



Biological and Bioorganic Chemistry

Some useful material

Kharkov V. N. Karazin National University
Institute for Chemistry

Department of Physical Organic Chemistry

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Teaching



Biological and Bioorganic Chemistry (Faculty of Medicine)

Lecturer: Dr. Denis Svechikarev

A semester-long introduction to organic, bioorganic and biological chemistry for first-year foreign students of the Faculty of Medicine is fully taught in English. The course comprises a small series of lectures, 10 seminars and 5 practice sessions and gives 2 credits according to ECTS.

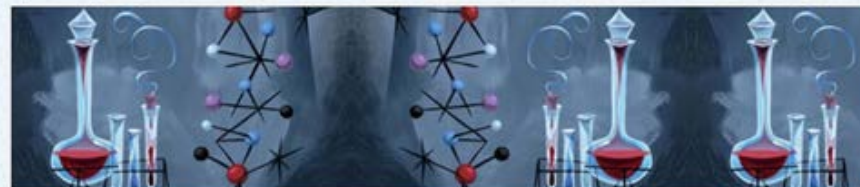
- [Lectures download \[PPT\]](#)
- [Material for seminars download \[PDF\]](#)
- [Calendar working plan \[PDF\]](#)
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will be announced ...

What shall we do?



Feb 19

Introduction to organic and biological chemistry. Classes and nomenclature of organic compounds. Saturated and unsaturated hydrocarbons. S_R and Ad_E reactions.

Mar 4

Aromatic hydrocarbons. Orientation in the aromatic ring. Halogen derivatives of hydrocarbons. S_N reactions. Alcohols, ethers. Polyhydric alcohols.

Mar 18

Carbonyl compounds – aldehydes and ketones. Carbohydrates.

Apr 1

Carboxylic acids and their derivatives: amides, nitriles, anhydrides. Esters, fats.

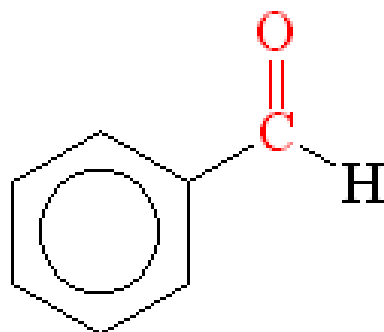
Apr 15

Amines, aminoacids, peptides. Heterocyclic compounds and their biological activity.

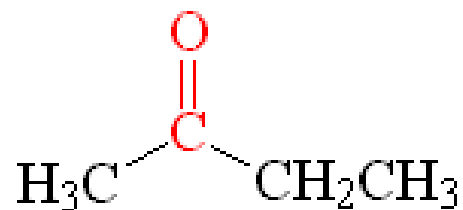
A chemistry laboratory setting with a central text box. The background shows a laboratory bench with various glassware, including beakers and flasks, and a person in a white lab coat working. The text box is white with a black border and contains the title "Aldehydes and ketones" in bold black font.

Aldehydes and ketones

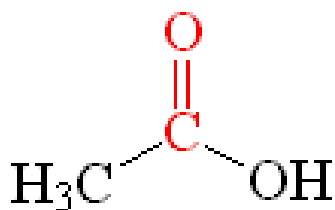
The carbonyl group



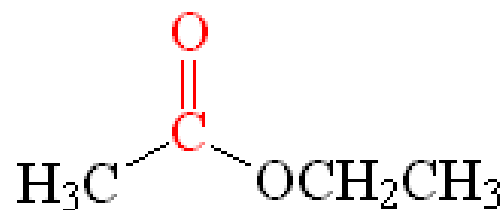
benzaldehyde



methyl ethyl ketone

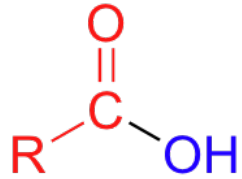


acetic acid

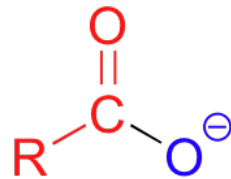


ethyl acetate

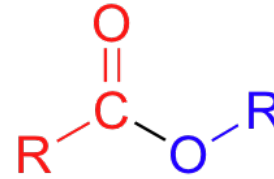
The carbonyl group



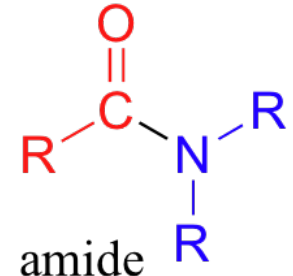
carboxylic acid



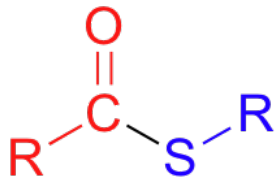
carboxylate



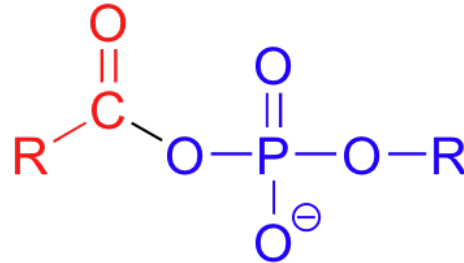
ester



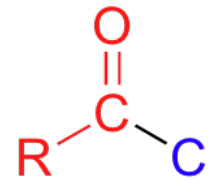
amide



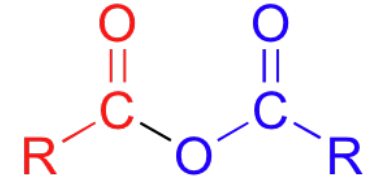
thioester



acyl phosphate



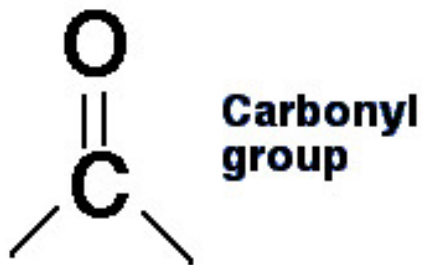
acyl chloride



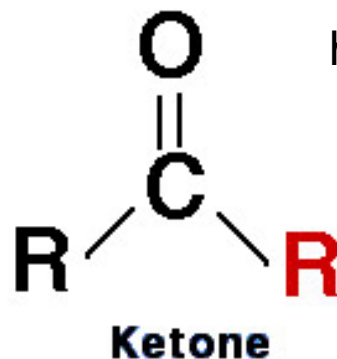
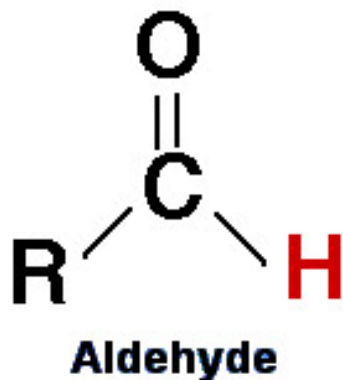
acid anhydride

Aldehydes and Ketones

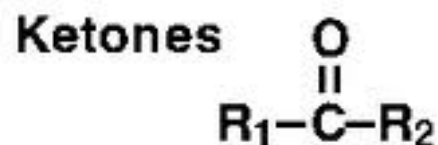
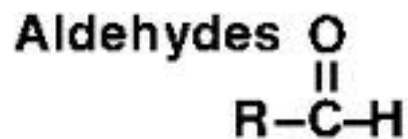
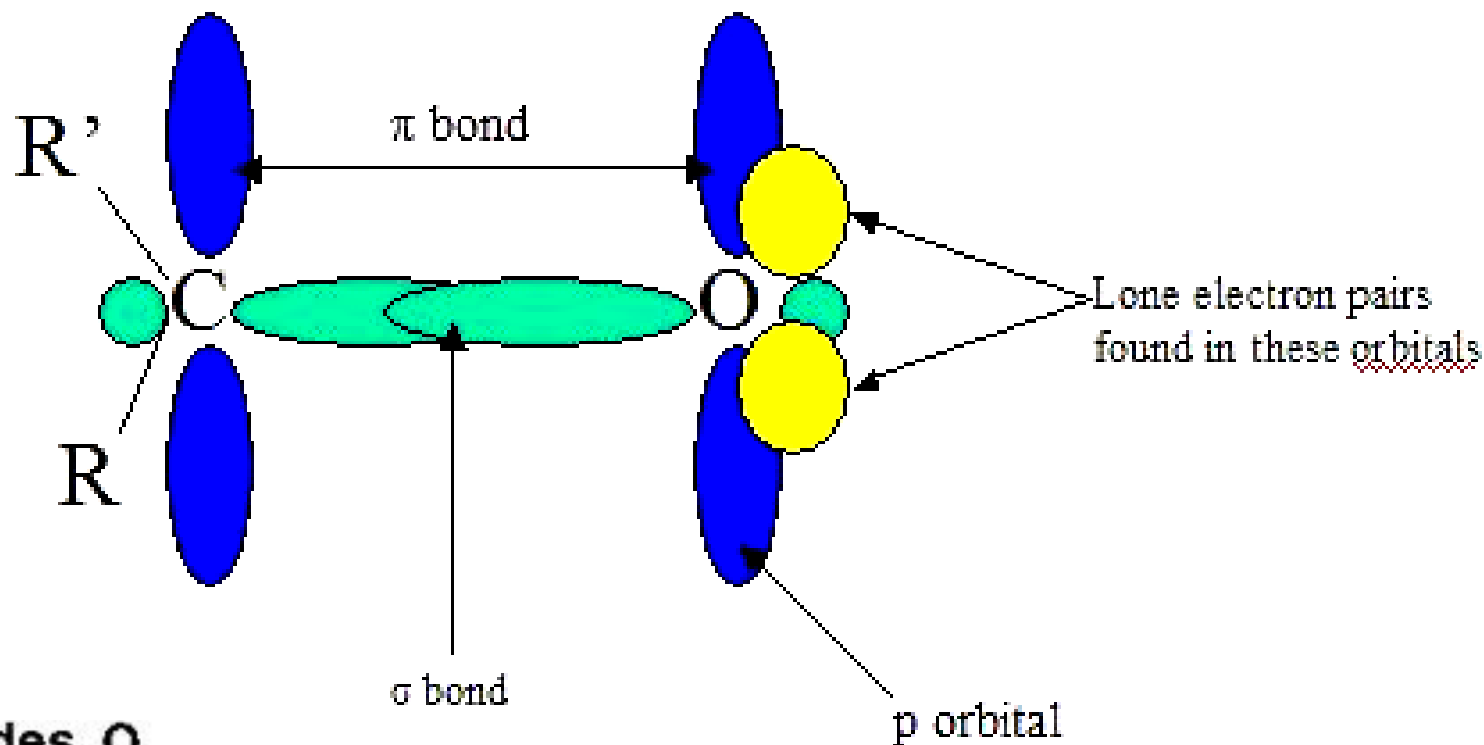
Aldehyde - an organic compound that contains the -CHO (aldehyde) group.



Ketone - an organic compound containing a nonterminal carbonyl (C=O) group flanked by two alkyl groups and having the general formula $\text{RR}'\text{C=O}$.



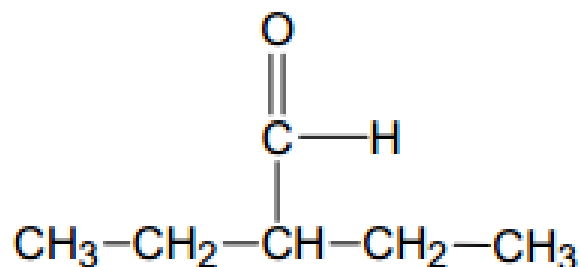
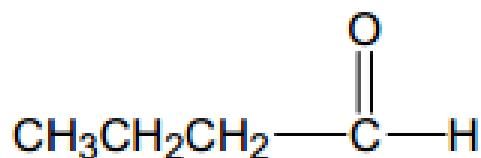
Structure of the carbonyl group



Naming aldehydes

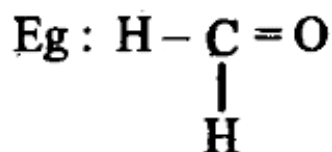
Nomenclature of Aldehydes

- Select the longest carbon chain *containing the carbonyl carbon*.
- The **-e** ending of the parent alkane name is replaced by the suffix **-al**.
- The carbonyl carbon is always numbered “1.” (It is not necessary to include the number in the name.)
- Name the substituents attached to the chain in the usual way.



