

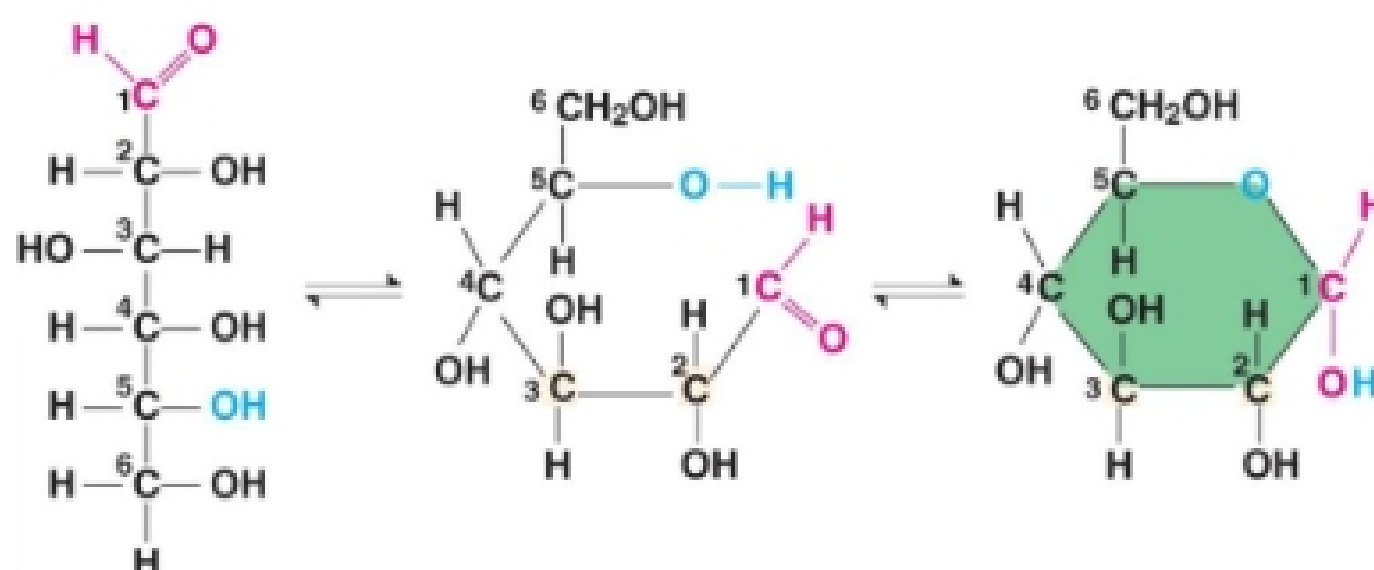
CHAPTER 5 AN INTRODUCTION TO CARBOHYDRATES

- **Carbohydrate:** any class of molecules that contain a carbonyl group, several hydroxyl groups, and several carbon-hydrogen bonds.
- **Sugar:** synonymous with carbohydrate. Though usually used in an informal sense to refer to small carbohydrates (monosaccharides and disaccharides).
- **Monosaccharides:** a molecule that has the molecular formula $(CH_2O)_n$ and cannot be hydrolyzed to form any small carbohydrates. Also called *simple sugar*.
- **Oligosaccharides:** a linear or branched polymer consisting of less than 50 monosaccharides joined by glycosidic linkages.
- **Polysaccharides:** a linear or branched polymer consisting of many monosaccharides joined by glycosidic linkages.
- The name carbohydrate is logical because the molecular formula of many of these molecules is $(CH_2O)_n$, Where n refers to the number of "carbon hydrate" groups.
- Carbohydrates consist of a carbonyl group and several hydroxyl groups along with many carbon hydrogen bonds.

5.1 SUGARS AS MONOMERS

WHAT DISTINGUISHES ONE MONOSACCHARIDE FROM ANOTHER?

