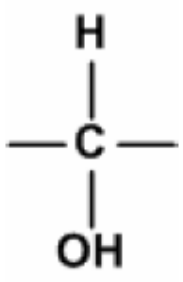
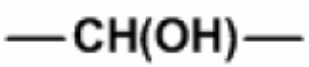
Saccharides

Vladimíra Kvasnicová

SACCHARIDES
(carbohydrates, glycides)

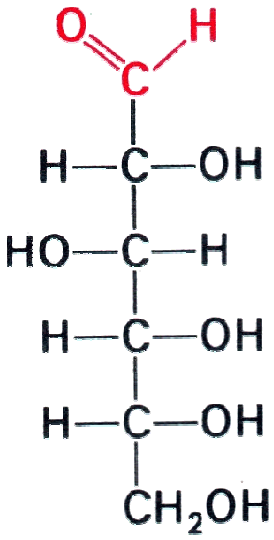




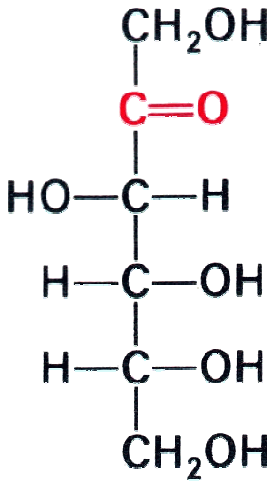
= **polyhydroxy**aldehydes

or

polyhydroxyketones

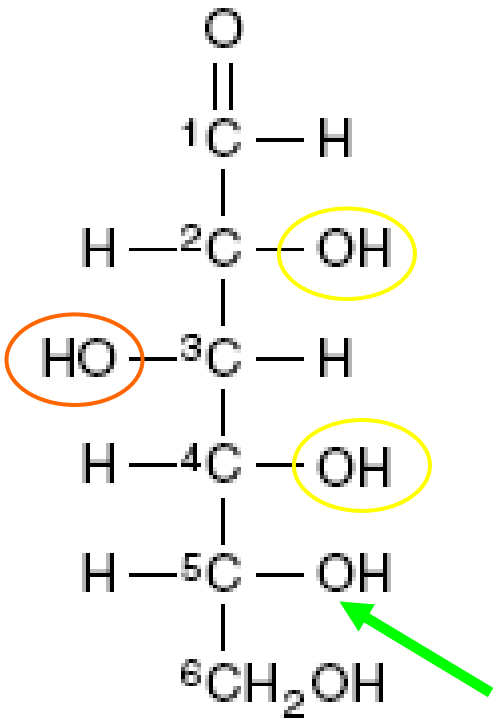


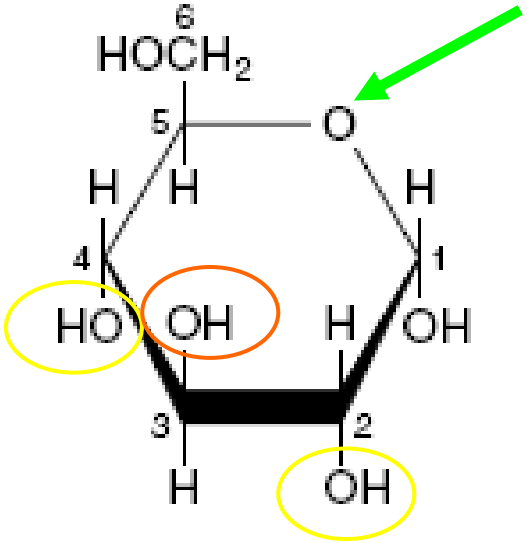
D-glucose

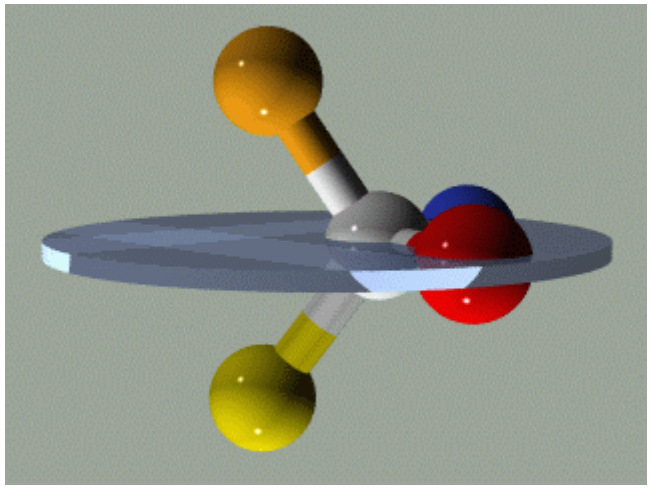


D-fructose

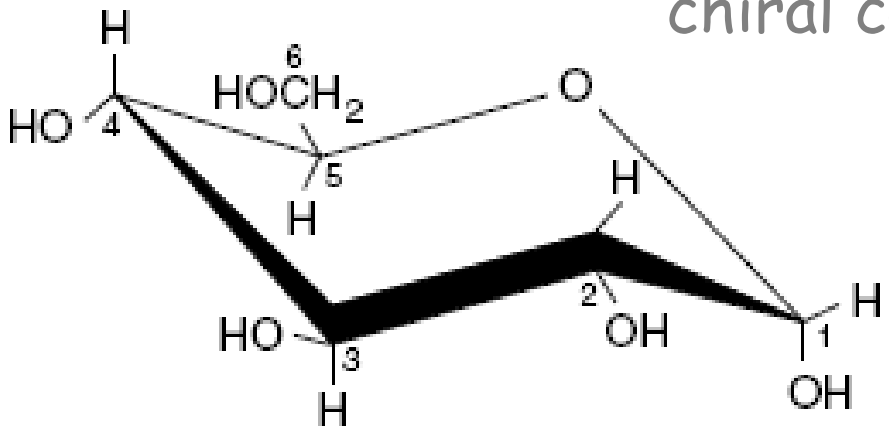
GLUCOSE – central role



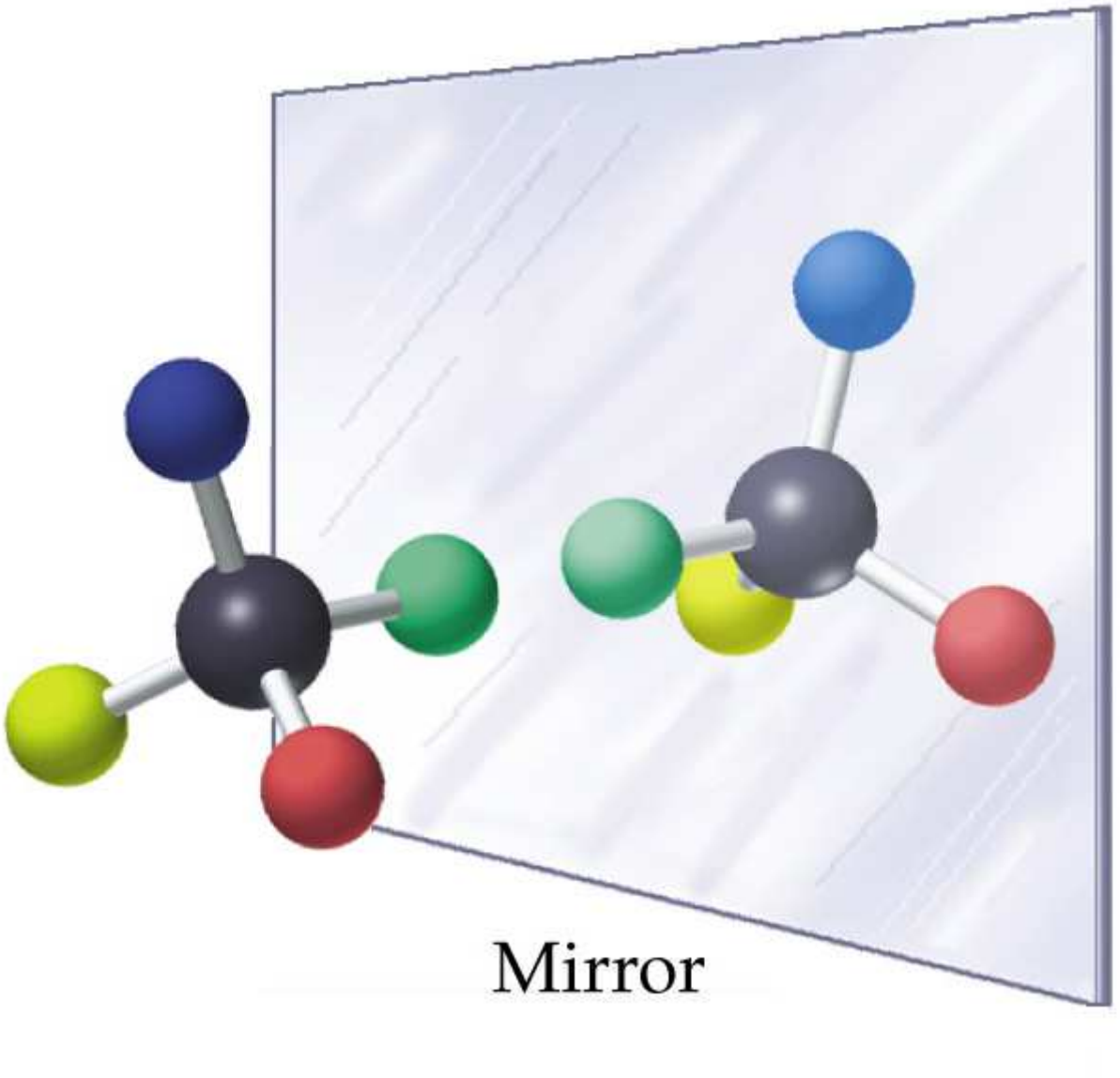




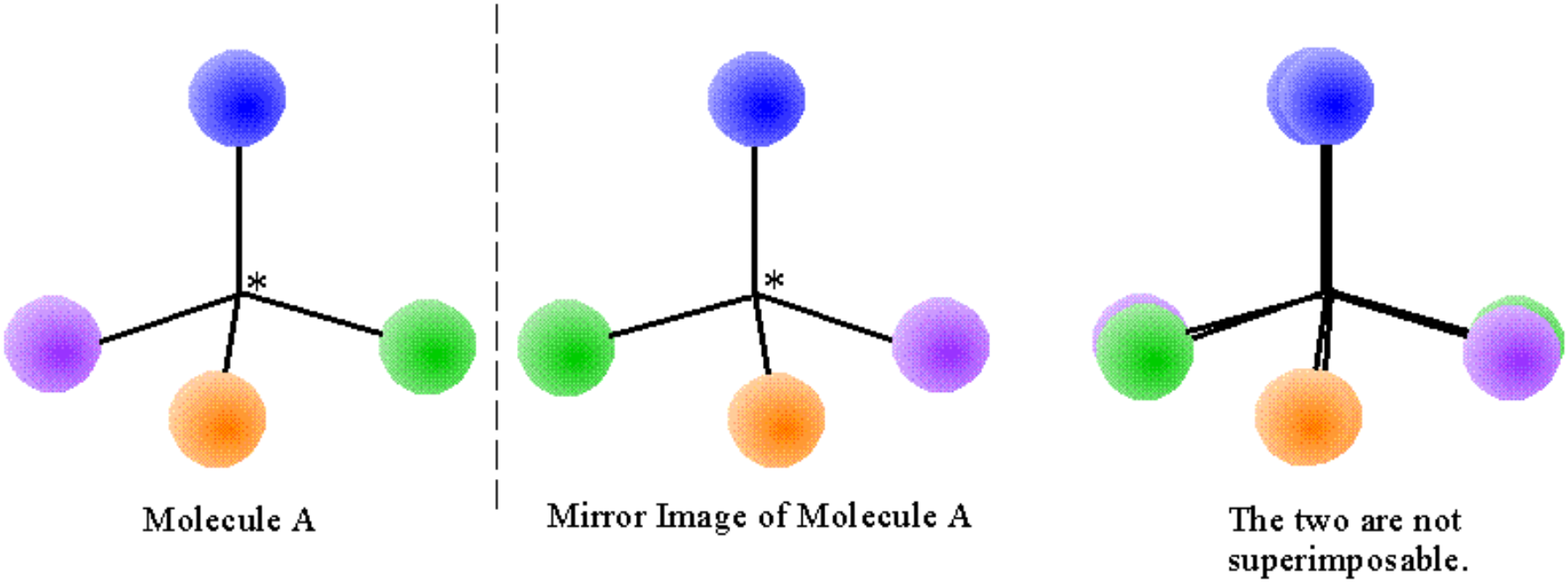
chiral carbon



The figures have been adopted from Harper´s Biochemistry a z http://www.vuw.ac.nz/staff/paul_teesdale-spittle/organic/chiral_web/images/fig1_5d.gif (April 2007)



The figure is found at http://astrobiology.berkeley.edu/Mars101/pix/image003.jpg (April 2007)



number of isomers for n(C*) = 2^n

n = 1, 2, 3, ...

The figure is found at http://webphysics.davidson.edu/Alumni/bedenius/liqcry/chiral.gif (April 2007)

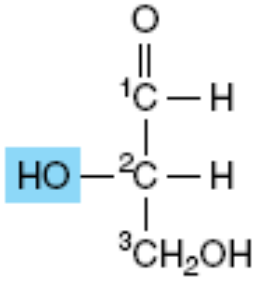
Classification of monosaccharides

	aldoses (-CHO)	ketoses (>C=O)
trioses (C3)	glyceraldehyde	dihydroxyacetone
tetroses (C4)	erythrose	erythrulose
pentoses (C5)	ribose	ribulose
hexoses (C6)	glucose	fructose

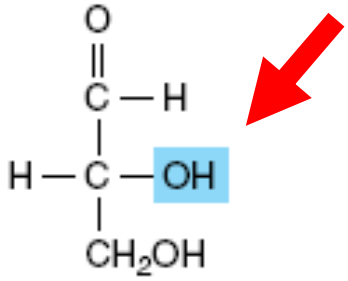
Isomers of monosaccharides

1) D- and L- izomers

= mirror images
(enantiomers)

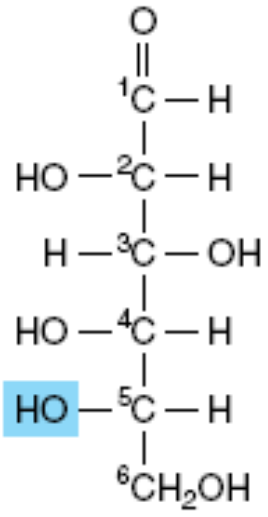


L-Glycerose
(L-glyceraldehyde)

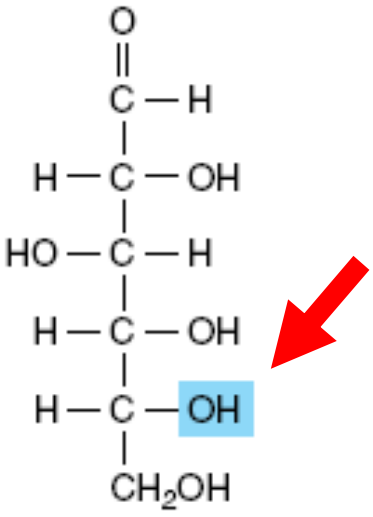


D-Glycerose
(D-glyceraldehyde)

nature important:
D-monosaccharides



L-Glucose

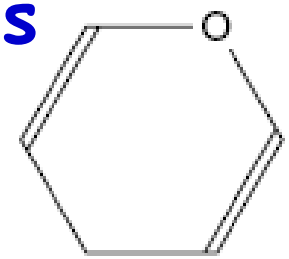


D-Glucose

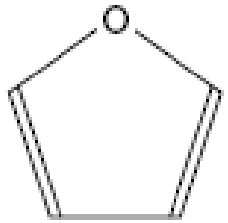
The figures have been adopted from Harper´s Biochemistry

