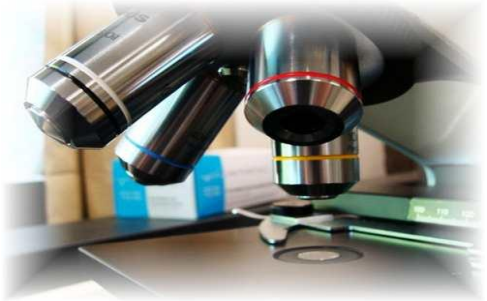

About Science Prof Online PowerPoint Resources

• Science Prof Online (SPO) is a free science education website that provides fully-developed Virtual Science Classrooms, science-related PowerPoints, articles and images. The site is designed to be a helpful resource for students, educators, and anyone interested in learning about science.

• 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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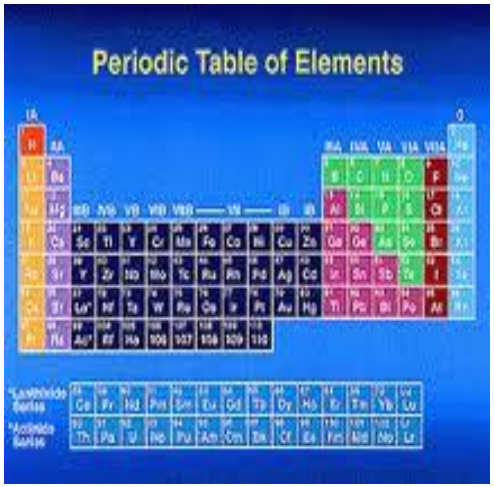
Image: Compound microscope objectives, T. Port

Chemistry of Microbiology

Image: Mannitol Salt Bacterial Growth Media, T. Port

Elements, Atoms, Molecules & Compounds

- **Elements** → Substances that can't be broken down any further.
- **Atom** → The smallest unit of an element.
- Two or more atoms joined together chemically: **Molecule**
- Molecule containing at least two different elements: **Compound**
- ***Examples of molecules:*** Carbon dioxide (CO_2) and methane (CH_4), molecular hydrogen (H_2), molecular oxygen (O_2) and molecular nitrogen (N_2).
- ***Examples of compounds***: Only molecules containing two or more elements, such as carbon dioxide (CO_2) and methane (CH_4).
- ***Q: Explain why all compounds are molecules but not all molecules are compounds.***



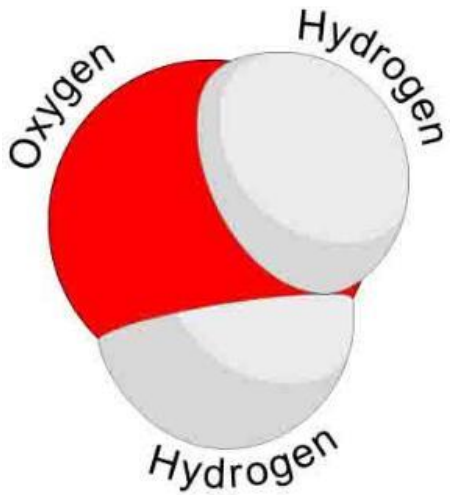
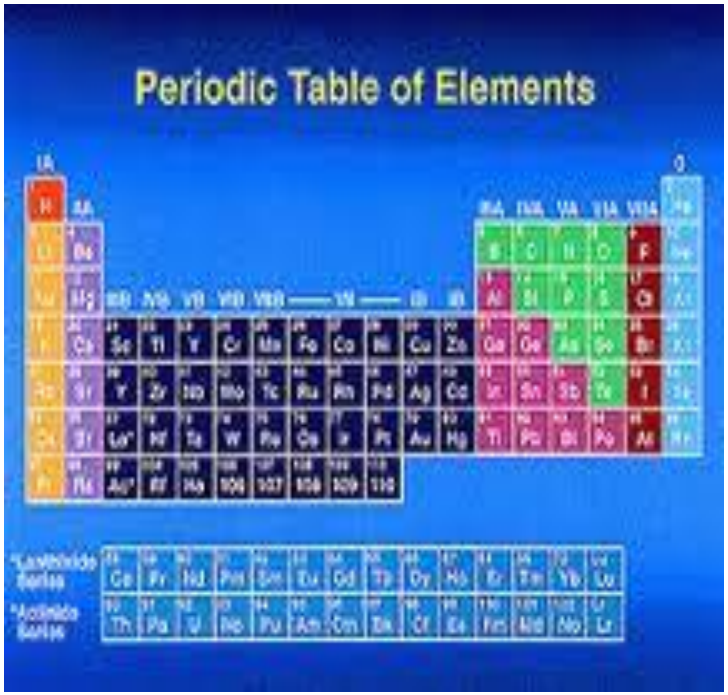


Image: Periodic Table of Elements, NASA; Water Molecule, Wiki

Chemical Shorthand



Follow this link to see Daniel Radcliff (Harry Potter) **sing "The Element Song".**

Chemical Symbol

- Begins with **one or two letters** based on elements name.
- ***Q:*** *What if there is more than one element that starts with the same letter?*
- Example: Carbon (C), Calcium (Ca), Chlorine (Cl)

Chemical Formula

- "Shorthand" for a compound.
- Contains chemical symbols of the elements that make up the molecule.
- Numerical subscripts represent number of atoms of each element in molecule.
  Example: H_2O *= water; has two hydrogen atoms and one oxygen.*
- More than one molecule of same type…the group of letters is preceded by number.
  Example $2H_2O$ *= two water molecules.*

Image: Periodic Table of Elements, NASA

The Structure of an Atom

Atoms are the basis for everything in the universe.

Q: What are the three basic parts of an atom?

- **?** = "-" negative charge
- **?** = "+" positive charge
- **?** = neutral (a charge of zero)

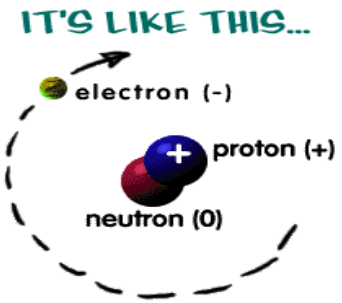
The thing that makes each element unique is the number of protons, since the number of neutrons and electrons can vary.

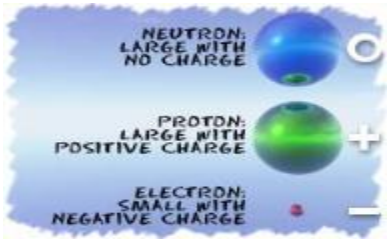
Protons and **neutrons** always in the center of atom (the nucleus).

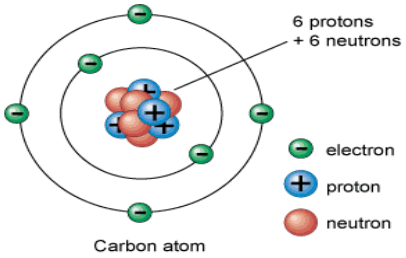
Electrons are found whizzing around nucleus in areas called orbitals.

Q: If there is an equal number of electrons and protons in an atom, what is it's charge?

Here are some examples:







NERDY SCIENCE JOKE: A neutron walks into a bar and asks "How much for a drink?"

Q: What does the bartender tell him?

Images: Structure of Atom, Chem4Kids Website; Carbon, Universe Today Website

Chemical Bonding and Electron Valences

The electrons in an atom are located at different **energy levels**.

Electrons in the highest energy level are called **valence electrons**.

Number of valence electrons governs an atom's bonding behavior.

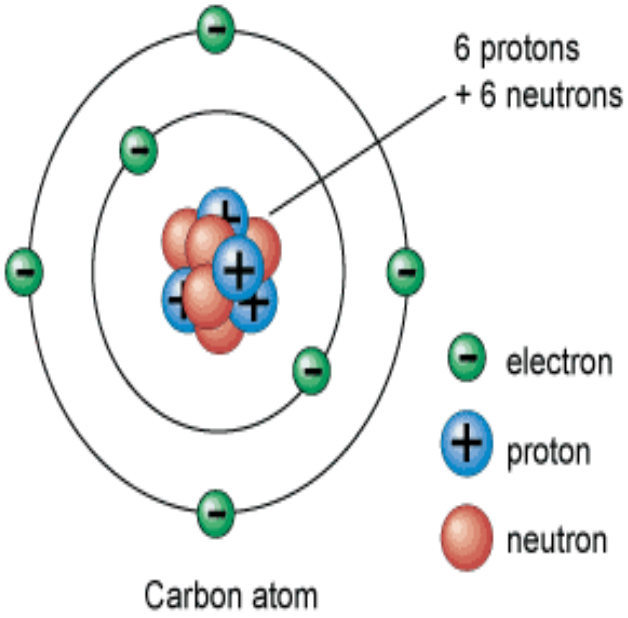
Q: What is the <u>max number</u> of valence electrons for a full valence shell?

Atoms are much more stable, or less reactive, with a full valence shell.

By moving electrons, the two atoms become linked. This is known as **chemical bonding**.

This stability can be achieved one of two ways:

- **Ionic** bond
- **Covalent** bond

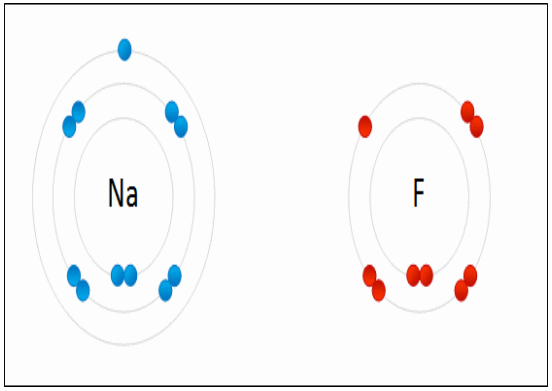


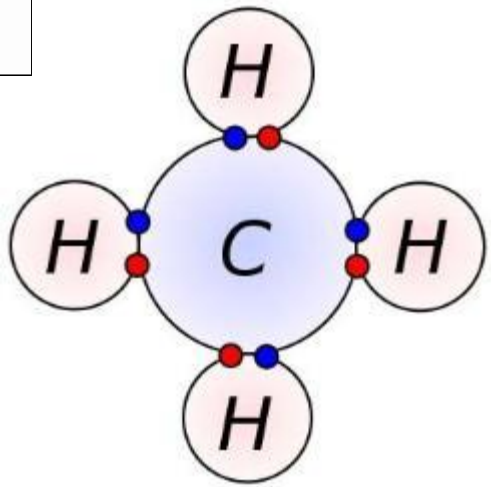
Images: Carbon, Universe Today Website

From the Virtual Microbiology Classroom on ScienceProfOnline.com

Three Main Types of Chemical Bonds:

1. **Ionic**
2. Covalent
3. Hydrogen





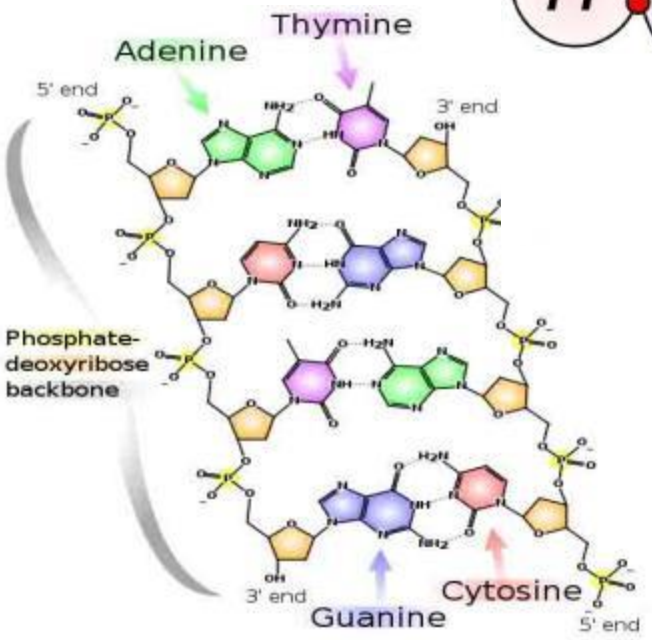
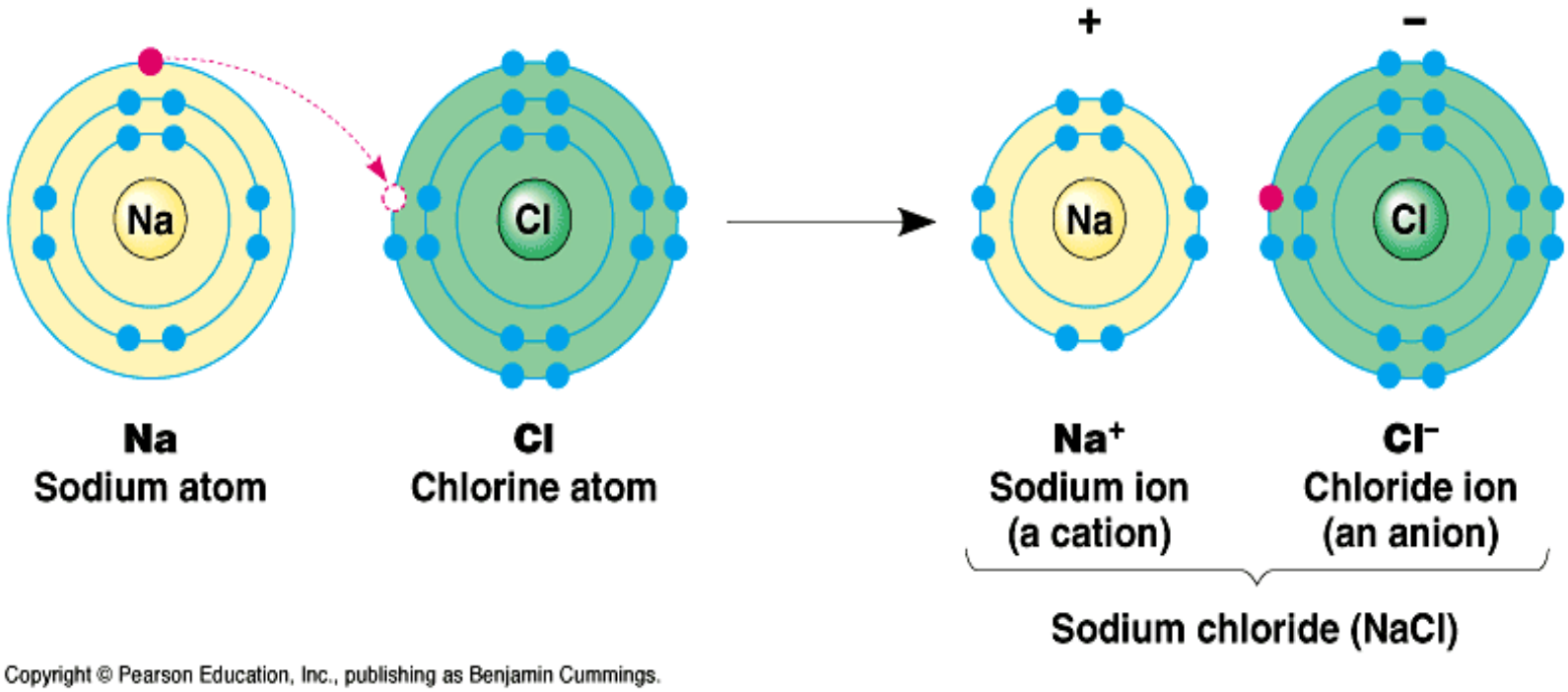


Image: Formation of ionic sodium fluoride, Wdcf; Methane Covalent Bonds, Dynablast, Wiki; DNA Chemical Structure, Madprime, Wiki

Ionic Bonds

Involves transfer of electrons between two atoms.

Found mainly … inorganic compounds.



Ion = an atom or group of atoms which have lost or gained one or more electrons, making them negatively or positively charged.

***Q**: What are positively charged ions (+) called?*

***Q**: What are negatively charged ions (-) called?*

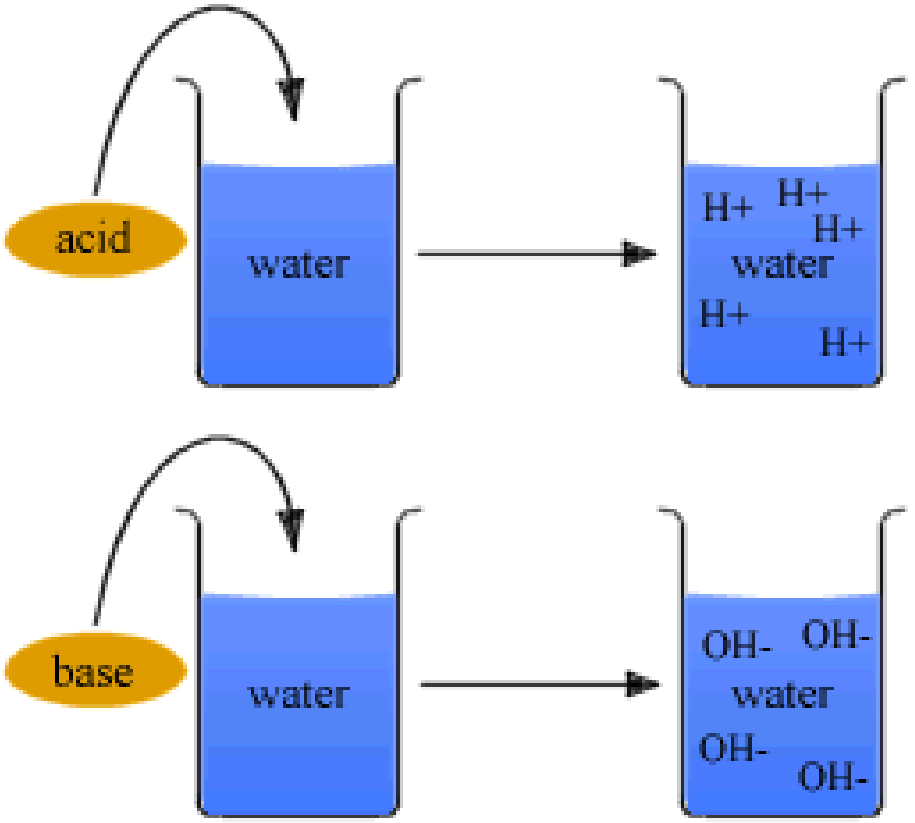
Images: Sodium Chloride, University of Winnepeg

From the Virtual Microbiology Classroom on ScienceProfOnline.com

Ions: Acids & Bases

An **acid** is any ionic compound that releases **hydrogen** _____ (H^+) in solution.

A **base** is any ionic compound that releases **hydroxide** _____ (^-OH) in solution.



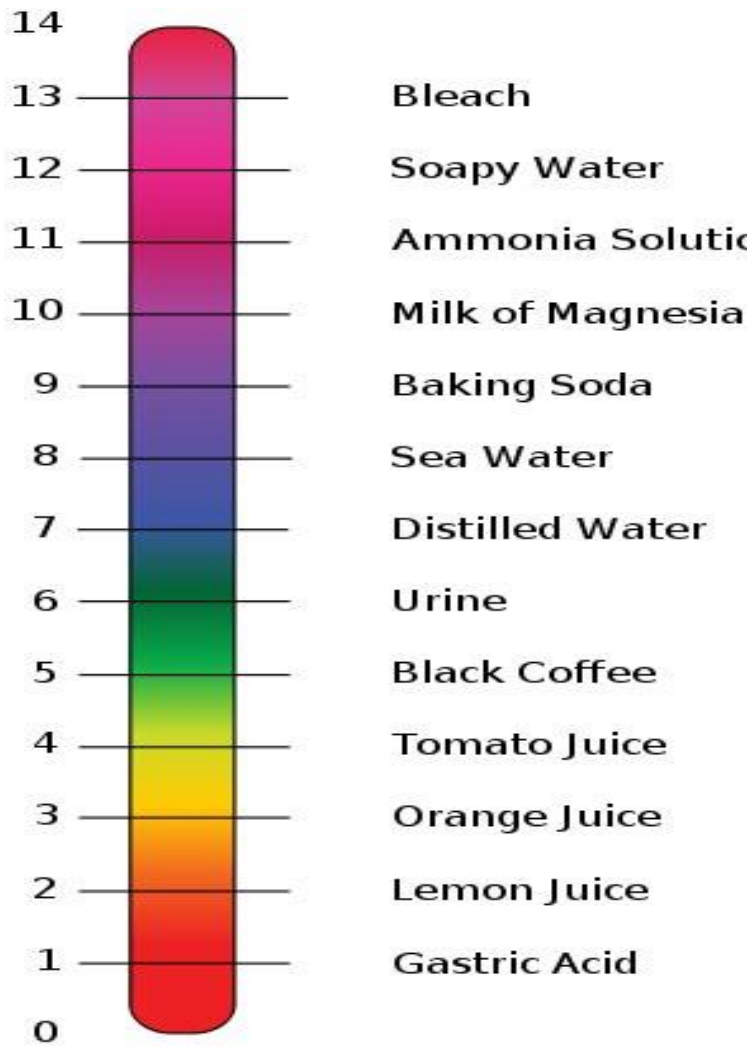
Measurements of Acidity & Alkalinity (pH)

Acidity of a solution > measured by concentration of hydrogen ions (H+).

pH ranges: 0 (very acidic) to 14 (very basic).

Change in just one unit of scale = tenfold change in H+ concentration.

