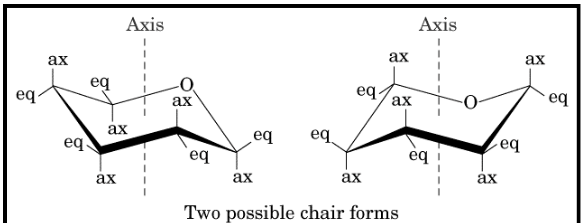
Summary of Carbohydrate Structures

See original handout pages for the following:

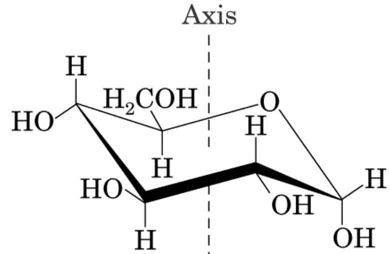
1. **Open chain and cyclic forms of monosaccharides**
2. **Disaccharide structures: maltose, sucrose, lactose**
3. **Shorthand structures of amylose, amylopectin (glycogen), and cellulose**
4. **Cyclization of aldoses and ketoses and rules for writing Hayworth projection formulas ("LURD", "BUAD")**

This version of the presentation does not have some graphics in the interest of making the file smaller

Chair Conformation of Pyranoses

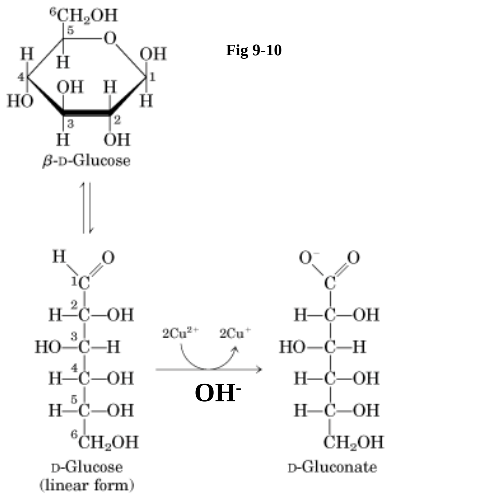


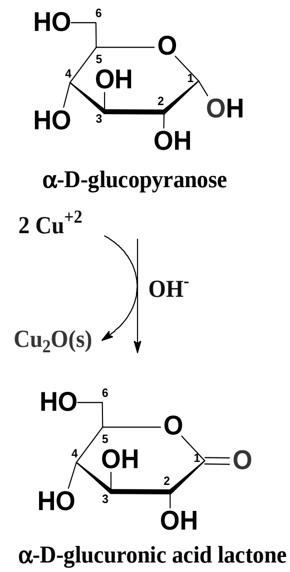
Two possible chair forms
(a)



α-D-Glucopyranose
(b)

Reducing Sugars: Aldoses

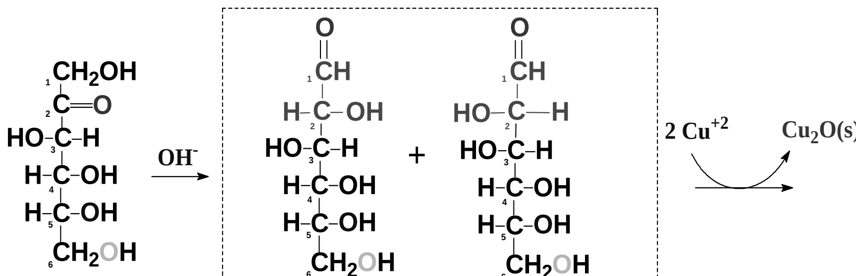




Alkaline reagent with copper(II) chelator:

Tartarate:	**Fehlings's solution**
Citrate:	**Benedict's solution**

Reducing Sugars: Open Chain Ketoses!