2) pyranoses and furanoses

- pyranoses: aldohexoses
- furanoses: fructose
  ribose

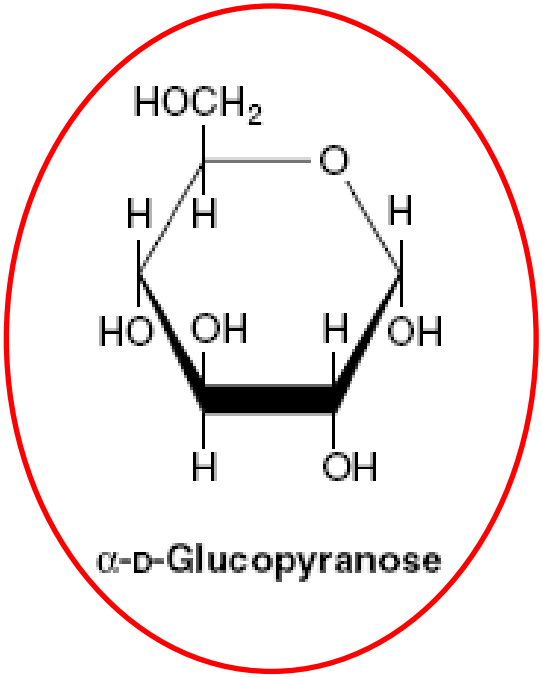


Pyran

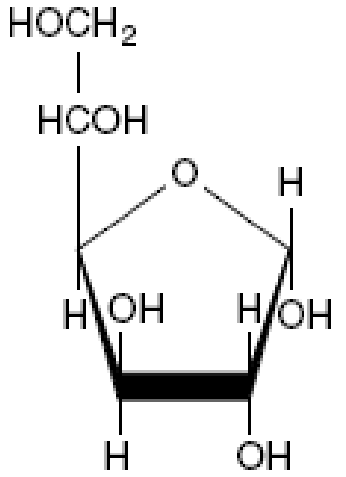


Furan

glucopyranose
predominates



α-D-Glucopyranose

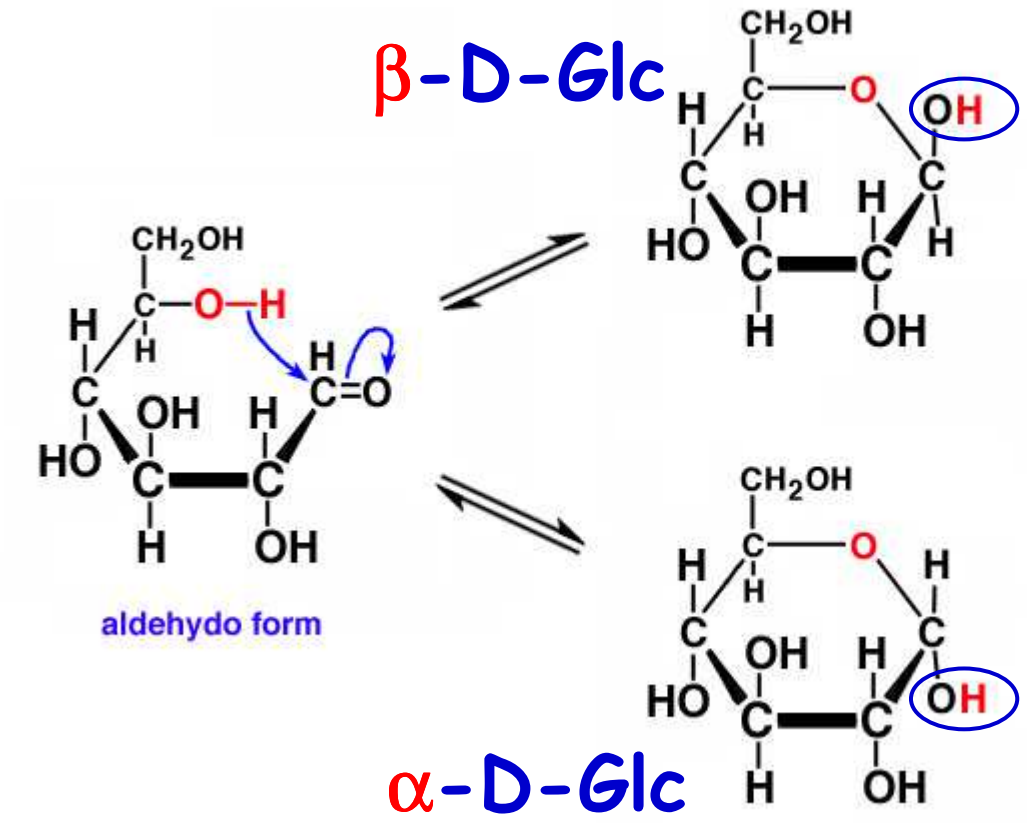


α-D-Glucofuranose

The figures have been adopted from Harper´s Biochemistry

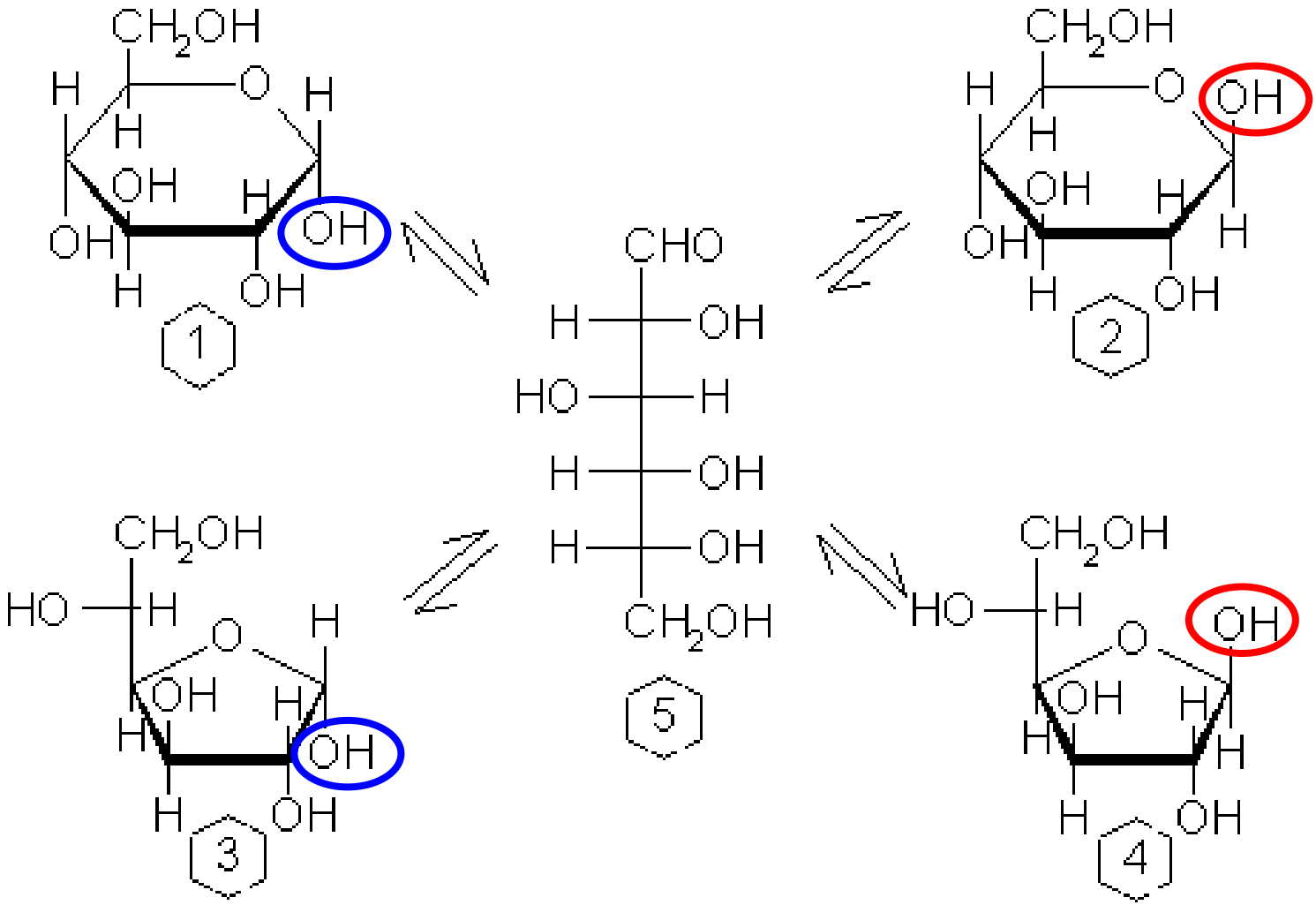
3) α and β anomers

only <u>cyclic</u> molecules



- *during dissolving of a saccharide in water the equilibrium between anomers is established = **mutarotation***
  (optical rotation of anomers is not the same)

