

# Advanced Cell Biology. Lecture 4

Alexey Shipunov

Minot State University

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# Outline

## Questions and answers

## Organic molecules

Basics of organic chemistry

Carbohydrates



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Questions and answers

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

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



# Organic molecules

## Basics of organic chemistry



# 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:  $R-CHO$ ,  $R-C \begin{array}{l} \diagup H \\ \diagdown O \end{array}$
- ▶ Ketones:  $R-CO-R$ ,  $R-C \begin{array}{l} \diagdown O \\ \diagup R \end{array}$
- ▶ Carboxylic acids:  $R-COOH$ ,  $R-C \begin{array}{l} \diagup O \\ \diagdown OH \end{array}$
- ▶ 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





# Organic molecules

## Carbohydrates

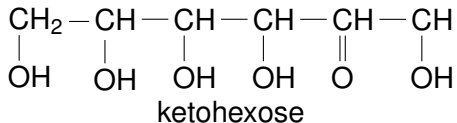
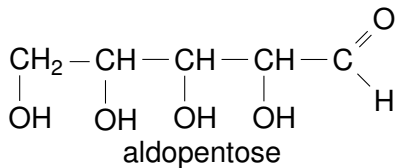


# Overview of carbohydrates

- ▶ 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

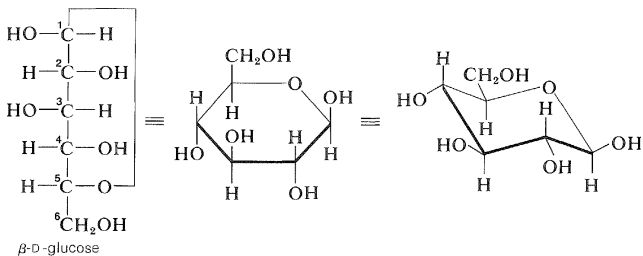
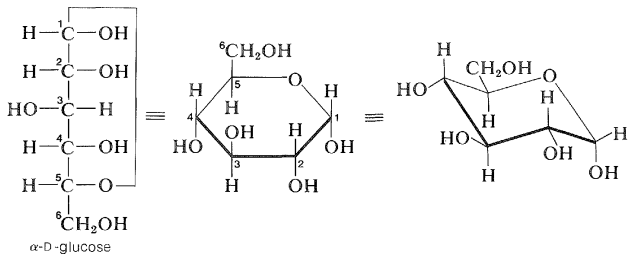


# Features of carbohydrates

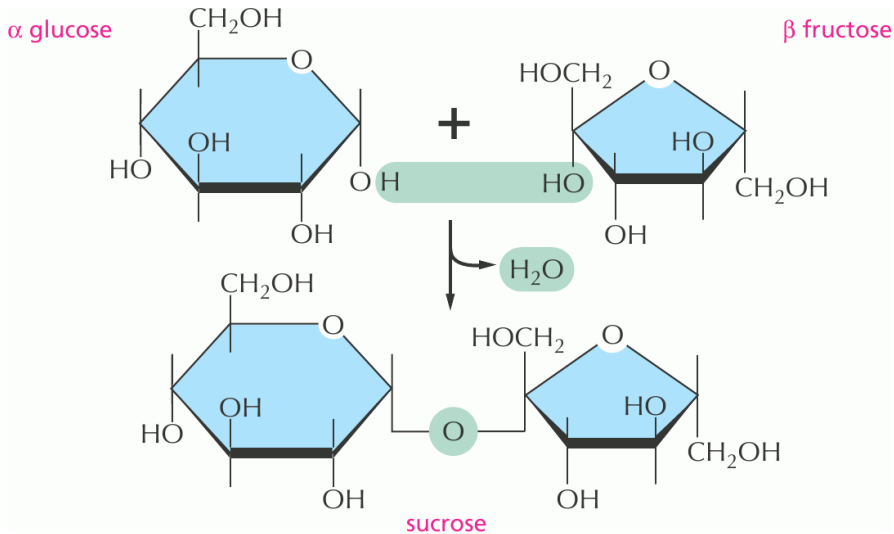
- ▶ Monosaccharides could form cyclic structures (rings)
- ▶ They have multiple asymmetric carbons, therefore multiple 3D isomers exist
- ▶ Moreover, ring may form in two different ways, so there are two additional isomers ( $\alpha$ - and  $\beta$ -)
- ▶ Reaction of condensation unites monosaccharides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



# $\alpha$ - and $\beta$ -glucose



# Reaction of condensation

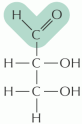
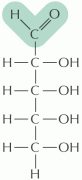
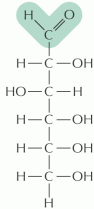
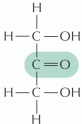
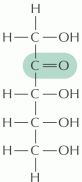
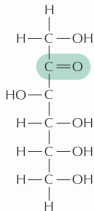