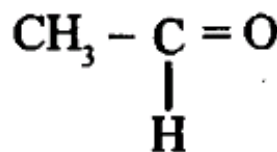
Naming aldehydes

name 'e' is deleted and replaced by 'al' .

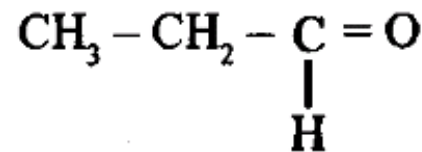


methanal

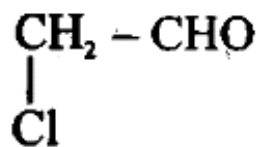
methane '-e' + 'al'



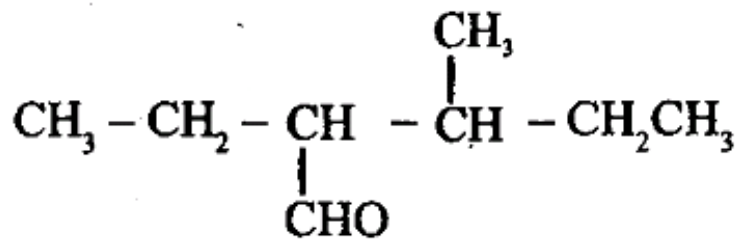
ethanal



propanal



2 - chloroethanal

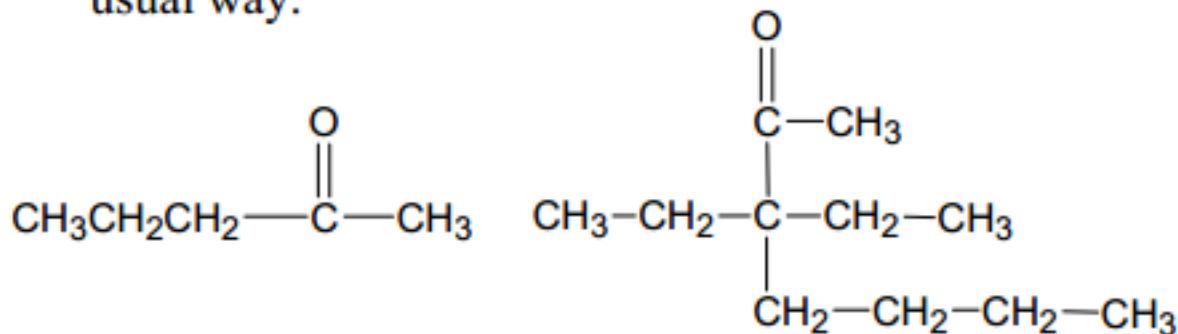


2 - ethyl - 3 - methylpentanal

Naming ketones

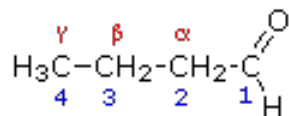
Nomenclature of Ketones

- Select the longest carbon chain *containing the carbonyl carbon*.
- The **-e** ending of the parent alkane name is replaced by the suffix **-one**.
- Number the chain starting with the end closest to the ketone group (i.e., the carbonyl carbon should have the lowest possible number).
- Name the substituents attached to the chain in the usual way.

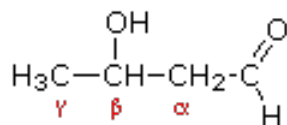


Naming aldehydes and ketones

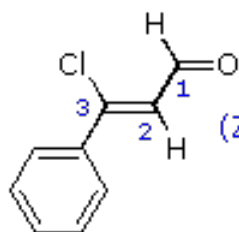
Aldehydes



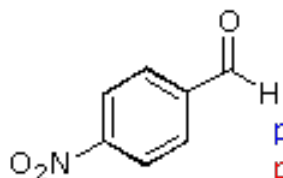
butanal
butyraldehyde



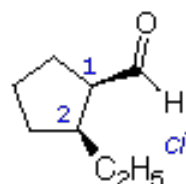
3-hydroxybutanal
 β -hydroxybutyraldehyde
or aldol



(Z)-3-chloro-3-phenyl-2-propenal



p-nitrobenzenecarbaldehyde
p-nitrobenzaldehyde

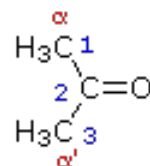


cis-2-ethylcyclopentanecarbaldehyde

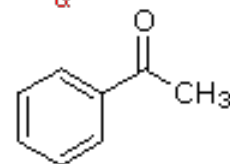


pentanedial
glutaraldehyde

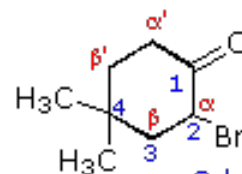
Ketones



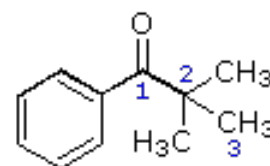
propanone
acetone



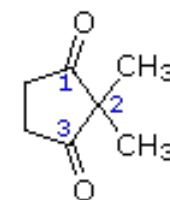
phenylethanone
acetophenone
methyl phenyl ketone



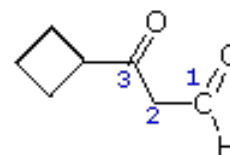
2-bromo-4,4-dimethylcyclohexanone



2,2-dimethyl-1-phenylpropanone
t-butyl phenyl ketone

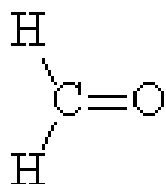


2,2-dimethyl-1,3-cyclopentanedione

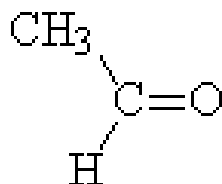


3-cyclobutyl-3-oxopropanal

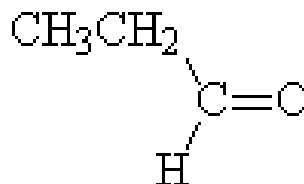
Trivial names of some aldehydes and ketones



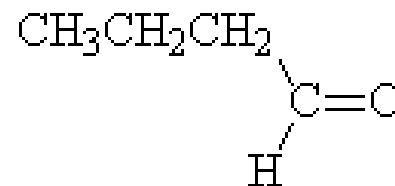
formaldehyde
(methanal)



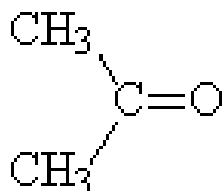
acetaldehyde
(ethanal)



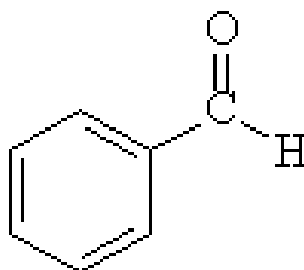
propionaldehyde
(propanal)



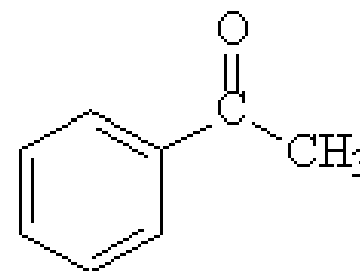
butyraldehyde
(butanal)



acetone
(propanone)

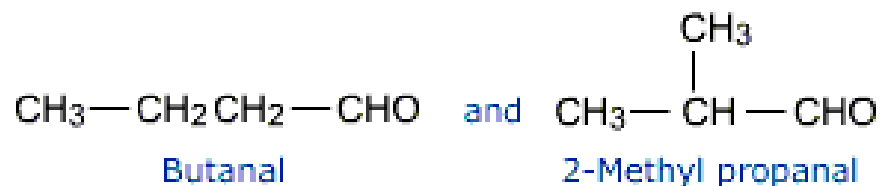
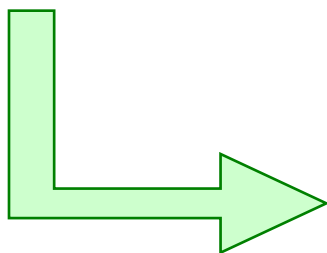
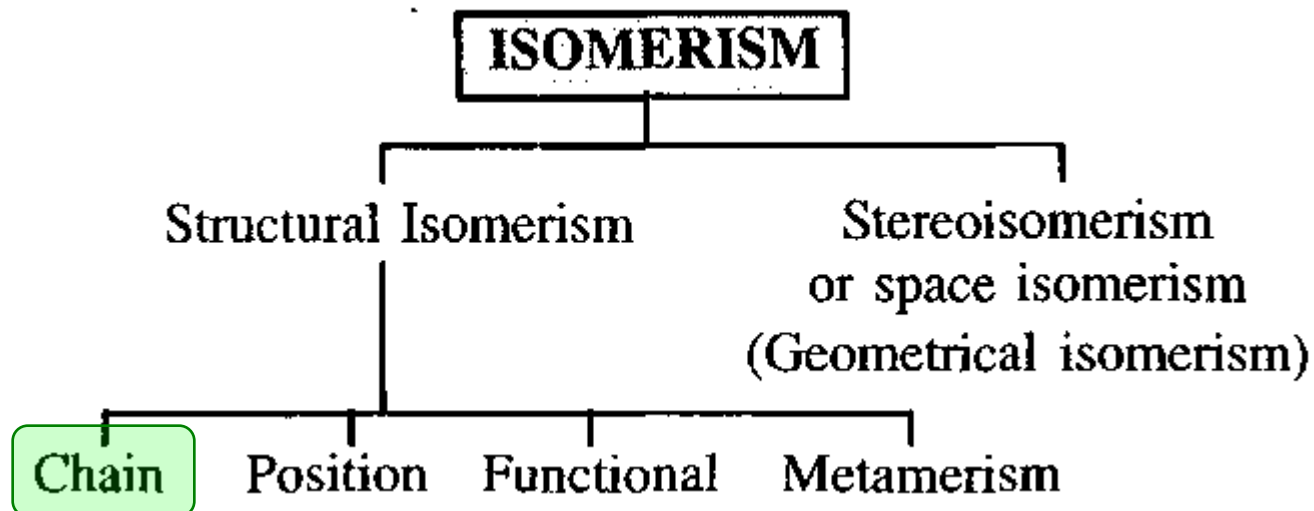


