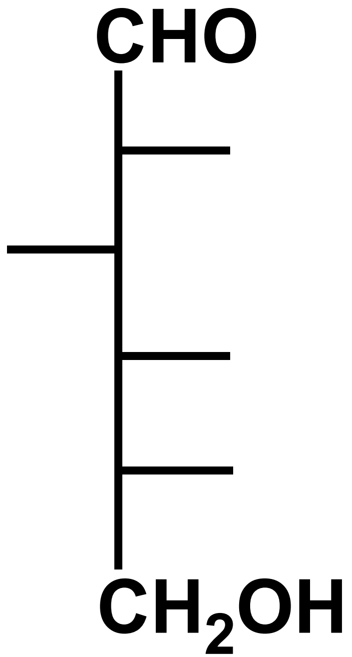
BIO 311C
Spring 2010

Your graded exam will be returned during your discussion period today and on Monday.

Rebecca will go over exam questions as requested during the discussion periods.

Lecture 13 – Friday 19 Feb.

An Abbreviated Way of Showing the Structural Formula of D-glucose



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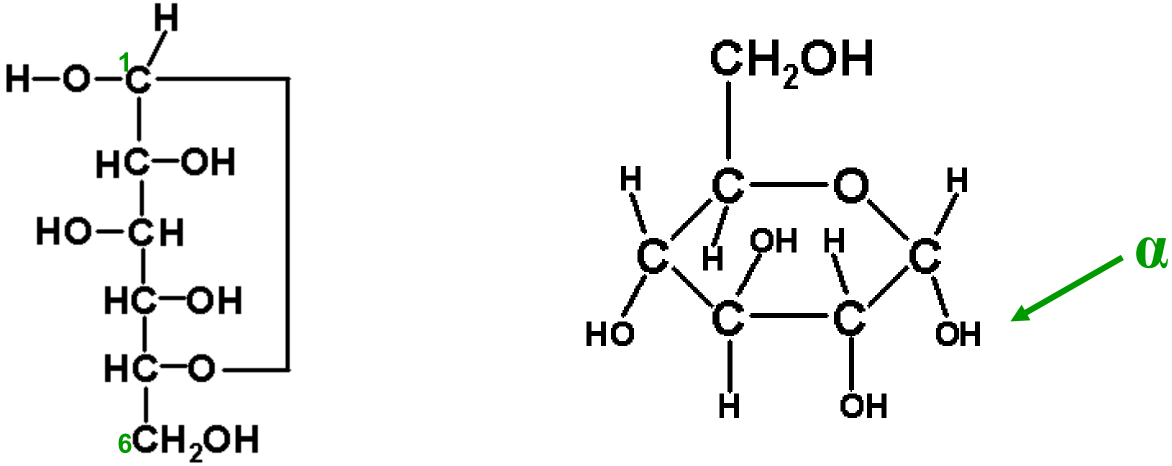
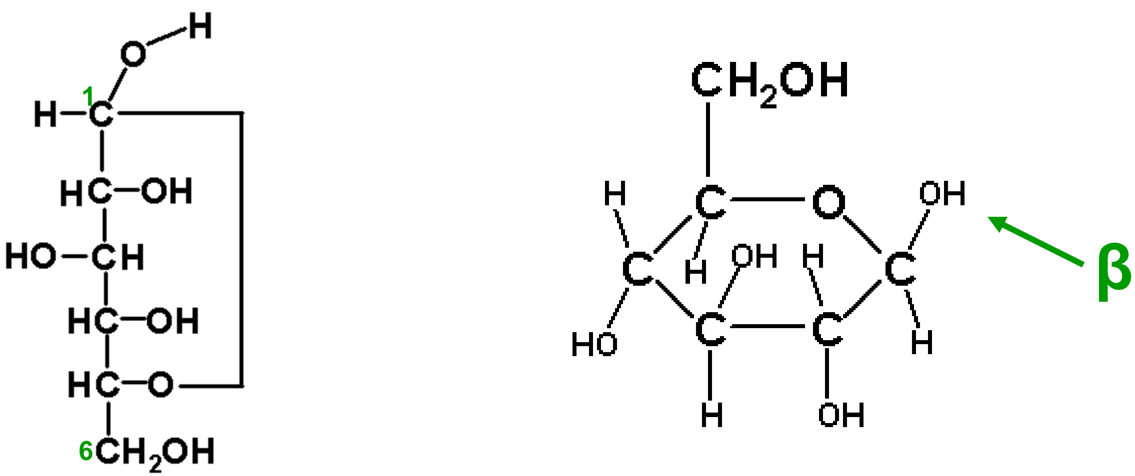


Ways of representing α-D-glucose



Ways of representing β-D-glucose

The "OH" on the disguised aldehyde or ketone functional group is written downward for α-sugars and is written up for β-sugars.

