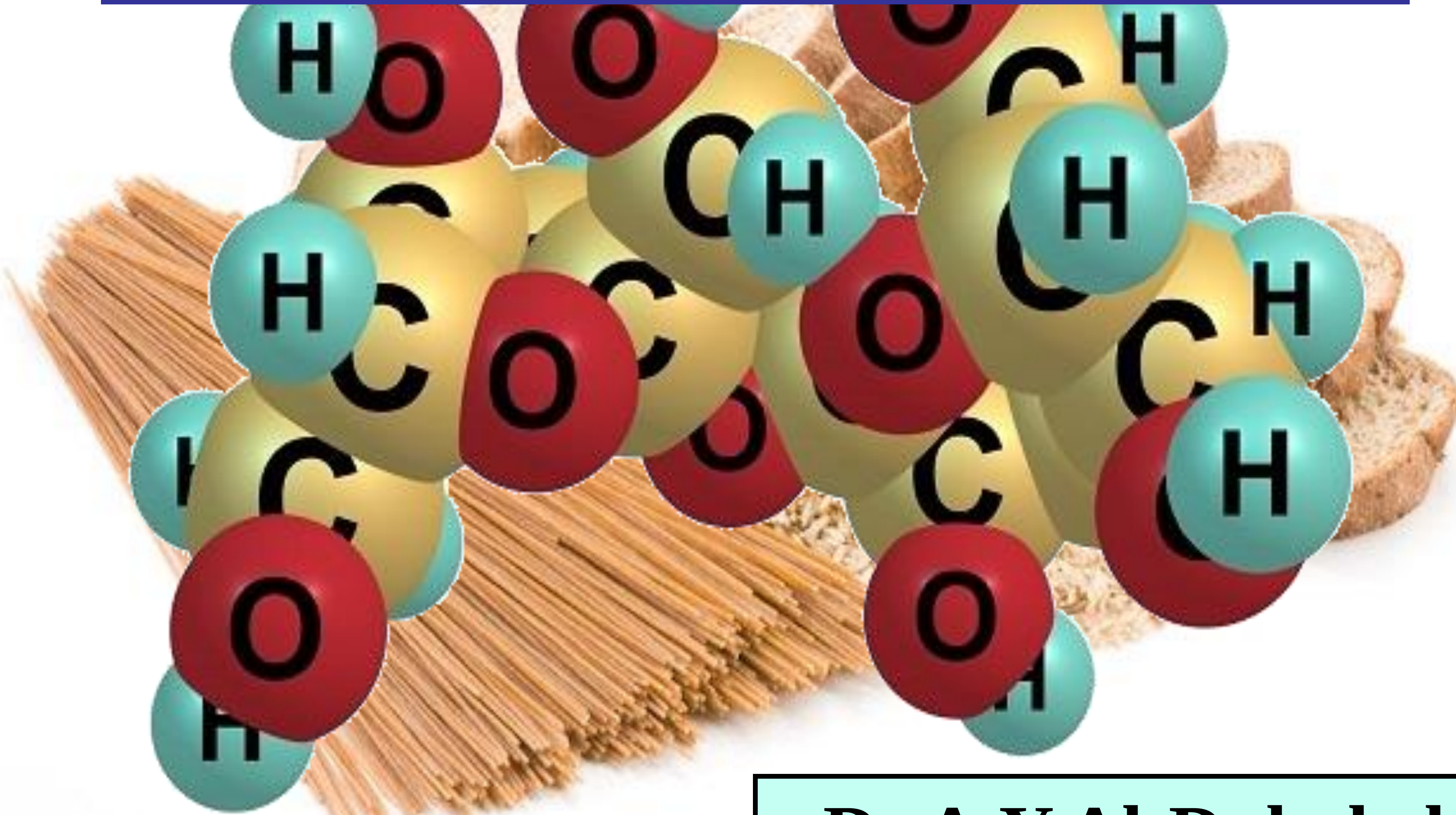
5-Carbohydrate



Dr.A.Y.Al-Dubakel

Carbohydrates derive their name from a Misleading Concept 'Hydrates of Carbon’

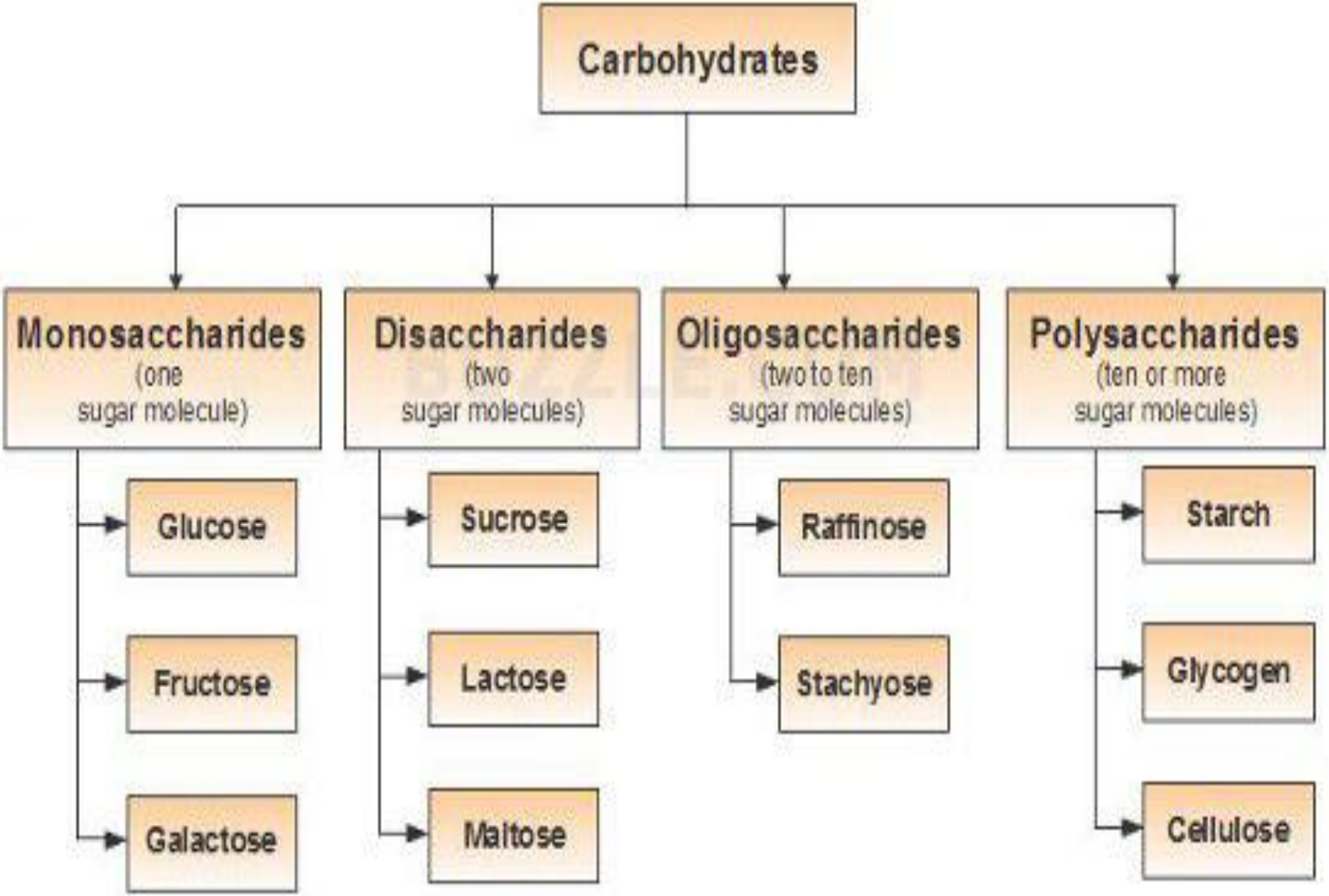
- **Hydrogen and Oxygen in Carbohydrates were found to be present in the same proportion as in water. (2:1).(E.g. Glucose $C_6H_{12}O_6$ or $C_6 (H_2O)_6$).**

