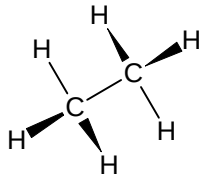
Chapter 25: The Chistry of Life: Organic and Biological Chemistry

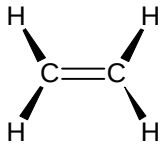
- **organic chemistry** – the study of carbon compounds
- **biochemistry** – the stuyd of the chemistry of living species

1.1 Introduction to Hydrocarbons

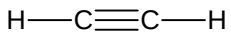
- made of only hydrogen and carbon
- 4 types: alkanes, alkenes, alkynes, and aromatic hydrocarbons
- **alkanes** – only single bonds
  - also called saturated hydrocarbons
  - have the largest amount of hydrogen atoms bonded to a single carbon atom



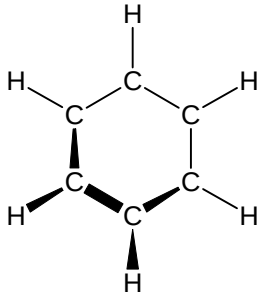
- **alkenes** (olefins) – have double carbon bonds



- **alkynes** – triple carbon bonds



- **aromatic hydrocarbons** – carbon atoms connected in a planar ring structure, joined by σ and π bonds between carbon atoms



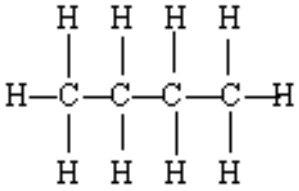
- **alkenes, alkynes and aromatic hydrocarbons** – unsaturated hydrocarbons
- less volatile with increasing molar mass
- very low molecular weight = gas at room temperature
- moderate molecular weight = liquid
- high molecular weight = solid

1.2 Alkanes

- methane major part of natural gas
  - used in home heating, gas stoves, hot-water heaters

- propane major part of bottled gas
    - used for home heating, cooking
- butane – used in disposable lighters, fuel canisters
- alkanes with 5-12 carbon atoms are found in gasoline
- formla for alkanes is called *condensed structural formulas*

Molecular Formula	**Condensed Structural Formula**	**Name**	**Boiling point (°C)**
CH_4	CH_4	Methane	-161
C_2H_6	$CH_3\ CH_3$	Ethane	-89
C_3H_8	$CH_3\ CH_2\ CH_3$	Propane	-44
C_4H_{10}	$CH_3\ CH_2\ CH_2\ CH_3$	Butane	-0.5
C_5H_{12}	$CH_3\ CH_2\ CH_2\ CH_2\ CH_3$	Pentane	36
C_6H_{14}	$CH_3\ CH_2\ CH_2\ CH_2\ CH_2\ CH_3$	Hexane	68
C_7H_{16}	$CH_3\ CH_2\ CH_2\ CH_2\ CH_2\ CH_2\ CH_3$	Heptane	98
C_8H_{18}	$CH_3\ CH_2\ CH_2\ CH_2\ CH_2\ CH_2\ CH_2\ CH_3$	Octane	125
C_9H_{20}	$CH_3\ CH_2\ CH_2\ CH_2\ CH_2\ CH_2\ CH_2\ CH_2\ CH_3$	Nonane	151
$C_{10}H_{22}$	$CH_3\ CH_2\ CH_2\ CH_2\ CH_2\ CH_2\ CH_2\ CH_2\ CH_2\ CH_3$	Decane	174



Lewis Structure

$CH_3\ CH_2\ CH_3$

Condensed structural formula

1.2.1 Structures of Alkanes

- tetrahedral geometry
- carbon-carbon single bond rotates easily at room temperature
- long chains tend to change shape

1.2.2 Structural Isomers

- straight-chained hydrocarbons – carbons atoms that are joined in a continuous chain
- branched-chain hydrocarbons – hydrocarbons with branched chains, 4 or more carbon atoms
- **structural isomers** – compounds with the same molecular formula but different bonding arrangements

1.2.3 Nomenclature of Alkanes

- **1)** Find the longest continuous chain of carbon atoms, and use the name of this chain as the base name of the compound.
- **2)** Number the carbon atoms in the longest chain, beginning with the end of the chain that is nearest to a substituent
- **3)** Name and give the location of each substituent group
- **4)** When two or more substituents are present list them in alphabetical order