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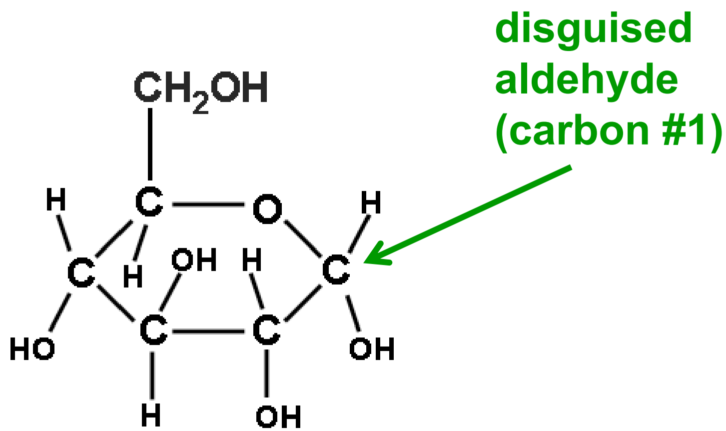
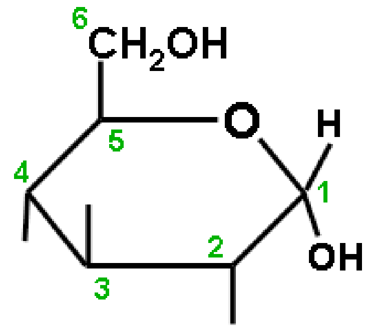
The ring form of a sugar is often shown in an abbreviated form.





abbreviated form

α-D-glucose

In the abbreviated form:

- the points where lines intersect represent carbon atoms;
- the hydrogen atoms on carbon atoms 1 - 5 are not shown; and
- the OH groups on carbon atoms 2 - 4 are shown only as vertical straight lines.

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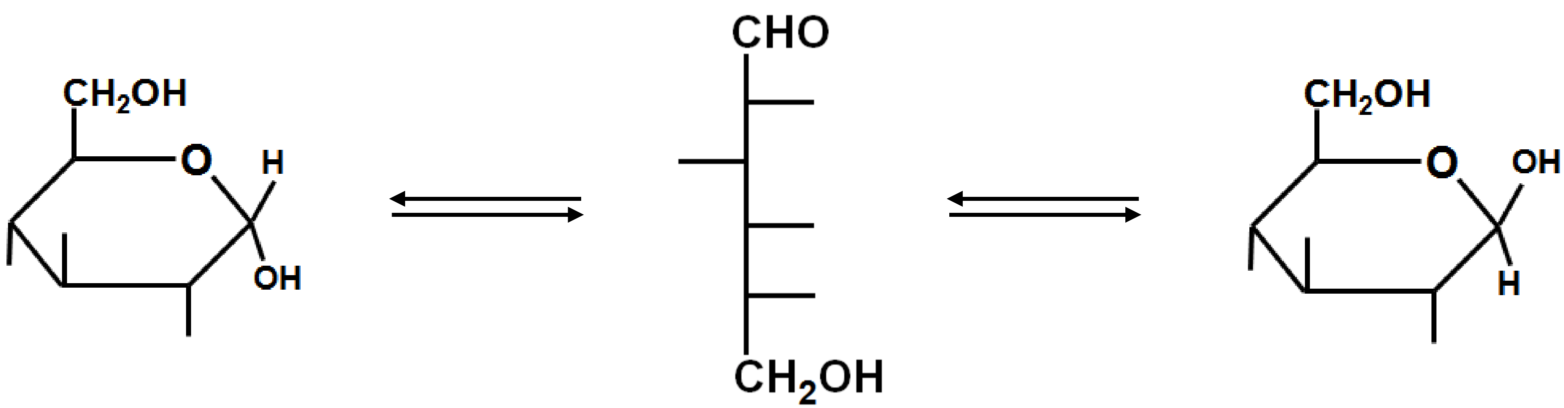
Interconversion of different forms of D-glucose, shown in abbreviated form.



α-D-glucose

D-glucose
(straight chain form)

β-D-glucose

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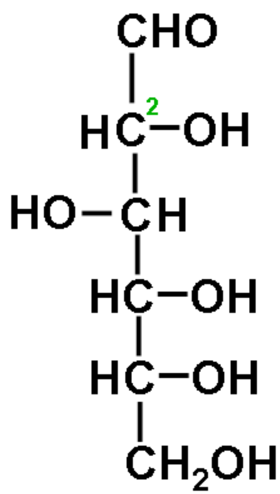
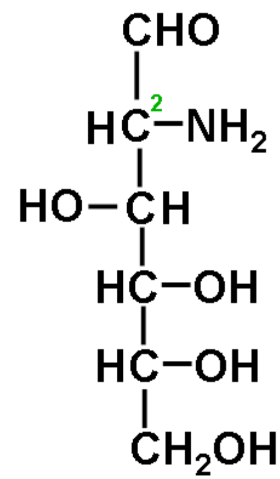
A <u>modified</u> <u>sugar</u> is a molecule that resembles a simple sugar, but with some modification

Example:



D-glucose
a simple sugar



2-amino-D-glucose
a modified sugar

Typically only one functional group of a simple sugar is altered in a modified sugar.