- **It is due to this fact that compounds derived their name “Carbon Hydrate”.**

Carbohydrates

These act as a third source of dietary energy.
Made of carbon, hydrogen, and oxygen in a 1:2:1 ratio
Carbohydrates are divided into two main groups
1)The <u>sugars</u> (Simple sugars) includes such things as glucose, sucrose and lactose
2) The non-sugars (Complex sugars), more complex materials such as <u>starch and various polysaccharides</u>

- Carbohydrates are the most abundant biomolecules in nature, having a direct link between solar energy and the chemical bond energy in living organisms.
- Source of rapid energy production
- Structural building blocks of cells
- Components of several metabolic pathways


Carbohydrates
Monosaccharides
(one
sugar molecule)
Disaccharides
(two
sugar molecules)
Oligosaccharides
(two to ten
sugar molecules)
Polysaccharides
(ten or more
sugar molecules)
Glucose
Fructose
Galactose
Sucrose
Lactose
Maltose
Raffinose
Stachyose
Starch
Glycogen
Cellulose

Carbohydrates

Monosaccharide

- Functional group
  - Aldoses e.g Glucose
  - Ketoses e.g Fructose
- Number of carbon atoms
  - Trioses
  - Tetroses
  - Pentoses
  - Hexoses
  - Heptoses

Oligosaccharide

- Di-saccharide
  - Maltose
  - Lactose
  - Sucrose
- Tri-saccharide
  - Raffinose
- Tetra-saccharide
  - Stachyose

Polysaccharide

- Homopoly-saccharide
  - Starch
  - Dextrin
  - Glycogen
  - Cellulose
  - Inulin
- Hetropoly-saccharide
  - Hyaluronic acid
  - Heparin
  - Chondroitin sulfate
  - Dermatan Sulfate
  - Keratan Sulfate

Classification of carbohydrates

Monosaccharides (simple sugars)

Simple sugars classified according to their number of carbon atoms: trioses (3-C), tetroses (4-C), pentoses (5-C), hexoses (6-C).
Examples:
Trioses – glyceraldehyde
Pentoses – ribose, xylose
Hexoses – glucose, fructose

Oligosaccharides (sugars)

Made up of 2-10 monomer units e.g. disaccharides have 2 monomer units, trisaccharides have 3, etc.
Examples:
Sucrose – glucose-fructose
Cellobiose – glucose-glucose
Lactose – glucose-galactose
Raffinose – glucose-fructose-galactose

Polysaccharides

Polymers made up of a large number of monomer units

Homopolysaccharides (homoglycans)

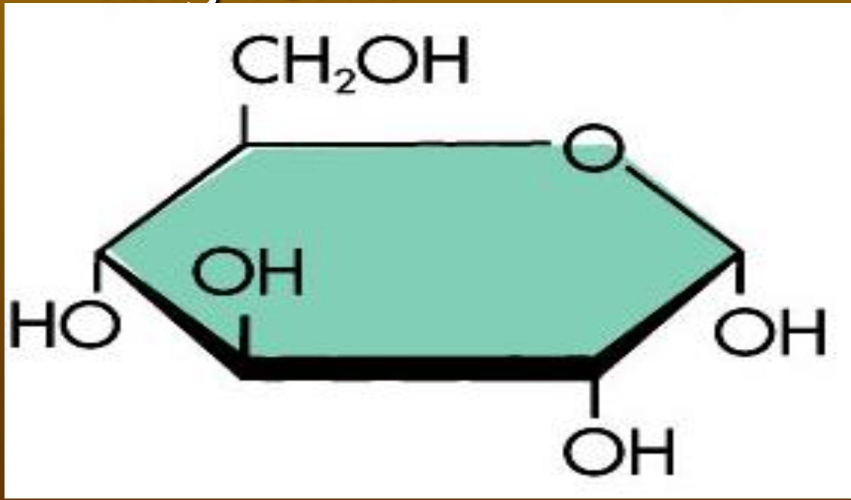
Made up of a single type of monomer. Glucans (e.g. starch, glycogen, cellulose) are polymers of glucose, fructans (e.g. inulin) of fructose, and xylans of xylose

