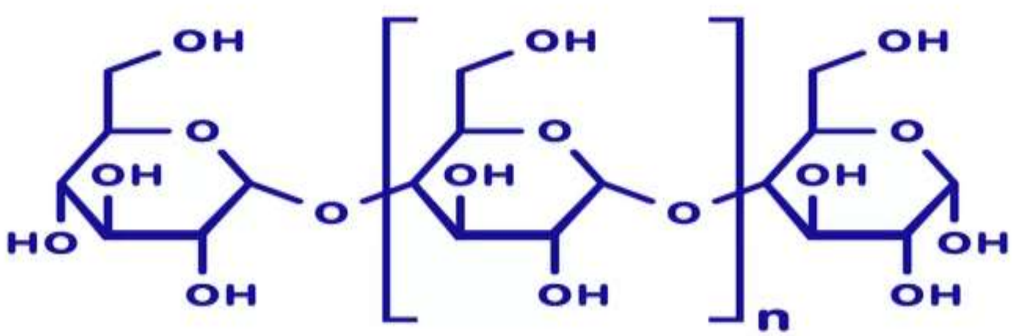
7/30/2020

“POLYSACCHARIDES”

The term "polysaccharides" broadly refers to complex, long-chain carbohydrates that provide nutritive elements in the human diet, and may also possess anti-inflammatory and/or immunomodulatory properties, among other health benefits. In a general sense, any sugar molecule that has a glycogen bond can be referred to as a polysaccharide. These substances can be comprised of as few as ten monosaccharides (the simplest carbohydrate), or up to thousands of monosaccharide molecules in various branched chain arrangements. The most common monosaccharides that comprise polysaccharide chains include the simple sugars glucose, fructose, galactose, and mannose (all of which are composed of the same elements: $C_6H_{12}O_6$). They are long chain polymeric carbohydrates composed of monosaccharide units bound together by glycosidic linkages. This carbohydrate can react with water (hydrolysis) using amylase enzymes at catalyst, which produces constituent sugars (monosaccharides, or oligosaccharides). They range in structure from linear to highly branched. Examples include storage polysaccharides such as starch and glycogen, and structural polysaccharides such as cellulose and chitin.

Polysaccharides are often quite heterogeneous, containing slight modifications of the repeating unit. Depending on the structure, these macromolecules can have distinct properties from their monosaccharide building blocks. They may be amorphous or even insoluble in water. When all the monosaccharides in a polysaccharide are the same type, the polysaccharide is called a *homopolysaccharide* or *homoglycan*, but when more than one type of monosaccharide is present, they are called *heteropolysaccharides* or *heteroglycans*.



Amylose is a polysaccharide is used to build starch and amylopectin

Natural saccharides are generally composed of simple carbohydrates called monosaccharides with general formula $(CH_2O)_n$ where n is three or more.

Examples of monosaccharides are glucose, fructose, and glyceraldehyde. Polysaccharides, meanwhile, have a general formula of $C_x(H_2O)_y$ where x is usually a large number between 200 and 2500. When the repeating units in the polymer backbone are six-carbon monosaccharides, as is often the case, the general formula simplifies to $(C_6H_{10}O_5)_n$, where typically $40 \le n \le 3000$.

As a rule of thumb, polysaccharides contain more than ten monosaccharide units, whereas oligosaccharides contain three to ten monosaccharide units; but the precise cut off varies somewhat according to convention. Polysaccharides are an important class of biological polymers. Their function in living organisms is usually either structure- or storage-related. Starch (a polymer of glucose) is used as a storage polysaccharide in plants, being found in the form of both amylose and the branched amylopectin. In animals, the structurally similar glucose polymer is the more densely branched glycogen, sometimes called "animal starch". Glycogen's properties allow it to be metabolized more quickly, which suits the active lives of moving animals.

