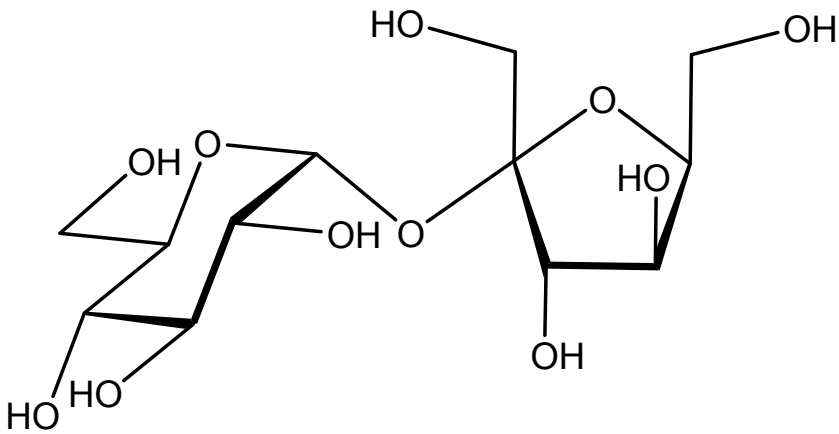
Carbohydrates – A General Introduction

Graduate course in
Carbohydrate Chemistry

Sugar



Sucrose, Saccharose, Cane sugar, Beet sugar, Table sugar

β-D-Fructofuranosyl-(2↔1)-α-D-glucopyranoside

β-D-Fru*f*-(2↔1)-α-D-Glc*p*

Sugar

Honey (fructose + glucose) was the main sweetener during the middle ages

Cane sugar arrived in Europe with the Moors around 700 A.D.

The *Continental blockade* (1806) during the Napoleonic wars made cane sugar unavailable

Beet sugar was developed as substitute for cane sugar

Sucrose, glucose (corn syrup) and inverted sugar, are the main sweeteners today

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Carbohydrate Chemistry

Sucralose & Olestra

Chlorinated sucrose

Sweetener 600x sweeter than sucrose

Sucrose fatty acid ester

Fat substitute

Inverted sugar

Sucrose $\rightarrow$ Glucose + Fructose

$[\alpha]_D$=+66° $[\alpha]_D$=+53° $[\alpha]_D$=−92°

Sweeter than sucrose

More difficult to crystallize (*e.g.* in sweets, chocolate …)

Glucose (“grape sugar”) is also called *dextrose*

Fructose (“fruit sugar”) is also called *laevulose*

What is a carbohydrate?

2-Carb-1.1. Carbohydrates

The generic term 'carbohydrate' includes monosaccharides, oligosaccharides and polysaccharides as well as substances derived from monosaccharides by reduction of the carbonyl group (alditols), by oxidation of one or more terminal groups to carboxylic acids, or by replacement of one or more hydroxy group(s) by a hydrogen atom, an amino group, a thiol group or similar heteroatomic groups. It also includes derivatives of these compounds. The term 'sugar' is frequently applied to monosaccharides and lower oligosaccharides. It is noteworthy that about 3% of the compounds listed by Chemical Abstracts Service (i.e. more than 360 000) are named by the methods of carbohydrate nomenclature.

Note. Cyclitols are generally not regarded as carbohydrates. Their nomenclature is dealt with in other recommendations.

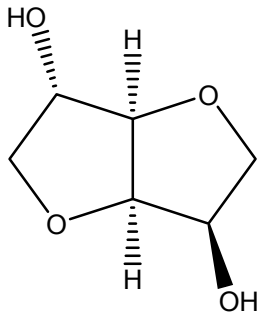
What is a monosaccharide?