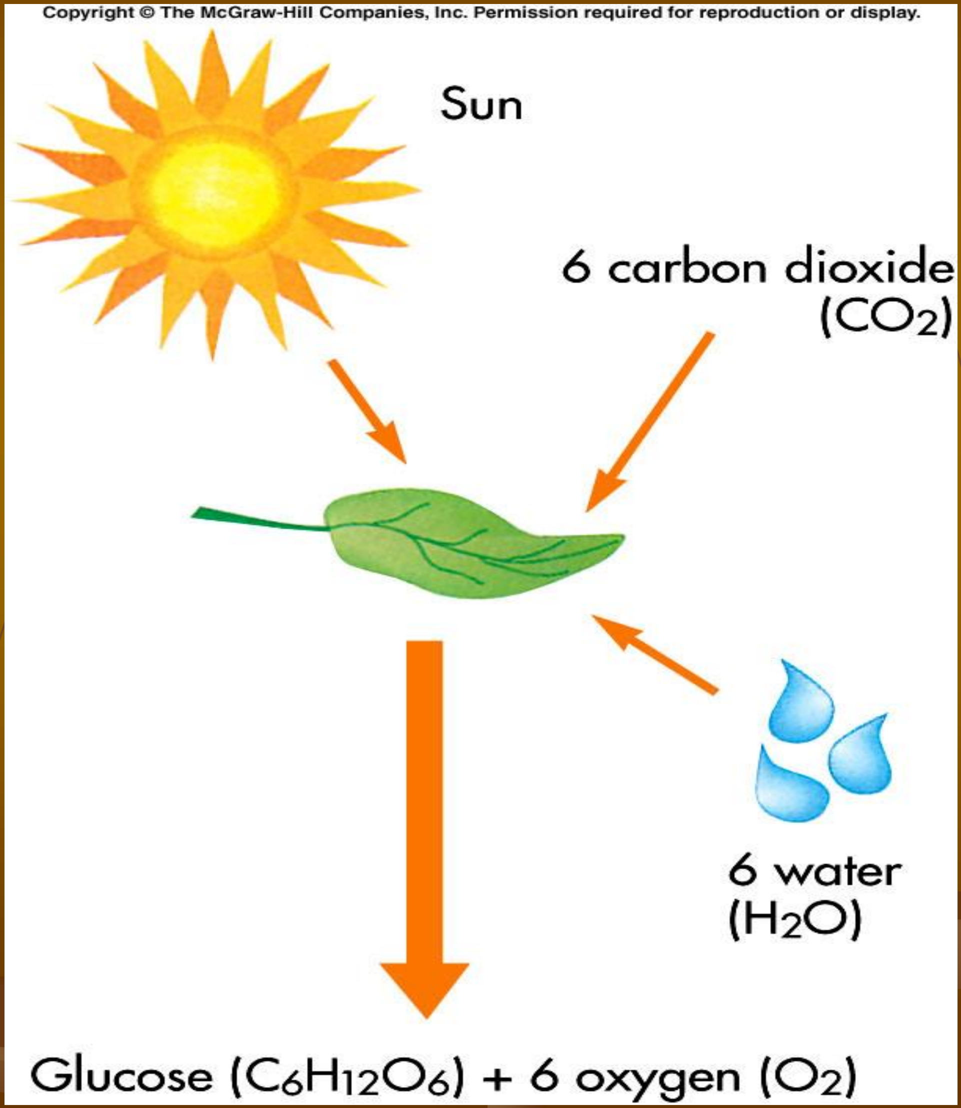
Heteropolysaccharides (mixed polysaccharides)

Made up of two or more types of monomer units and derived products. Hydrolysis of hemicelluloses, gums and pectins yields complex mixtures of pentoses, hexoses and derived products.

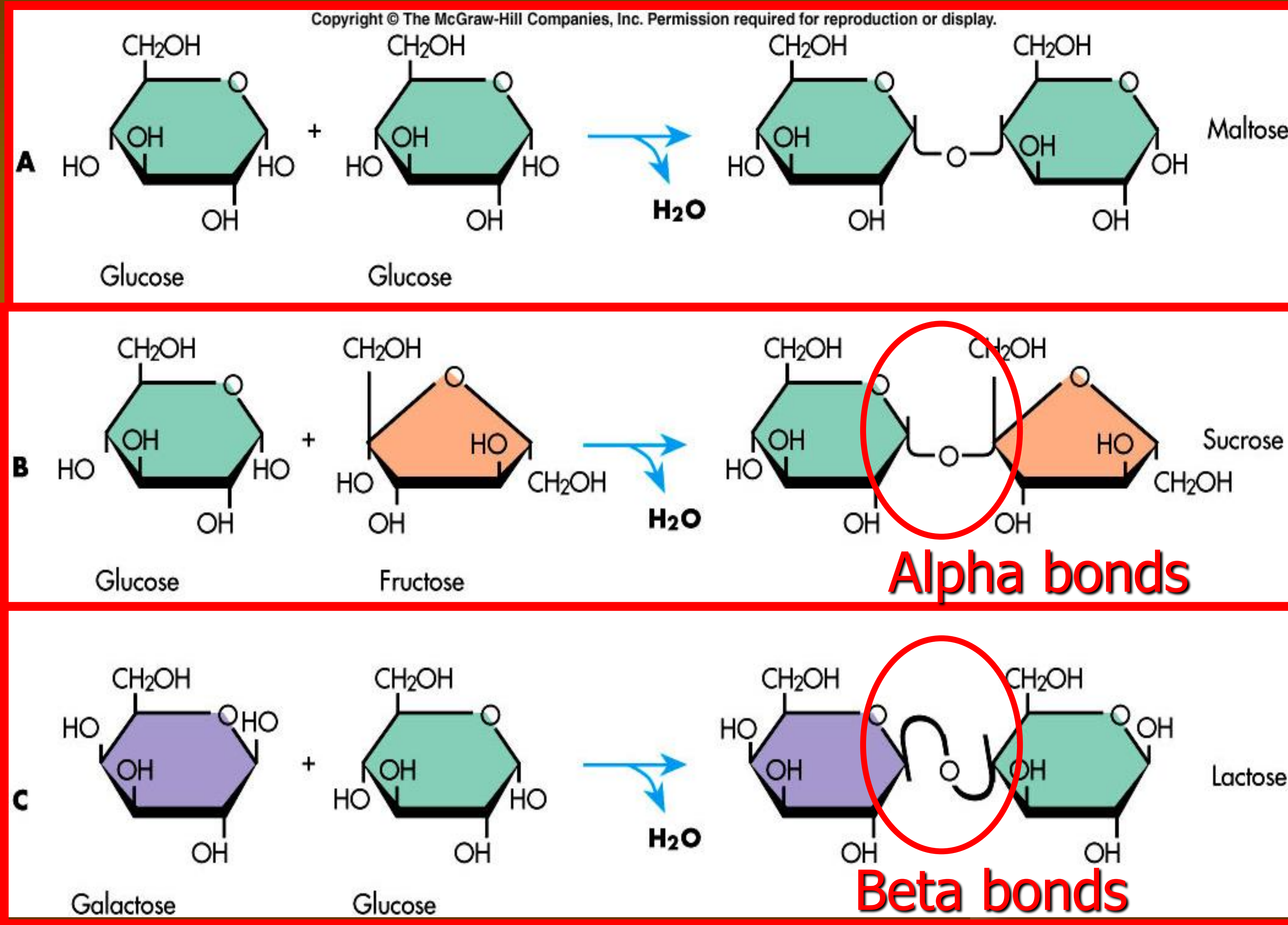
Monosaccharides GLUCOSE

- Also called hexose or dextrose, blood sugar
- Principle building block of all other carbohydrates
- Typically exists in the ring form