benzaldehyde

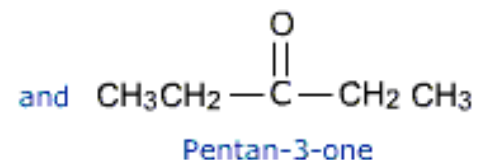
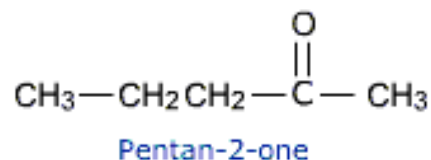
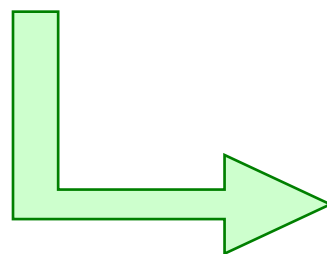
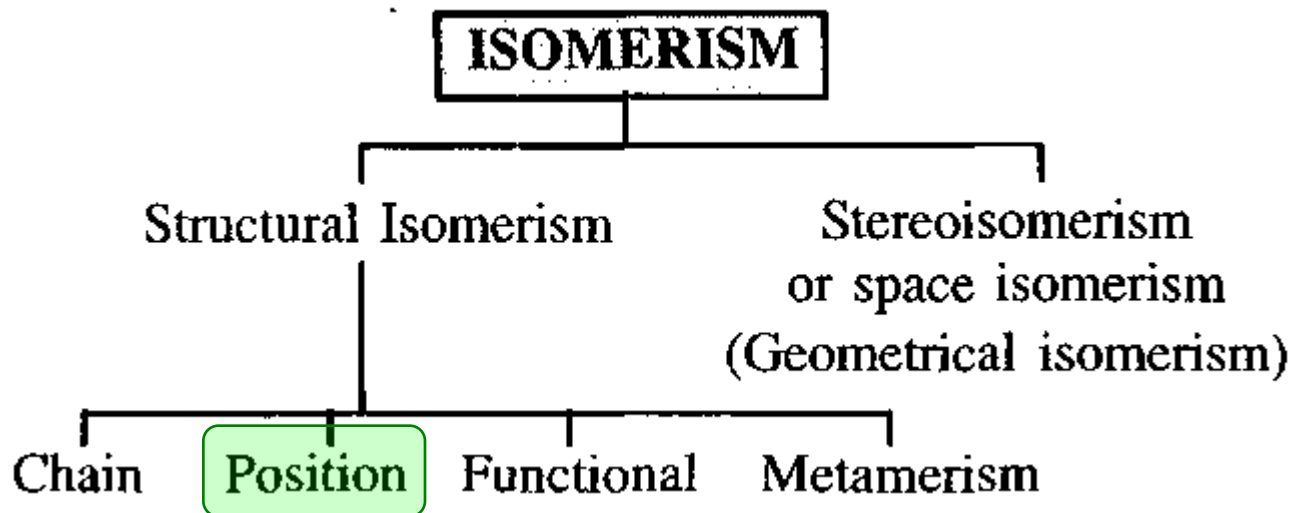


acetophenone

Isomerism of aldehydes and ketones



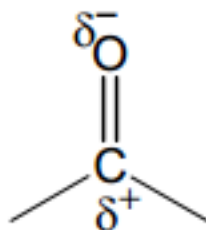
Isomerism of aldehydes and ketones



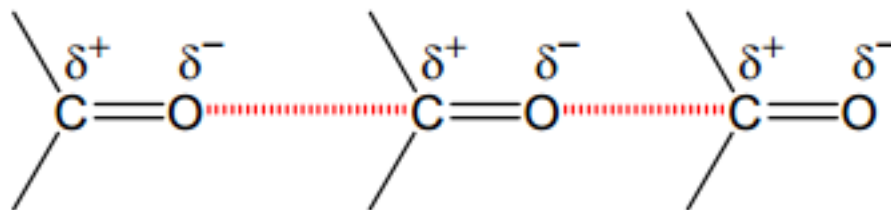
Physical Properties of Aldehydes and Ketones

The Polarity of the Carbonyl Group

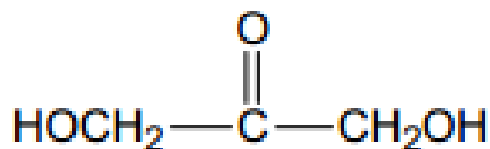
- Carbonyl compounds are polar, containing a dipole along the carbon-oxygen double bond.



- This creates weak attractive forces between carbonyl compounds, but these attractions are not as strong as those that result from hydrogen-bonding.



Important aldehydes and ketones



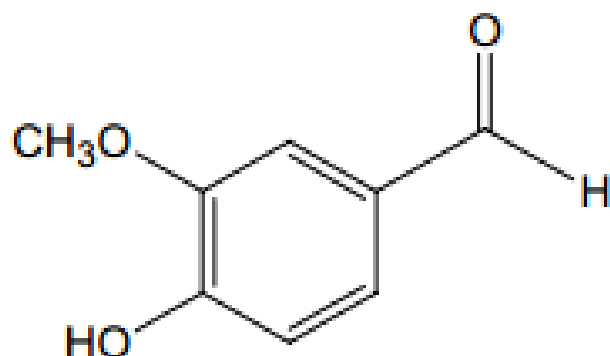
Dihydroxyacetone

Active ingredient in "bronzers" that provide fake suntan coloration; reacts with dead, outer skin cells to produce a darker color; fades as the dead skin cells slough off.



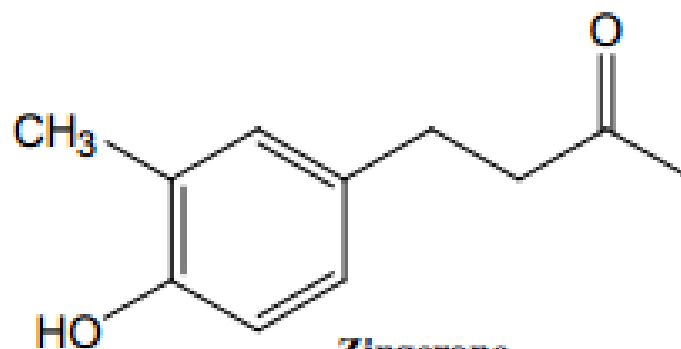
2-Heptanone

Found in oil of clove; also present in the odor of many fruits and dairy products, and is also responsible for the odor of blue cheese.



Vanillin

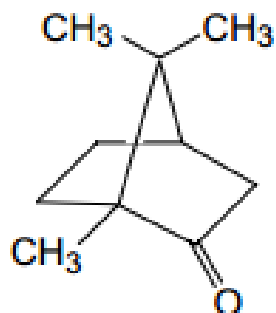
flavoring in Vanilla beans



Zingerone

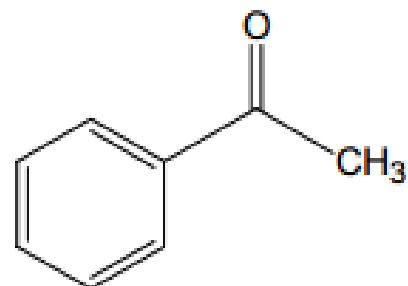
The pungent, hot component of ginger

Important aldehydes and ketones



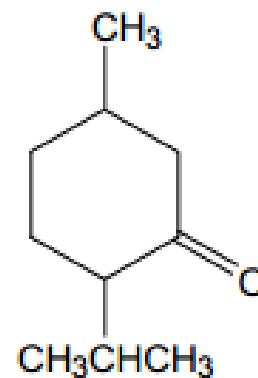
Camphor

Isolated by steam distillation from the camphor tree of China and Japan. Camphor is a counter-irritant (produces a superficial inflammation to reduce deeper inflammation) and antipruritic (anti-itching) medication; it appears to selectively stimulate cold sensors. It also stimulates the respiratory systems and inspires deep breathing, but can cause convulsions and respiratory collapse in larger doses.



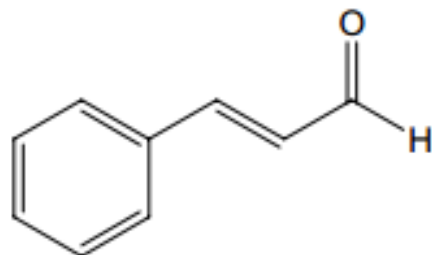
Acetophenone

Used in perfumery, and as an organic solvent; also used in the synthesis of some pharmaceuticals



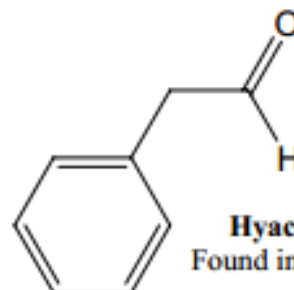
Menthone

Important aldehydes and ketones



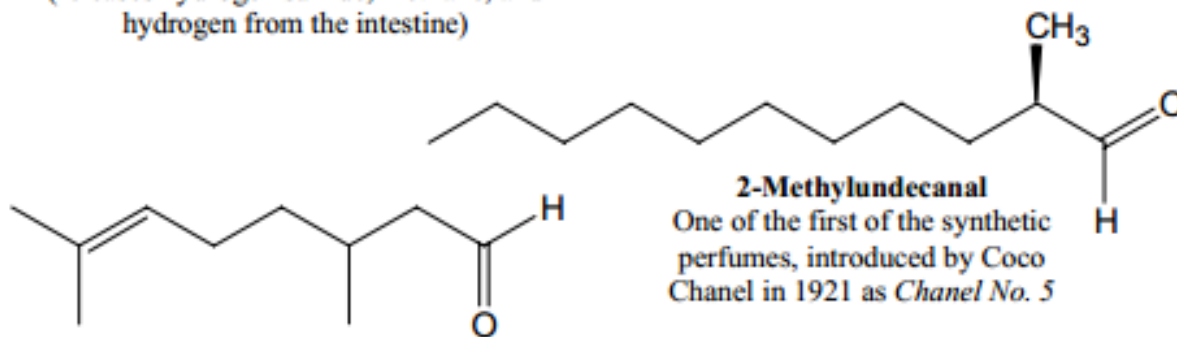
Cinnamaldehyde

The flavoring in oil of cinnamon; obtained by steam distillation from the bark of the cinnamon tree; has a *carminative* action (releases hydrogen sulfide, methane, and hydrogen from the intestine)



Hyacinthin

Found in hyacinth



Citronellal

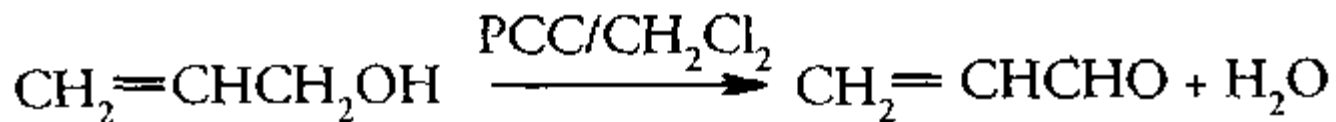
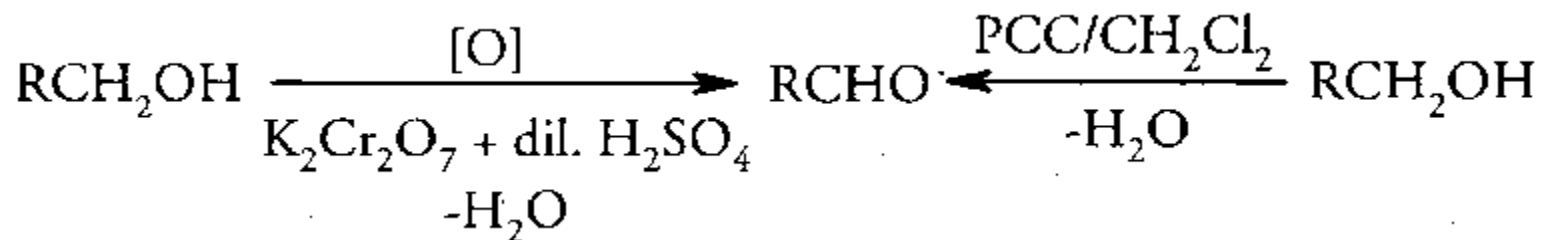
Found in citronella oil; used as an insect repellent

2-Methylundecanal

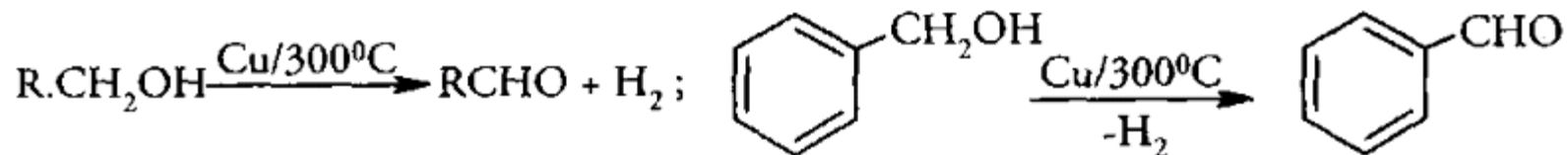
One of the first of the synthetic perfumes, introduced by Coco Chanel in 1921 as *Chanel No. 5*