2-Carb-1.2. Monosaccharides

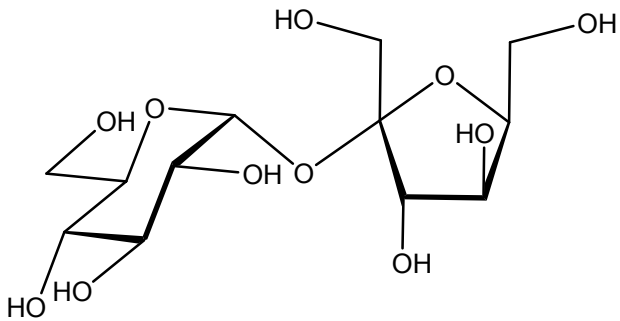
Parent monosaccharides are polyhydroxy aldehydes H-$[CHOH]_n$-CHO or polyhydroxy ketones H-$[CHOH]_n$-CO-$[CHOH]_m$-H with three or more carbon atoms.

The generic term 'monosaccharide' (as opposed to oligosaccharide or polysaccharide) denotes a single unit, without glycosidic connection to other such units. It includes aldoses, dialdoses, aldoketoses, ketoses and diketoses, as well as deoxy sugars and amino sugars, and their derivatives, provided that the parent compound has a (potential) carbonyl group.

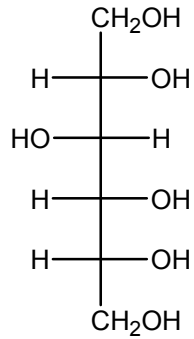
Some “carbohydrates”



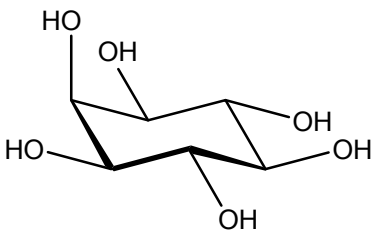
Isosorbide



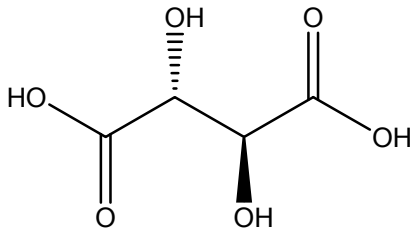
Sucrose (cane sugar)



