Biomolecules Structure & Function 9A

9.A compare the structures and functions of different types of biomolecules, including carbohydrates, lipids, proteins, and nucleic acids

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

Metabolism

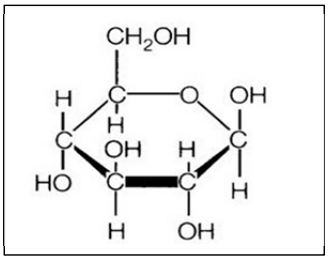
- **Anabolism**: the formation of large, complex molecules by linking smaller, simpler molecules (condensation reactions – form water).
- **Catabolism**: the breakdown of large, complex molecules into smaller molecules (hydrolysis reactions – add water).
  - Anabolic reactions require energy input (= 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).

Cells Contain Organic Molecules

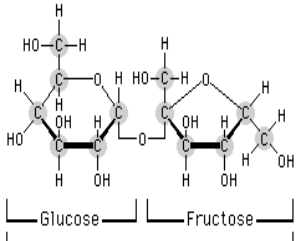
- Most common elements in living things are **carbon, hydrogen, nitrogen, and oxygen.**

2. These four elements constitute about 95% of your body weight.

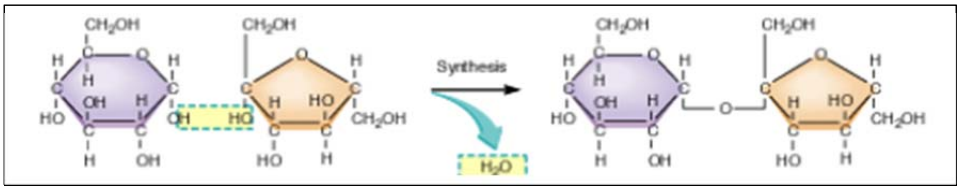
Carbohydrates [General formula $C(H_2O)_n$]



- 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



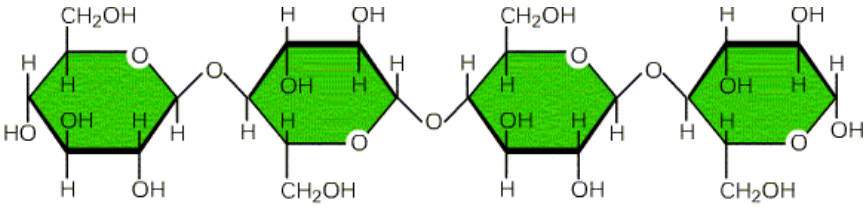
- **Disaccharides**: double sugars i.e. two sugar units linked together (condensation - forming water – e.g. maltose, sucrose, lactose)
- **Maltose**: glucose + glucose — intermediate between glucose and starch
- **Sucrose**: glucose + fructose — transported in the phloem of plants
- **Lactose**: glucose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



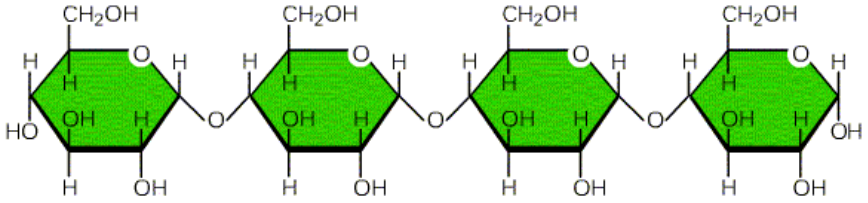
Polysaccharides: multisugars — the three examples are 'polyglucoses'

1. **Cellulose**: plant cells walls (= fiber in our diet) is a long (100's) polymer of Glucose molecules. However the orientation of the sugars is a little different. In Cellulose, every other sugar molecule is "upside-down".
2. **Starch**: a long (100's) polymer of Glucose molecules, where all the sugars are oriented in the same direction. Starch is one of the primary sources of calories for humans. (plant glucose reserve)
3. **Glycogen**: glucose reserve of animals (liver and muscle) and fungi. is another Glucose polymer. Glycogen is a stored energy source, found in the Liver and muscles of Humans. Glycogen is different from both Starch and Cellulose in that the Glucose chain is branched or "forked".