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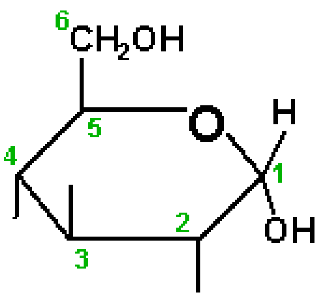
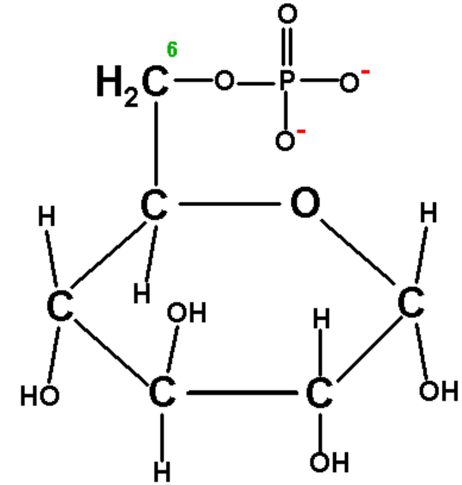
Some important modified sugars in cells



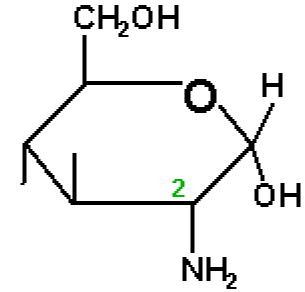
α-D-glucose

add phosphate functional group

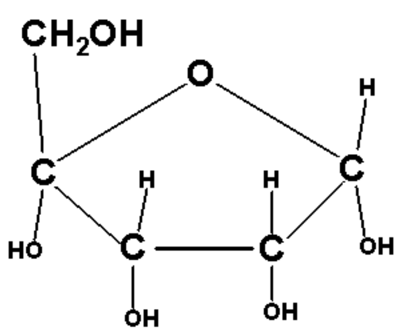


α-D-glucose-6-phosphate

add amino functional group

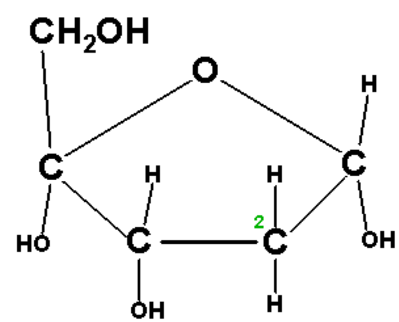


2-amino-α-D-glucose



α-D-ribose

remove oxygen atom



2-deoxy-α-D-ribose

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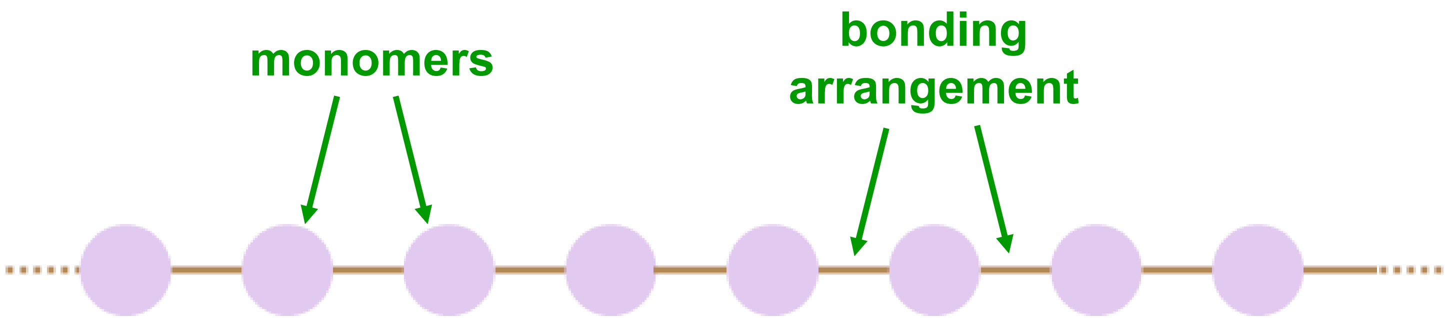
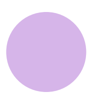
Illustration and Description of a Polymer



Representation of a polymer

Polymers are large molecules that are characterized by:



- many identical (or very similar) small molecules, called monomers, that are chemically bonded together.

- a characteristic kind of chemical bonding that holds the monomers together.

Most monomers that are used to form polymers in living cells have an H atom and an OH functional group that are removed during polymer formation.

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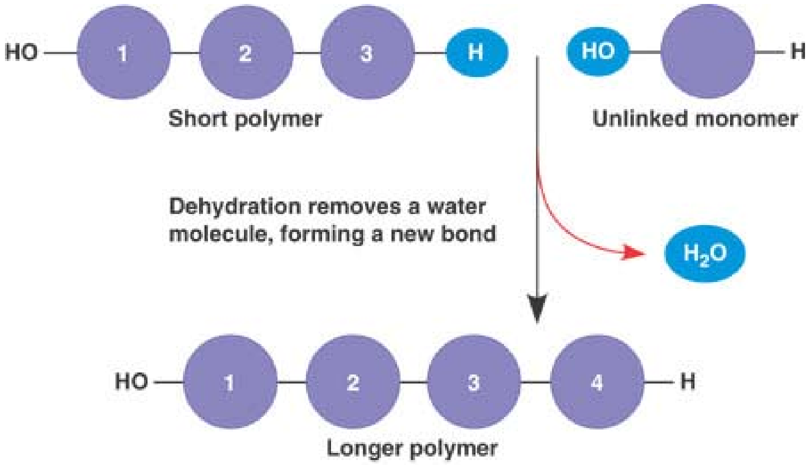
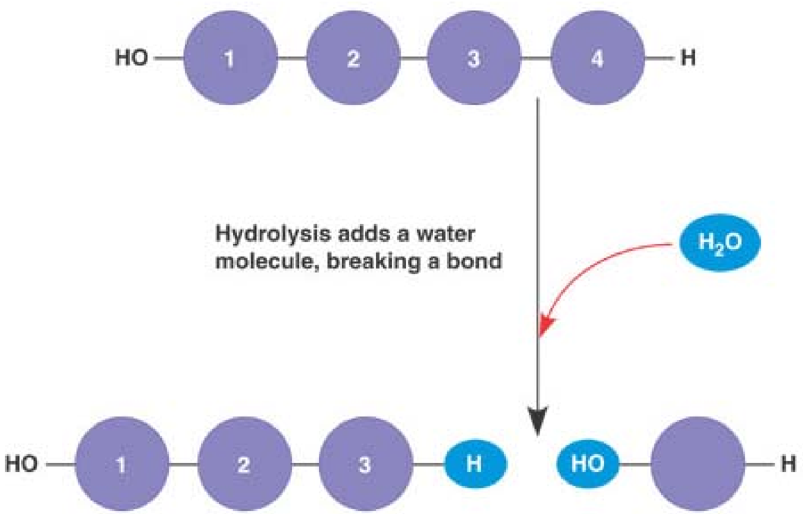
Most polymers in cells are formed in a kind of chemical reaction called a dehydration reaction and are taken apart in the reverse kind of chemical reaction, called a hydrolysis.

