Organic Molecules

Functional Groups

alcohols, ethers, aldehydes, ketones

Carbohydrates / Saccharides / Sugars

Dr. Ron Rusay

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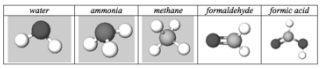
Sugars (Carbohydrates)

Common Functional Groups

Name	General Formula
Alcohols	R−OH
Ethers	R−O−R′
Amines	$R-NH_2$
Carboxylic Acids	R-C(=O)-OH



Sugars (Carbohydrates)

Common Functional Groups

Name	General Formula
Aldehydes	R-C(=O)-H
Ketones	R-C(=O)-R'
Carboxylic Acids	R-C(=O)-OH
Esters	R-C(=O)-OR'
Amides	R-C(=O)-N(R')(R")

Carbohydrate ("-ose") Formation

Photosynthesis

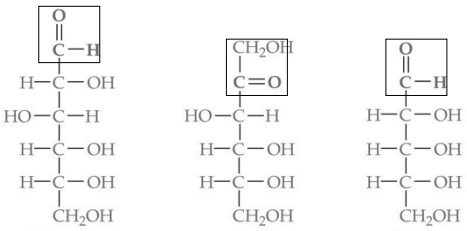
light + chlorophyll + two greenhouse gases, which provide sugars ("carbs") + oxygen

$$n\,CO_2 + n\,H_2O \longrightarrow C_n(H_2O)_n + n\,O_2$$

- Empirical formula = CH_2O
- Monosaccharides (simple sugars)
- C_5 : pent-oses – *rib-ose*
- C_6 : hex-oses – *fruct-ose, gluc-ose*

Can be either an ald-ose (aldehyde + alcohols) or ket-ose (ketone + alcohols)

Aldose

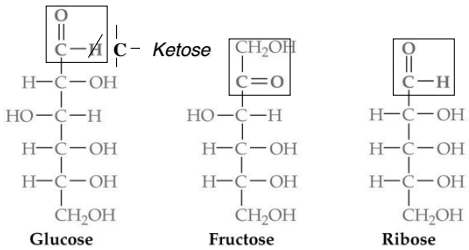


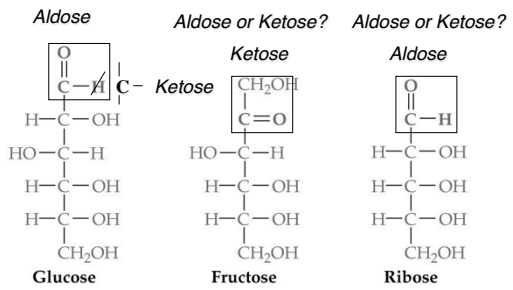
Aldose

Aldose or Ketose?

Aldose or Ketose?

Ketose

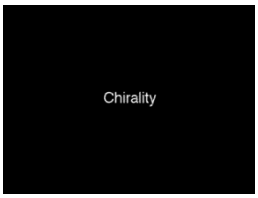




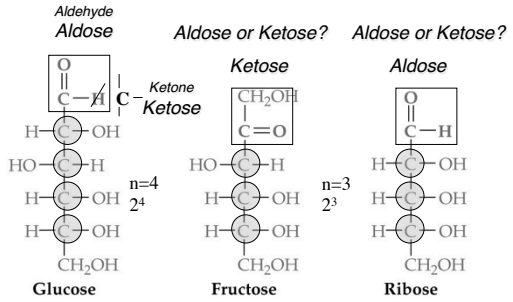
There are 2^n possible stereoisomers, where n = the number of chiral atoms. Glucose? Fructose? Ribose?

Chirality & Carbon Atoms

http://chemconnections.org/general/movies/Chirality.mov

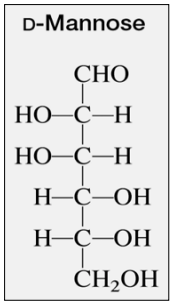


Each carbon atom with four different substituents is chiral. Sugars have many chiral carbon atoms and 2^n possible stereoisomers.



There are 2^n possible stereoisomers, where n = the number of chiral atoms (alcohols). Glucose? Fructose? Ribose?

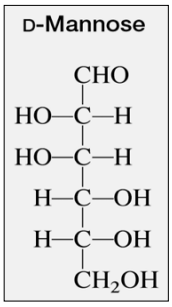
QUESTION



The monosaccharide mannose has how many chiral carbon centers?

