repair, defence and reproduction.

## Metabolism

- **Anabolism:** the formation of large, complex molecules by linking smaller, simpler molecules (*condensation reactions – form water*).
- **Catabolism:** the breakdown of large, complex molecules into smaller molecules (*hydrolysis reactions – add water*).
  - Anabolic reactions require energy input (= *endothermic – need ATP*)
  - Catabolic reactions release energy (= *exothermic*).
- **Metabolism** is the full set of chemical processes carried out by a living organism (*i.e. anabolism + catabolism*).

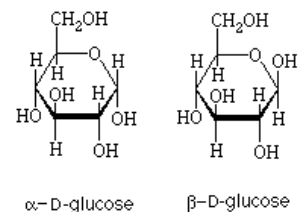
## Water:

### Importance of Water for Organisms

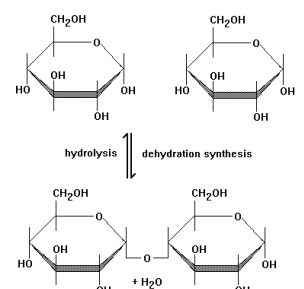
- Fluid component: 90% of cytoplasm, 92% of blood plasma, 97% of tissue fluid and lymph.
- Multipurpose solvent: medium for metabolism and transport.
- Takes part in metabolic reactions
  - Photosynthesis: water is a raw material in the light stage.
  - Respiration: aerobic respiration produces water.
  - Anabolism: produced when macromolecules are made (*condensation*).
  - Catabolism: water is used to break the bonds in macromolecules (*hydrolysis*).
- Movement of materials through cell membranes: diffusion, osmosis and active transport.
- Turgor plays an important role in the support of plants.
- Good absorber of heat
  - Water is a temperature-stable medium - which is important for homeostasis.
  - Vaporisation of water is an excellent cooling mechanism.

## Carbohydrates [General formula $C(H_2O)_n$ ]

- Elements: CHO (only).
- **Monosaccharides:** single sugar unit (*glucose, fructose, galactose*)
  - Pentoses:  $C_5H_{10}O_5$  Deoxyribose (DNA) and Ribose (RNA & ATP)
  - Hexoses:  $C_6H_{12}O_6$  Glucose, Fructose, Galactose
  - *N.B. Be sure you can draw both  $\alpha$ - and  $\beta$ - glucose!*

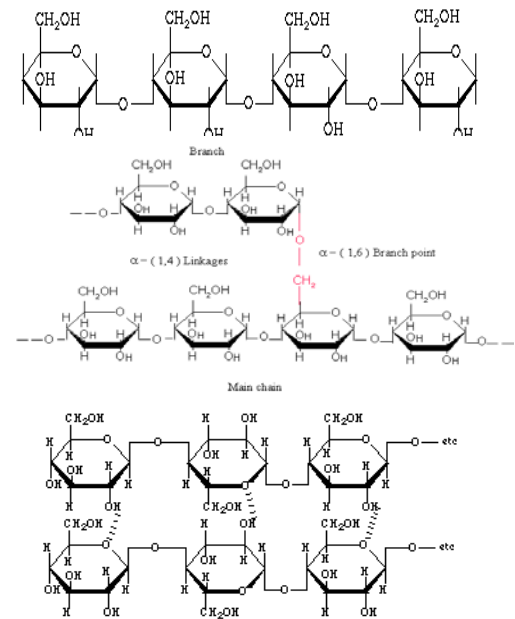


- **Disaccharides:** double sugars i.e. two sugar units linked together (condensation - forming water – e.g. *maltose, sucrose, lactose*)
  - **Maltose:** glucose + glucose — intermediate between glucose and starch (*N.B. draw!*)
  - **Sucrose:** glucose + fructose — transported in the phloem of plants
  - **Lactose:** glucose + galactose — the sugar present in milk



**Polysaccharides:** multisugars — the three examples are ‘polyglucoses’

- o **Starch:** plant glucose reserve
  - made of  $\frac{1}{3}$  **amylose** (1:4  $\alpha$  glycosidic bonds only)
  - and  $\frac{2}{3}$  **amylopectin** (1:4 & 1:6  $\alpha$  glycosidic bonds)
- o **Glycogen:** glucose reserve of animals (*liver and muscle*) and fungi. Similar to **amylopectin**
- o **Cellulose:** plant cells walls (= fibre in our diet)
  - Made of 1:4  $\beta$  glycosidic bonds only



### Structural Role of Carbohydrates

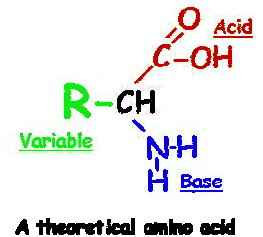
- **Cellulose** walls of plant cells.
- **Chitin** in the cell walls of fungi.