Synthesis of aldehydes

oxydation by potassium dichromate of pyridinium chlorochromate (PCC)

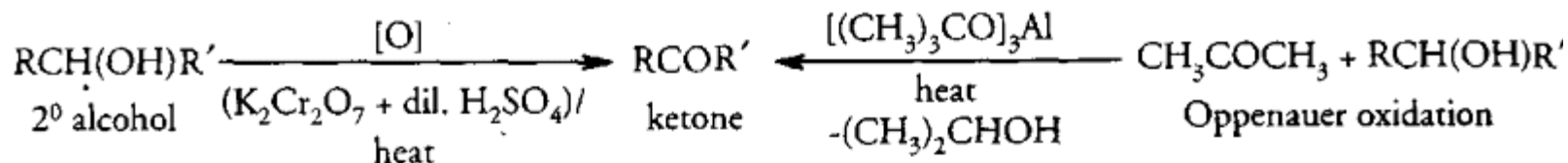


dehydrogenation by copper under heating

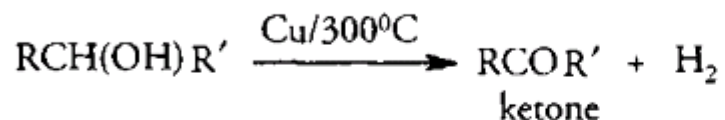


Synthesis of ketones

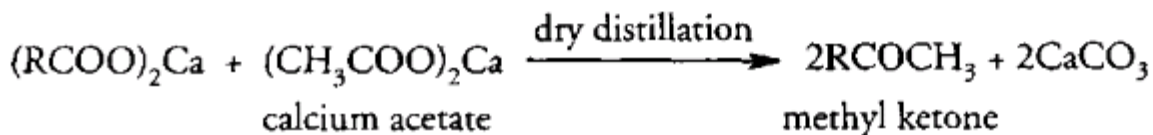
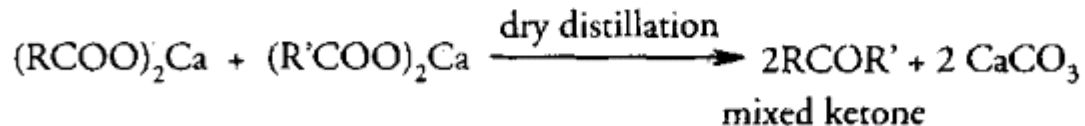
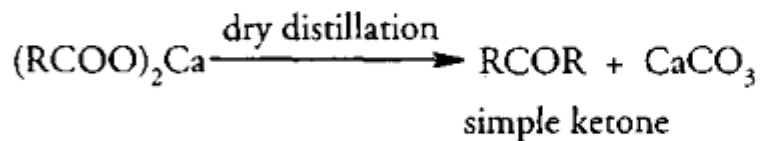
from secondary alcohols



Dehydrogenation of secondary alcohols yield ketones



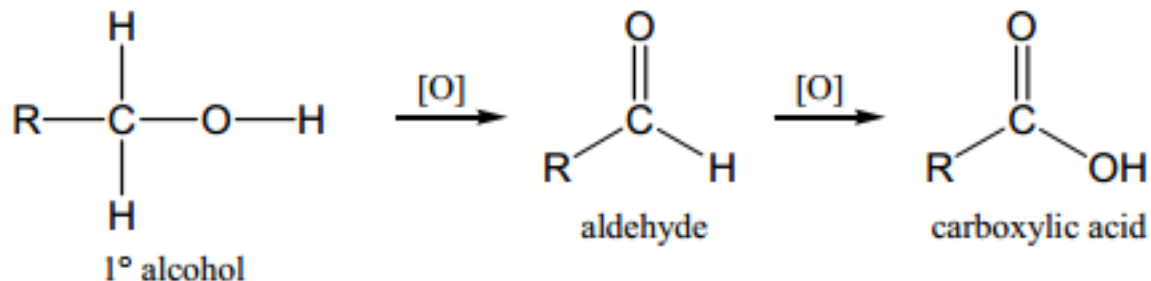
from calcium salts of carboxylic acids



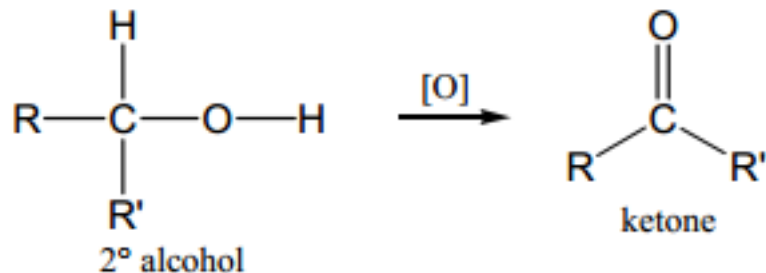
Reactions of the carbonyl group

Oxidation of Alcohols to Produce Carbonyls

- Aldehydes, like primary alcohols, can be oxidized to produce carboxylic acids:



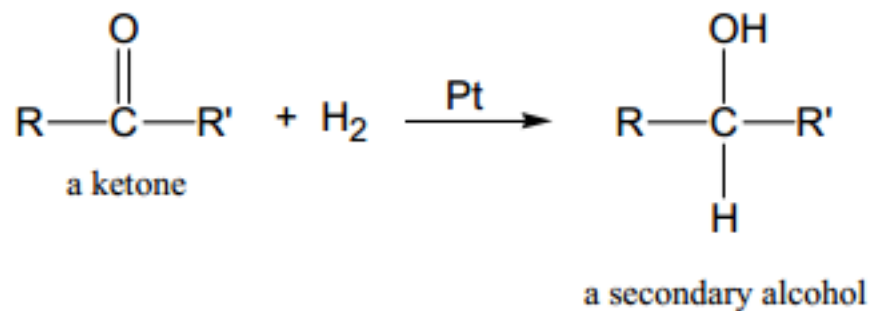
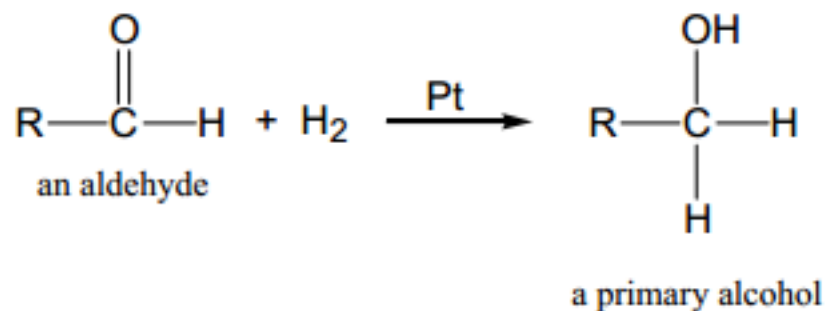
- Secondary alcohols can be oxidized to produce ketones, which are not further oxidized:



Reactions of the carbonyl group

Hydrogenation of Aldehydes and Ketones

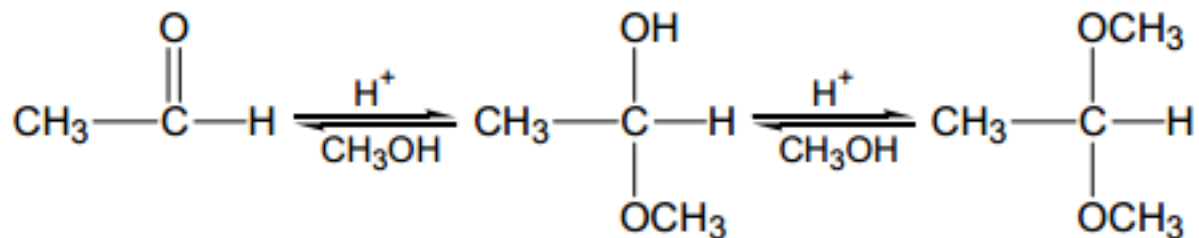
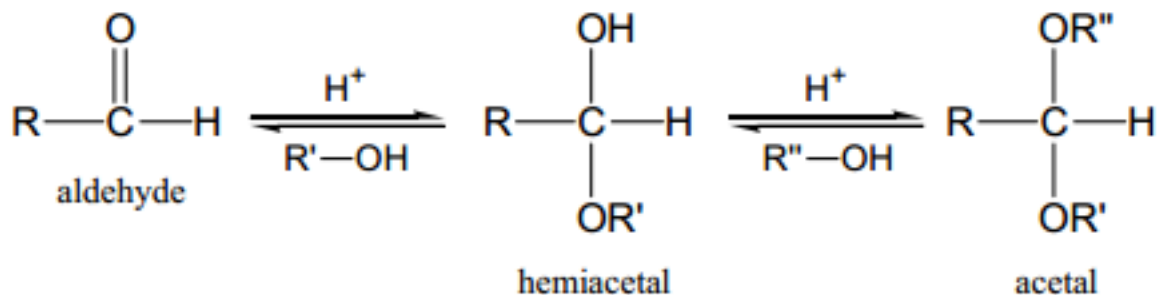
- **Hydrogenation** of aldehydes and ketones with hydrogen gas and a platinum catalyst produces alcohols:



Reactions of the carbonyl group

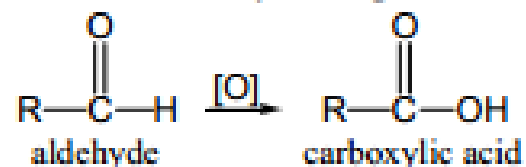
Addition of Alcohols to Aldehydes

- Aldehydes react with alcohols first to form **hemiacetals**, which then react with excess alcohol to produce **acetals**.

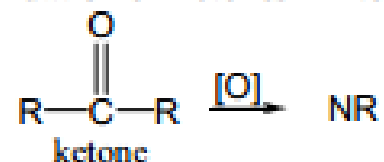


Reactions of the carbonyl group

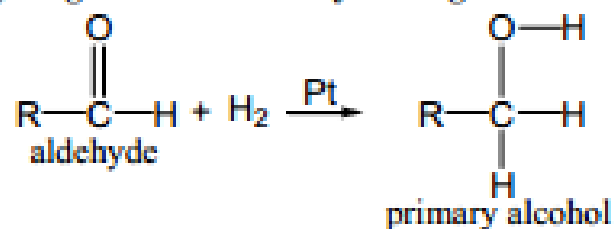
1. Oxidation of Aldehydes to give Carboxylic Acids



