- DISACCHARIDES

Disaccharides

Three Important Disaccharides—Maltose, Lactose, and Sucrose

The formation of these three common disaccharides are:

$$\alpha\text{-D-glucose} + \text{D-glucose} \rightarrow \text{maltose} + H_2O\ [\text{glycosidic bond } \alpha(1 \rightarrow 4)]$$

$$\beta\text{-D-galactose} + \text{D-glucose} \rightarrow \text{lactose} + H_2O\ [\text{glycosidic bond } \beta(1 \rightarrow 4)]$$

$$\alpha\text{-D-glucose} + \beta\text{-D-fructose} \rightarrow \text{sucrose} + H_2O\ [\text{glycosidic bond } \alpha,\beta(1 \rightarrow 2)]$$

Disaccharides

Maltose (Malt Sugar)

- Maltose is known as malt sugar.
- **The glycosidic bond is α(1→4).**

- It is formed by the breakdown of starch by the action of the enzyme **α-amylase**.
- Intestinal enz Maltase gives 2 units of glucose

-Ex: Barley seeds (Grains), Germinating cereals, Malt etc

- One of the anomeric carbons is free, so maltose is a reducing sugar.

Disaccharides

Lactose (Milk Sugar)

- The **glycosidic bond is β(1→4).**
- One of the anomeric carbons is free, so lactose is a reducing sugar.
- **Sources** : Milk and Milk products
- Lactose producing in **lactating mammary glands**
- Enzyme lactase hydrolyses lactose to glucose and galactose

Lactose intolerance

- An intolerance to lactose can occur in people who inherit or lose the ability to produce the enzyme lactase that hydrolyzes lactose into its monosaccharide units.
- Symptoms: Persistent diarrhea, giddiness, anorexia etc
- Treatment:

Disaccharide: Sucrose

- Inversion:

- Sucrose, as such is **dextrorotatory** (+66.5°) But, when hydrolysed, sucrose becomes levorotatory (–28.2°). The process of change in optical rotation from dextrorotatory (+) to levorotatory (–) is referred to as inversion.

- The hydrolysed mixture of sucrose, containing glucose and fructose, is known as **invert sugar**.

- Sucrose is hydrolyzed to fructose and glucose by an enzyme ***sucrase*** which is also called ***invertase.***

Polysaccharides

Storage and structural polysaccharides are made up of glucose units, but they are structurally and functionally different because of their glycosidic bonds and difference in branching.

- **Polysaccharides have:**
- High molecular weight
- Only sparingly soluble in water.
- Not sweetish and
- do not exhibit any of the properties of aldehyde or ketone group (glycosidic bond).

- Polysaccharides are of **two types**
- i. Homopolysaccharides (homoglycans):
- ii. Heteropolysaccharides (heteroglycans:

Homopolysaccharides (Homoglycans)

- When a polysaccharide is made up of several units of one and the same type of monosaccharide unit called homopolysaccharide.
- The most common homoglycans are:

1. Starch
2. Dextrins
3. Glycogen
4. Inulin
5. Cellulose

Heteropolysaccharides (Heteroglycans*)*

- They contain two or more different types of monosaccharide units or their derivatives.

- Heteropolysaccharide present in human beings is glycosaminoglycans(GAG) or mucopolysaccharides

1. Heparin
2. Chondritin sulfate
3. Hyaluronic acid
4. Dermatan sulfate
5. Keratan sulfate
6. Blood group polysaccharides.

Homopolysaccharide

--Storage Polysaccharides:

starch—Amylose and amylopectin:

Starch is a mixture of amylose and amylopectin and is found in plant foods.

- **Amylose makes up 20%** of plant starch and is made up of 250–4000 D-glucose units bonded α(1→4) in a **continuous chain**.
- Long chains of amylose tend to coil.

Homopolysaccharides

----Amylopectin—starch

- **Amylopectin makes up 80%** of plant starch and is made up of D-glucose units **connected by α(1→4) glycosidic bonds.**
- About every 25 glucose units of **amylopectin,** a **branch** polymer having both α-(1 → 4) and α-(1 → 6) linkages. The branch points in amylopectin are created by α-1 → 6 bonds.

- Amylopectin is a branched and occur at an interval of 20 to 30 units of glucose.

- When we consume starch, our digestive system breaks it down into glucose units for use by our bodies.

Dextrin

- Partial hydrolysis of starch by **acids** or **α-amylase (enzyme)** produces substances known as dextrins.

- These also occur in honey.

- All dextrins have few free aldehyde groups and can show mild reducing property.

Polysaccharides

Glycogen

- ***Glycogen*** is a storage polysaccharide found in animals.
- Glycogen is stored in the liver and muscles.
- Its structure is identical to amylopectin, except that α(1→6) branching occurs about every 12 glucose units.
- When glucose is needed, glycogen is hydrolyzed in the liver to glucose.

Structural Polysaccharides

Cellulose

- ***Cellulose*** contains glucose units bonded $\beta(1\rightarrow4)$.
- This glycosidic bond configuration changes the three-dimensional shape of cellulose compared with that of amylose.
- The chain of glucose units is straight. This allows chains to align next to each other to form a strong rigid structure.

Polysaccharides

Cellulose

- Cellulose is an insoluble fiber in our diet because we lack the enzyme cellulase to hydrolyze the $\beta(1\rightarrow4)$ glycosidic bond.
- Whole grains are a good source of cellulose.
- Cellulose is important in our diet because it assists with digestive movement in the small and large intestine.
- Some animals and insects can digest cellulose because they contain bacteria that produce cellulase.

Polysaccharides, Continued

Chitin

- ***Chitin*** makes up the exoskeleton of insects and crustaceans and cell walls of some fungi.
- It is made up of *N*-acetylglucosamine containing $\beta(1\rightarrow4)$ glycosidic bonds.
- It is structurally strong.
- Chitin is used as surgical thread that biodegrades as a wound heals.
- It serves as a protection from water in insects.
- Chitin is also used to waterproof paper, and in cosmetics and lotions to retain moisture.

ABO Blood Types

- ***ABO blood types*** refer to carbohydrates on red blood cells.

- These chemical markers are oligosaccharides that contain either three or four sugar units.

- Sugar units are D-galactose, L-fucose, *N*-acetylglucosamine, and *N*-acetylgalactosamine.

Carbohydrates and Blood, Continued

- Type O blood is considered the universal donor while type AB blood is considered the universal acceptor.
- The following table shows the compatibility of blood groups.

TABLE 5.3 COMPATIBILITY OF BLOOD GROUPS

Blood Group	Can Receive Blood Types	Cannot Receive Blood Types
A	A,O	B, AB
B	B, O	A, AB
AB[a]	A, B, AB, O	Can receive all blood types
O[b]	O	A, B, AB

[a]AB universal acceptor.
[b]O universal donor.

Carbohydrates and Blood, Continued

Heparin

- ***Heparin*** is a medically important polysaccharide because it prevents clotting in the bloodstream.
- It is a highly ionic polysaccharide of repeating disaccharide units of an oxidized monosaccharide and D-glucosamine. Heparin also contains sulfate groups that are negatively charged.
- It belongs to a group of polysaccharides called ***glycosaminoglycans***.

Chapter Summary

5.1 Classes of Carbohydrates

Carbohydrates are classified as ***monosaccharides*** (simple sugars), ***disaccharides*** (two monosaccharide units), ***oligosaccharides*** (three to nine monosaccharide units), and ***polysaccharides*** (many monosaccharide units).