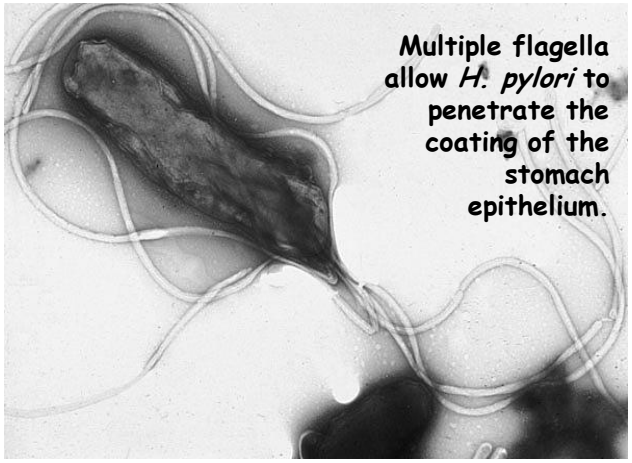
If concentration of H+ = OH - … neutral.



Images: pH scale, Edward Stevens, Wiki

Meet the Microbe!

Species: *Helicobacter pylori*



GRAM NEGATIVE
Microaerophilic, Acidophile
Helically shaped
Never normal flora

Robin Warran & **Barry Marshall** identified *H. pylori* in 1982, and discovered link between *H. pylori* and ulcers.

***H. pylori* virulence factors:**
- Make proteins that inhibit acid production
- Flagella propel through stomach lining to epithelial cells
- Have adhesins
- Make enzymes to inhibit phagocytosis

What Is an Ulcer?

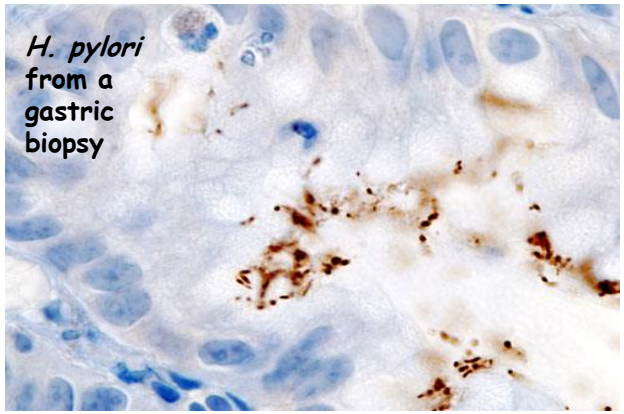
A sore or hole in lining of the stomach or duodenum (the first part of the small intestine).

Not caused by stress or eating spicy food, but these factors can make ulcers worse.

Incidence:

Many people have *H. pylori* infection, but most infected people, do not develop ulcers.

H. pylori produces enzyme urease, which breaks down urea (normally secreted into the stomach) to carbon dioxide and ammonia. The ammonia is converted to ammonium that neutralizes gastric acid.. The ammonia produced is toxic to the epithelial cells and damages them.



Images: *Helicobacter pylori*, Yutaka Tsutsumi, M.D; Histopathology of *H.pylori* from a gastric biopsy, KGH

Mannitol Salt (MSA)

Mannitol Salt media is both **selective** & **differential**.

1. **Selective** because it has a high NaCl (7.5%) concentration, and few types of bacteria can grow on this hypertonic medium.

   Members of genus *Staphylococcus* are halophilic, and grow well on this media.

2. **Differential** because this medium contains a pH-sensitive dye to identify organisms that ferment mannitol (a sugar-alcohol). Organic acids wastes mannitol fermenters produce change the medium from red to yellow.

   MSA works well for identifying **pathogenic staphylococci**, such as *Staphylococcus aureus*, which will ferment mannitol.

   Most non-pathogenic staphylococci *(Staphylococcus epidermidis)* will not ferment mannitol.

Q: Regardless of the color of the plate, what do know about bacteria found growing on Mannitol Salt?

Q: If there is growth, what additional info can then be obtained about bacteria growing based on color of the medium.

Watch **VIDEO**:

How to Interpret Mannitol Salt Agar (MSA)

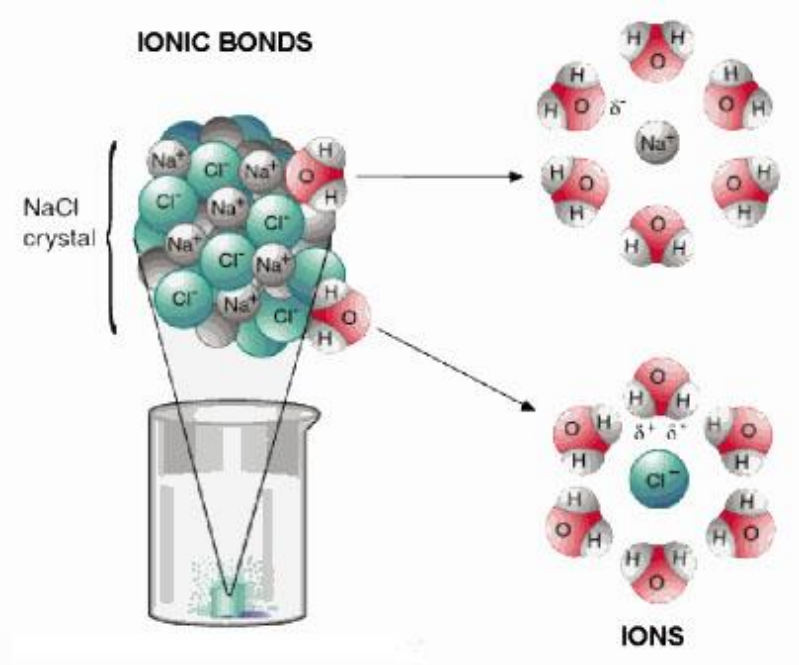
Images: Sterile Mannitol Salt Agar & Positive & negative differential reaction on Mannitol Salt Agar, T. Port

Ions & Salts

- Compounds that dissociate in water and produce cations other than H+ and anions other than OH- are called **salts**.

- The most familiar salt is **sodium chloride**, the principal component of **common table salt**.

- **Other examples of salts:**
  - Baking soda (NaHCO3)
  - Epsom Salts (MgSO4)



Salts: The Role of Buffers

- Certain salts, called **buffers**, can combine with excess hydrogen (H+) or hydroxide (OH-) ions.

- Produce substances less acidic or alkaline.

- ***Example:***
Antacids are buffers made of the salt calcium carbonate (CaCo3).

Images: Antacid Tablets, Wiki

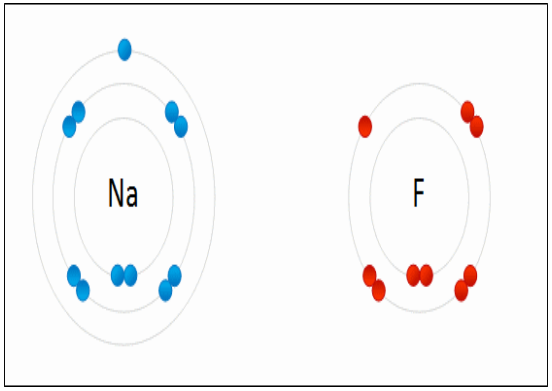
Antacids & Food Poisoning

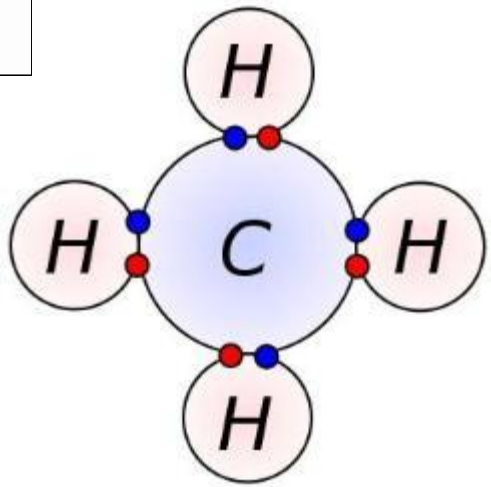
- Acidic environment of stomach kills many bacteria before they can cause disease.
- Researchers have found that antacids, in a simulated gastric environment, significantly increase survival rate of *Vibrio vulnificus*, leading cause of food-poisoning fatalities in US.

Images: *Vibrio vulnificus*, PHIL 7815, Antacid Tablets, Wiki Raw Oysters, David.Monniaux, Wiki

Three Main Types of Chemical Bonds:

1. Ionic
2. **Covalent**
3. Hydrogen





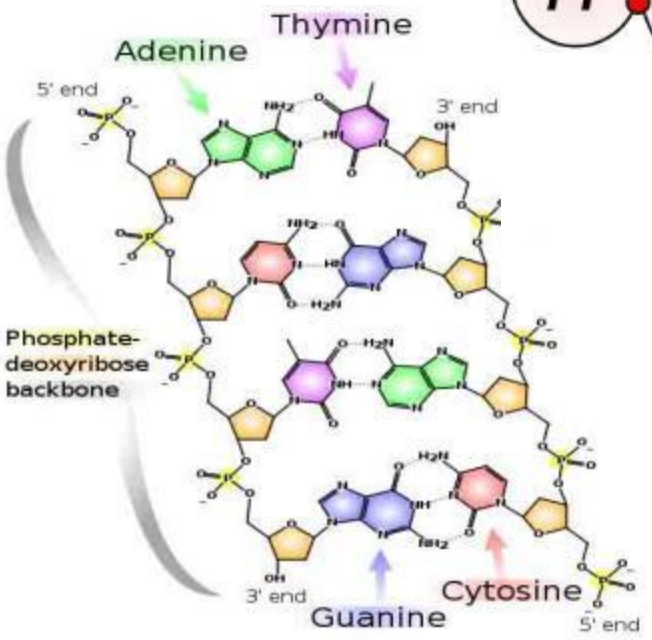
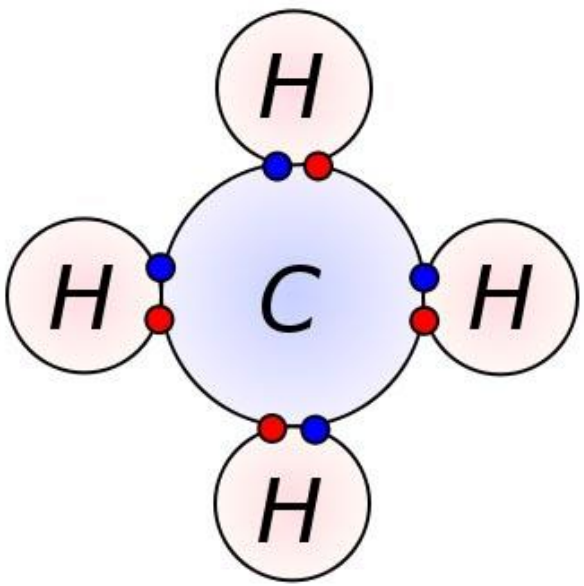


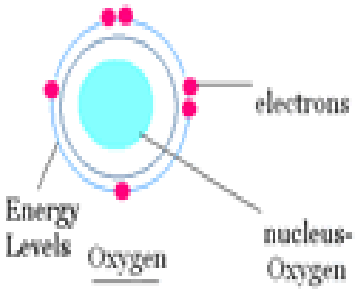
Image: Formation of ionic sodium fluoride, Wdcf; Methane Covalent Bonds, Dynablast, Wiki; DNA Chemical Structure, Madprime, Wiki

Covalent Bonds

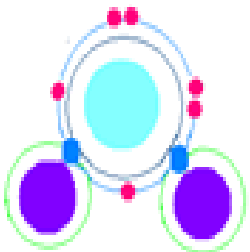
***Covalent Bonds*:** Involve the sharing of a pair of electrons between two atoms.