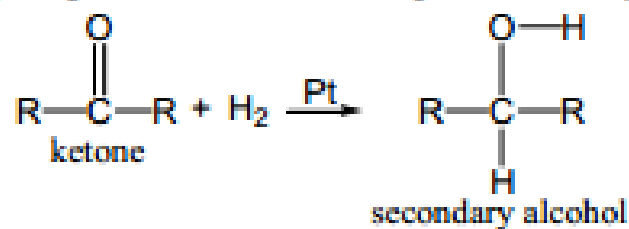
2. Oxidation of Ketones — No Reaction



3. Hydrogenation of Aldehydes to give Primary Alcohols

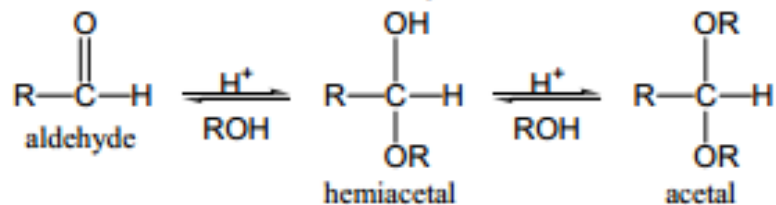


4. Hydrogenation of Ketones to give Secondary Alcohols

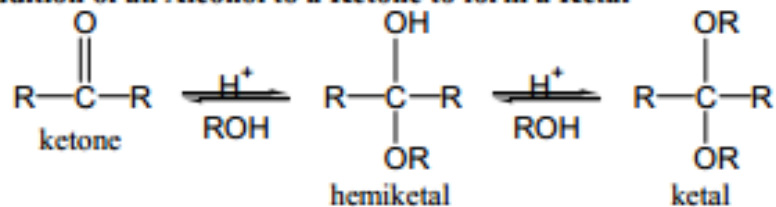


Reactions of the carbonyl group

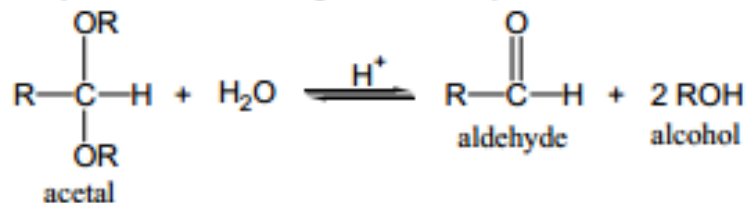
5. Addition of an Alcohol to an Aldehyde to form an Acetal



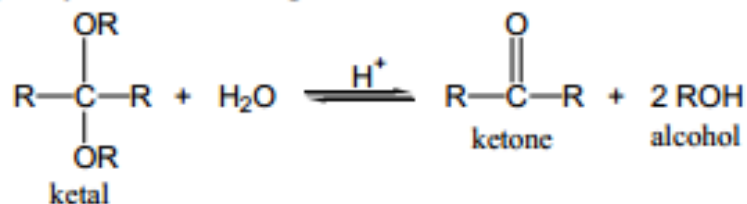
6. Addition of an Alcohol to a Ketone to form a Ketal