The figure is found at http://www.cbs.umn.edu/bmbb/brl/carb/CarbTJSA/Haworth/TwoAnomers.jpg (October 2007)



1) α-D-glucopyranose

2) β-D-glucopyranose

5) D-glucose

3) α-D-glucofuranose

4) β-D-glucofuranose

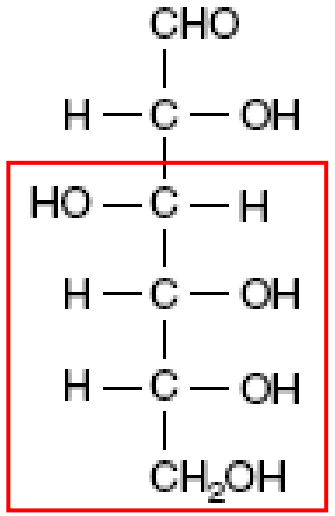
4) aldo-/keto- isomers

aldose / ketose

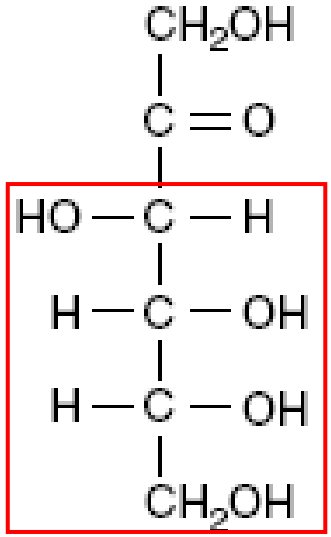
glyceraldehyde / dihydroxyacetone

ribose / ribulose

glucose /fructose



D-Glucose



D-Fructose

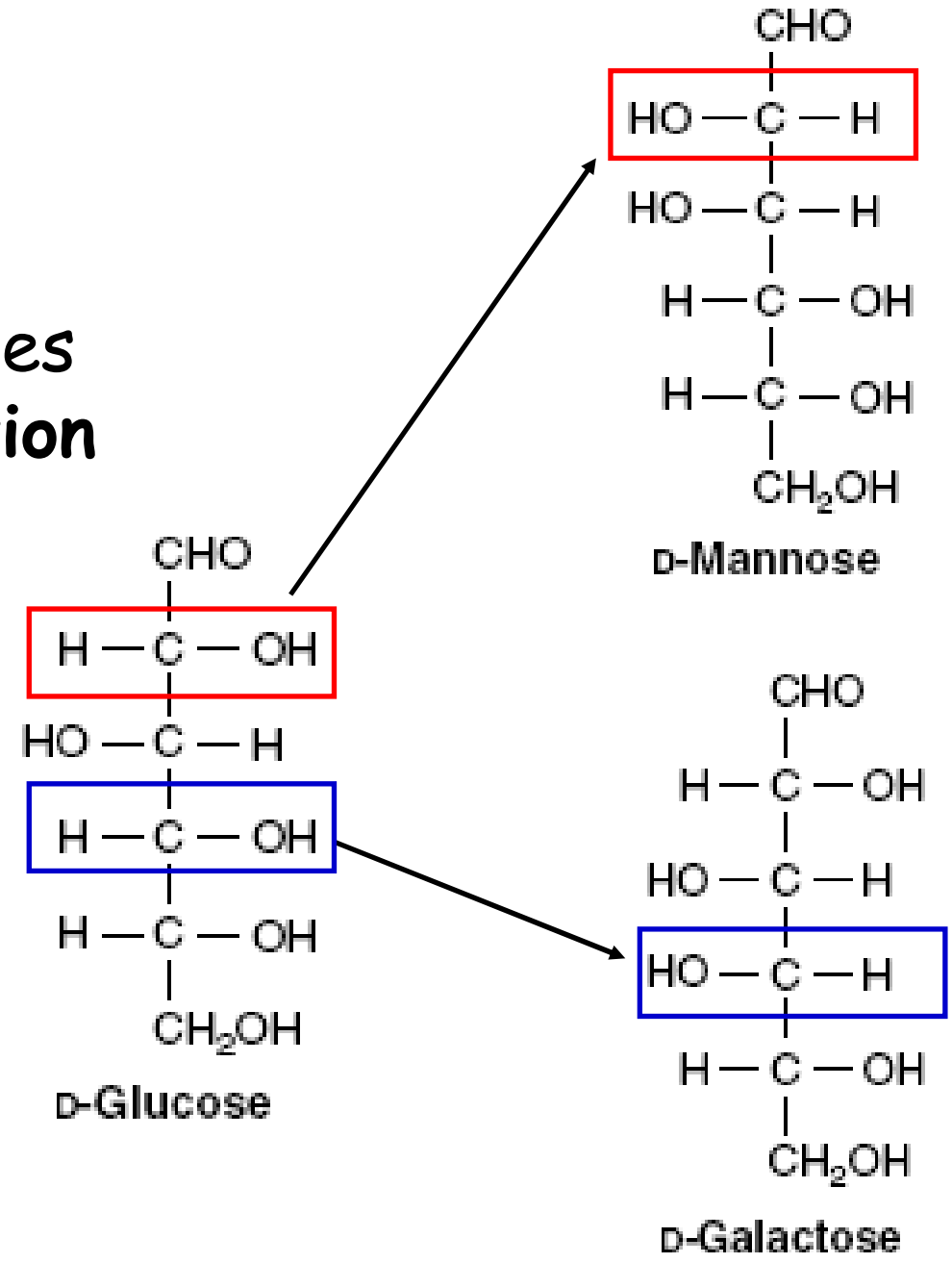
The figures have been adopted from Harper´s Biochemistry

5) epimers

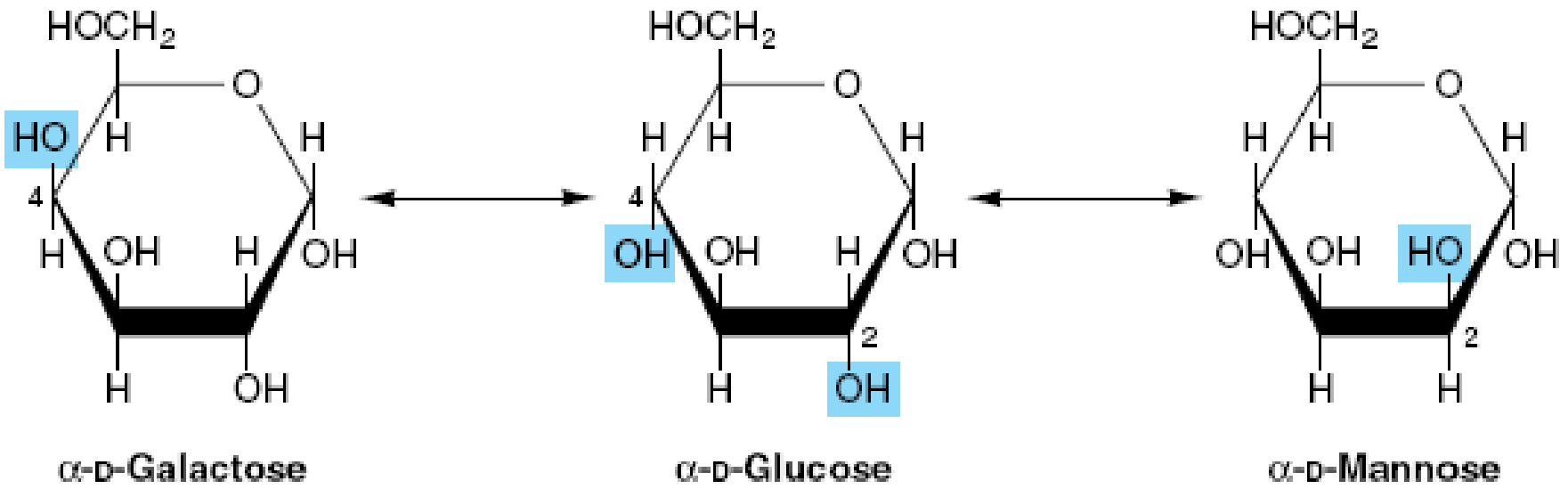
= isomers of saccharides differing in **orientation of only one –OH group in space**