OPEN CHAIN FORM

Ketose rearrances to mixture of aldoses which can be oxidized by Cu^{2+} reagents either as the open chain form or as the cyclic form

Functions of Monosaccharides

Glyceraldehyde and dihydroxyacetone (C_3):

-Intermediates in glycolysis

-Precursors for glycerol used for triglyceride and phosphoglyceride biosynthesis

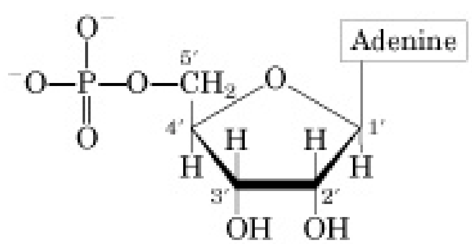
Ribose (C_5): **$(CH_2O)_n$ partly oxidized, readily available energy source**

-Source of energy for plants and animals

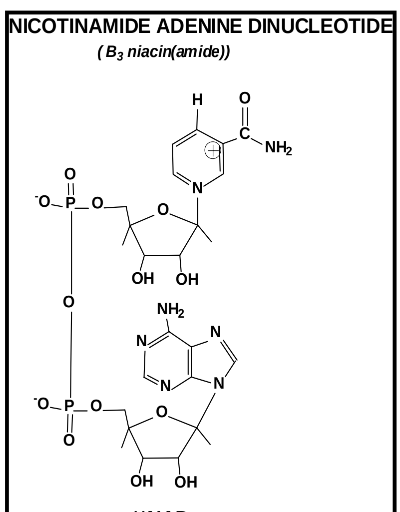
-Monomer unit for vitamin-derived coenzymes **(NAD^+, FAD, etc)**

-Monomer unit for RNA

Ribofuranose in RNA and coenzymes



Adenosine 5'-monophosphate



**NAD
(oxidized form)

Functions of Monosaccharides

$(CH_2O)_n$ partly oxidized, readily available energy source

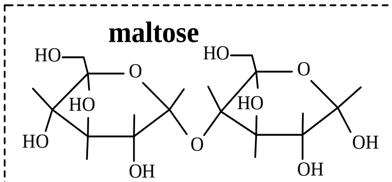
Glucose (C_6):

- **-Source of energy for plants and animals in glycolysis**
- **-Monomer unit for cellulose in plants**

Fructose (C_6):

- **-Source of energy for plants and animals in glycolysis**

DISACCHARIDES: Maltose



O-α-D-glucopyranosyl-(1 -> 4)-α (or β)-D-glucopyranose
(ending = "ose" since anomeric OH is free)

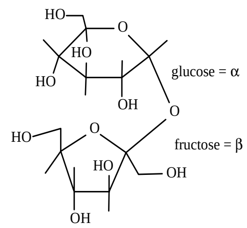
Provides energy for germinating seeds (breakdown product of amylopectin and amylose in germinating seeds)

Hydrolyzed into glucose by an enzyme called

α-glucosidase

DISACCHARIDES: Sucrose

sucrose



O-α-D-glucopyranosyl-(1 -> 2)-β-D-fructofuranoside
(ending = "oside" since anomeric O is derivatized)

Storage saccharide in…

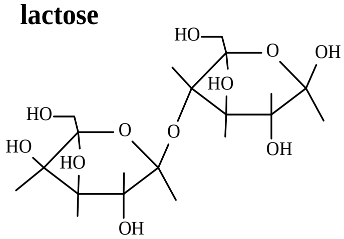
…sugar beets

…sugar cane

Hydrolyzed into glucose and fructose by an enzyme called invertase

DISACCHARIDES: Lactose

lactose



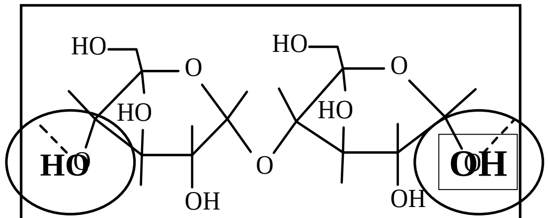
O-β-D-galactopyranosyl-(1 -> 4)-β -D-glucopyranose

