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# Polysaccharides

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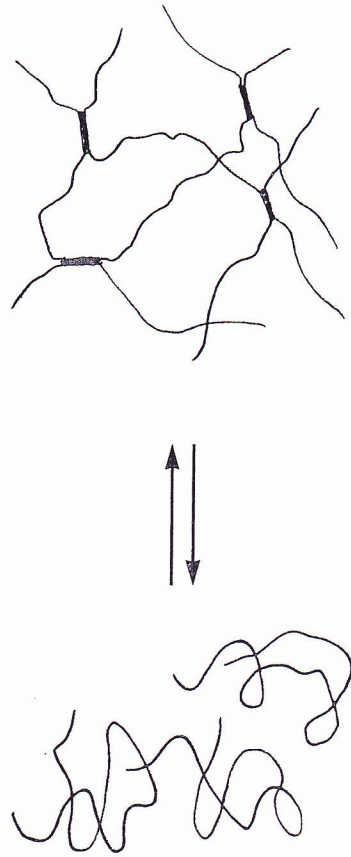
In this brief introductory chapter, a detailed presentation of the structure, properties, functions and methods of investigation of polysaccharides is out of the question: such is not the object of pharmacognosy. However, it is useful to highlight here some basic concepts that the reader may complete by referring to biochemistry and specialized textbooks and publications.

Polysaccharides (or glycans) are arbitrarily defined as high-molecular weight polymers resulting from the condensation of a large number of monosaccharide molecules. Each sugar is linked to its neighbor through a glycosidic linkage formed by the theoretical elimination of a water molecule between the hemiacetal hydroxyl group on C-1 of one sugar and any of the hydroxyl groups on the other sugar molecule.

As natural molecules, polysaccharides are virtually universal, and they ensure, in living organisms, a large number of vital functions, some of which are, so far, poorly understood. They are responsible for the rigidity of cell walls in higher plants (or on the contrary for the flexibility of the thallus of algae), or they are energy storage forms (starch and other polysaccharides in plants, and also glycogen in animals), or

which is therefore the determining influence of the polymer structure on the ability to form gels:

- regular homogeneous polymers form very extensive junction zones, have high structural organization, and are essentially precipitates;
- heterogeneous polymers with no regular sequences are dispersed in the solvent and form viscous solutions;
- polymers with regular sequences interrupted by irregular patterns can form punctual junction zones and therefore elastic gels. The junction zones can involve helical structures (e.g., agarose, carrageenans) or chain pile-ups (e.g., pectins, alginates, see below).



Gel formation: formation of punctual junction zones

### 3. ISOLATION AND STRUCTURAL ANALYSIS

**Isolation.** Polysaccharides dissolve in water, possibly in the presence of mineral acids (as for pectin extraction) or of various salts (carbonates in the case of algin). In the laboratory, aprotic dipolar solvents can also be used. The elimination of salts and of low molecular-weight molecules can be done by dialysis, by using ion exchange resins, by molecular gel filtration or by extraction (for example, elimination of oligosaccharides and of pigments by ethanol or acetone).

Polysaccharide fractionation is delicate: it calls for resorting to precipitation techniques (by immiscible solvents, by salt addition, by changing the pH). Chromatographic techniques find broad application: on charcoal, on native or substituted reticulated polyglucan gels, or on ion exchangers, among others. Sometimes, the structural peculiarities of the polysaccharide to be isolated may allow the use of specific techniques such as the formation of boric complexes, formation of inclusion derivatives, or the use of quaternary ammonium salts. In all cases, purification is followed by physical and chemical determinations: optical

they protect tissues against dehydration due to their hydrophilicity, or they are sometimes substances elaborated by an organism for defense purposes (e.g., microorganism cell walls).

### 1. STRUCTURE OF POLYSACCHARIDES

Homogeneous polysaccharides can be distinguished, resulting from the condensation of a large number of molecules of the same sugar, from heterogeneous polysaccharides, which result from the condensation of molecules of different types of sugars. Several varied components may participate in the formation of the polysaccharides, especially the heterogeneous ones: hexoses, pentoses, anhydrohexoses, sugar ethers, sulfuric esters, and others. Homogeneous or heterogeneous, polysaccharides may be linear or branched. An important aspect of the structure is the sugar sequence within the polymer.

