Chemicals of Life

Need for food

- Food is a source of energy and raw materials for organisms.
- Need it to provide energy for vital activities of the body
- Repair of worn-out parts of the body and cell-division; to stay healthy

Food provides energy for vital activities

- All living organisms require energy to stay alive
- Through photosynthesis, plants use light energy from sun to convert raw materials from surroundings into food such as **carbohydrates.**
- Contain store of energy called **chemical energy**
- Animals must consume green plants directly or indirectly to get **stored energy**

Energy conversion

- Energy can be converted from one form to another
- E.g. muscle cells convert chemical energy stored in food into kinetic energy
- When energy is converted, some energy is lost as heat energy
- To make up for this loss, food must provide more energy than an organism uses up.
- Organisms require food even at rest

Raw Materials ☾ Protoplasm

- Need to grow, reproduce and repair worn-out parts
- Organisms must make new protoplasm from food

Nutrients

- Organic Nutrients (contain carbon – obtained from living organisms)
    - Carbohydrates
    - Fats
    - Proteins
- Inorganic Nutrients (does not contain carbon)
    - Water

Water

- Essential component of protoplasm
- In mammals, 70% of body weight is water
- Is the medium or substance in which chemical reactions occur in an organism

- Water helps to transport dissolved substances around the body
- Digested products from small intestine to other parts of the body
- Excretory products or waste products from the tissue cells.
- Hormones from glands to part of the body which require them

Water is key component of

- Protoplasm
- Lubricants
- Digestive juices
- Blood
- Tissue fluid

Needed for hydrolysis in digestion.

Carbohydrates

- Organic compounds made of elements carbon (C), Hydrogen (H) and Oxygen (O).
- The hydrogen and oxygen atoms are present in the ration 2:1. $C_x(H2O)_y$.
- Most carbohydrates are hydrophilic (water-loving)

Functions

- Needed as a substrate for respiration
- For supporting structures – e.g. cell walls in plants
- Converted into amino acids and fats
- For formation of nucleic acids.

Sugars

- All sugars are sweet and soluble in water.
- Will lower water potential when dissolved (osmotically active)

Monosaccharides

Polymers which make up larger molecules (polymers) such as disaccharides and polysaccharides.

Most common single sugars(monosaccharides)

- Six carbon atoms
- E.g. glucose, fructose and galactose
- Same general formula – $C_6H_{12}O_6$
- Different structural formula (atoms are arranged differently)

Disaccharides

Each molecule of a double sugar (disaccharide) is made up of 2 molecules of single sugars (monosaccharides).

- General formula – $C_{12}H_{22}O_{11}$
- Common Disaccharides
    - Maltose (glucose + glucose)
    - Sucrose (glucose + fructose)
    - Lactose (glucose + galactose)
- Same general formula, but different structures.

Polysaccharides

Complex carbohydrates are long chains of sugars – polymers of monosaccharides.

- E.g. Starch – storage in plants
    - Potatoes and grains contain mainly starch. Animals can digest starch because their digestive systems break the bonds between glucose monomers.
- E.g. Glycogen – storage in animals
    - Also made up of glucose monomers
    - More extensively branched.
- E.g. Cellulose – cell wall and structure
    - Major component of wood
    - Polymer of glucose, linked in a unique way
    - Cellulose cannot be broken down by animals.

Dehydration Synthesis / Condensation Reaction (*Anabolic*)

- Is a chemical reaction in which two simple molecules are joined together to form a larger molecule with the removal of one molecule of water.
- Forms a glycosidic bond
- One water molecule is losxt
- E.g. Formation of Maltose from 2 glucose molecules

Hydrolysis / Hydrolytic reaction (*Catabolic*)

- Hydrolysis or a hydrolytic reaction is a reaction in which a water molecule is needed to break up a complex molecule into smaller molecule.
- Double sugar can be split into two single sugar molecules by using an enzyme.
- E.g. solution of maltose mixed with enzyme maltase, glucose molecules are produced.
- A molecule of water is needed to split up the maltose molecule.