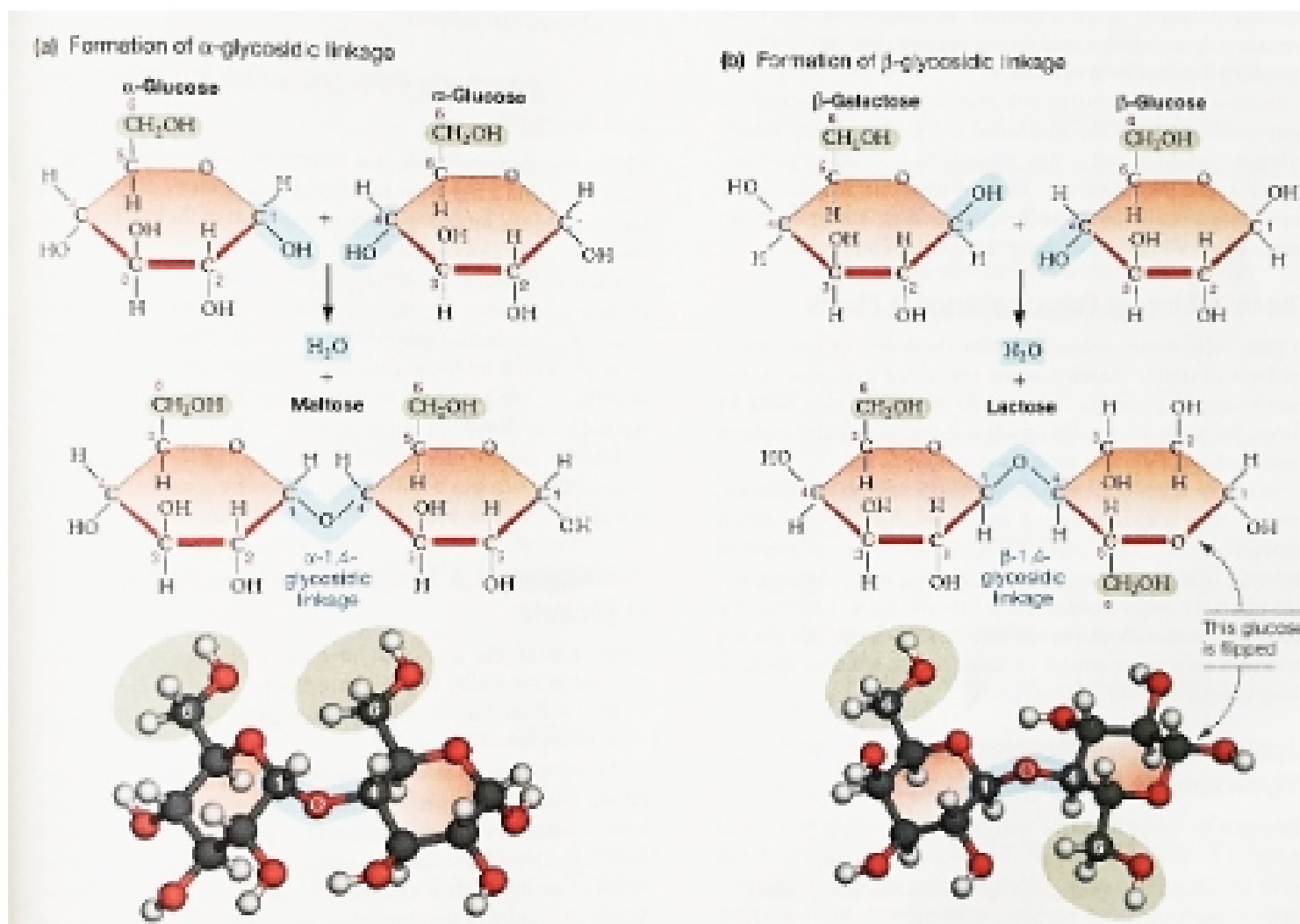
- Monosaccharides are the monomers of carbohydrates.
- The carbonyl groups that serves as one of the monosaccharides distinguishing features can be found either at the end of the molecules- forming an **aldehyde sugar** (an aldose) or within the carbon chain- forming a **ketone sugar** (a ketose).
- By convention, the carbons in a monosaccharide are numbers consecutively, starting with the end nearest the carbonyl group.
- **Triose:** a three carbon sugar.
- **Pentose:** a five carbon sugar.
- **Hexose:** a six carbon sugar.
- In aqueous solutions, sugars tend to form rings made by the carbon containing the carbonyl group and one of the carbons with the hydroxyl group.
- When a cyclic structure forms in glucose, the C-1 carbon forms a bonds with the oxygen atom of the C-5 hydroxyl and transfers its hydrogen to the C-1 carbonyl, turning it into a hydroxyl group.
- Transfer of hydrogen between C-5 and C-1 functional groups preserves the number of atoms and hydroxyls found in the ring and linear forms.