The following are classically distinguished:

- periodic-sequence polysaccharides. The sugars occur along the chain in a pattern that repeats itself regularly (amylose, cellulose...). The conformation of this type of polymer is determined mainly by the conformation of the glycosidic link:
  - if  $\beta$ -(1 $\rightarrow$ 4), the shape is a very elongated ribbon (e.g., cellulose),
  - if  $\alpha$ -(1 $\rightarrow$ 4), the polymer may adopt a helical shape (e.g., amylose),
  - in some cases, the conformation is loose and flexible as the result of a large degree of freedom with respect to rotation; such is the case of structures with (1 $\rightarrow$ 6) bonds;

• interrupted-sequence polysaccharides. Zones with regular periodicity alternate with heterogeneous zones. Potential polymer-polymer interactions make gel formation possible;

• completely heterogeneous polysaccharides. Potential interactions are of the polymer-solvent type.

### 2. BEHAVIOR OF POLYSACCHARIDES: GEL FORMATION

*\* that the inter-polymer bonds are weak (hydrogen bonds, coordination); the covalency of the bond requires that bonds must be able to form in sufficient numbers;*

Many polysaccharides are characterized by their ability to form gels, that is solid three-dimensional macromolecular arrays that retain the liquid phase within their lattice. Gel formation is, in a way, the passage from disorder (a true solution) to a certain order created by the partial association of chains or of segments of a chain. The more the chains or chain segments associate, the more rigid the gel: partial syneresis (gel contraction) may occur. If the organization becomes too great, the structure approaches that of a precipitate. The reversibility of gel formation implies

**Structural Analysis.** The structural analysis of polysaccharides is exceedingly complex and requires the combined use of physical (spectroscopy and spectrometry) and chemical methods (hydrolysis, methanolysis, partial hydrolysis, formation of derivatives, controlled degradation of the polymer and its derivatives, and so forth). Elaborating on the methodologies in use would exceed the scope of this text. Specialized books and publications should be consulted for a description of the techniques for the determination of the monosaccharide composition, of the linkage types, of the molecular weight, how to estimate chain length, how to discover and locate branching points, and so on.

#### 4. MONOGRAPHS

Any attempt at classification turns out to be somewhat arbitrary: the diversity of structures and of uses of polysaccharides and related drugs leads us to adopt a classification based on botanical origin:

- polysaccharides from microorganisms and fungi;
- polysaccharides from algae;
- polysaccharides from higher plants (homogeneous and heterogeneous).

#### 5. BIBLIOGRAPHY

- Aspinall, G.O. *The Polysaccharides*, vol. 1, (1982), vol. 2 (1983), vol. 3 (1985), Academic Press, New York.
- Aspinall, G.O. (1987). Chemical Modification and Selective Fragmentation of Polysaccharides, *Acc. Chem. Res.*, **20**, 114-120.
- Doublier, J.-L. (1993). Rhéologie des polysides en milieu aqueux: solutions, gels et mélanges, *JAA*, **111** (01-02), 22-28.

## Polysaccharides from Lower Plants

## Polysaccharides from microorganisms and fungi

To date, sugar polymers used by man are obtained chiefly from higher plants, or are semisynthesized from natural polymers: many have been known and utilized for centuries. Their plant origin is not without drawbacks, such as irregular supply in unusual climatic conditions and resulting price fluctuations, uneven quality, and at times, lack of reproducibility of the physical properties due to the variability inherent to living matter.

Polymers from biotechnology alleviate these inconveniences: they are produced under controlled conditions, and with remarkably constant quality and physical properties.

Although for the time being the number of polysaccharides produced by microorganisms and approved for sale is very limited, it might increase in the future, based on the number of products that are published or under study.

#### ● DEXTRANS, dextran (INN)

Dextrans are glucose polymers or glucans made of  $\alpha$ -D-glucopyranosyl residues linked 1 $\rightarrow$ 6. These molecules are more or less branched of high molecular weight