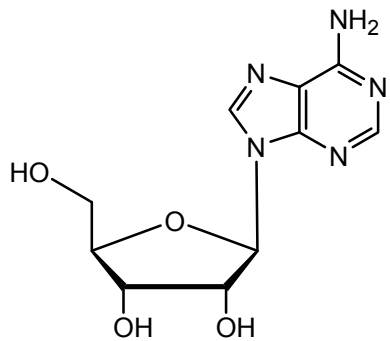
sorbitol



myo-Inositol

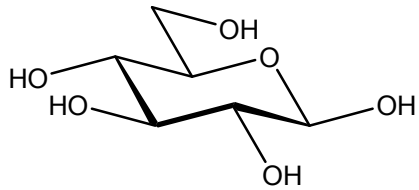


meso-tartaric acid

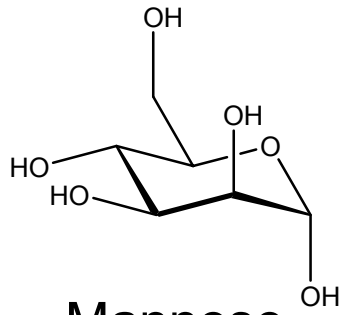


Adenosine

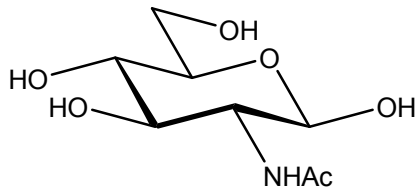
“Common” Monosaccharides



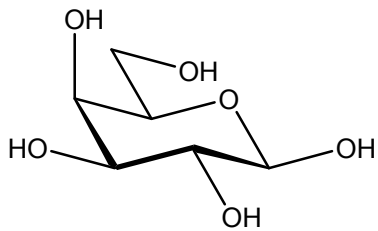
Glucose



Mannose



2-Acetamido-2-deoxyglucose



Galactose

Monosaccharides

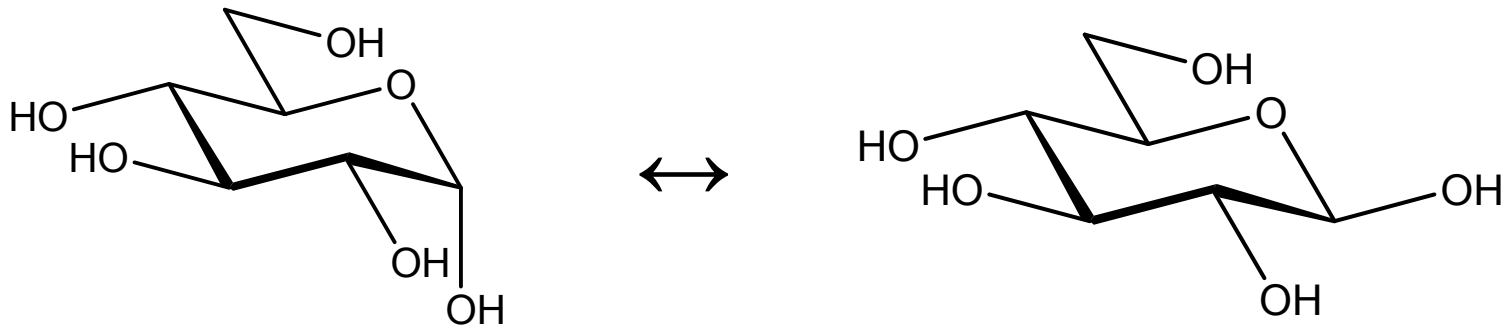
Mammalian glycoproteins contain about 10 different monosaccharides

More than 100 different monosaccharides are found in microbial glucans

Common functional groups are:
Amides, amines, carboxylic acids, esters, ethers, sulphates and phosphates

