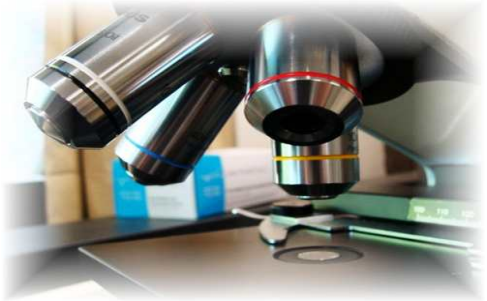

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• The SPO Virtual Classrooms offer many educational resources, including practice test questions, review questions, lecture PowerPoints, video tutorials, sample assignments and course syllabi. New materials are continually being developed, so check back frequently, or follow us on Facebook (Science Prof Online) or Twitter (ScienceProfSPO) for updates.

• Many SPO PowerPoints are available in a variety of formats, such as fully editable PowerPoint files, as well as uneditable versions in smaller file sizes, such as PowerPoint Shows and Portable Document Format (.pdf), for ease of printing.

• Images used on this resource, and on the SPO website are, wherever possible, credited and linked to their source. Any words underlined and appearing in blue are links that can be clicked on for more information. PowerPoints must be viewed in *slide show mode* to use the hyperlinks directly.

• Several helpful links to fun and interactive learning tools are included throughout the PPT and on the Smart Links slide, near the end of each presentation. You must be in *slide show mode* to utilize hyperlinks and animations.

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Image: Compound microscope objectives, T. Port

Organic Chemistry Basics

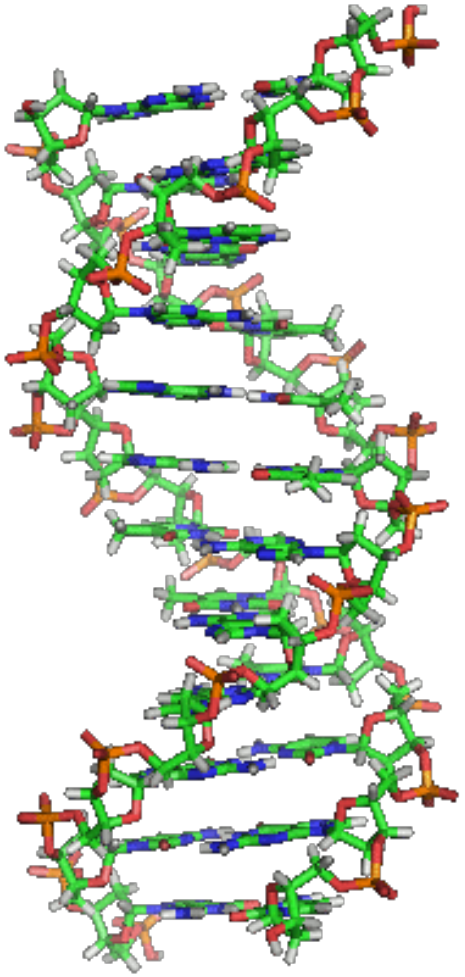


Image: DNA, Richard Wheeler

? Inorganic vs Organic Molecules ?

- **Inorganic Molecules >**
  Molecules that *don't* have Carbon Hydrogen (C-H) bonds.

- The major organic macromolecules (big molecules with carbon-hydrogen bonds) found in living things are:

1. carbohydrates
2. proteins
3. nucleic acids
4. lipids

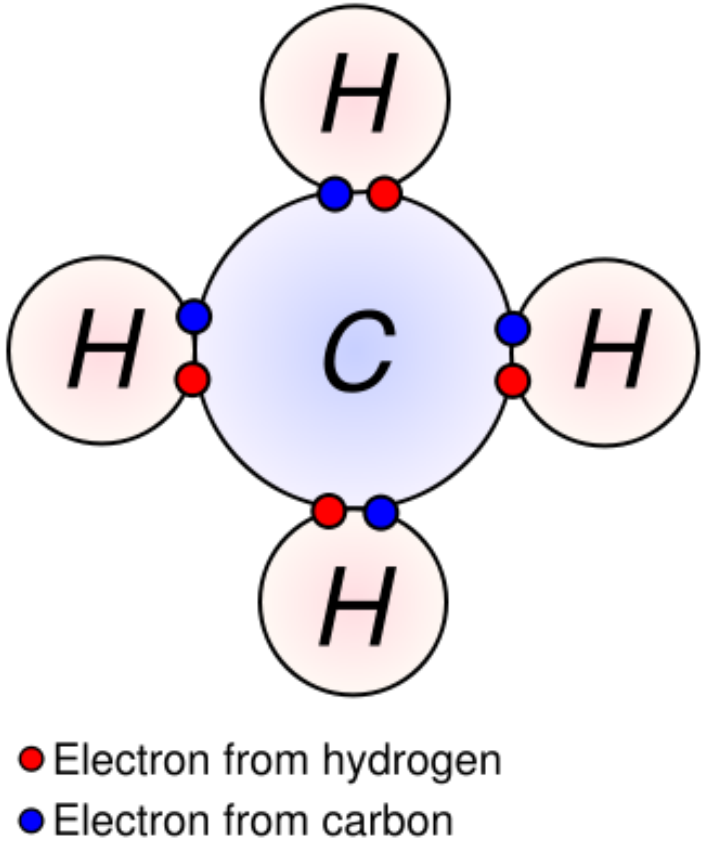
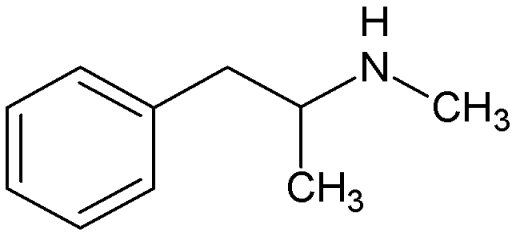


Image: Methane Covalent Bonds, Dynablast, Wiki

Everyday Science

In chemistry, *organic* does NOT mean all natural and healthy.

For example gasoline, nicotine, many pesticides and drugs, including crystal meth, are all carbon based organic molecules, but definitely NOT good for you!



