

Advanced Cell Biology. Lecture 4

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Outline

Organic molecules

- Basics of organic chemistry

- Carbohydrates

Previous final question: the answer

Name one chemical element which is NOT biogenic

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Name one chemical element which is NOT biogenic
Heavy metals (like Au, Ag, Hg, Pb), radioactive elements (like U), inert gases (like He, Ne) and many others

Biogenic elements (again)

1 H 1																	He
Li	Be											5 B 11	6 C 12	7 N 14	8 O 16	9 F 19	Ne
11 Na 23	12 Mg 24											Al	14 Si 28	15 P 31	16 S 32	17 Cl 35	Ar
19 K 39	20 Ca 40	Sc	Ti	23 V 51	24 Cr 52	25 Mn 55	26 Fe 56	27 Co 59	28 Ni 59	29 Cu 64	30 Zn 65	Ga	Ge	As	34 Se 79	Br	Kr
Rb	Sr	Y	Zr	Nb	42 Mo 96	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	53 I 127	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Ha													

Hydrophobic “bonds”

- ▶ Inside water solutions, hydrophobic (non-solvable) molecules often united in groups
- ▶ This process is often called “hydrophobic” bonds

Carbon and carbon skeleton

- ▶ Carbon atom has a small size and 4 electrons in the outer layer
- ▶ Consequently, it can form 4 bonds per atom, double and triple bonds, and may even form long chains of same element
- ▶ Other elements with similar features: silicon (same Group IV!), nitrogen, sulfur

Basic classes of organic molecules

- ▶ Hydrocarbons with single, double and triple bonds: C_nH_m
- ▶ Aromatic hydrocarbons (arenes): benzene etc.
- ▶ Alcohols and phenols: $R-OH$
- ▶ Ethers: $R-O-R$
- ▶ Aldehydes: $R-CHO$
- ▶ Ketones: $R-CO-R$
- ▶ Carboxylic acids: $R-COOH$
- ▶ Amines: $R-NH_2$

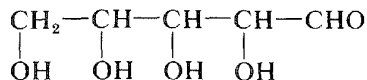
Basic groups of biochemical compounds

- ▶ Mono-, disaccharides (sugars) and polysaccharides: alcohols + ketons / aldehydes
- ▶ Fatty acids and lipids: hydrocarbons + carboxylic acids
- ▶ Amino acids and proteins: amines + carboxylic acids
- ▶ Nucleotides and nucleic acids: sugars + amines + phosphorous acid

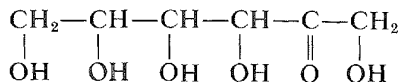
Overview of carbohydrates

- ▶ Approximate formula is $C_n(H_2O)_m$, but this is only approximation, the real structure has nothing water-related
- ▶ Chemically, basic carbohydrates (monosaccharides) are **keto- or aldo- polyalcohols** (poly- starts from 3)
- ▶ Polymeric carbohydrates (polysaccharides) are combination of multiple identical monosaccharides, dimeric (disaccharides) contain two monosaccharides

Aldoses and ketoses



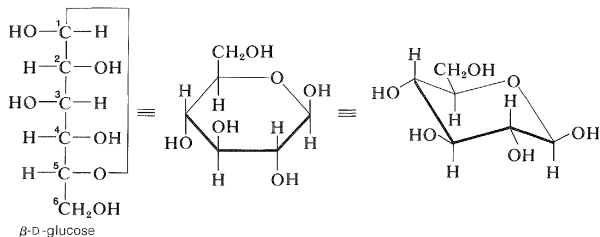
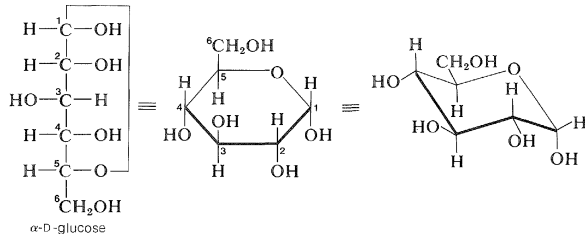
aldopentose



