ORGANIC COMPOUNDS

Content Statements:

B1.1.1 Chemical properties of a carbon atom allowing for the formation of diverse compounds upon which life is based

B1.1.2 Production of macromolecules by condensation reactions that link monomers to form a polymer

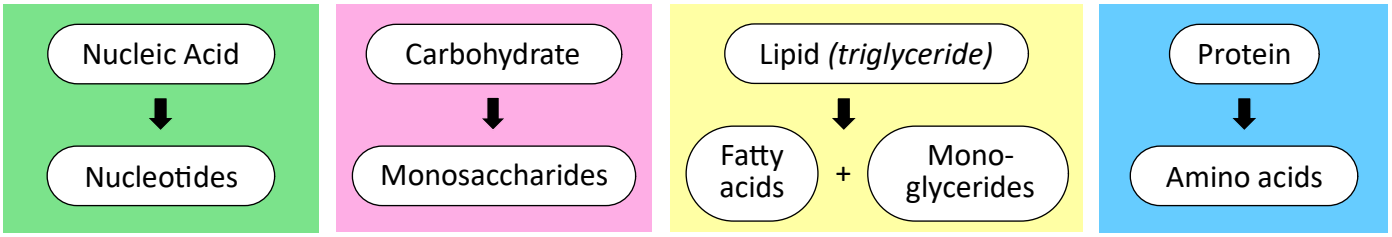
B1.1.3 Digestion of polymers into monomers by hydrolysis reactions

ORGANIC COMPOUNDS

Living organisms are composed of organic compounds. An organic compound is essentially a compound that **contains carbon** and is **found in living things** (certain exceptions exist, including CO_2 and carbonates). Carbon atoms can form four covalent bonds, allowing for a diversity of stable carbon compounds to exist.

MONOMERS → POLYMERS

Complex organic molecules may be comprised of smaller **recurring** subunits called monomers. Monomeric subunits might not be identical, but will share the same basic structural characteristics. Carbohydrates, nucleic acids and proteins are all composed of monomers. Lipids **do not** contain monomers, but may be comprised of distinctive subunits (e.g. triglycerides are made up of glycerol and three fatty acid chains).

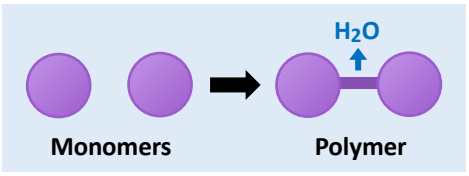


METABOLISM

Metabolism describes the totality of chemical processes that occur within a cell in order to maintain life. These metabolic processes provide a source of energy for biological processes and enable the synthesis and assimilation of cellular materials for use within the cell. Metabolic reactions can broadly be described as being either anabolic or catabolic:

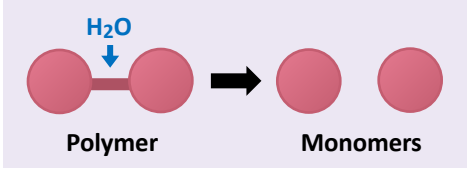
Anabolism:

- Smaller compounds are **combined** to form larger compounds
- In the case of organic compounds, this involves **condensation**
- Water is **released** as a by-product of condensation reactions



Catabolism:

- Large compounds are **broken down** into smaller compounds
- In the case of organic compounds, this involves **hydrolysis**
- Water is **required** as an input for hydrolysis reactions



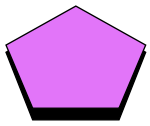
TYPES OF ORGANIC MOLECULES

There are 4 classes of organic compounds found in cells: carbohydrates, lipids, nucleic acids and proteins.