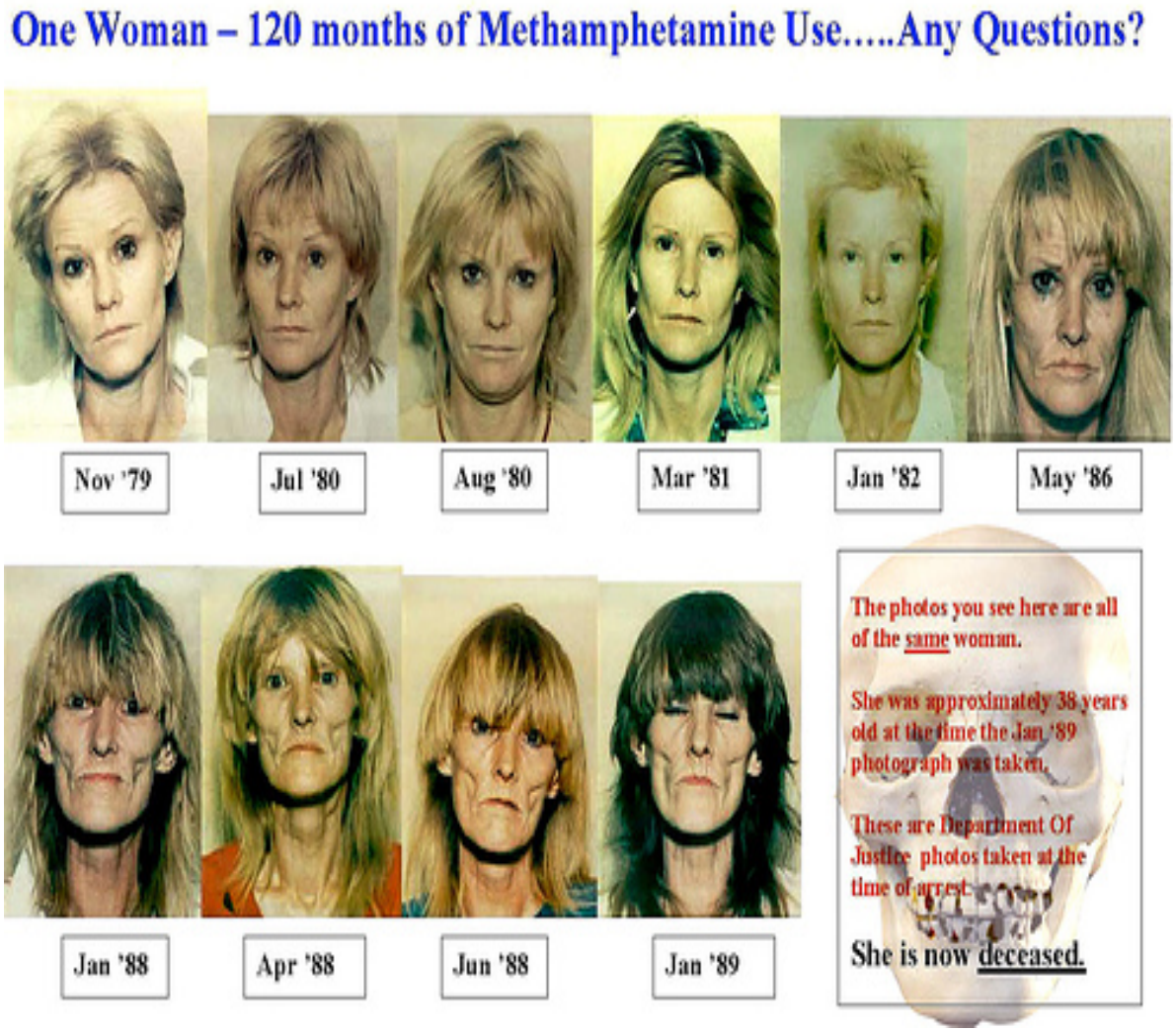
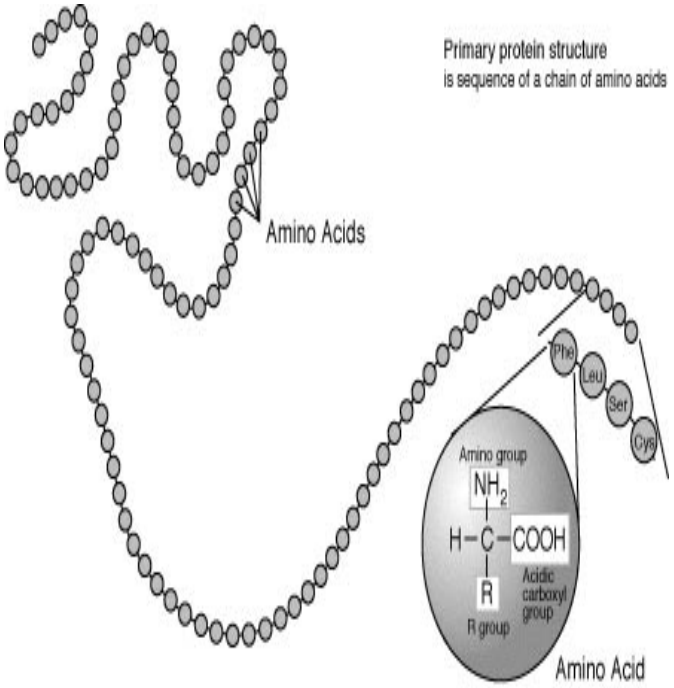
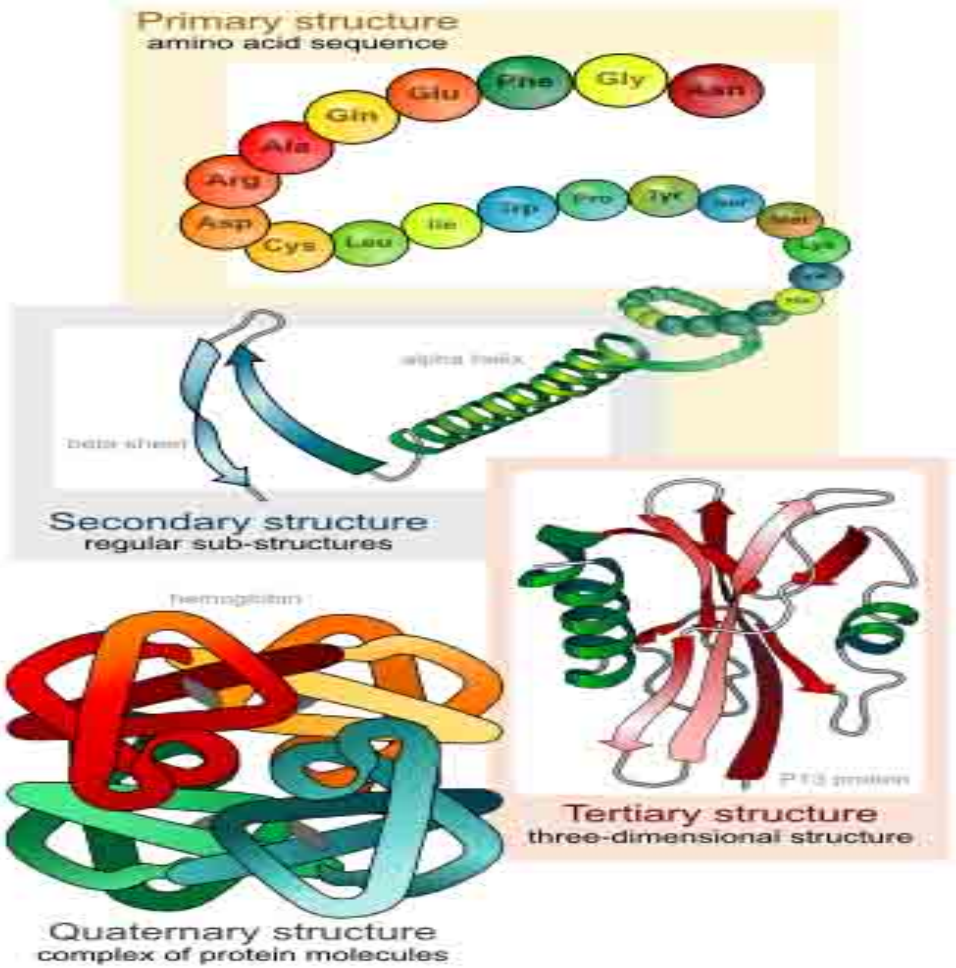


Image: Chemical structure of meth, Wiki; Woman over course of 10 years of meth use, Don Hankins

Organic compounds can be extremely large, complex molecules.





Images: Protein Primary Structure, Wiki; Levels of protein structure, M Ruiz

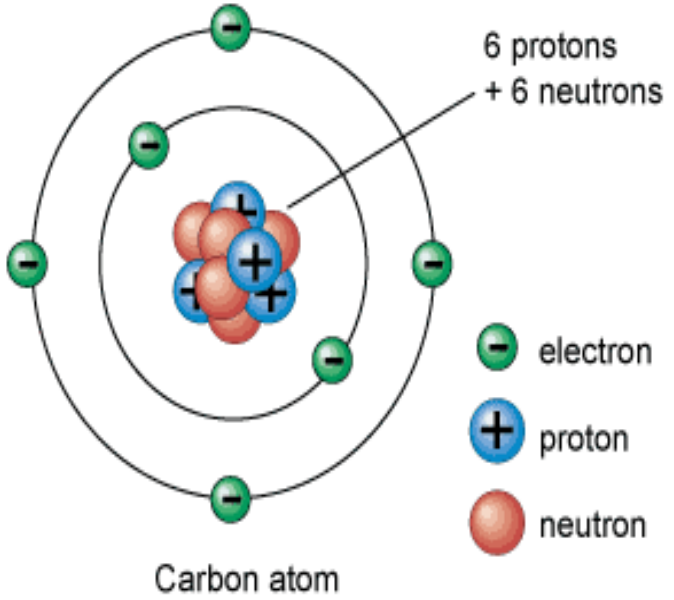
Carbon

Little Atom, Big Deal

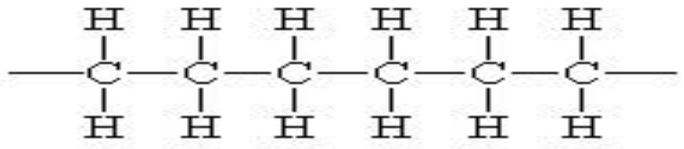
The chemical basis of life.

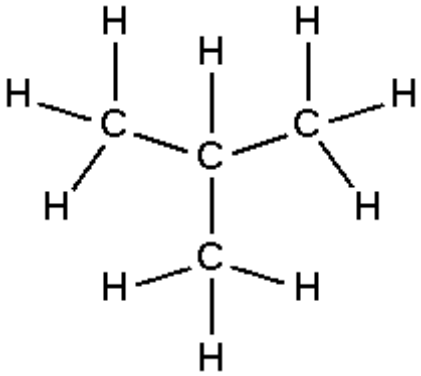
This element is abundant in all known life forms.

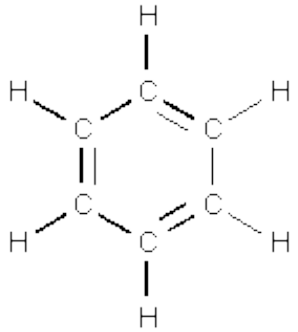
Structure of all living things are molecules built on a carbon frame work, such as DNA, sugars, fats and proteins.



Carbon atom


Polyolefin





Video:
[That's Why Carbon Is a Tramp](#)
from Crash Course Biology

Images: Carbon, Universe Today Website; Isobutane, Wiki

What's so special about carbon? #1

Carbon has 4 valence electrons.

So each carbon atom can form ____ covalent bonds.

Most commonly forms bonds with hydrogen.