Textbook Fig. 5.2, p. 69



Dehydration reaction in the synthesis of a polymer

Synthesis of a polymer in a dehydration reaction.



Hydrolysis of a polymer

Removing a monomer from a polymer in a hydrolysis reaction.

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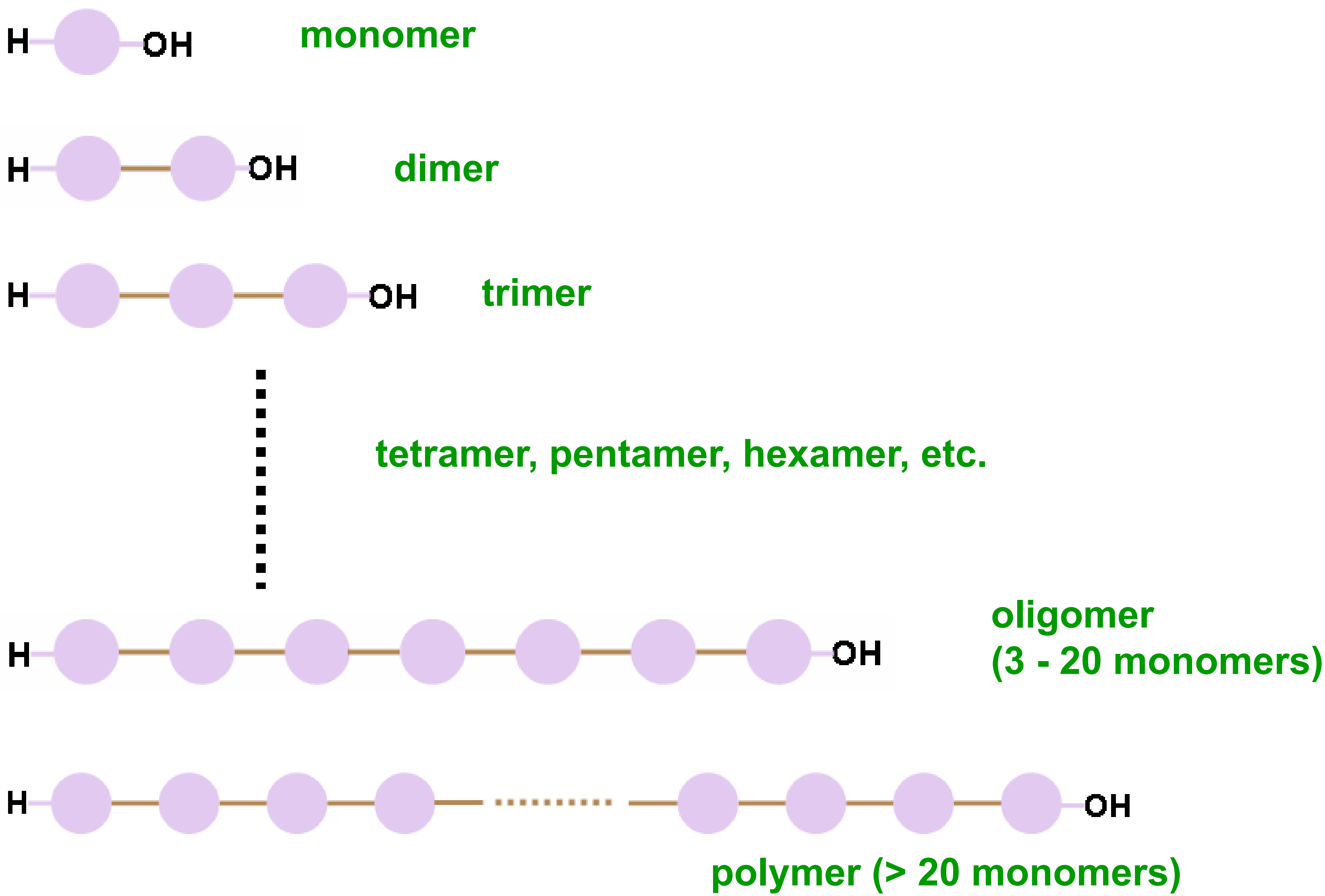
Names of Units of Various Sizes



