

Carbohydrate

*Naturally occurring polysaccharide in food
sea weed polysaccharide sources and use*

Carbohydrate-

- Carbohydrates are commonly **called as sugars** - composed of C, H and O
- Term saccharide is derived from the Latin word "sacchararum" from the sweet taste of sugars.
- Compounds like glucose, fructose, starch and cellulose are called as carbohydrates.
- types - **Monosaccharides, Disaccharides and Polysaccharides**
- Monosaccharides are the simplest form of carbohydrate and contain different classes such as Trioses, Tetroses, etc.

CARBOHYDRATE:

- “The organic compounds which yield polyhydric aldehyde or ketone on hydrolysis are called as carbohydrates.”
- empirical formula as **(CH₂O)_n**.
- The name "carbohydrate" means a "hydrate of carbon.”
- For example glucose is written, C₆H₁₂O₆.

CLASSIFICATION OF CARBOHYDRATE

A) Monosaccharides

B) Oligosaccharides

C) Polysaccharides - Homopolysaccharides and Heteropolysaccharides

MONOSACCHARIDES:

- They are simplest group of carbohydrate which cannot be hydrolyzed into simplest sugar.
- They are divided into different classes on the basis of number of carbon atoms present in it like TRIOSSES, TETROSES, PENTOSSES etc.

OLIGOSACCHARIDES:

- They are formed by the condensation of a **few monosaccharide units (2-10)**
- During the union of monosaccharide units water molecule is eliminated and the remaining units are linked through an oxygen bridge called as **glycosides bond**
- They are being divided into Disaccharide and Trisaccharides.
- DISACCHARIDE – SUCROSE, MALTOSE, LACTOSE

Polysaccharides

- Polysaccharides consist of repeating units of Monosaccharide or their derivatives held together **by glycosidic bond**.
- These structures are often linear, but may contain various degrees of branching.
- Polysaccharides are often quite heterogeneous, containing slight modifications of the repeating unit.

DEFINITION:

- Polysaccharides are the complex carbohydrates.
- They are made up of chains of monosaccharide (the sugars) which are linked together by glycosidic bonds, which are formed by the condensation reaction.”

TYPES AND STRUCTURAL FEATURES:

Homopolysaccharides:

- They are such polysaccharides which on hydrolysis yield a single type of monosaccharides.
- Thus, Glucans are polymers of glucose and fructosans are polymers of fructose.
- When all the monosaccharides in a polysaccharide are the same type the polysaccharide is called a **homopolysaccharide** or **homoglycan**.

IMPORTANT HOMOPOLYSACCHARIDES

STARCH:

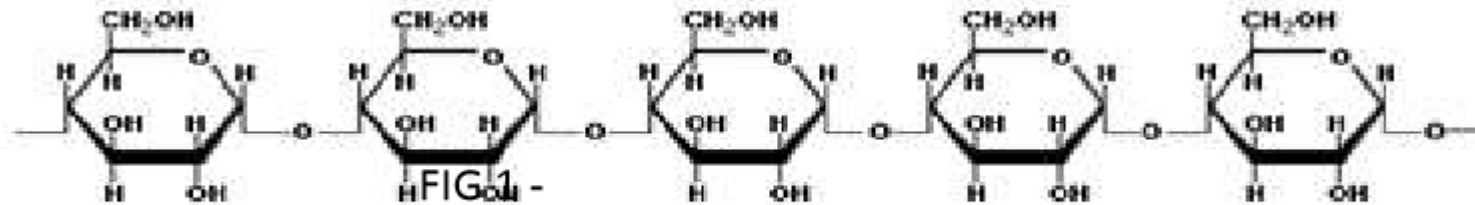
- Starch is the carbohydrate result of plants which is the important dietary source animals including man.
- High content of starch is **found in cereals, tubers, vegetables,**
- Starch is homopolymer composed of units held by **α -glucosidic bonds.**

COMPOSITION OF STARCH

consists of 2-polysaccharide components, **water soluble amylose (15-20%)** and **water insoluble amylopectin (80-85%).**

Structure of Starch:

- Starch when hydrolysed yields α -D-Glucopyranose shown by Haworth.
- In starch molecule, α -D-Glucopyranose units are linked with each other through oxygen atoms at carbon atom no. 4.