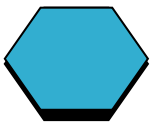
- **Carbohydrates:** Used primarily as a **short-term energy source** (e.g. glucose), also involved in cellular structure (e.g. cellulose in plant cell walls) and signalling (membrane receptors are often glycoproteins)
- **Lipids:** Primary **component of cell membranes** (e.g. phospholipids), also involved in structure (waxes), cellular signalling (steroid hormones) and as a long-term energy source (e.g. triglycerides)
- **Nucleic Acids:** Function as a **genetic blueprint** for cellular activity – DNA serves as a master copy, while RNA functions as a transient copy that is used to synthesis proteins (via transcription and translation)
- **Proteins:** Serve a **wide variety of functions** within a cell – including structure (e.g. collagen), signalling (e.g. peptide hormones), immunity (e.g. antibodies) and maintaining metabolic control (e.g. enzymes)

CARBOHYDRATES

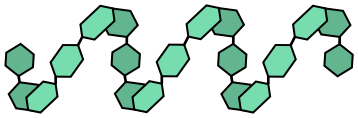
Carbohydrates are comprised of monomeric units called **monosaccharides**. These subunits form ringed structures that are covalently combined by condensation polymerisation to form polysaccharides. **Glucose** is an example of a monosaccharide that is used as an energy source within the cell. It can form a variety of polymers; including **glycogen** (energy storage in animals), **starch** (storage in plants) and **cellulose** (structural component within plant cell walls). **Ribose** is another example of a monosaccharide that functions as a core component of all nucleic acids (RNA contains ribose, while DNA contains the modified form – deoxyribose).



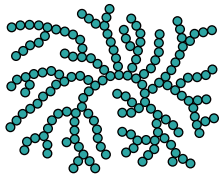
Ribose
(Pentose / 5C)



Glucose
(Hexose / 6C)



Starch (Amylose)

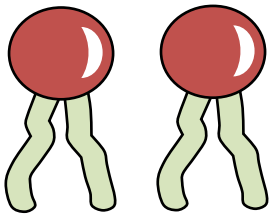


Glycogen

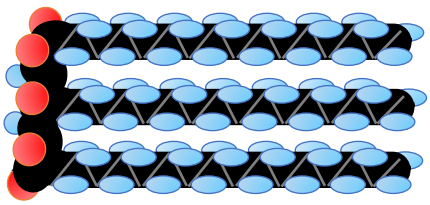
MONOSACCHARIDES	VS	POLYSACCHARIDES

LIPIDS

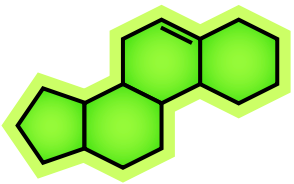
Lipids are non-polar compounds that typically include long chains of hydrocarbons called fatty acids. They do not contain monomers, but may be composed of **distinct subunits**. **Triglycerides** consist of a glycerol subunit combined with three fatty acid chains (via condensation reactions) and function as a source of long-term energy storage within a cell. **Phospholipids** have only two fatty acid chains attached to the glycerol, but include a polar phosphate group which makes the molecule **amphipathic** (possessing both hydrophilic and hydrophobic properties). Phospholipids function as the primary component of membranes. **Steroids** (such as cholesterol) do not consist of any subunits and are composed of four fused carbon rings.



PHOSPHOLIPIDS
Phosphate + fatty acids (×2)



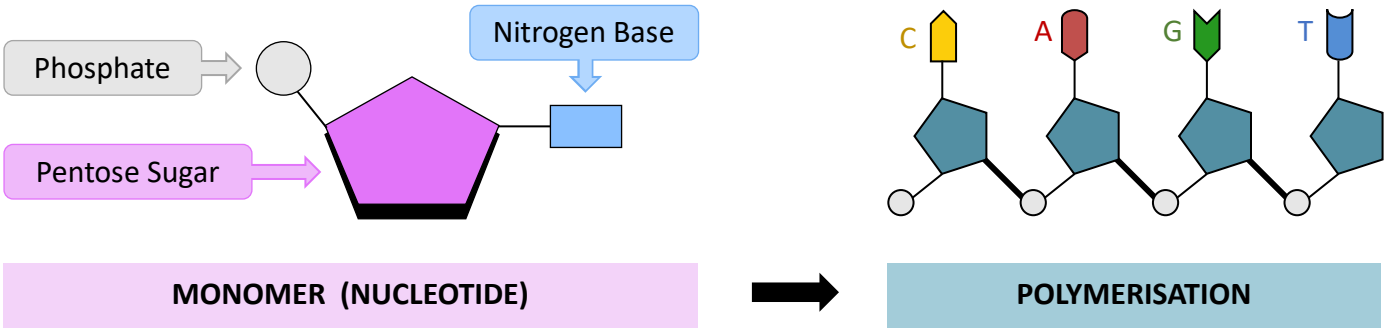
TRIGLYCERIDE
Glycerol + fatty acids (×3)



