College of Medicine

Medical Chemistry

Lecture No. 1

Organic Compounds Containing Carbon, Hydrogen and Oxygen: Alcohols and Ethers

First stage

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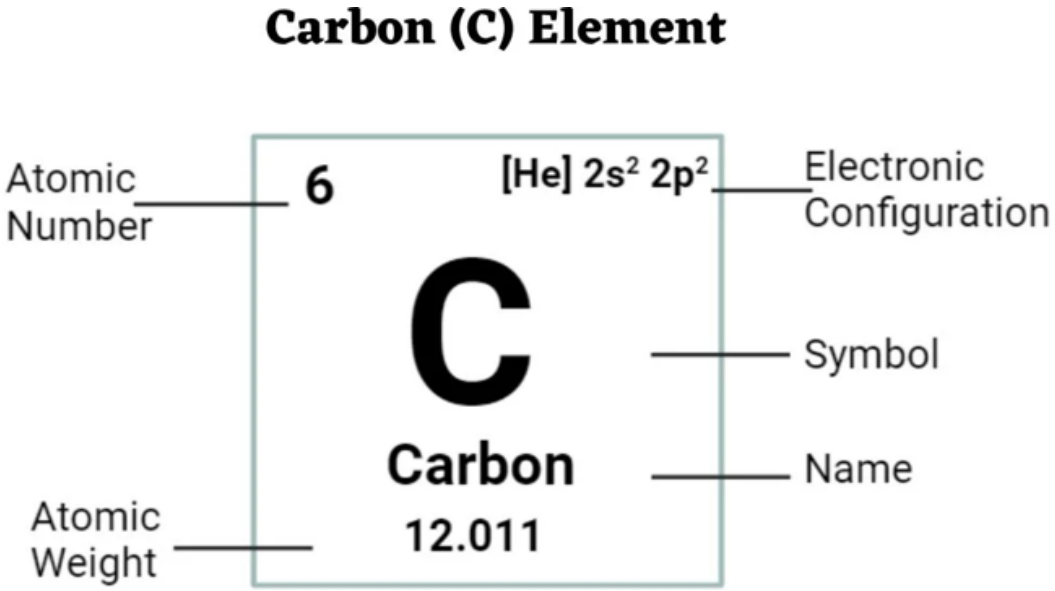
Organic chemistry

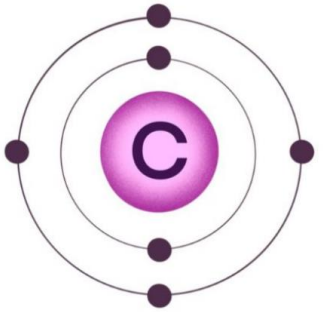
The term "organic chemistry" was first used in about 1807, when Swedish chemist Jöns Jacob introduced it to explain the study of compounds derived from the living resources available in nature.

- **Living organisms consist mostly of carbon-based compounds**
- **The compounds of carbon its ability to form large, complex, and diverse molecules**
- **Proteins, DNA, carbohydrates, and other molecules that distinguish living matter are all composed of carbon compounds**

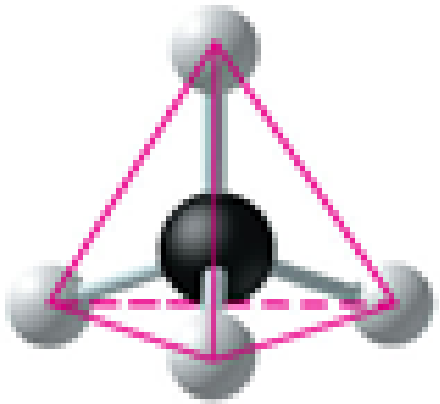


Carbon Skeletons

- Each C atom can form a maximum of 4 bonds because Carbon has 4 valence electrons, thus makes 4 bonds