A. None
B. Two
C. Four
D. Six

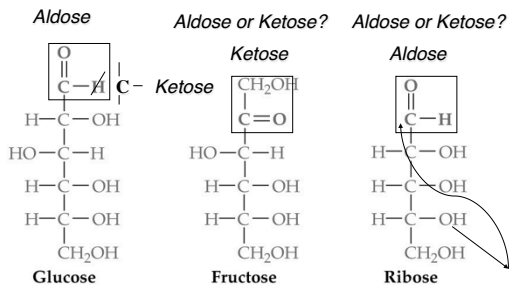
QUESTION



The monosaccharide mannose has how many stereoisomers?

A. four
B. six
C. eight
D. sixteen
E. thirty two

Sugars, Saccharides
Carbohydrates

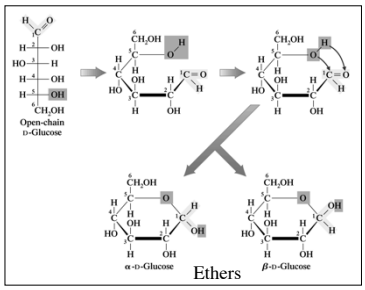


There are 2^n possible stereoisomers, where n = the number of chiral atoms. Glucose? 16 Fructose? 8 Ribose? 8

And +1: Cyclization

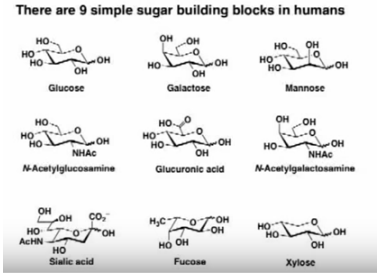
Plus the cyclized forms of each of the sixteen, which adds a chiral carbon, D-Glucose for example:

D-glucose can cyclize through an intramolecular reaction



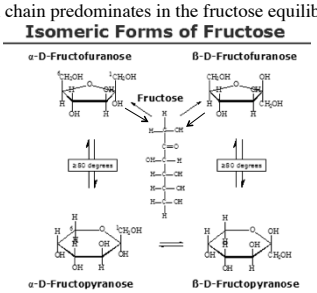
Ethers

Simple Sugars & Glycosides in Humans



Sugar Equilibrium

The open chain predominates in the fructose equilibrium mixture



Amount of each form varies in the equilibrium mixture of each different sugar.

Different Raw & Refined Sugars (Carbohydrates)

Rum

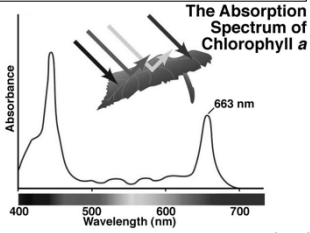
Historical Significance & the 1791 British Sugar Boycott

British Abolition of the Slave Trade Act in 1807

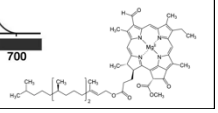
Photosynthesis

Energy Capture → Carbohydrates (Sugars)

$$n\ CO_2(g) + n\ H_2O(g) + \text{energy} \xrightarrow{\text{Chlorophyll a}} \textbf{CARBOHYDRATES}$$

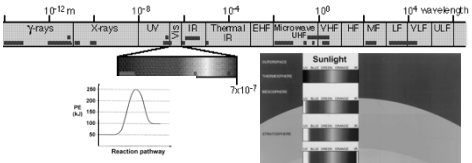


a complex collection of enzymes with:



Artificially possible?

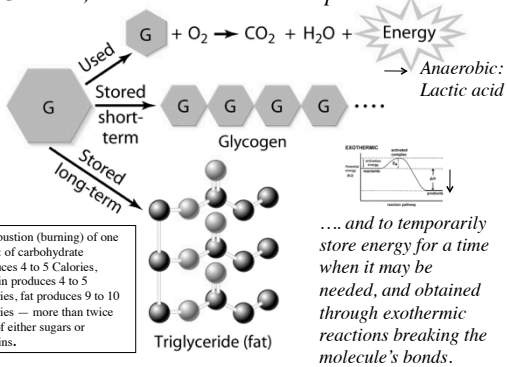
Plants absorb energy; i.e., visible light.