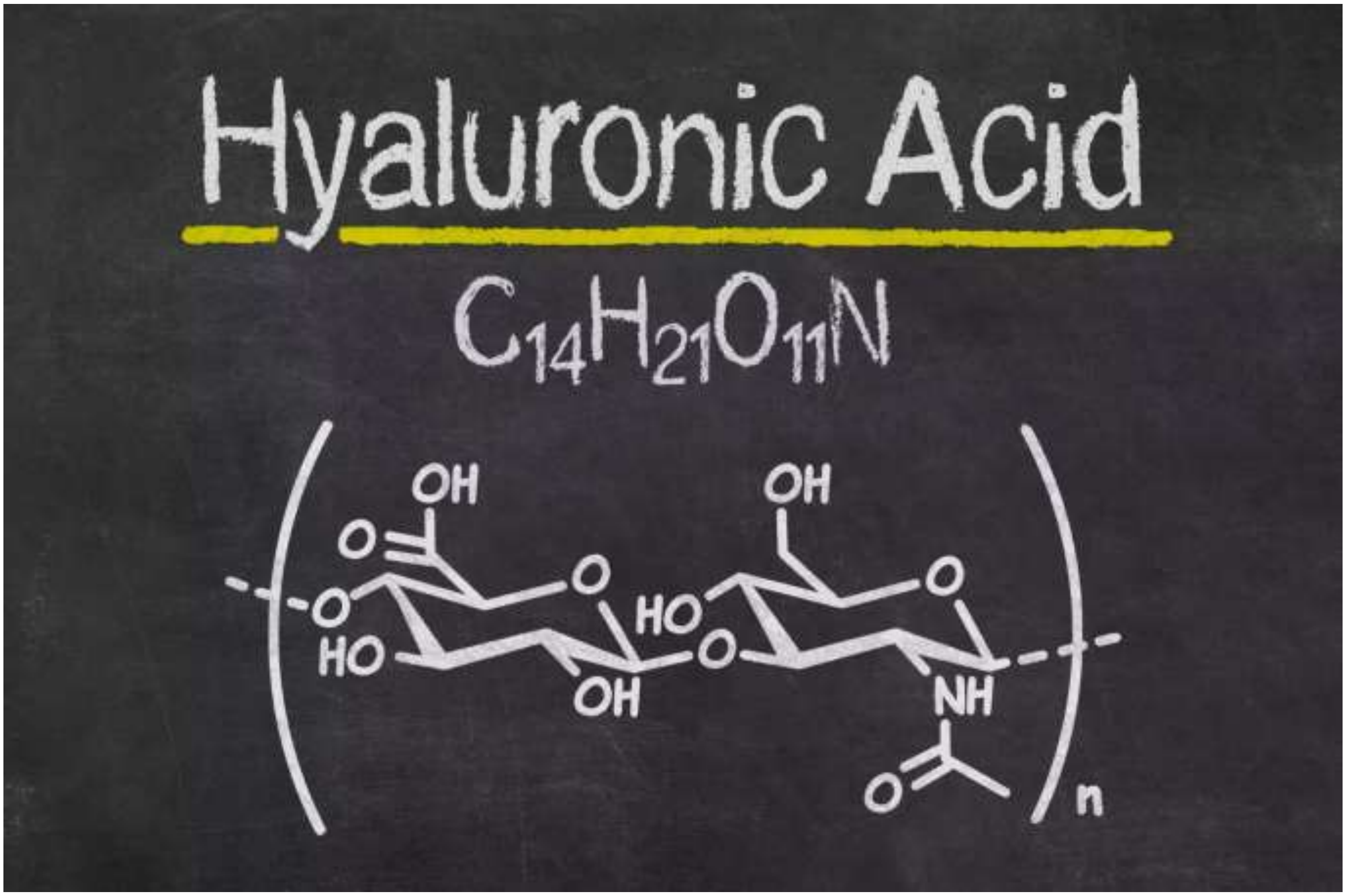
Cellulose and chitin are examples of structural polysaccharides. Cellulose is used in the cell walls of plants and other organisms, and is said to be the most abundant organic molecule on Earth. It has many uses such as a significant role in the paper and textile industries, and is used as a feedstock for the production of rayon (via the viscose process), cellulose acetate, celluloid, and nitrocellulose. Chitin has a similar structure, but has nitrogen containing side branches, increasing its strength. It is found in arthropod exoskeletons and in the cell walls of some fungi. It also has multiple uses, including surgical threads. Polysaccharides also include callose or laminarin, chrysolaminarin, xylan, arabinoxylan, mannan, fucoidan and galactomannan.