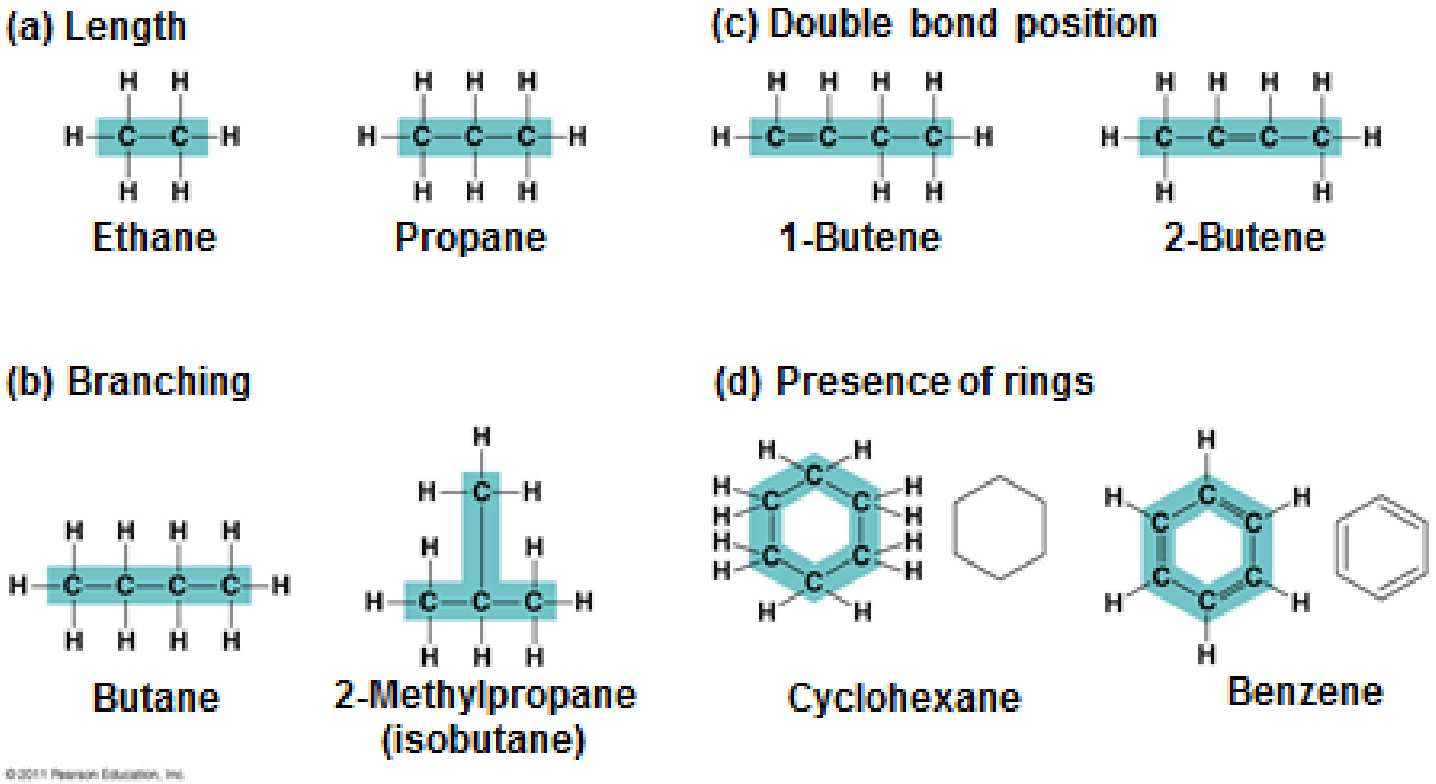


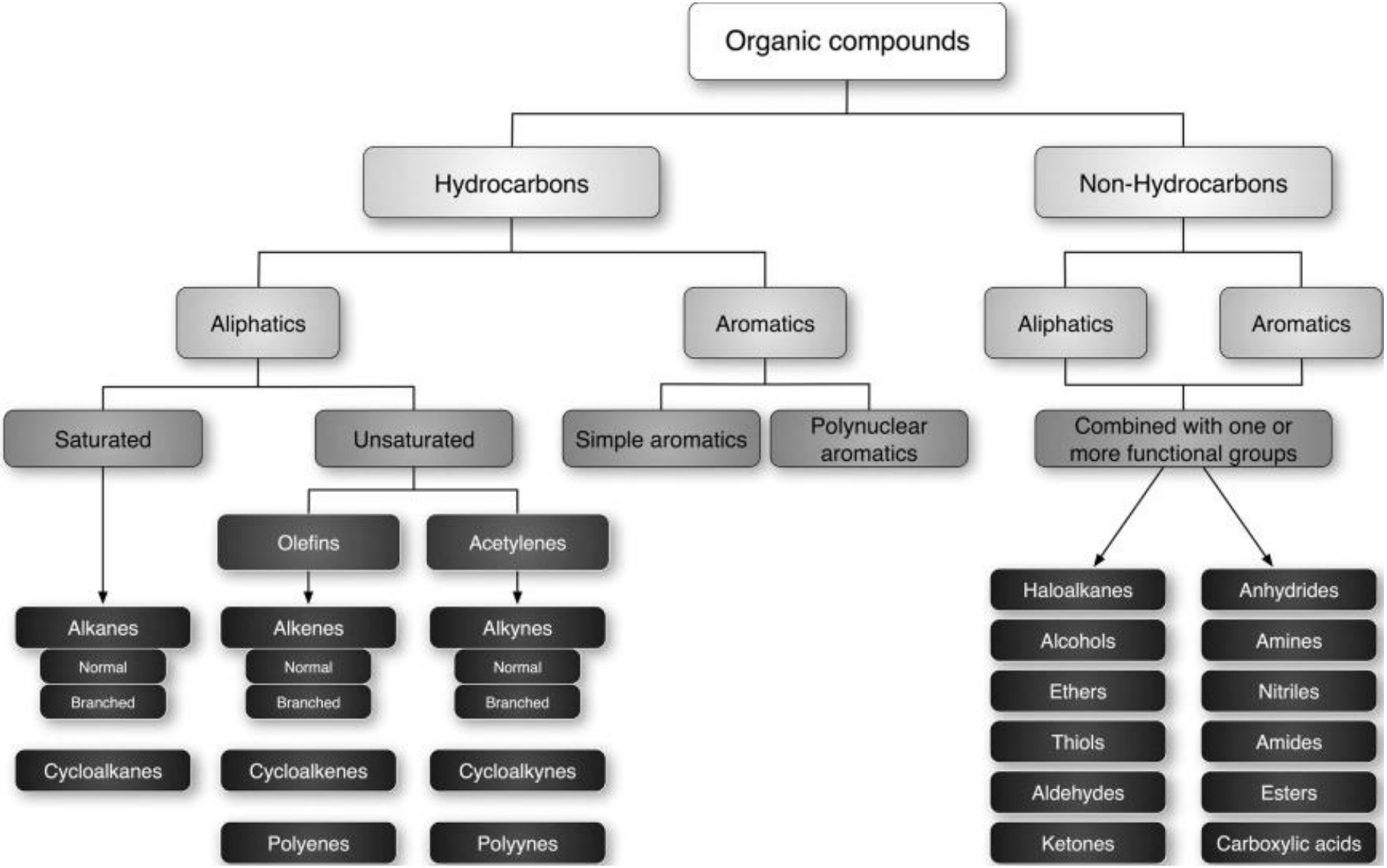
- With four valence electrons, carbon can form four covalent bonds with a variety of atoms
- This ability makes large, complex molecules possible
- In molecules with multiple carbons, each carbon bonded to four other atoms has a tetrahedral shape