In turn, plants produce molecules that store the sun's energy through endothermic reactions that form carbohydrates such as glucose.

http://chemistry.beloit.edu/Stars/EMSpectrum/index.html

Glucose, which animals burn to produce:

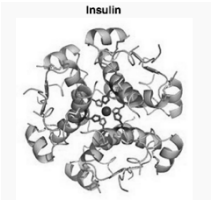


→ *Anaerobic: Lactic acid*

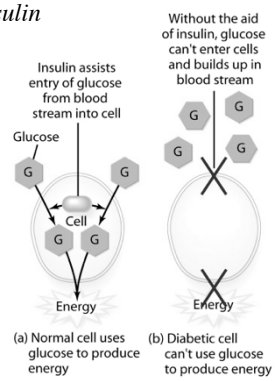
Combustion (burning) of one gram: of carbohydrate produces 4 to 5 Calories, protein produces 4 to 5 Calories, fat produces 9 to 10 Calories — more than twice that of either sugars or proteins.

…. and to temporarily store energy for a time when it may be needed, and obtained through exothermic reactions breaking the molecule's bonds.

Sugars/Glucose & Insulin



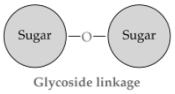
Zinc is @ the center



Carbohydrates

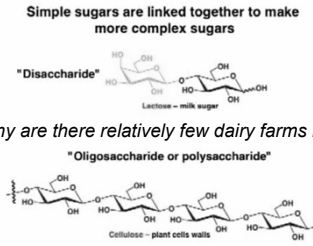
Prof. Carolyn Bertozzi: https://www.youtube.com/watch?v=VBwNMR3C0Ys&feature=PlayList&p=10F61E434B646DE1&index=1%20

- Disaccharides
  - (2 cyclic monosaccharides joined by a "glycoside" linkage α-alpha or β-beta [ether]
- e.g. (glucose + fructose) ⟶ sucrose



- Polysaccharides
  - (many linked monosaccharide units)
- e.g. starch (α-alpha), cellulose (β-beta)

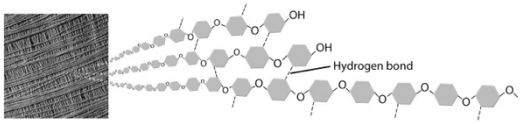
Disaccharide & Polysaccharide



Why are there relatively few dairy farms in Asia?

Do you eat starch? ..easily digested α-linkages
…tree bark (fiber)? .. Non digestible β-linkages
Do they smell and taste appetizing?

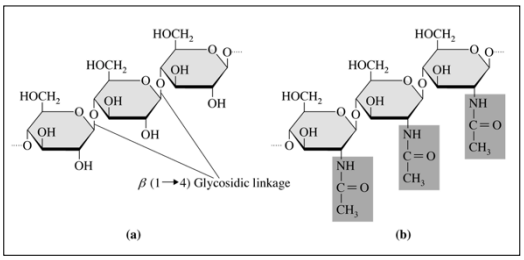
- *Humans cannot digest cellulose, only alpha (α)-sugars, not (β)- beta.*
- *Goats and termites can digest (β)- beta sugars using enzymes humans do not have*



(a) Cellulose fibrils in a plant cell wall

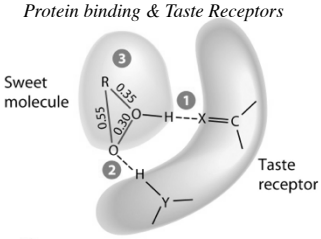
(b) Structure of cellulose in a fibril

The structures of cellulose (a) and exoskeleton, chitin (b). In both substances, all glycosidic linkage are of the β-(1, 4) type.



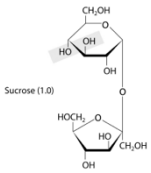
Do you eat fried grasshoppers? … the shells of shrimp?

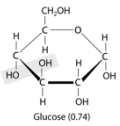
Protein binding & Taste Receptors



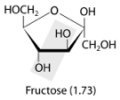
- *Sweet*
- *Sour*
- *Bitter*
- *Salty*
- *Umami*

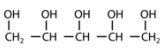
1. —H in OH group on sweet molecule forms hydrogen bond with X— on receptor.
2. O— on sweet molecule forms hydrogen bond with H— in HY group on receptor.
3. Hydrophobic area behind O— atoms on sweet molecule.