Man = 2-epimer of Glc

Gal = 4-epimer of Glc



The figures have been adopted from Harper´s Biochemistry

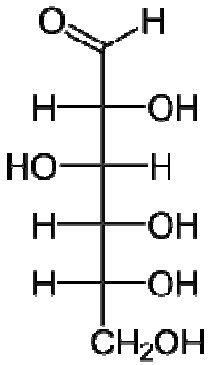


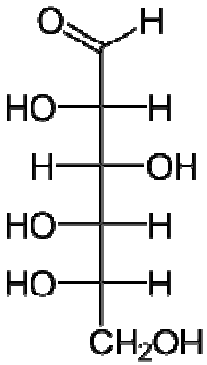
Gal is found in lactose (milk sugar)

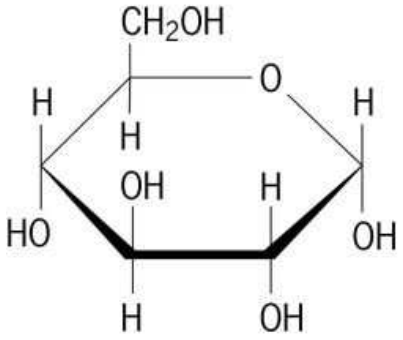
Gal and Man and their derivatives are found in heteroglycosides

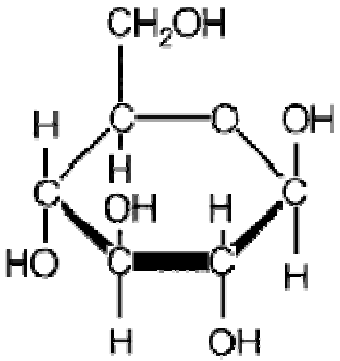
The figures have been adopted from Harper´s Biochemistry

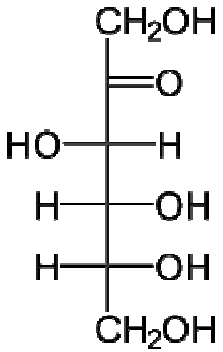
Exercise

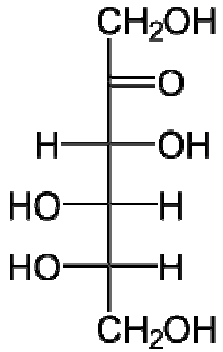

O
H
H
OH
HO
H
H
OH
H
OH
CH2OH

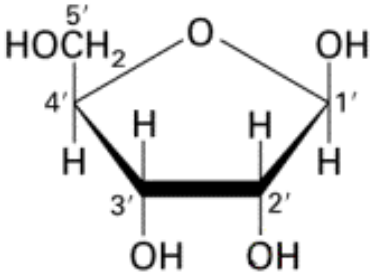

O
H
HO
H
H
OH
HO
H
HO
H
CH2OH

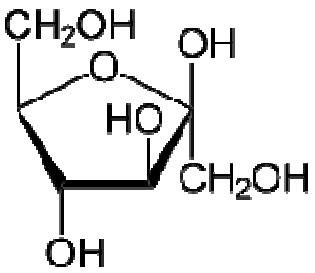

CH2OH
O
H
H
H
OH
H
HO
OH
H
OH

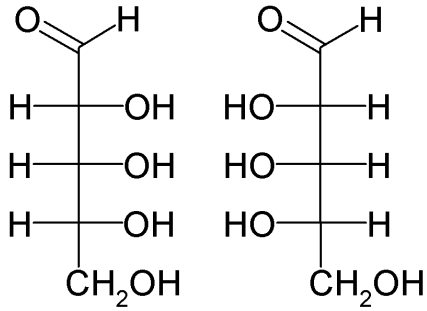

CH2OH
H
C
O
OH
H
C
OH
H
C
HO
C
C
H
H
OH


CH2OH
O
HO
H
H
OH
H
OH
CH2OH


CH2OH
O
H
OH
HO
H
HO
H
CH2OH


5′
HOCH2
O
OH
4′
1′
H
H
H
H
3′
2′
OH
OH

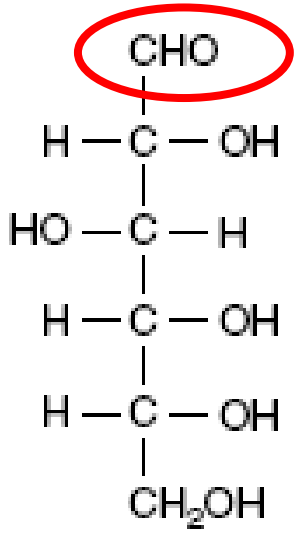

CH2OH
OH
O
HO
CH2OH
OH


O
H
H
OH
H
OH
H
OH
CH2OH
O
H
HO
H
HO
H
HO
H
CH2OH

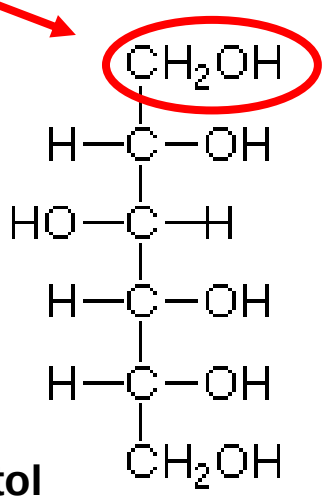
Derivates of monosaccharides

1) sugar alcohols are formed by reduction of the carbonyl group

glucose → glucitol (= sorbitol)
fructose ↗
mannose → mannitol
galactose → galactitol



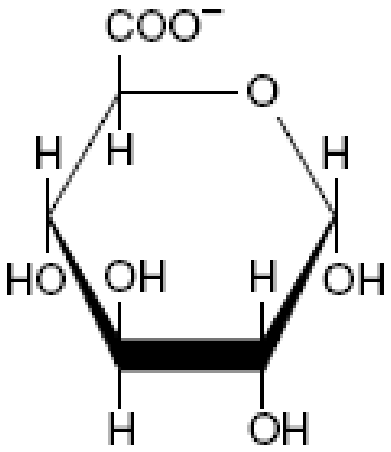
D-Glucose

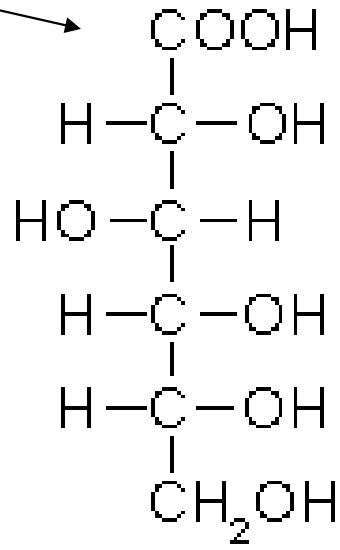


D-Glucitol

2) oxidation of saccharides produces **acids**:

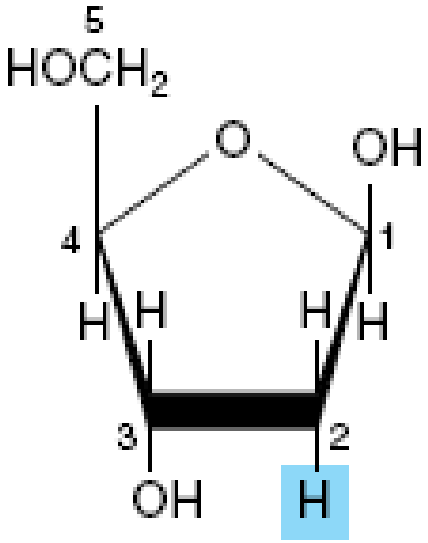
- **aldaric acids** (glucaric)
  both C1 and C6 is oxidized = *dicarboxylic a.*
- **aldonic acids** (gluconic)
  oxidation of C1
- **alduronic** (glucuronic)
  oxidation of C6





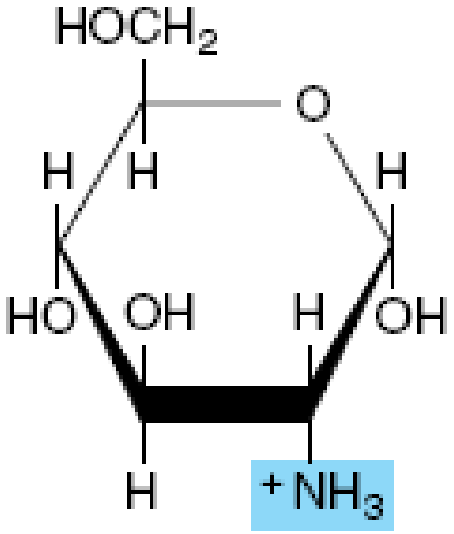
3) deoxysaccharides are formed by reduction of secondary –OH group