Carbon skeletons

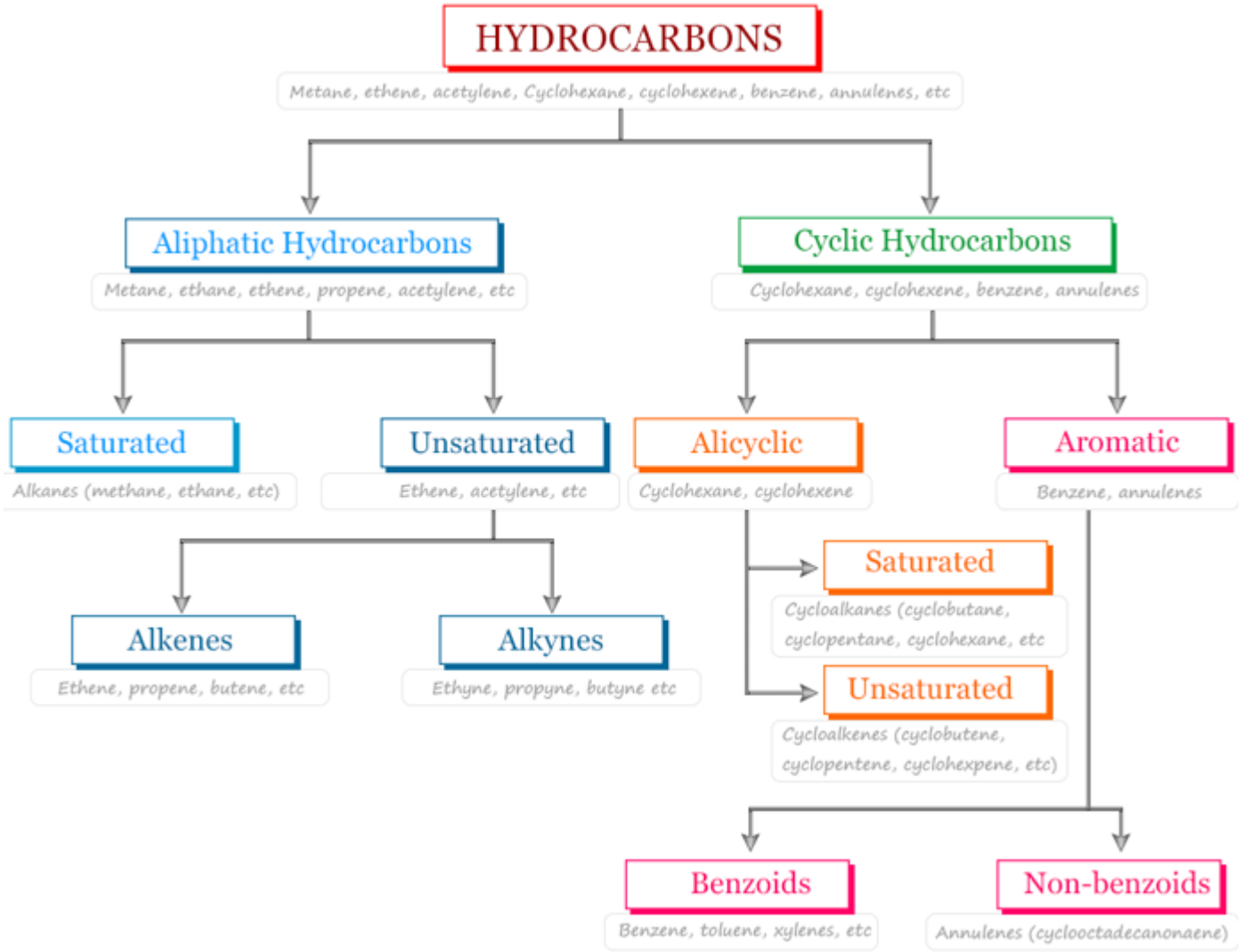
- Carbon chains forming the skeletons of most organic molecules
- Carbon chains vary in length and shape




Organic compounds
Hydrocarbons
Non-Hydrocarbons
Aliphatics
Aromatics
Aliphatics
Aromatics
Saturated
Unsaturated
Simple aromatics
Polynuclear aromatics
Combined with one or more functional groups
Olefins
Acetylenes
Alkanes
Normal
Branched
Alkenes
Normal
Branched
Alkynes
Normal
Branched
Haloalkanes
Alcohols
Ethers
Thiols
Aldehydes
Ketones
Anhydrides
Amines
Nitriles
Amides
Esters
Carboxylic acids
Cycloalkanes
Cycloalkenes
Cycloalkynes
Polyenes
Polyynes

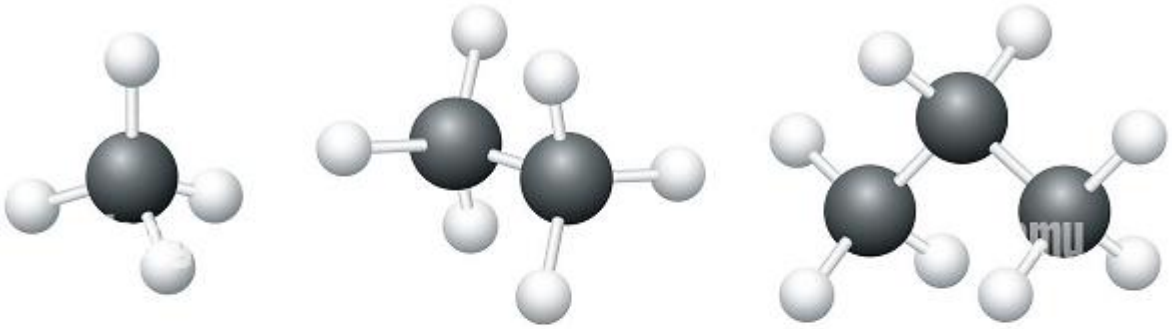
Hydrocarbons

- **Hydrocarbons are organic molecules consisting of *only* carbon and hydrogen**