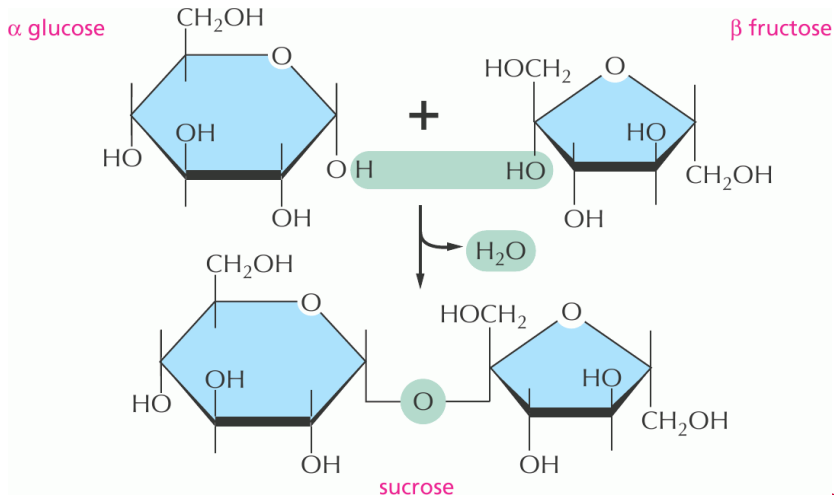
ketohexose

Features of carbohydrates

- ▶ Monosaccharides could form cyclic structures (rings)
- ▶ They have multiple asymmetric carbons, therefore multiple 3D isomers exist
- ▶ Moreover, ring may form in two different ways, so there are two additional isomers (α - and β -)
- ▶ Reaction of condensation unites monosaccharides in di- and polysaccharides
- ▶ When uniting, α - and β - monosaccharides can form different kinds of links

α - and β - glucose

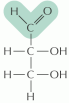
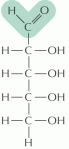
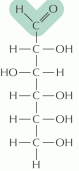
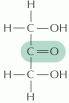
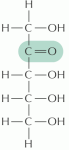
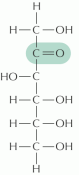
Reaction of condensation



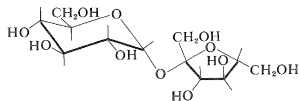
Most important mono-, di and trisaccharides

- ▶ Pentoses $C_5H_{10}O_5$: ribose, ribulose, xylose (wood sugar)
- ▶ Hexoses $C_6H_{10}O_6$: fructose (with five carbons in the ring), glucose and its isomers mannose and galactose (brain sugar)
- ▶ Disaccharides $C_{12}H_{20}O_{12}$: sucrose (cane/beet sugar, glucose + fructose); lactose (milk sugar, glucose + galactose); maltose (malt sugar, glucose \times 2)
- ▶ Trisaccharides $C_{18}H_{30}O_{18}$: raffinose (product of bacterial degrading of polysaccharides)

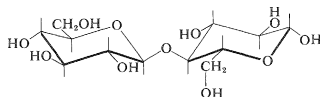
Monosaccharides

	3-carbon (TRIOSES)	5-carbon (PENTOSES)	6-carbon (HEXOSES)
ALDOSES	 <p>glyceraldehyde</p>	 <p>ribose</p>	 <p>glucose</p>
KETOSES	 <p>dihydroxyacetone</p>	 <p>ribulose</p>	 <p>fructose</p>

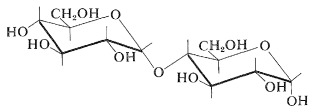
α - and β - disaccharides



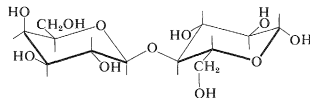
sucrose



cellobiose



maltose

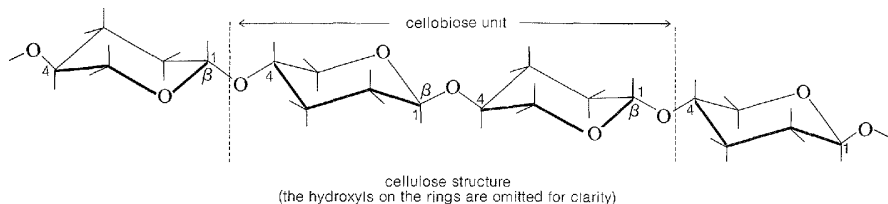


lactose

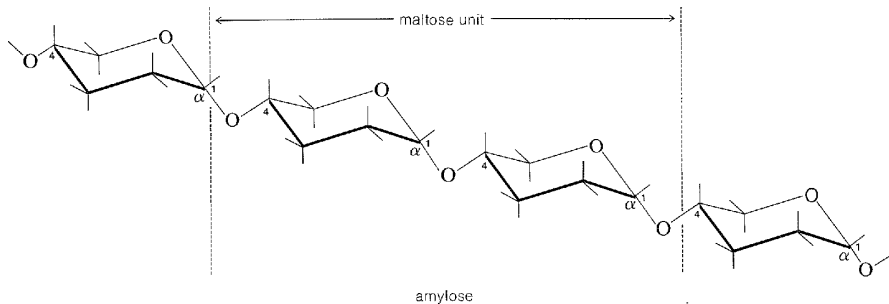
Most important polysaccharides

- ▶ Cellulose (unbranched poly- β -glucose)
- ▶ Amylose and amylopectin (unbranched and branched poly- α -glucose)
- ▶ Chitin (amino-poly- β -glucose)
- ▶ Hemicelluloses (poly-xyloses)