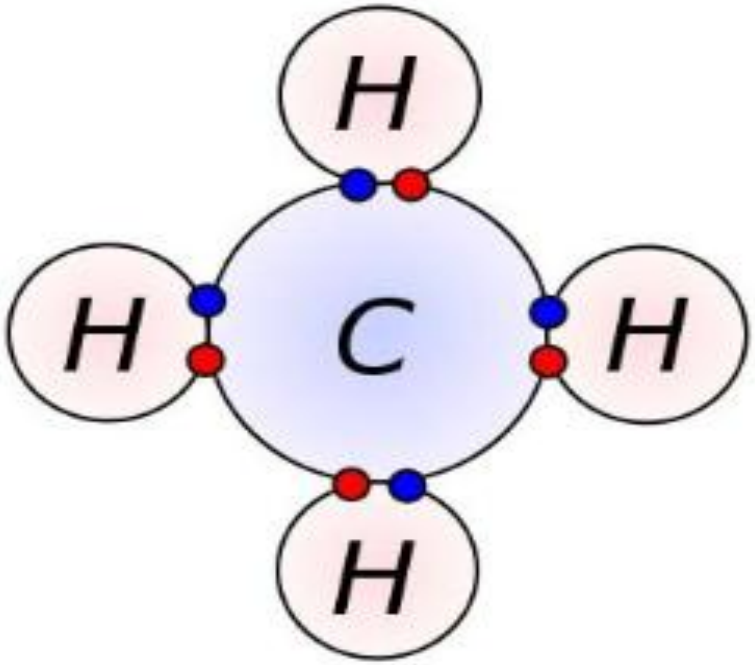


Image: Methane Covalent Bonds, Dynablast, Wiki;

Periodic Table

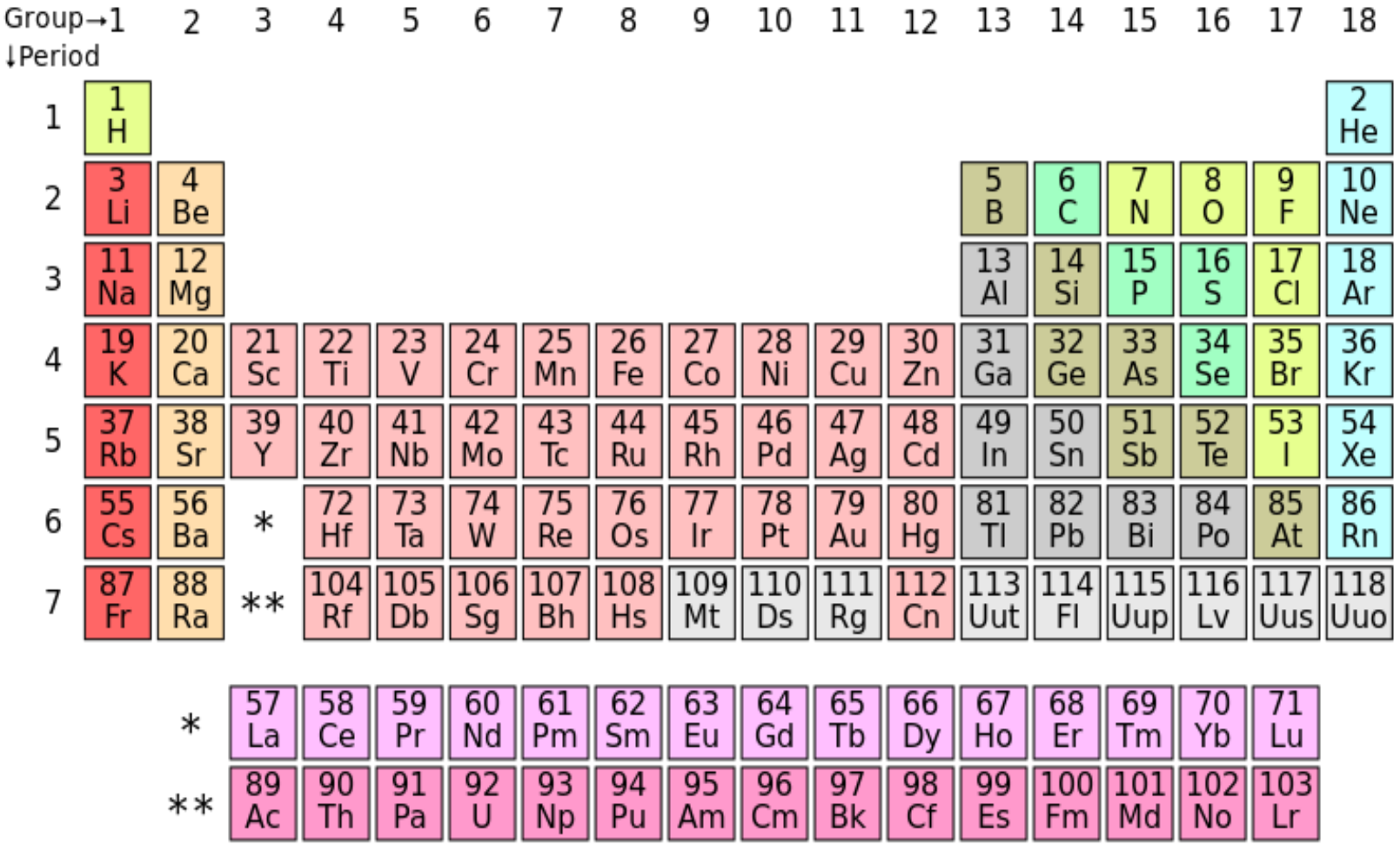
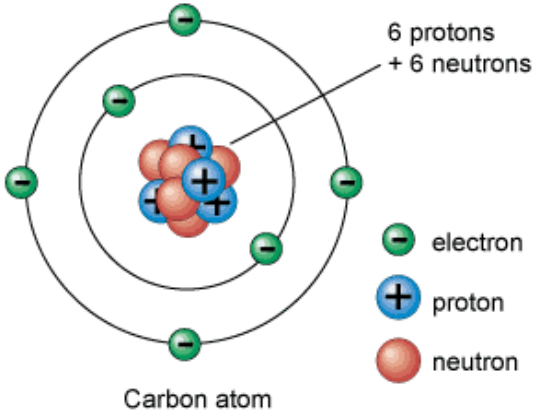


Image: Periodic Table of Elements

What's so special about carbon? #2



There can be single, double or even triple bonds between carbon atoms.

A single bond forms when a pair of electrons are shared in a covalent bond.

A double bond forms when two pairs of electrons shared, a triple bond when three pairs of electrons shared.

Hydrogen	H•	H•
Carbon	•Ċ•	•Ċ•
Water	H:Ö:H	H-Ö-H
Ethylene	H H C::C H H	H H C=C H H
Acetylene	H:C:::C:H	H-C≡C-H

Images: Carbon, Universe Today Website; Chemical bonds, Wiki

Single vs. Double Bonds

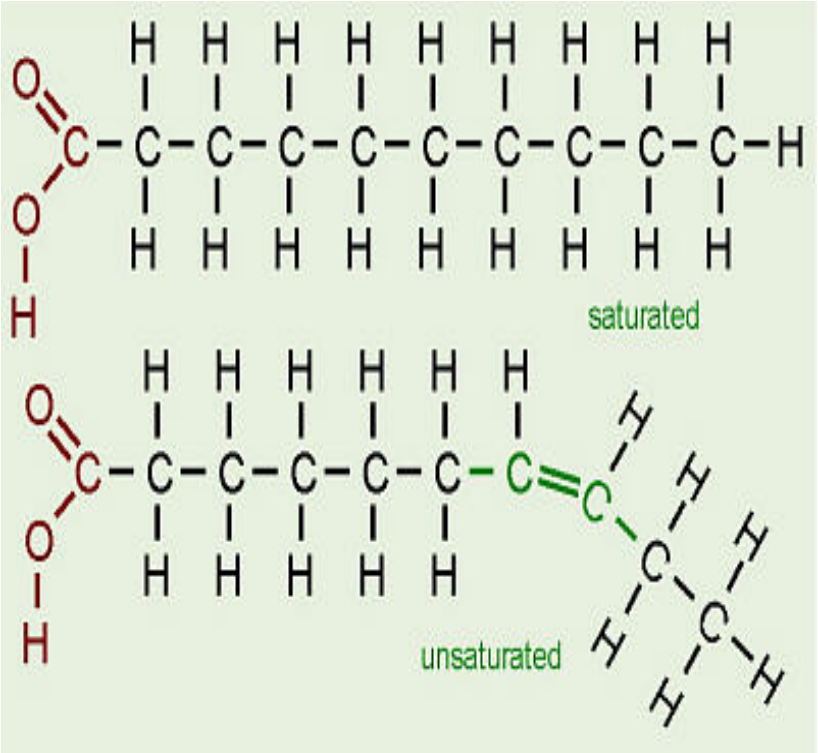
The difference between saturated and unsaturated fatty acids

Saturated fats

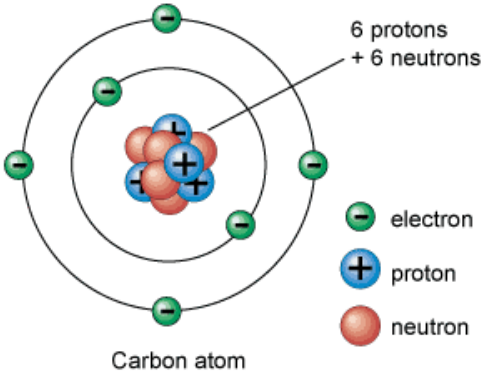
- Mostly from animal sources.
- Single bonds between the carbons in their fatty acid tails (all carbons are bonded to max number of hydrogens possible).
- Hydrocarbon chains fairly straight and packed closely together … so _____at room temperature.

Unsaturated fats (oils)

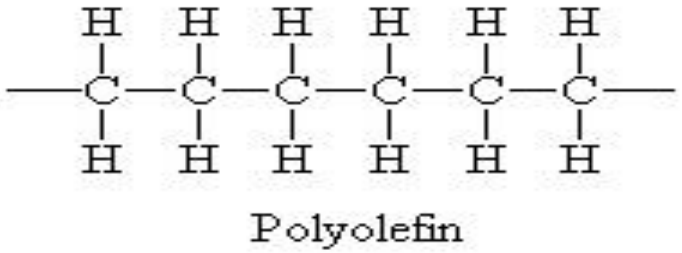
- Mostly from plant sources.
- Have double bonds between some carbons in the hydrocarbon tail, causing bends or "kinks" in shape.
- Kinks in hydrocarbon tails, so unsaturated fats can't pack closely together … _____ at room temp.