STARCH

Physical properties of Starch:

- White amorphous powder having no taste and no odor.
- It consists of two polysaccharides units i.e. amylose and **amylo pectin insoluble in water** but swells up to form a gel in water.

Chemical properties of Starch:

Reaction with Iodine:

- Soluble Starch gives blue colour with iodine. The colour disappears on heating to 80°C and reappears on cooling.

Effect of Heat:

- On heating Starch to 200-250°C, it is changed to dextrin (low molecular weight)

Uses of Starch

- Main constituents of food to produce heat.
- Employed as an adhesive in book binding.
- Manufacture of Glucose and alcoholic beverages.
- Used as a gelatin in preparation of sweets.
- In paper industry

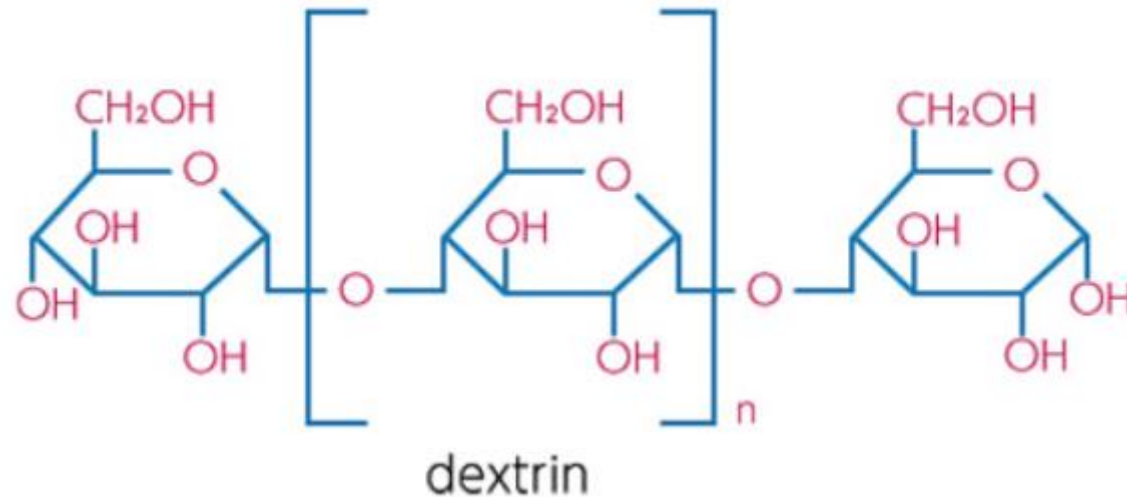
Dextrin:

- **They are the breakdown products of starch by the enzyme hydrolysis.**
- Starch is sequentially hydrolyses through different dextrin and finally to maltose and glucose.
- The various intermediate are soluble starch, amylopectin, erythro dextrin

Structure Of Dextrin

Dextrin is a polysaccharide similar to amylopectin, but the main chains are formed by $\alpha(1-6)$ glycosidic linkages

- And the side branches are attached by 1 $\alpha(1-4)$ linkages.



Uses of Dextrin:

- It is used commercially in confectioneries, as food additives, and as plasma volume expanders

INULIN:

- Inulin is a polymer of fructose.
- It occurs in Dahlia bulbs, garlic, onion
- It is of low molecular weight(5000) polysaccharides , easily soluble in water

Structure of Inulin:

- **Inulins, also called fructans**, are polymers consisting of fructose units that typically have a terminal glucose.
- Oligofructose has the same structure as inulin, but the chains consist of 10 or fewer fructose units. Oligofructose has approximately 30 to 50 percent of the sweetness of sugar