2-deoxy-D-ribose

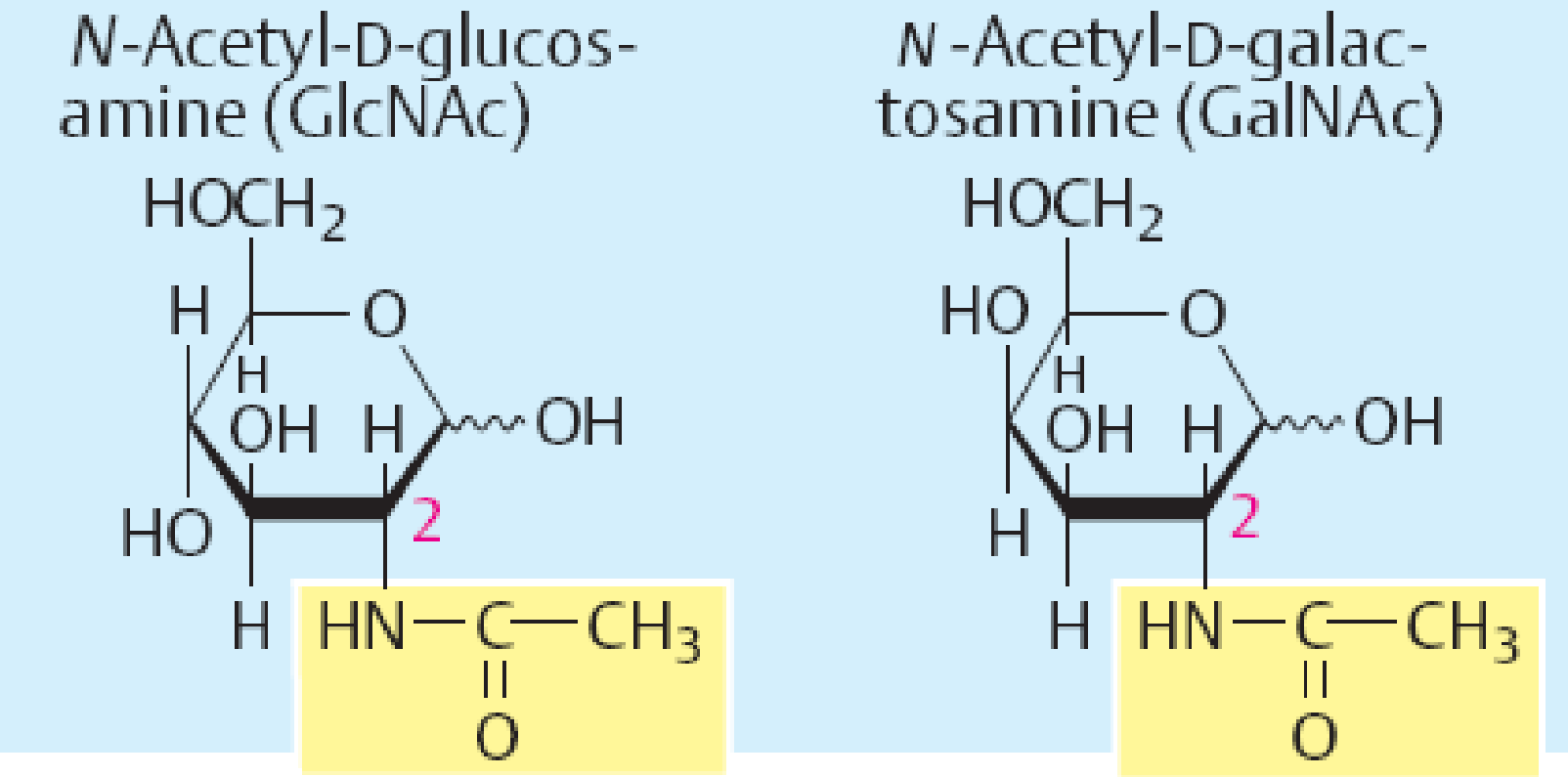


4) amino saccharides contain one amino group instead of one –OH group

D-glucose amine



The figures have been adopted from Harper´s Biochemistry



amino saccharides are often

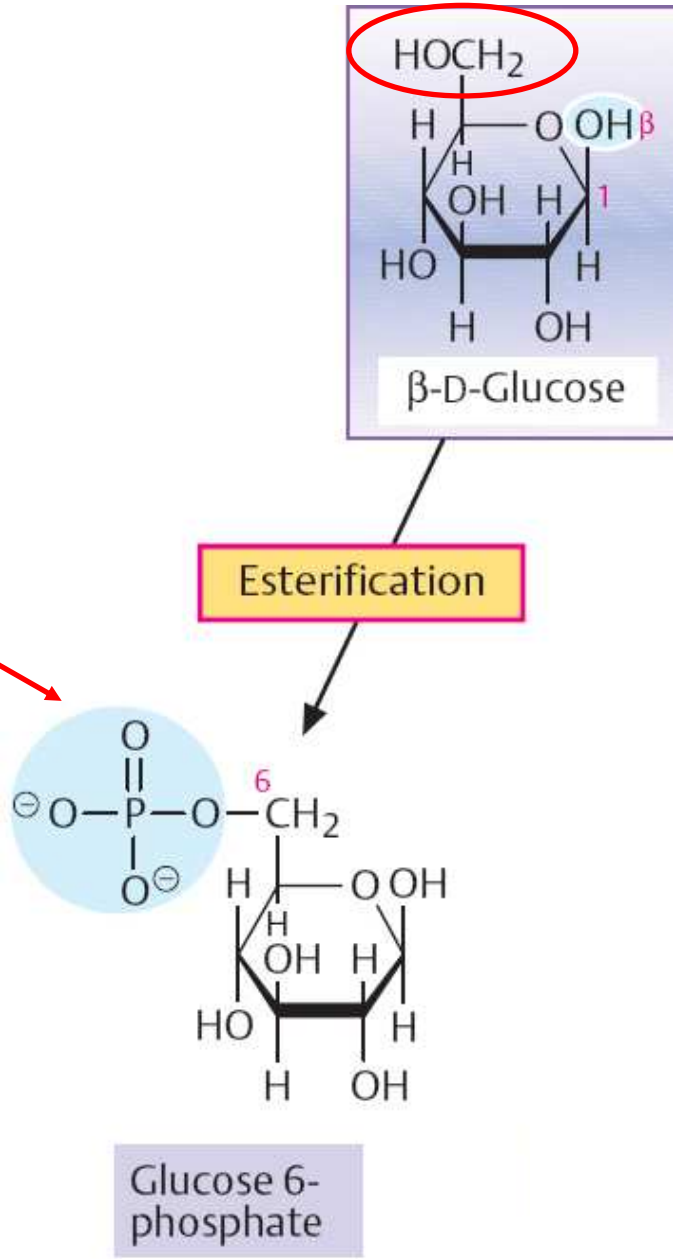
acetylated

(found in heteroglycosides)

The figure has been adopted from J.Koolman, K.H.Röhm / Color Atlas of Biochemistry, 2nd edition, Thieme 2005

5) esters are formed by esterification

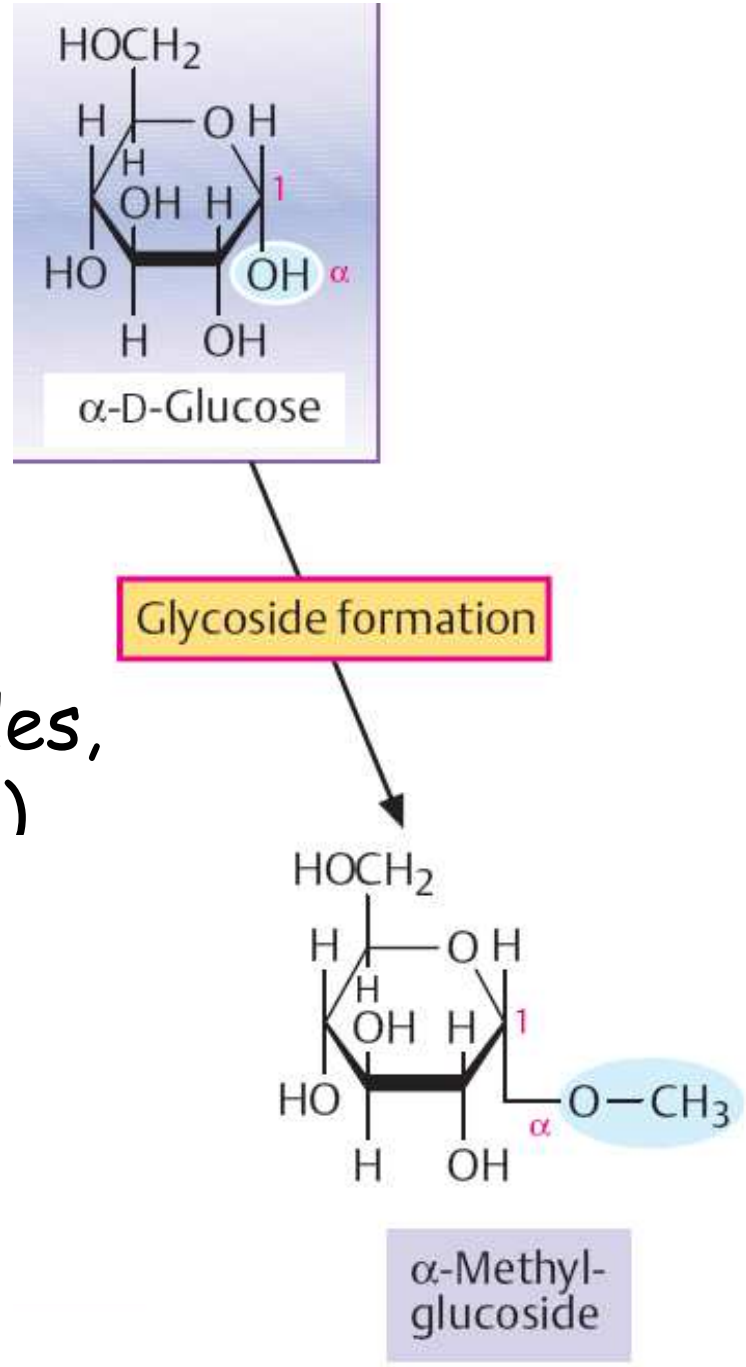
- with H_3PO_4 (intermediates of metabolism)
- with H_2SO_4 (found in proteoglycans)



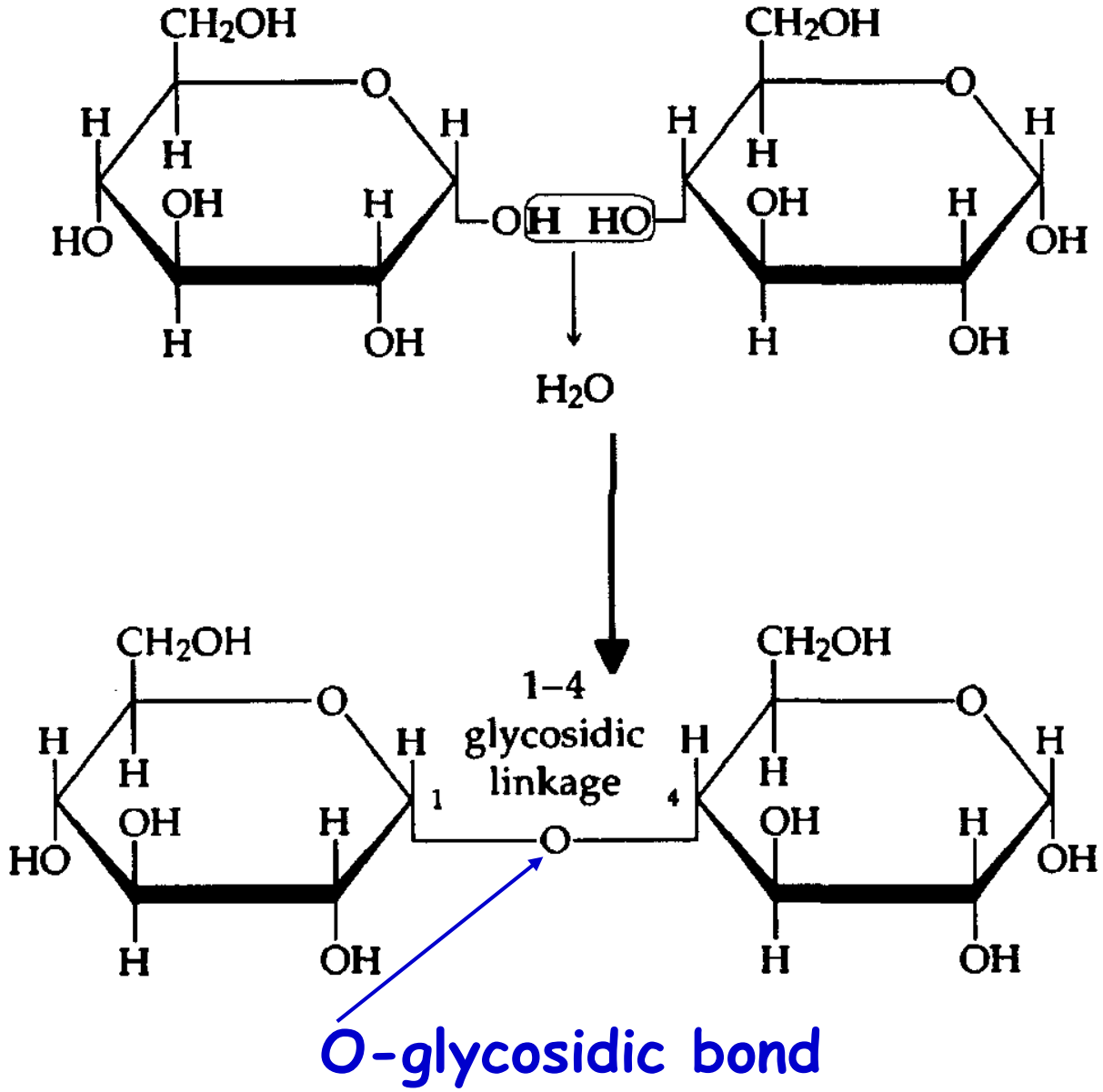
The figure has been adopted from J.Koolman, K.H.Röhm / Color Atlas of Biochemistry, 2nd edition, Thieme 2005