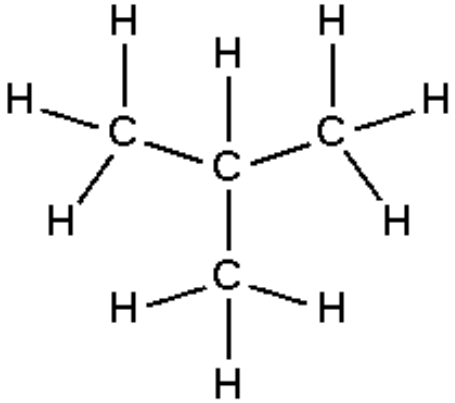
What's so special about carbon? #3

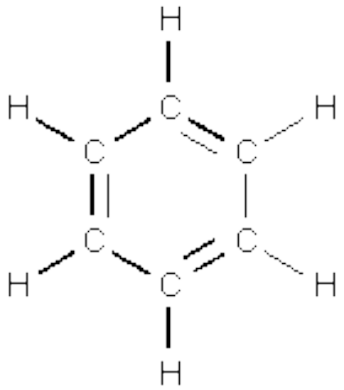


Carbon backbone of an organic molecule can be arranged many different ways.



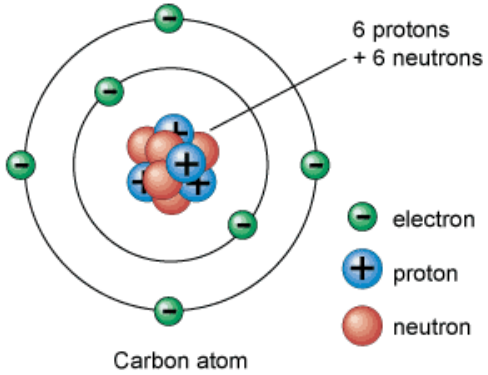
Long straight chains, branched or arranged in closed rings (cyclic compounds).





Images: Carbon, Universe Today Website; Isobutane, Wiki

What's so special about carbon? #4

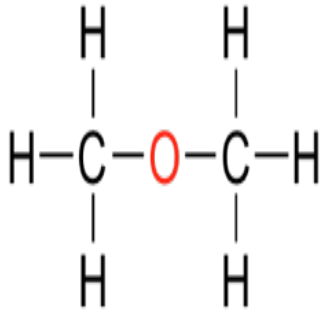


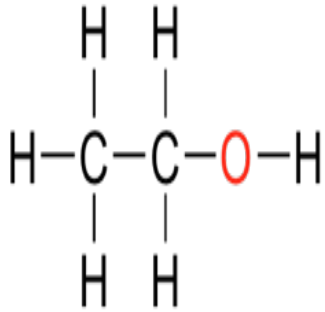
Isomers: Organic compounds can have **isomers**.

Same molecular formula but structurally different in some way.

Have different chemical properties.

Functional Groups: Organic compounds very similar structure can have slightly just a few different atoms, called functional groups, that make the molecules have very different chemical properties.





< ISOMERS >

dimethyl ether

C_2H_6O

ethanol

C_2H_6O

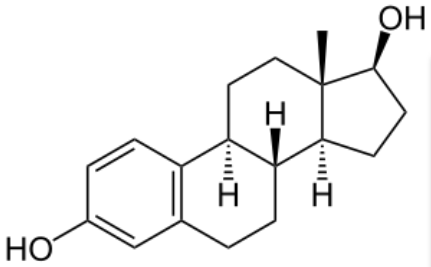
Colorless gas

Booze

Images: Carbon, Universe Today Website

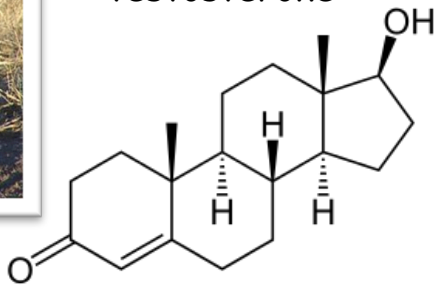
Importance of Functional Groups

- **Functional groups** = specific groups of atoms or bonds within molecules that are responsible for the characteristic chemical reactions of those molecules.
- Addition of other elements to carbon skeleton.
- Replace H's on the carbon backbone.
- Note how only small differences in molecular structure can give rise to very different biological functions.



estradiol

testosterone



Images: Male lion, Testosterone molecule, Estradiol molecule, Female lion, Wiki

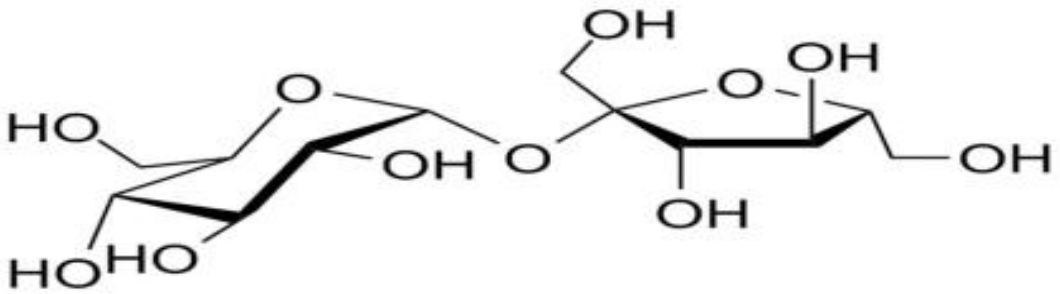
Study Table of Organic Macromolecules

(We will fill this in as we go through the rest of the lecture.)

Macromolecule (polymer)	**Made of what type of monomer?**	**Is there another name for this polymer?**	**What are the main elements in this macromolecule?**	**Examples**
1.				
2.				
3.				
4.				

Organic Molecules
Carbohydrates

- "carbon" - hydrates"
- One carbon molecule to one water molecule $(CH_2O)_n$.
- saccharide is a synonym for carbohydrate.
- The prefixes on the word "saccharide" relates to the size of the molecule (mono-, di-, tri- poly-).



BOOGERS!

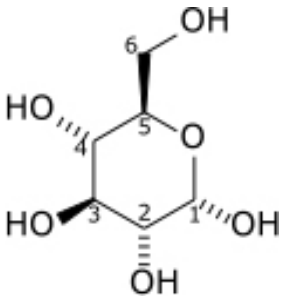
You probably know that jelly beans are full of refined sugars…carbs. You may not know that boogers contain carbs as well. Boogers are dried-up mucus and dirty nose debris. Mucus is made mostly out of sugars and protein.

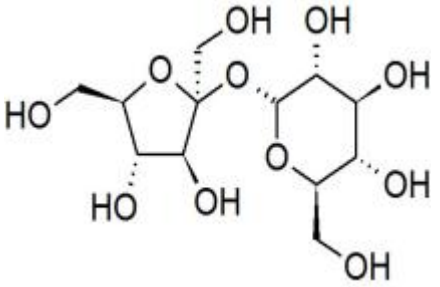
Images: Jelly beans, T. Port;
Giraffe picking nose with tongue, Sucrose moleculee Wiki

Organic Molecules - Carbohydrates

Monosaccharides

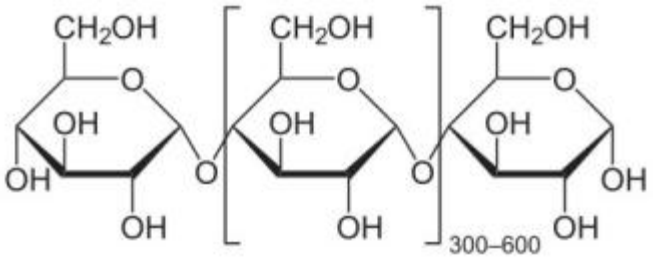
- **single** sugars (one molecule)
- simplest
- **glucose*, fructose





Disaccharides

- **double** sugars
- combination of two monosaccharides
- * **sucrose** = glucose + fructose
- * **lactose** = glucose + galactose



Polysaccharides

- macromolecules; **polymers** composed of several sugars
- can be same monomer (many of same monosaccharide) or mixture of monomers
- **food storage** carbohydrates: ***glycogen*** (animals) ***starch*** (plants)
- **structural** carbs: ***chitin*** (animals), ***cellulose*** (plants)

Organic Molecules - Proteins

Proteins are macromolecules, **polymers** composed of monomers called…

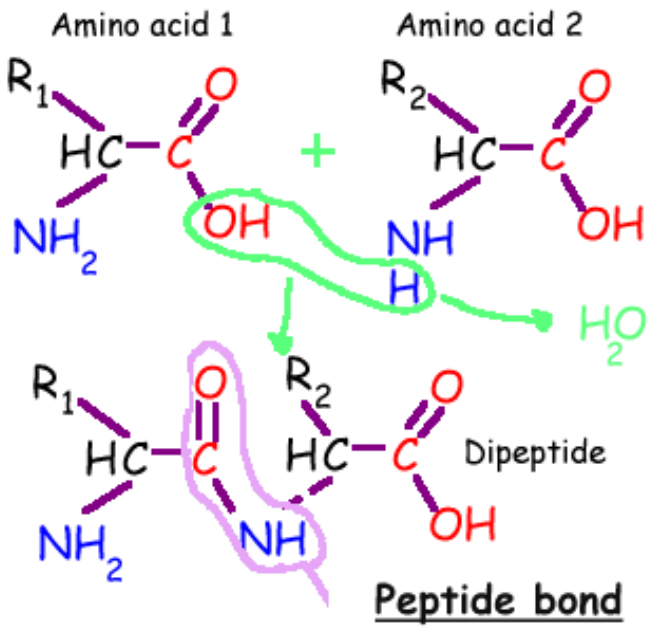
Amino acids contain a:

1. base amino group ($-NH_2$)
2. acidic carboxyl group (-COOH)
3. hydrogen atom

…all attached to same carbon atom (the a – carbon…alpha carbon).