Mutarotation

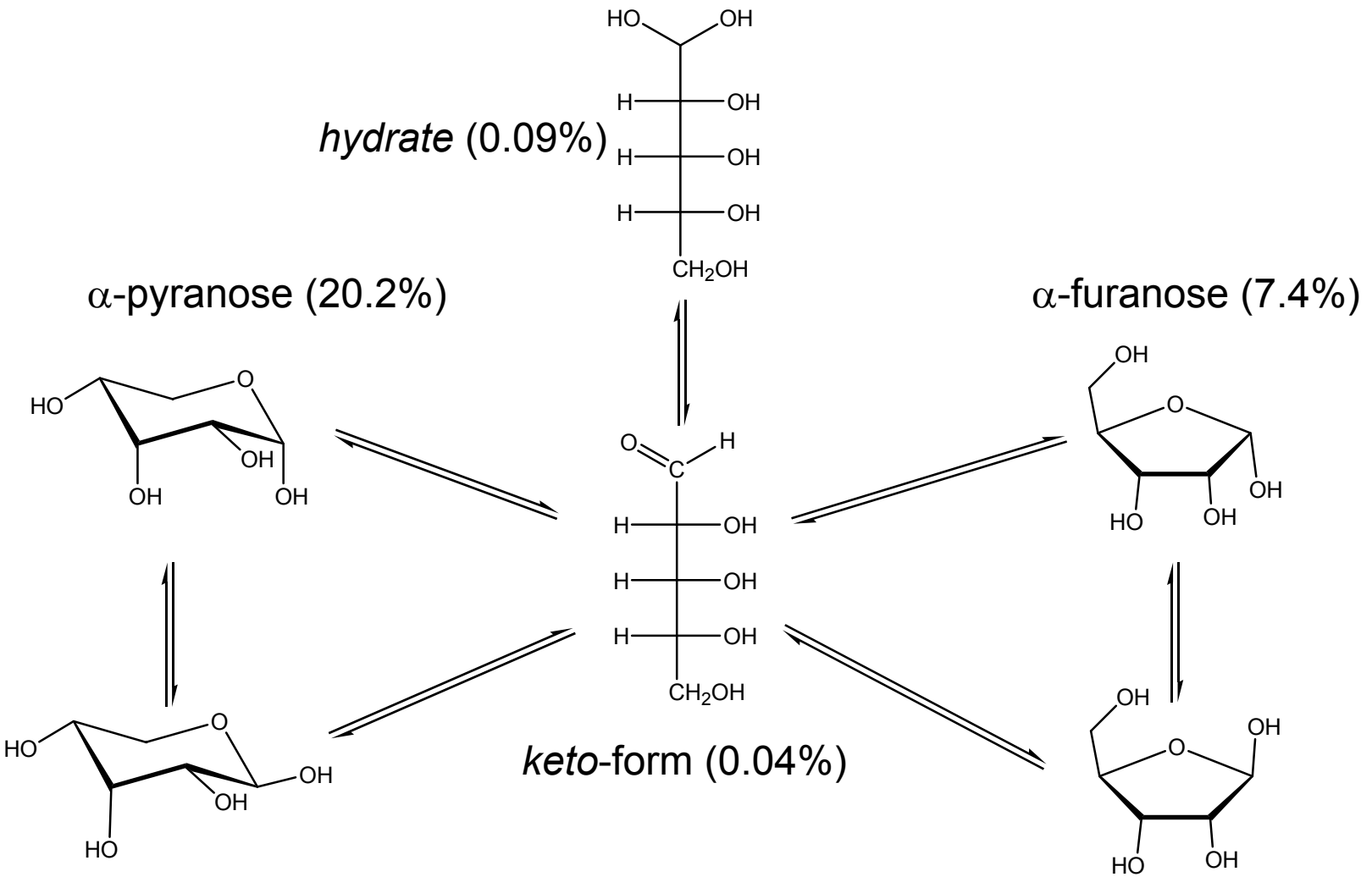
Glucose, $[\alpha]_D$=+53° in water at equilibrium