DISACCHARIDES



OLIGOSACCHARIDES

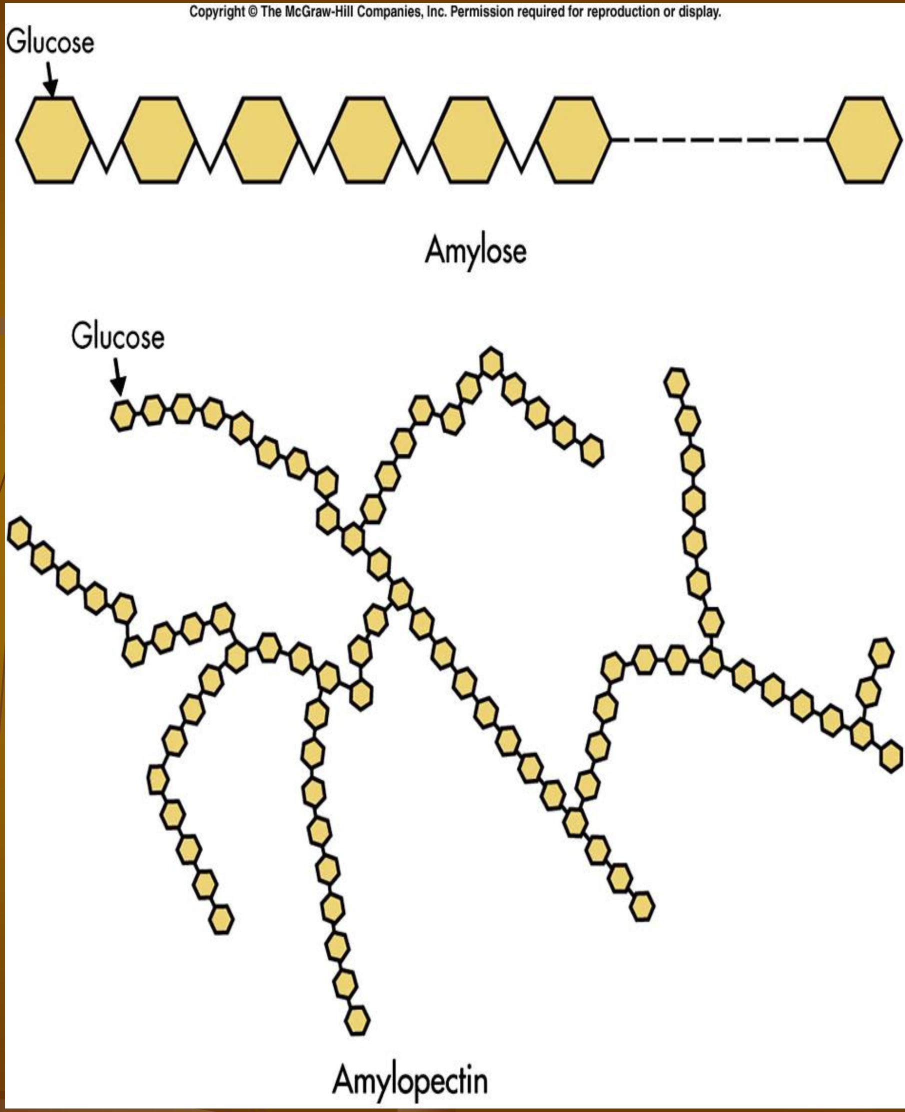
- 3-10 monosaccharides: raffinose
- Found in legumes
- Not digested by the body
- Metabolized by bacteria in the large intestine
- Raffinose= galactose+glucose+fructose

POLYSACCHARIDES

- Digestible polysaccharides:
  - Starch: Amylose + Amylopectin
  - Glycogen
- Non-digestible polysaccharides: Fibers
  - Soluble fiber
  - Insoluble fiber

STARCHES

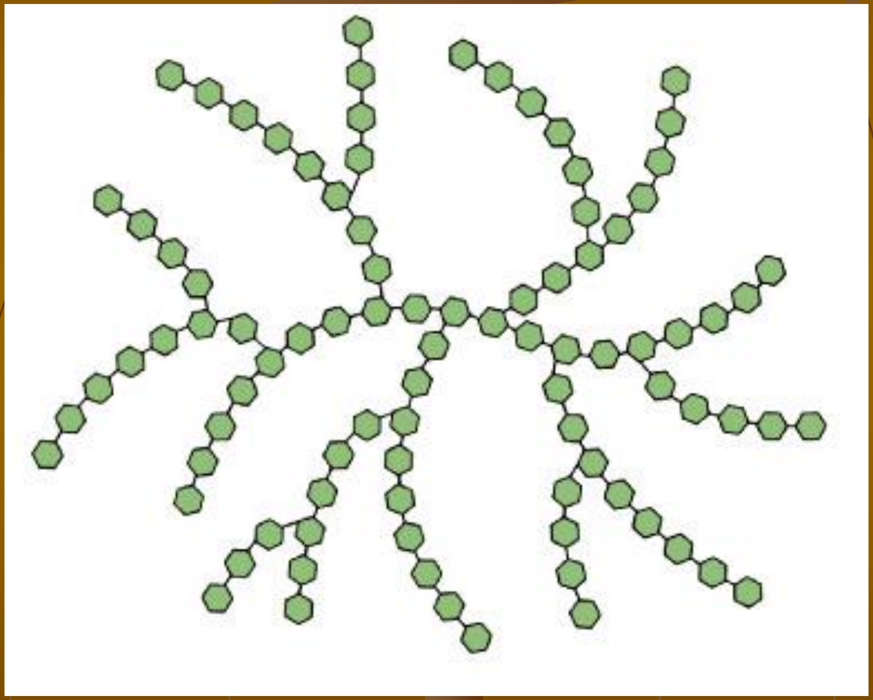
- 3000 monosaccharides
- Contain alpha bonds
- Amylose is straight chain
- Amylopectin is branched chain