- Many distinct monosaccharides exist because of their variable structure:
 - Aldose or ketose placement of carbonyl group.
 - Variation in carbon number.
 - Different arrangements of hydroxyl groups in space.
 - Alternative ring forms.

5.2 THE STRUCTURE OF POLYSACCHARIDES

- When two sugars are linked together, they are known as **disaccharides**.
- Sugars can be covalently linked into chains.
- Monosaccharides polymerize when a condensation reaction occurs between two hydroxyl groups, resulting in a covalent interaction call a **glycosidic linkage**.
- The inverse reaction, hydrolysis, cleaves these linkages.



- Because glycosidic linkages form between hydroxyl groups, and because every monosaccharide contains at least two hydroxyls, the location and geometry of glycosidic linkages can vary widely among polysaccharides.

STARCH: A STORAGE

POLYSACCHARIDE IN PLANTS

- Starch consist entirely of alpha glucose monomers joined by glycosidic linkages.
- Starch is usually a mixture of two polysaccharides: one is an unbranched molecule called amylose, which contains only alpha- 1, 4, glycosidic linkages. The other is a branched molecule called amylopectin.

- The branching in amylopectin occurs when glycosidic linkages form between the C-1 carbon of a glucose monomer on one strand and the C-6 carbon of glucose on another strand.

GLYCOGEN: A HIGHLY BRANCHED STORAGE POLYSACCHARIDE IN ANIMALS

- Glycogen plays the same storage role that starch performs in plants.
- Glycogen is stored in liver and muscle cells.
- When you start exercising, enzymes begin breaking glycogen into glucose monomers, which are then processed in muscle cells to supply energy.
- Glycogen is a polymer of alpha glucose and is nearly identical to the branched form of starch. However, instead of an alpha-1, 6, glycosidic linkage occurring in about 1 out of every 30 monomers, a branch occurs in about 1 out of every 10 glucose subunits.