Identifying Reducing Sugars

Benedict's Reagent

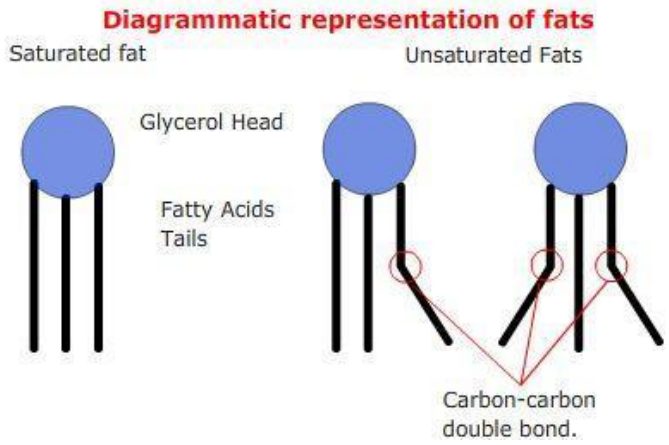
- Blue solution containing copper (II) sulphate. Some sugars reduce the copper (II) sulphate to copper(I). They produce a brick-red precipitate of copper (I) oxide when boiled with Benedict's solution.Sugars with this property are called reducing sugars. Glucose, maltose, fructose, and maltose are reducing sugars.
- Colour changes with different concentrations of RS
    - Trace of reducing sugar - Blue to green mixture
    - Moderate amount of reducing sugar – blue to yellow or orange precipitate
    - Large amount of reducing sugar – Blue to brick-red or orange-red precipitate

Lipids

Lipids are hydrophobic (water-fearing).
Lipids are not macromolecules or polymers. They are not building blocks like carbohydrates.

Fats

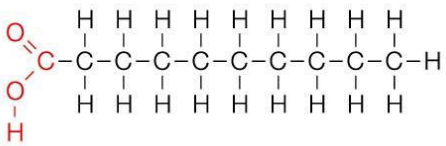
- Organic compounds made up of elements such as carbon, hydrogen and oxygen.
- Contain less oxygen in proportion to hydrogen
- No general formula as proportions of elements that make up fats are not fixed.
- Fats can be animal fats or plant fats.
- Commonly used as store of energy, especially by animals.
- A pound of fat contains twice as much energy than a pound of carbohydrates
    - Difficult to burn fats easily.
- Fat is stored in adipose cells
    - Swell and shrink when we deposit and withdraw fat from them.
    - Cushions vital organs
    - Insulates us



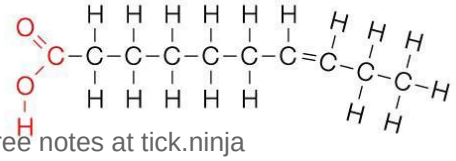
Fats can be broken down into fatty acids and glycerol

Fat molecule + three water molecules → Glycerol + 3 fatty acids

Saturated



Unsaturated



Fatty substance called **cholesterol** is usually found together with polysaturated fats.

- May cause coronary heart disease.
- Some people also develop gallstones which are made up mostly of cholesterol

Unsaturated fats are thought to replace cholesterol level in the blood. Unsaturated fats should replace animal fats in diet.

Hydrogenation

To use a vegetable oil but needs the product to be solid.

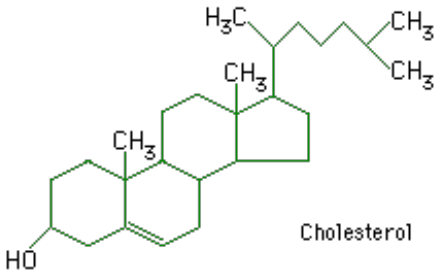
- Converting of unsaturated fats to saturated fats
- Unfortunately produces unhealthy trans-fat toos

Steroids

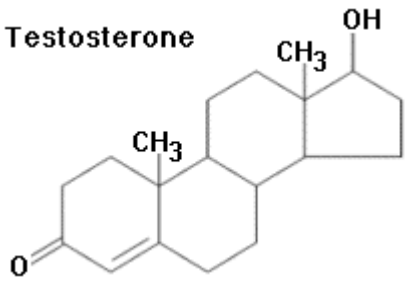
All steroids have a carbon skeleton with four fused rings. Steroids vary based on functional groups attached to this set of rings, and these chemical variations affect their function.