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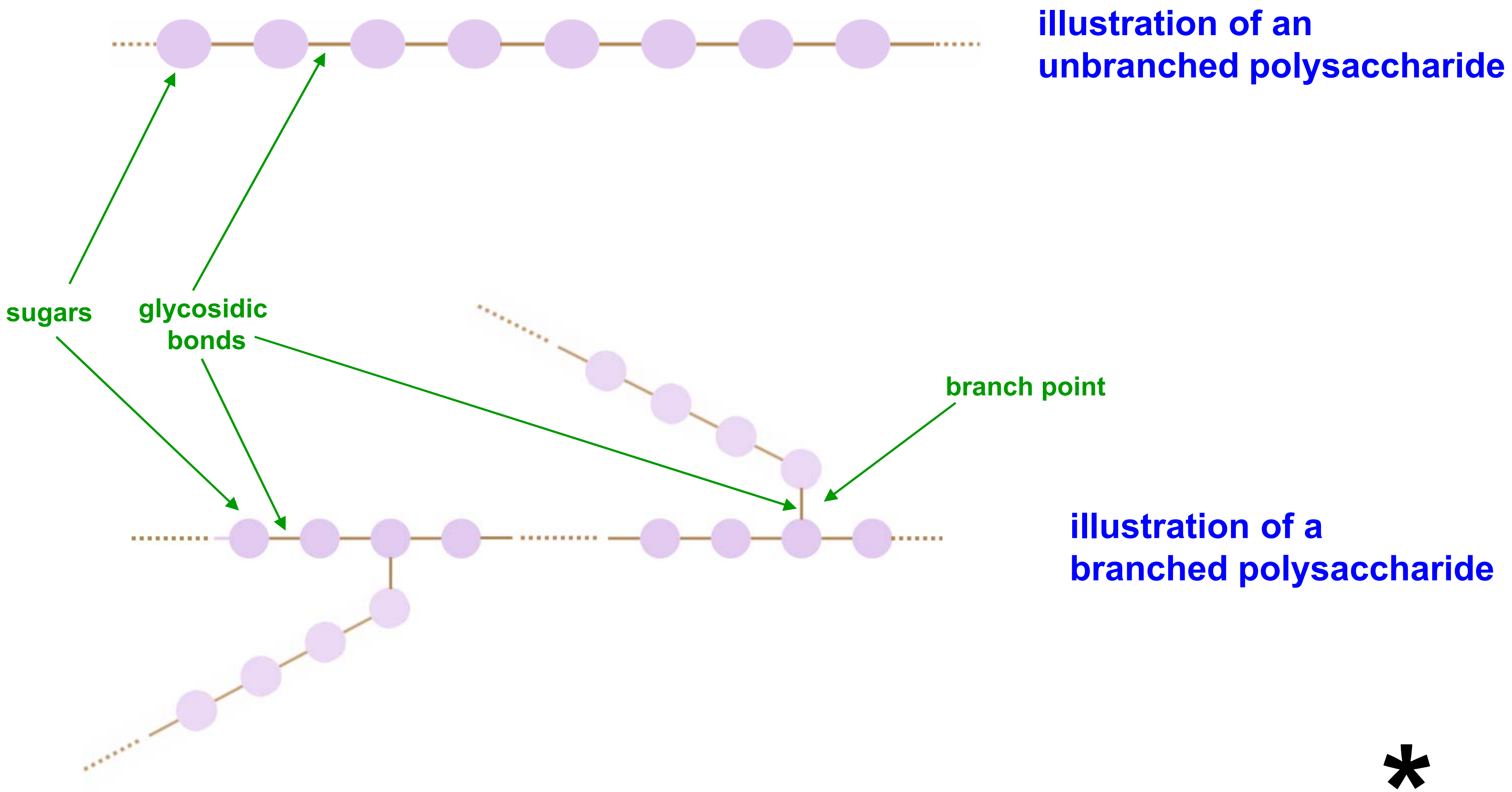
A polysaccharide is a polymer consisting of many sugars held together by glycosidic bonds. Some, but not all, kinds of polysaccharides are branched.



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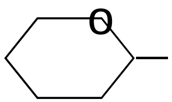
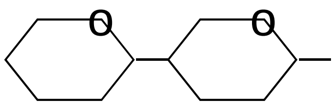
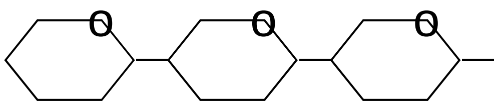
Illustrations Showing Very Abbreviated Structures of a Monosaccharide, a Disaccharide, an Oligosaccharides and a Polysaccharide



monosaccharide (a simple sugar)

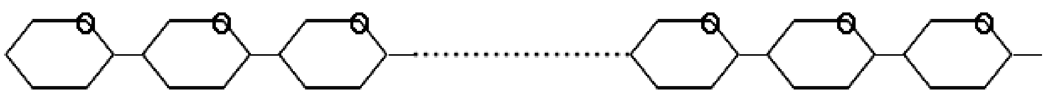


disaccharide (a double sugar)



trisaccharide

oligosaccharide (somewhere between 3 and 20 sugars)



polysaccharide (more than 20 sugars)

This abbreviated illustration doesn't show any detail of the kinds of sugars involved or the glycosidic bonds holding the sugars together.