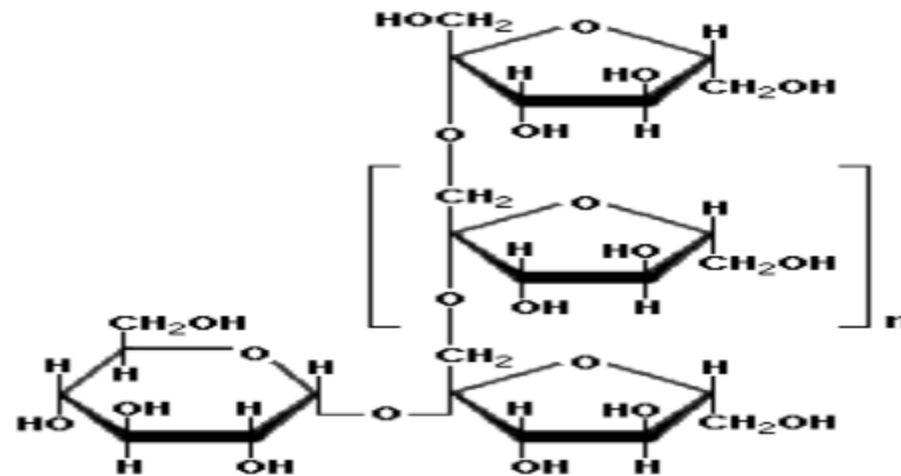


FIG 3 - INULIN

Uses of Inulin:

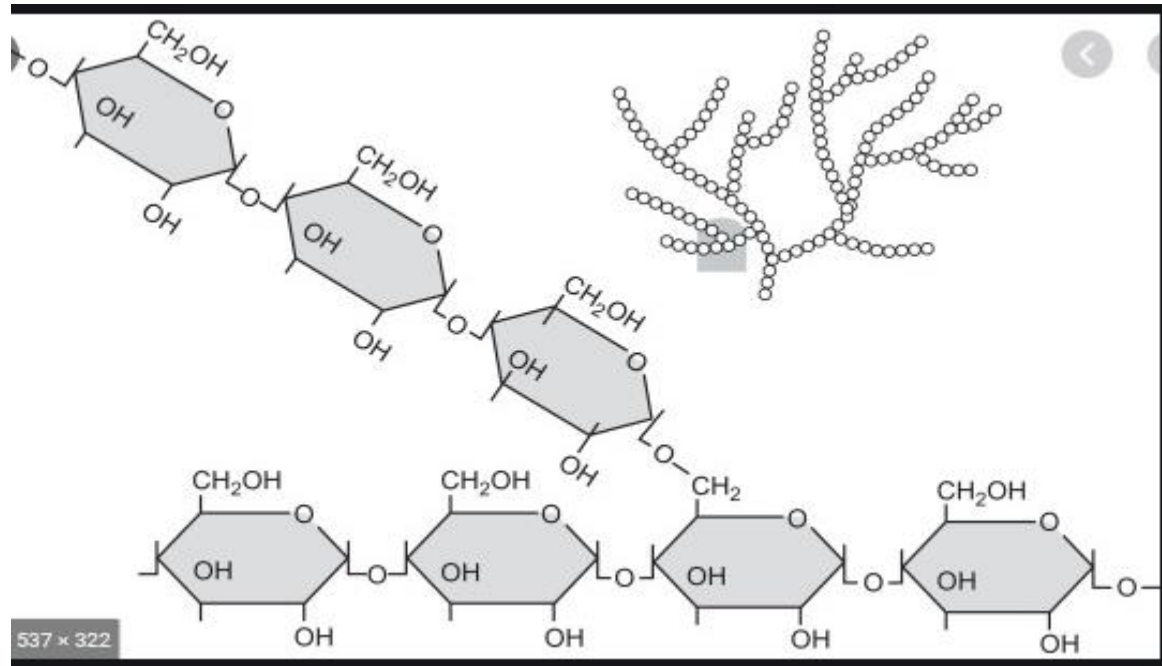
- Inulin is less soluble than Oligofructose and has a smooth creamy texture that provides a fat-like mouth feel.
- Inulin and Oligofructose are non-digestible by human intestinal enzymes, but they are totally fermented by colonic microflora.

GLYCOGEN:

- Glycogen is the carbohydrate reserve in animals called as animal starch.
- It is present in **high concentration in liver followed by muscle, brain, etc.**
- Glycogen is also found in plants that do not possess chlorophyll.

Structure of Glycogen:

- The structure of Glycogen is similar to that of amylopectin with more no. of branches.
- Glucose is the repeating unit in the Glycogen joint together by the (1-4) glycosidic bonds and α -(1-6) glycosidic bonds at branching points.



Uses of Glycogen:

- It act as storage food reserve in animals and help in glycolysis.
- Provides energy when needed.