# Most important mono-, di and trisaccharides

- ▶ 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)

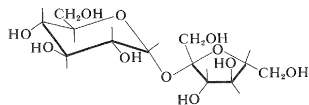


# Monosaccharides

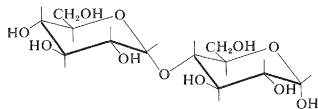
	3-carbon (TRIOSES)	5-carbon (PENTOSES)	6-carbon (HEXOSES)
ALDOSES	 <p>glyceraldehyde</p>	 <p>ribose</p>	 <p>glucose</p>
KETOSES	 <p>dihydroxyacetone</p>	 <p>ribulose</p>	 <p>fructose</p>



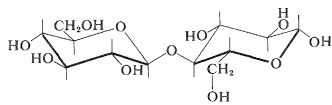


$\alpha$ - and  $\beta$ - disaccharides $\alpha$ -

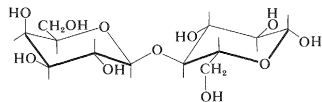
sucrose



maltose

 $\beta$ -

cellobiose



lactose

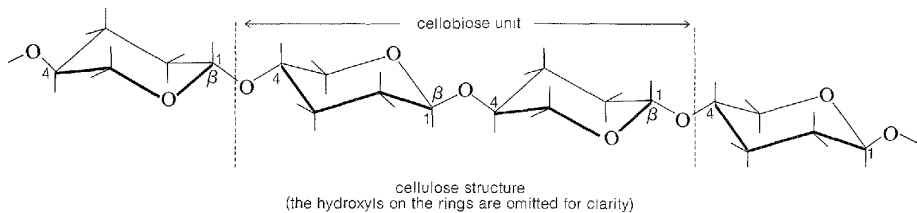


# Most important polysaccharides

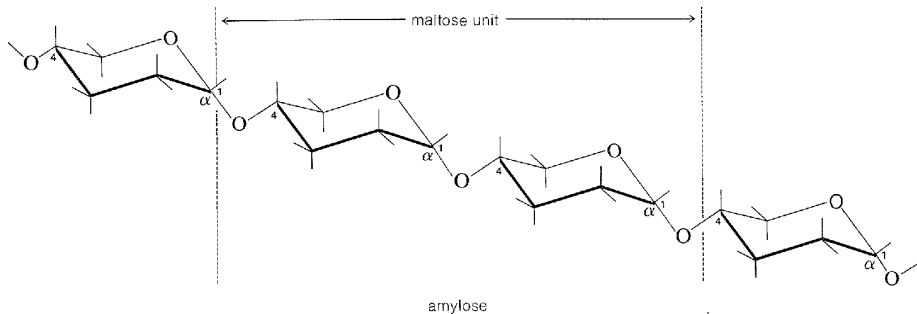
- ▶ Cellulose (unbranched poly- $\beta$ -glucose)
- ▶ Amylose and amylopectin (unbranched and branched poly- $\alpha$ -glucose)
- ▶ Chitin (amino-poly- $\beta$ -glucose)
- ▶ Hemicelluloses (poly-xyloses)



