

Advanced Cell Biology. Lecture 4

Alexey Shipunov

Minot State University

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Outline

Questions and answers

Organic molecules

Carbohydrates

Fatty acids and lipids

Storage lipids: oils and fats

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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

- ▶ Inert gases: He, Ne, Kr, Xe
- ▶ Heavy metals: Au, Os, W, Pb, Hg
- ▶ Radioactive atoms: U, Pt

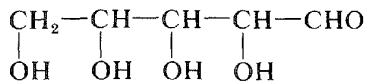
Organic molecules

Carbohydrates

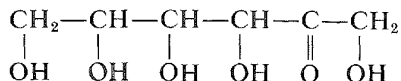
Overview of carbohydrates

- ▶ 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



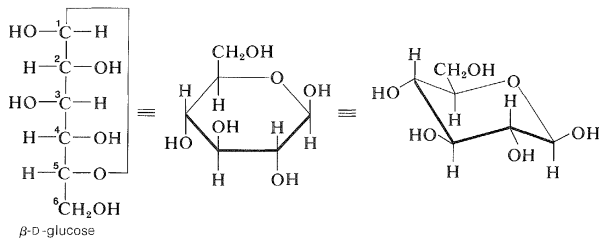
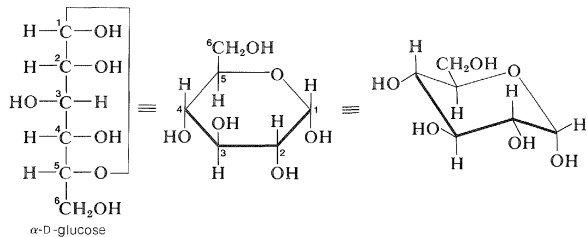
aldopentose



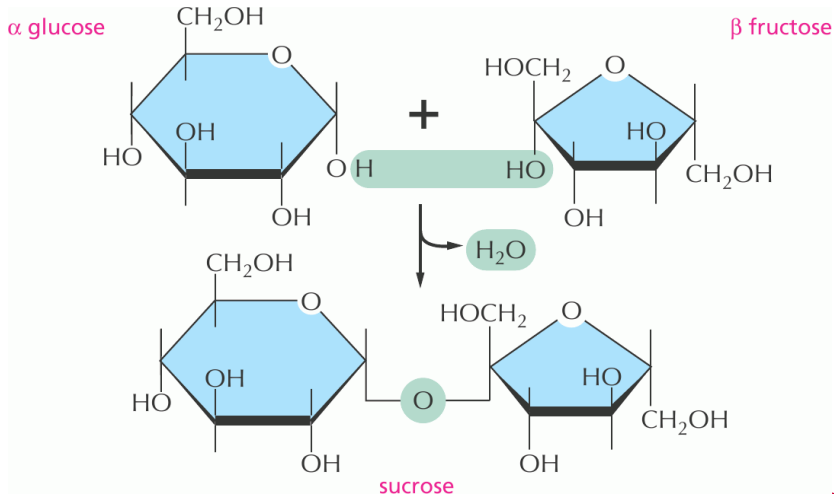
ketohehexose

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

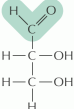
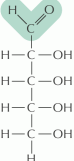
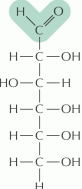
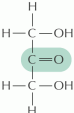
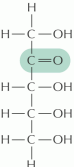
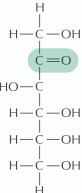
Reaction of condensation



Most important mono-, di and trisaccharides

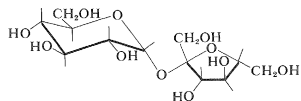
- ▶ Pentoses $C_5H_{10}O_5$: ribose, ribulose, xylose (wood sugar)
- ▶ Hexoses $C_6H_{10}O_6$: fructose (with five carbons in the ring), glucose and its isomers mannose and galactose (brain sugar)
- ▶ Disaccharides $C_{12}H_{20}O_{12}$: sucrose (cane/beet sugar, glucose + fructose); lactose (milk sugar, 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>