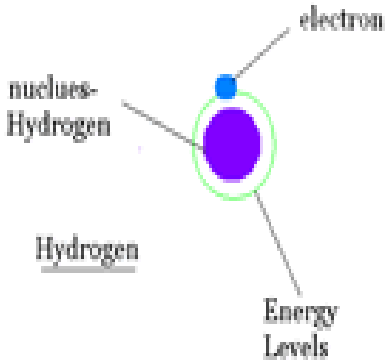
Found mainly … organic compounds





If combined you get...





... H_2O

Because the Oxygen and Hydrogen are sharing two electrons. It has two have two Hydrogen Atoms , because Hydrogen only has one electron.

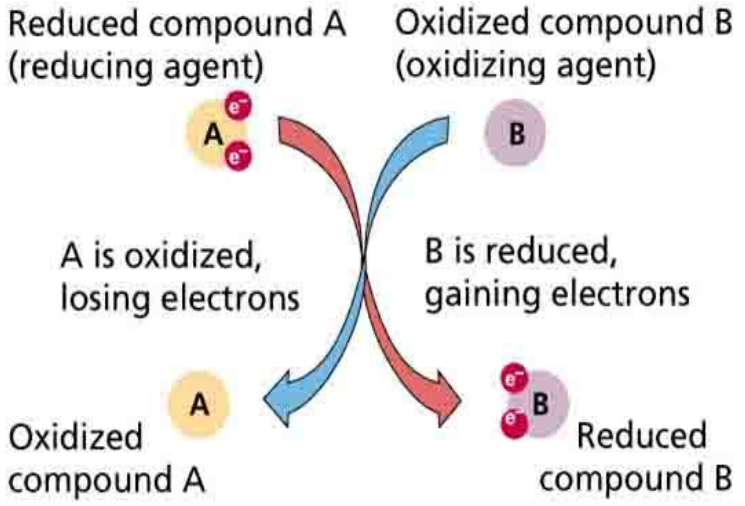
Image: Methane Covalent Bonds, Dynablast, Wiki

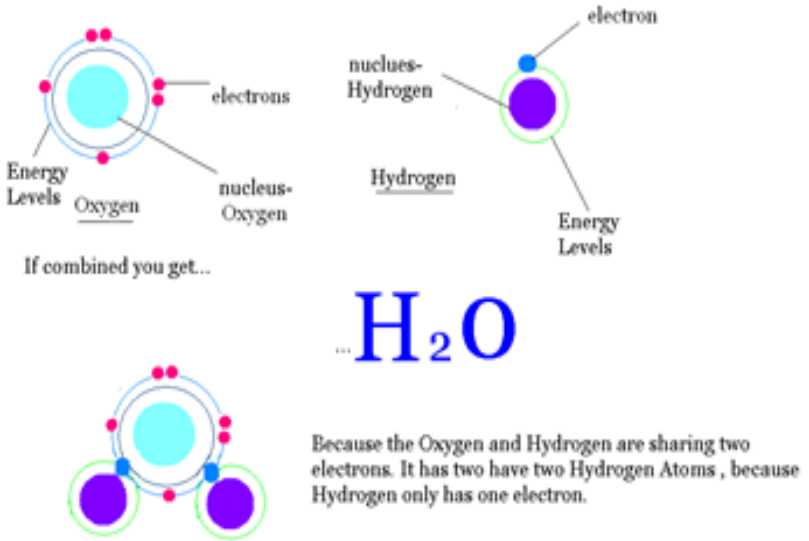
Oxidation - Reduction Reaction

- Or **Redox** reaction = chemical reactions in which electrons are ***gained, lost*** (*Q: What kind of bond?*) or ***shared*** (*Q: What kind of bond?*) in a chemical reaction.

- **oxidation**: ***loss*** of electrons by a molecule, atom or ion.

- **reduction**: ***gain*** of electrons by a molecule, atom or ion.





Oil Rig

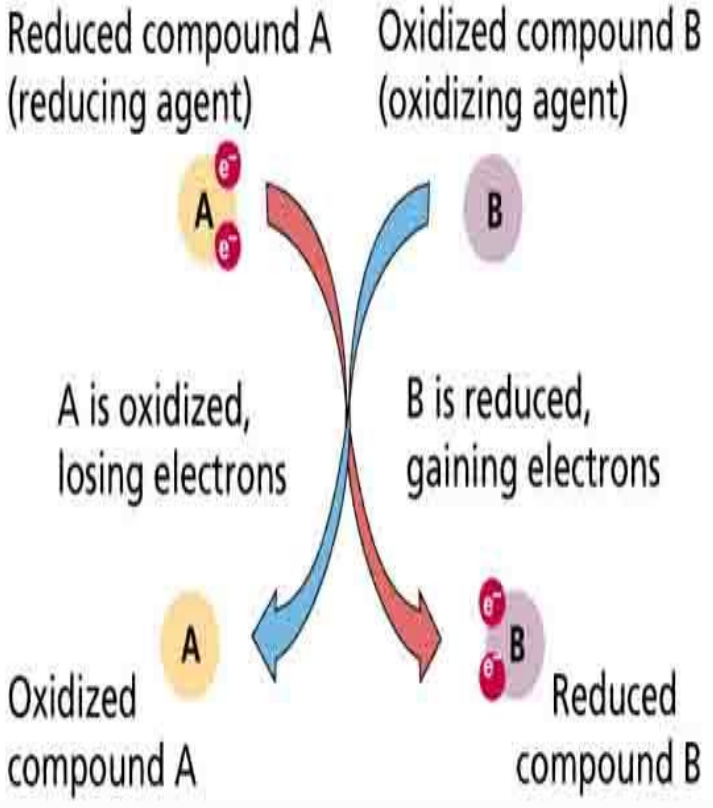
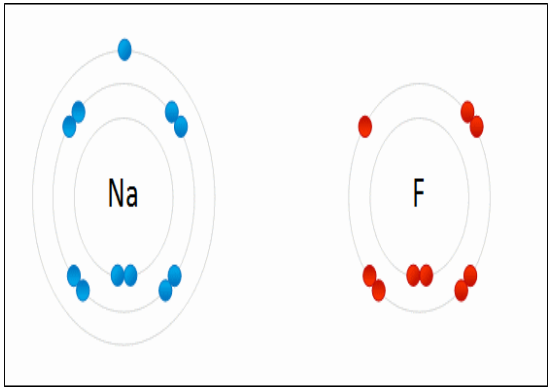


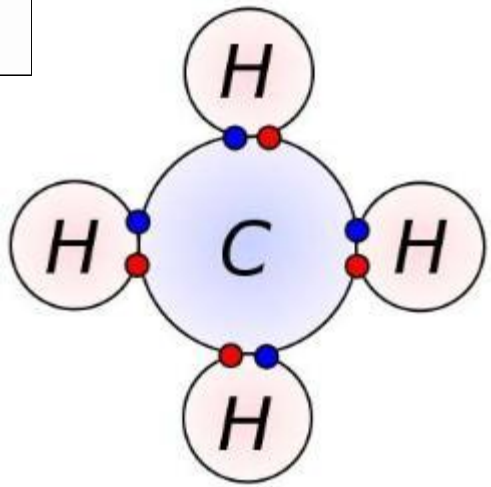
Image: Oil Rig Platform, Nasa

From the Virtual Microbiology Classroom on ScienceProfOnline.com

Three Main Types of Chemical Bonds:

1. Ionic
2. Covalent
3. **Hydrogen**





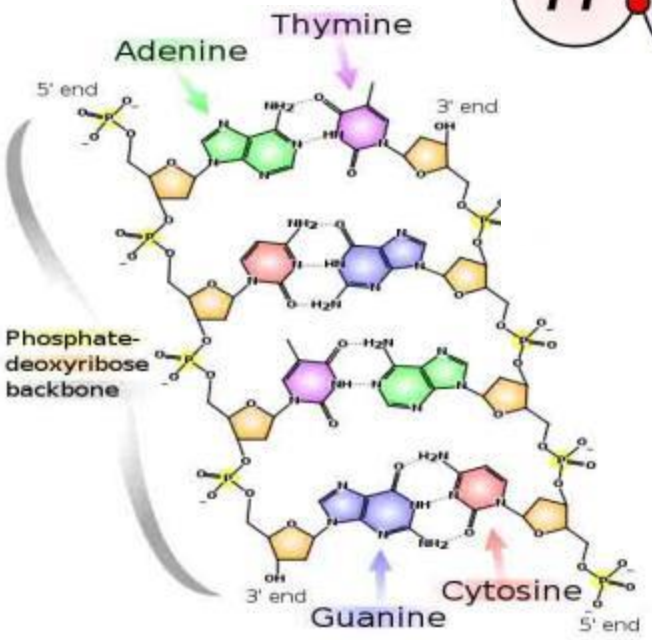


Image: Formation of ionic sodium fluoride, Wdcf; Methane Covalent Bonds, Dynablast, Wiki; DNA Chemical Structure, Madprime, Wiki

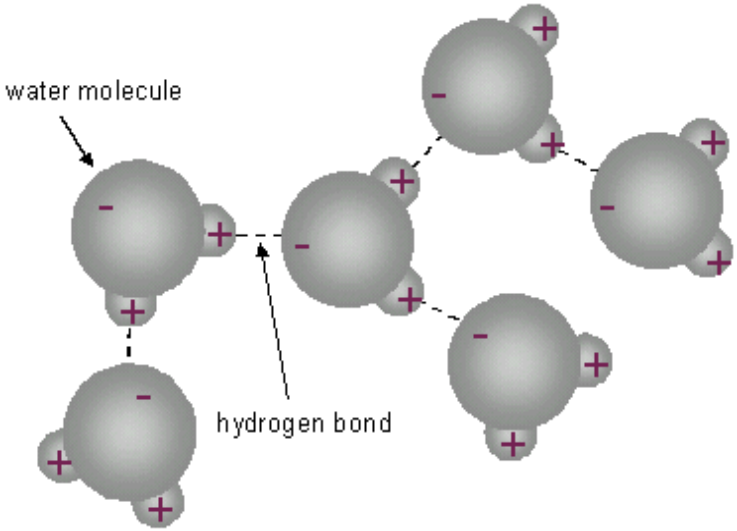
Hydrogen Bonds

Hydrogen Bonds: When an atom of hydrogen is attracted to another electronegative atom in addition to the one it is covalently bonded to.