7. Hydrolysis of an Acetal to give an Aldehyde

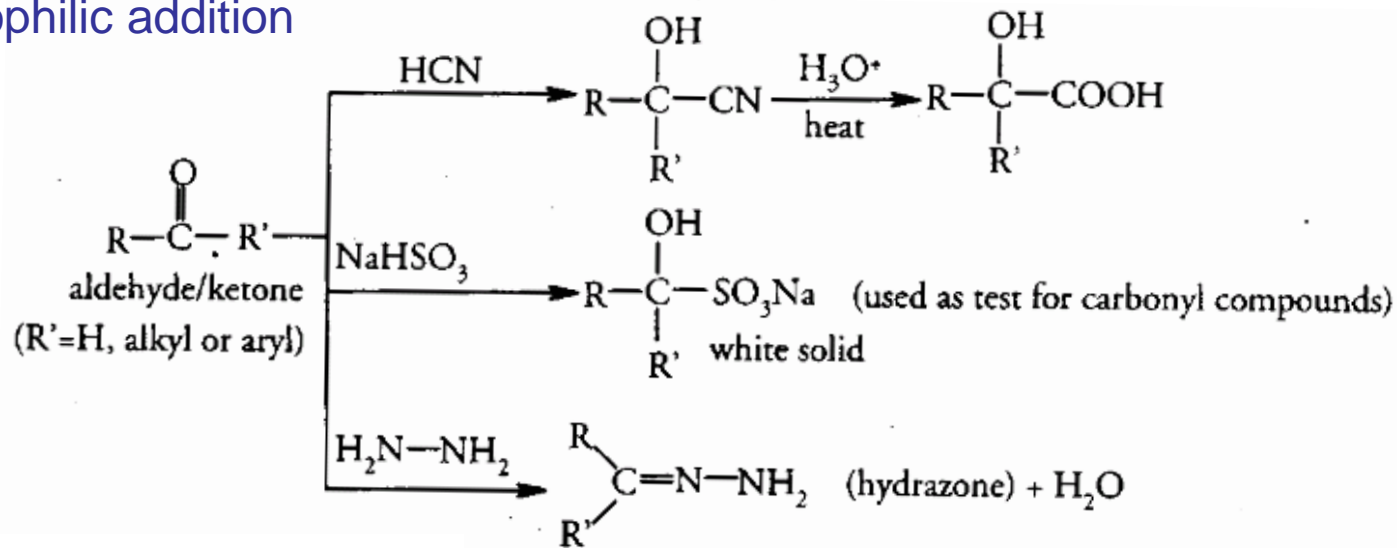


8. Hydrolysis of a Ketal to give a Ketone

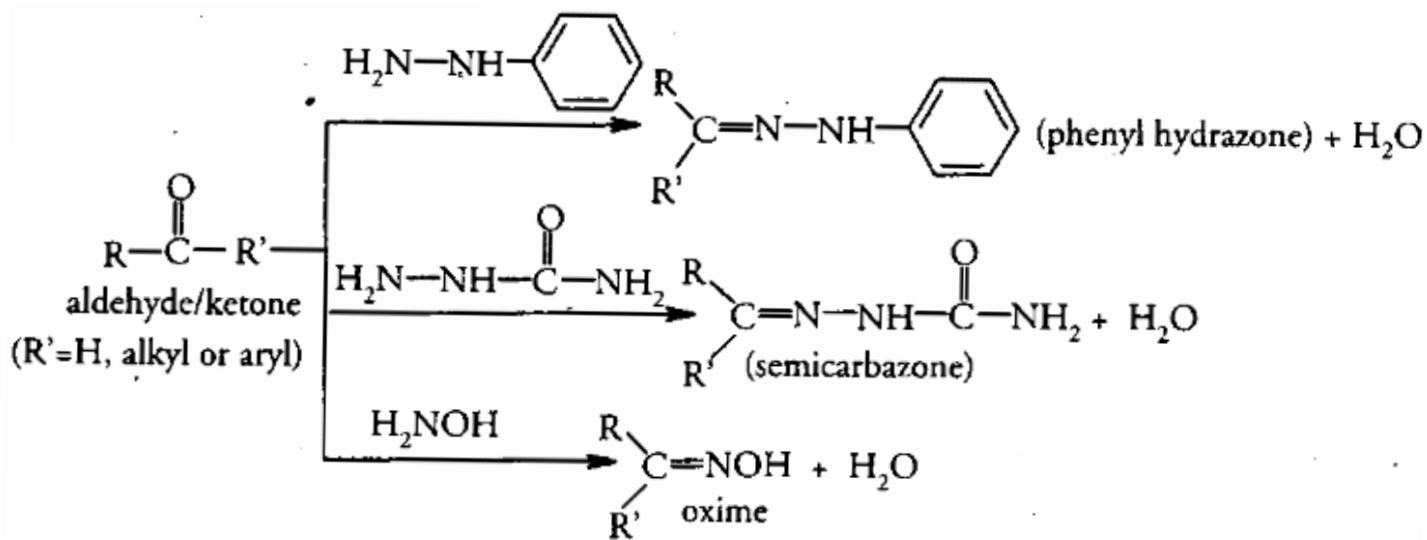


Reactions of the carbonyl group

nucleophilic addition

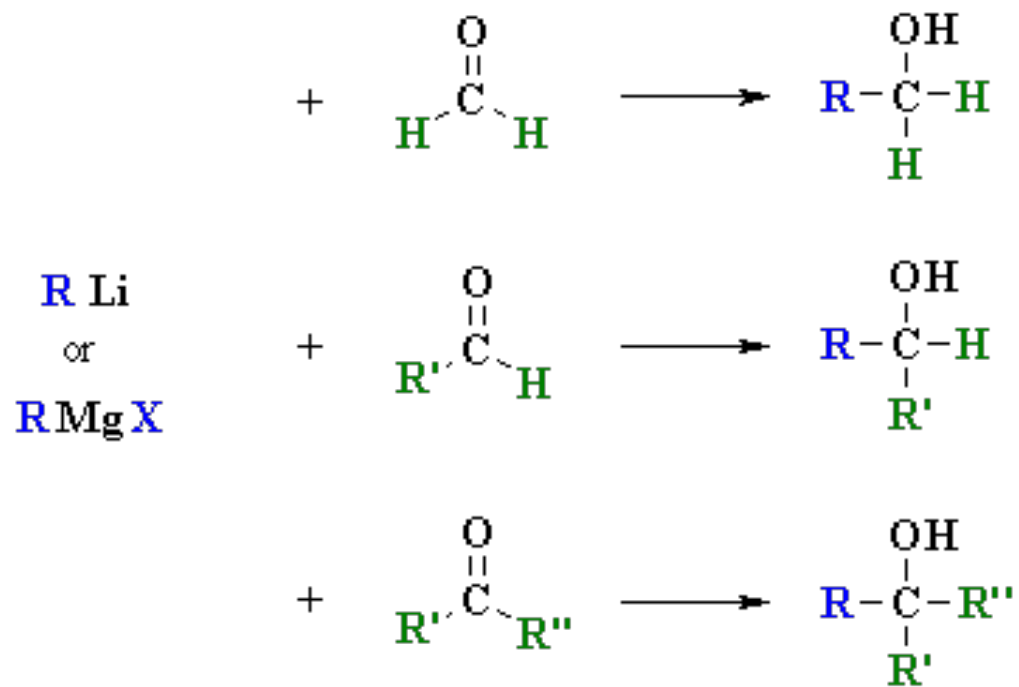


condensation

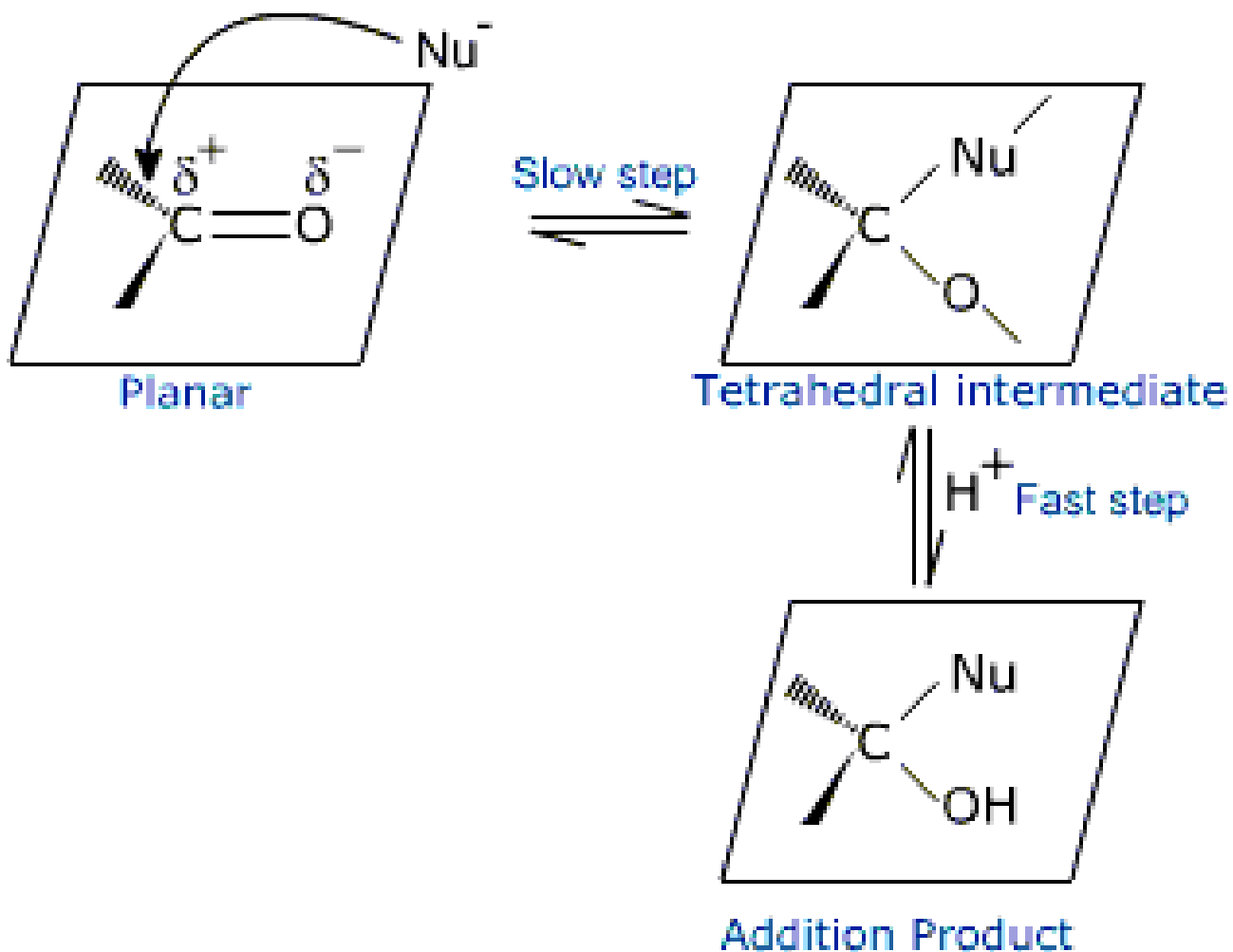


Reactions of the carbonyl group

Addition of lithium organic
compounds and Grignard reactives

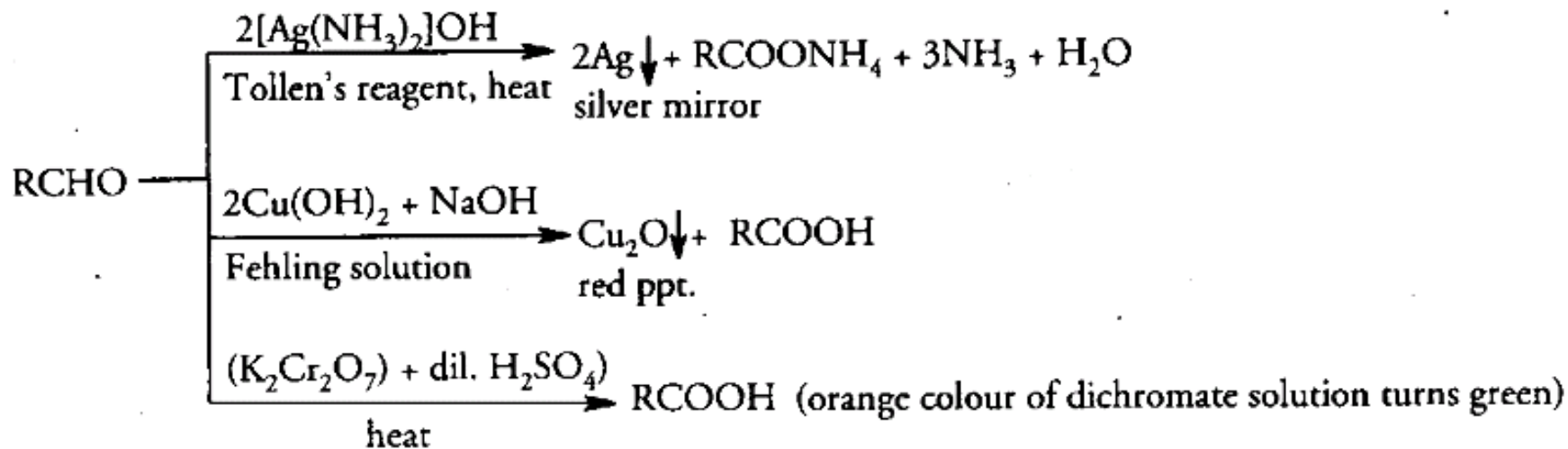


Reactions of the carbonyl group - Ad_N

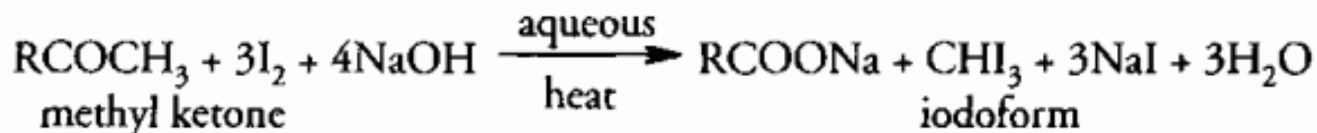


Reactions of the carbonyl group

oxidation of aldehydes



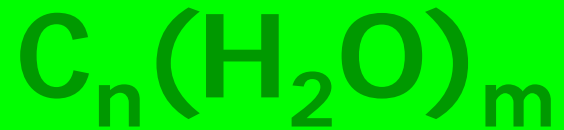
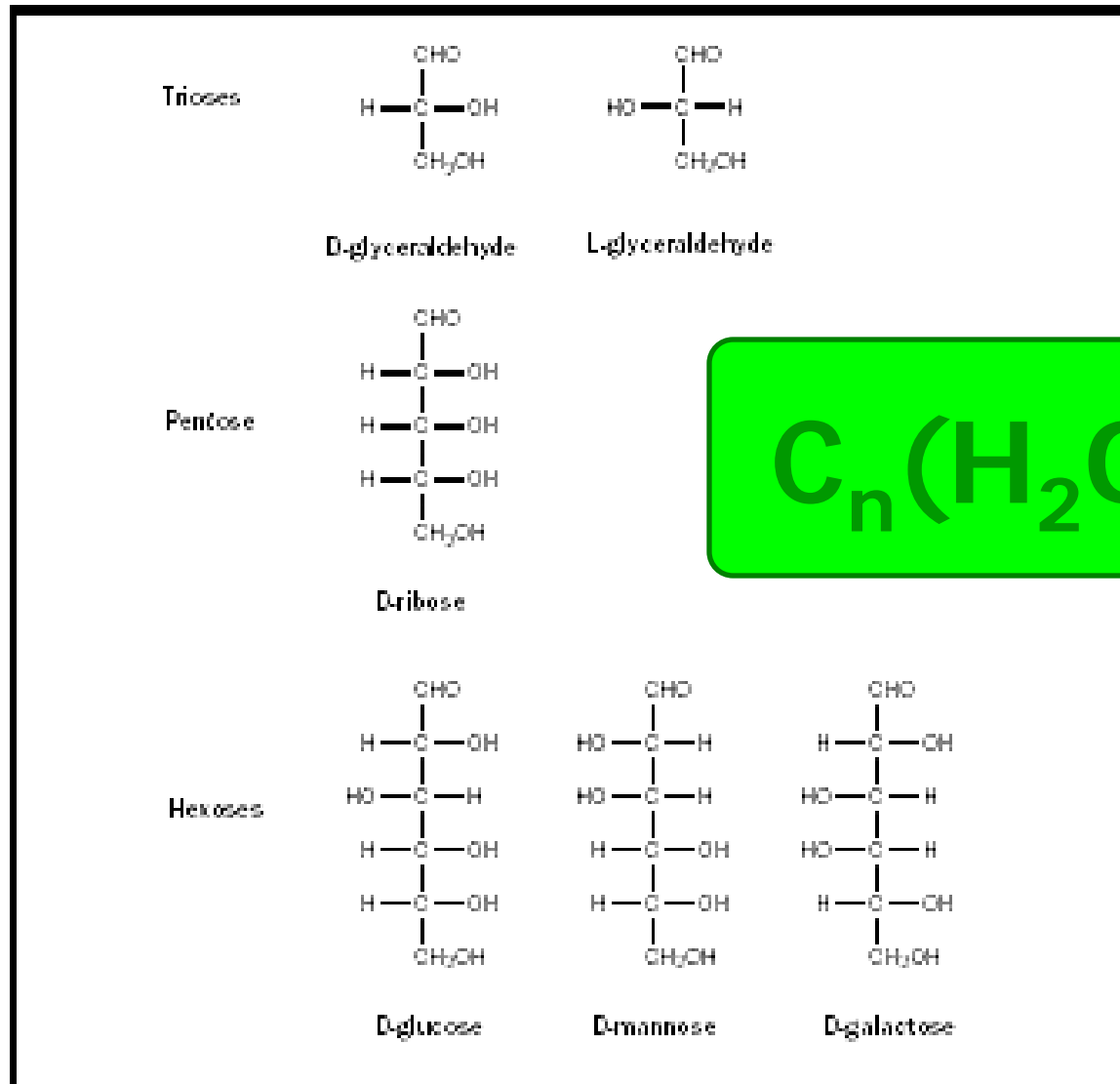
Iodophorm reaction



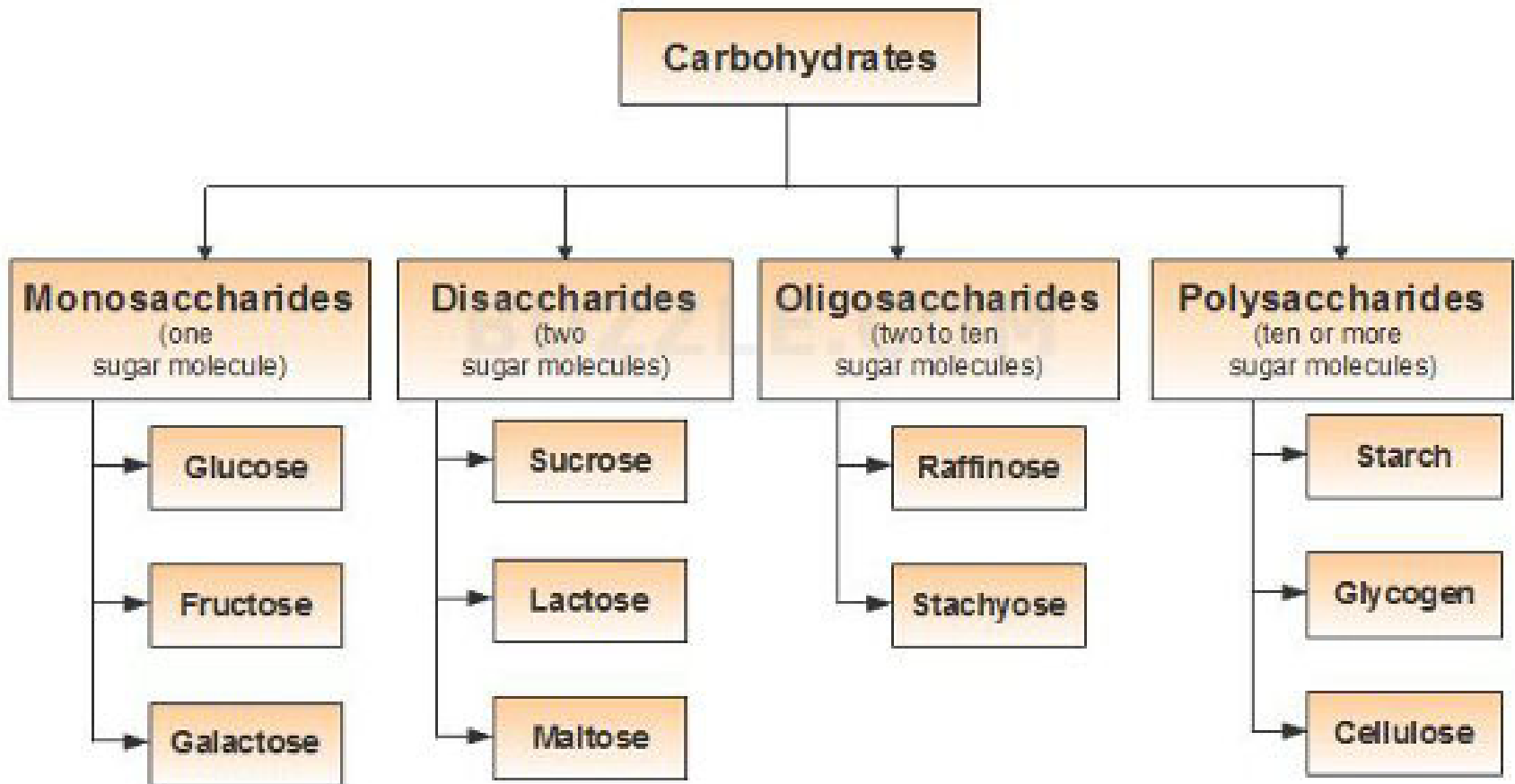
A collage of various carbohydrate-rich foods including bread, pasta, fruits, and vegetables. The central focus is a large, bold text box containing the word "Carbohydrates".