1.2.4 Cycloalkanes

- alkanes that form rings or cycles
- carbon rings with fewer than five carbon atoms are strained
- more reactive

1.2.5 Reactions of Alkanes

- at room temperature alkanes do not react with acids, bases, or strong oxidizing agents
- important for it's combustion in air; bases for fuels

1.3 Unsaturated Hyrocarbons

1.3.1 Alkenes

- double carbon bonds
- ethene or ethylene simplest alkene\
- nomenclature of alkenes come from the name of the corresponding alkane
- the –ane ending is changed to –ene
- **geometrical isomers** – compounds that have the same molecular formula and the same groups bonded to one another but differ in the spatial arrangement of these groups
- geometrical isomers have distinct physical properties and differ in chemical behavior
- the double carbon bond is resistant to twisting
- rotation about a double bond is a key process in the chemistry of vision

1.3.2 Alkynes

- one or more triple bonds
- simplest alkyne is acetylene
- highly reactive
- named by changing the alkane ending (-ane) to –yne

1.3.3 Addition Reactions of Alkenes and Alkynes

- **addition reactions** – a reactant is added to the two atoms that form the multiple bond
- **hyrogenation** – reaction between al alkene and H_2

1.3.4 Aromatic Hydrocarbons

- simplest is benzene
- stability comes from the stabilization of the π electrons through delocalization in the π orbitals
- represented by a hexagon with an inscribed circle
- **substitution reactions** – one atom of a molecule is removed and replaced by another atom or group of atoms

1.4 Functional Groups; Alcohols and Ethers

- **functional group** – site of reactivity in an organic molecule; controls how the molecule behaves or functions
- chemistry of an organic molecule is determined by the functional groups it contains

1.4.1 Alcohols (R-OH)

- **alcohols** – hydrocarbon derivatives in which one ore more hydrogens of a parent hydrocarbon have been replaced by a hydroxyle or alcohol functional group

1.4.2 Ethers (R-O-R')

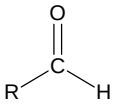
- **ethers** – two hyrocarbon groups are bonded to one oxygen
- formed from two molecules of alcohol by splitting out a molecule of water
- **condensation reaction** – reaction where water is split out from two substances

- used in solvents

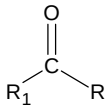
1.5 Compounds with a Carbonyl Group

- carbon oxygen double bonds

1.5.1 Aldehydes and Ketones

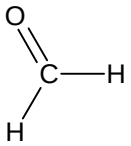


aldehydes



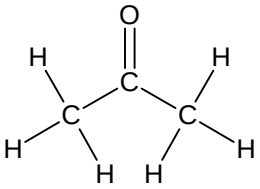
ketones

- carbonyl group in aldehydes has at least one attached hydrogen atom



formaldehyde

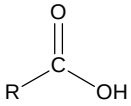
- carbonyl group in ketones occurs at the interior of a carbon chain



Acetone

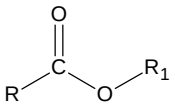
- prepared by oxidizing alcohols

1.5.2 Carboxylic Acids



- carboxylic acids contain carboxyl functional group (COOH)
- important for manufacturing of polymers
- produced by oxidation in which the OH group is attached to the CH_2

1.5.3 Esters



- carboxylic acids that undergo condensation with alcohols
- have pleasant odors
- saponification – hydrolysis of an ester in a base

1.5.4 Amines and Amides

- **amines** – organic bases; general formula R_3N
- **amides** – anines containing a hydrogen bonded to nitrogen that undergoes condensation

1.6 Introduction to Biochemistry

- **biosphere** – part of the earth where living organisms are formed and living
  - includes influences on life of the atmosphere, natural waters, solid earth
- living organisms require a large amount of energy
- **biopolymers** – three categories: proteins, polysaccharides (carbohydrates), and nucleic acids

