CARBOHYDRATE

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CARBOHYDRATE CHEMISTRY

1. **Definition, classification, biological importance.**
2. **Monosaccharides- structure, classification & properties.**
3. **Isomerism.**
4. **Disaccharides, Oligosaccharides- structure, importance.**
5. **Polysaccharides- homo & heteropolysaccharides, their structure & function.**

Carbohydrates are aldehyde or ketone derivatives of polyhydric alcohols.

BIOMEDICAL IMPORTANCE

1. Knowledge of the structure & properties of carbohydrates is essential in understanding its role in physiological processes.
2. Glucose is the major fuel of the tissues.
3. Other carbohydrates of importance :- Glycogen for storage; Ribose in nucleic acid; Galactose in lactose of milk; in certain complex lipids & in combination with protein in glycoproteins & proteoglycans.
4. Non digestible carbohydrates serve as dietary fibres.

BIOMEDICAL IMPORTANCE

Diseases associated with carbohydrates:-

1. Diabetes mellitus
2. Galactosemia
3. Glycogen storage diseases
4. Lactose intolerance.

CLASSIFICATION

1.**MONOSACCHARIDES-**

TRIOSES, TETROSES, PENTOSES, HEXOSES, HEPTOSES OR OCTOSES(depending on the no. of C-atoms), ALDOSES OR KETOSES(depending on whether aldehyde or ketone group is present)

2.**DISACCHARIDES**.

3.**OLIGOSACCHARIDES**.

4.**POLYSACCHARIDES-**

HOMOPOLYSACCHARIDES & HETEROPOLYSACCHARIDES.

- Carbohydrates also can combine with lipids to form **glycolipids**

  OR

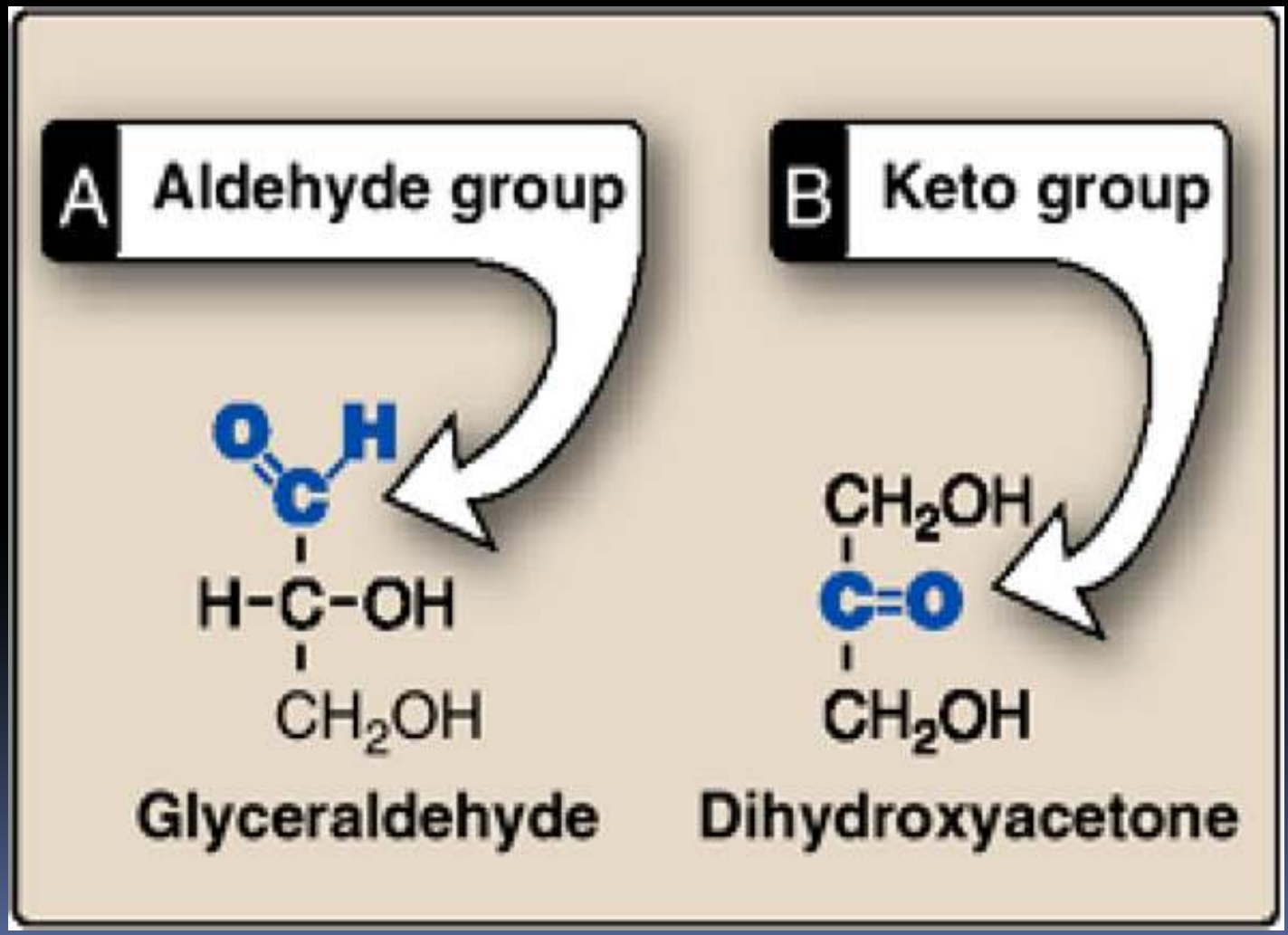
- With proteins to form **glycoproteins**.

MONOSACCHARIDES

- Contains only one sugar group (mono-one, saccharin-sugar).
- Cannot be hydrolysed to simpler form.
- Depending on the no. of C-atoms, may be triose, tetrose, pentose etc.

- Carbohydrates with an aldehyde as their most oxidized functional group are called Aldoses.

- whereas those with a keto as their most oxidized functional group are called Ketoses


A Aldehyde group
B Keto group
O
H
C
H-C-OH
CH2OH
Glyceraldehyde
CH2OH
C=O
CH2OH
Dihydroxyacetone

COMMON MONOSACCHARIDES

No. Of Carbon atoms	Generic name	ALDOSES	KETOSES
3	TRIOSE	GLYCERALDEHYDE	DIHYDROXY ACETONE PHOSPHATE
4	TETROSE	ERYTHROSE	ERYTHRULOSE
5	PENTOSE	RIBOSE	RIBULOSE
6	HEXOSE	GLUCOSE	FRUCTOSE
7	HEPTOSE	GLUCOHEPTOSE	SEDOHEPTULOSE

DISACCHARIDES

Formed when two monosaccharides combine together by a glycosidic linkage with the elimination of molecule of water.

i.e., DISACCHARIDES , ON HYDROLYSIS YIELD TWO MOLECULES OF MONOSACCHARIDES.

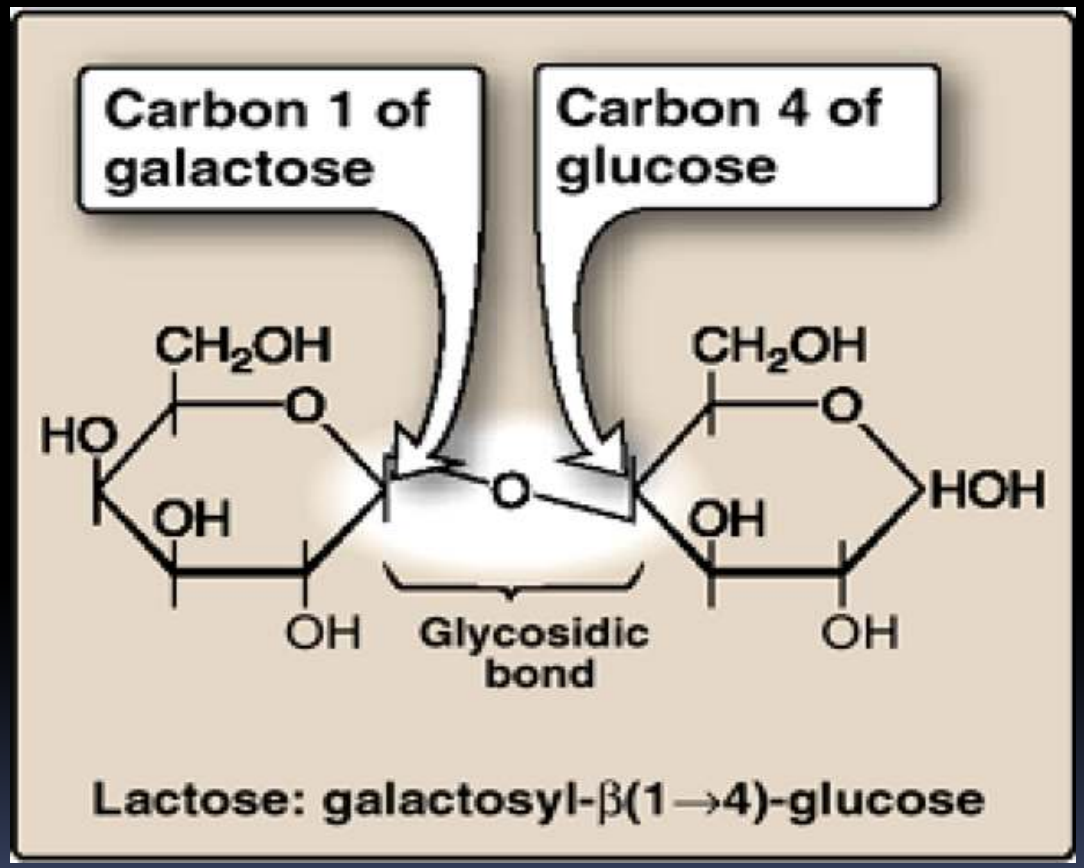
EXAMPLES OF DISACCHARIDES:-

ON HYDROLYSIS

LACTOSE:- yields one molecule of glucose and one of galactose

MALTOSE :- yields two molecules of glucose.

