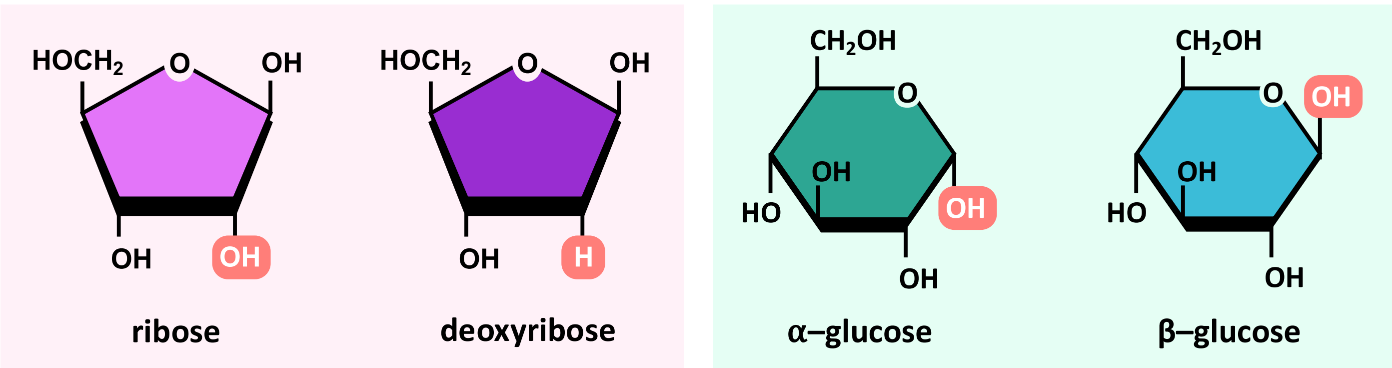
CARBOHYDRATES

Content Statements:

B1.1.2	Production of macromolecules by condensation reactions that link monomers to form a polymer
B1.1.4	Form and function of monosaccharides
B1.1.5	Polysaccharides as energy storage compounds
B1.1.6	Structure of cellulose related to its function as a structural polysaccharide in plants
B1.1.7	Role of glycoproteins in cell–cell recognition

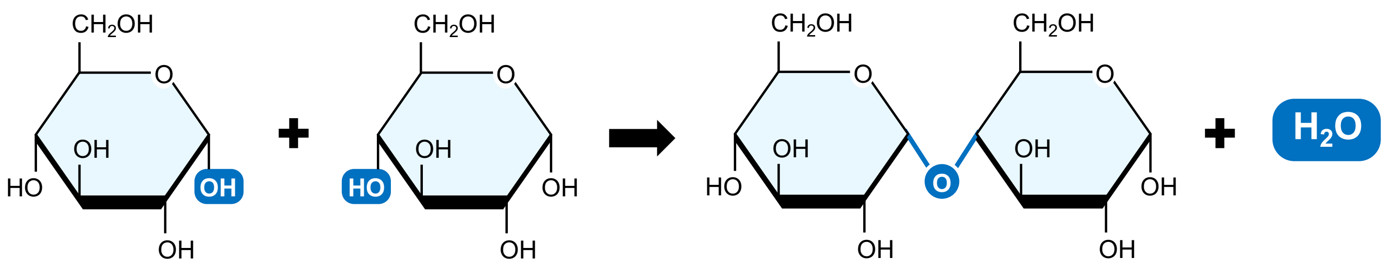
MONOSACCHARIDES

Carbohydrates are a class of organic biomolecules composed of carbon (C), hydrogen (H) and oxygen (O). These atoms are typically present in a standard ratio of $(CH_2O)_n$. Carbohydrates are composed of recurring monomers called **monosaccharides**. These monosaccharides tend to adopt a more energetically favourable configuration by forming a cyclic ring structure. Most monosaccharides contain either five carbons (pentose sugars) or six carbons (hexose sugars). An example of a pentose sugar is **ribose** – a core component of RNA nucleotides and ATP. DNA nucleotides have a modified version missing an oxygen atom (*deoxy*ribose). An example of a hexose sugar is **glucose** – a monosaccharide that is used preferentially by cells as a source of stored chemical energy. Glucose monomers exists as two distinct isomers (α*–glucose* and β*–glucose*) that differ in structure according to the orientation of hydroxyl group (–OH) attached to the 1’–carbon atom.