### Metabolic Role of Carbohydrate

- **Energy source:** energy released by the respiration of glucose is used to make ATP.
- **Energy storage:** starch in plants, glycogen in animals and fungi.

### Protein

- **Elements:** C, H, O, N and S in all proteins. *N.B. Only 2 (of 20) amino-acids contain S.*
- **Monomer:** Amino acids are the subunits that are linked by peptide bonds (*primary structure*)
- **20 different** amino acids - each different sequence of amino acids produces a different protein (*controlled by DNA and mRNA*).
- Each protein has a specific functional shape (*N.B. active site/enzyme-substrate complexes*).
  - o **Primary structure** - the amino-acid sequence (peptide bonds)
  - o **Secondary structure** - ( $\alpha$ -helix and  $\beta$ -pleated sheet).
    - Caused by H-bonds (pH!)
  - o **Tertiary structure** - the **fold**s making the **active site**.
    - Caused by H-bonds and disulphide bridges.
    - Affected by heat ( $>60^{\circ}\text{C}$ ) and pH – **denaturing**.
- **Protein synthesis** takes place on the ribosomes (*70s and 80s*) - on the rough e.r.

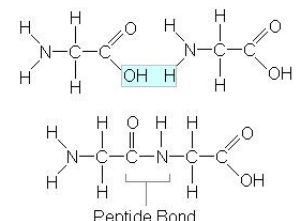


### Structural Role of Protein

- **Keratin:** in hair and outer layer of the skin.
- **Myosin:** major protein in skeletal and cardiac muscle.

### Metabolic Role of Protein

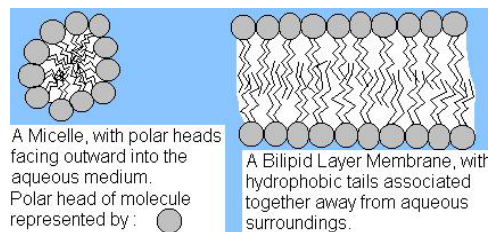
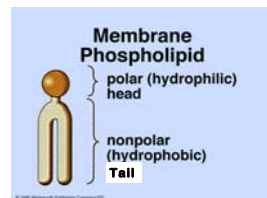
- Many proteins **function as enzymes** (specific biological catalysts).
  - o ‘active site’ – tertiary structure (affected by pH, high temps)
  - o ‘Enzyme-substrate complex’
- **Carrier proteins** in membranes (70%) (*‘facilitated diffusion’ and ‘active transport’*)
- Some proteins function as **hormones** (*insulin*).



A molecule of water is removed from two glycine amino acids to form a peptide bond.

## Triglycerides (Lipids)

- **Elements:** CHO – with more H but less O than carbohydrates.
- Composed of glycerol with 3 x fatty acids ester-bonded to the glycerol.
  - Oil – lipid that is liquid at room temperature.
  - Fat – solid lipid at room temperature.
  - Wax – solid at 100°C
- Phospholipid: two fatty acids and a phosphate group linked to the glycerol. Forms **phospholipid bilayer** in membranes



## Structural Role of Lipid

- Phospholipids are very important in cell membrane structure.
- The protective wax cuticle on the outside of leaves.

## Metabolic Role of Lipids

- Energy storage: more than twice the energy of carbohydrate or protein.
- Energy source: released during respiration.
- Some lipids function as hormones (*sex hormones – oestrogen, progesterone, testosterone*)

## Food Tests

### Starch

- **Yellow-brown iodine solution** is placed on the food sample.
- A **blue-black colour** indicates that starch **is** present.
- A **yellow-brown** colour indicates that starch **is not** present.

### Sugars

**Reducing sugars** e.g. all **but** sucrose.

- Add an equal volume of **blue Benedict's Reagent** to the food solution.
- Heat (**B**oil).
- The **Blue Benedicts** reagent **becomes** **Brick-red**, if reducing sugar present.

**Non-Reducing Sugar N.B. Only** for sucrose.

- Add an equal volume of **blue Benedict's Reagent** to the food solution.
- Add a few drops of dil. HCl
- Neutralise with dil. NaOH solution
- Heat (**B**oil).
- The **Blue Benedicts** solution **becomes** **Brick-red**, if non-reducing sugar present

### Lipid

- Shake the food with ethanol and/or warm gently
- Pour into cold water
- A **CLOUDY-WHITE EMULSION** forms if lipid is present.

### Protein

- **Biuret Test:** Add **Biuret solution** to the food solution (N.B. must be a **solution** of food).
- Shake gently.
- A **lilac colour** (from **pale blue**) indicates protein is present.
- N.B. **NO HEAT**