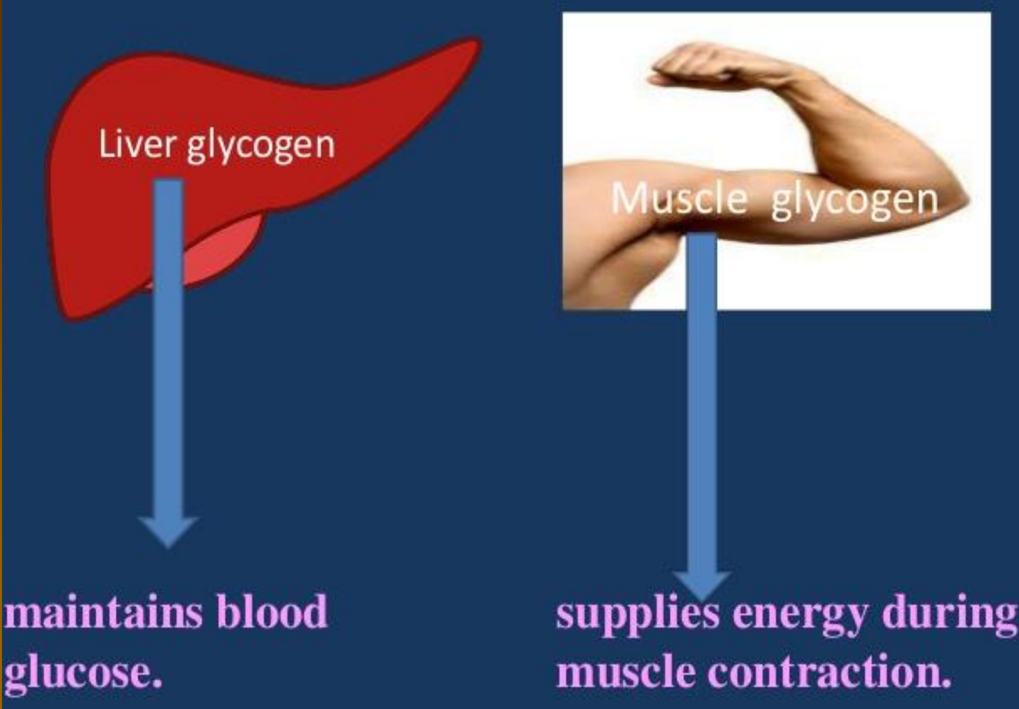


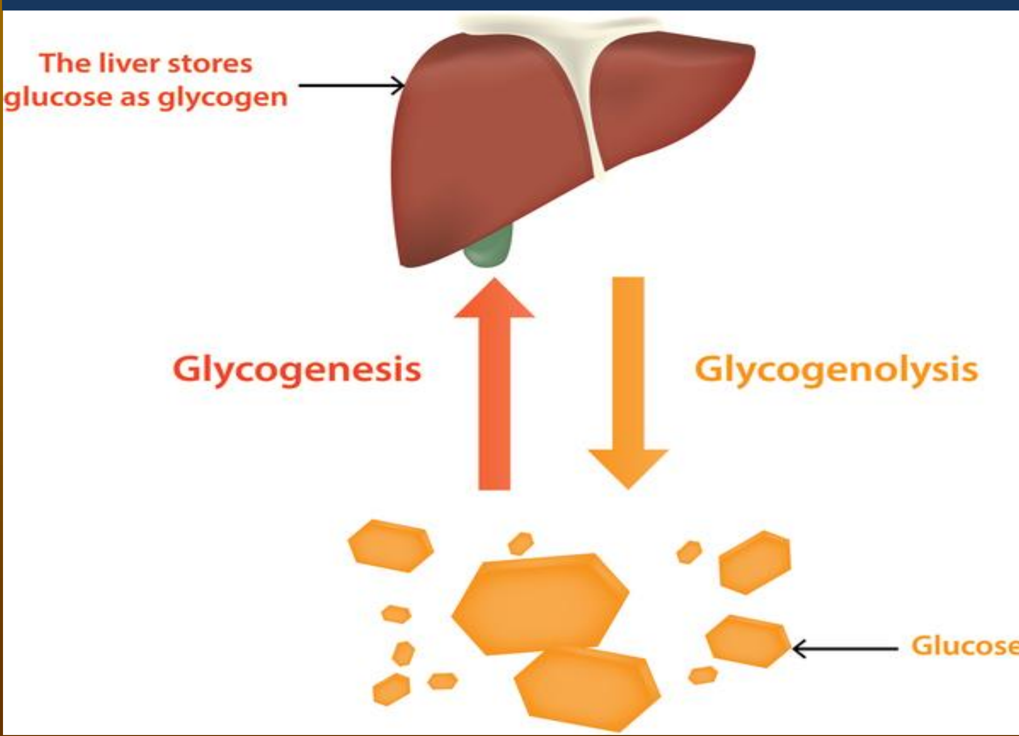
Amylose + Amylopectin = Glucose polymers

GLYCOGEN

- Storage form of glucose in animals and humans
- Structure is similar to amylopectin but with more complex branching
- Numerous alpha bonds
- Found in liver (400 kcal) and muscles (1400 kcal)







Glycogen Metabolism

1. Liver glycogen:

-Forms 8-10% of the wet weight of the liver.

-Maintains blood glucose (especially between meals).

-Liver glycogen is depleted after 12-18 hours fasting.

2. Muscle glycogen:

-Forms 2% of the wet weight of muscle.