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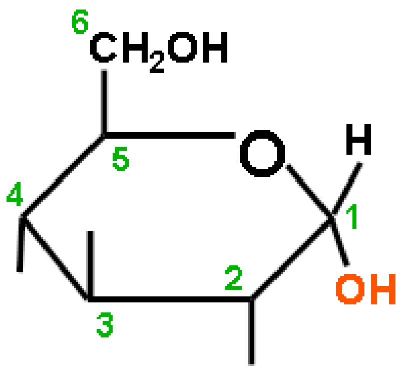
A glycosidic bond is formed in a dehydration reaction between a disguised aldehyde (or ketone) functional group and a true alcohol functional group.



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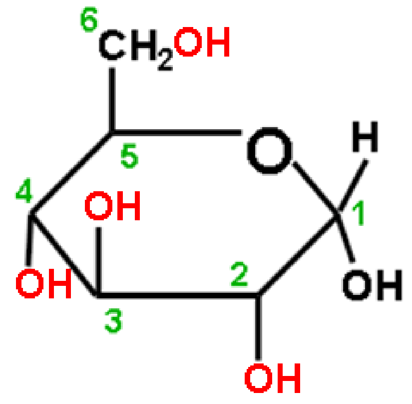

Sugar #1

The red "OH" unit shown in this sugar is a disguised aldehyde functional group.

Sugar #2

Red "OH" units shown in this sugar are true alcohol functional groups.

In order for a specific glycosidic bond to form between two sugars in a dehydration reaction within a cell:

1. a source of energy (in most cases ATP) must be available;
2. a specific enzyme must be available. The enzyme determines the acceptable <u>conformation</u> (α or β) of the disguised aldehyde/ketone functional group of sugar #1, and which specific alcohol group of sugar #2 will react.

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Definitions:

<u>Configuration</u> of a biological molecule:

The chemical structure of a molecule, determined by the covalent bonding arrangement of its atoms.

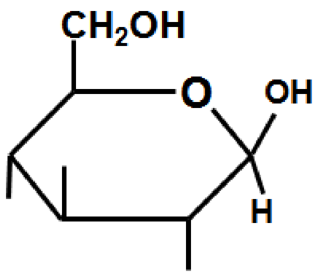
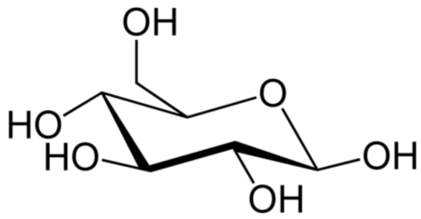


Illustration of the molecular structure (configuration) of D-glucose, showing the β conformation.

<u>Conformation</u> of a biological molecule:

The 3-dimensional shape of a molecule, determined by way that the molecule is rotated around its covalent single bonds.



More accurate illustration of a conformation of β-D-glucose.

You will not be responsible on exams for knowing conformations of sugar molecules, such as the one shown in the lower illustration.

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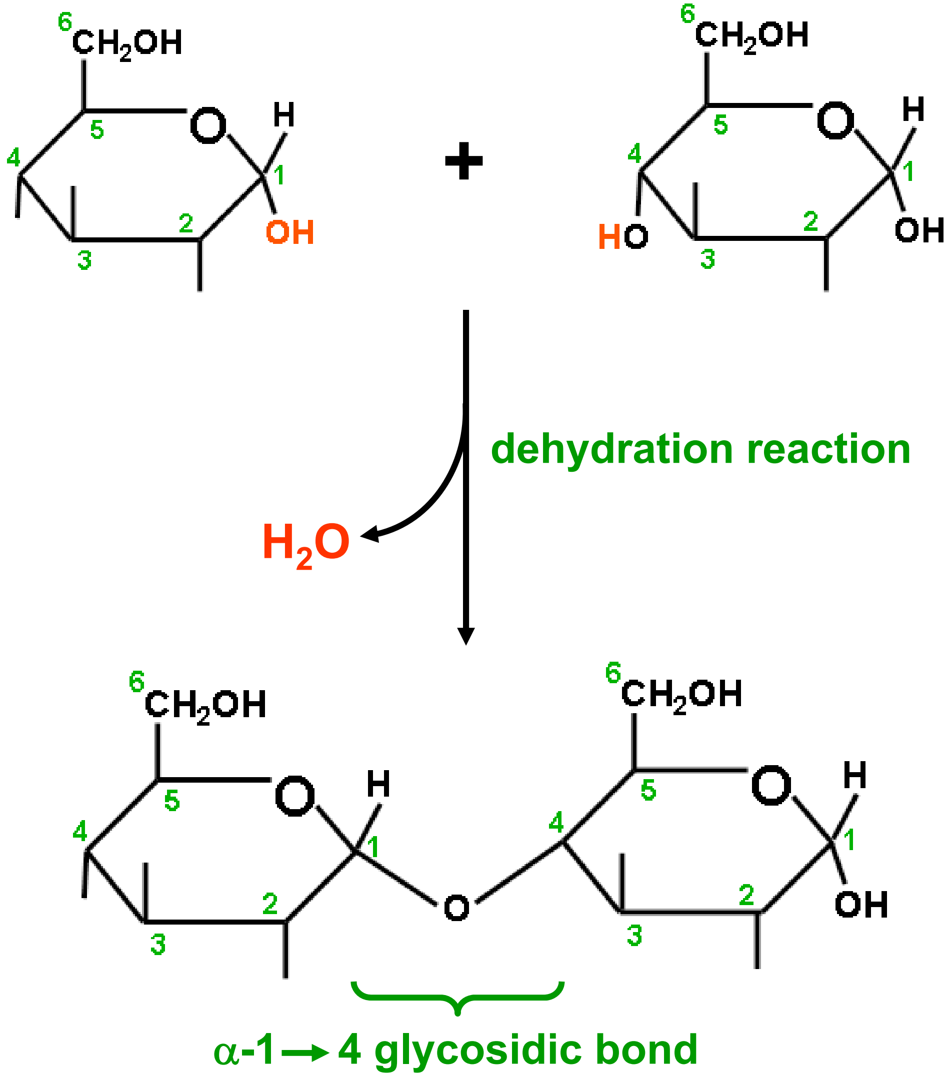
Formation of a Disaccharide with an "alpha" Glycosidic Bond from Two Monosaccharides