In some covalent bonds electrons are shared *unequally* by the hydrogen and the atom that the hydrogen is bound to. When the electrons in a covalent bond are not equally shared, the molecule is **polar**.

See the **polar, covalent bonds** of *each individual water molecule* below.

See the **hydrogen bond attractions** *between the hydrogens and the oxygens of nearby, but separate water molecule below.*



Found in water, proteins & DNA

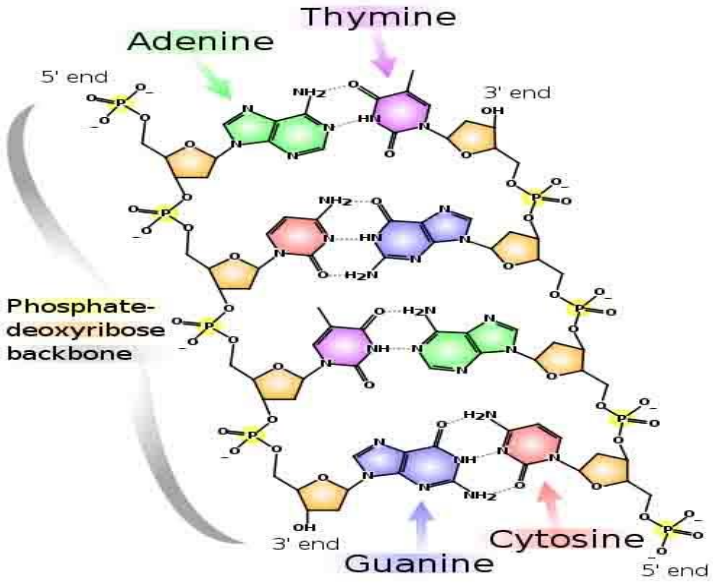
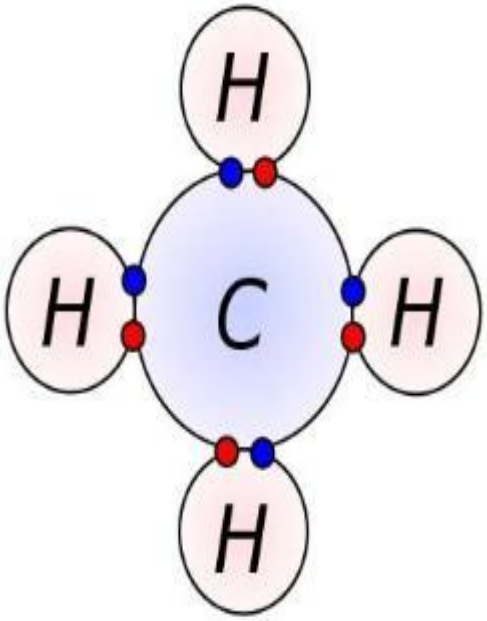
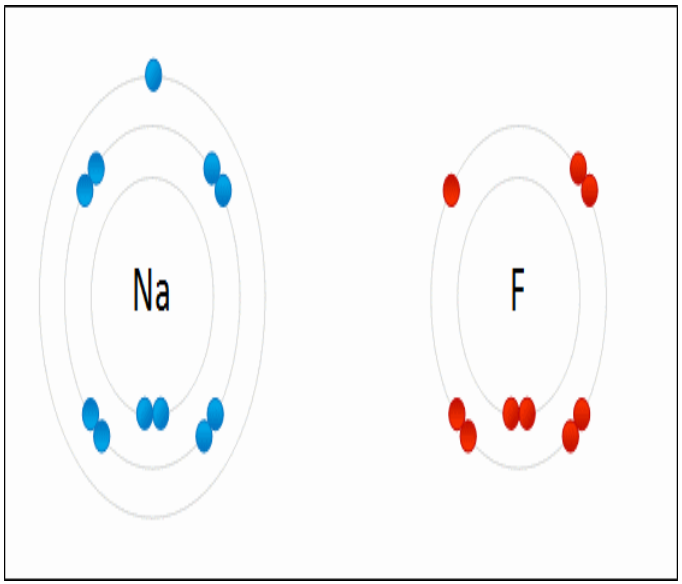


Image: DNA Chemical Structure, Madprime, Wiki; Water Striders, Markus Gayda, Wiki

REVIEW!

Animated lessons on
Chemical Bonding





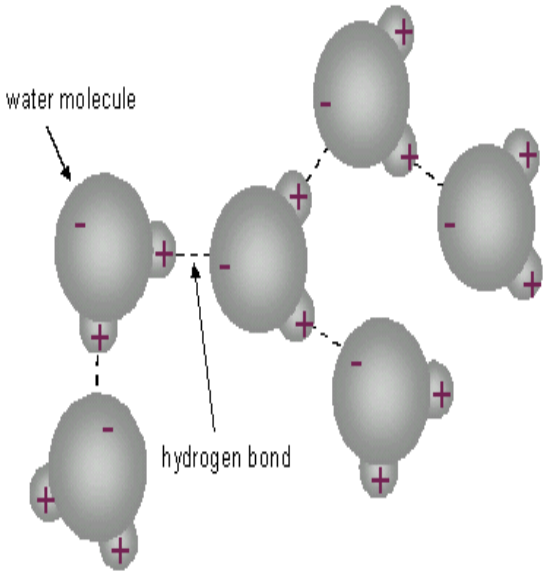


Image: Methane Covalent Bonds, Dynablast; Formation of ionic sodium fluoride,

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

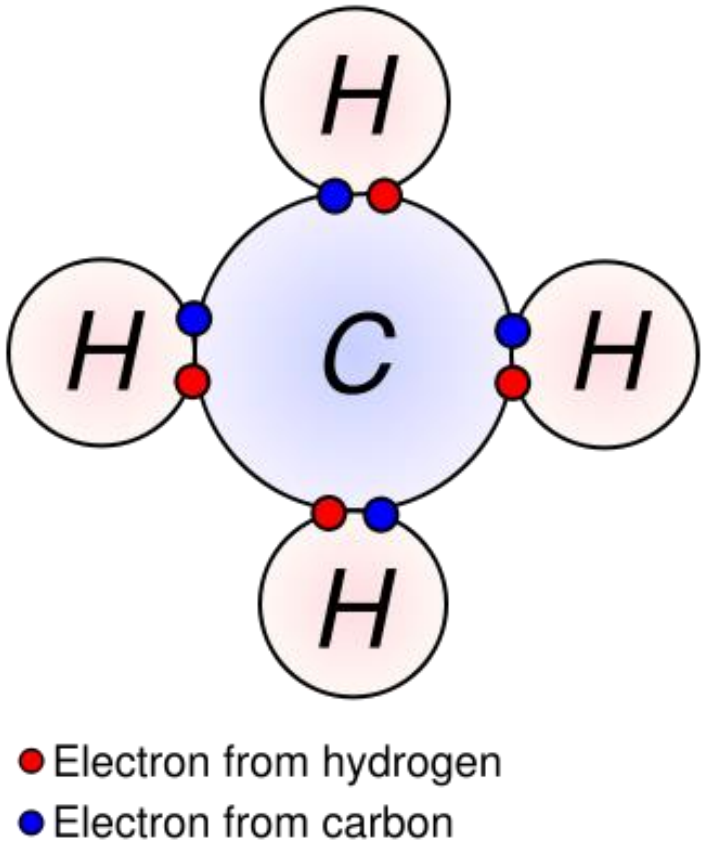
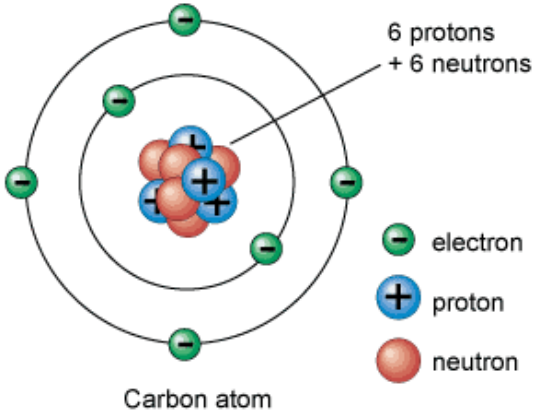


Image: Methane Covalent Bonds, Dynablast, Wiki

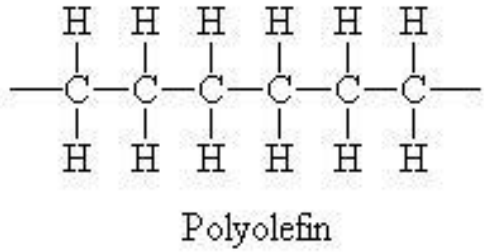
Carbon

Little Atom, Big Deal



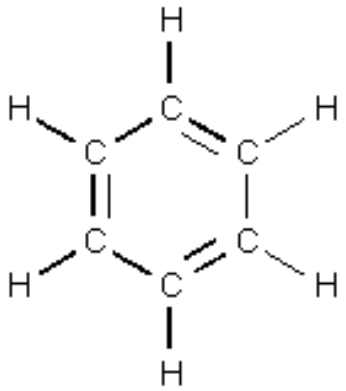
The chemical basis of life. Abundant in all known life forms.

Essential to complex organic macromolecules, because each carbon atom can form **4** bonds (usually involving hydrogen, oxygen and/or nitrogen).



Able to form **polymers** (big organic molecules).

- The atoms can bond with each other to form long chains.
- Sometimes the ends of these chains join together to form a ring.
- Double bonds form when atoms share two electrons (two covalent bonds).



Images: Carbon, Universe Today Website

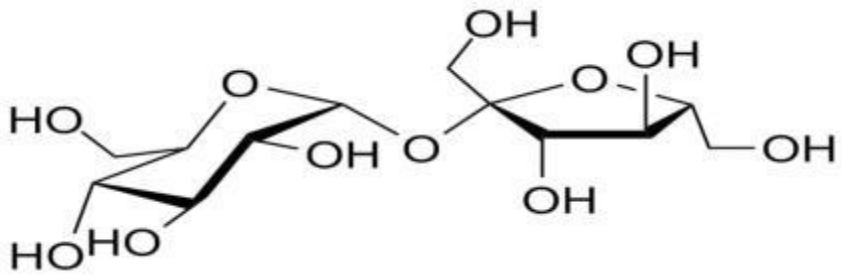
Study Table of Organic Macromolecules

(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?	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-).



