Carbohydrates

☆ Consist of 1 or more sugars ⇝ Carbonyl + poly Hydroxyl

☆ They can be classified according to:

1) Number of sugars

Mono, di, oligo, polysaccharide

2) Position of carbonyl

Aldose, Ketose

↳ peripheral ↳ within the chain

3) Number of Carbons

Triose, Tetrose, pentose, Hexose, ...

↳ 3C ⇝ the simplest

	Aldose	Ketose
Triose	glyceraldehide	dihydroxyacetone
Pentose	Ribose, Xylose	Xylulose
Hexose	Mannose 2, 3	Fructose (sweatest)
	Galactose 3, 4	Sorbose
	Glucose[3]	

Essintial energy source, blood sugar

☆ Sugars can exist in both linear or ring forms (more common)

Rings ⇝ have ether, they are hemiketals or hemiacetal

↳ Furanose ⇝ 5 membered Ring, Pyronose ⇝ 6 membered ring

Isomerism

Isomers ⇝ same molecular formula but diffirant structure and arrangement

Number of isomer = 2^{n} ↳ number of chiral C

Chiral ⇝ 4 differant groups, No double bonds (The first, last carbons and Carbonyl ⇝ Achiral)

Constitusional isomers: differant C=O position (aldose, ketose)

Stereoisomers (all of them are non-superimposable): diffirant 3D oreintation (Right, left) ↳ down, up

Enantiomers ⇝ all chiral carbons are rotated

- ↳ Mirror image
- ↳ Penultimat (last) C: Right ⇝ D, Left ⇝ L
- ↳ Mammalians use only D-isomers

Diastereomers ⇝ 1 or more chiral C rotated (not all)

- ↳ Not mirror image
- ↳ Epimer ⇝ only 1 chiral C is rotated

Anomers ⇝ differant oreintation on the anomeric C

up ⇝ β, down ⇝ α

C of carbonyl ↳ C1 ⇝ aldose, C2 ⇝ ketose

Modified sugars

1) Oxidation (sugar acids)

↳ of anomeric, last C ⇝ form COOH

Weak agent ⇝ anomeric ⇝ -onic acid

Strong agent ⇝ both ⇝ -aric acid

Last C ⇝ Require enzymes ⇝ -uronic acid

All monosaccharides can be oxidized

- ↳ Ketose ⇝ converted into enediol (indirect)
- ↳ Aldose ⇝ Converted into lactone (indirect)

☆ When Vitamin C is oxidized ⇝ loses its activity

Causes Scurvy

☆ Benedict's test

Cu^{+2}, NaOH ⇝ Cu_2O precipitate

detect reducing sugars

☆ Tollen's test

$Ag(NH_3)_2^+$

detect cyclic Reducing sugars

☆ Blood glucose test

Glucose oxidase

2) Reduction

- Sugar Alcohol
  - anomeric C.
  - itol ⇝ glycerol (glyceraldehyde, Dihydroxyacetone)
    - Sorbitol (glucose, fructose, sorbose)
    - Mannitol (mannose, fructose)
    - Xylitol (xylose, Xylulose)
- Deoxy sugars
  - any OH
  - 2-deoxyribose ⇝ DNA
  - Fucose = 6-deoxy galactose

3) Sugar esters

Phosphorylation (add Ⓟ) of any C

4) Amino sugars

add NH_2 to any C except anomeric

☆ It name end -amine

☆ usually followed by acetylation

5) Glycosides

add any group to anomeric

⇝ O-glycoside

⇝ N-glycoside ⇝ Nucleotide

⇝ C-glycoside ⇝ Disaccharides

☆ Glycoside can't be converted from Ring to linear

Disaccharides

- 2 sugars — glycosidic bond
- formed by glycosyl transferase

Sucrose

Hetero

α-Glucose + β-fructose

1-2

Non-Reducing

Sucralose ⇝ artificial sweetner

~~OH~~ → Cl

Lactose

β-Galactose + α-Glucose

1-4

Reducing

Lactose = Milk sugar

Lactulose ⇝ isomer of lactose

- ↑ water absorption from colon
- ↑ Gut bacteria
- ↑ short FAs and remove toxic ammonia
- modulate immunity

Maltose

Homo

α-Glucose + α-Glucose

1-4

Reducing

Lactose intolerance ⇝ Lactase deficiency ⇝ Cause bloating and diarrhea

Galactosemia ⇝ missed galactose metabolizing enzyme ⇝ swell of brain cells ⇝ Retardation and Cataract

Oligosaccharides

Hetero

Raffinose ⇝ α-Galactose + α-Glucose + β-fructose = α-Galactose + Sucrose

- we can't break it ⇝ we lack α-galactosidase

Polysaccharides

1) Storage
- Glycogen ⇝ animal ⇝ α 1-4 (1-6) (Most branched; on Branch)
- Starch ⇝ plants ⇝ α 1-4 (1-6)
- Dextran ⇝ Yeast and bacteria ⇝ α 1-6 (1-2, 1-3, 1-4)

Homo → α-Glucose → Branched → Except amylose

Starch has 2 types: Amylose (unbranched), amylopectin (branched)

Branching importance ⇝ ↑ water soluble + ↑ access to glucose = ↑ effecient energy consumption

2) Structural:

Chitin	Cellulose	Pectin
N-acety β-glucose	β-glucose	Hetero (α-Galactoruinic acid)
Animals exoskeleton	Plant	Plant
β 1-4 unbranched	β 1-4 unbranched	β 1-4 unbranched

We Can Break only α bonds (weaker), but β-bond (stronger, rigid) are not broken in our bodies ⇝ be don't have β-glycosidase

3) GAG (Glycosaminoglycans)
- Repeated units & Hetero disaccharides
  - amino sugar ⇝ ⊕
  - Sugar with sulfate or carboxyl ⇝ ⊖ (Repulsion)
- Hyaluronate ⇝ Shock absorbance, lubricant
  - Synovial fluid, Vitreous humor, loose Connective
- Chondrotin sulfate ⇝ Most abundant GAG ⇝ Cartilage
- Heparin ⇝ anti-coagulant

Proteoglycans & Peptidoglycans

GAGs → NAM, NAG (β(1-4))

→ protein, peptide

→ Lubricant, cell adhesion, structural Component, stimulate proliferation

Glycoprotein

O-linked ⇝ Serine, Threonine, hydroxylysine

N-Linked ⇝ Asparagine

Functions: protein folding, targeting, ↑ half-life

Signaling and communication

Reducing sugars:

Mono ⇝ all Reducing, Poly ⇝ all non-Reducing

Di ⇝ Sucrose (Non), Lactose and Maltose (Reducing)

Molecular formula: $(CH_2O)_n$ − # H_2O