Hydrocarbons

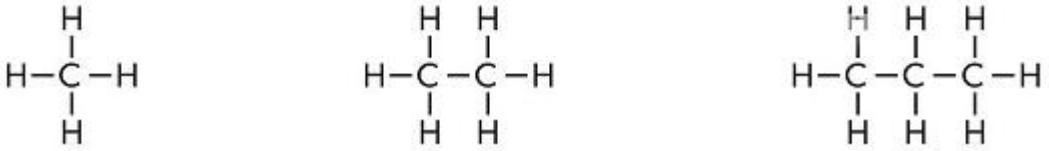
Saturated compound: **organic compounds in which carbon atoms are bonded by single bonds (formula of alkane= C_nH_{2n+2}), exp**:



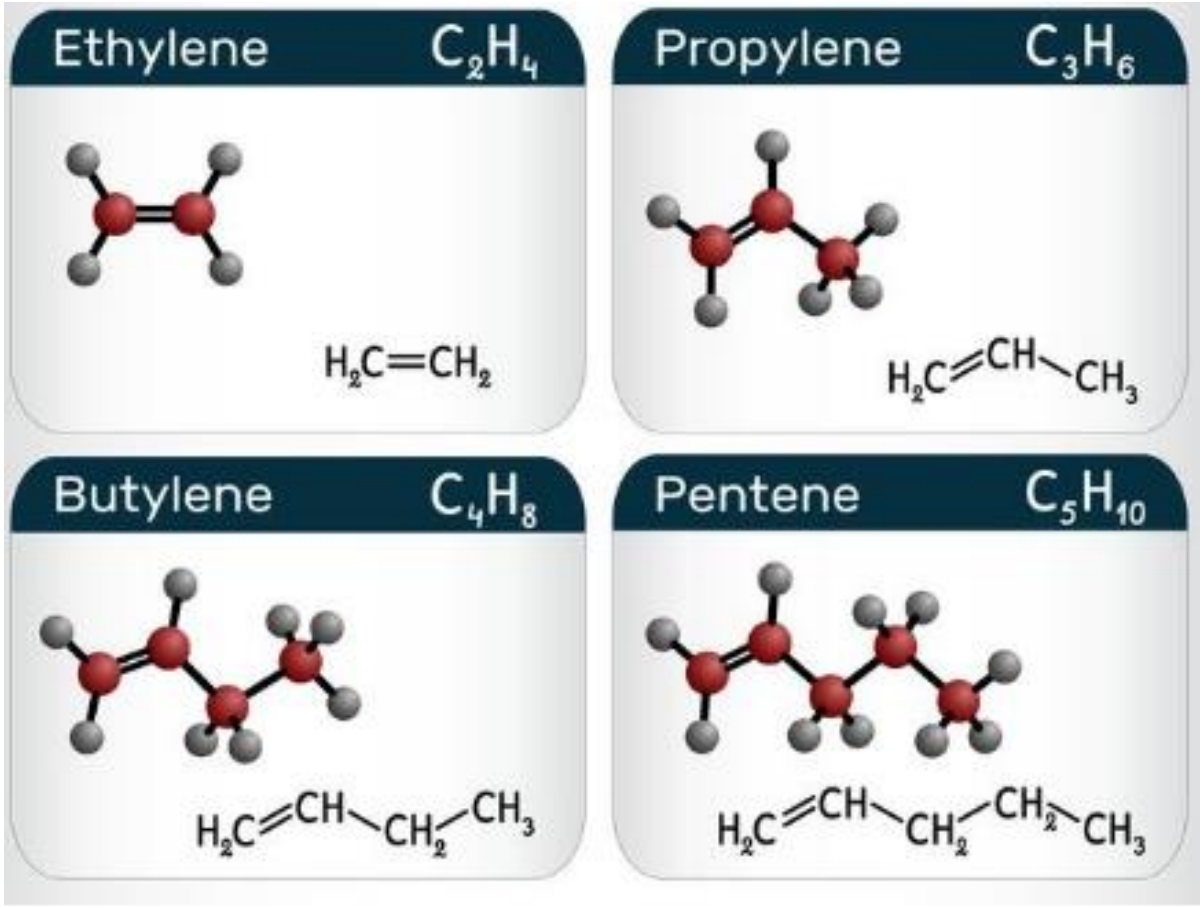
CH_4 Methane

C_2H_6 Ethane

C_3H_8 Propane



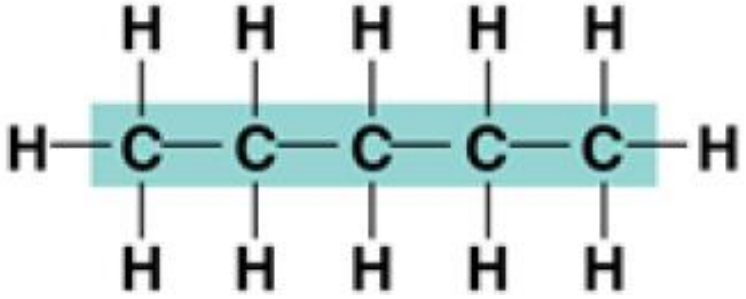
unsaturated compound; - **Compound where carbon atom has double (formula of alkene = C_nH_{2n}) or triple bonds(formula of alkyne= C_nH_{2n-2}) , exp:**