SUCROSE:- yields one molecule of glucose& one of fructose.


Carbon 1 of galactose
Carbon 4 of glucose
CH2OH
O
HO
OH
OH
O
CH2OH
O
HOH
OH
OH
Glycosidic bond
Lactose: galactosyl-β(1→4)-glucose

OLIGOSACCHARIDES

(OLIGO-a few)

Yield 2 to 10 monosaccharide units on hydrolysis.

Eg., **MALTOTRIOSE & RAFFINOSE** are trisaccharides containing 3 glucose units.

POLYSACCHARIDES

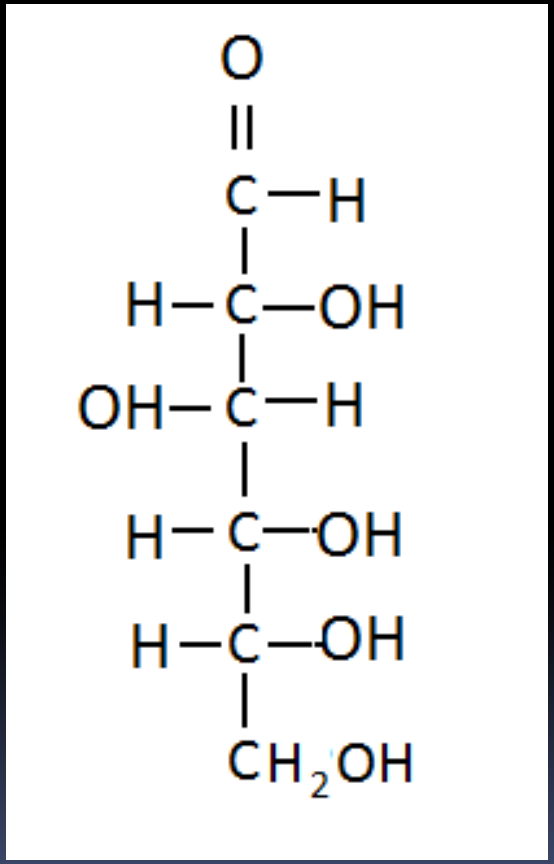
- Yield more than 10 molecules of monosaccharides on hydrolysis(poly-many).
- **Homopolysaccharides** yield only one type of monosaccharide units.
- **Heteropolysaccharides** yield more than one type of monosaccharides on hydrolysis.

PROPERTIES OF MONOSACCHARIDES

FROM THE BIOMEDICAL POINT OF VIEW, GLUCOSE IS THE MOST IMPORTANT MONOSACCHARIDE.

GLUCOSE IS A ALDOHEXOSE

- ALDEHYDE GROUP ON C 1
- HEXOSE
- POLYHYDROXY COMPOUND
- PRIMARY ALCOHOL GROUP ON 6TH CARBON
- STRAIGHT CHAIN / OPEN CHAIN PROJECTION FORMULA



Important

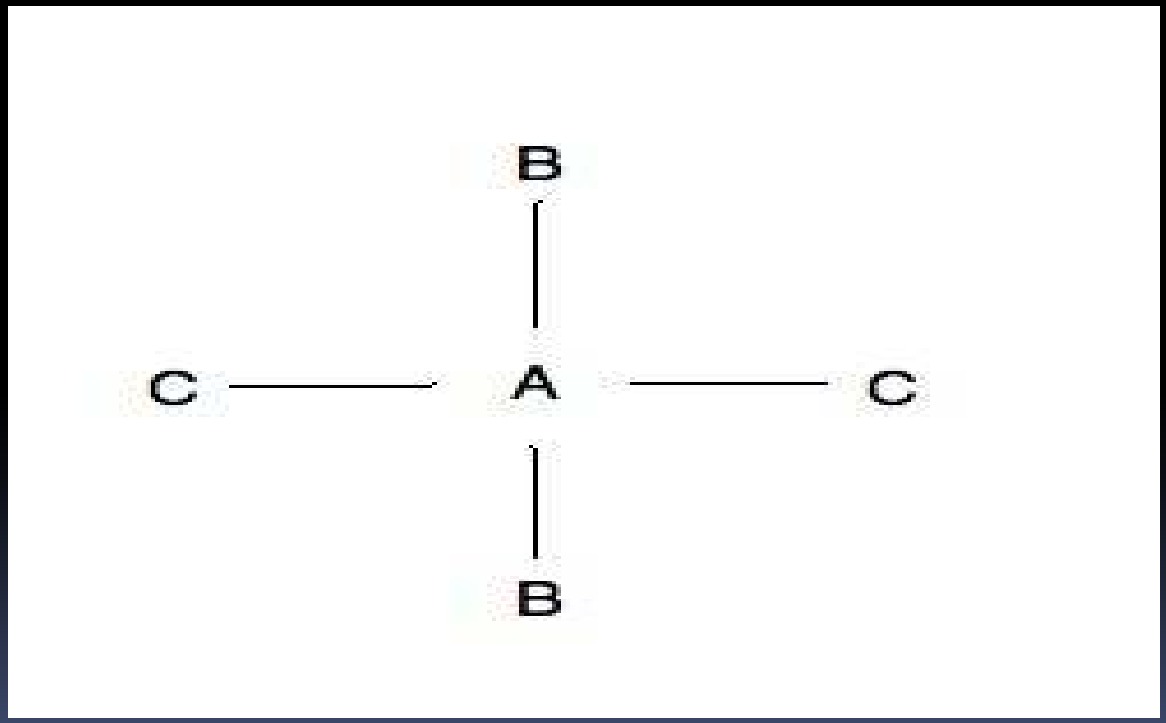
- Isomers
- Epimers
- Enantiomers
- Anomers
- D-form & L-form
- d-form & l-form
- α-form & β-form
- (+) form & (-) form

Isomers

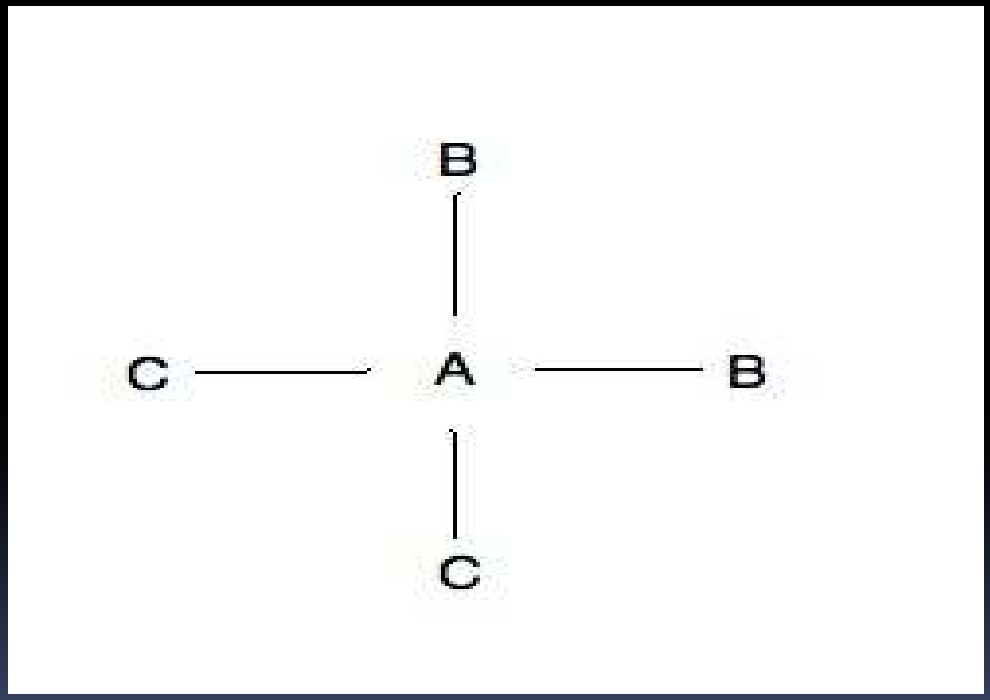
- Isomers are molecules that have the same molecular formula, but have a different arrangement of the atoms in space. (different structures).

- For example, a molecule with the formula AB_2C_2, has two ways it can be drawn:

Isomer 1



Isomer 2



Examples of isomers:

1. Glucose
2. Fructose
3. Galactose
4. Mannose

Same chemical formula C6 H12 O6

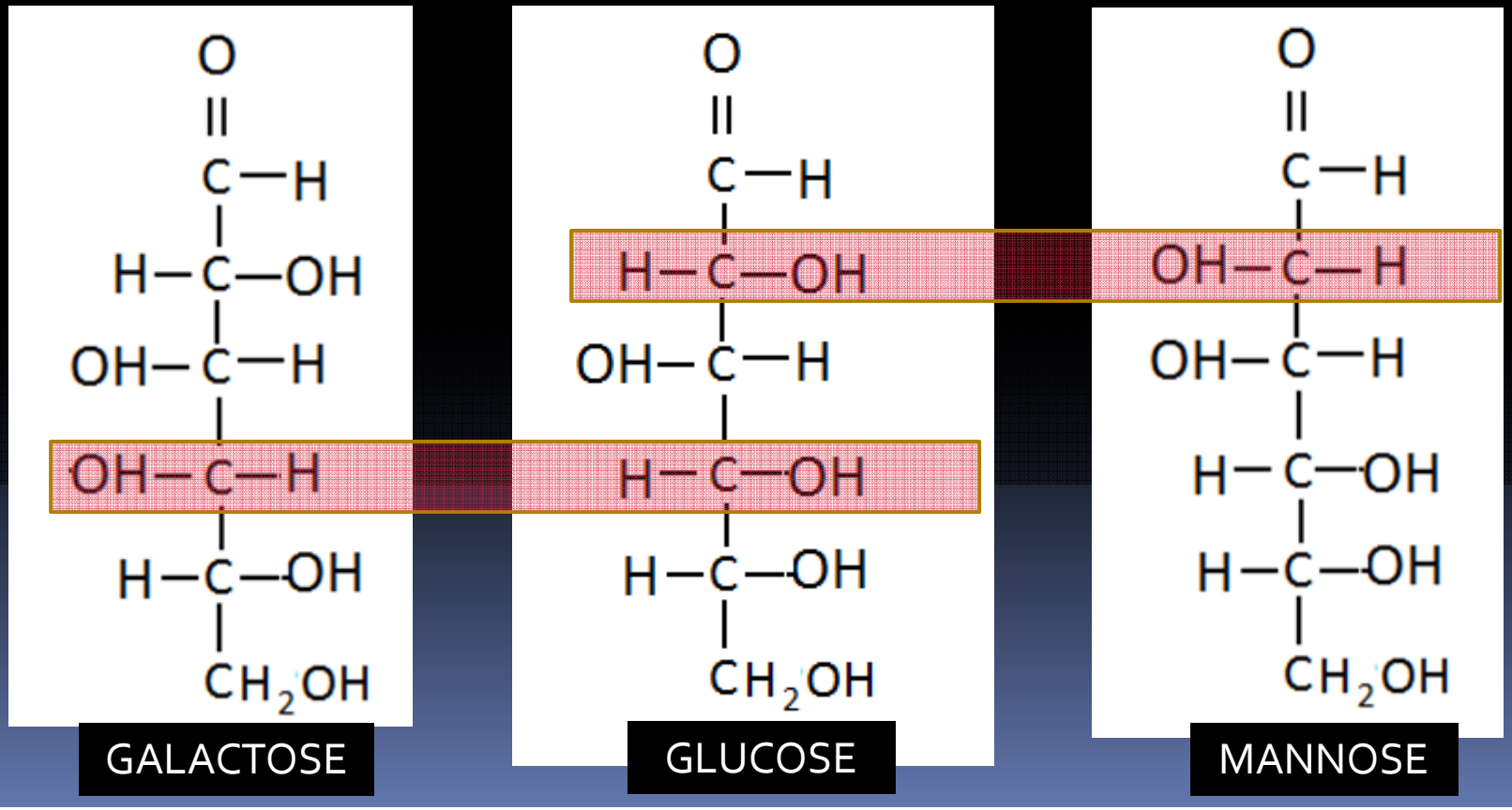
EPIMERS

- **EPIMERS** are sugars that **differ in configuration at ONLY 1 POSITION.**

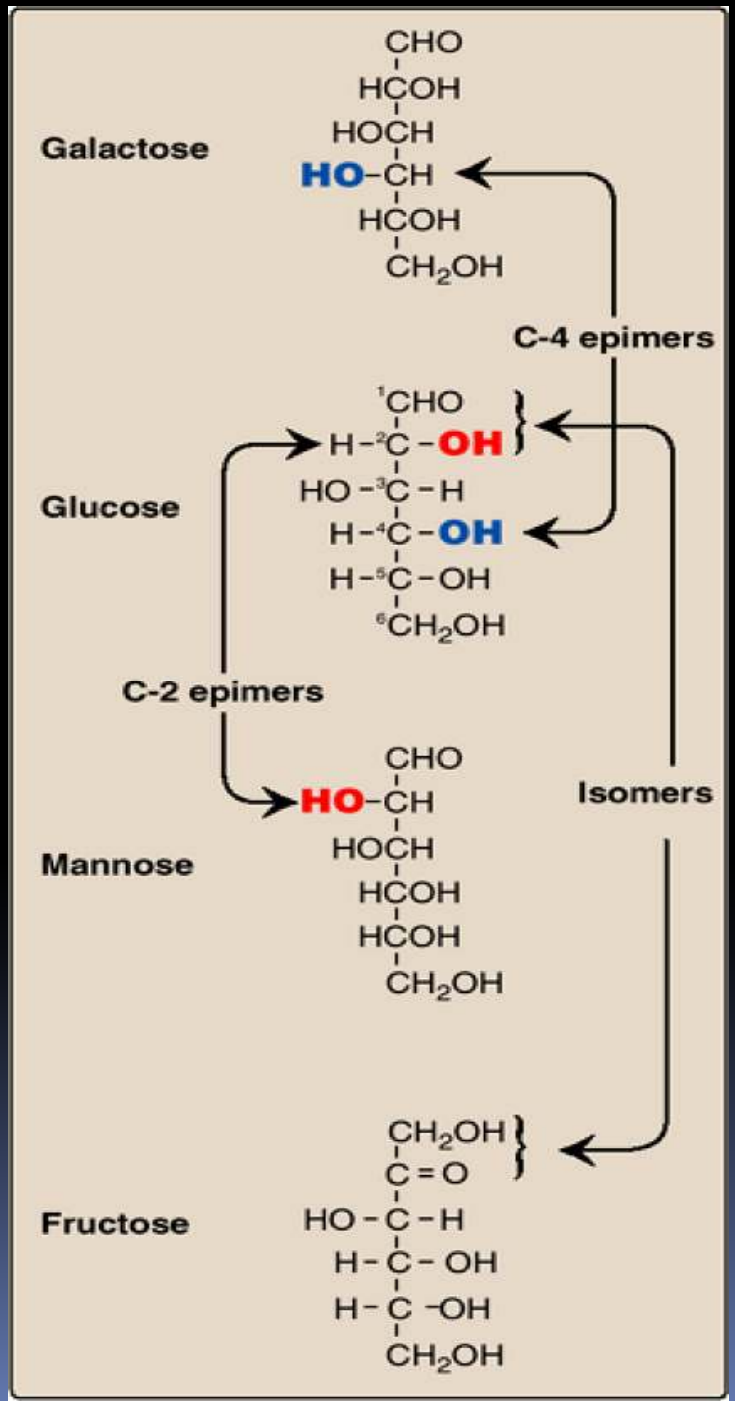
EPIMERS

DIFFERS IN POSITION OF -OH GROUP AROUND A SINGLE CARBON ATOM OTHER THAN PENULTIMATE CARBON

GLU & GAL ARE C-4 EPIMERS WHILE GLU & MANNOSE ARE C2 EPIMERS



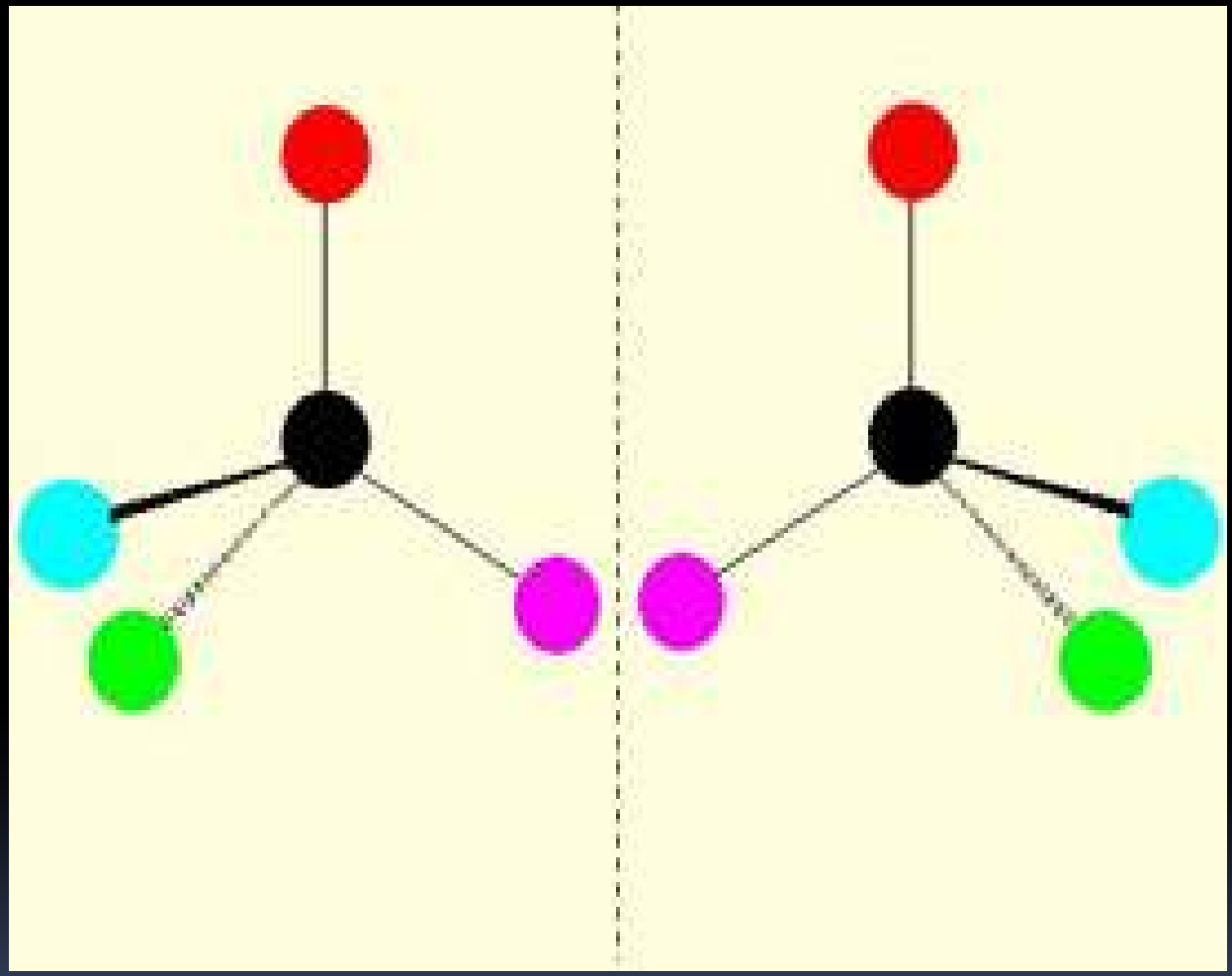
- Examples of epimers :
  - D-glucose & D-galactose (epimeric at C4)
  - D-glucose & D-mannose (epimeric at C2)

