Organic Chemistry

Organic Chemistry history

- Organic chemistry is the study of carbon and carbon containing molecules

- It spans across many applied disciplines, but in particular:

* 1. Polymer chemistry
  2. Petroleum engineering
  3. Biochemistry

Organic chemistry wasn’t always well known

- Until the early 19th century, the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ theory simply assumed there were living things (organic chemicals) and non-living things (inorganic molecules)

- In 1828, Friedrich Wöhler accidentally synthesized urea

- “I must tell you that I can prepare urea without requiring a kidney or an animal, either man or dog.”

- From then on, organic simply meant that the compounds contained carbon

\* Note: Not everything containing carbon is considered organic

- Ex: CO2

- similarly, we include VERY few things that don’t contain carbon at all

What’s so great about carbon?

- carbon has four valence electrons

- it NEEDS four more for a stable octet

- it gets these by *sharing* four electrons in bonds

- no really, it NEEDS FOUR BONDS ALWAYS!

- note that carbon uses \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ orbitals

- this means its orbitals point in 3-D directions to minimize e- pair angles

Carbon compounds come in a few main groups

- these are supplemented by \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ that may add additional properties to molecules

- \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ are molecules made entirely of hydrogen and carbon

- if saturated, there are ONLY single bonds

- These include \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

- if unsaturated, there are one or more DOUBLE or TRIPLE bonds

- These include \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\* yes, this same analysis applies to biomolecules

- you may have heard of saturated or unsaturated fats

- saturated means only single bonds

- unsaturated means they contain double or triple bonds, called “\_\_\_\_\_\_\_\_\_\_\_”

Isomerism

- this is the phenomena of two compounds having the same molecular formula, but different spatial arrangements

- this is especially important in biochemistry, since much of it is dependent on chemical shape

Ex: Find two isomers with the formula .

Alkanes, Alkenes, and Alkynes

- Alkanes

- straight- or branched-chain hydrocarbons with only SINGLE BONDS between carbons

- these have the formula 

- Alkenes

- unsaturated hydrocarbons containing at least one DOUBLE bond between carbons

- this results in two fewer hydrogens than alkanes

- Alkynes

- unsaturated hydrocarbons containing at least one TRIPLE bond between carbons

- this results in four fewer hydrogens than alkanes

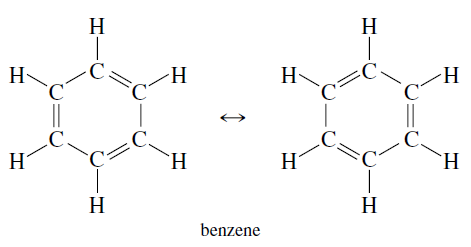
- we use the simple numbering system:

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| meth- | eth- | prop- | but- | pent- | hex- | hept- | oct- | non- | dec- |

- you specify parts by counting from the shortest end of a chain to the first appendage

Ex For each alkane, identify the longest chain, then name the molecule.

|  |  |  |
| --- | --- | --- |
|  |  |  |
|  |  |  |



Aromatic Hydrocarbons

- these are sometimes referred to as “benzene ”

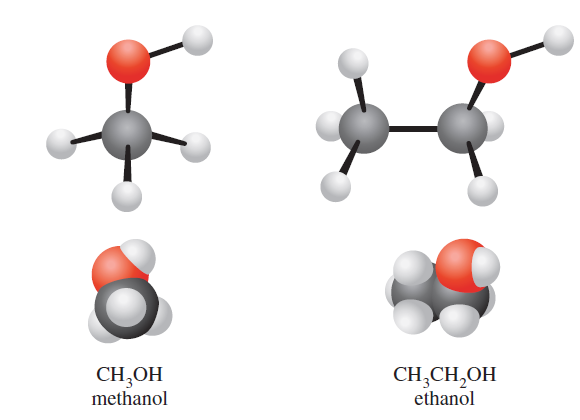
- their primary identification is the ring structure central to the atom

- the rings consists of alternating bonded - double bonded carbons

- it was later found that the six carbons form a massive hybrid 1.5 bond

- 1 bond from s-orbitals

- .5 bond from 3 bonds shared with six carbons

Functional groups

- these are distinct groups of atoms that attach to any hydrogen in a hydrocarbon