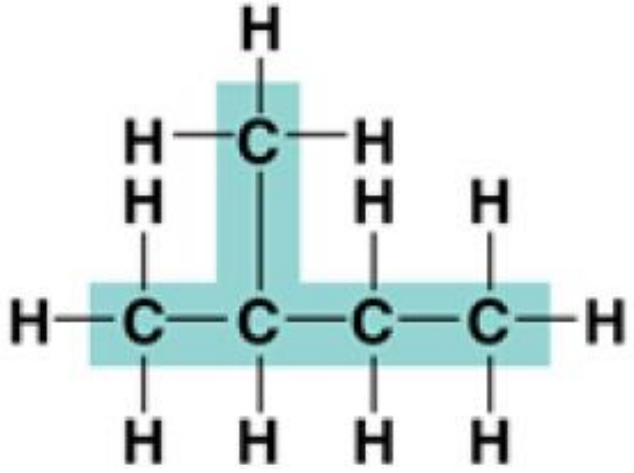


Isomers

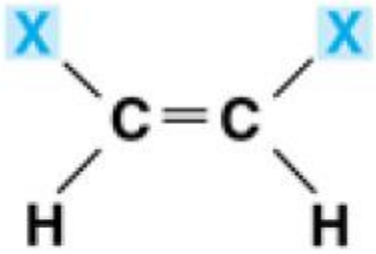
- **Isomers** are compounds with the ***same molecular formula*** but ***different structures,*** thus ***different properties.***

–Structural isomers have different covalent arrangements of their atoms

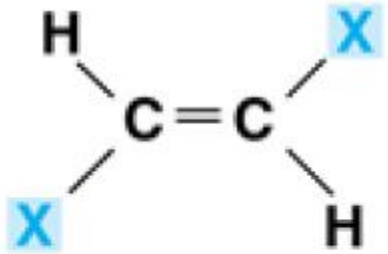




–*Cis-trans* isomers have the same covalent bonds but differ in spatial arrangements

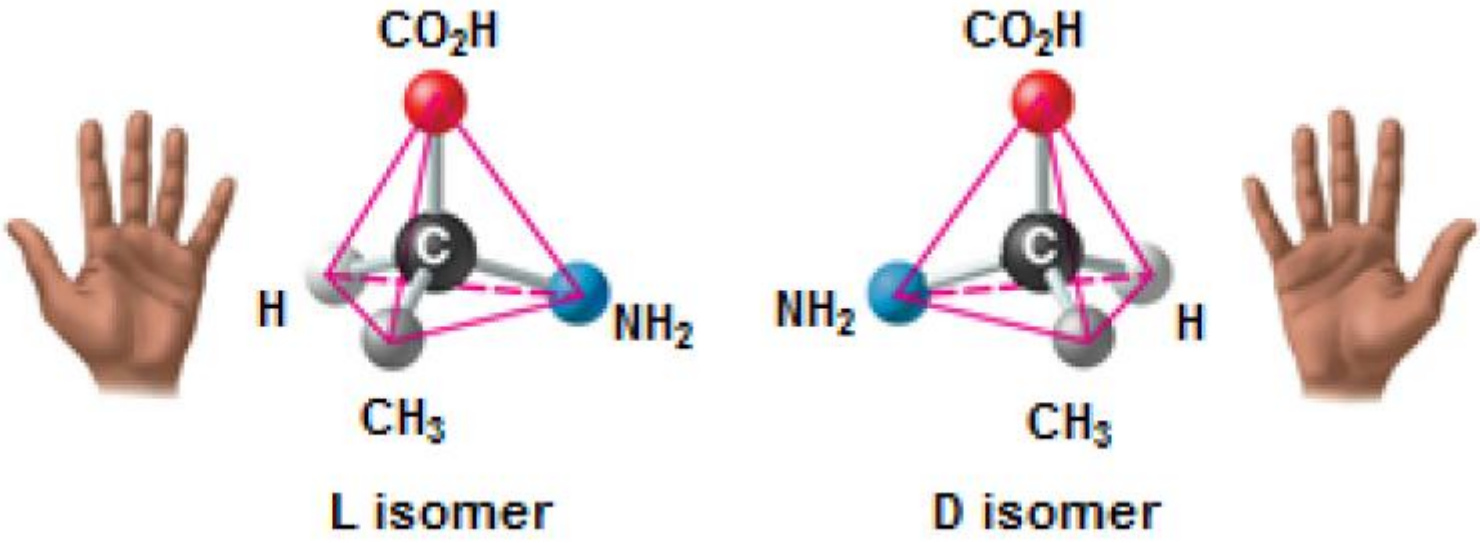


cis isomer: The two Xs are on the same side.



trans isomer: The two Xs are on opposite sides.

—**Enantiomers** **are isomers that are mirror images of each other & rotate light differently**



- **Enantiomers are important in the pharmaceutical industry**
- **Two enantiomers of a drug may have different effects**
- **Usually only one isomer is biologically active**