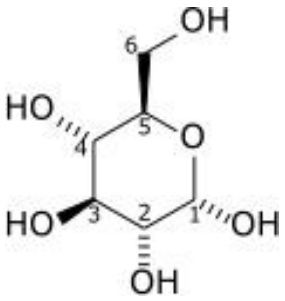
You probably know that chocolate cake is full of refined sugars…carbs. You may not know that boogers contain carbs as well. Boogers are dried-up mucus and dirty nose debris. Mucus is made mostly out of sugars and protein. Looks like this little punkin is double dipping. Bon appetite!

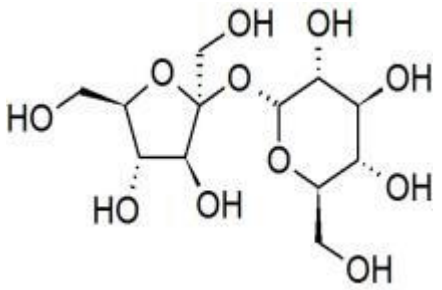
Image: Sucrose, Wiki

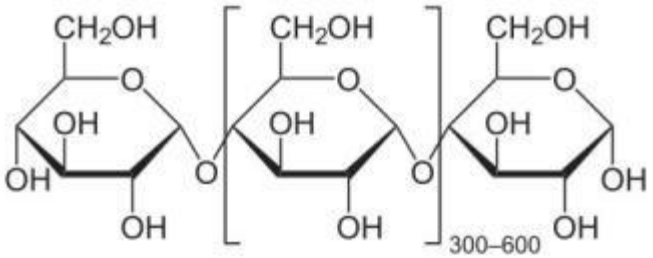
Organic Molecules - Carbohydrates

Monosaccharides

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







Disaccharides

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

Polysaccharides

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

MacConkey's (MAC)

MacConkey's media is both **selective & differential**.

1. **Selective** because it *only grows* ***Gram-negative*** *bacteria*. Inhibits the growth of **Gram-positive** bacteria.

2. **Differential** because neutral red (pH-sensitive dye) and lactose (type of sugar) have been added to media.

- Bacteria that use **lactose** (a disacchride) for food, produce acidic metabolites that trigger the **pH** sensitive dye to turn pink.
- So lactose fermenting bacteria will grow in bright pink colonies while non-lactose fermenters will be colorless and clear.

Q: Regardless of the color of the plate, what do know about bacteria found growing on MacConkey's?

Q: If there is growth, what additional information is provided when the color of the bacteria is examined?

Enteric bacteria are the most frequently encountered bacteria isolated from many types of clinical specimens. They are most commonly lactose fermenters.

Watch **VIDEO**:

How to Interpret MacConkey's Agar (MAC)

Image: McConkey's growing *Salmonella* on the left, and *E. coli* on the right, T. Port

Organic Molecules - Proteins

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

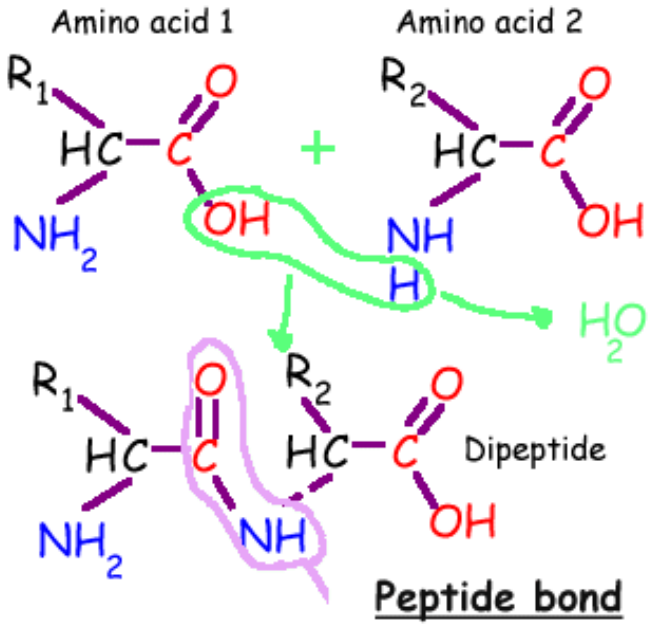
Amino acids contain a:

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.

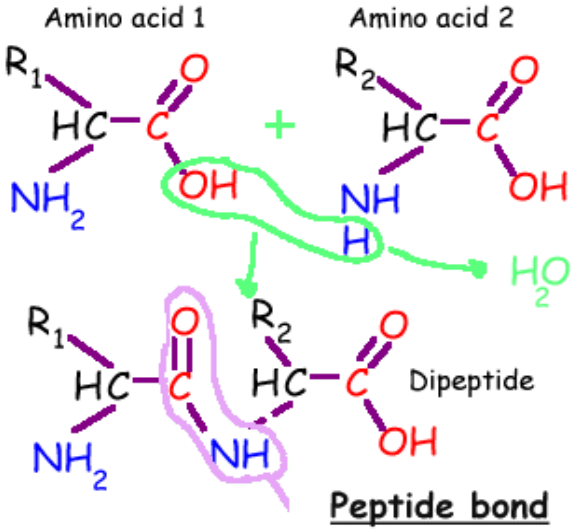
Side groups important … affects the way a proteins amino acids interact with one another, and how a protein interacts with other molecules.



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.

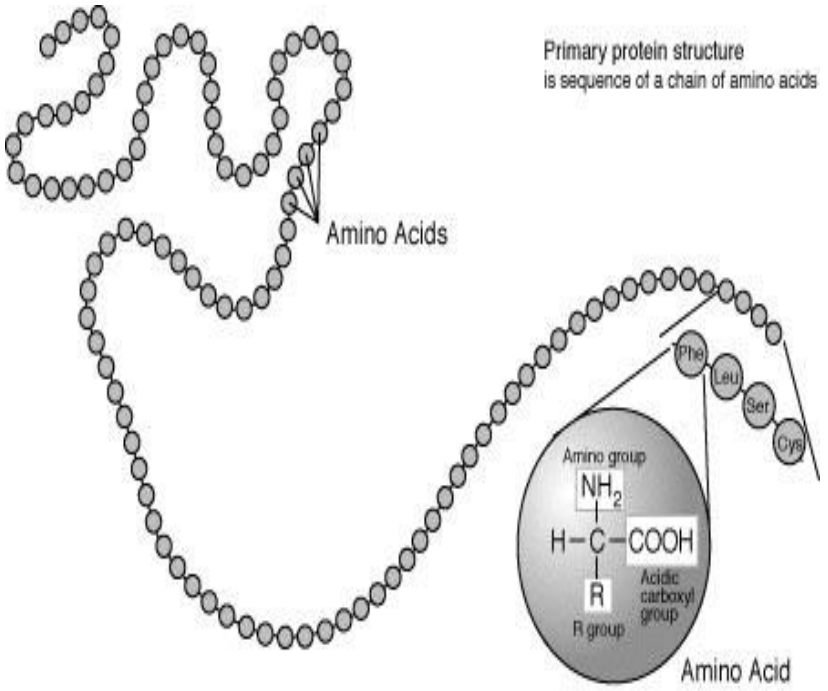


Image: Protein Primary Structure, Wiki

Protein Structure

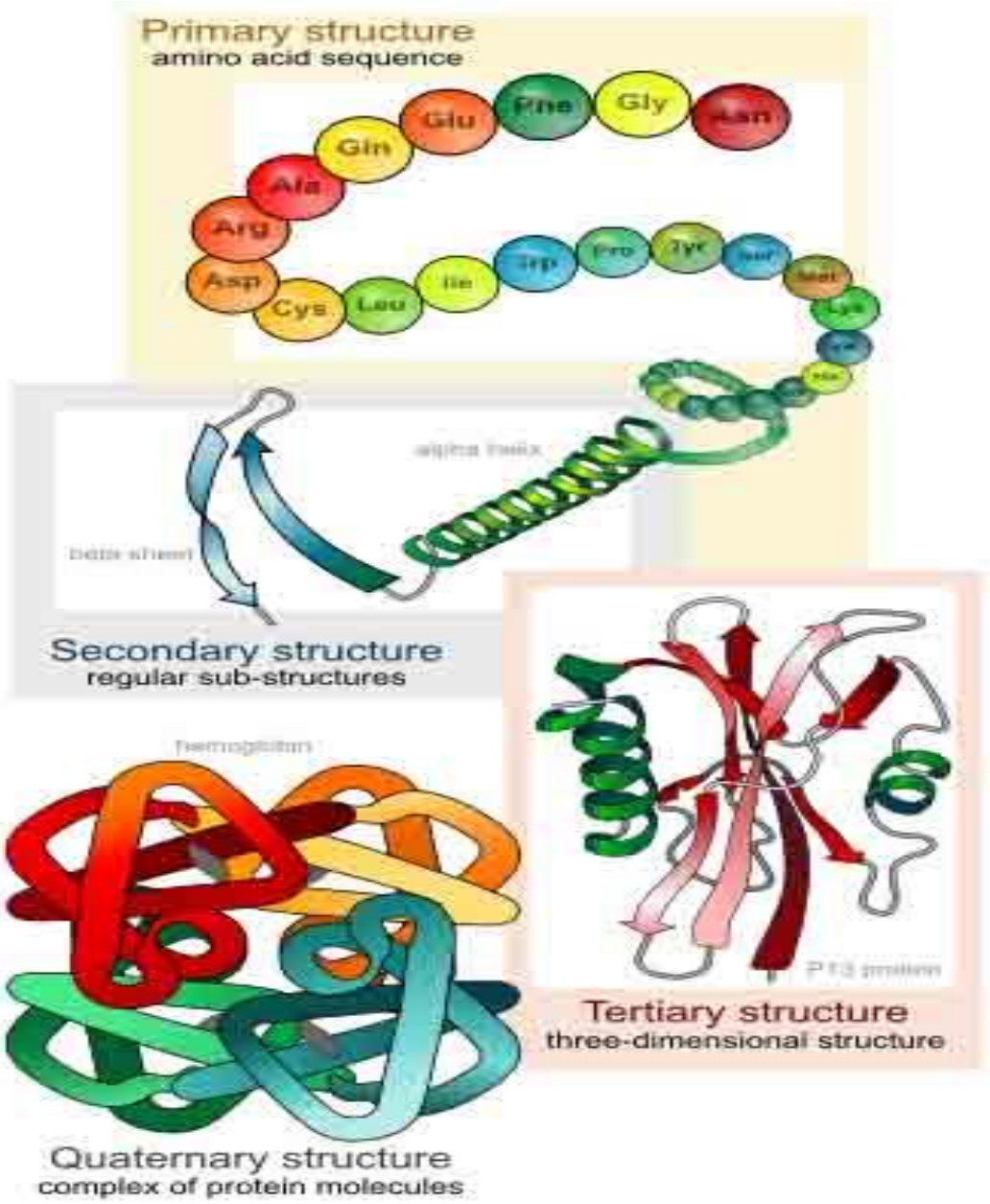
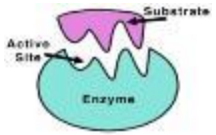


Image: Levels of protein structure, M Ruiz

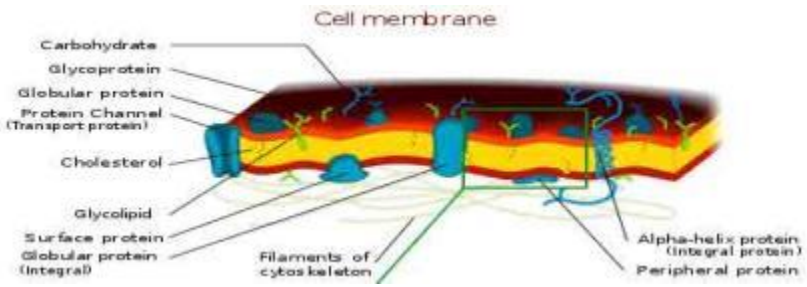
Organic Molecules - Proteins



Complex organic macromolecules fundamental to living cells.