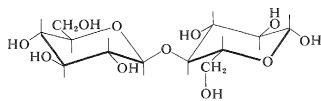
α - and β - disaccharides

α -

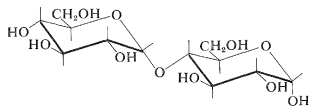


sucrose

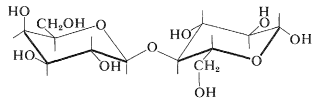
β -



cellobiose



maltose

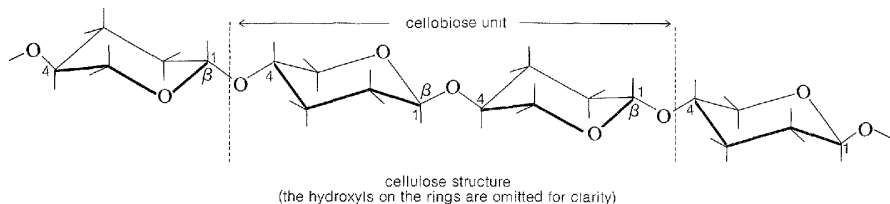


lactose

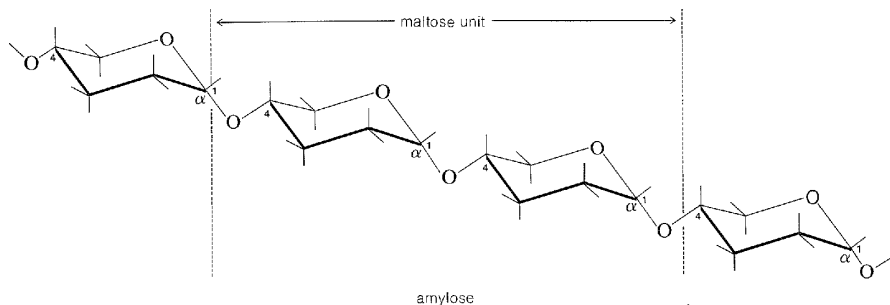
Most important polysaccharides

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

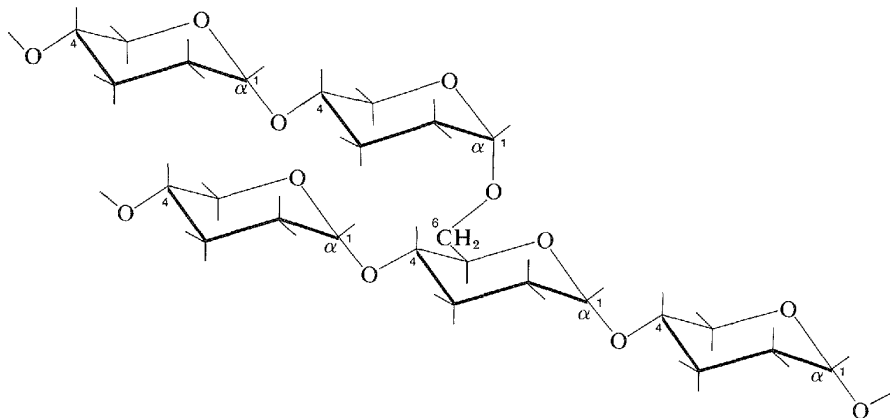
Cellulose



Amylose

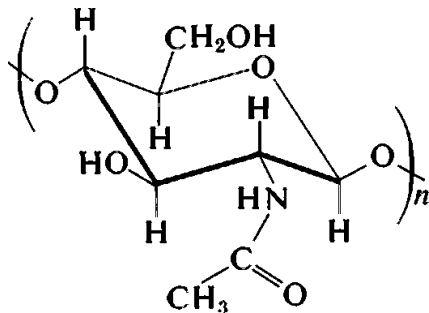


Amylopectin



amylopectin

Unit of chitin



chitin

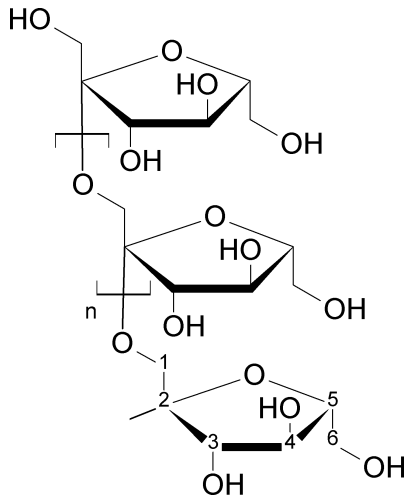
Starch and glycogen

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

Inulin

- ▶ Polymer of fructose (poly- β -fructose), often has a fibrous structure
- ▶ Typically, occurs in many plants of sunflower family (e.g., *chicory*, *dandelion* or *Jerusalem artichoke*)