4. Fourth bond attaches a-carbon to a side group (--R) that varies among different amino acids.

Side groups important … affects the way a proteins amino acids interact with one another, and how a protein interacts with other molecules.

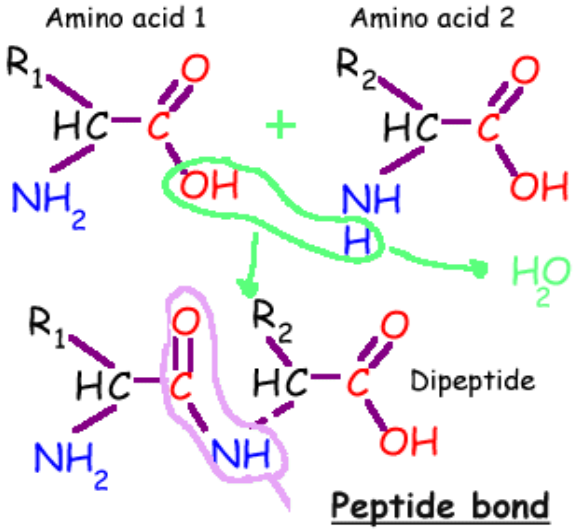


Essential amino acids:
Cannot be synthesized by the body. They must be ingested in the diet.

Arginine * Histidine * Methionine* Threonine * Valine * Isoleucine * Lysine * Phenylalanine * Tryptophan * Leucine

Organic Molecules – **Proteins**

Peptide Bonds



Link amino acids together in chains, like the beads on a necklace.

A **dipeptide** is 2 amino acids linked together.

A **polypeptide**, more than two.

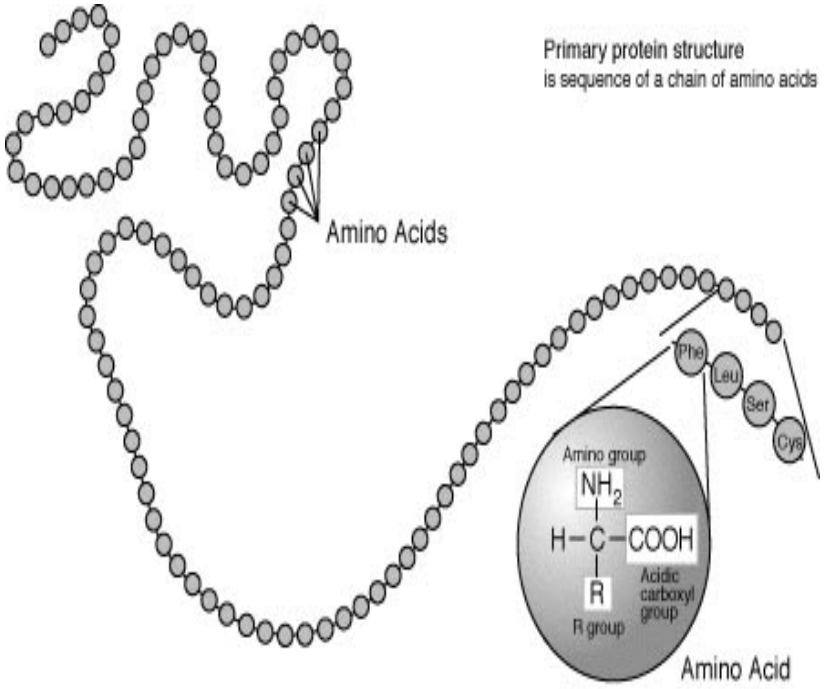


Image: Protein Primary Structure, Wiki

Levels of Protein Structure

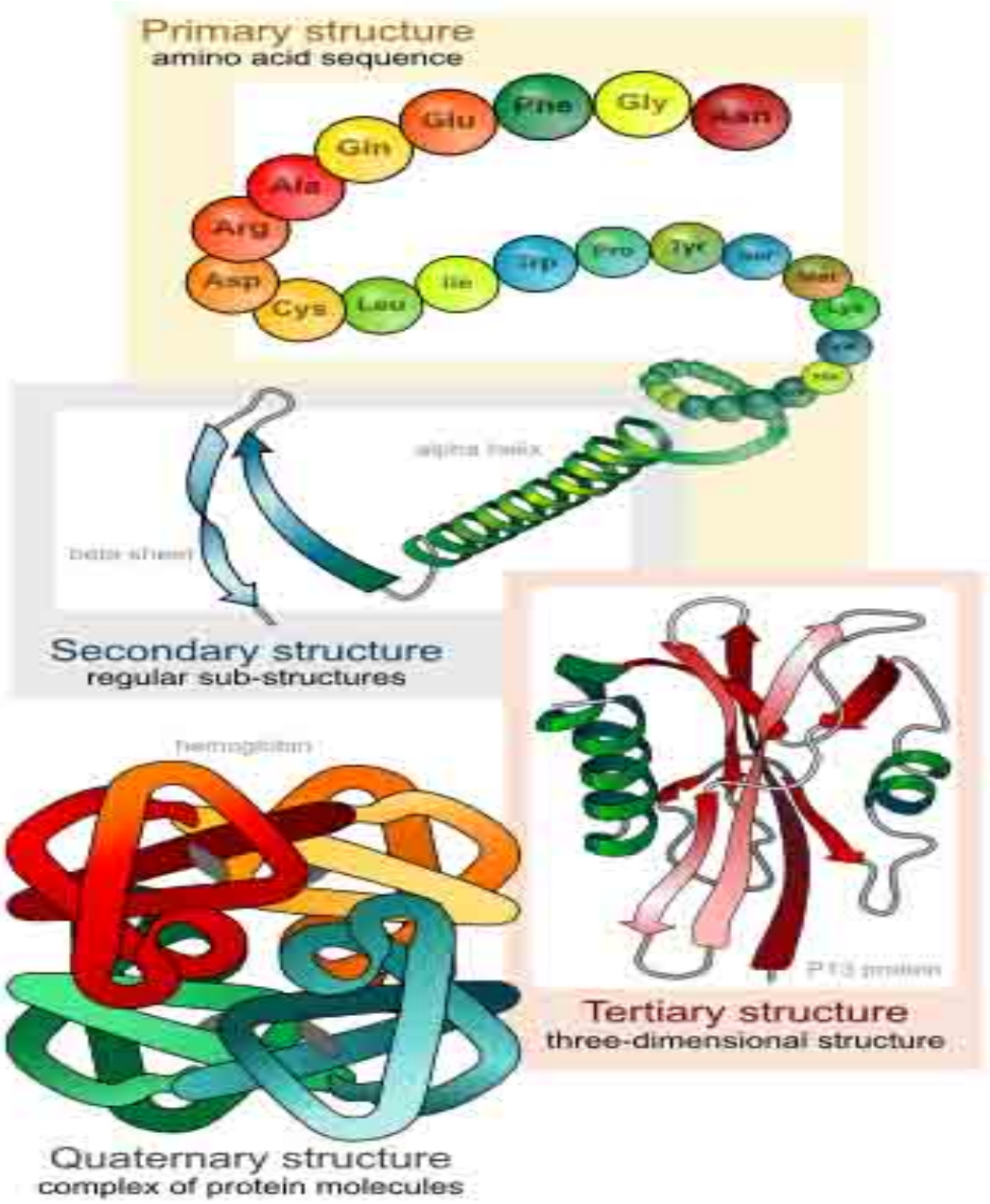
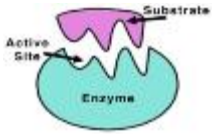


Image: Levels of protein structure, M Ruiz

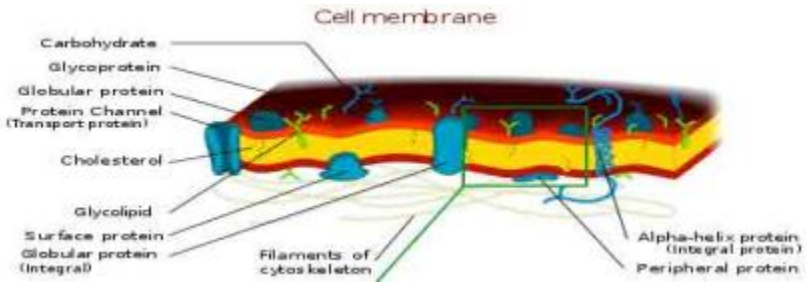
Organic Molecules - Proteins



Complex organic macromolecules fundamental to living cells.

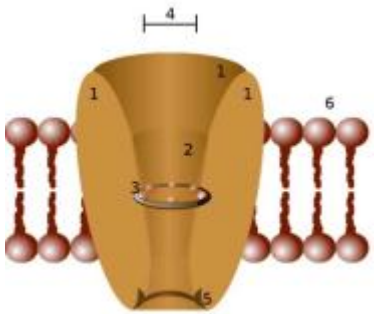
Composed of one or more chains of amino acids.

Proteins perform many functions in cells, including:



1. Structural

- Components in cell walls, membranes, and within cells themselves.

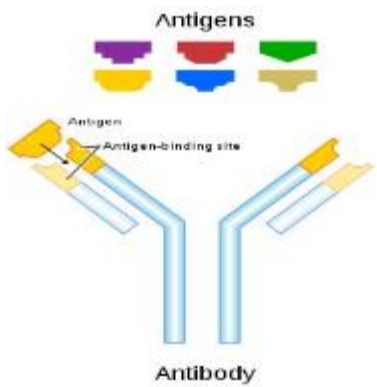


2. Enzymes

- Chemicals that speed up a chemical reaction.
- The catalysts in cells are called enzymes.

3. Regulation

- Some regulate cell function by stimulating or hindering either the action of other proteins or the expression of genes.