Found in milk, lactose provides energy to nursing infant

Hydrolyzed by

laccase = β-galactosidase

WRITING AMYLOSE POLYMER

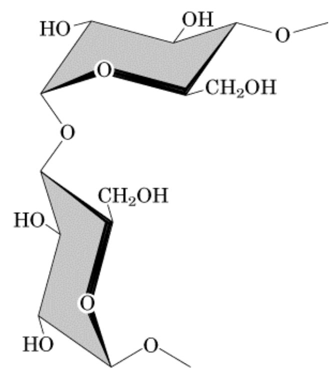


Linear α-(1 ->4) linked polymer of glucose

The reducing end of the polymer

(hemiacetal)

The nonreducing end of the polymer

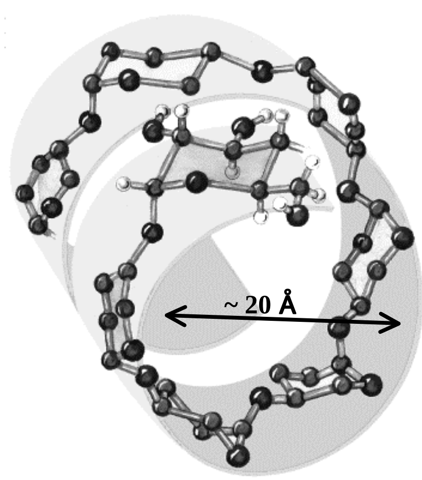


(α1→4)-linked D-glucose units

(a)

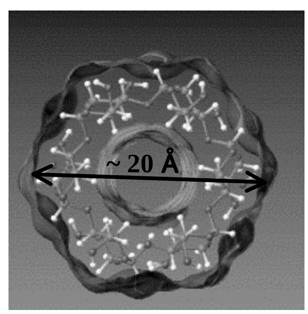
Fig 09-16.GIF

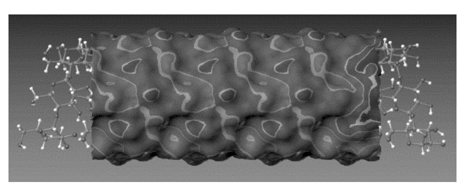
THREE-DIMENSIONAL AMYLOSE



(b)

Fig 09-16.GIF

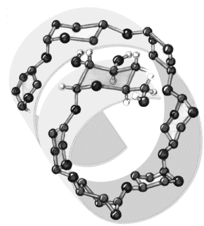




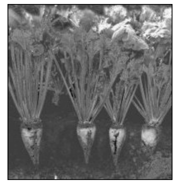
http://www.wellesley.edu/Chemistry/chem227/sugars/amylose-end.gif

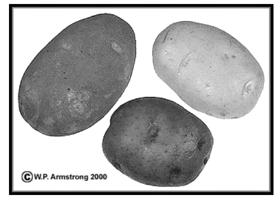
BIOLOGICAL FUNCTION OF AMYLOSE

Amylose is a storage polymer for glucose in plants



(b)





Q: How is the structure of amylose related to its biological function?

A: The amylose polymer is a storage polymer for glucose. It has a helical structure which allows for more glucose to be packed into a given volume.

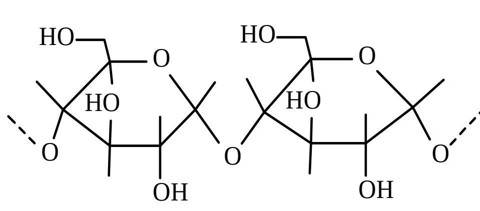
HYDROLYSIS OF AMYLOSE: α-Amylase

(in saliva and pancreatic juices of animals)

(in plants and all other living organisms)

α-Amylase is an endoglycosylase:

It randomly hydrolyzes within the linear polymer (> 3) giving a mixture of maltose and glucose



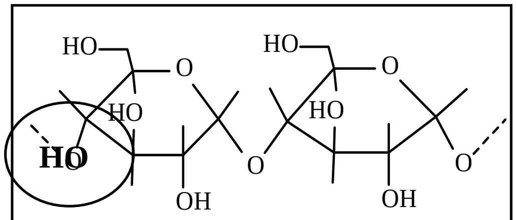
Linear α-(1 ->4) linked polymer of glucose

(b)

HYDROLYSIS OF AMYLOSE: β-Amylase
(in germinating seeds, sweet potatoes)

β-Amylase is an exoglycosylase:

It removes maltose units from the nonreducing ends of the amylose (> 4)



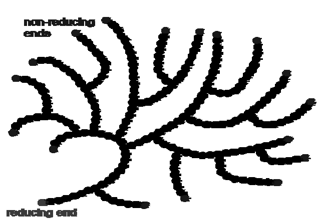
Linear α-(1 ->4) linked polymer of glucose

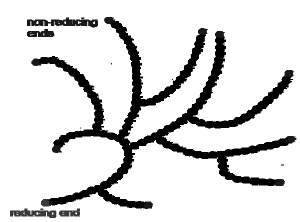
(b)

The nonreducing end of the polymer

How are Glycogen and Amylopectin Different?

Polymer	Occurance	Function
Glycogen 4-10 glucose/linear segments	Liver, muscle	Storage polymer for glucose
Amylopectin > 12 glucose/linear segments	Plants	" "

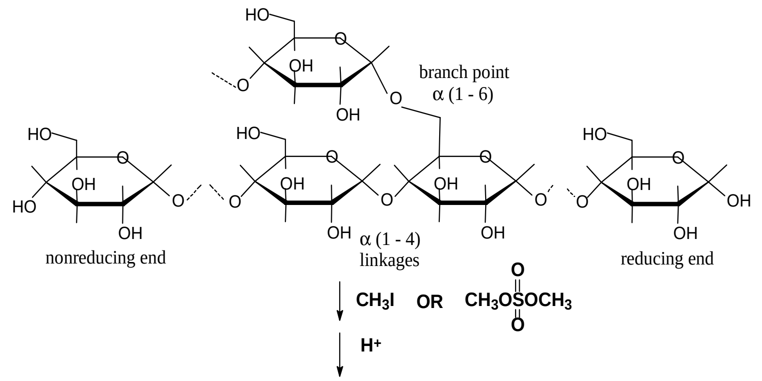




How are the structures of glycogen and amylopectin related to their biological function?

Periodate oxidation (lab) and methylation can determine degree of branching

METHYLATION OF GLYCOGEN VERSUS AMYLOPECTIN



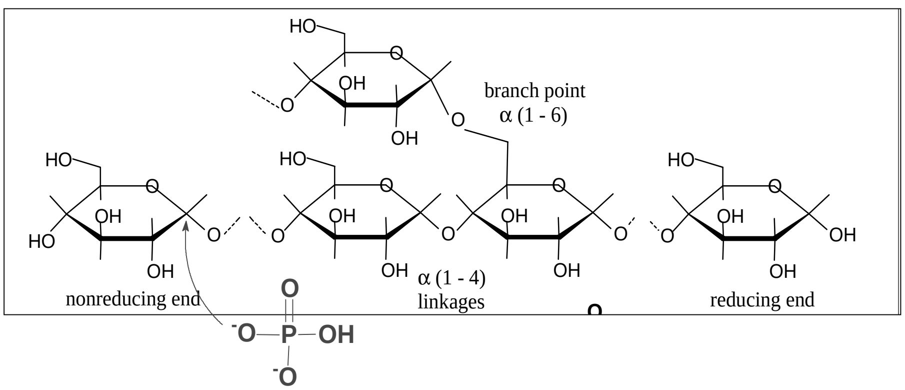
Polymer I: 8.5 % 2,3 dimethyl glucose
Polymer II: 2.1 % 2, 3 dimethyl glucose

+ what other products?
(draw structural formulas for all products)

Which polymer is glycogen and which is amylopectin and why?