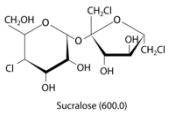




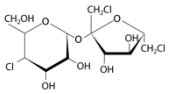
Sweetness factor = 1.0 *Sweetness factor = 0.74*



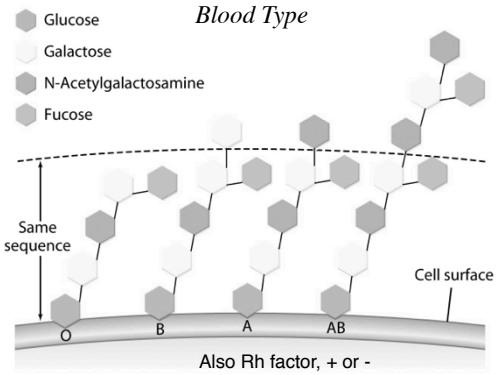




Relative Sweetness Scale - Sucrose = 1	
Compound	Rating
Saccharin	300 X
Cyclamate	30 X
Aspartame	180 X
Acesulfame	200 X
Sucralose	600 X



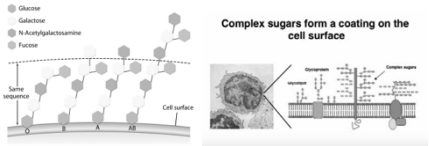
Blood Type



Also Rh factor, + or -

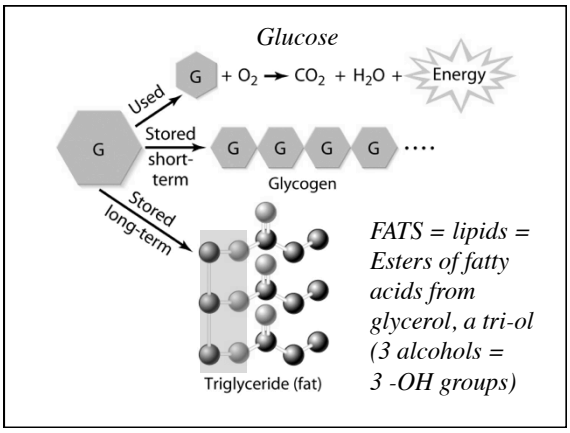
Blood Histocompatibility

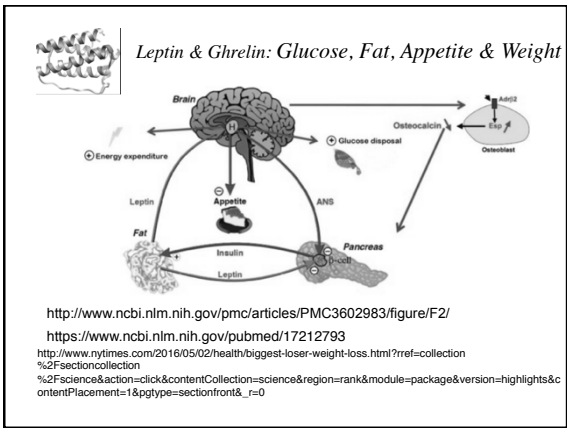
http://anthro.palomar.edu/blood/Rh_system.htm



Red blood cell compatibility table

Recipient	Donor								US	WORLD
	O−	O+	A−	A+	B−	B+	AB−	AB+		
O−	✓								6.6	4.5
O+	✓	✓							37	36
A−	✓		✓						6.4	3.5
A+	✓	✓	✓	✓					36	28
B−	✓				✓				1.5	1.5
B+	✓	✓			✓	✓			8.5	21
AB−	✓		✓		✓		✓		0.6	0.5
AB+	✓	✓	✓	✓	✓	✓	✓	✓	3.4	5


Glucose
G + O_2 → CO_2 + H_2O + Energy
Used
G
Stored
short-
term
G G G G ....
Glycogen
Stored
long-term
Triglyceride (fat)
FATS = lipids =
Esters of fatty
acids from
glycerol, a tri-ol
(3 alcohols =
3 -OH groups)


Leptin & Ghrelin: Glucose, Fat, Appetite & Weight
Brain
Osteocalcin
Adrb2
Esp
Osteoblast
Glucose disposal
Energy expenditure
Leptin
Appetite
ANS
Fat
Insulin
Pancreas
Leptin
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3602983/figure/F2/
https://www.ncbi.nlm.nih.gov/pubmed/17212793
http://www.nytimes.com/2016/05/02/health/biggest-loser-weight-loss.html?rref=collection
%2Fsectioncollection
%2Fscience&action=click&contentCollection=science&region=rank&module=package&version=highlights&c
ontentPlacement=1&pgtype=sectionfront&_r=0