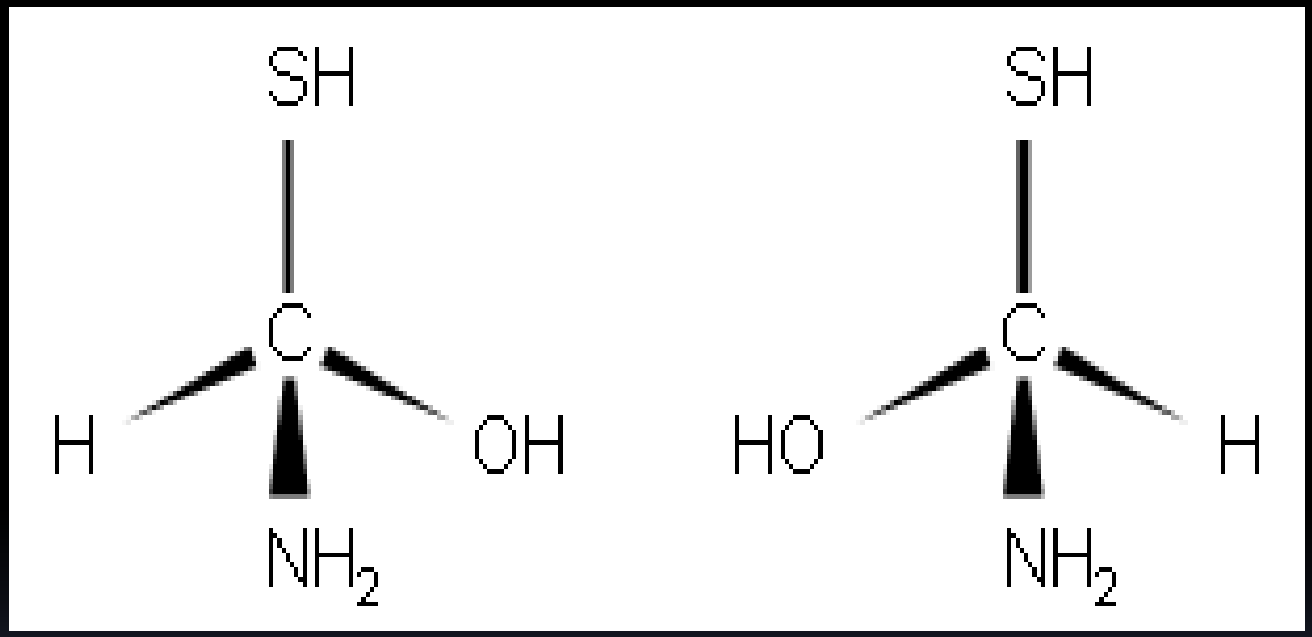

Galactose
Glucose
Mannose
Fructose
C-4 epimers
C-2 epimers
Isomers

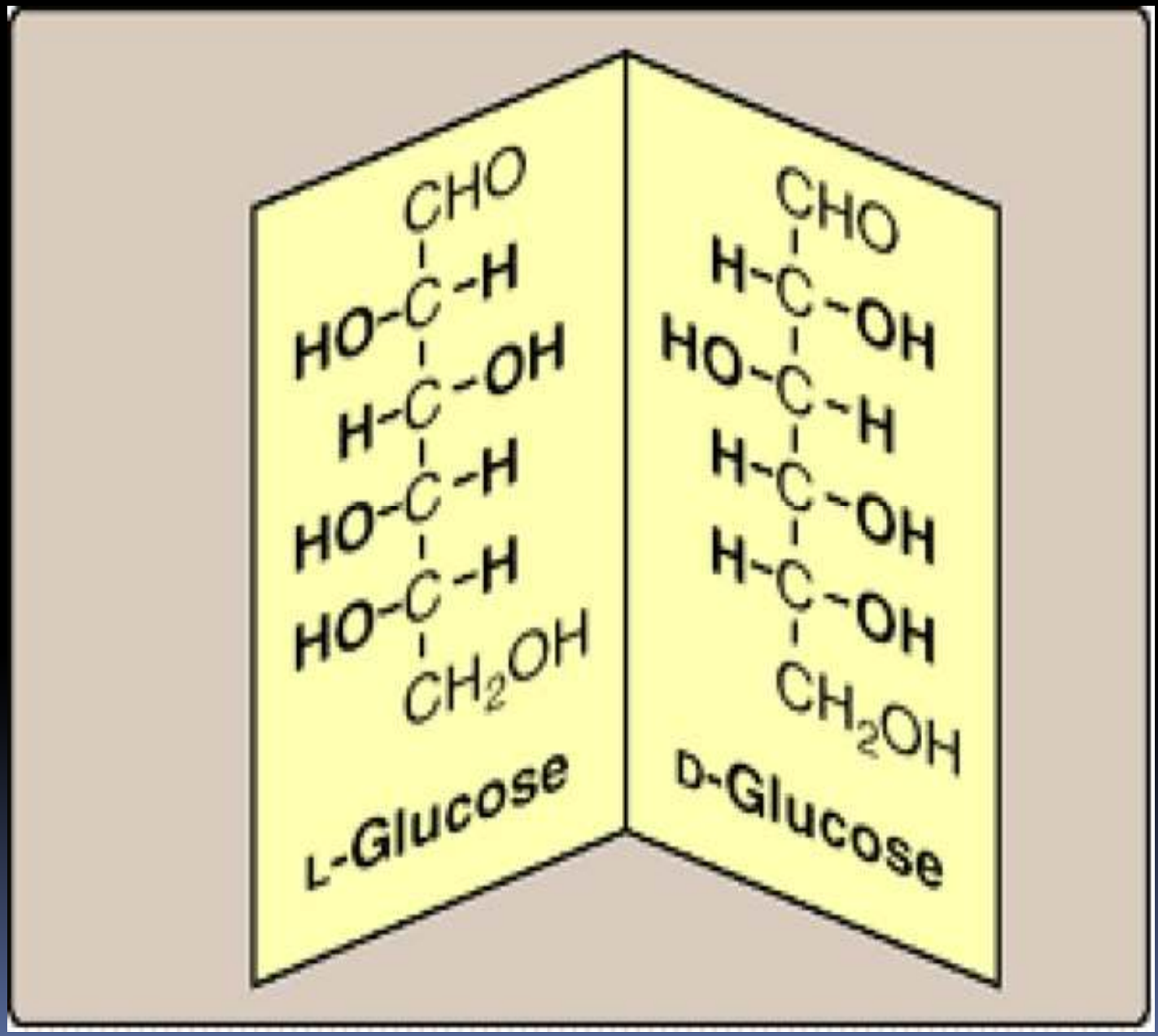
ENANTIOMERS

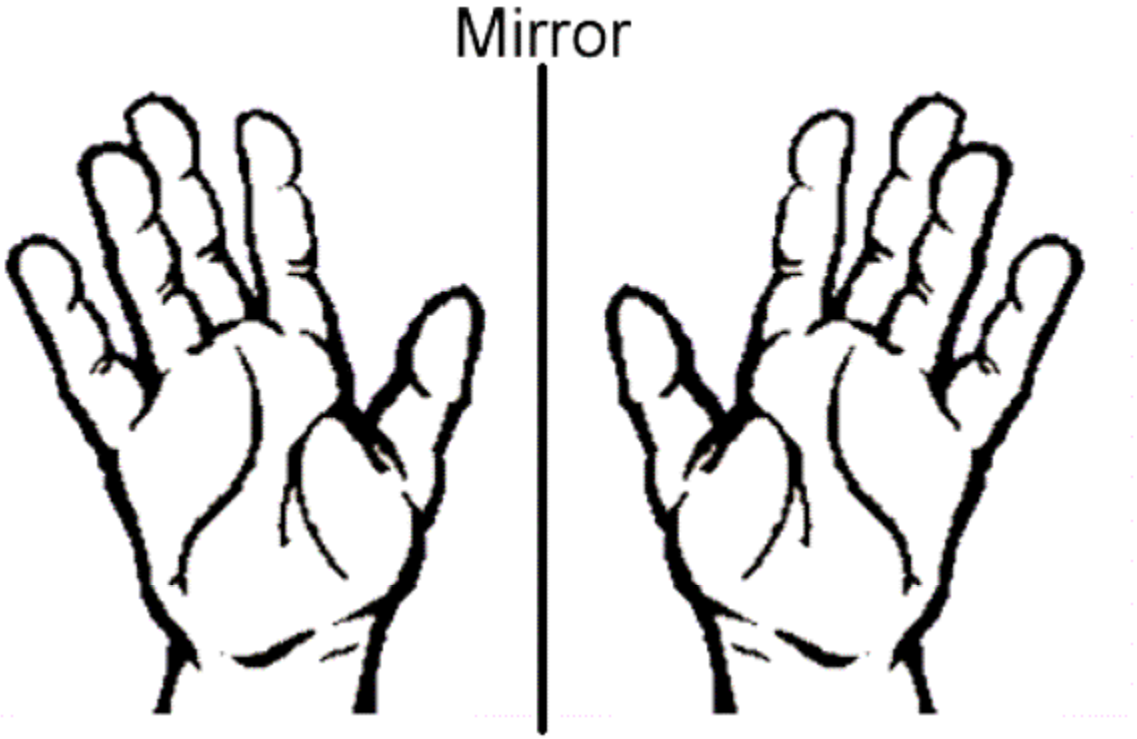
Non-Superimposable *COMPLETE* mirror image (differ in configuration at **EVERY CHIRAL CENTER.)**

- In **D** form the OH group on the asymmetric carbon is on the **right**.
- In **L** form the OH group is on the **left side**.
- D-glucose and L-glucose are **enantiomers:**