4. Transportation

- Some act as channels and "pumps" that move substances into or out of cells.

5. Defense

- Antibodies = proteins that defend your body against microorganisms
- Some bacteria produce proteins (bacteriocins) that kill other bacteria.

Images : Cell Membrane, Wiki; Channel Protein, Wiki; **Antibody**, **Wiki**

Organic Molecules – Nucleic Acids

Nucleic acids (both RNA and DNA) are macromolecules; polymers made up of monomers called **nucleotides**.

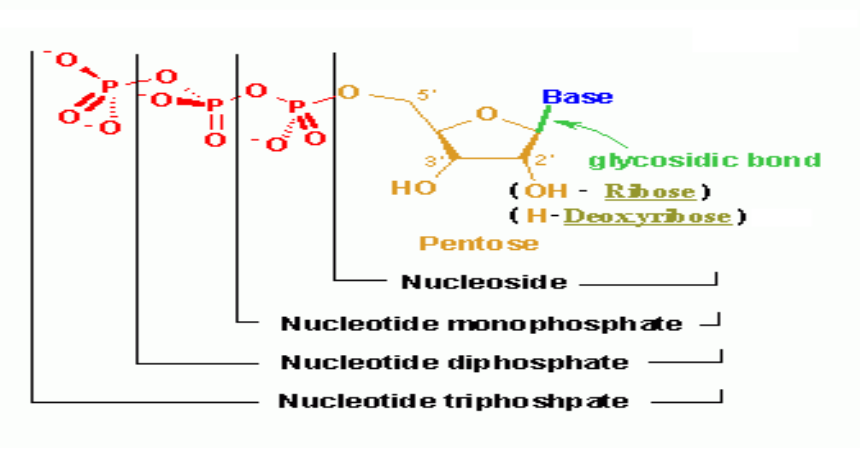
Nucleic acids **deoxyribonucleic acid** (DNA) and **ribonucleic acid** (RNA) = genetic material of cells.

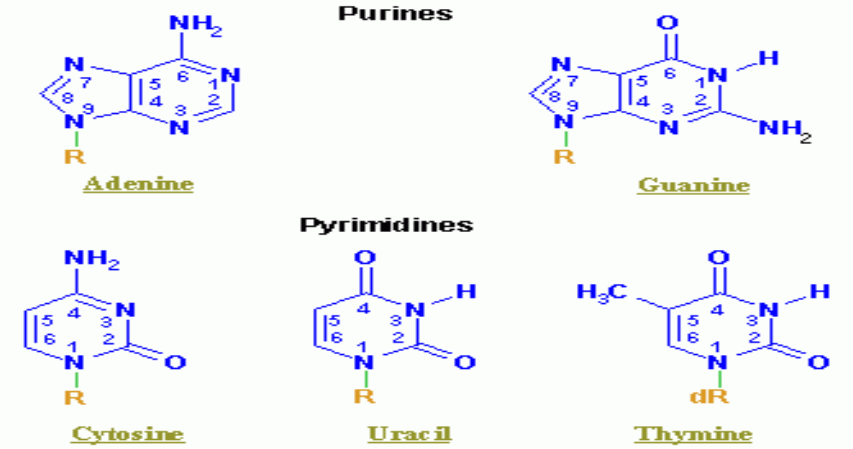
Names derived from type of **sugar** contained within molecules = **ribose**

Nucleotides

Each monomer of nucleic acid is a **nucleotide** and consists of 3 portions:

- a **sugar**
- one or more **phosphate**
- one of five cyclic **nitrogenous bases**
  - +adenine, guanine (double-ringed purines)
  - + cytosine, thiamine or uracil (single-ringed pyrimidines)





From the Virtual Biology Classroom on ScienceProfOnline.com

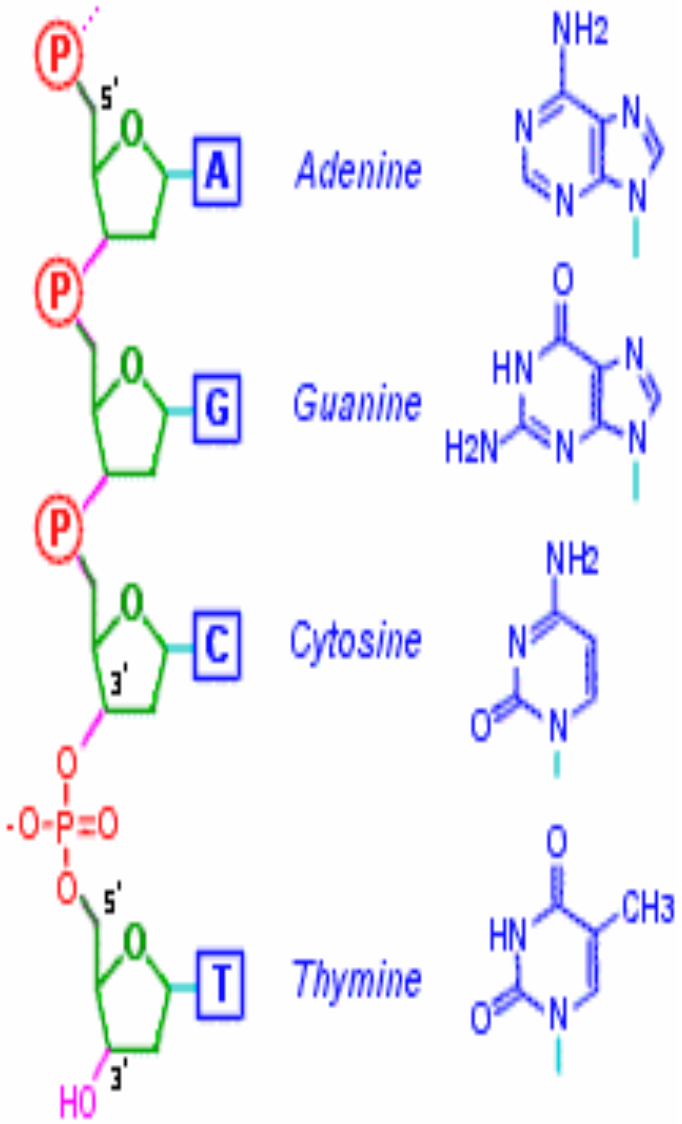
Image: Nucleotide Structure, Wikipedia

Organic Molecules – Nucleic Acids

Nucleic Acid Structure

Nucleotides linked by covalent bonds between **sugar** of one nucleotide and **phosphate** of next *(sugar-phosphate backbone).*

Nitrogenous **bases** extend from it like teeth of a comb.



Nucleic Acids - DNA

DNA is a double stranded molecule, analogous to a ladder.

The "ladder" =

- two deoxyribose-phosphate chains form the "**side rails**"
- base pairs, linked by hydrogen bonds, form the "**rungs**".

Purine Bases (double ring)
Adenine & Guanine

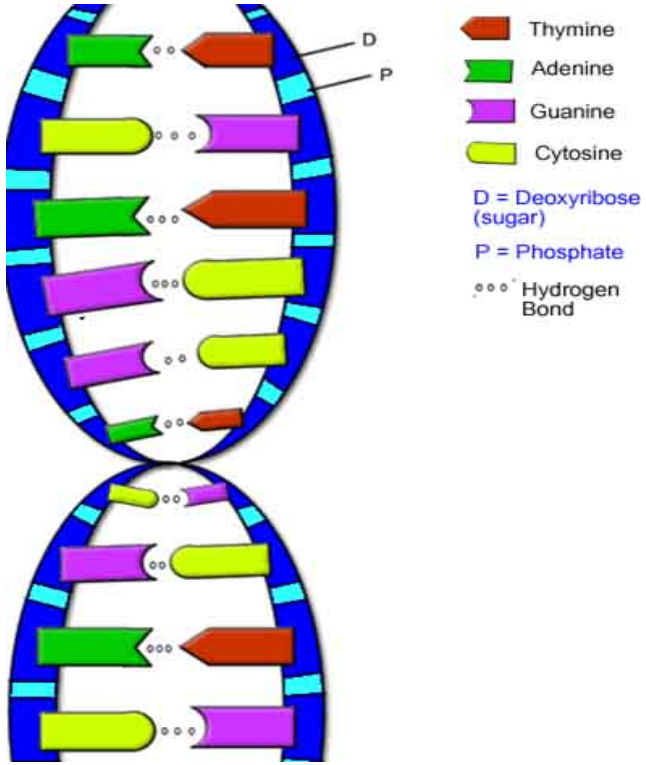
Pyrimidine Bases (single ring)
Cytosine & Thymine

Base Pairs *(purine always pairs with pyrimidine):*

Adenine + Thymine
Cytosine + Guanine

Q: How do I remember this?

Hydrogen bonds **attract the bases** from one strand to the bases on the other strand and also **twist the phosphate-sugar backbones** into a helix.