6) glycosides are formed by reaction with alcohols or amines

- O-glycosidic bond
  (oligo and polysaccharides, connection to proteins)
- N-glycosidic bond
  (in nucleic acids, connection to proteins

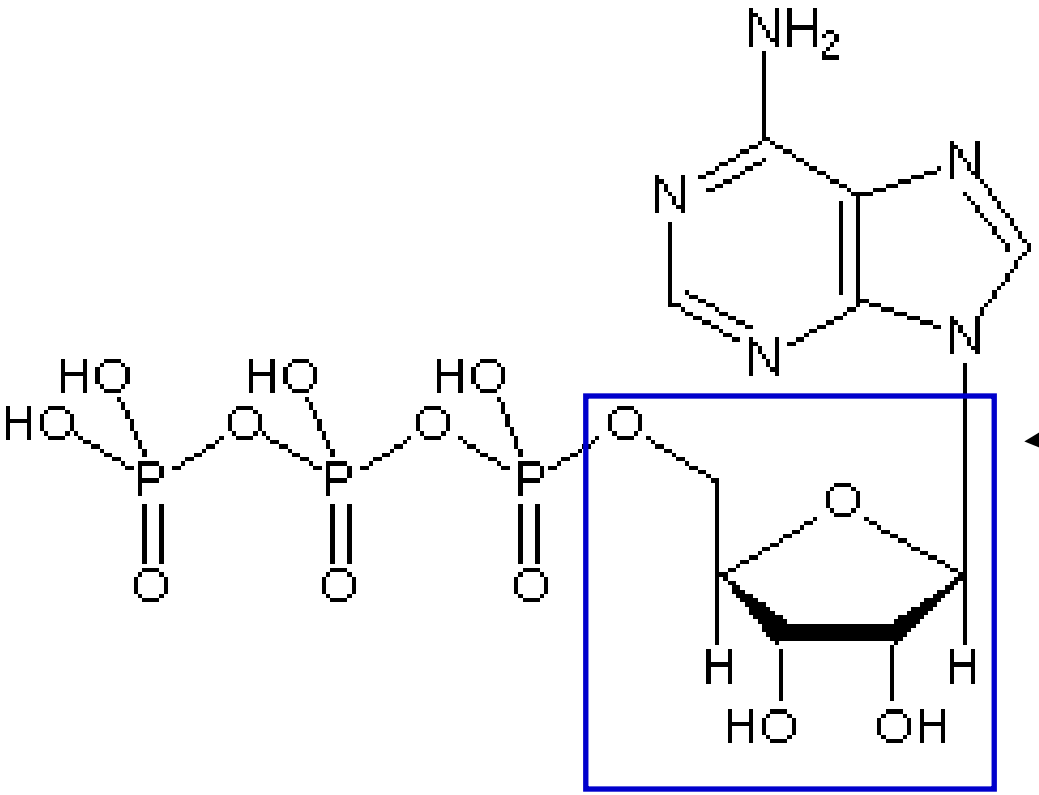


The figure has been adopted from J.Koolman, K.H.Röhm / Color Atlas of Biochemistry, 2nd edition, Thieme 2005



The figure is found at http://www.nmc.edu/~koverbaugh/bio115/Image14.gif (October 2007)

Adenosine triphosphate (ATP)

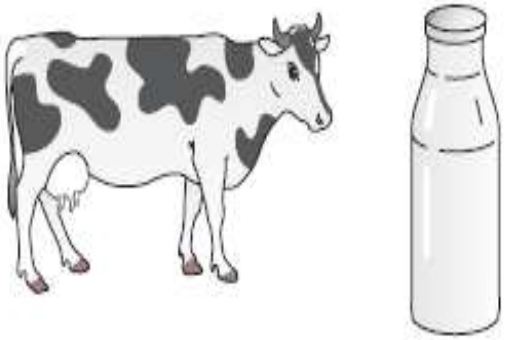


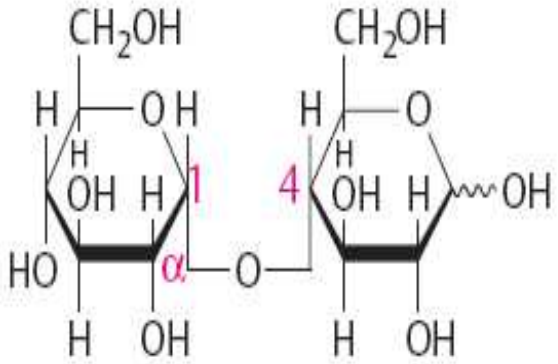
N-glycosidic bond

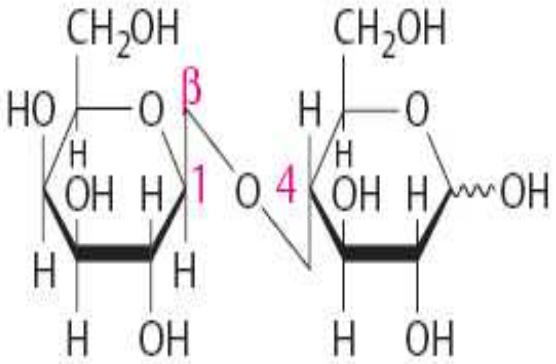
ribose

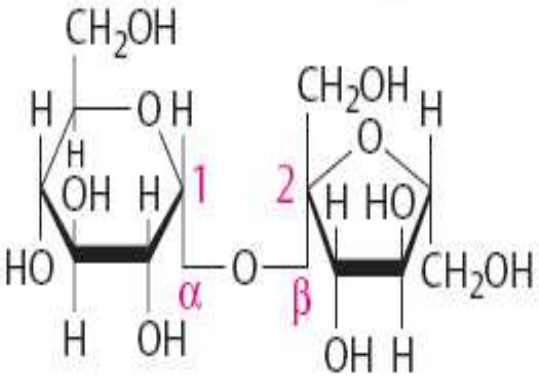
The figure is found at http://www.thebestlinks.com/images/f/f5/ATP.png (October 2007)

DISACCHARIDES









1. Maltose
α-D-Glucopyranosyl-
(1→4)-D-glucopyranose

2. Lactose
β-D-Galactopyranosyl-
(1→4)-D-glucopyranose

3. Sucrose
α-D-Glucopyranosyl-
(1↔2)-β-D-fructofuranoside

α-Glc(1→4)Glc

β-Gal(1→4)Glc

α-Glc(1→2)β- Fru

The figure has been adopted from J.Koolman, K.H.Röhm / Color Atlas of Biochemistry, 2nd edition, Thieme 2005

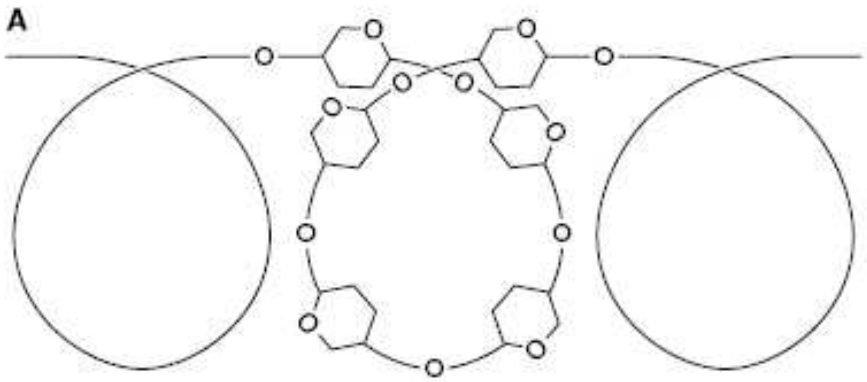
POLYSACCHARIDES

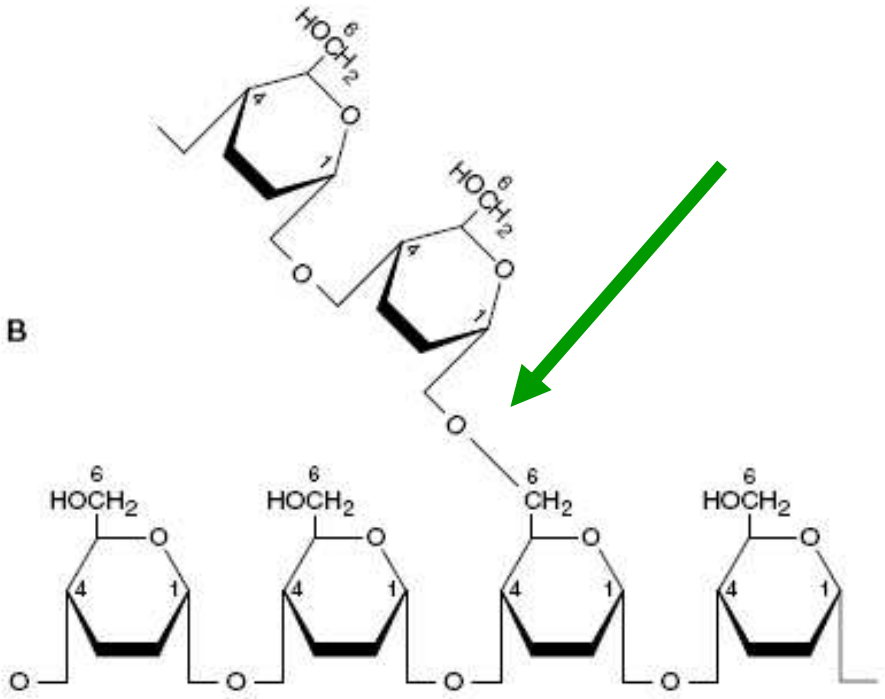
- **homopolysaccharides**
  starch, glycogen,
  cellulose, inuline
- **heteropolysaccharides**
  glycoproteins,
  proteoglycans

- **branched**
- **unbranched**

- **storage**
  starch,
  glycogen,
  inuline
- **structural**
  cellulose,
  proteoglycans