HOMOPOLYSACCHARIDE VS. HETEROPOLYSACCHARIDE

Polysaccharides may be classified according to their composition as either homopolysaccharides or heteropolysaccharides.

homopolysaccharide or homoglycan consists of one sugar or sugar derivative. For example, cellulose, starch, and glycogen are all composed of glucose subunits. Chitin consists of repeating subunits of *N*-acetyl-*D*-glucosamine, which is a glucose derivative.

A **heteropolysaccharide** or heteroglycan contains more than one sugar or sugar derivative. In practice, most heteropolysaccharides consist of two monosaccharides (disaccharides). They are often associated with proteins. A good example of a heteropolysaccharide is hyaluronic acid, which consists of *N*-acetyl-*D*-glucosamine linked to glucuronic acid (two different glucose derivatives).



Hyaluronic acid is an example of heteropolysaccharide

Structural and Storage Polysaccharides

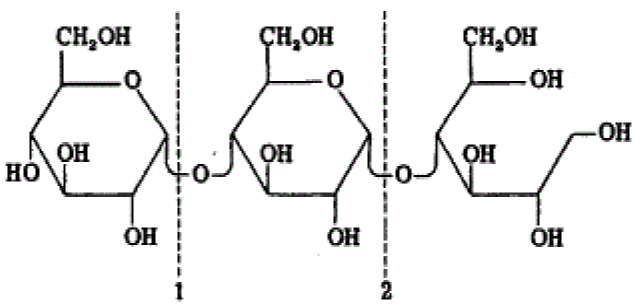
There are two primary classifications of polysaccharides: storage, which refers to the type that serves as an energy reserve, and structural, which refers to the type that builds up the cell walls in plants and within the skeletons of animals. A storage polysaccharide is typically composed of a singular type of monosaccharide, which can be either a homopolysaccharide or a homoglycan, and usually manifests in the form of starch or glycogen. These types of polysaccharides can be found in grains, corn, potatoes, and certain fruits. Structural or non-starch polysaccharides are comprised of more than one type of monosaccharide, collectively called heteropolysaccharides or heteroglycans.

These manifest as cellulose, chitin (which is indigestible), beta-glucans, and alginates found in plants.

Storage polysaccharides

Starch ...

Starch is a glucose polymer in which glucopyranose units are bonded by *alpha*-linkages. It is made up of a mixture of amylose (15–20%) and amylopectin (80– 85%). Amylose consists of a linear chain of several hundred glucose molecules, and Amylopectin is a branched molecule made of several thousand glucose units (every chain of 24–30 glucose units is one unit of Amylopectin). Starches are insoluble in water. They can be digested by breaking the *alpha*-linkages (glycosidic bonds). Both humans and other animals have amylases, so they can digest starches. Potato, rice, wheat, and maize are major sources of starch in the human diet. The formations of starches are the ways that plants store glucose.