Images: Model of DNA Molecule, Field Museum, Chicago, T. Port DNA, Biology Corner Website

DNA molecule

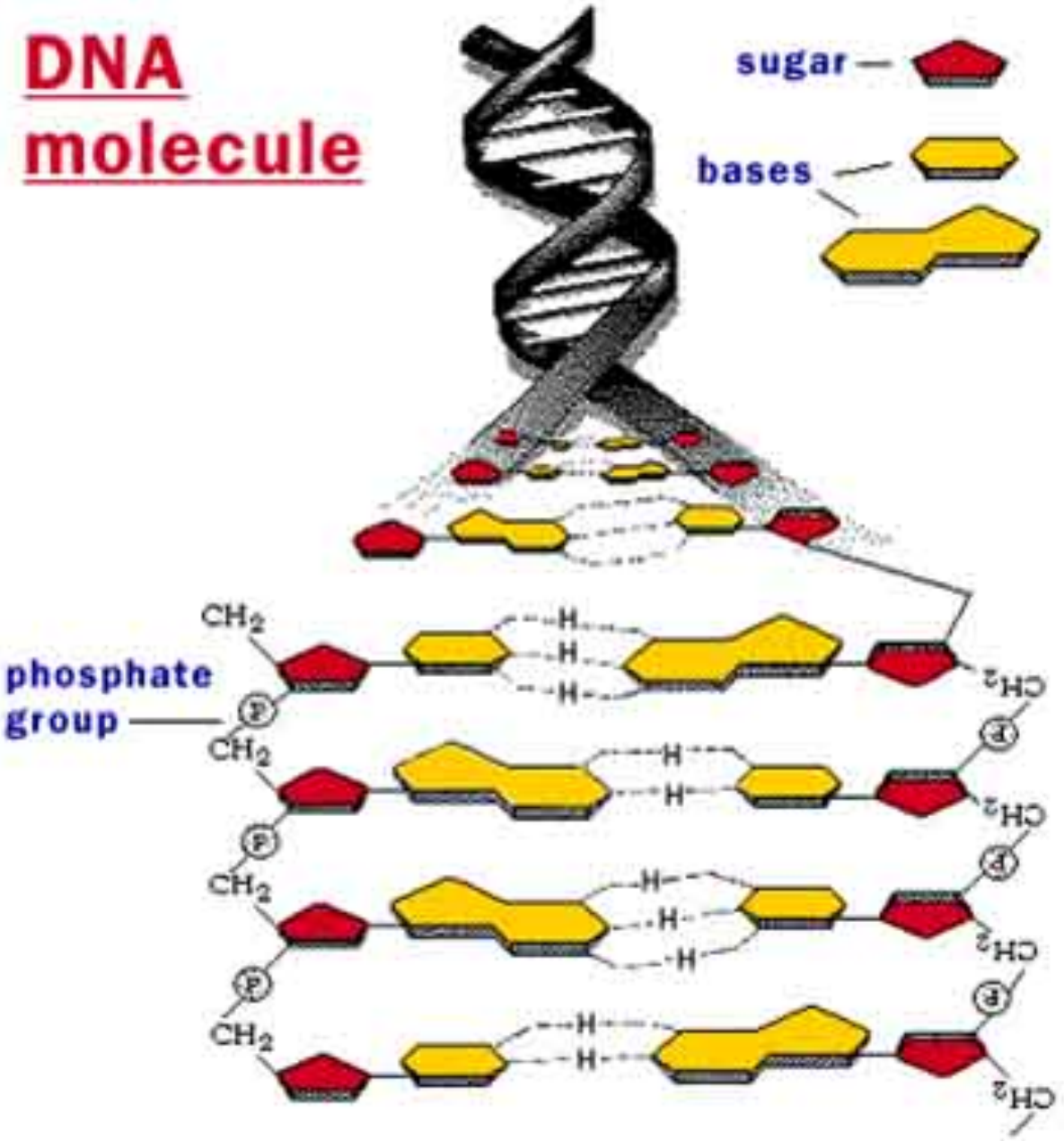
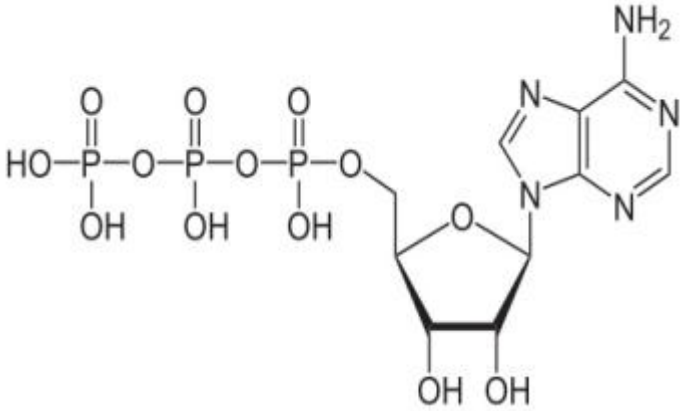


Image: DNA Molecule, National Science Foundation

ATP Production and Energy Storage

- **Q: This molecule has a sugar, a base and three phosphate groups. What kind of monomer is it?**
- **Adenosine 5'-triphosphate**
- Multifunctional "molecular currency" of intracellular energy transfer.
- Organisms release energy from nutrients; can be concentrated and stored in high-energy phosphate bonds of ATP.
- Transports chemical energy within cells for metabolism.
- Produced as energy source during **photosynthesis** and **cellular respiration**.
- Consumed by many enzymes and a multitude of cellular processes



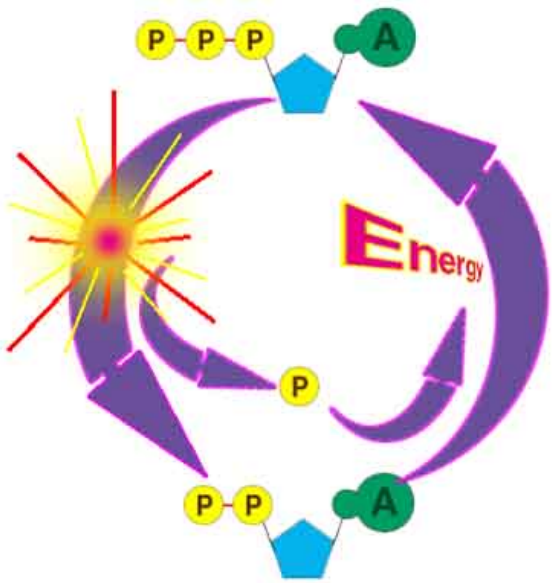


Image: ATP Molecule, NEUROtiker; ATP-ADP Cycle, CUNY

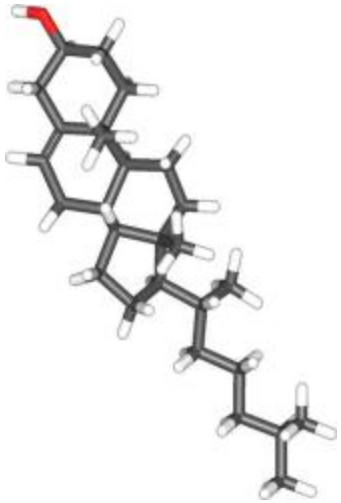
Organic Molecules – Lipids

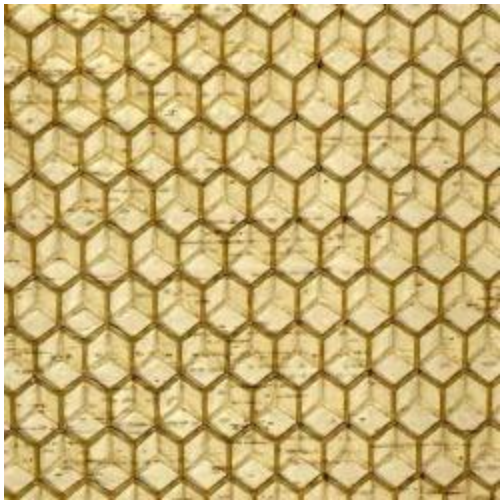
(Fats, Phospholipids, Waxes & Steroids)

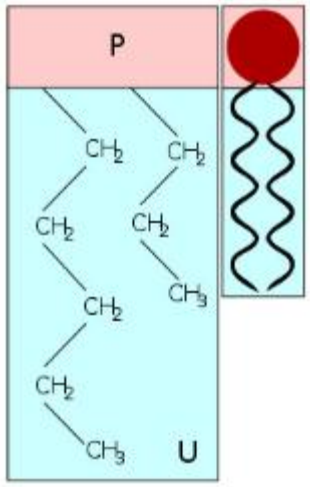
Hydrophobic macromolecules…insoluble in water.

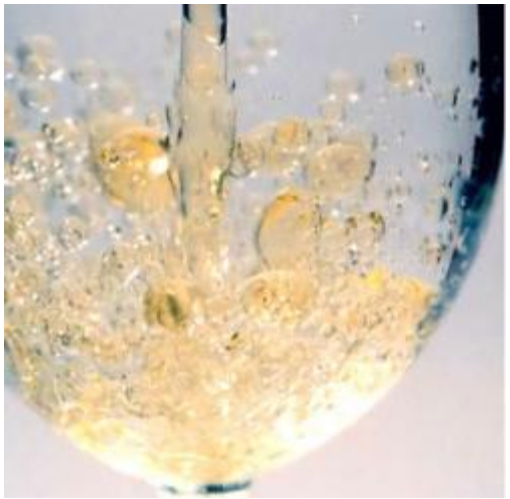
Not attracted to water because …

non-polar covalent bonds linking carbon & hydrogen aren't attracted to the *polar bonds of water.*





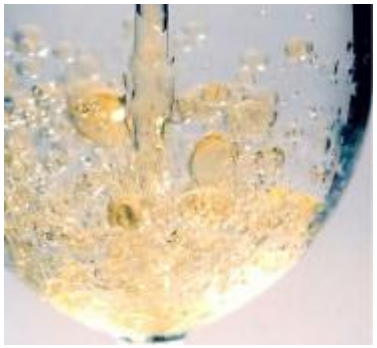




Images: Cholesterol, Wiki; Phospholipid Structure, Bryan Derksen. Wiki Honeycomb, Wikii; Oil & Water, Kidipede