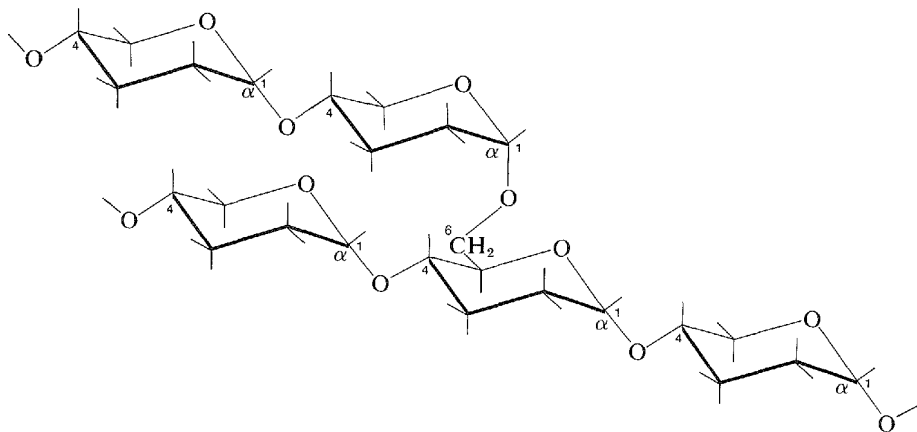
# Cellulose



# Amylose



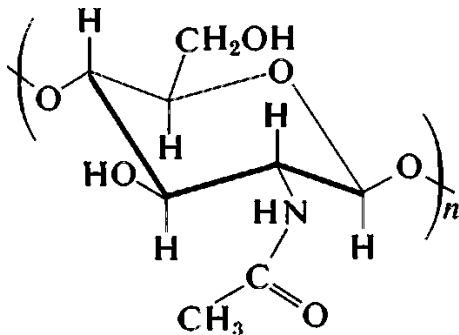
# Amylopectin



amylopectin



# Unit of chitin



chitin



# Starch and glycogen

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



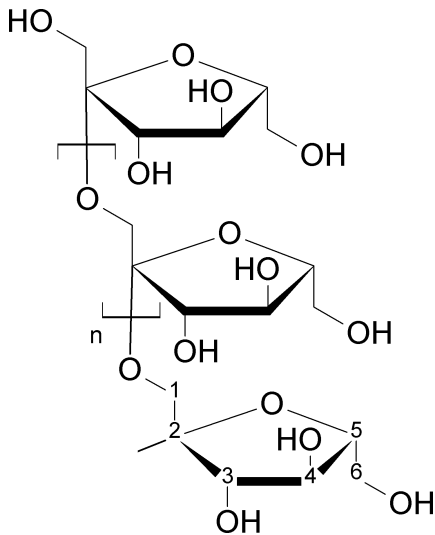
# Inulin

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





# Inulin structure

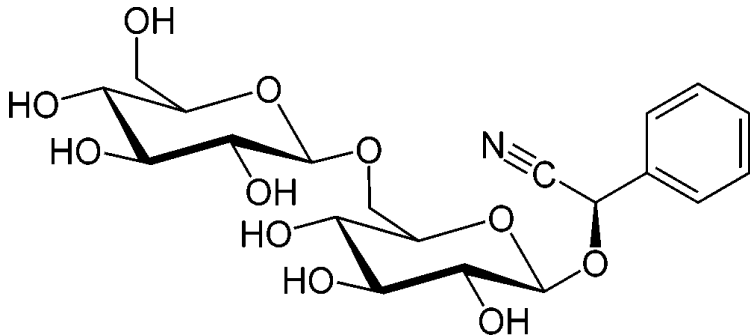


## Some important molecules related to carbohydrates

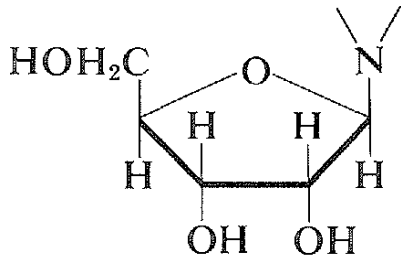
- ▶ **Glycosides**: monosaccharides bonding through oxygen to various compounds, including amines (nucleosides)
- ▶ **Pectins**: polymers of galacturonic acid (derivative of glucose)
- ▶ **Vitamin C** (ascorbic acid): derivative of glucose with acidic properties



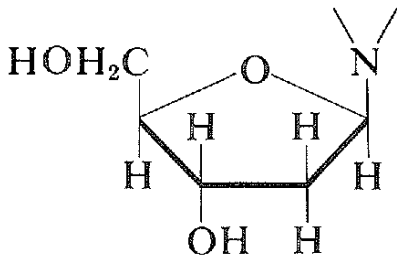
# Amygdalin glycoside from almond



## Nucleosids (glycosides)



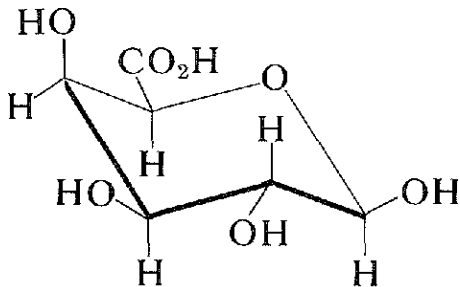
ribonucleoside  
(partial structure)



deoxyribonucleoside  
(partial structure)



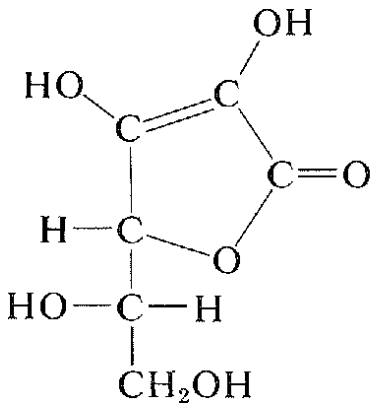
# Galacturonic acid (pectins)



$\beta$ -D-galacturonic acid



# Ascorbic acid (vitamin C)



L-ascorbic acid



# Final question (2 points)



## Final question (2 points)

What is the difference between  $\alpha$ - and  $\beta$ - glucose?





# Summary

- ▶ Carbohydrates are aldo- or keto- polyalcohols and their polymers; most of them are using as structural molecules or sources of energy



# For Further Reading



## A. Shipunov.

*Advanced Cell Biology* [Electronic resource].

2011—onwards.

Mode of access:

[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 2-3, 2-4.*