- they effectively replace a hydrogen

- they give very specific properties to any given molecule

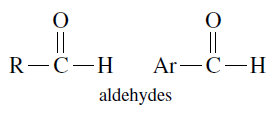
- molecules of the same functional group are VERY similar in behavior

Alcohols

- characterized:

- this group is called the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

- the important part of this group is that it adds \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ to the molecule

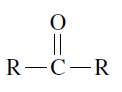
The Carbonyl Group

- this group is characterized by:

\* note the double bond

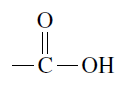
- if this is added to the end of a molecule, it’s called a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Ex: Formaldehyde, CH2O



- if added somewhere “in the middle”, it’s called a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Ex: Acetone, CH3COCH3

Carboxylic acids

- characterized by

- this group is called the

- WAIT! ACID?! HOW?!

\* these release a H+ in solution =)

Ex: Acetic acid, CH3COOH, reacts with sodium hydroxide. Show the chemical reaction;

label products.

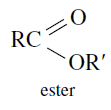
Ethers

- characterized by the formula

\* note that alcohols and ethers have the same formula

- it is important to know the name, so we know the structure!

Ex: C2H6O can represent either:

Esters

- characterized by

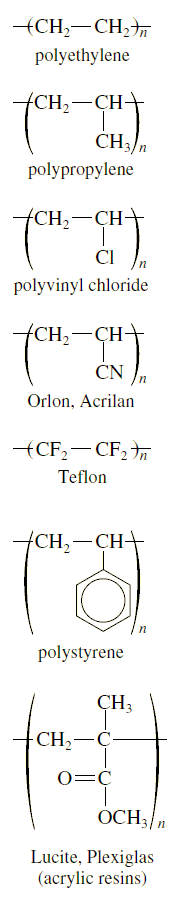
- created by the process of



- these smell GOOD!

- account for many artificial scents

Ex. Acetic acid and ethyl alcohol produce ethyl acetate and water.

Polymers and Plastics

- polymers are LONG chain molecules

- they are made up of one or more monomers

- most polymers are made by addition polymerization

- must begin with an step called \_\_\_\_\_\_\_\_\_\_\_\_\_

- this requires formation of a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

- this causes the rapid step called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

- finally, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ results when radicals collide with each other and bond

\* thus, polymers are of non-uniform length!

Ex Draw a polypropylene chain that is four monomers in length.

**Biochemistry**

Biology and chemistry are not mutually exclusive!

- biology must obey all chemical rules

- most of biology relies on \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

- these are giant molecules with molecular weights greater than even 100,000g/mol