Organic Molecules – Lipids

*(**Fats**, Phospholipids, Waxes & Steroids)*



Fats

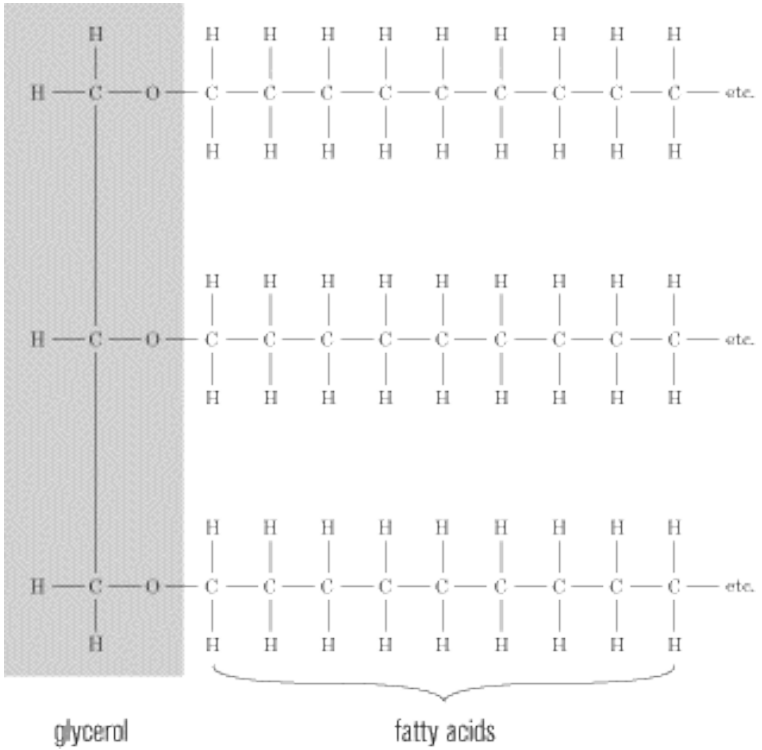
Fats and oils are made from two kinds of molecules:

- **glycerol**

  (a type of alcohol)

- **fatty acids**

  (triglycerides)



Images: Oil & Water, Kidipede

Organic Molecules – Lipids

*(Fats, **Phospholipids**, Waxes & Steroids)*

Phospholipids

- Phospholipids are a major component of all cell membranes.
- Most phospholipids contain a diglyceride as the tail, and a phosphate group for head.
- Hydrocarbon tails are **hydrophobic**, but phosphate heads are **hydrophilic**.
- So phospholipids are soluble in both water and oil.
- Tails from both layers facing inward and the heads facing outward = **phospholipid bilayer**.

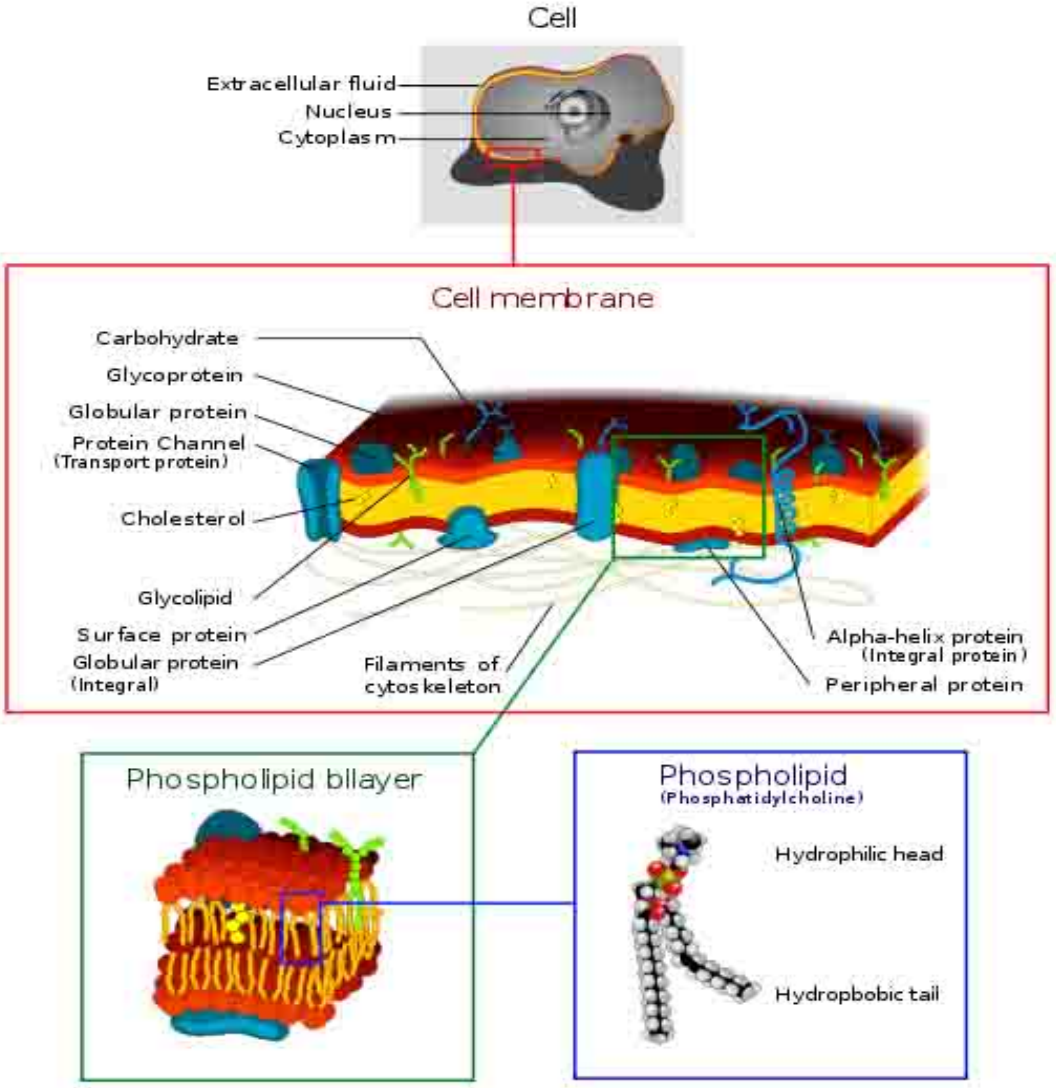
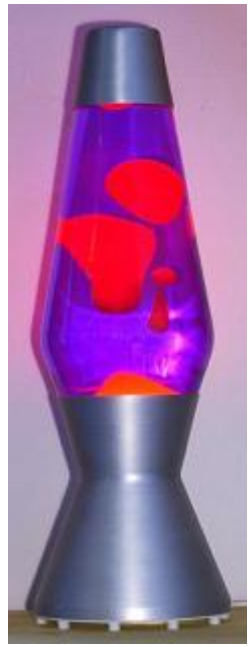


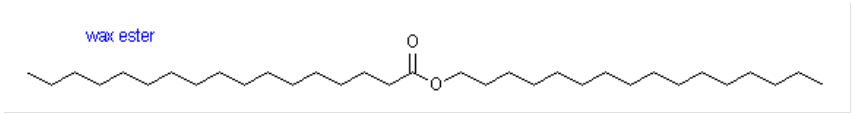
Image: Cell Membrane, Wiki;

Organic Molecules – Lipids

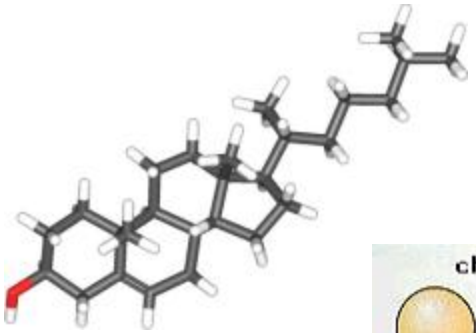
*(Fats, Phospholipids, **Waxes & Steroids**)*



Waxes



- Do not have a hydrophilic head: so completely water insoluble.



Steroids

- The central core of a cholesterol molecule (4 fused rings) is shared by all steroids.
- Cholesterol is precursor to our **sex** hormones and Vitamin **D**.
- Our cell membranes contain cholesterol (in between the phospholipids) to help keep membrane "fluid" even when exposed to cooler temperatures.

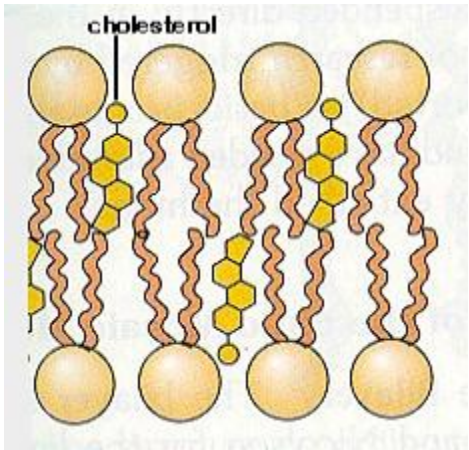


Image: Lava Lamp, Wiki; Cholesterol molecule, Wiki; Phospholipids & Cholesterol, Cytochemistry.net

Confused?

Here are some links to fun resources that further explain Chemistry:

Smart Links

- Organic Chemistry Main Page on the Virtual Cell Biology Classroom of Science Prof Online.
- "What Kind of Bonds Are These?" song and slide show by Mark Rosengarten
- Macromolecules interactive science tutorial.
- DNA Structure Cell Biology Animation from John Kyrk.
- Build a DNA Molecule from University of Utah.
- "Chemistry" a song by Kimya Dawson.
- Redox Reactions video lecture by Kahnacademy
- "Sugar, Sugar" song by The Archies.
- Chem4Kids website by Rader.
- "Better Living Through Chemistry" a song by Queens of the Stone Age.
- "Chemistry" a song by Rush.

(You must be in PPT slideshow view to click on links.)