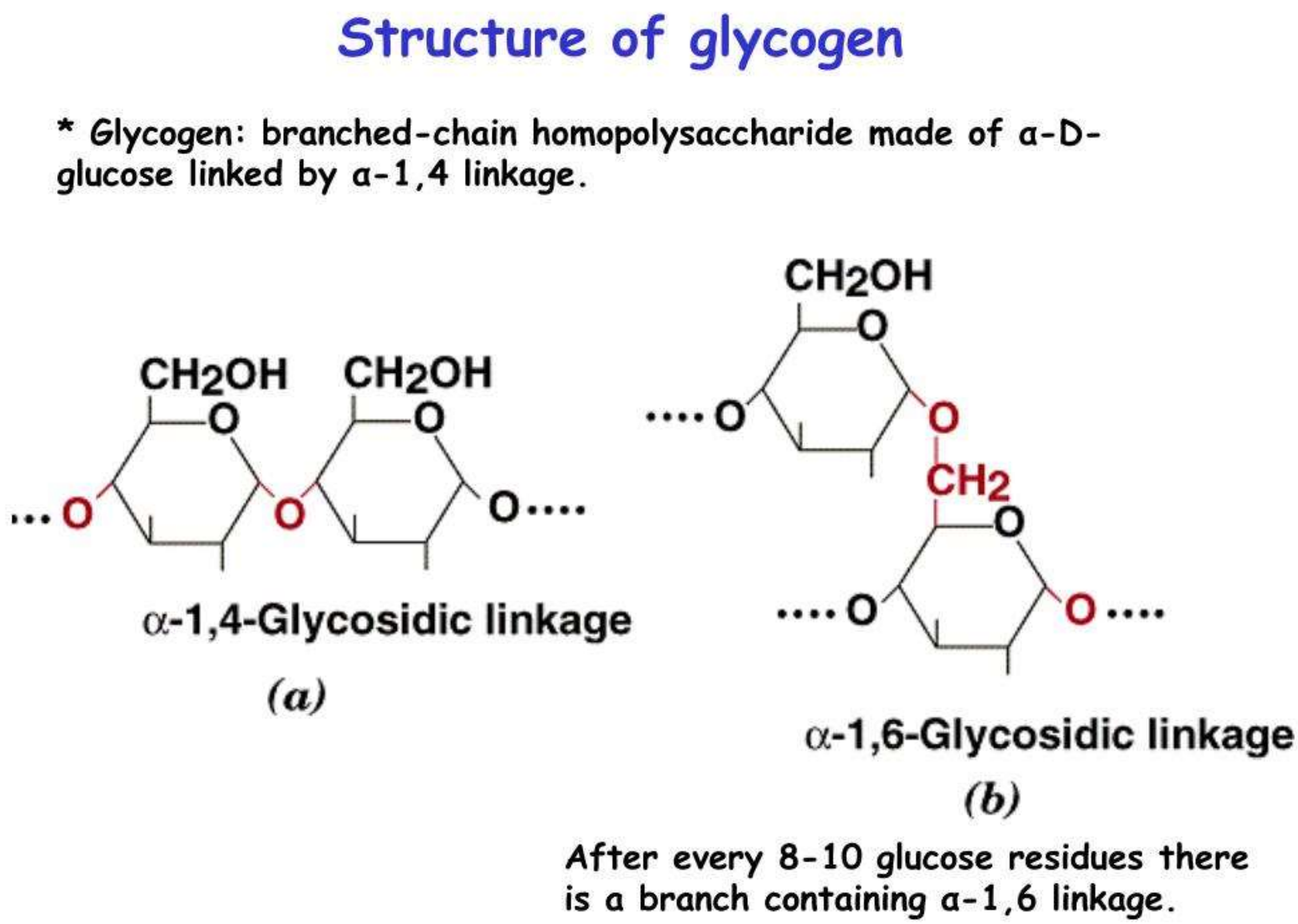


Chemical structure of starch, a polysaccharide

Glycogen ...

Glycogen serves as the secondary long term energy storage in animal and fungal cells, with the primary energy stores being held in adipose tissue. Glycogen is made primarily by the liver and the muscles, but can also be made by glycogenesis within the brain and stomach.

Glycogen is analogous to starch, a glucose polymer in plants, and is sometimes referred to as *animal starch*, having a similar structure to amylopectin but more extensively branched and compact than starch. Glycogen is a polymer of α(1→4) glycosidic bonds linked, with α(1→6)-linked branches. Glycogen is found in the form of granules in the cytosol/cytoplasm in many cell types, and plays an important role in the glucose cycle. Glycogen forms an energy reserve that can be quickly mobilized to meet a sudden need for glucose, but one that is less compact and more immediately available as an energy reserve than triglycerides (lipids).