- we’ll see only a few of these

Carbohydrates

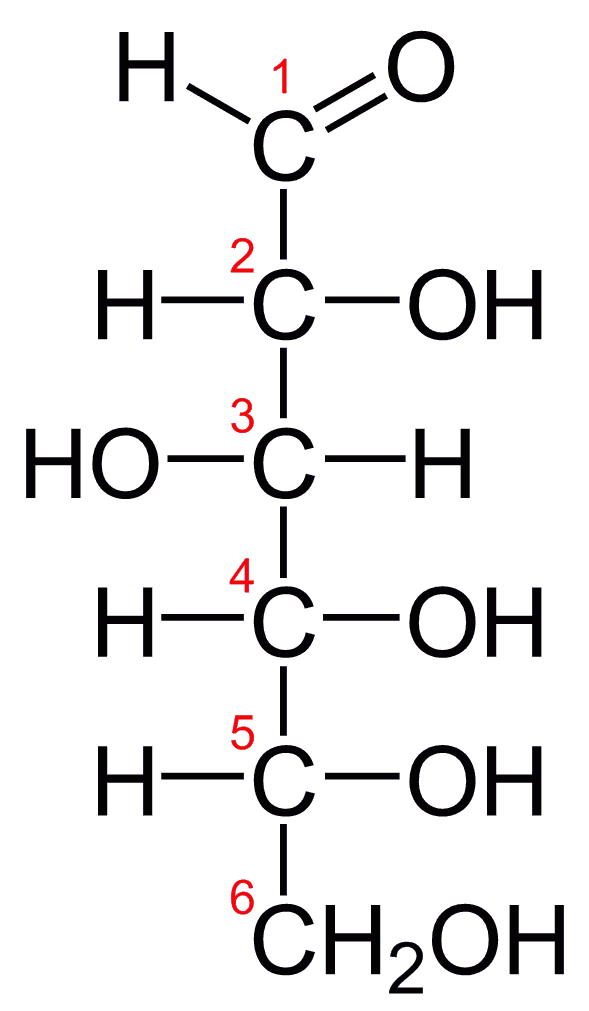
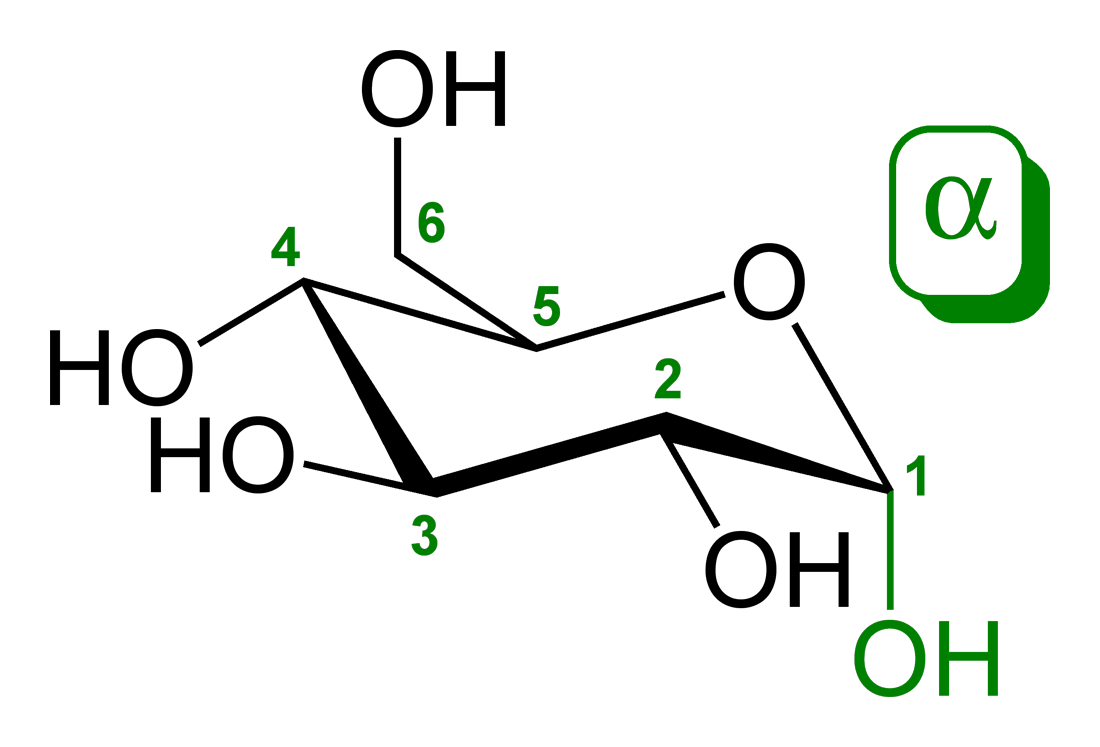
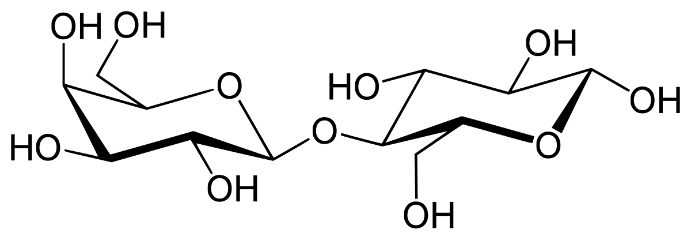
- these are sugars and their polymers

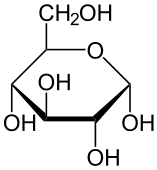
- simple sugars serve as fuel for us (monosaccharides and disaccharides)

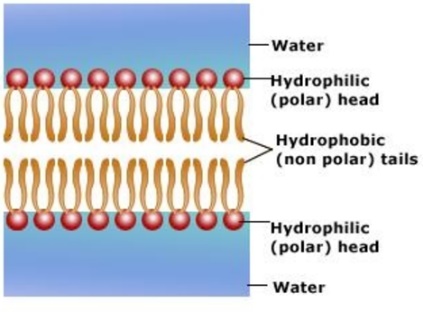
- examples are glucose, fructose, sucrose, lactose, and maltose