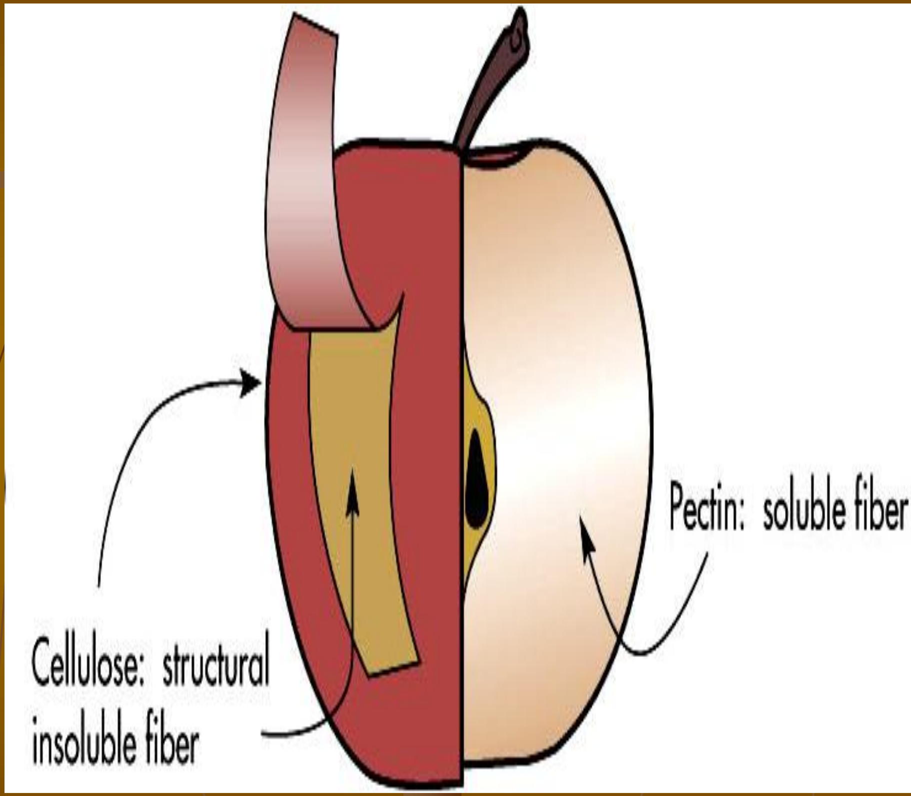
-Supplies glucose within muscles during contraction.

DIFFERENCES BETWEEN MUSCLE AND LIVER GLYCOGEN

	Liver glycogen	Muscle glycogen
- Amount	Liver has more conc.	muscle has more amounts.
- Sources	blood glucose and other radicals	blood glucose only
- Hydrolysis	give blood glucose	due to absence of phosphatase enzyme not give free glucose but give lactic acid
- Starvation	changes to blood glucose	not affected.
- Muscular ex.	depleted.	depleted.
- Hormones	• insulin → ↑↑↑ • adrenaline →↓↓↓ • thyroxine →↓↓↓ • glucagons →↓↓↓	• insulin → ↑↑↑ • adrenaline → ↓↓↓ • Thyroxine → ↓↓↓ • glucagons → no effect due to absence of its receptors

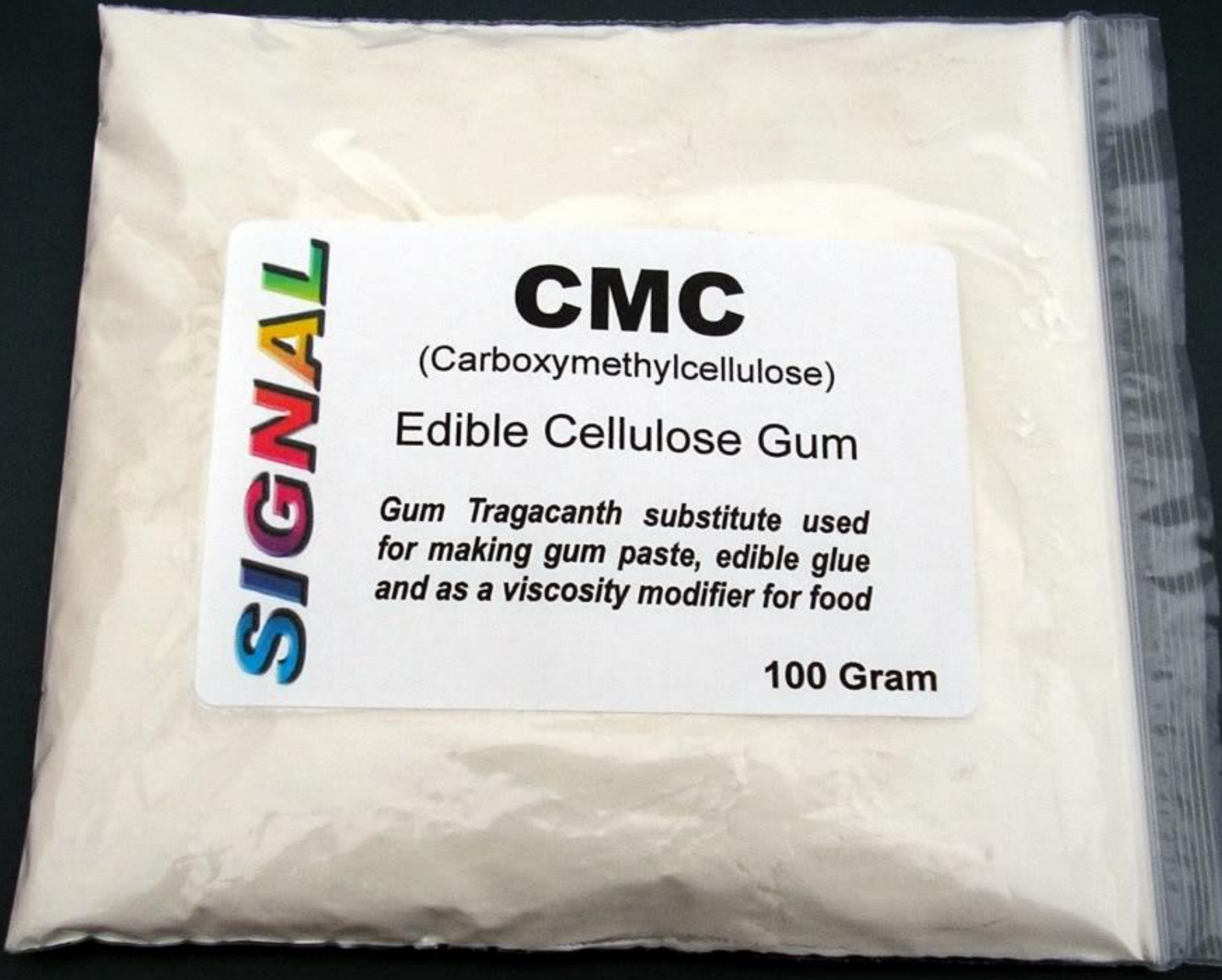
Chemical Composition of Fibers

- Contain beta bonds
- Insoluble: not fermented
  - Cellulose
  - Hemicellulose
  - Lignin*
- Soluble: 1.5-2.5 kcal/g
  - Gum
  - Pectin
  - Mucilage



mucilage

Sorbitol, Carrageeenan, cellulose gum


SIGNAL
CMC
(Carboxymethylcellulose)
Edible Cellulose Gum
Gum Tragacanth substitute used for making gum paste, edible glue and as a viscosity modifier for food
100 Gram