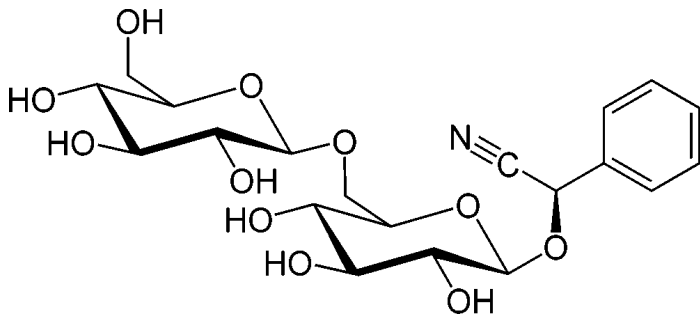
Inulin structure



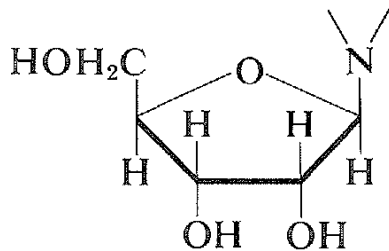
Some important molecules related to carbohydrates

- ▶ **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

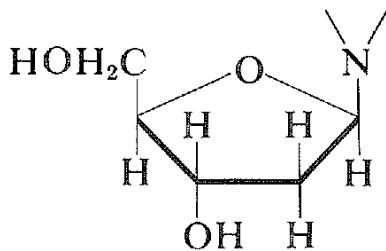
Amygdalin glycoside from almond



Nucleosids (glycosides)

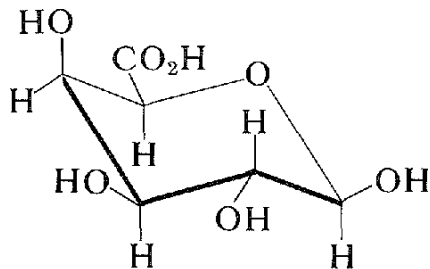


ribonucleoside
(partial structure)



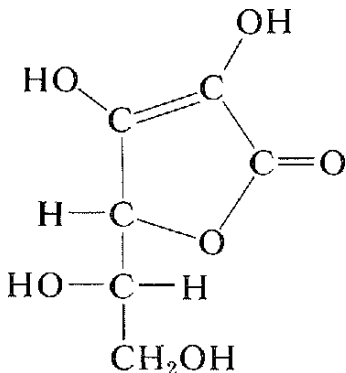
deoxyribonucleoside
(partial structure)

Galacturonic acid (pectins)



β -D-galacturonic acid

Ascorbic acid (vitamin C)



L-ascorbic acid

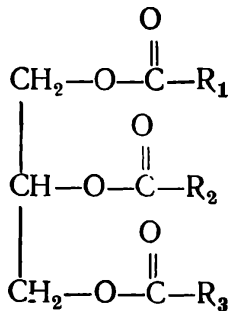
Fatty acids and lipids

Storage lipids: oils and fats

Storage lipids: oils and fats

- ▶ Fatty acids are massive ($C > 15$) hydrocarbon acids
- ▶ Oils and fats are esters (complex ethers) of glycerol and (often different) fatty acids: **triacylglycerols**, or **triglycerides**
- ▶ Stable, hydrophobic and high-energetic molecules

Triacylglycerols (triglycerides)