SH
C
H
OH
NH2
SH
C
HO
H
NH2


CHO
HO-C-H
H-C-OH
HO-C-H
HO-C-H
CH2OH
L-Glucose
CHO
H-C-OH
HO-C-H
H-C-OH
H-C-OH
CH2OH
D-Glucose

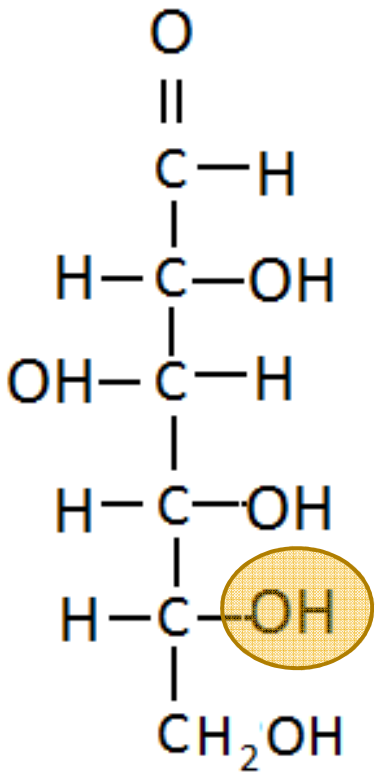


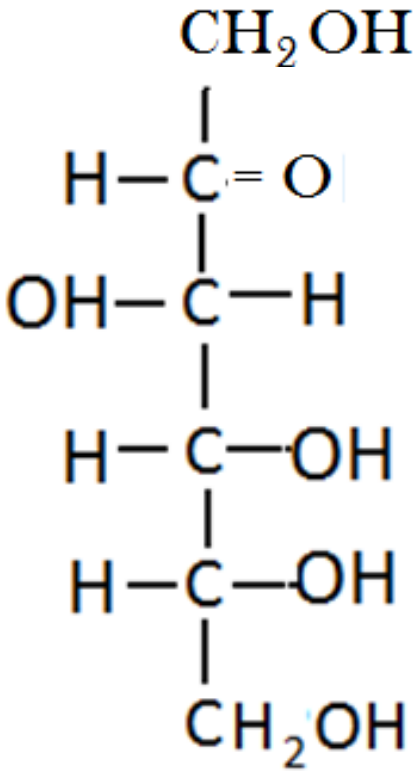
The mirror image of a chiral substance cannot be superimposed on the original image. Hands are chiral, as are sugars and amino acids.

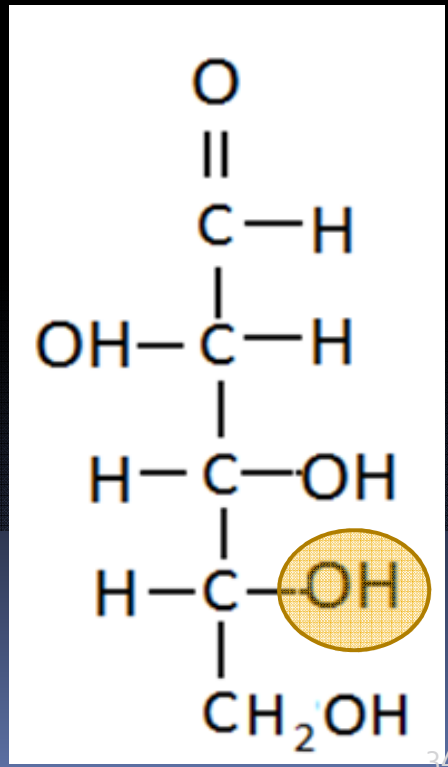
D-L ISOMERISM

D-GLUCOSE , D-FRUCTOSE, D-RIBOSE…

MOST NATURALLY OCCURRING SUGARS ARE D-TYPE.

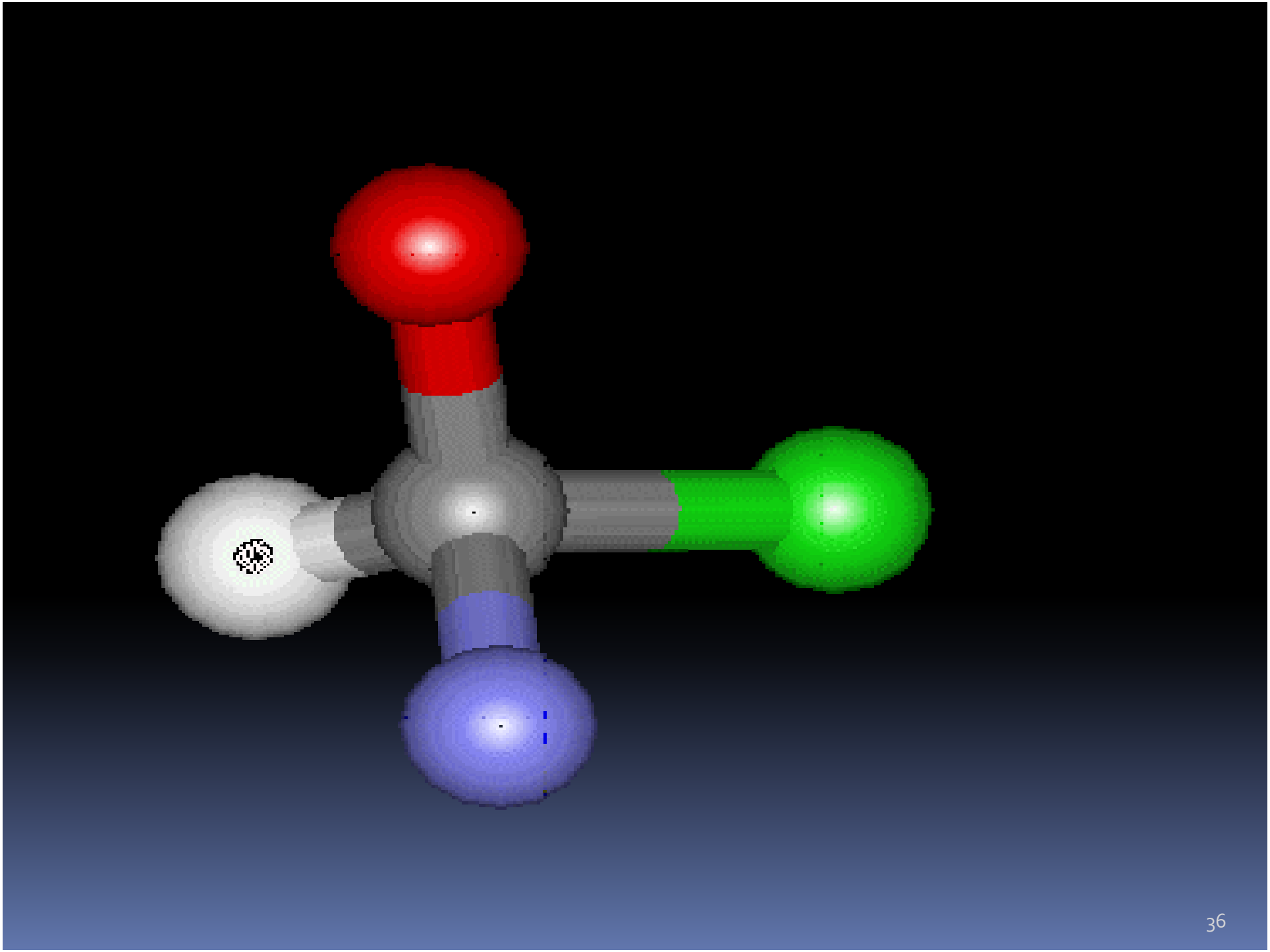






Asymmetric carbon

- A carbon linked to four different atoms or groups farthest from the carbonyl carbon
- Also called **Chiral** carbon



Cyclization

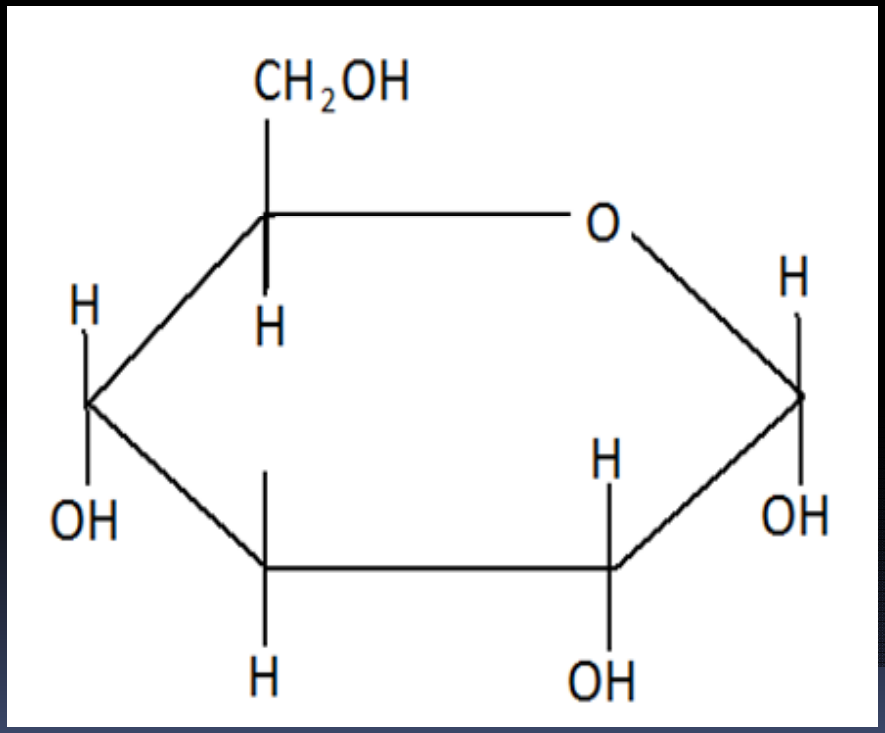
- Less then 1%of CHO exist in an open chain form.
- Predominantly found in **ring form**.
- involving reaction of C-5 OH group with the C-1 aldehyde group or C-2 of keto group.