$[\alpha]_D$=+112°

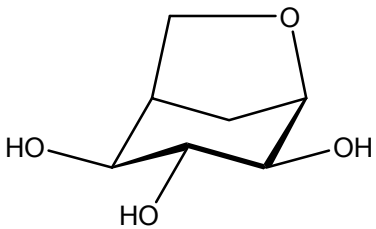
$[\alpha]_D$=+19°

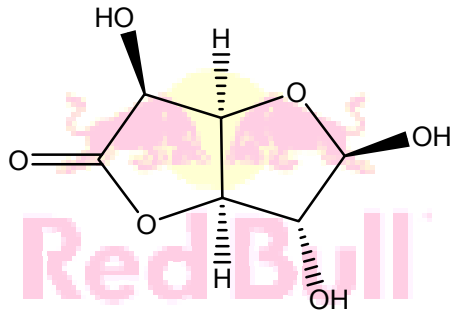
Mutarotation of ribose



More complications…

Some compounds form anhydrides or lactones…



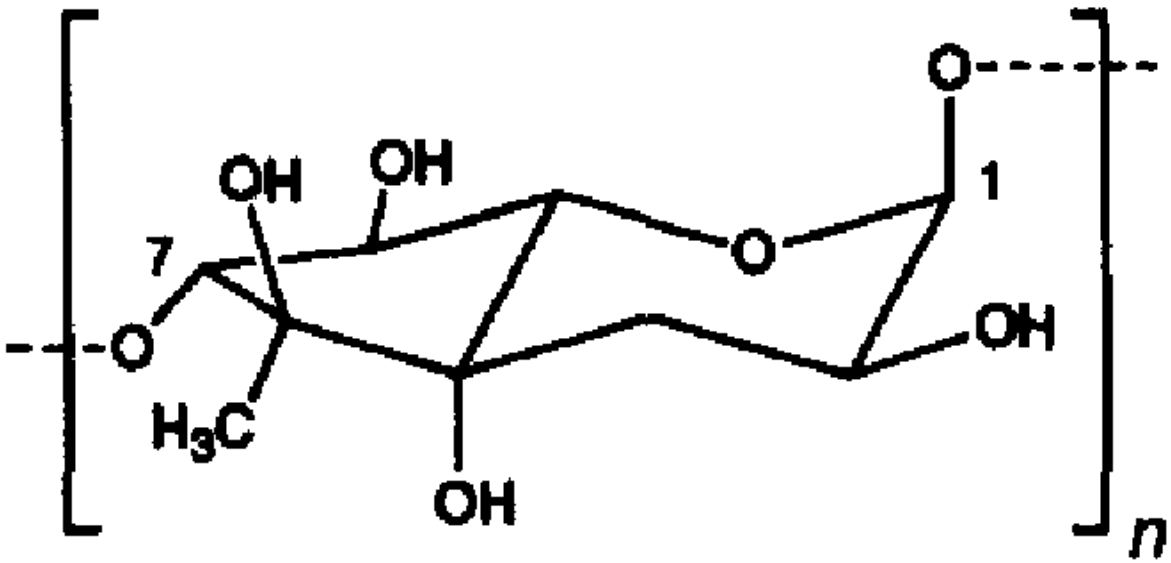


1,6-anhydro-β-D-idopyranose

β-D-glucofuranurono-6,3-lactone
(used in some energy drinks)