- polysaccharides have hundreds or thousands of monosaccharides

- animals store \_\_\_\_\_\_\_\_\_\_\_\_\_\_; plants store \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 - animals may only sustain for about a day on this



Lipids

- fat soluble molecules that are

- may be large molecules (about 16 – 18 carbons long)

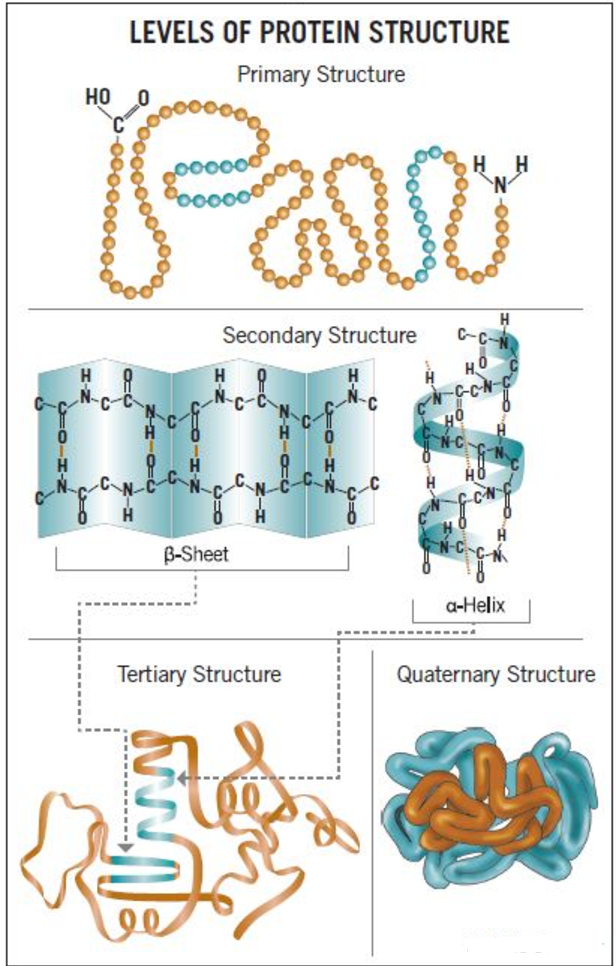
- this class encompasses fats, oils, phospholipids, and steroids

- these can store a whole lot of energy!

- fats can be deposited as adipose tissue in mammals

- fats contain roughly twice as much energy as a polysaccharide

- also adds additional heat insulation



Proteins

- very very VERY important in biology!

- made of amino acid polymers, called a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

- only 20 amino acids are required to make ALL proteins

- just different sequences

- function depends on 3-D \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Primary** structure: AA sequence

**Secondary** structure: foldings or helices caused by \_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Tertiary** structure: irregular contortions caused by side chains interactions

**Quaternary** structure: results from interactions between polypeptides

- if proteins heat up too much, they undergo \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

- structures break down, and thus protein does not exist anymore

- often cannot be put back how it should be

Enzymes

- biocatalysts for reactions that requires putting parts together or breaking them apart

- they are proteins themselves, and also are very important in putting proteins together (or breaking them down)

- a goes into an ezyme’s

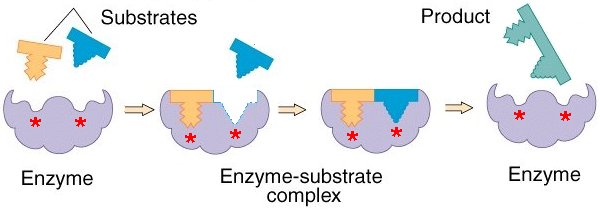
- this forms a complex

- enzyme inhibitors are other molecules/proteins that may enter the active site, but cannot react

- thus, the actual substrate can’t enter and the reaction doesn’t happen

- this is not always a bad thing

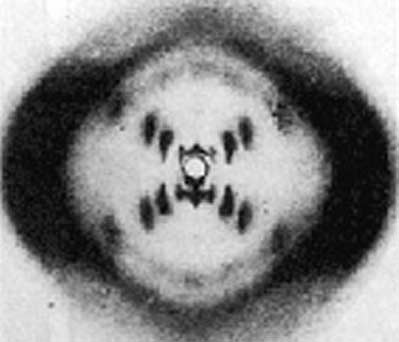
- are inorganic compounds or elements that help enzymes to activate or function