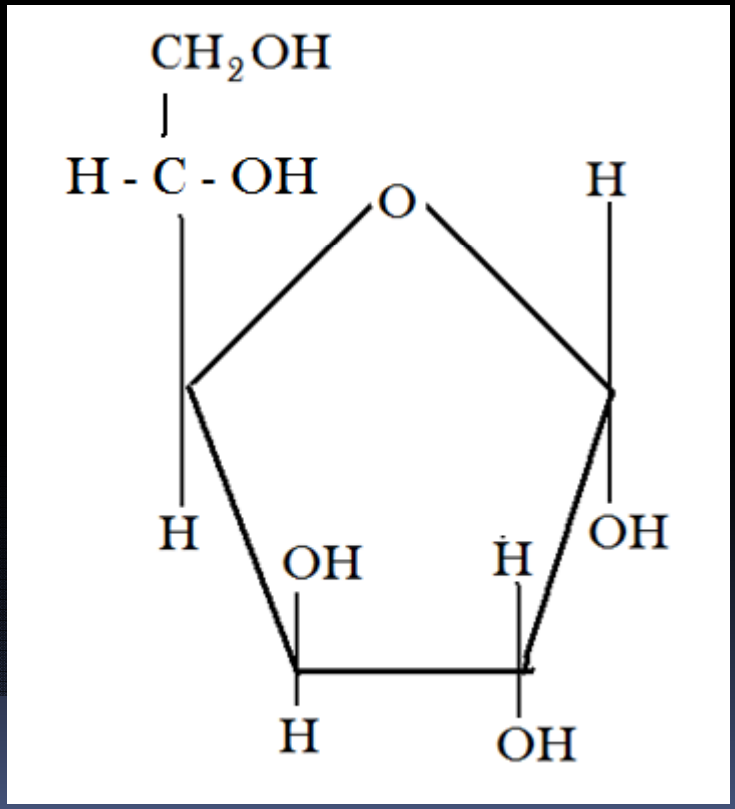
- Six membered ring structures are called **Pyranoses .**

- five membered ring structures are called **Furanoses** .

PYRANOSE-FURANOSE ISOMERISM

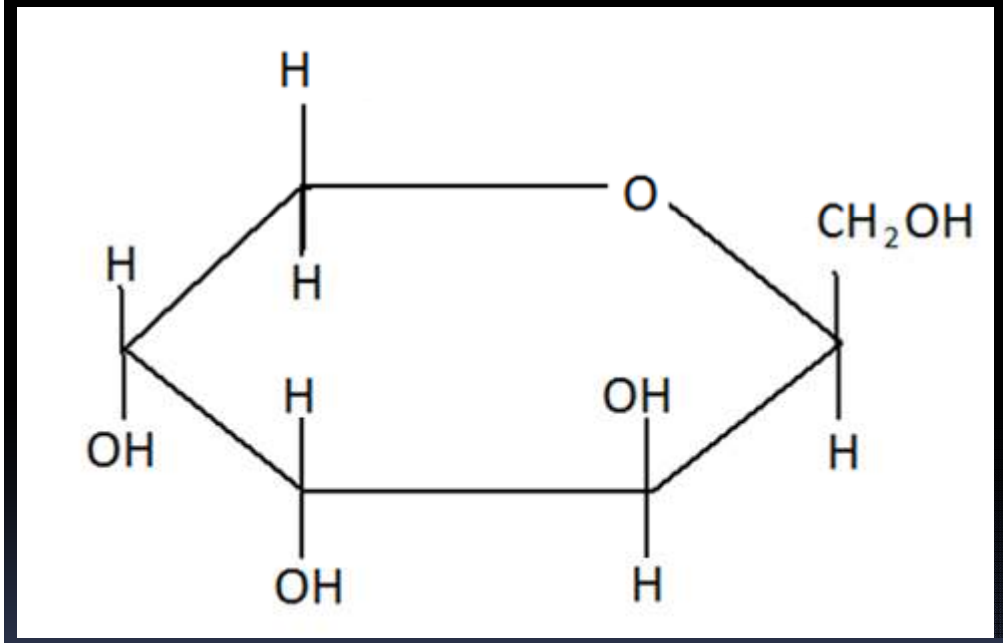
α-D-GLUCOPYRANOSE & α-D-GLUCOFURANOSE

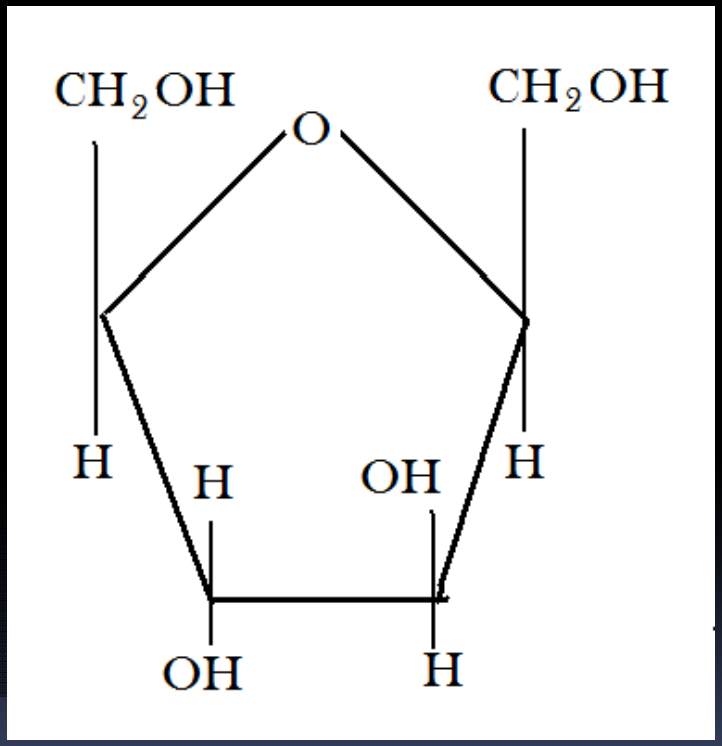


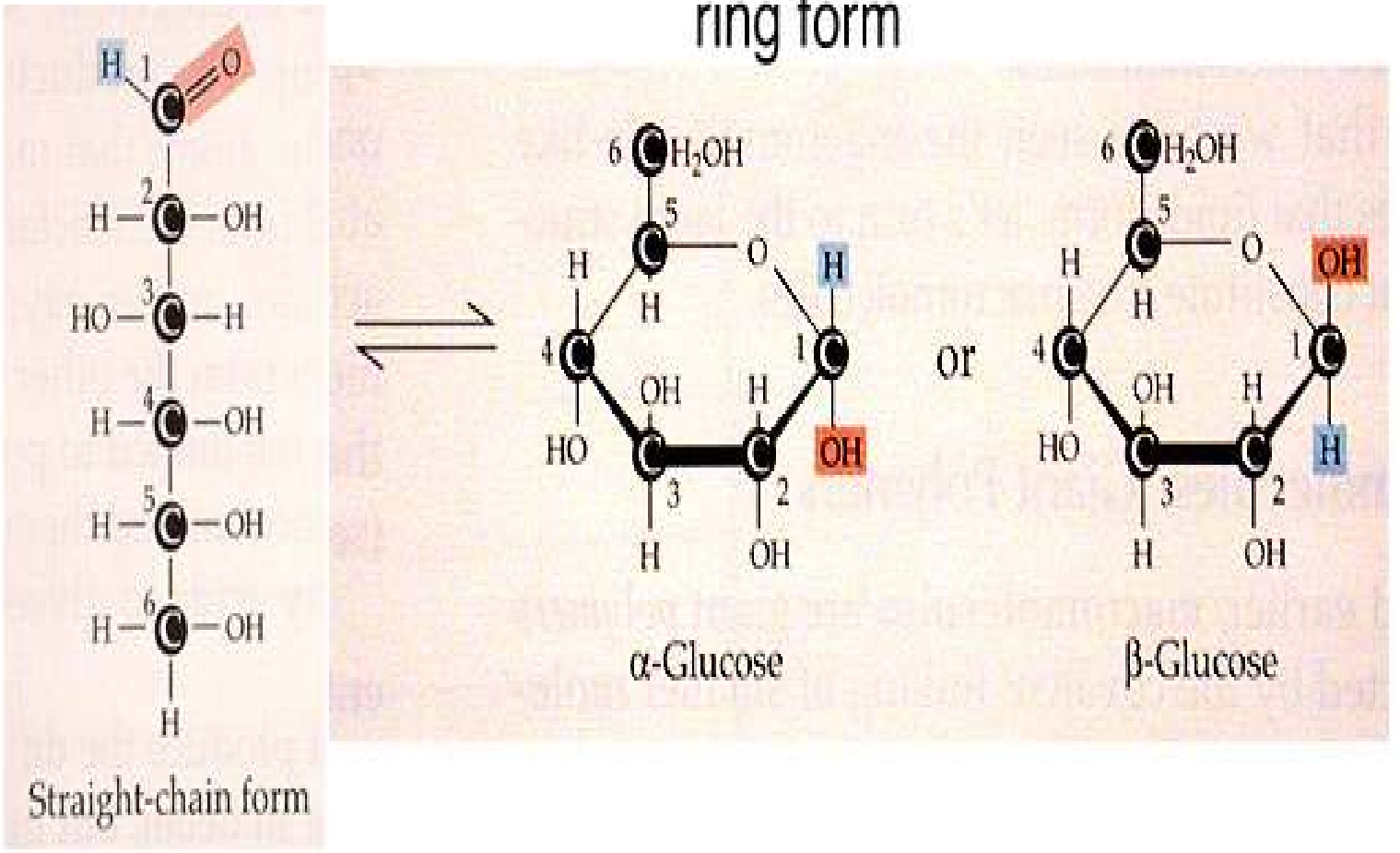


PYRANOSE-FURANOSE ISOMERISM

α-D-FRUCTOPYRANOSE & α-D-FRUCTOFURANOSE






ring form
Straight-chain form
α-Glucose
or
β-Glucose

Anomeric carbon

- The carbonyl carbon after cyclization becomes the anomeric carbon.
- This creates **α** and **β** configuration.
- In **α** configuration the OH is on the same of the ring in fischer projection. In Haworths it is on the trans side of CH_2OH.