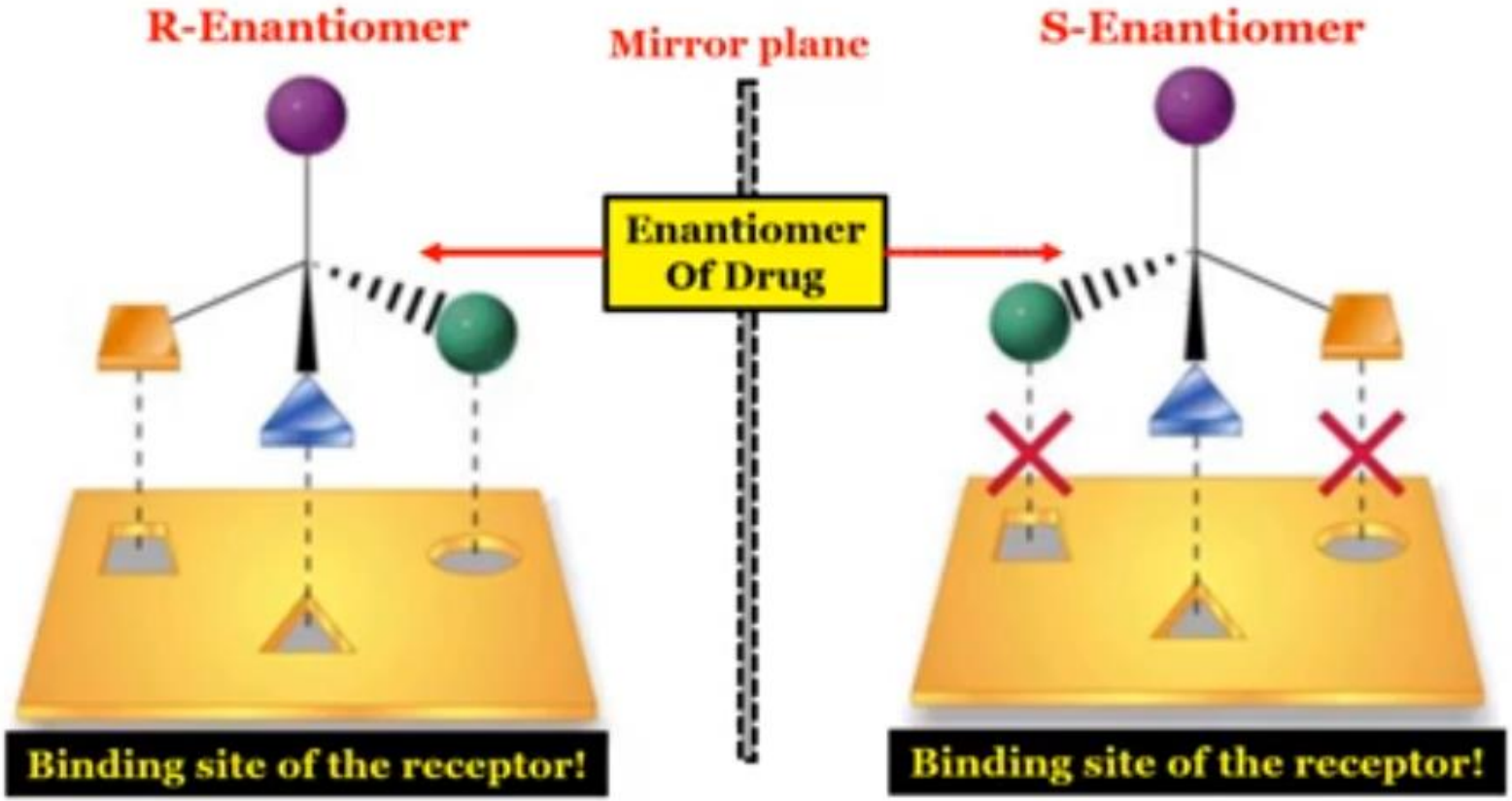
Drug	Condition	Effective Enantiomer	Ineffective Enantiomer
Ibuprofen	Pain; inflammation	 *S*-Ibuprofen	 *R*-Ibuprofen
Albuterol	Asthma	 *R*-Albuterol	 *S*-Albuterol

Drug	Condition	Effective Enantiomer	Ineffective Enantiomer
Ibuprofen	Pain; inflammation	 *S*-Ibuprofen	 *R*-Ibuprofen
Albuterol	Asthma	 *R*-Albuterol	 *S*-Albuterol

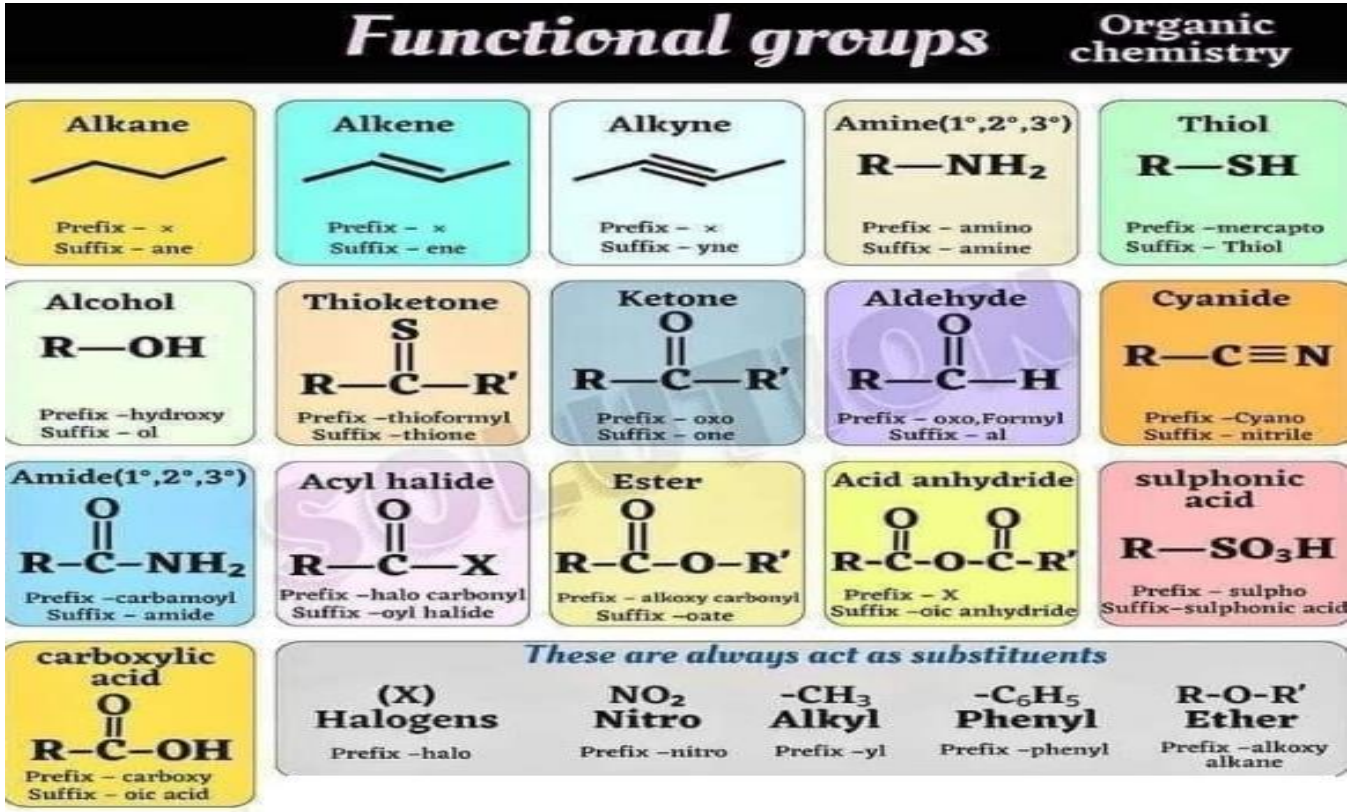
The R means Rectus in Latin (means right) and S means Sinister in Latin (means Left). Molecules that rotate the plane polarised light to right is said as R isomer. Molecule that rotate the plane polarised light to left is said as S isomer.