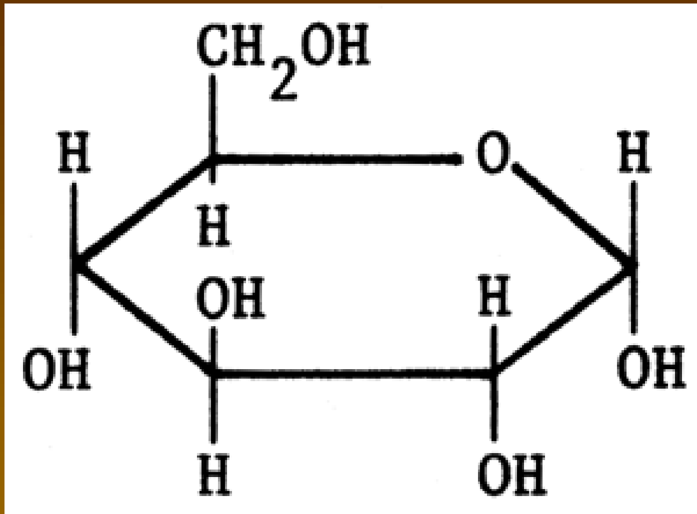
Starch: composed of two structural components, amylose and amylopectin. the relative proportions of amylose and amylopectin within plant starches varies depending on the species (20–30% amylose and 70–80% amylopectin), the fundamental unit of these two structural components is α-D-glucose. Amylose consists of long unbranched chains of 100 or more D-glucose units joined together by α-1,4 linkages. Amylopectin is composed of highly branched chains of D-glucose units (20–30 units per branch); the units being joined together by α-1,4 linkages and also α-1,6 linkages.

Cellulose: composed of very long chains of D-glucose units joined together by β-1,4 linkages. It is a very stable polysaccharide and is the most abundant carbohydrate in nature; forming the fundamental structure of the plant cell wall. Cellulose has great tensile strength and is resistant to chemical attack. Although cellulose can be hydrolysed by strong acid treatment, with the exception of micro-organisms, few non-ruminant animals have the necessary endogenous enzymes (i.e.. cellulases) capable of hydrolysing and digesting cellulose. The cellulase enzymes which are capable of attacking cellulose are only found in germinating seeds, fungi and bacteria (i.e.. such as those present in the digestive tract of ruminants). An example of a nearly pure form of cellulose is cotton.

Glycogen: composed of branched chains of α-D-glucose units joined together by α -1,4 linkages and α -1,6 linkages; the latter being more numerous in glycogen (as compared with amylopectin) due to the presence of more and shorter branches of 10–20 glucose units. Glycogen is the form in which carbohydrate is stored within the animal body; being particularly concentrated in the liver and muscle

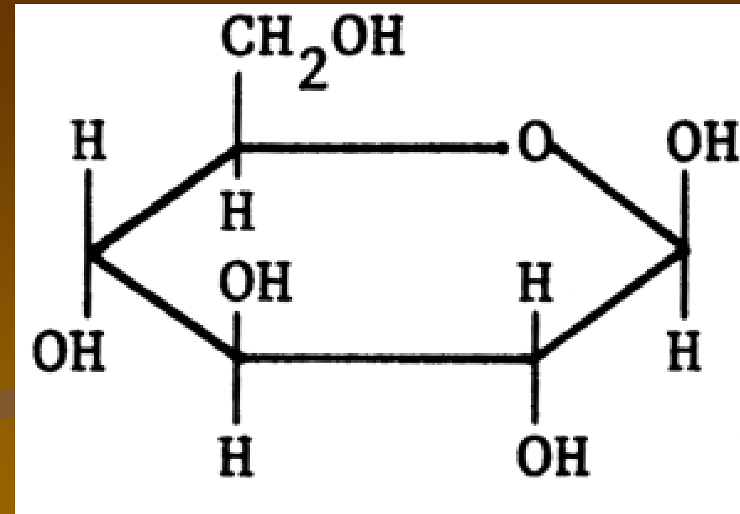
Chitin: is composed of repeating units of N-acetyl-D-glucosamine joined together by β -1,4 linkages and is therefore similar in structure to cellulose. Chitin is the major structural component of the cuticle of insects and the exoskeleton of crustaceans

Glucosamine is one of the most abundant **monosaccharides**. It is produced commercially by the hydrolysis of crustacean exoskeletons starch