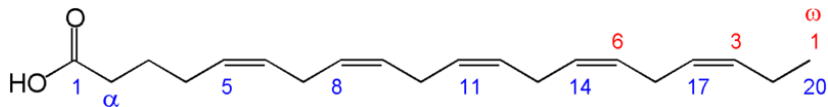
Diversity of fatty acids

- ▶ **Saturated:** contain only single bonds between carbons
- ▶ **Unsaturated:** contain also double bonds
- ▶ Unsaturated typically have bend chain, and much lower melting temperature
- ▶ Trans fats contain hydrogenated unsaturated oils

Examples of fatty acids

- ▶ *Palmitic acid* (C_{15}): from animal fats
- ▶ *Stearic acid* (C_{17}): from animal fats
- ▶ *Oleic acid* ($C_9 = C_8$): from olive
- ▶ *Linoleic acid* ($C_6 = C_3 = C_8$): from flax
- ▶ *Omega-3 fatty acids* (next slide) are considered now as important health factors

EPA, eicosapentaenoic acid (omega-3)

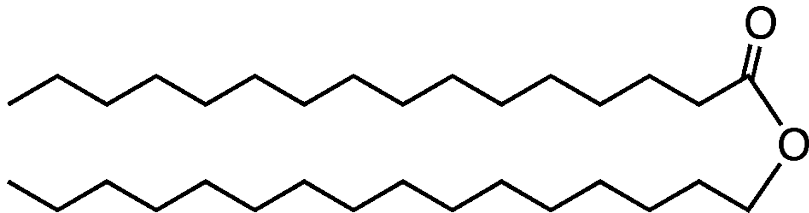


Probably, produces decrease in human depression

Waxes

- ▶ Waxes are esters of fatty acids and fatty alcohols (alcohols with long chains)
- ▶ Have high melting temperatures
- ▶ Use as structural and protective molecules, both in animals and plants

Cetyl palmitate wax

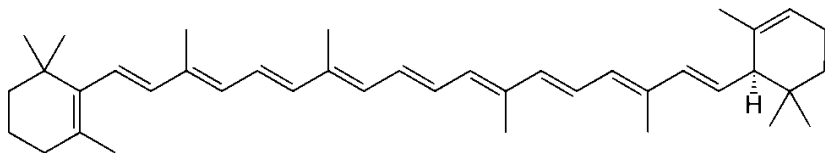


Primary constituent of spermaceti, the wax found in the skull of sperm whales

Plant lipids: isoprenoids

- ▶ Derivatives of isoprene, $\text{CH}_2=\text{CH}-\text{C}(\text{CH}_3)=\text{CH}_2$
- ▶ Simple polyisoprenoids (*terpenes*) form some aroma compounds
- ▶ Complex polyisoprenoids (*terpenoids*) are carotenes and other plant pigments, and also components of latex

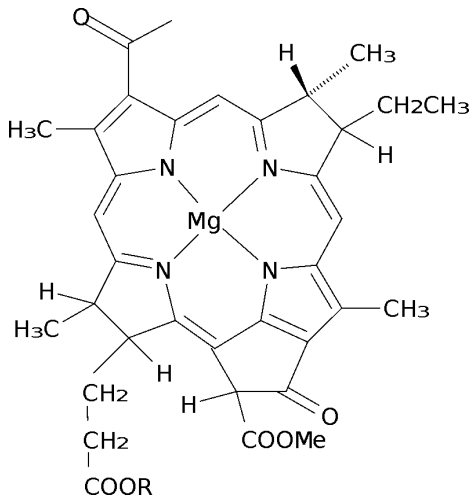
α -carotene (terpenoid: complex polyisoprenoid)



Porphyrins

- ▶ Occur in plants and animals
- ▶ Easily form complexes with metals and gases
- ▶ *Chlorophyll* and *heme* (red blood pigment) are examples of porphyrins

Bacteriochlorophyll *a* (porphyrin)



└ Fatty acids and lipids

└ Storage lipids: oils and fats

Final question (2 points)

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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
- ▶ Lipids are extremely diverse; the only characteristic uniting them is their hydrophobic behavior

For Further Reading



A. Shipunov.

Advanced Cell Biology [Electronic resource].

2011—onwards.

Mode of access: `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 2-3, 2-4.