CELLULOSE: A STRUCTURAL POLYSACCHARIDE IN PLANTS

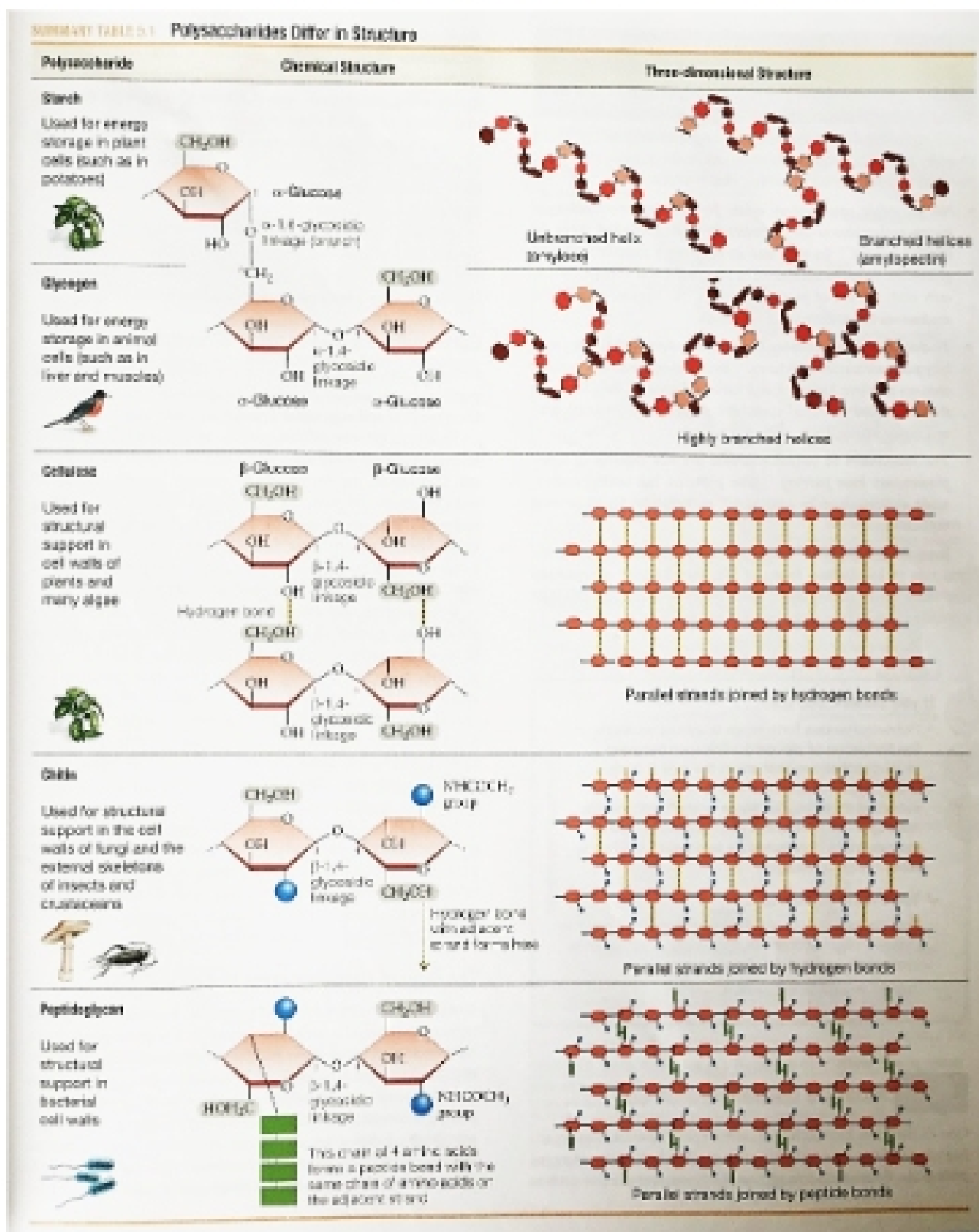
- Plant cells are surrounded by a material called the cell wall, a protective sheet that occurs outside the membrane.
- Cellulose is the major component of the cell wall.
- Cellulose is a polymer of beta glucose monomers, joined by beta-1,4 glycosidic linkages.
- The flipped orientation of the glucose beta linkage is important because:
 - o 1. It generates a linear molecule, rather than a helix seen in starch.
 - o 2. It permits multiple hydrogen bonds to form between adjacent parallel strands of cellulose.
- Cellulose forms long parallel strands that are joined by hydrogen bonds.

CHITIN: A STRUCTURAL POLYSACCHARIDE IN FUNGI AND ANIMALS

- Chitin is a polysaccharide that stiffens the cell walls of fungi, protists, and many animals.
- Chitin is similar to cellulose but instead of consisting of glucose monomers, the monosaccharide involved is one called N-acetylglucosamine (abbreviated NAG)
- NAG monomers are joined by beta- 1,4 glycosidic linkages.
- Chitin is formed into strands by the NAG subunits and strengthened by hydrogen bonds between strands.

PEPTIDOGLYCAN: A STRUCTURAL POLYSACCHARIDE IN BACTERIA

- Peptidoglycan give bacterial cells walls strength and firmness.



- Peptidoglycan has a long backbone formed by two types of monosaccharides that alternate with each other and are linked by beta-1,4 glycosidic linkages. In addition, a short chain of amino acids is attached to one of the two sugar types.
- When molecules of peptidoglycan align, the peptide bonds link the amino acid chains on adjacent strands.

POLYSACCHARIDES AND CHEMICAL EVOLUTION

- Polysaccharides probably played little to no role in chemical evolution because:
 - o 1. No plausible mechanism exists for the polymerization of monosaccharides under conditions that prevailed on early earth.
 - o 2. No polysaccharides have been discovered that can catalyze polymerization reactions.