2 α-D-glucose

↓

maltose + H_2O

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The word "bond" is used in several somewhat different ways in this course.

Bond Type	Bond Length (Å)	Bond Angle (deg.)	Bond Strength (KJ/mol)
covalent	~ 1	~ 109	100 - 500 (typical 400)
polar	several	N.A.	N.A.
hydrogen	~ 3	~ 180	15 - 40 (typical 40)
electrovalent	several	N.A.	N.A.
van der waals	< 3	N.A.	N.A.
hydrophobic	N.A.	N.A.	N.A.

1. The six different kinds of "chemical bonds" presented in the table at right represent broad classes of chemical bonding that are determined by types of electron distributions and attractions among atoms.

2. The covalent bonding arrangement between two specific kinds of functional groups is sometimes called a "bond". For example:
   a. ester bond (formed from an acid and an alcohol)
   b. acid-anhydride bond (formed from two acids)

3. A covalent bonding arrangement between two specific functional groups of a specific class of molecule is also sometimes called a "bond". For example:
   a. glycosidic bond (formed between two sugars)
   b. glyceride bond (formed from a fatty acid and glycerol)
   c. peptide bond (formed between two amino acids)

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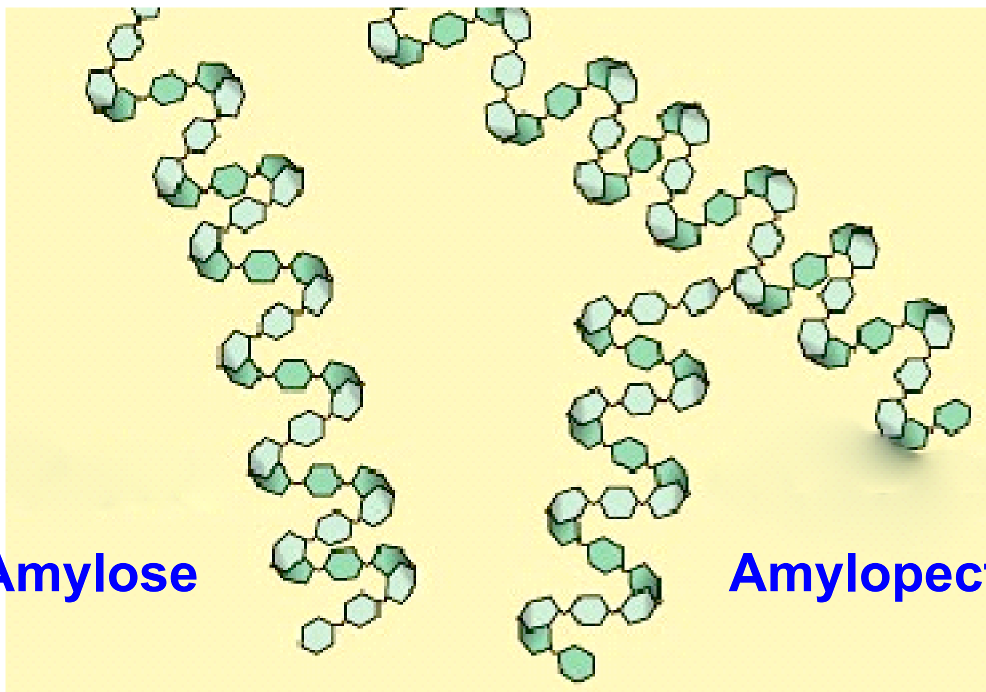
Molecular Composition of Starch and Glycogen

n α-D-glucose → amylose — α-1→4 glycosidic bonds

n α-D-glucose → amylopectin — α-1→4 and α-1→6 glycosidic bonds



From textbook Fig. 5.6, p. 72

Starch (in plants) is an aggregate of amylose and amylopectin.

Glycogen (in animals) is similar to amylopectin, but the chains are shorter and more highly branched.