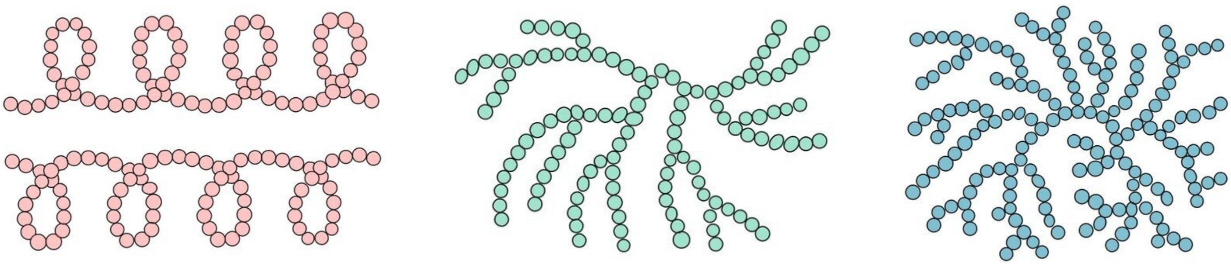
POLYSACCHARIDES

Monosaccharides are covalently joined together by condensation polymerisation to form polysaccharides. The monosaccharides are connected by **glycosidic linkages** and water is released as a by-product. The type of polysaccharide formed is determined by the monosaccharides involved and their bonding arrangements.



ENERGY STORAGE

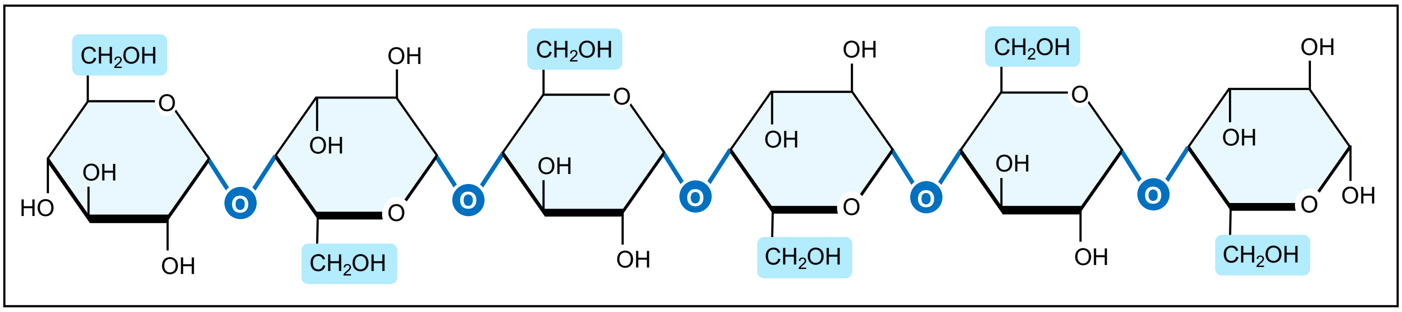
One of the primary functions of carbohydrates is to act as a short-term energy storage molecule within the cell. Monosaccharides (primarily glucose) can be oxidised via cell respiration to release the energy stored within their chemical bonds, which can in turn be used to synthesise ATP (the energy currency of the cell). Monosaccharides are suited to this function because they are small, polar molecules which are hydrophilic and easy to transport between cells. Organisms will store these glucose monomers as compact polymers that are insoluble due to their size, but can be rapidly digested (via hydrolysis) to mobilise the energy stores of the cell. Monomers of **α–glucose** are combined via 1'–4' glycosidic linkages to form long chains, that are then branched via additional 1'–6' linkages. Plants store these α–glucose sugars as either **starch** (plants) or **glycogen** (animals). Starch molecules can either adopt a helical structure (*amylose*) or a branched structure (*amylopectin*). Glycogen is branched, with the 1'–6' linkages occurring more regularly than in amylopectin.



Starch *(amylose)* | Starch *(amylopectin)* | Glycogen

STRUCTURE

Carbohydrates can also function as a structural component within a cell. Polymers of **β–glucose** will form linear strands due to the alternating arrangement of the monomeric subunits (every second β–glucose sugar is inverted in the chain). These linear strands can be cross-linked with hydrogen bonds to form a mechanically stable polysaccharide called **cellulose**. Cellulose is a principal component of plant cell walls.



RECOGNITION

Proteins may be complexed to carbohydrates to form **glycoproteins**. Glycoproteins are commonly employed by the cell as surface markers (**antigens**). Human red blood cells can be categorised according to the type of glycoprotein that is present on the cell surface (A or B). These glycoproteins function as identification tags to allow the immune cells to recognise the blood cells as 'self'. Blood transfusions with different blood types will be unsuccessful as the immune system attacks foreign cells). The exception is AB blood – these individuals will be compatible with all blood types as they possess both the A and the B glycoproteins.