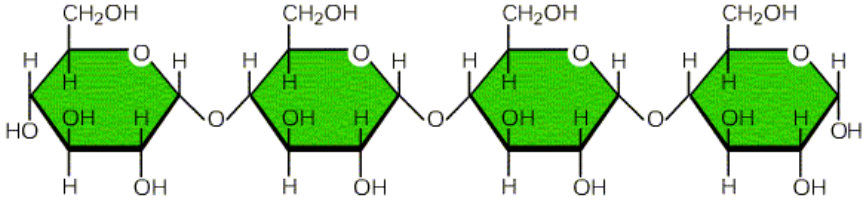
Cellulose



Starch



Glycogen



Structural Role of Carbohydrates

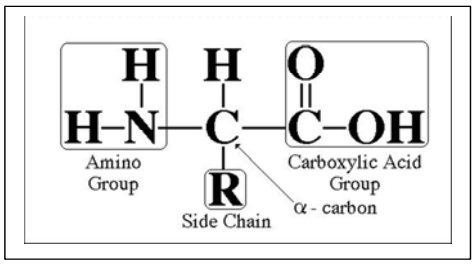
- **Cellulose** walls of plant cells.
- **Chitin** in the cell walls of fungi.

Metabolic Role of Carbohydrate As carbohydrates are digested they are converted into sugars that is used to store energy.

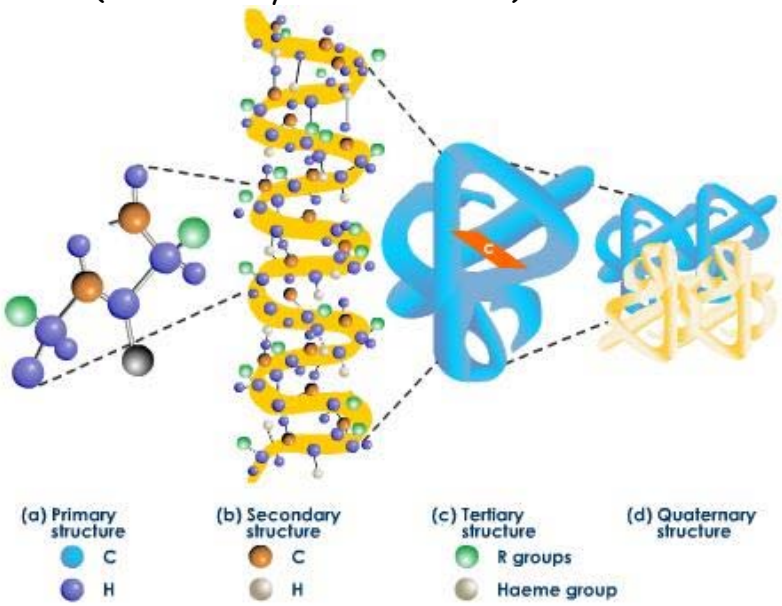
- **Energy source**: energy released by the respiration of glucose is used to make ATP.
- **Energy storage:** starch in plants, glycogen in animals and fungi.