… and a few may even have more than one aldehyde/keto function

β-caryose



4,8-cyclo-3,9-di-*deoxy*-L-*erythro*-D-*ido*-nonose

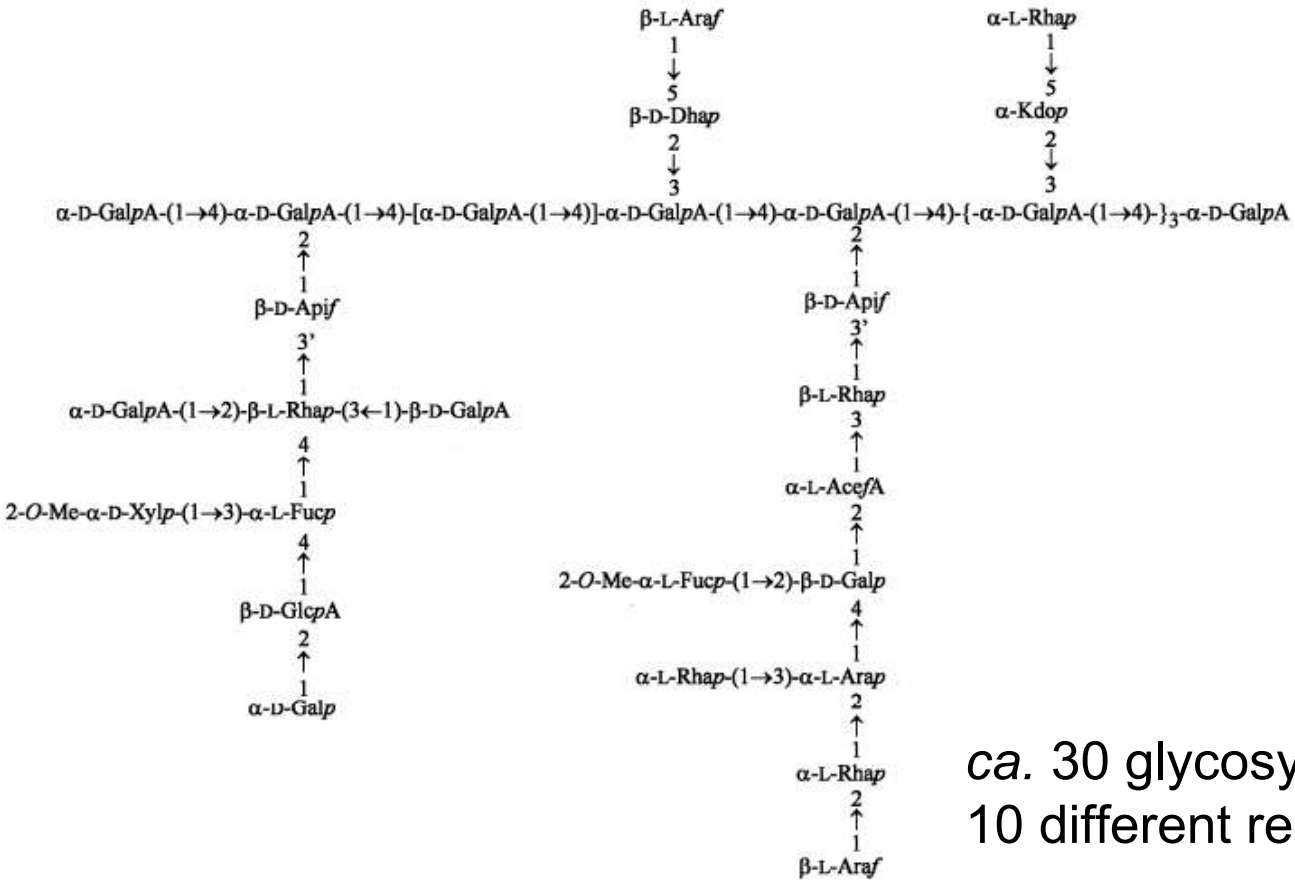
Disaccharides

Non-reducing	
Sucrose	Cane sugar
Trehalose	in yeast
Reducing	
Lactose	Milk sugar
Maltose	Malt sugar
Cellobiose	

Oligosaccharides

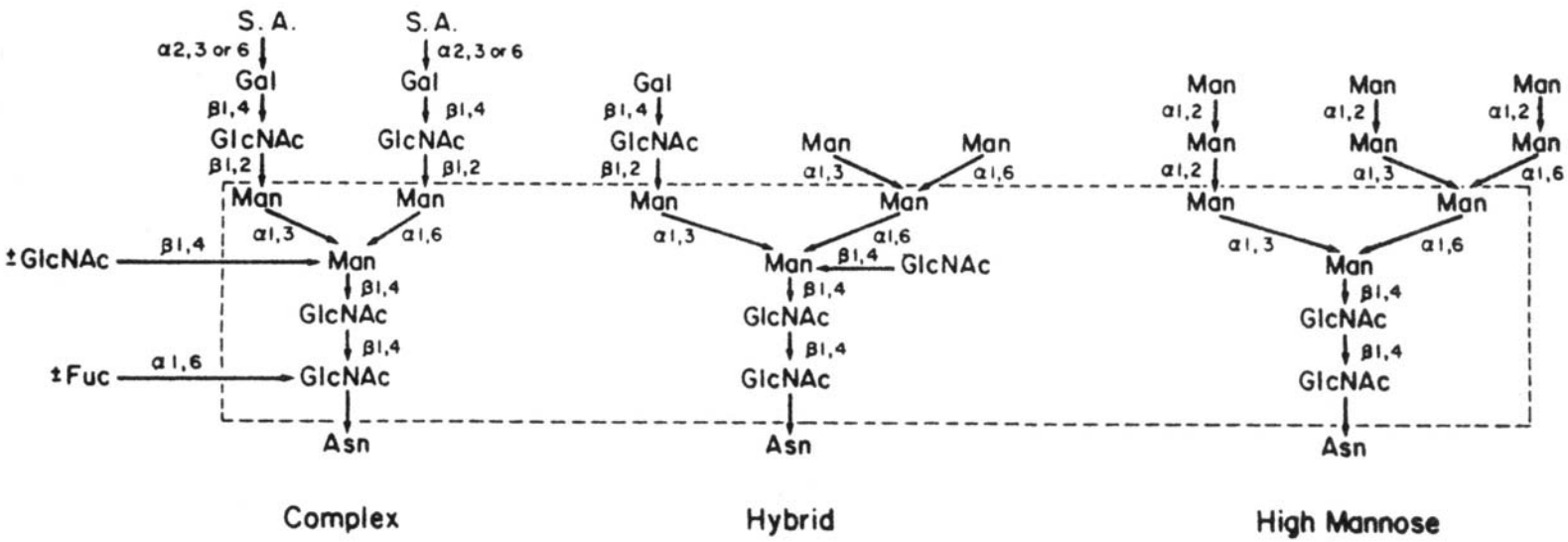
N-glucans	linked to ASN in proteins
Blood group antigens	linked to ceramide (a lipid)
Milk-oligosaccharides	lactose at the reducing end