Enantiomers are important in the pharmaceutical industry

- **Two enantiomers of a drug may have different effects**
- **Usually only one isomer is biologically active**



- **Functional groups** are the components of organic molecules that are most involved in chemical reactions
- The number and arrangement of functional groups give each molecule its unique properties



Hydroxyl

STRUCTURE

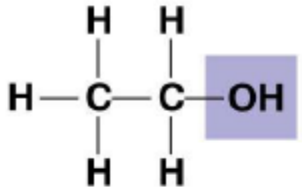
—OH

(may be written HO—)

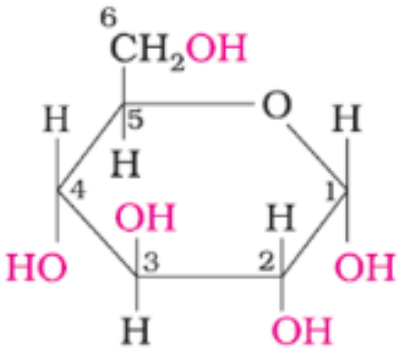
NAME OF COMPOUND

Alcohols (Their specific names usually end in *-ol*.)

EXAMPLE



Ethanol



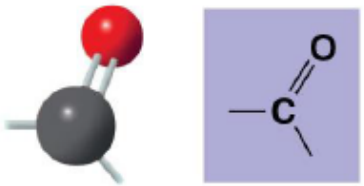
glucose

FUNCTIONAL PROPERTIES

- Is polar as a result of the electrons spending more time near the electronegative oxygen atom.
- Can form hydrogen bonds with water molecules, helping dissolve organic compounds such as sugars.

Carbonyl

STRUCTURE

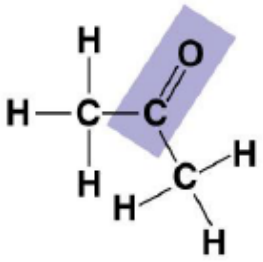


NAME OF COMPOUND

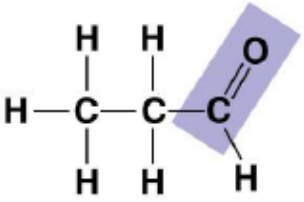
Ketones if the carbonyl group is within a carbon skeleton

Aldehydes if the carbonyl group is at the end of the carbon skeleton

EXAMPLE



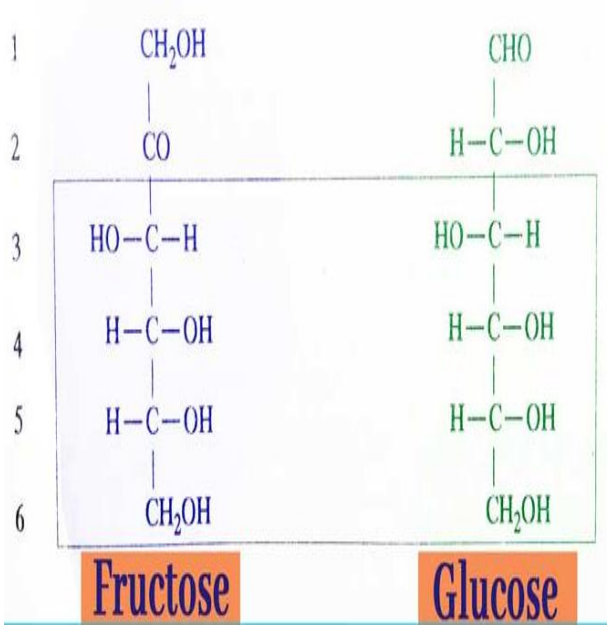
Acetone



Propanal

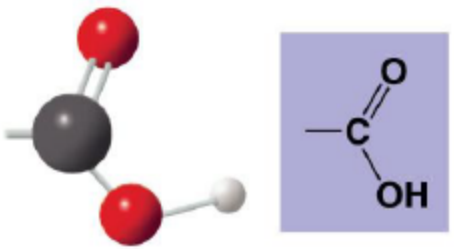
- A ketone and an aldehyde may be structural isomers with different properties, as is the case for acetone and propanal.
- Ketone and aldehyde groups are also found in sugars, giving rise to two major groups of sugars: ketoses (containing ketone groups) and aldoses (containing aldehyde groups).