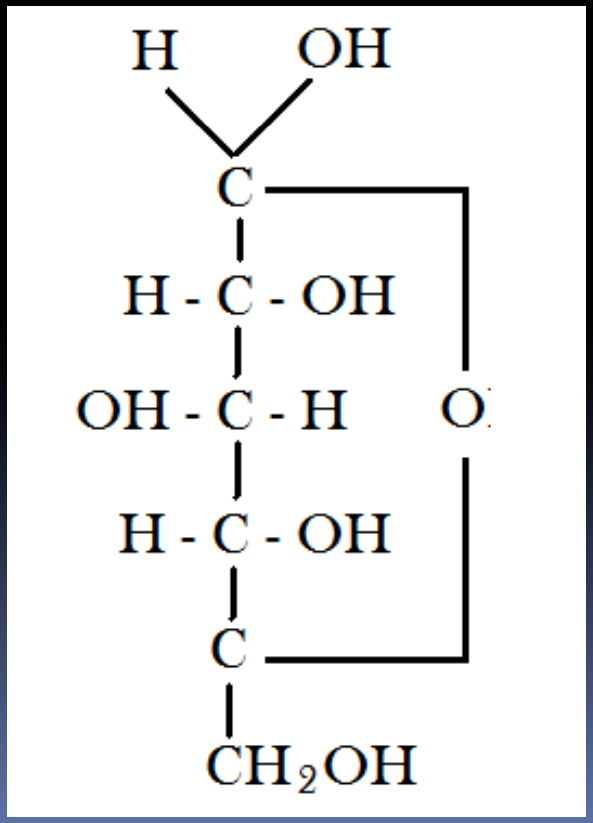
RING STRUCTURE OF GLUCOSE

HEMI-ACETAL OR HEMI-KETAL LINKAGE

α-D-GLUCOSE.

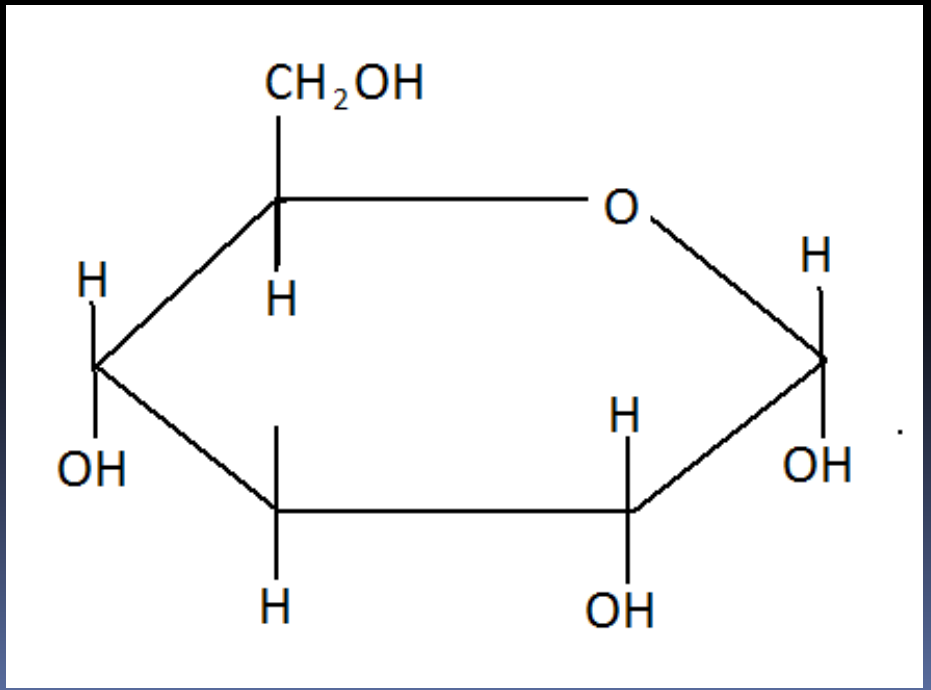
CLOSED RING STRUCTURE

(FISCHER FORMULA)



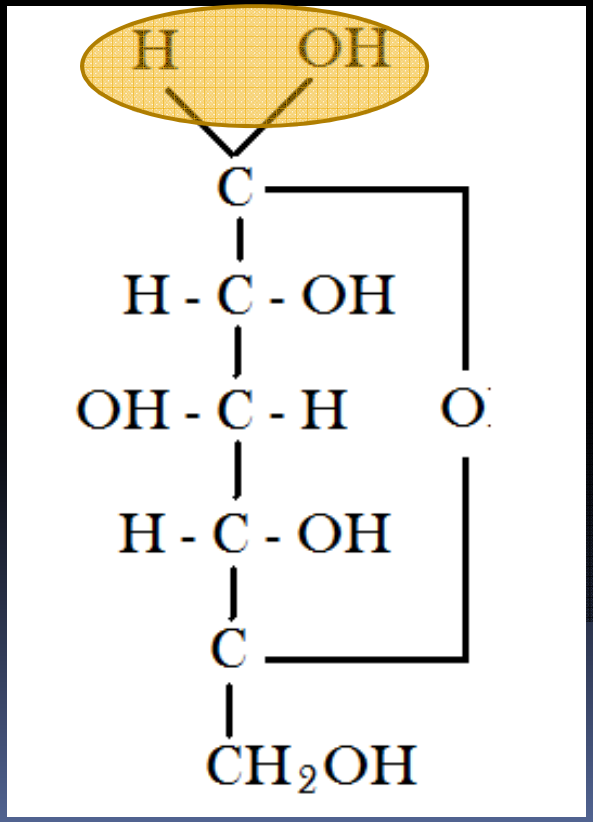
PYRANOSE RING STRUCTURE (HAWORTH FORMULA)

GLUCOSE CAN HAVE PYRAN OR FURAN RING BUT PYRAN RING IS MORE PREDOMINANT.