In the liver hepatocytes, glycogen can compose up to 8 percent (100–120 grams in an adult) of the fresh weight soon after a meal. Only the glycogen stored in the liver can be made accessible to other organs. In the muscles, glycogen is found in a low concentration of one to two percent of the muscle mass. The amount of glycogen stored in the body—especially within the muscles, liver, and red blood cells varies with physical activity, basal metabolic rate, and eating habits such as intermittent fasting. Small amounts of glycogen are found in the kidneys, and even smaller amounts in certain glial cells in the brain and white blood cells. The uterus also stores glycogen during pregnancy, to nourish the embryo.

Glycogen is composed of a branched chain of glucose residues. It is stored in liver and muscles.

Functions of Glycogen

- It is an energy reserve for animals.
- It is the chief form of carbohydrate stored in animal body.
- It is insoluble in water. It turns brown-red when mixed with iodine.
- It also yields glucose on hydrolysis.

Inulin

Inulin is a naturally occurring polysaccharide, Complex carbohydrate composed of Dietary fiber a plant-derived food that cannot be completely broken down by human digestive enzymes.

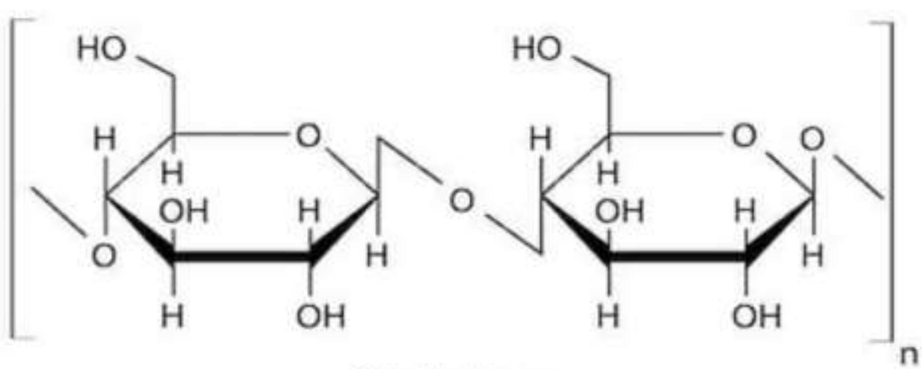
Structural polysaccharides

Arabinoxylans ...

Arabinoxylans are found in both the primary and secondary cell walls of plants and are the copolymers of two sugars: arabinose and xylose. They may also have beneficial effects on human health.

Cellulose ...

The structural components of plants are formed primarily from cellulose. Wood is largely cellulose and lignin, while paper and cotton are nearly pure cellulose. Cellulose is a polymer made with repeated glucose units bonded together by *beta* linkages. Humans and many animals lack an enzyme to break the *beta*-linkages, so they do not digest cellulose. Certain animals such as termites can digest cellulose, because bacteria possessing the enzyme are present in their gut. Cellulose is insoluble in water. It does not change color when mixed with iodine. On hydrolysis, it yields glucose. It is the most abundant carbohydrate in nature.