rhamnogalacturonan II



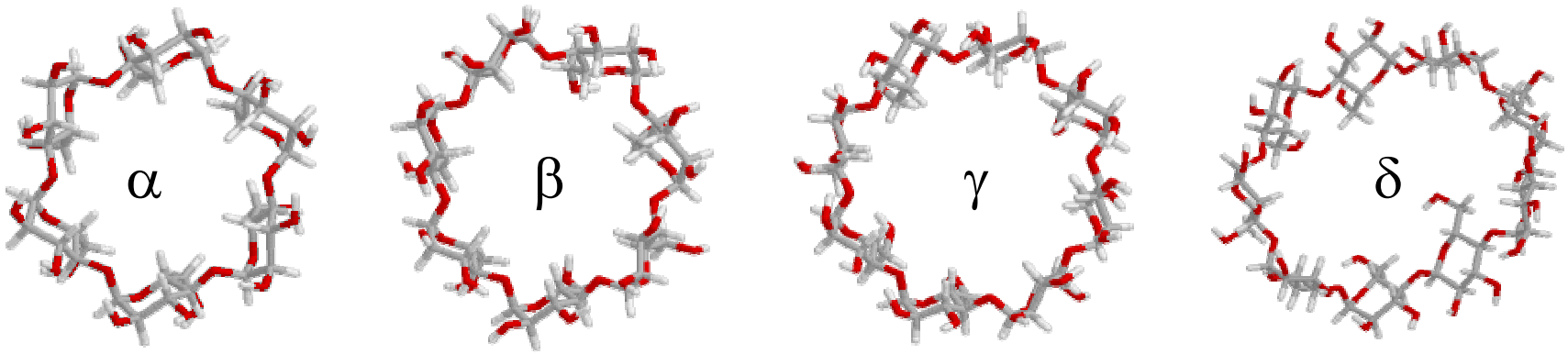
ca. 30 glycosylresidues
10 different residues