CELLULOSE:

- Cellulose widely occurs in vegetables because it forms fundamental constituent of cell walls and vegetable tissues.
- Sources of cellulose: Cotton, wood, paper, jute, hemp. All of them contain small amount of mineral matter which is left as residues when they are burnt.

Physical properties of Cellulose:

- It occurs in the form of hollow fiber which has characteristic appearance and dimension.
- Cellulose is soluble in ammoniacal solution of cupric hydroxide and insoluble in all organic solvents.

Chemical properties of cellulose:

Hydration:

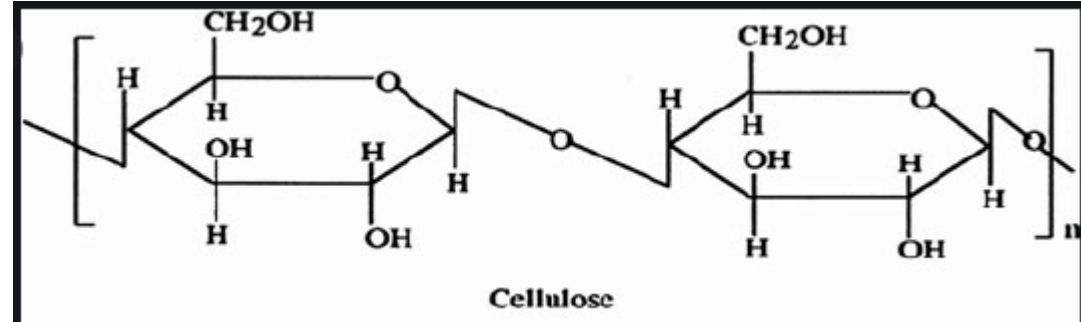
- On treatment with acids it is exchanged to hydrated cellulose called hydrocellulose.

Action of alkalis:

- When cellulose is treated with 15-20% caustic soda solution its reticulated fibrous walls swell to a cylindrical shape.

Structure of cellulose:

- Cellulose is composed of β -D-glucose units linked by $\beta(1-4)$ glycosidic bonds.



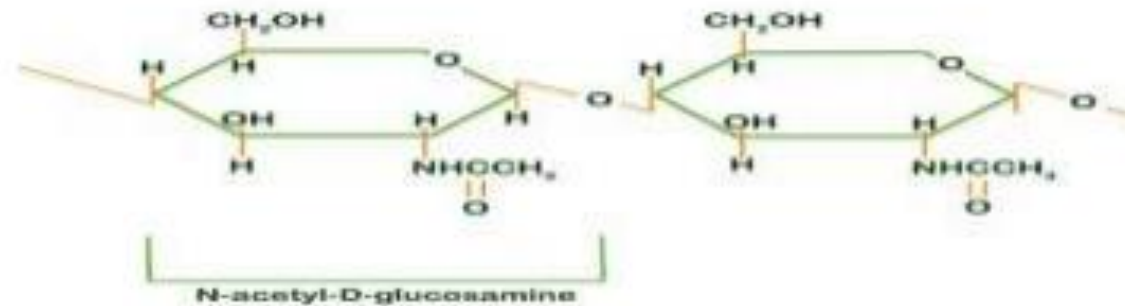
Industrial Application of Cellulose:

Textile Industry:

- Cellulose employed in manufacture of cotton and linen.
- Jute is employed in smaller extent.
- Wrappings.
- Explosives: Gum, cotton which is cellulose tri-nitrate is used as **blasting and propellant explosives.**

Chitin:

- Composed of **N-Acetyl, D-Glucosamine** units held together by **β -(1-4)** Glycosidic bonds.
- Structural polysaccharides found in the exoskeleton of some invertebrates.



Heteropoly saccharides:

- When the polysaccharides are composed of different types of sugars, referred to as heteropoly saccharides/heteroglycans.

