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).*

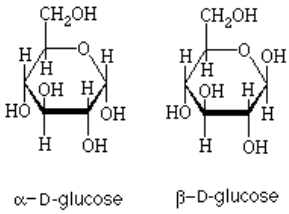
Water:

Importance of Water for Organisms

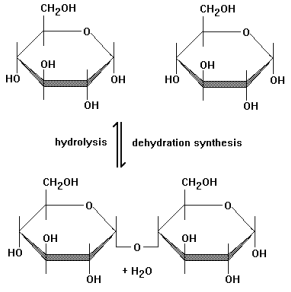
- Fluid component: 90% of cytoplasm, 92% of blood plasma, 97% of tissue fluid and lymph.
- Multipurpose solvent: medium for metabolism and transport.
- Takes part in metabolic reactions
    - Photosynthesis: water is a raw material in the light stage.
    - Respiration: aerobic respiration produces water.
    - 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 α- and β- glucose!*

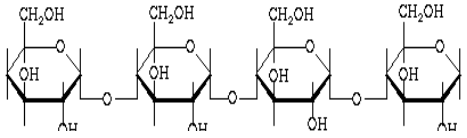


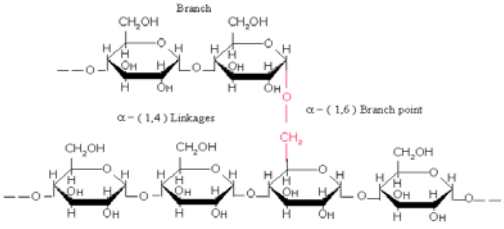
- **Disaccharides**: double sugars i.e. two sugar units linked together (condensation - forming water – e.g. *maltose, sucrose, lactose)*
    - **Maltose**: glucose + glucose — intermediate between glucose and starch ***(N.B. draw!)***
    - **Sucrose**: glucose + fructose — transported in the phloem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



Polysaccharides: multisugars — the three examples are 'polyglucoses'

- **Starch**: plant glucose reserve
  - made of ⅓ **amylose** (1:4 α glycosidic bonds only)

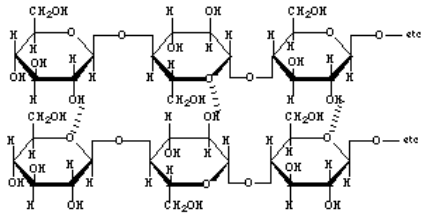




  - and ⅔ **amylopectin** (1:4 **&** 1:6 α glycosidic bonds

- **Glycogen**: glucose reserve of animals (*liver and muscle)* and fungi. Similar to **amylopectin**

- **Cellulose**: plant cells walls (= fibre in our diet)
  - Made of 1:4 β glycosidic bonds only



Structural Role of Carbohydrates

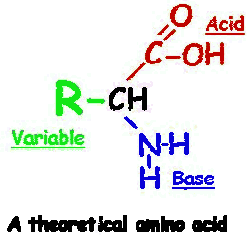
- **Cellulose** walls of plant cells.
- **Chitin** in the cell walls of fungi.

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

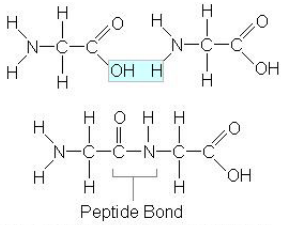
- **Elements**: C, H, O, N and S in all proteins. *N.B. Only 2 (of 20) amino-acids contain S.*
- **Monomer:** Amino acids are the subunits that are linked by peptide bonds (*primary structure)*
- **20 different** amino acids - each different sequence of amino acids produces a different protein (*controlled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



A theoretical amino acid

Structural Role of Protein

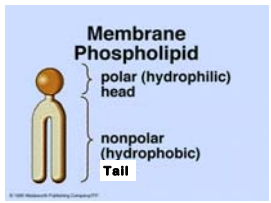
- Keratin: in hair and outer layer of the skin.
- Myosin: major protein in skeletal and cardiac muscle.



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

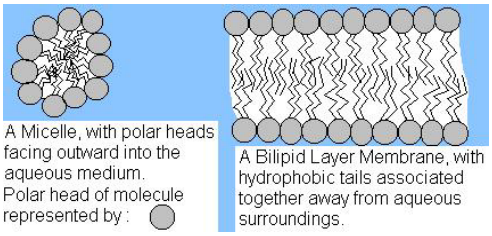
Metabolic Role of Protein

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



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 **B**enedict's Reagent to the food solution.
- Heat (**B**oil).
- The **B**lue Benedicts reagent **b**ecomes **B**rick-red, if reducing sugar present.

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

- Add an equal volume of blue **B**enedict's Reagent to the food solution.
- Add a few drops of dil. HCl
- Neutralise with dil. NaOH solution
- Heat (**B**oil).
- The **B**lue Benedicts solution **b**ecomes **B**rick-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**