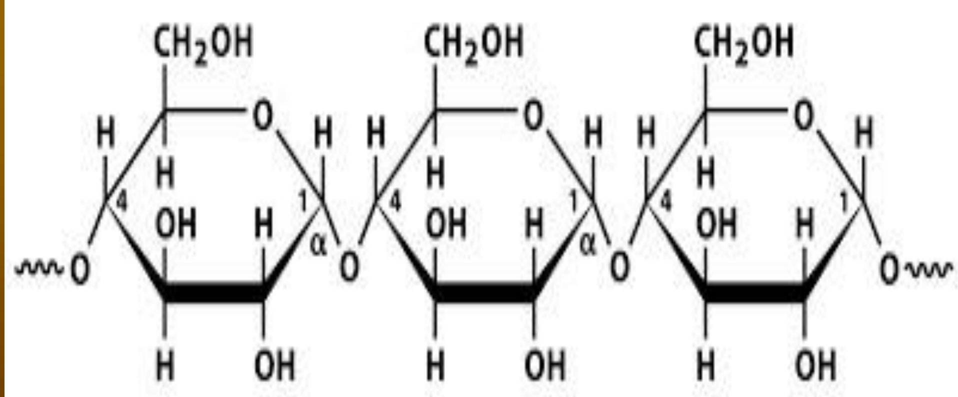


α-D-glucose

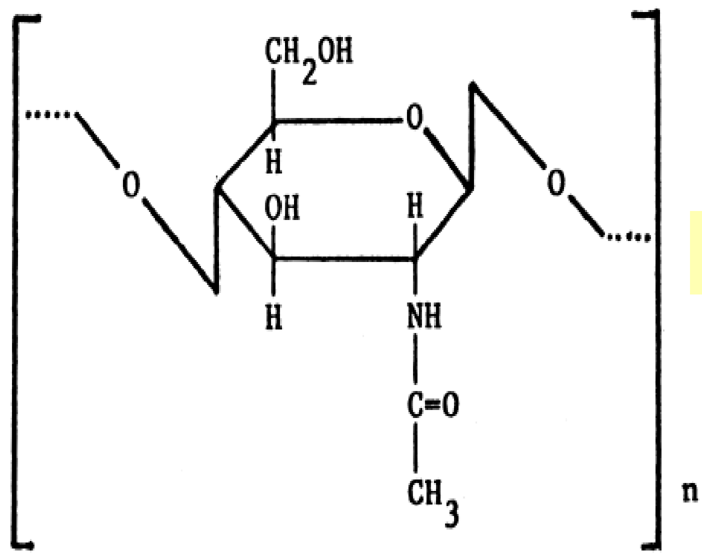
cellulose



β-D-glucose



Glycogen



Chitin

The biological importance of the structural difference between α and β -D-glucose :

the structural configuration determining the physical and subsequent biological properties of polysaccharides composed of individual monosaccharide units. For example, the polysaccharide cellulose is composed of insoluble zig-zag chains of β-glucose units, whereas the polysaccharides starch and glycogen are composed of more biological reactive helical or branched chains of α-glucose units

Dietary carbohydrate utilization

The ability of carnivorous fish species to hydrolyze or digest complex carbohydrates is limited due to the weak amylotic activity in their digestive tract

From a fish feed aspect, glucose and starch are of importance. As carnivorous fish, salmonids lack sufficient quantities of the enzymes necessary for efficient digestion and metabolism of most carbohydrates. Levels in proprietary diets are consequently low, carbohydrates giving way to increases in other components such as oil. For herbivorous fish, the carbohydrate content of man-made diets is correspondingly higher.

Thus, for fish species such as trout, as the proportion of dietary starch is increased, starch digestibility decreases accordingly

in long term feeding trials with carnivorous fish species (i.e.. salmonids) it has been shown that high dietary carbohydrate levels depress growth, elevate liver glycogen levels, and cause eventual mortality

By contrast, warmwater omnivorous or herbivorous fish species such as carp (*C. carpio*), channel catfish (*I. punctatus*), tilapia (*O. niloticus*), and eel (*A. japonica*) have been found to be more tolerant of high dietary carbohydrate levels; the dietary carbohydrate being effectively utilized as a dietary energy source or excess stored in the form of body lipid

In fish and shrimp no absolute dietary requirement for carbohydrate has been established to date. This contrasts with that of dietary protein and lipid, where specific dietary requirements have been established for certain essential amino acids and fatty acids. To a large extent this has been due:

A-The carnivorous/omnivorous feeding habit of the majority of farmed fish and shrimp species.

B-The ability of fish and shrimp to synthesize carbohydrates (ie. glucose) from non-carbohydrate substrates such as protein and lipid (a process called gluconeogenesis).

C-The ability of fish and shrimp to satisfy their dietary energy requirements through protein and lipid catabolism alone if so required

However, despite the apparent absence of a dietary requirement for carbohydrate in fish or shrimp, there is no doubt that carbohydrates perform many important biological functions within the animal body. For example; glucose, the end product of carbohydrate digestion in animals, serves as the major energy source of brain and nervous tissue, and as a metabolic intermediate for the synthesis of many biologically important compounds, including the chitin exoskeleton of crustacean, the nucleic acids RNA and DNA, and the mucopolysaccharide mucous secretions.

Although carbohydrates may be regarded as non-essential dietary nutrients for fish and shrimp, their inclusion in practical diets is warranted because:

A-They represent an inexpensive source of valuable dietary energy for noncarnivorous fish and shrimp species.

B-Their careful use in practical diets can spare the more valuable protein provision (a procedure called 'protein sparing')for growth instead of energy

C-They serve as essential dietary constituents for the manufacture of water stable diets when used as binders (i.e.. gelatinized starch, alginates, gums).

D-Certain carbohydrate sources serve as dietary components which can increase feed palatability and reduce the dust content of finished feeds (i.e.. cane or beet molasses).

End of Carbohydrate

The term carbohydrate expresses the originally determined empirical formula $C_X(H_2O)_Y$, but some compounds not showing the 2:1 ratio of hydrogen to oxygen also have many of the chemical properties of carbohydrates, e.g. deoxyribose (C5H10O4). Further, a number of compounds that contain small proportions of nitrogen and sulphur in addition to carbon, hydrogen and oxygen have characteristics considered typical for this class of nutrients . Classification of the carbohydrates may be made according to the size of the molecule Monosaccharides are simple sugars that cannot be hydrolysed into smaller units.

When two to ten monosaccharide units are linked together they form an oligosaccharide, and when more than ten monosaccharide units are joined together they produce a polysaccharide. Most polysaccharide molecules contain several hundred to several thousand monosaccharide residues. In nature, the carbohydrates are usually present as long-chain polysaccharides, the polysaccharides having either a structural or energy storage function.

Fibers

Type	Component(s)	Examples	Physiological Effects	Major Food Sources
Insoluble (Poorly Fermented)				
Noncarbohydrate	Lignins	Wheat bran	Increases fecal bulk; estrogen-like effects	Whole grains
Carbohydrate	Cellulose Hemicelluloses	Wheat products Brown rice	Increases fecal bulk Decreases intestinal transit time	All plants Wheat, rye, rice, vegetables
Soluble (Viscous)				
Carbohydrate	Pectins, gums, mucilages, some hemi-celluloses	Apples, bananas, oranges, carrots, barley, oats, kidney beans	Delays gastric emptying; slows glucose absorption; can lower blood cholesterol	Citrus fruits, oat products (beta-glucan in particular), beans, thickeners added to foods