Mucopolysaccharides :

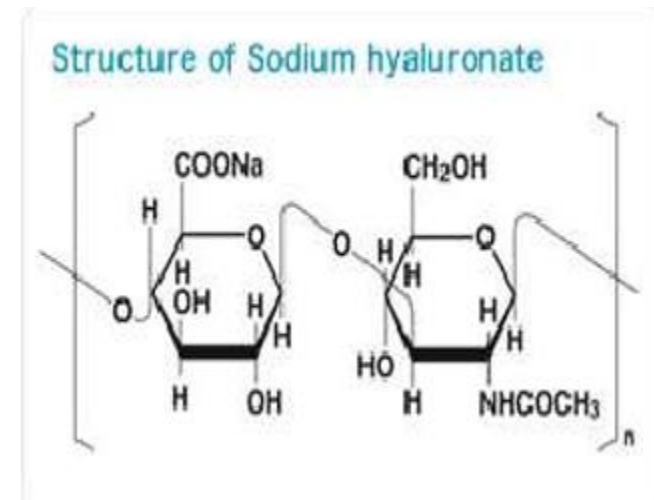
- They are heteroglycans made up of repeating unit of sugar derivatives namely amino/uronic acid.
- They are commonly known as glucosamine glycans (GAG).
- Some of the Mucopolysaccharides found in combination with proteins to form mucoproteins/proteoglycans.

HYALURONIC ACID:

- Important GAG found in the ground substance of synovial fluid of joints and vitreous humor of eyes.
- Present in connective tissue and forms a gel around

Structure of Hyaluronic Acid:

- Composed of alternative units of D-Glucuronic acid and N-acetyl D-Glucosamine. These two molecules formed disaccharides units held together by β -(1-3) Glycosidic bonds.



CHONDROTIN SULFATE:

- Chondroitin 4-sulfate is a major constituent of various **mammalian tissue**

Structure of chondroitin sulfate:

- Chondroitin 4-sulfate consists of repeating units disaccharides units composed of D- glucuronic acid and N- acetyl galactosamine.

HEPARIN:

- An anticoagulant that occurs in blood, lung, liver, spleen, etc.
- Heparin helps in the release of enzyme lipoprotein lipase which helps in clearing the turbidity of lipemic plasma.

Dermatan Sulfate:

- Compound mostly occur in the skin is structurally related to chondroitin 4-sulfate.

BIOLOGICAL IMPORTANCE OF POLYSACCHARIDES

- These act as a metabolic reserve in plants and animals – **starch, glycogen.**
- They also serve as mechanical structures in plants and animals.
- Wood, cotton, paper are made of cellulose which are useful in our day to day life.
- Cellulose nitrates are used as explosives, lacquers, photograph.
- Films are used for **packing materials.**
- Normally, **heparin act as an anticoagulant** for the prevention of blood is a polysaccharide.

Sea weed polysaccharide

Seaweeds are the most abundant source of polysaccharides as alginate, agar, fucoidan, agarose, as well as carrageenan

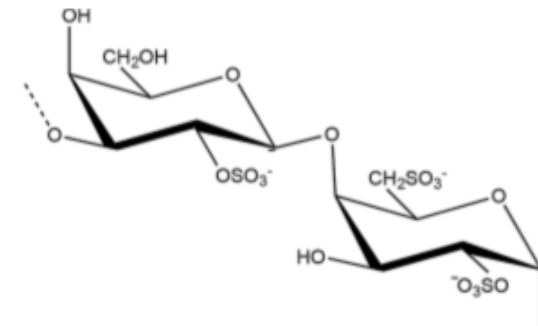
- Past two decades numerous studies have been reported on seaweeds-derived polysaccharides for biomedical and biological applications (tissue engineering, drug delivery, wound healing, and biosensor)
- **Alginate, carrageenan, fucoidan, and ulvan** are widely used marine derived polysaccharides for biological and biomedical applications due to their biocompatibility and availability.

Alginate

- Alginate is an anionic polysaccharides and commonly available in cell wall of seaweed.
- It forms a viscous gum with water and having capacity to absorb water around 200–300 times of its own weight.
- Alginate, the mannuronic–acid and guluronic acid-constituted polysaccharide from brown seaweed (Phaeophyceae), including *Laminaria hyperborean*, *Laminaria digitata*, *Laminaria japonica*, *Ascophyllum*, and *Macrocystis pyrifera*
- Alginate applied as a biomaterial in wound healing, tissue engineering , orthopedics, and dental implant surgery because of its low toxicity, relatively low cost, good biocompatibility, and osteo conductivity
- The thickening, gel-forming and stabilizing property.
- alginate most widely used biopolymer with broader range of applications including tissue engineering, drug delivery, biosensor, and wound dressing