Carbohydrates

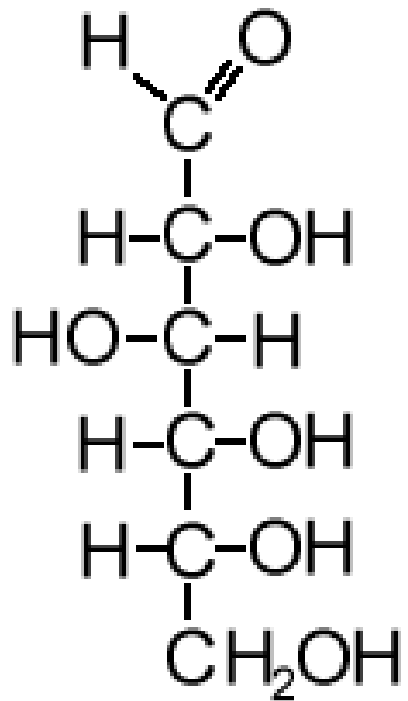
Representatives of carbohydrates



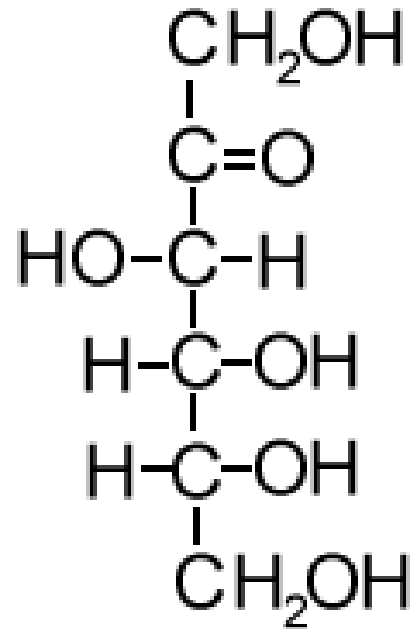
Representatives of carbohydrates



Representatives of carbohydrates

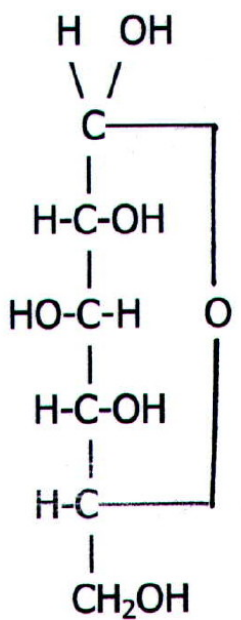


Glucose



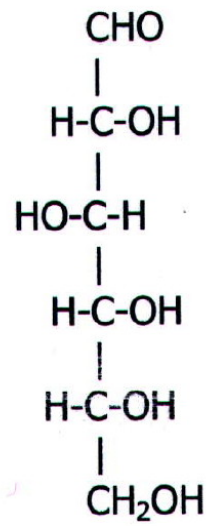
Fructose

Open-chain and cyclic carbohydrates



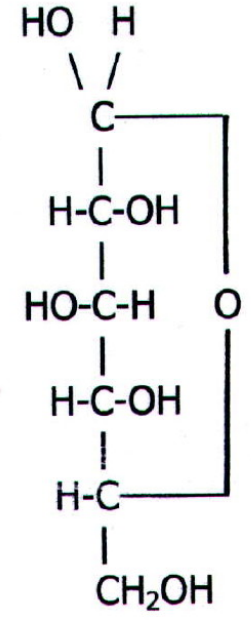
α -D-glucose

\rightleftharpoons

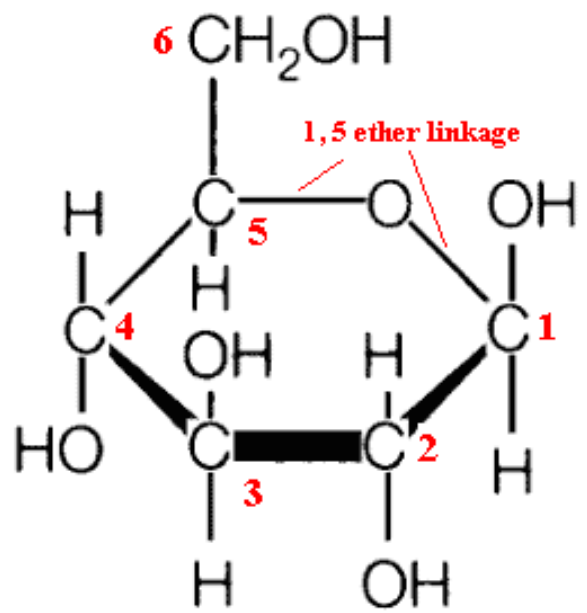


open chain

\rightleftharpoons

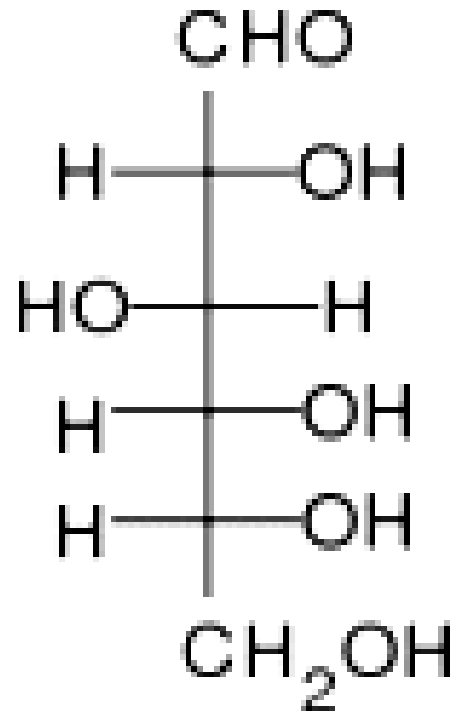


β -D-glucose

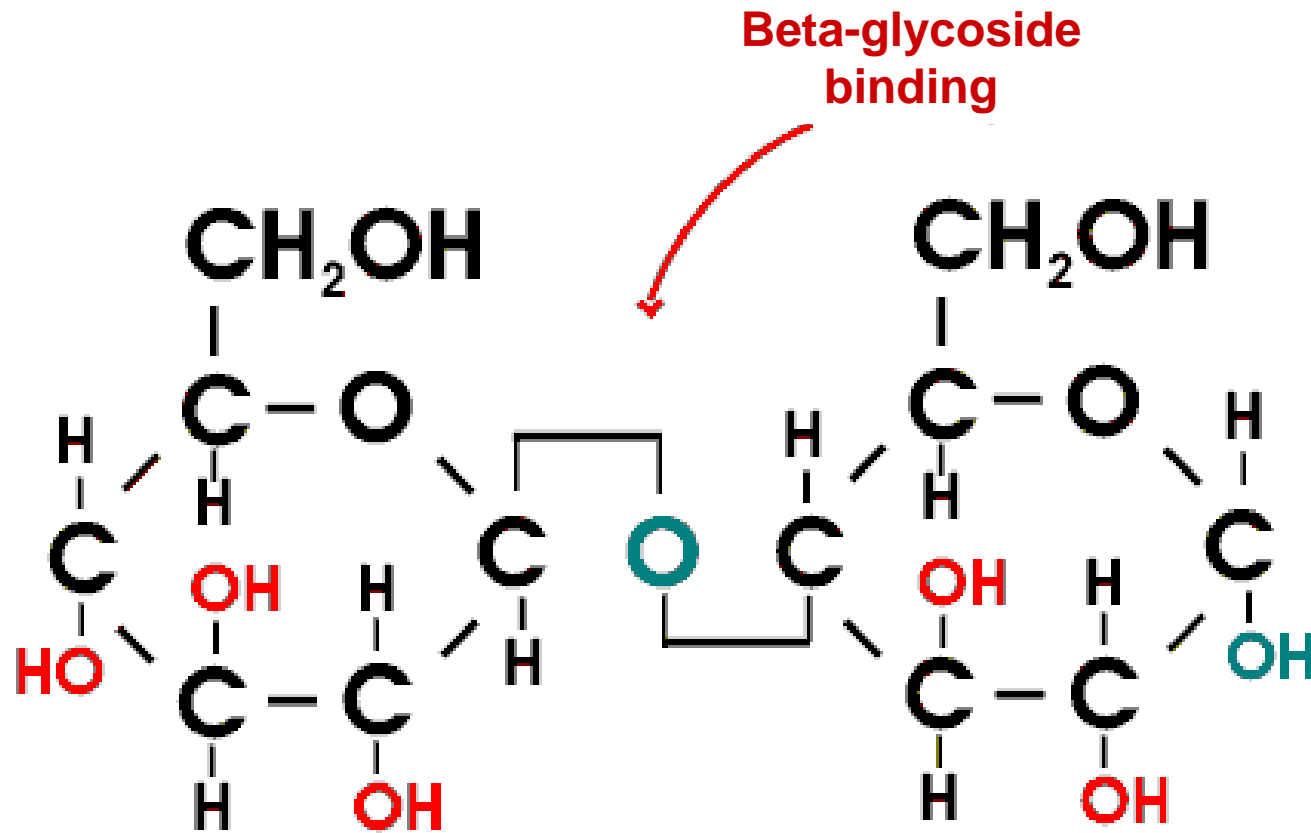


D-glucose

Open-chain and cyclic carbohydrates



Condensation of carbohydrates



Cellobiose
(Glucose- β (1->4)-glucose)

Physiological role of carbohydrates

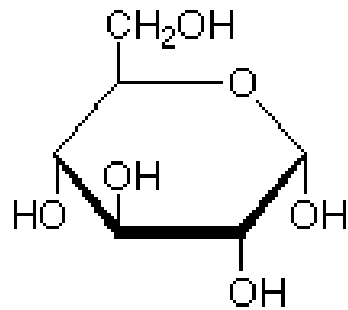


Monosaccharides are the major source of fuel for metabolism, being used both as an energy source (glucose being the most important in nature) and in biosynthesis. When monosaccharides are not immediately needed by many cells they are often converted to more space efficient forms, often polysaccharides. In many animals, including humans, this storage form is glycogen, especially in liver and muscle cells. In plants, starch is used for the same purpose.