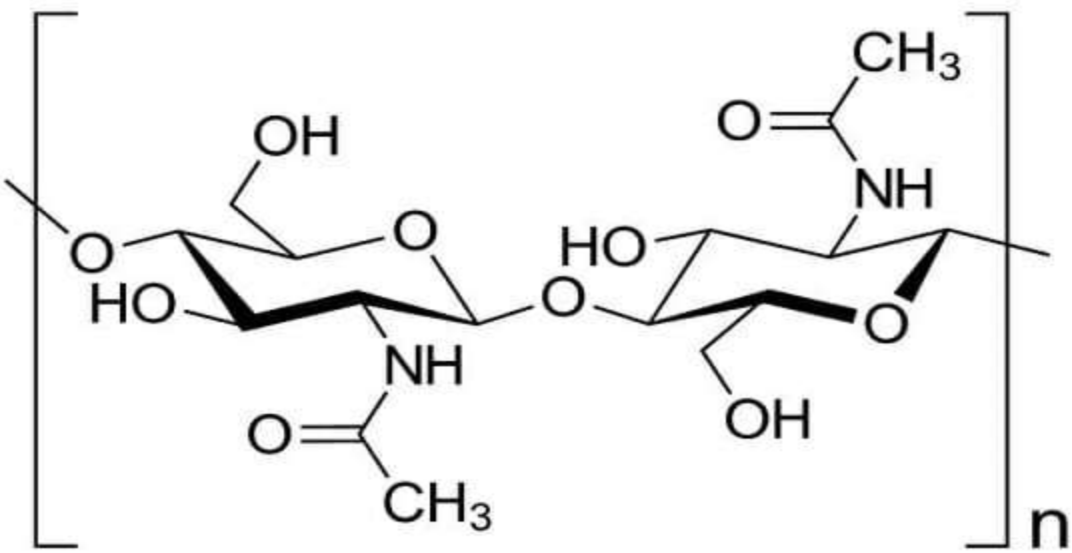


Cellulose

Chitin is one of many naturally occurring polymers. It forms a structural component of many animals, such as exoskeletons.

Over time it is bio-degradable in the natural environment. Its breakdown may be catalyzed by enzymes called chitinases, secreted by microorganisms such as bacteria and fungi, and produced by some plants. Some of these microorganisms have receptors to simple sugars from the decomposition of chitin. If chitin is detected, they then produce enzymes to digest it by cleaving the glycosidic bonds in order to convert it to simple sugars and ammonia.

Chemically, chitin is closely related to chitosan (a more water-soluble derivative of chitin). It is also closely related to cellulose in that it is a long unbranched chain of glucose derivatives. Both materials contribute structure and strength, protecting the organism.



Chemical structure of chitin, a polysaccharide

Pectins ...

Pectins are a family of complex polysaccharides that contain 1,4-linked α-galactosyluronic acid residues. They are present in most primary cell walls and in the non-woody parts of terrestrial plants.

Polysaccharide Functions

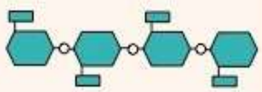
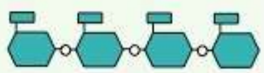
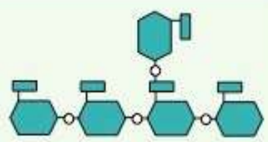
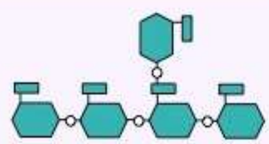
The three main functions of polysaccharides are providing structural support, storing energy, and sending cellular communication signals. The carbohydrate structure largely determines its function. Linear molecules, like cellulose and chitin, are strong and rigid. Cellulose is the primary support molecule in plants, while fungi and insects rely on chitin. Polysaccharides used for energy storage tend to be branched and folded upon themselves. Because they are rich in hydrogen bonds, they are usually insoluble in water. Examples of storage polysaccharides are starch in plants and glycogen in animals. Polysaccharides used for cellular communication are often covalently bonded to lipids or proteins, forming glycoconjugates. The carbohydrate serves as a tag to help the signal reach the proper target. Categories of glycoconjugates include glycoproteins, peptidoglycans, glycosides, and glycolipids. Plasma proteins, for example, are actually glycoproteins.

A polysaccharide is a type of carbohydrate. It is a polymer made up of many sugar subunits, called monosaccharides.

Polysaccharides may be linear or branched. They may consist of a single type of simple sugar (homopolysaccharides) or two or more sugars (heteropolysaccharides).

The main functions of polysaccharides are structural support, energy storage, and cellular communication.

Examples of polysaccharides include cellulose, chitin, glycogen, starch, and hyaluronic acid.

	Cellulose	**Starch**		**Glycogen**
		Amylose	**Amylopectin**	
Source	Plant	Plant	Plant	Animal
Subunit	β-glucose	α-glucose	α-glucose	α-glucose
Bonds	1-4	1-4	1-4 *and* 1-6	1-4 *and* 1-6
Branches	No	No	Yes (~per 20 subunits)	Yes (~per 10 subunits)
Diagram				
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