STEROIDS
4 × fused carbon rings

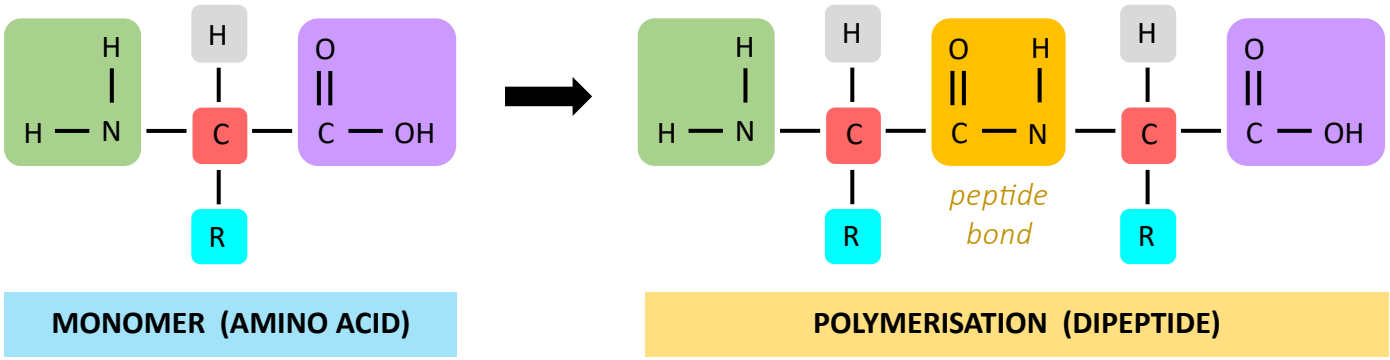
NUCLEIC ACIDS

Nucleic acids are composed of monomeric subunits called **nucleotides**. Each nucleotide contains a nitrogenous base that is attached to a backbone consisting of a sugar and a phosphate molecule. Nucleotides are joined together by condensation polymerisation to form long polymeric chains. The bases protrude from the sugar-phosphate backbone to form a sequence that functions as a code for protein assembly. **DNA** functions as a master copy, while **RNA** serves as a transient copy that plays an active role in the manufacturing of proteins.



PROTEINS

Proteins are composed of long chains of monomers called **amino acids**. These amino acids are joined together via condensation polymerisation to form **polypeptide chains**. There are 20 different amino acids and their order in a polypeptide sequence determines the overall shape and biological properties of the resulting protein. As most polypeptide chains contain between 50 – 2000 amino acid residues, organisms are capable of producing a huge range of possible proteins with a wide variety of functions. Protein sequences are encoded by nucleic acids, and so proteins function to enact the genetic instructions of a cell.



INORGANIC MOLECULES

Organic compounds are formed from inorganic sources and may create inorganic by-products if digested.

- All organic compounds contain carbon (C), hydrogen (H) and oxygen (O) in varying ratios
- Nucleic acids and proteins always possess nitrogen (N), while nucleic acids also contain phosphorus (P) and proteins *may* contain sulphur (S) – depending on the specific amino acids present in a polypeptide.

Inorganic molecules also play important roles in the functioning of the cells that comprise living organisms.

- Oxygen gas (O_2) is required for aerobic cell respiration (producing ATP from the breakdown of glucose)
- Carbon dioxide gas (CO_2) is used by plants to synthesise vital organic molecules (like carbohydrates)
- Water (H_2O) comprises ~70% of the cell's internal environment and functions as a transport medium
- Trace minerals (e.g. Na^+, K^+, Cl^-) are necessary for maintaining survival in multicellular organisms