STARCH $(Glc)_n$





amylose $(maltose)_n$

$\alpha(1\rightarrow4)$ glycosidic bonds

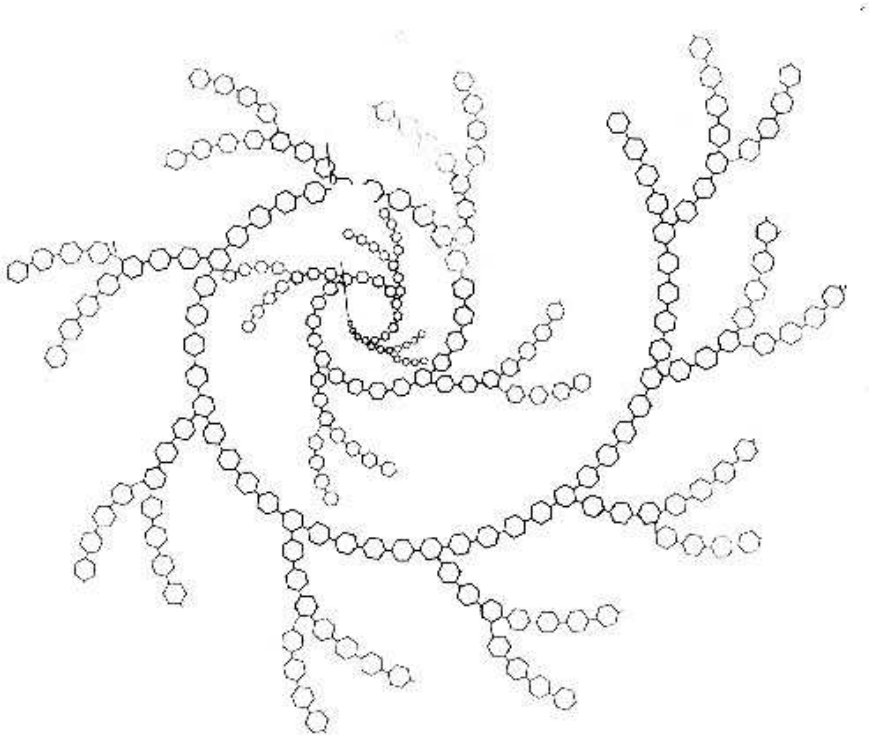
amylopectine

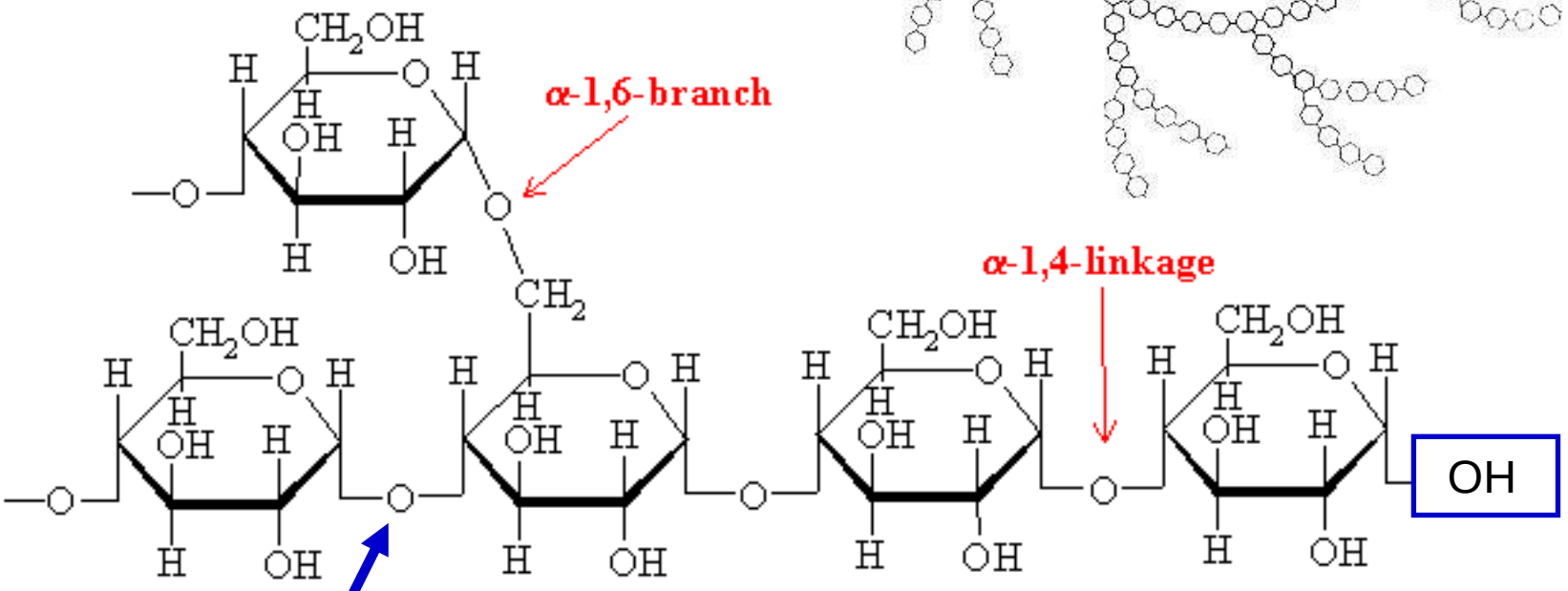
$\alpha(1\rightarrow4)$ glycosidic bonds

$\alpha(1\rightarrow6)$ glycosidic bonds

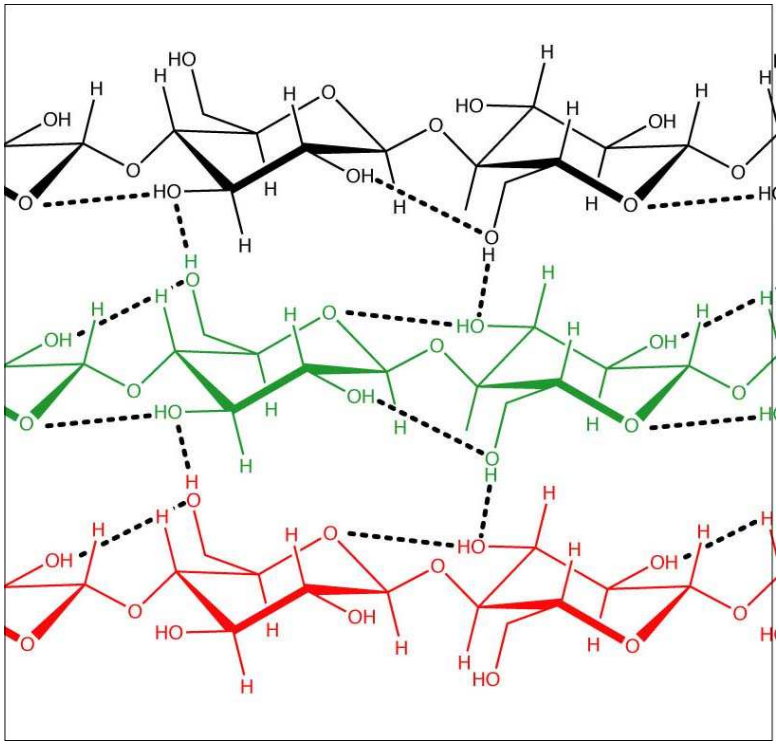
The figures have been adopted from Harper´s Biochemistry

GLYCOGEN $(Glc)_n$



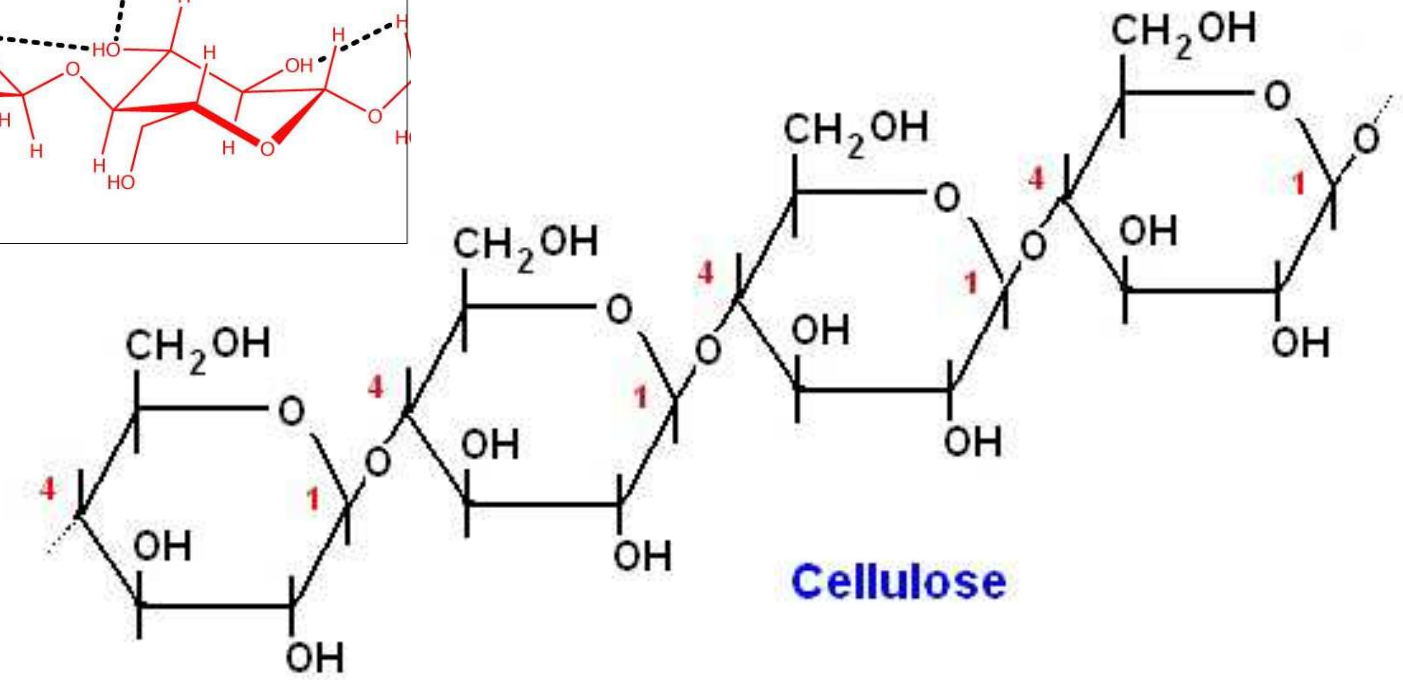


The figure is found at http://students.ou.edu/R/Ben.A.Rodriguez-1/glycogen.gif (October 2007)