N-linked glucans



Cyclic oligosaccharides

E.g. cyclodextrins, $[4)\text{-}\alpha\text{-D-Glc}p\text{-}(1\rightarrow]_n$



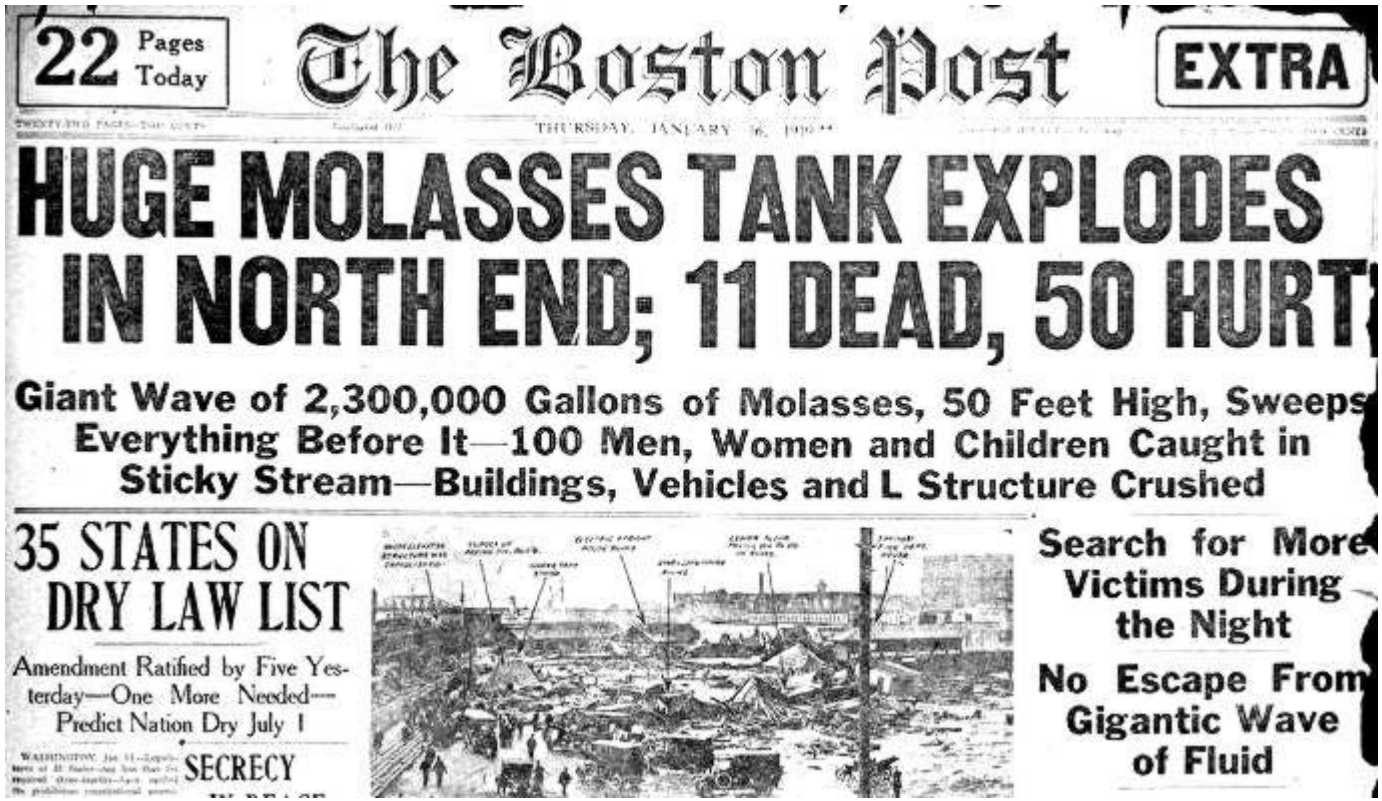
Used to stabilize flavours and pharmaceuticals

Polysaccharides

Energy storage
Starches (amylose, glycogen, amylopectin) (glucans)
Levan and inulin (fructans)

Structure - cellwalls
Cellulose (plants)
Chitin (yeast and arthropods)
Glucosaminoglucans (animals)
Murein (peptidoglucan, bacteria)

Molasses -*a thick, syrupy derivative of the juice of the sugarcane plant or the processing of sugar beet*



22 Pages Today

The Boston Post

EXTRA

THURSDAY, JANUARY 16, 1919

HUGE MOLASSES TANK EXPLODES IN NORTH END; 11 DEAD, 50 HURT

Giant Wave of 2,300,000 Gallons of Molasses, 50 Feet High, Sweeps Everything Before It—100 Men, Women and Children Caught in Sticky Stream—Buildings, Vehicles and L Structure Crushed

35 STATES ON DRY LAW LIST

Amendment Ratified by Five Yesterday—One More Needed—Predict Nation Dry July 1

SECRECY

Search for More Victims During the Night

No Escape From Gigantic Wave of Fluid

"Hey, let's be careful out there."

Sgt. Esterhaus, Hill Street Blues