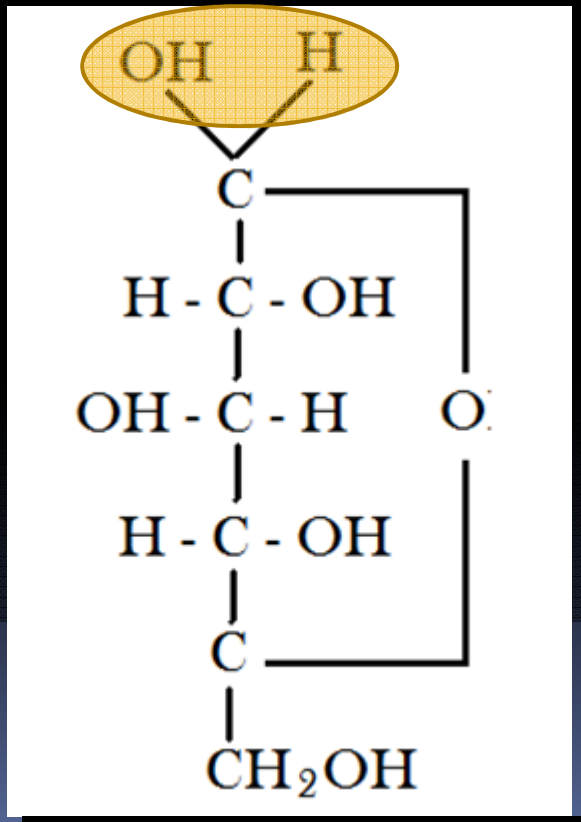


ANOMERS

POSITION OF -OH GROUP ON ANOMERIC CARBON IN RELATION TO PRIMARY ALCOHOL GROUP



β-D-GLUCOPYRANOSE

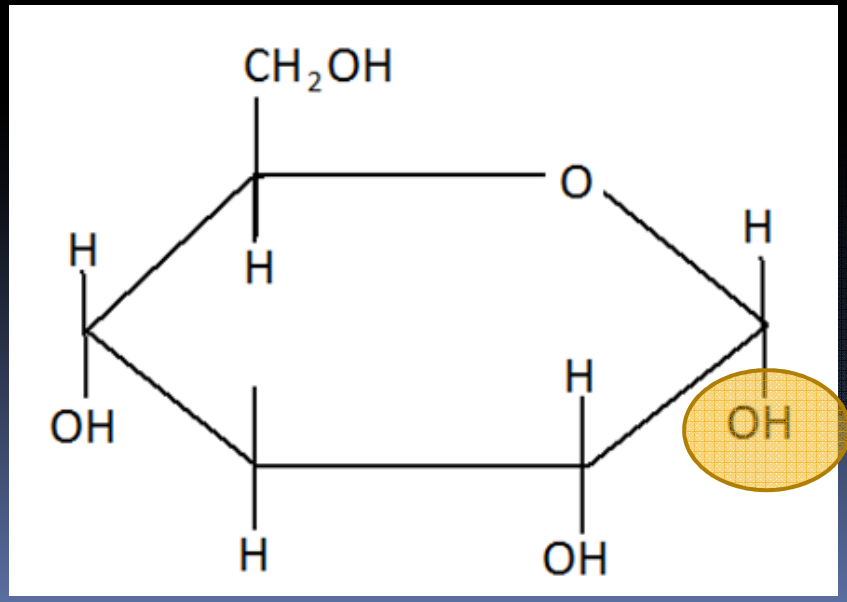


α-D-GLUCOPYRANOSE

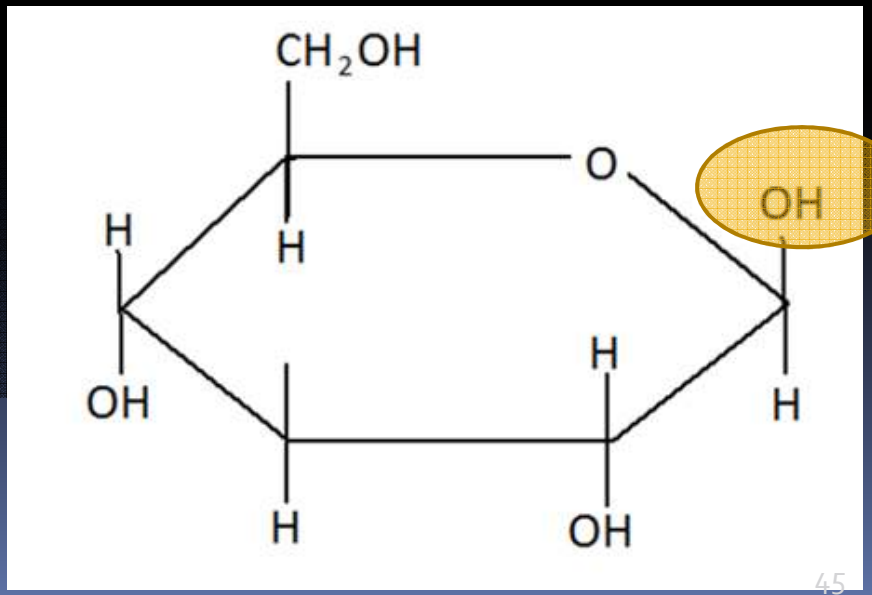
ANOMERS

SHOWN IN PYRANOSE RING STRUCTURE

α-D-GLUCOPYRANOSE



β-D-GLUCOPYRANOSE



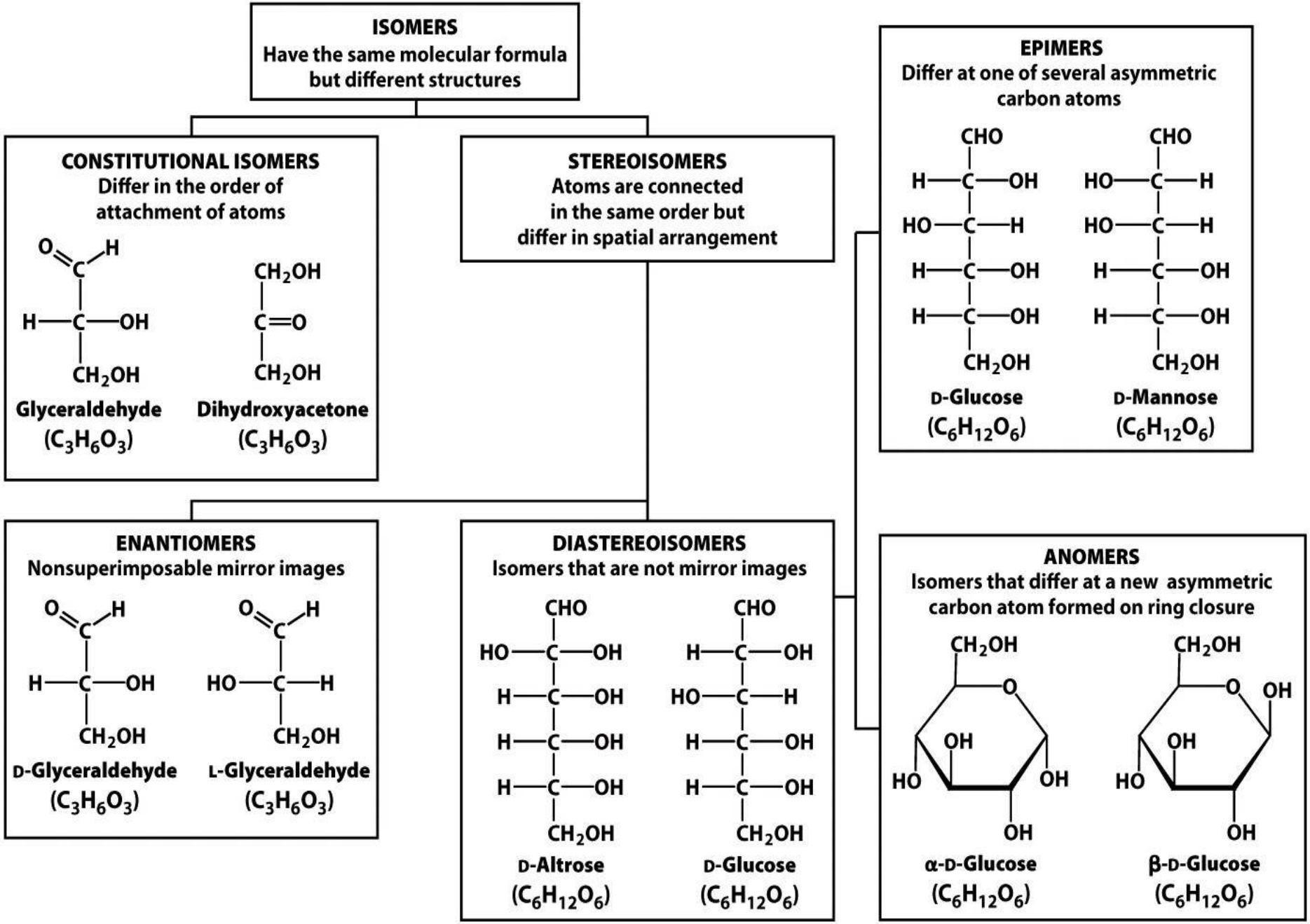


Figure 9.1
Biochemistry: A Short Course, **First Edition**

SUGARS EXHIBIT VARIOUS FORMS OF ISOMERISM

- Two broad types:

  STEREO-ISOMERISM & OPTICAL ISOMERISM

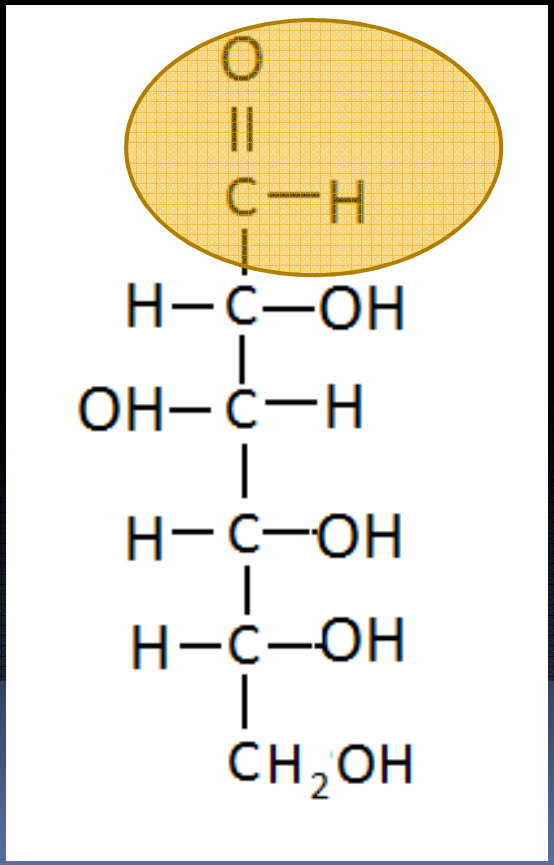
- Stereo-isomers have same structural formula but different spatial configuration.
- No. of possible isomers of a compound is 2^n where 'n' is the no. of asymmetric carbon atoms.

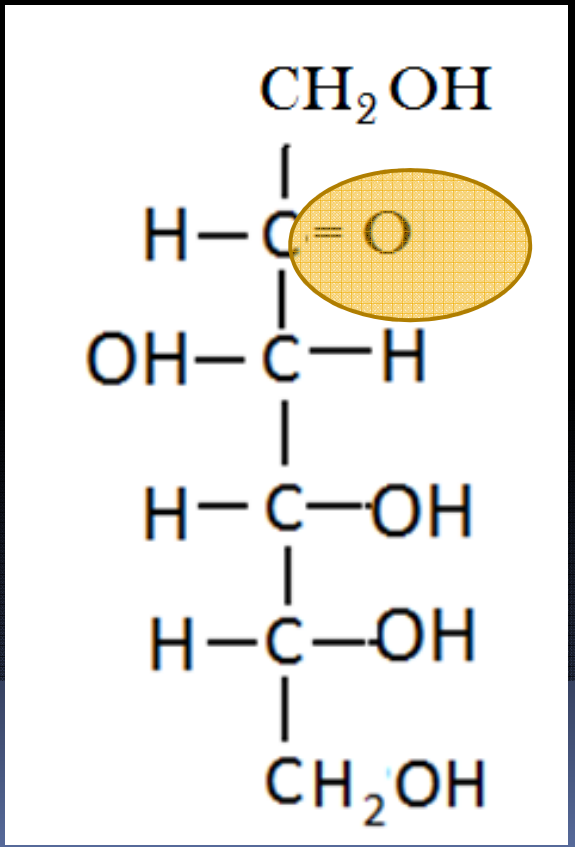
STEREO-ISOMERISM

1. D-L ISOMERISM.
2. PYRANOSE – FURANOSE ISOMERISM.
3. ANOMERS .
4. EPIMERS.
5. ALDOSE- KETOSE ISOMERISM.

ALDOSE- KETOSE ISOMERISM

GLUCOSE & FRUCTOSE





OPTICAL - ISOMERISM

- BASED ON ROTATION OF PLANE POLARISED LIGHT WHEN IT PASSES THROUGH A SOLUTION OF A CARBOHYDRATE.
- CALLED 'd' OR (+) WHEN plane of light TURNS RIGHT or clockwise (dextrorotatory)
- CALLED 'l' OR (-) WHEN plane of light TURNS LEFT or counter-clockwise (levorotatory)

OPTICAL - ISOMERISM

- Glucose is dextrorotatory while fructose is levorotatory
- Glucose also called dextrose & fructose also called laevulose because of optical activity.
- When equal amounts of d & l isomers are present, activity of each isomer will cancel one another.
- Such a mixture is called racemic mixture.


Thank You!