CELLULOSE

β-Glc(1→4)Glc

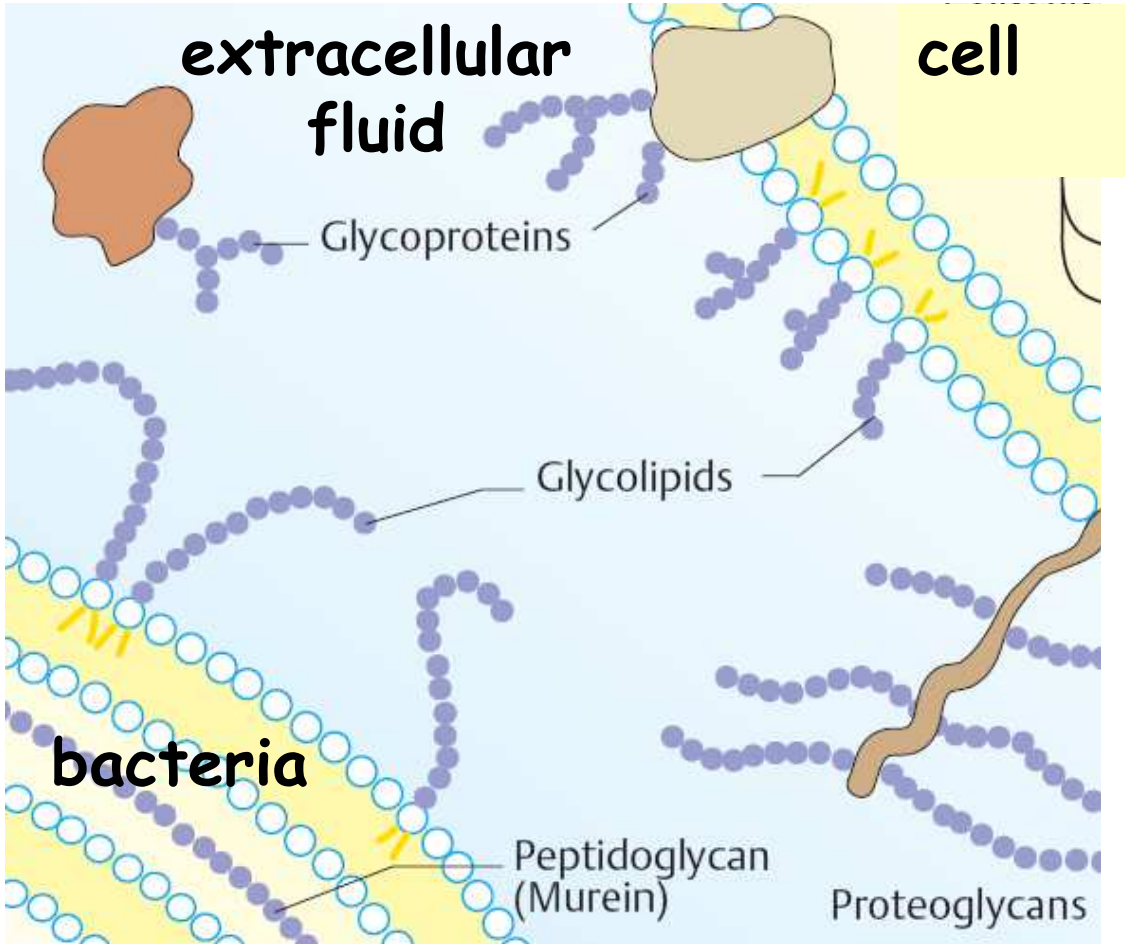


The figures are found at http://web.chemistry.gatech.edu/~williams/bCourse_Information/6521/carbo/glu/cellulose_int_2.jpg http://www.kjemi.uio.no/14_skole/modul/Evina_organisk/Org_K3fig14_cellulose.JPG (October 2007)

heteroglycosides = complex saccharides

- **proteoglycans**
- **glycoproteins**
- **glycolipids**

„glycan"
= polysaccharide



The figure has been adopted from: J.Koolman, K.H.Röhm / Color Atlas of Biochemistry, 2nd edition, Thieme 2005

PROTEOGLYCANS

↓

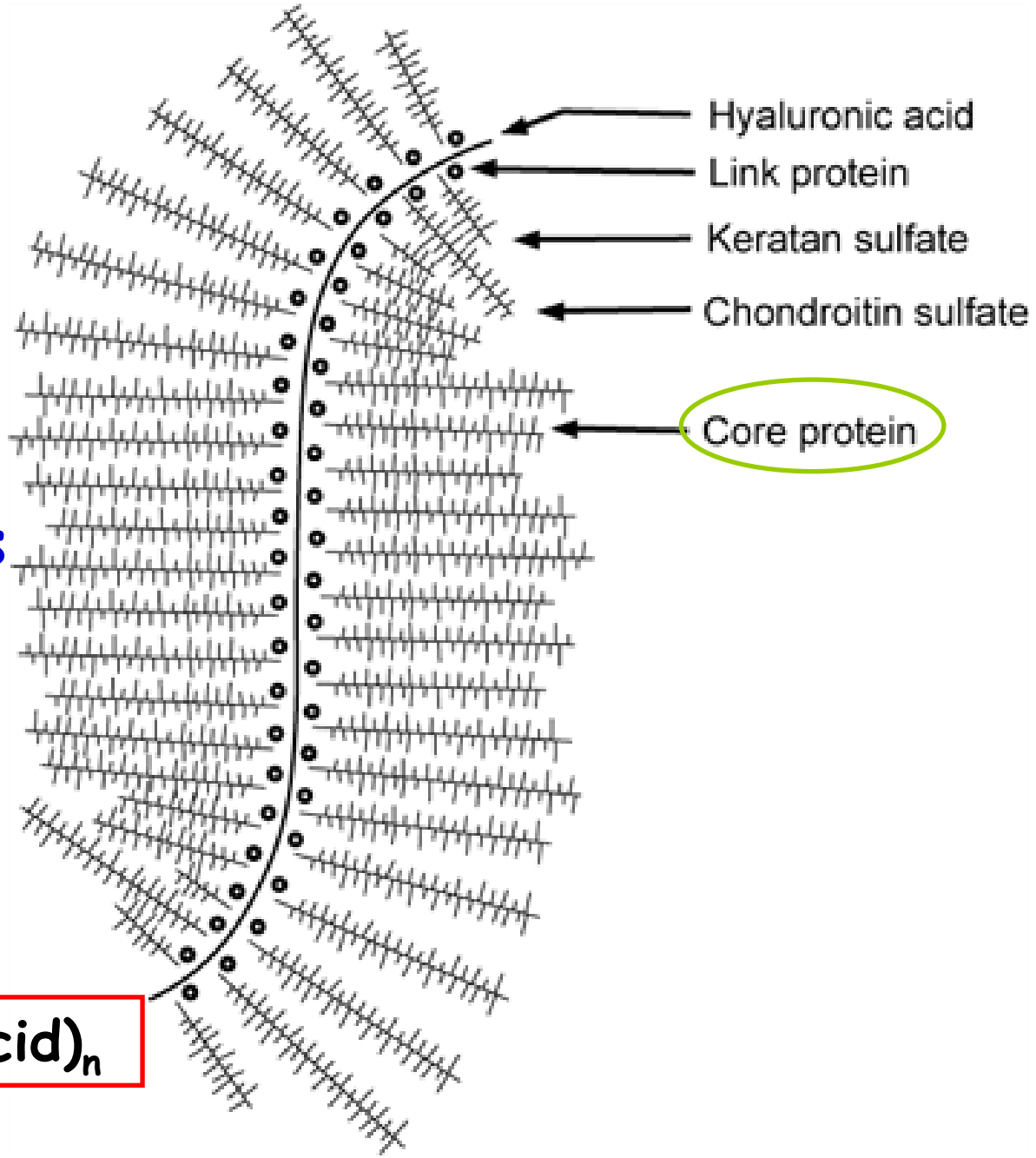
core protein

+

glycosaminoglycans
(GAG)

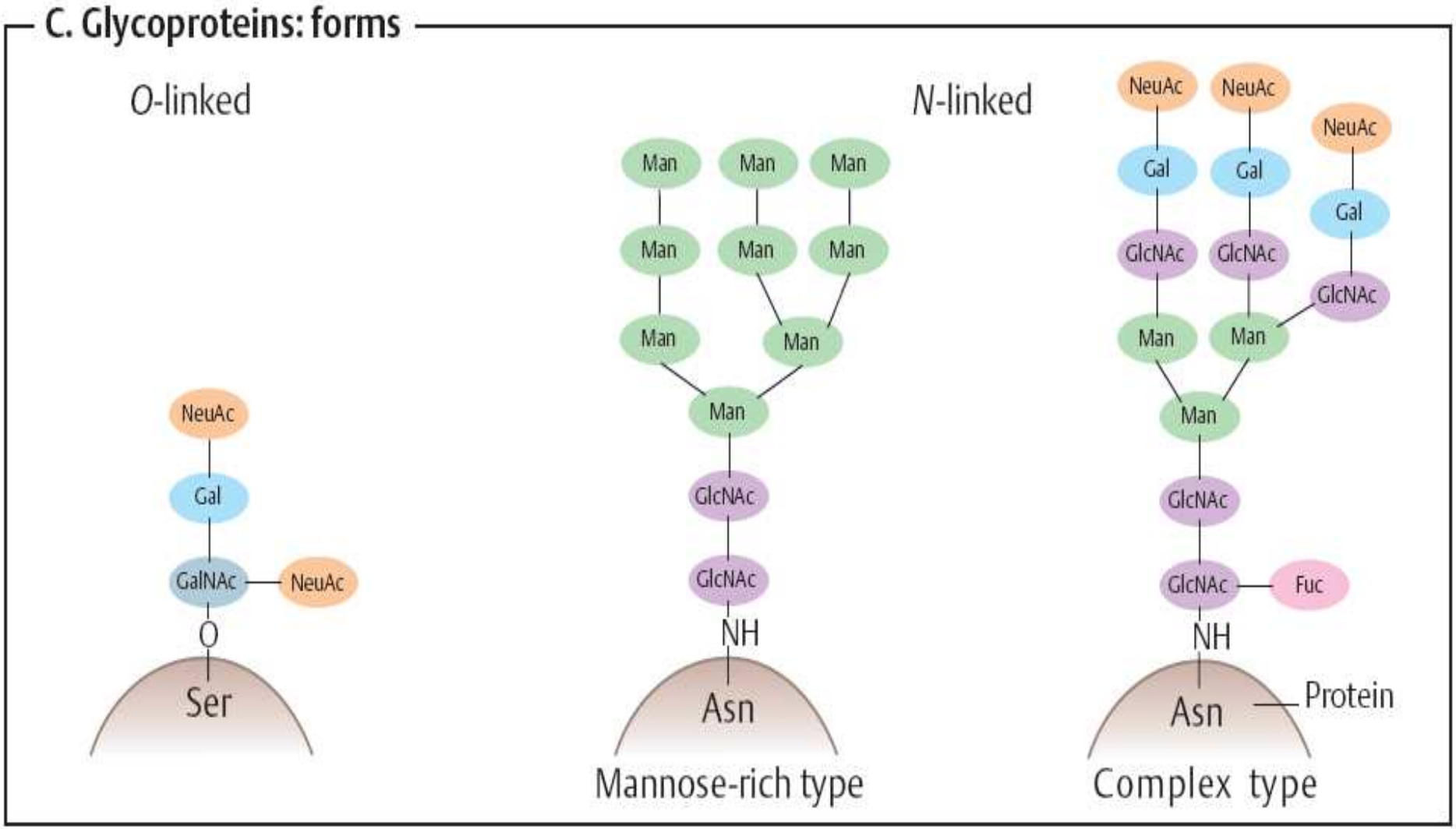
↓

(aminosugar-uronic acid)$_n$



The figure is found at http://www.grandmeadows.com/archives/truth1.gif (October 2007)

GLYCOPROTEINS



The figure has been adopted from J.Koolman, K.H.Röhm / Color Atlas of Biochemistry, 2nd edition, Thieme 2005