FUNCTIONAL PROPERTIES



Carboxyl

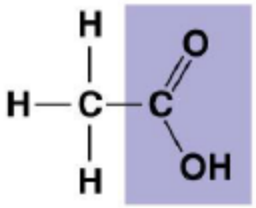
STRUCTURE



NAME OF COMPOUND

Carboxylic acids, or organic acids

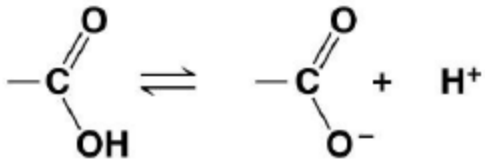
EXAMPLE



Acetic acid

FUNCTIONAL PROPERTIES

- Acts as an acid; can donate an H^+ because the covalent bond between oxygen and hydrogen is so polar:

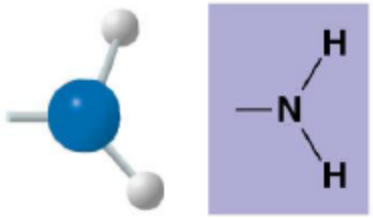


Nonionized Ionized

- Found in cells in the ionized form with a charge of 1– and called a carboxylate ion.

Amino

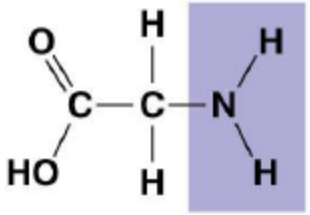
STRUCTURE



Amines

NAME OF COMPOUND

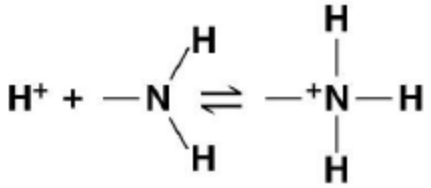
EXAMPLE



Glycine

FUNCTIONAL PROPERTIES

- Acts as a base; can pick up an H^+ from the surrounding solution (water, in living organisms):

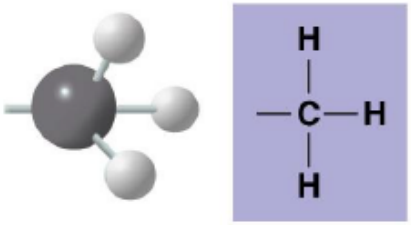


Nonionized Ionized

- Found in cells in the ionized form with a charge of 1+.

Methyl

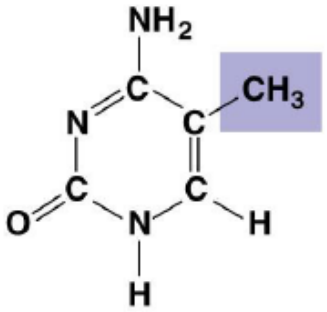
STRUCTURE



Methylated compounds

NAME OF COMPOUND

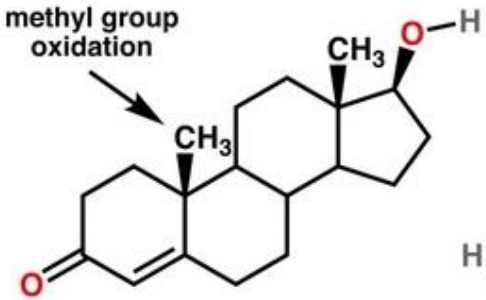
EXAMPLE



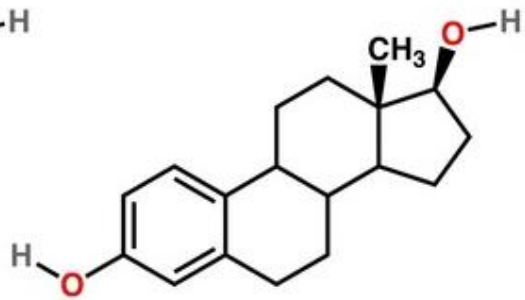
5-Methyl cytidine

FUNCTIONAL PROPERTIES

- Addition of a methyl group to DNA, or to molecules bound to DNA, affects the expression of genes.
- Arrangement of methyl groups in male and female sex hormones affects their shape and function.



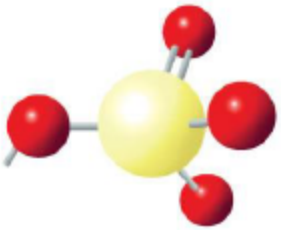
testosterone

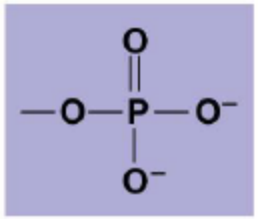


estradiol

Phosphate

STRUCTURE

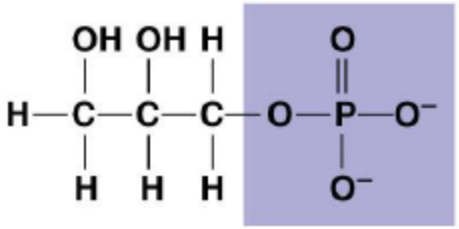




Organic phosphates

NAME OF COMPOUND

EXAMPLE



Glycerol phosphate

FUNCTIONAL PROPERTIES

- Contributes negative charge to the molecule of which it is a part (2– when at the end of a molecule, as at left; 1– when located internally in a chain of phosphates).
- Molecules containing phosphate groups have the potential to react with water, releasing energy.

ATP: An Important Source of Energy for Cellular Processes

- One phosphate molecule, **adenosine triphosphate** (**ATP**), is the primary energy-transferring molecule in the cell
- ATP consists of an organic molecule called adenosine attached to a string of three phosphate groups