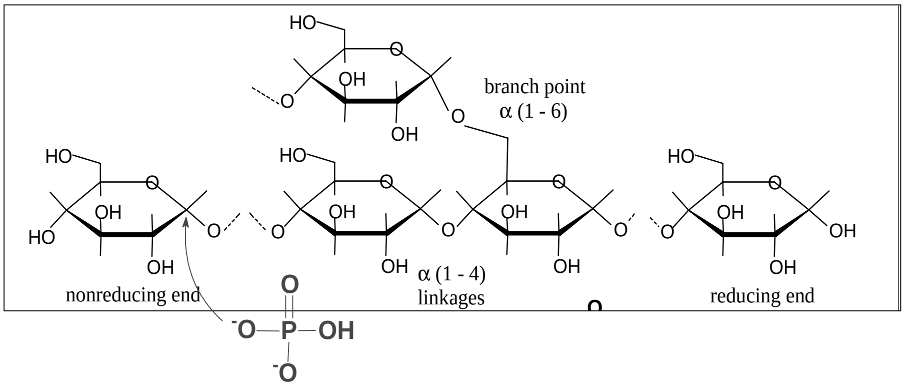
Enzyme that hydrolyze glycogen

Polymer	Hydrolytic Enzymes
Glycogen	Glycogen Phosphorylase gluc-(gluc)$_n$ + Pi → (gluc)$_n$ + gluc-1-Pi



Enzyme that hydrolyze amylopectin

Polymer	Hydrolytic Enzymes
Amylopectin	**Starch Phosphorylase** gluc-(gluc)$_n$ + Pi → (gluc)$_n$ + gluc-1-Pi



What happens next with these branched polymer?

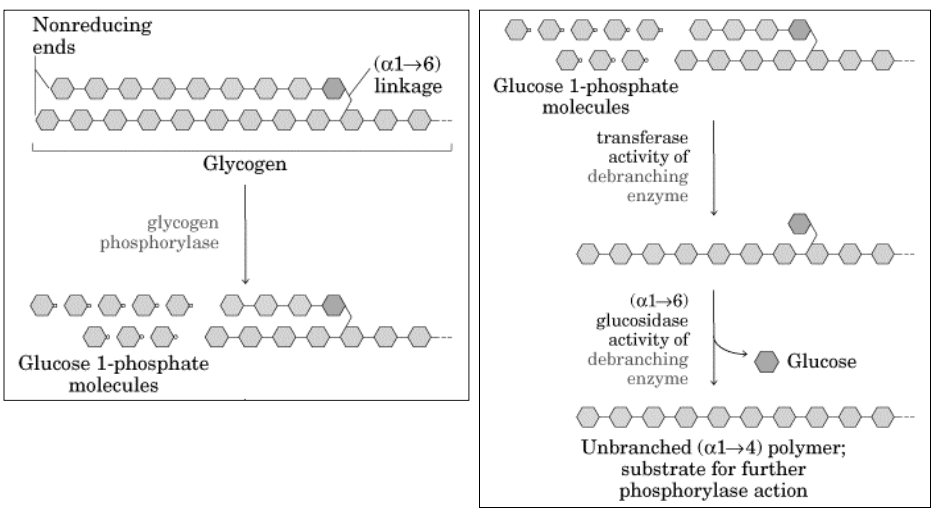
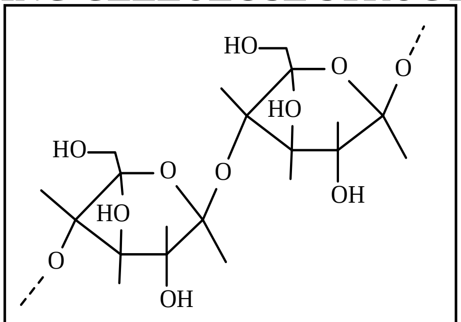


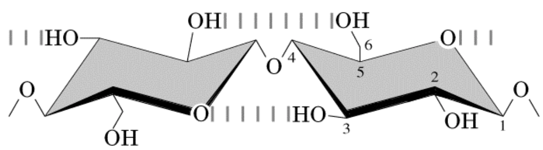
Fig 15-13.GIF

WRITING CELLULOSE STRUCTURE



Linear β-(1 ->4) linked polymer of glucose

Actual orientation of adjacent glucose residues:



(β1→4)-linked D-glucose units

Fig 9-17.GIF (a)

Linear fibers aggregate into sheets…

Sheets aggregate into microfibrils…

Microfibrils aggregate into stiff, rigid structures

What is the biological function of cellulose?

Cellulose provides…

1. Structural ridigity to plants
2. Another polymer for glucose storage

How is the structures of cellulose related to its biological function?

What enzyme can hydrolyze cellulose?