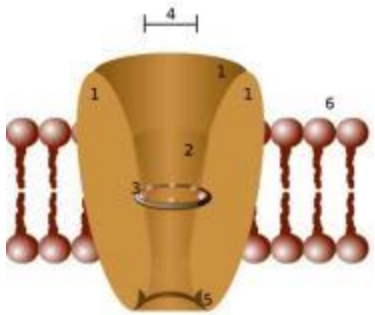
Composed of one or more chains of amino acids.

Proteins perform many functions in cells, including:



1. Structural

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

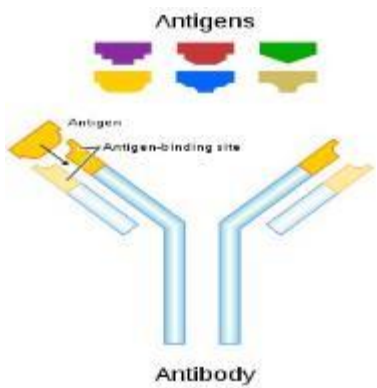


2. Enzymes

- 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

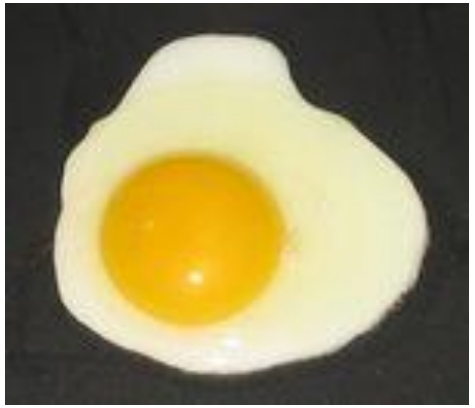
- Some act as channels and "pumps" that move substances into or out of cells.

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**

Q: How do you sabotage a protein?



- Alteration of a protein shape through some form of external stress

- Example, by applying heat, acidic or alkaline environment

- Denatured protein can't carry out its cellular function .

Irreversible egg protein denaturation caused by high temperature (while cooking it).

Organic Molecules – Nucleic Acids

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

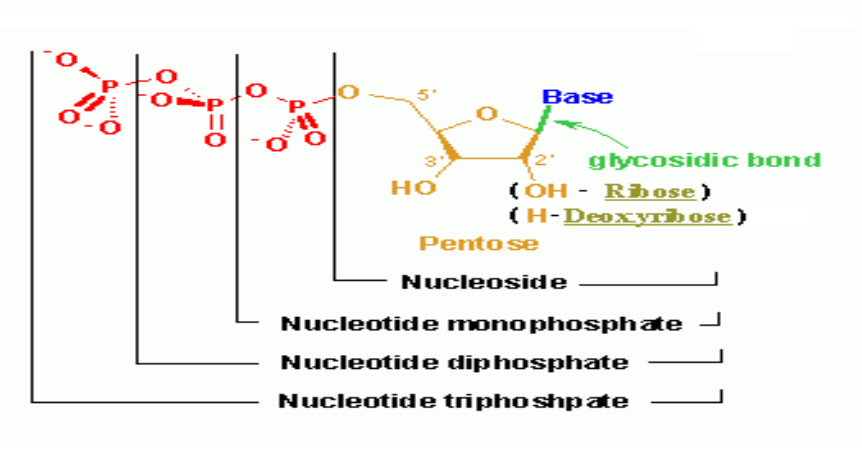
Nucleic acids **deoxyribonucleic acid** (DNA) and **ribonucleic acid** (RNA) = genetic material of cells.

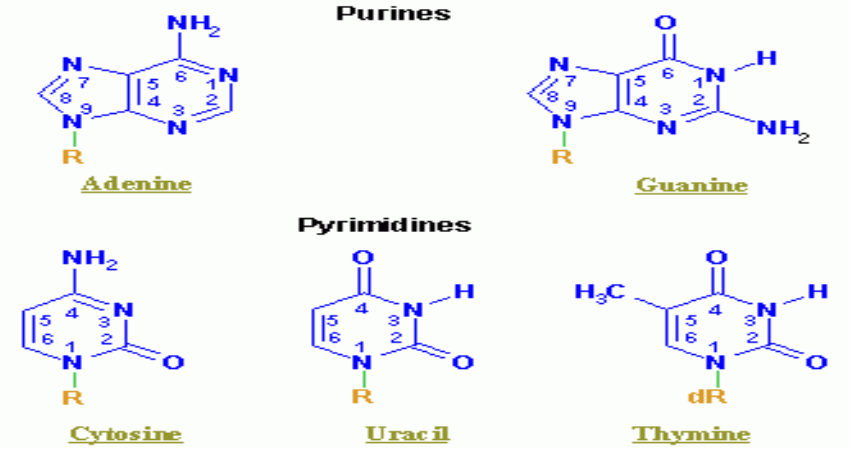
Names derived from type of **sugar** contained within molecules = **ribose**

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 Microbiology Classroom on ScienceProfOnline.com

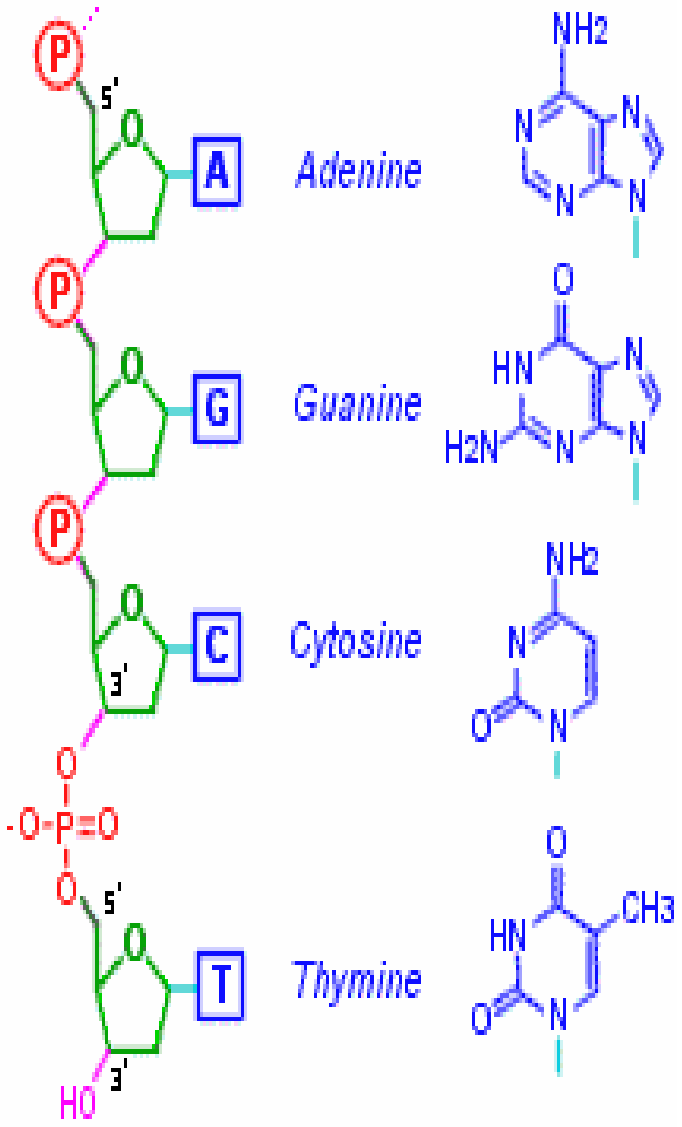
Image: Nucleotide Structure, Wikipedia

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

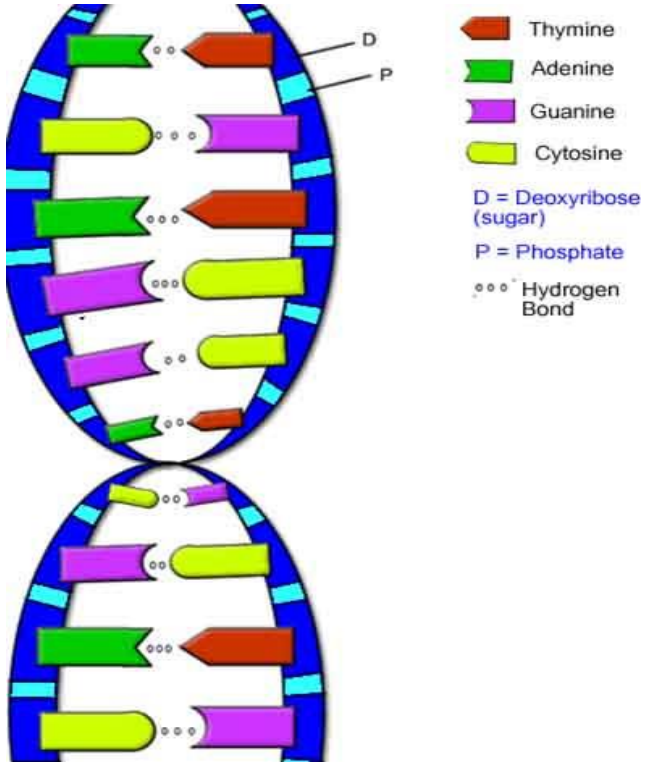
Pyrimidine Bases (single ring)
Cytosine & Thymine