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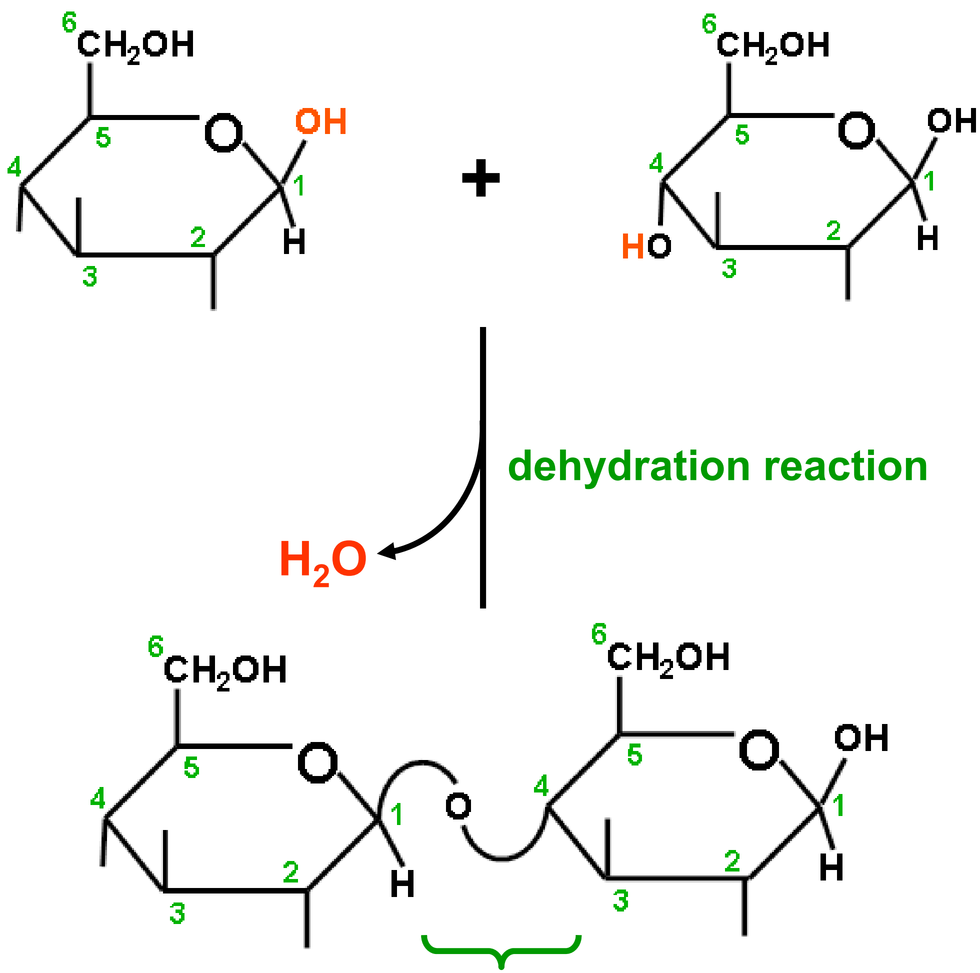
Formation of a Disaccharide with a "beta" glycosidic bond from Two Monosaccharides



β-1 → 4 glycosidic bond

2 β-D-glucose

↓

cellobiose + H_2O

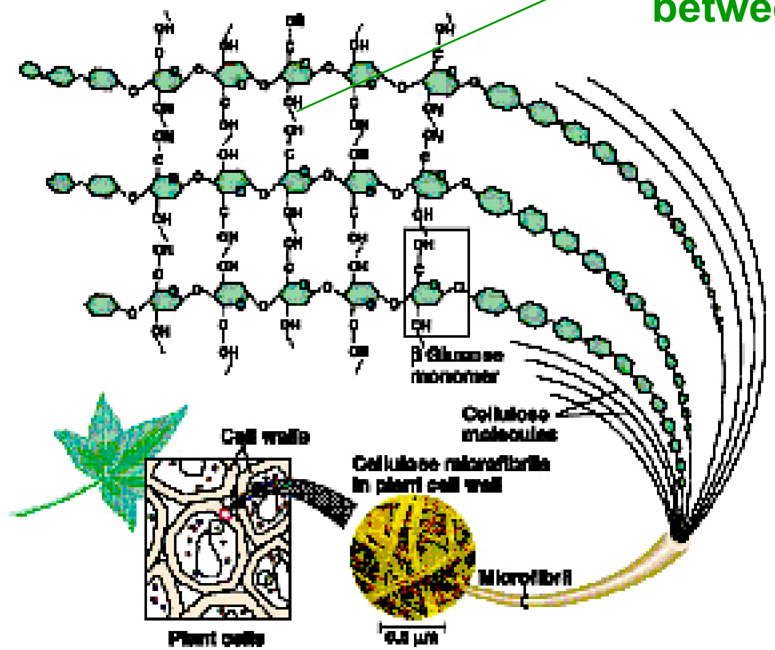
*

n β-D-glucose ⟶ cellulose

β-1→4 glycosidic bonds

hydrogen bonding between chains

Cellulose



from textbook Fig 5.7, p. 73

The polysaccharide chains of cellulose are not branched.

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Some General Functions Performed by Carbohydrates in Cells

They are a major form of food and energy storage in cells.
(usually as polysaccharides)
examples: starch, glycogen

They are a major form of food and energy transport between cells in multicellular organisms.
(usually as monosaccharides or oligosaccharides)
examples: glucose, sucrose

They are a major form of food and energy transport within cells.
(usually as monosaccharides or modified sugars)
example: glucose-6-phosphate

cont. →

*

Some General Functions Performed by Carbohydrates in Cells (cont.)

They are a major structural component of many kinds of cells in multicellular organisms.

(oligosaccharides and polysaccharides)

examples: cellulose and other polysaccharides in plant cell walls;
oligosaccharides exterior to animal cells

They act as recognition sites for external signals on the surfaces of many kinds of cells.

(oligosaccharides and polysaccharides)

example: ABO antigens on the surfaces of red blood cells.

They serve as building units for many kinds of complex molecules in cells.

(modified sugars)

example: simple sugars covalently bonded to nucleotides.

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