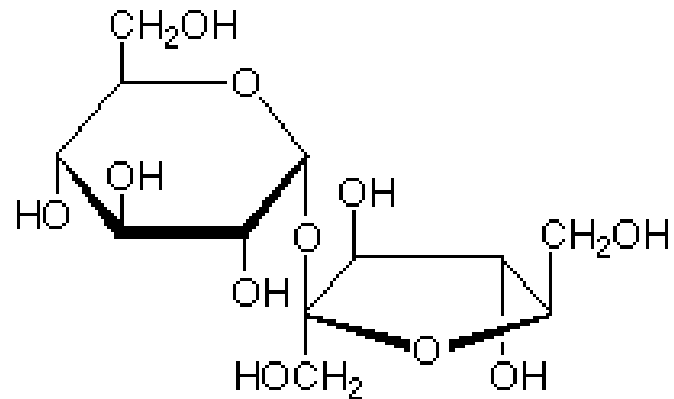


Polysaccharides

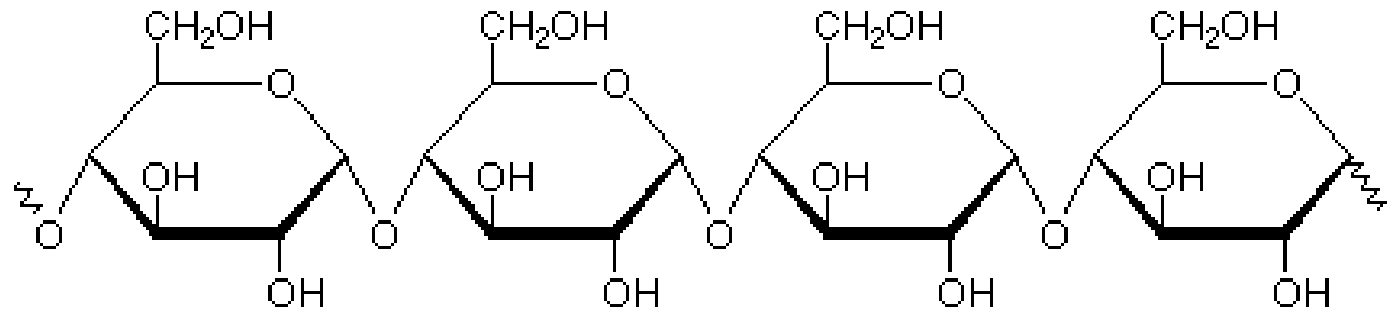
Disaccharides



monosaccharide (glucose)

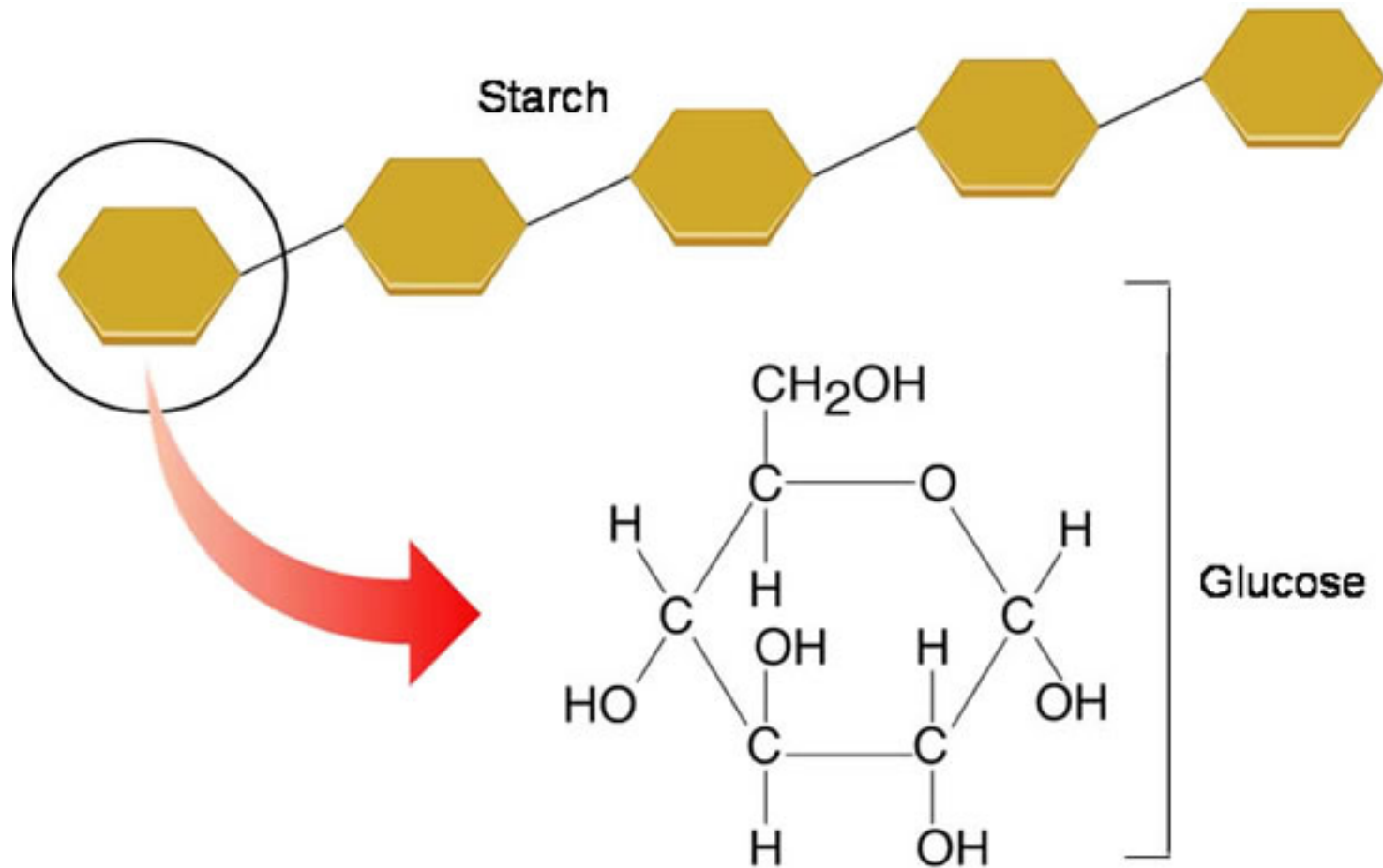


disaccharide (sucrose)

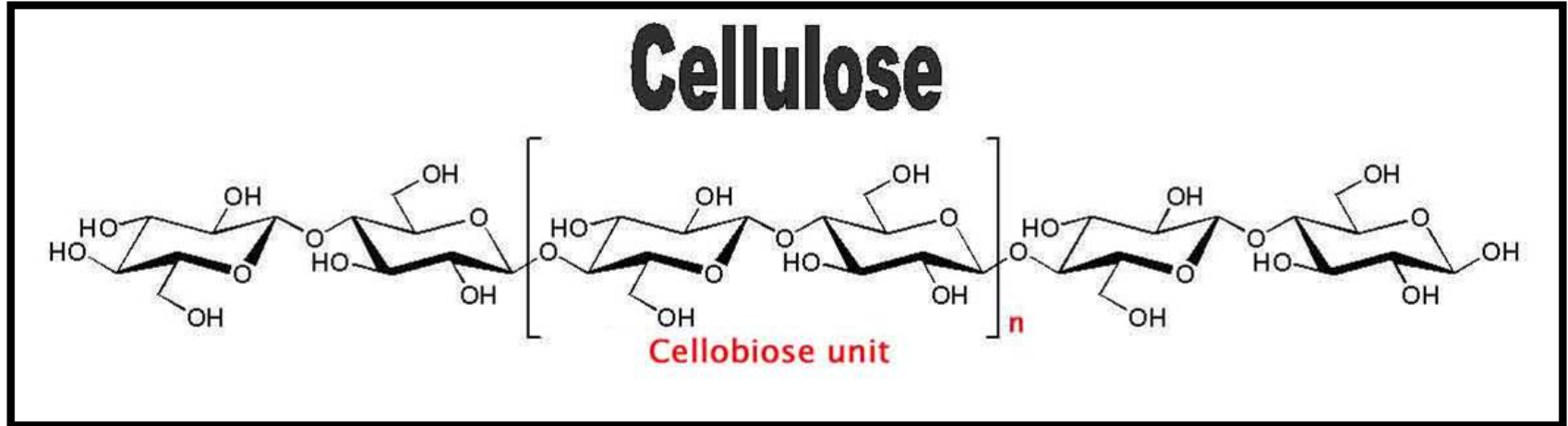


polysaccharide (amylose starch)

Structure of polysaccharides

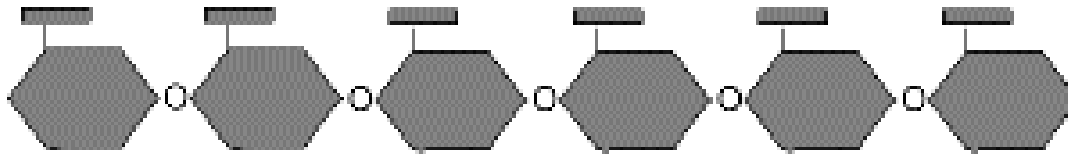


Structure of polysaccharides

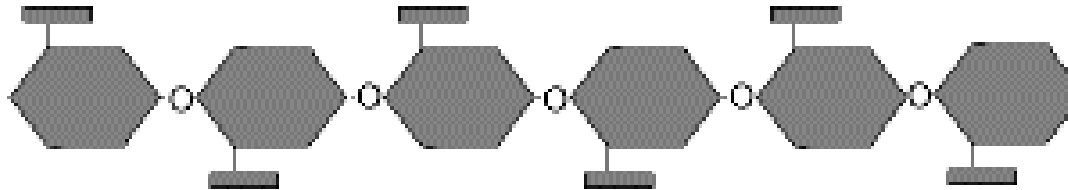


Structure of polysaccharides

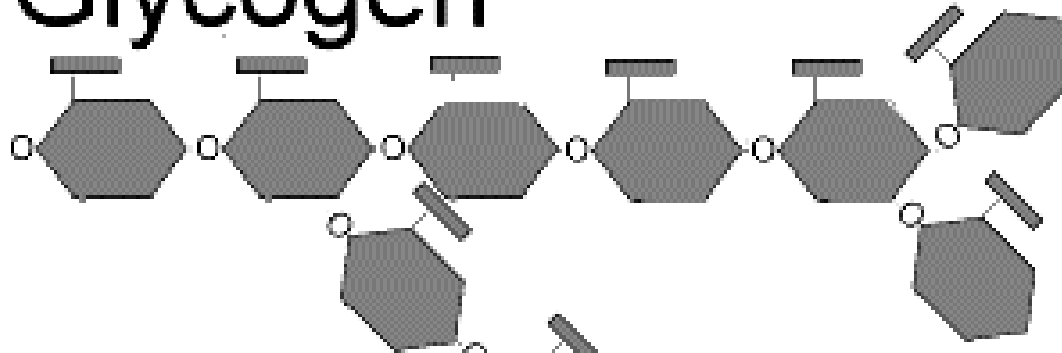
Starch



Cellulose



Glycogen



Physiological role of polysaccharides



Carbohydrates are not necessary building blocks of other molecules, and the body can obtain all its energy from protein and fats. The brain and neurons generally cannot burn fat for energy, but use glucose or ketones.

Organisms typically cannot metabolize all types of carbohydrate to yield energy. Glucose is a nearly universal and accessible source of calories. Polysaccharides are also common sources of energy. Many organisms can easily break down starches into glucose, however, most organisms cannot metabolize cellulose or other polysaccharides like chitin. These carbohydrates types can be metabolized by some bacteria.

Even though these complex carbohydrates are not very digestible, they may comprise important dietary elements for humans. Called dietary fiber, these carbohydrates enhance digestion among other benefits.

What shall we do?



Feb 19

Introduction to organic and biological chemistry. Classes and nomenclature of organic compounds. Saturated and unsaturated hydrocarbons. S_R and Ad_E reactions.

Mar 4

Aromatic hydrocarbons. Orientation in the aromatic ring. Halogen derivatives of hydrocarbons. S_N reactions. Alcohols, ethers. Polyhydric alcohols.

Mar 18

Carbonyl compounds – aldehydes and ketones. Carbohydrates.

Apr 1

Carboxylic acids and their derivatives: amides, nitriles, anhydrides. Esters, fats.

Apr 15

Amines, aminoacids, peptides. Heterocyclic compounds and their biological activity.