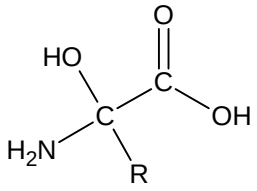
1.7 Proteins

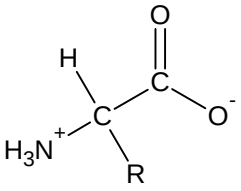
- macromolecular substances
- 50% body's dry weight is pı
- composed of amino acids

or

1.7.1 Amino Acids

- differ in the R group
- building block of all proteins - α-amino acid
- general form:

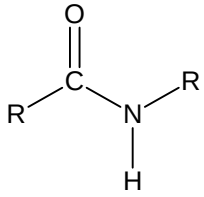




- **chiral** - any molecule containing a carbon with four different attached groups
- **enantiomers** – mirror-image of chiral
- enantiomers and chiral have the same physical properties
- differ in chemical reactivity toward other chiral molecules

1.7.2 Polypeptides and Proteins

- **peptide bond** – condesation reaction between the carboxyl group of one amino acid and the amino group of another amino acid



- **polypeptides** – large number of amino acids that are linked together by peptide bonds
- proteins are polypeptide molecules
  - weighs from 6000 to over 50 million amu

1.7.3 Protein Structure

- **primary structure** – arrangement of amino acids along a protein chain
  - makes the protein unique
- **secondary structure** – the way segments of the protein chain are oriented in a regular pattern
- **α-helix** – most important and common secondary structure arrangement
  - first propoesed by Linus Pauling and R. B. Corey
- **tertiary structure** – overal shape of a protein

- **globular protein** – a protein that folds into a compact spherical shape
  - soluble in water, mobile within cells
- **enzymes** – large protein molecules that serve as catalysts

1.8 Carbohydrates

- written as $C_x(H_2O)_y$
- glucose the most abundant carbohydrate $C_6H_{12}O_6$
- not really hydrates of carbon but polyhydroxly aldehydes and ketones

1.8.1 Disaccharides

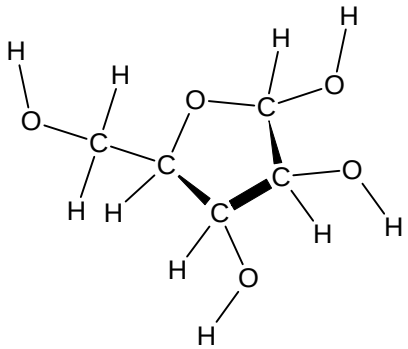
- **monosaccharides** – simple sugars that can't be broken into smaller molecules by hydrolysis with aqueous acids
- **disaccharide** – two linked monosaccharides
- two common disaccharides: sucrose, lactose

1.8.2 Polysaccharides

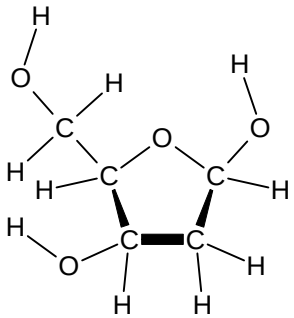
- made of several monosaccharide units
- **starch** – group of polysaccharides
  - food storage in plant seeds and tuers
- **glycogen** – starchlike substance synthesized in the body
  - 5000 to more than 5 million amu
  - energy bank in the body; muscles and liver
- cellulose – major strructural unit of plants
  - straight chains of glucose units
  - more than 500,000 amu

1.9 Nucleic Acid

- **nucleic acids** – biopolymers that are chemical carriers of an organisn't genetic information
- **deoxyribonucleic acids (DNA)** – huge molecules with molar weights of 6-16million amu
- **ribonucleic acids (RNA)** – smaller molecules with molecular weights of 20,000 to 40,000 amu
- DNA found inside the nucleus of a cell, RNA found outside nucleus in the cytoplasm
- DNA stores the genetic information of the cell and controls the production of proteins
- RNA carries information from the DNA out of the nucleus
- Monomers of nucleic acids (nucleotides) have three parts:
  - 1) A phosphoric acid molecule, H_3PO_4
  - 2) A fice-carbon sugar
  - 3) A nitrogen-containing organic base



ribose



deoxyribose

- deoxyribose has one less oxygen atom at carbon 2 than ribose

- nucleic acids are polynucleotides
- DNA molecules made of two DNA chains that form a double helix

molecular structures created from ChemSketch program
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