Common steroids:

- Cholesterol
    - Essential component in body
    - In membranes that surround cells
    - Base steroid for production of other steroids



- Testosterone
    - Produced by males
    - Causes buildup of muscle and bone mass during puberty and maintains masculine traits



Anabolic Steroids:

- Synthetic steroids that mimic certain steroids such as testosterone so as to treat diseases or increase body performance.
- E.g. THG
- Disadvantages
    - Violent mood swings
    - Depression
    - Liver damage
    - High cholesterol
    - Infertility

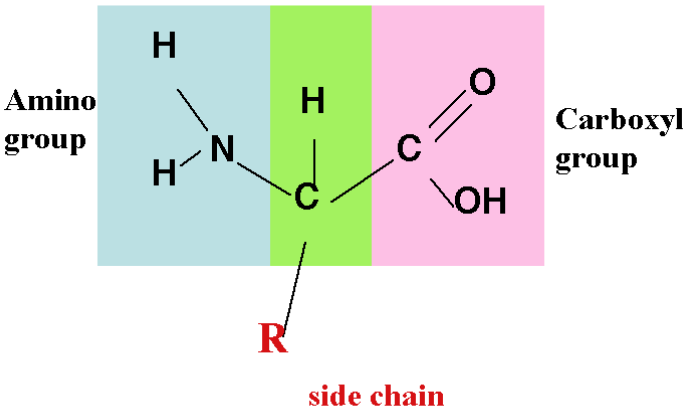
Proteins

Very complex organic substances made up of the elements carbon hydrogen oxygen and nitrogen. Another element, sulfur, may also be present.

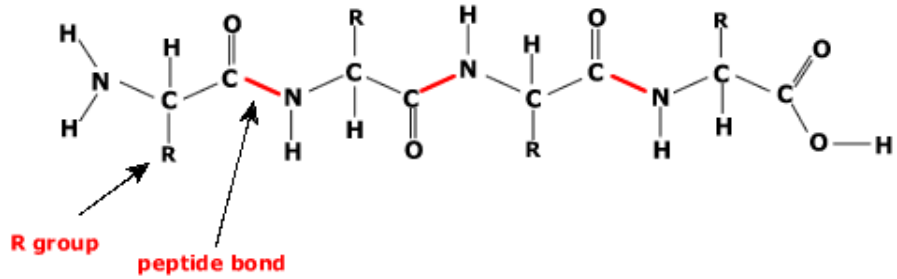
Necessary in everything that cells do

Proteins are always present in protoplasm. Largest and most complicated of all food substances.

Amino acids are building blocks of proteins. The R side chain varies with the 20 different types of Amino acids.



Amino acids link up to form polypeptides, through condensation reactions.
Bond formed between amino acids is a **peptide** bond.



This polypeptide folds due to attractions and hydrogen bonding to form 3-dimensional structures. This folding is key in enzymes' active site and function.

Globular Proteins

- Transport protein
    - Haemoglobin, membrane pumps
- Enzymes
    - Proteins that catalyze chemical reactions in body
- Antibodies
    - Protein involved in immunity

Biuret's test for proteins

1. Add 1cm3 of Sodium Hydroxide solution to 2cm3 of protein solution
2. Shake mixture thoroughly
3. Add copper sulfate mixture to mixture, drop by drop, shaking after each drop
4. Positive : Purple coloration is seen
5. Negative : solution remains blue (color of copper sulfate solution)