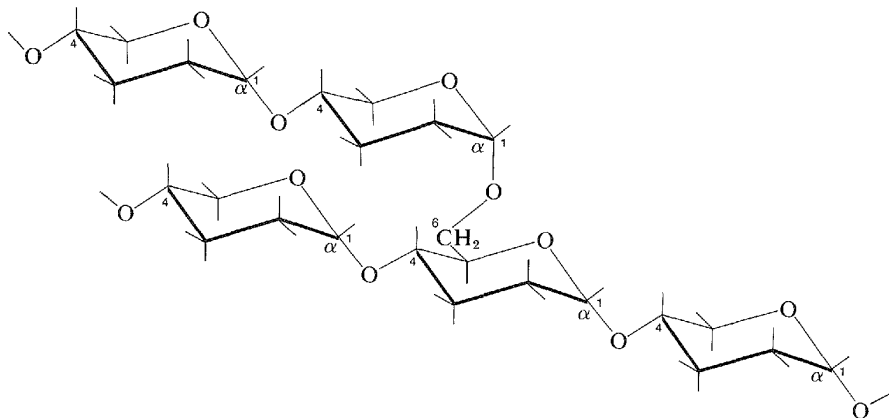
Cellulose



Amylose

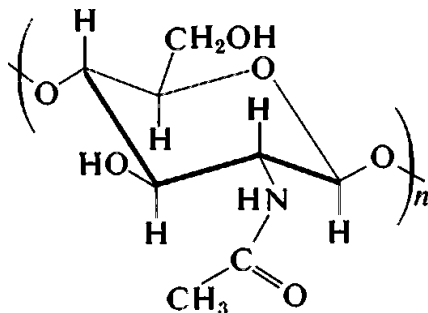


Amylopectin



amylopectin

Unit of chitin



chitin

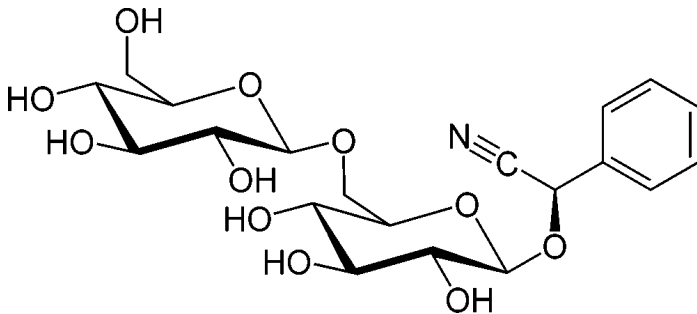
Starch and glycogen

- ▶ Starch: amylose + amylopectin*
- ▶ Glycogen: \approx pure amylopectin

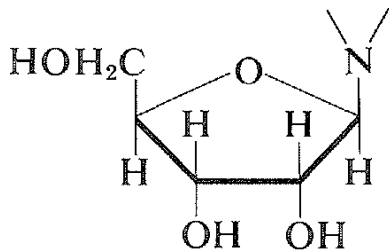
Some important molecules related to carbohydrates

- ▶ Glycosides: monosaccharides bonding through oxygen to various compounds, including amines (nucleosides)
- ▶ Pectins: polymers of galacturonic acid (derivative of glucose)
- ▶ Vitamin C (ascorbic acid): derivative of glucose with acidic properties

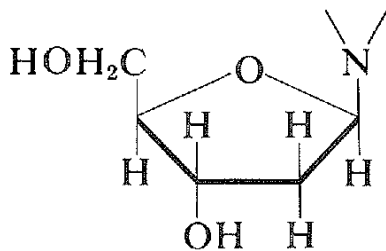
Amygdalin glycoside from almond



Nucleosids

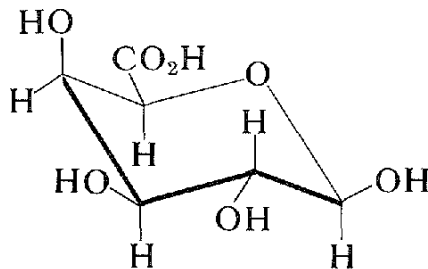


ribonucleoside
(partial structure)



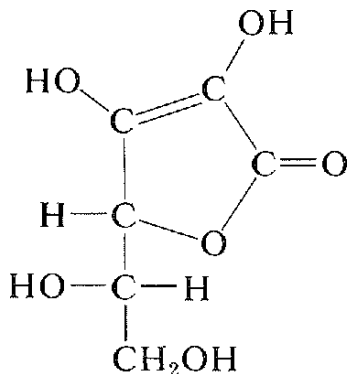
deoxyribonucleoside
(partial structure)

Galacturonic acid



β -D-galacturonic acid

Ascorbic acid (vitamin C)



L-ascorbic acid

Final question (2 points)

Final question (2 points)

What is the difference between α - and β - glucose?

Summary

- ▶ Carbohydrates are aldo- or keto- polyalcohols and their polymers
- ▶ Most of them are used as structural molecules or sources of energy

For Further Reading



A. Shipunov.

Advanced Cell Biology [Electronic resource].

2011—onwards.

Mode of access: [http:](http://)

[//ashipunov.info/shipunov/school/biol_250](http://ashipunov.info/shipunov/school/biol_250)



B. Alberts et al.

Essential Cell Biology. 3rd edition.

Garland Science, 2009.

Chapter 2: Molecules in cells, Panels 2-1, 2-3.