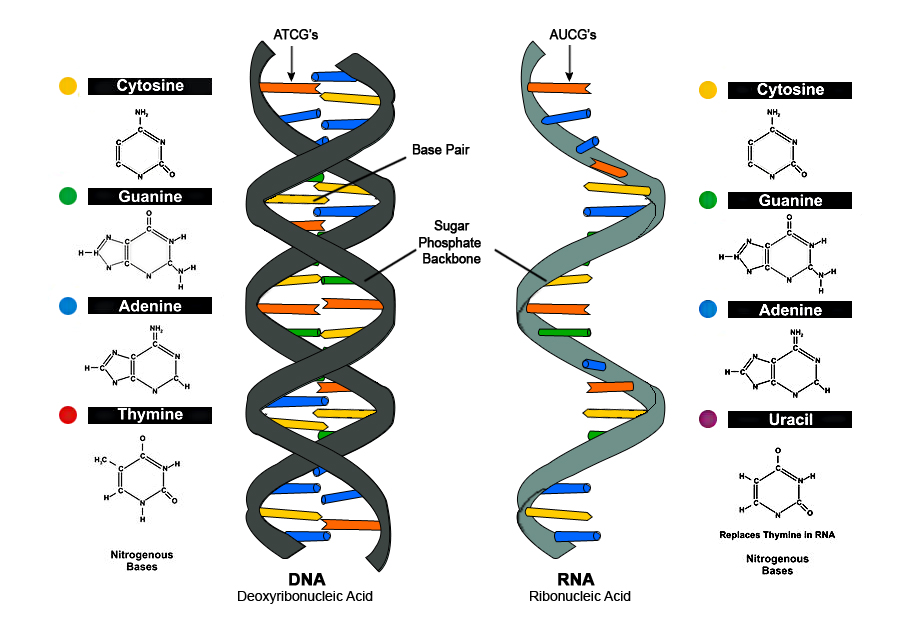
Nucleic Acids (DNA and RNA)

- their workings are beyond the scope of this class

- we may say it is made up of a nitrogenous base and a five-carbon sugar

 - each is held by a phosphate bridge

- all inheritance (and life itself) is due to this structure

RNA:

- uses the sugar ribose

- single strand, using bases:

A = adenine G = guanine

C = cytosine U = uracil

DNA:

- uses the sugar deoxyribose

- includes the base T = thymine instead of U

- base pairs are always:

- two strands are held together by

- the resulting structure is a

- James and Francis originally proposed this structure

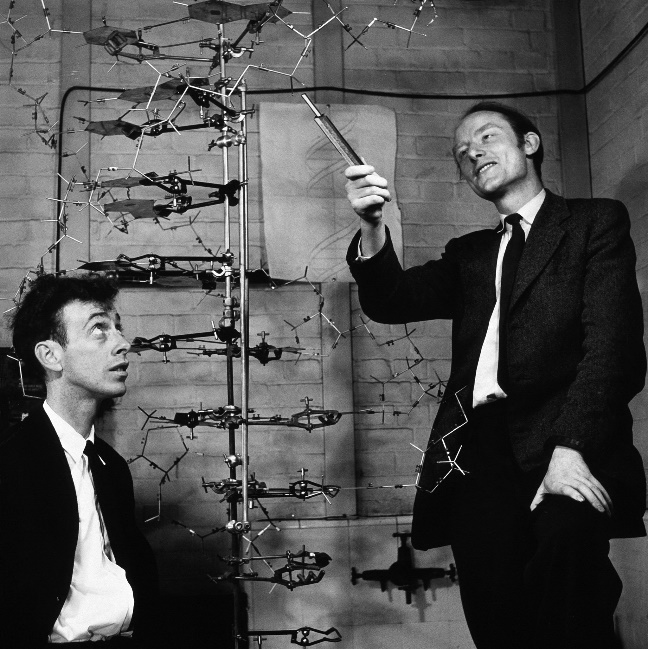
- Rosalind was the X-ray crystallographer who took the photo leading Watson and Crick to this conclusion

- the polymerase chain reaction ( )is used to multiply a single piece of DNA thousands of times over

- you place a single strand of DNA into a “soup” of nucleotides, a VERY specific DNA polymerase enzyme, and short pieces of synthetic strand DNA used as “primers” for synthesis

- recently, development of has allowed for the editing of genes of DNA

- this raises ethical questions of “designer” genes

**Amino Acids – Structures, Names, and Abbreviations**