Protein

- Elements: C, H, O, N and S in all proteins. 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

- 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 disulfide bridges. → Affected by heat (>60°C) and pH – denaturing.
- Quaternary Structure - Results from interactions among 2 or more polypeptides

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).
- 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 100oC
  - ✓ 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

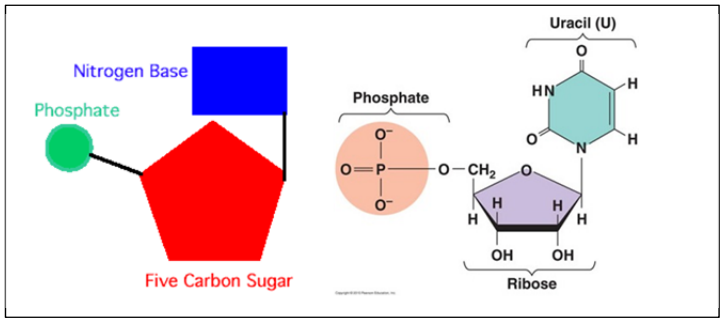
• Energy storage: more than twice the energy of carbohydrate or protein.
• Energy source: released during respiration.
• Some lipids function as hormones (sex hormones – estrogen, progesterone, testosterone)

D. Nucleic Acids

Nucleic acids: Nucleotides

Nucleic acids are composed of nucleotide monomers. Nucleotides have three parts:

- A Nitrogenous Base
- A Five-Carbon Sugar
- A Phosphate Group

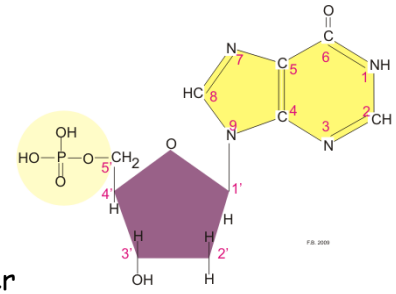


THREE kinds:

DNA:

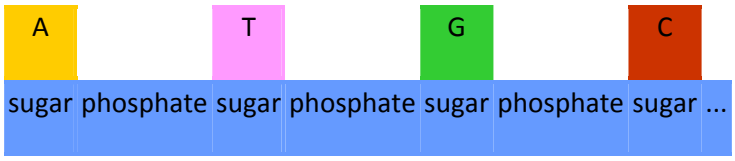
Structure

Chemical Structure of the DNA Nucleotides

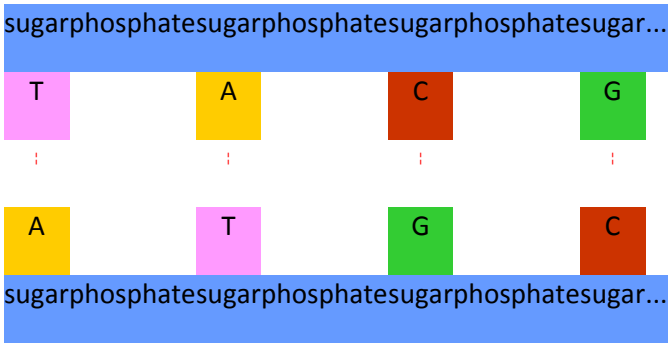


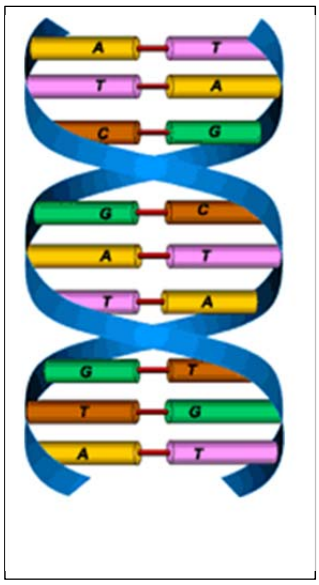
Monomer

These nucleotides bind to the sugar backbone of the molecule as follows:



The versatility of DNA comes from the fact that the molecule is actually double-stranded. The nucleotide bases of the DNA molecule form complementary pairs: the nucleotides hydrogen bond to another nucleotide base in a strand of DNA opposite to the original. This bonding is specific, and adenine always bonds to thymine (and vice versa) and guanine always bonds to cytosine (and vice versa). This bonding occurs across the molecule leading to a double-stranded system as pictured below:





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Function

- can self replicate
- makes up genes which code for proteins
- is passed from one generation to another
- bases A, T G and C
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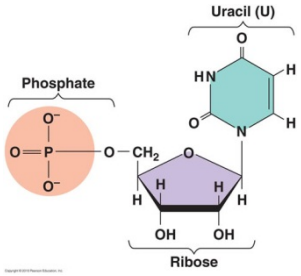
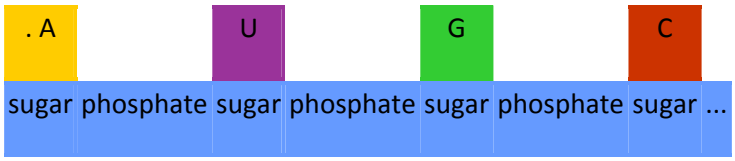
RNA:

Structure



Monomer:



RNA

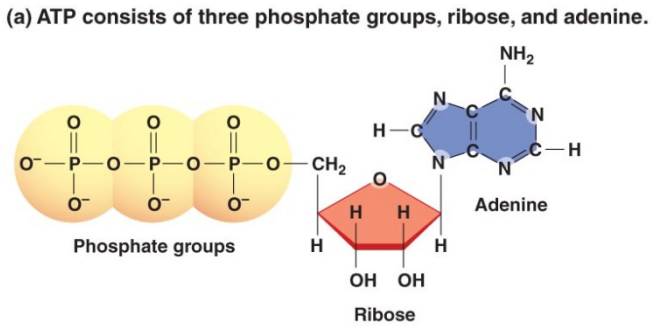
- single stranded
- bases A, U G and C

Function

- functions in actual synthesis of proteins coded for by DNA
- is made from the DNA template molecule

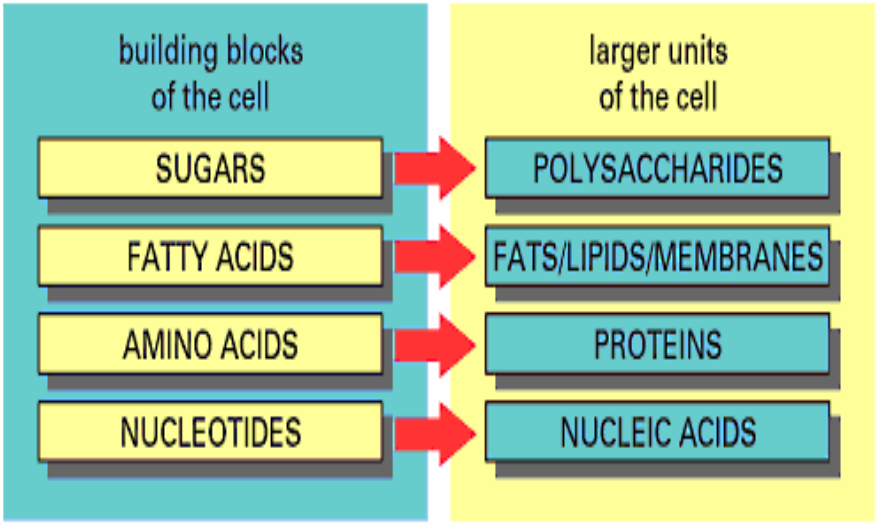
ATP

Structure



Function

Transfer chemical energy from one molecule to another (e.g. ATP)



Food Tests

Starch

• **Yellow-brown** iodine solution is placed on the food sample.
• A **blue-black** color indicates that starch is present.
• A yellow-brown color 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 (Boil).
• The Blue Benedicts reagent becomes **Brick-red**, if reducing sugar present.

Non-Reducing Sugar .

• Add an equal volume of **blue** Benedict's Reagent to the food solution.
• Add a few drops of dil. HCl

• Neutralize with dil. NaOH solution
• Heat (Boil).
• 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** color (from **pale blue**) indicates protein is present.
• N.B. NO HEAT