Carrageenans

- Carrageenan an anionic sulfated polysaccharides, has straight chain backbones of alternating 3-linked β -D-galactopyranose, 4-linked α -galactopyranose residue Several of its α -galactose residue may exist in the form of 3,6-anhydro derivatives
- Carrageenan are mainly extracted from seaweed such as **euchema, chondrus crispus, gigartina stellate, hypnea, and solieria**
- Biomedical applications of carrageenans
- Carrageenans have been extensively studied marine derived polysaccharides in drug delivery, tissue engineering, and wound heading applications.

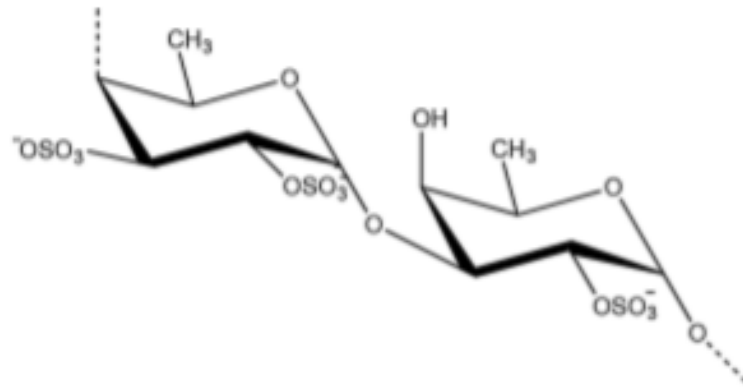


Fucoidan

- Fucoidan, first isolated by Kylin is known to produce much immunobiological responses in humans.
- The larger proportion of fucoidan for example consist of molecular L-fructose, sulphate, and other minor sugars such as xylose, galactose, mannose, and glucuronic acid
- **Fucusvesiculosus** is one of the commercially available fucoidan, a polysaccharide which contains a linear backbone of 1,3 linkage α -L-fuco pyranose
- Fucoidan can be isolated from seaweeds such as *Undaria pinnatifida*, *Cladosiphon okamuranus*, *Fucus vesiculosus*, and *Ascophyllum nodosum*.

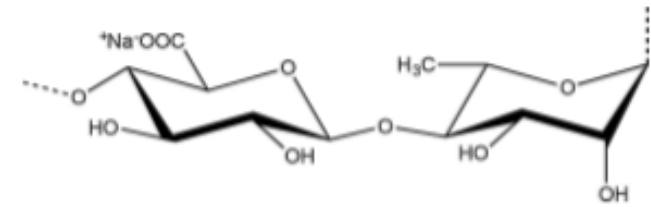
Biological application of fucoidan

- Low molecular weight fucoidan can controlling inflammatory pathologies related to ulcer, Anti-tumor, anti-thrombosis gastric protection. anti-cancer anti-viral , anti inflammatory, anti-coagulation, anti-oxidants are known properties of biological activities in fucoidan



Ulvan

- Ulvan composed of structural subunits of **uronic acids and neutral sugars** i.e., glucuronic acid, iduronic acids, rhamnose, xylose, and glucose residues respectively
- Ulvan have repeating disaccharide unit of b-D-glucuronosy 1-(1, 4) a-L-rhamnose 3-sulfate (aldobiouronic acid).
- Ulvan can be extracted from the cell walls of green seaweeds belonging to the Ulvales. Ulvan from *U. lactuca*



BIOLOGICAL APPLICATION

- Ulvan have exhibited strong antioxidant, antitumor, immunostimulatory, anti-inflammatory, anticoagulant, lipid lowering, antiviral, antibacterial, antiprotozoan, hyperplasiaprevention, gastrointestinal, regenerative, and nano medicine applications

- Seaweed polysaccharides are sources of active biological compound with varieties of potentials in biomedical applications.
- Biocompatibility, cell adhesion, higher cell proliferation, hydrogel forming ability, fibrillar collagen matrix formation, stimulation of in vitro and in vivo angiogenesis are important properties of marine seaweeds derived polysaccharides. Hence, they will be promising biomaterials in tissue engineering, drug delivery, and biosensor