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

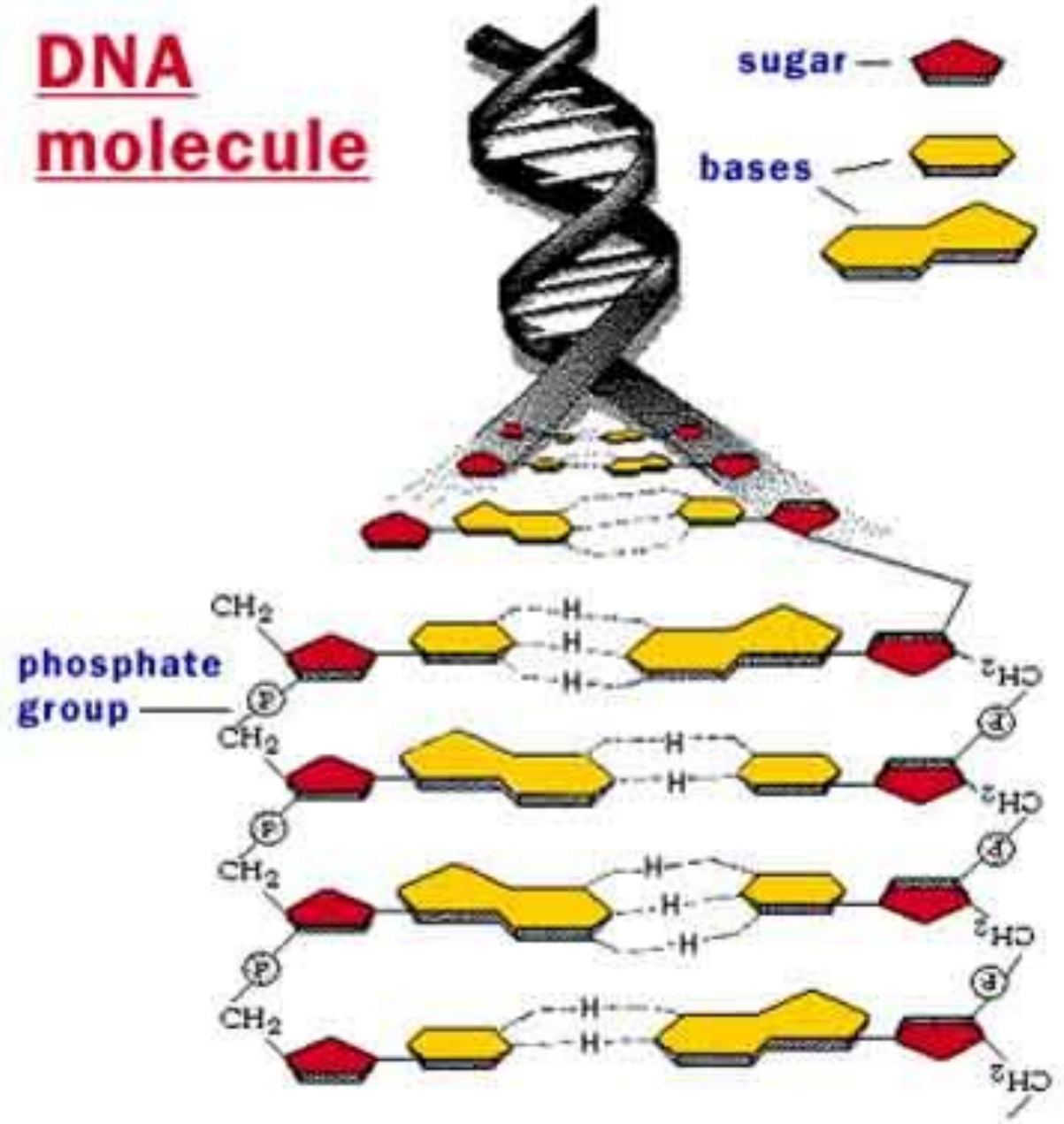
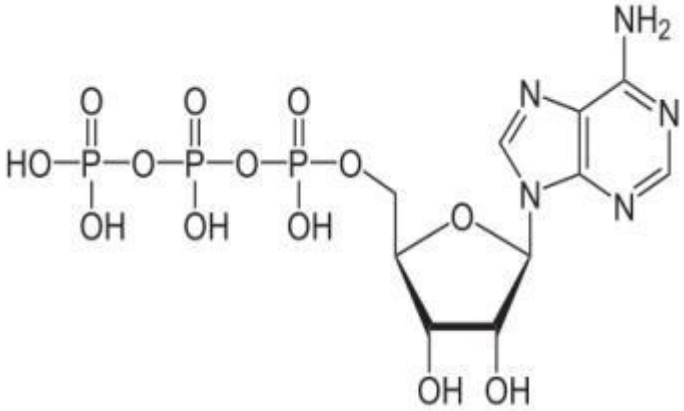


Image: DNA Molecule, National Science Foundation

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



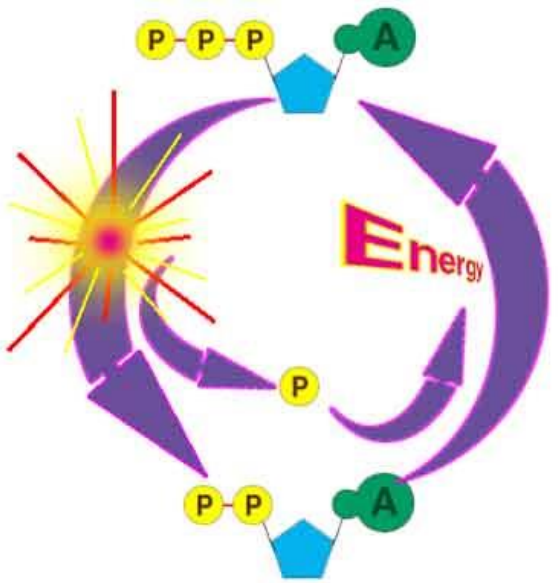


Image: ATP Molecule, NEUROtiker; ATP-ADP Cycle, CUNY

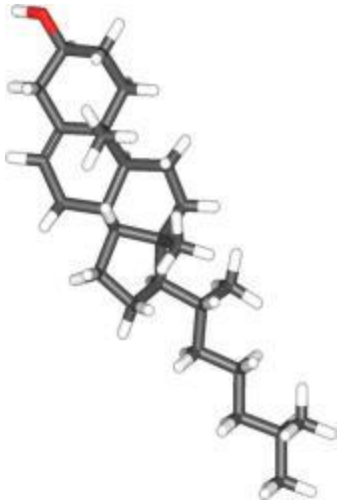
Organic Molecules – Lipids

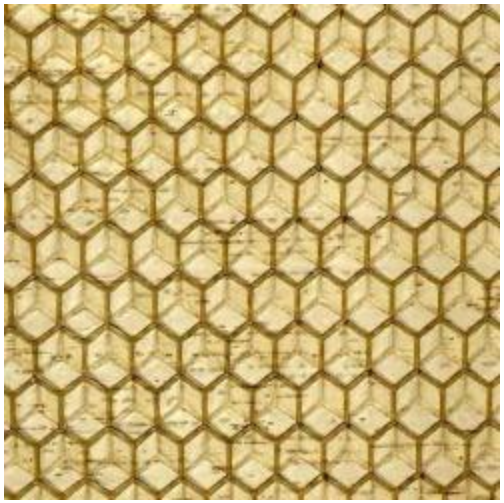
(Fats, Phospholipids, Waxes & Steroids)

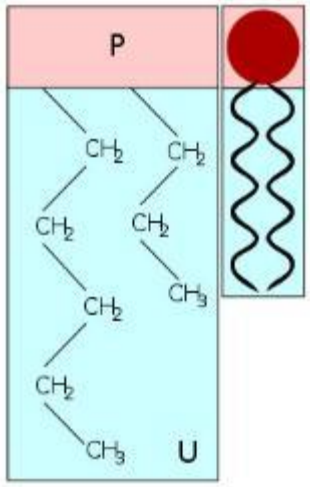
Hydrophobic macromolecules…insoluble in water.

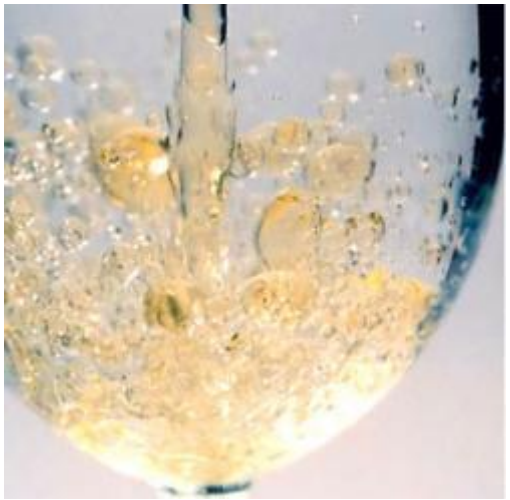
Not attracted to water because …

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





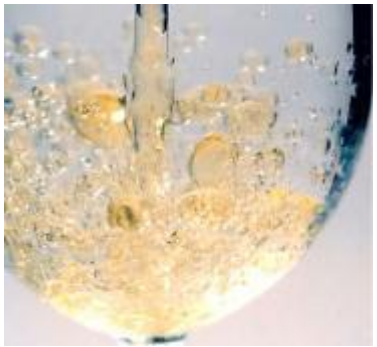




Images: Cholesterol, Wiki; Phospholipid Structure, Bryan Derksen. Wiki Honeycomb, Wikii; Oil & Water, Kidipede

Organic Molecules – Lipids

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



Fats

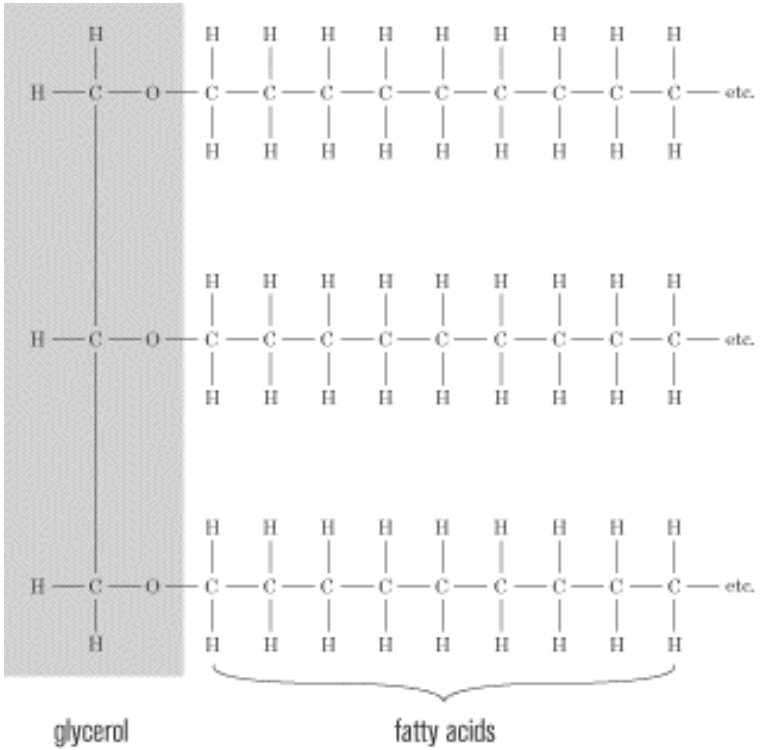
Fats and oils are made from two kinds of molecules:

- **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**.

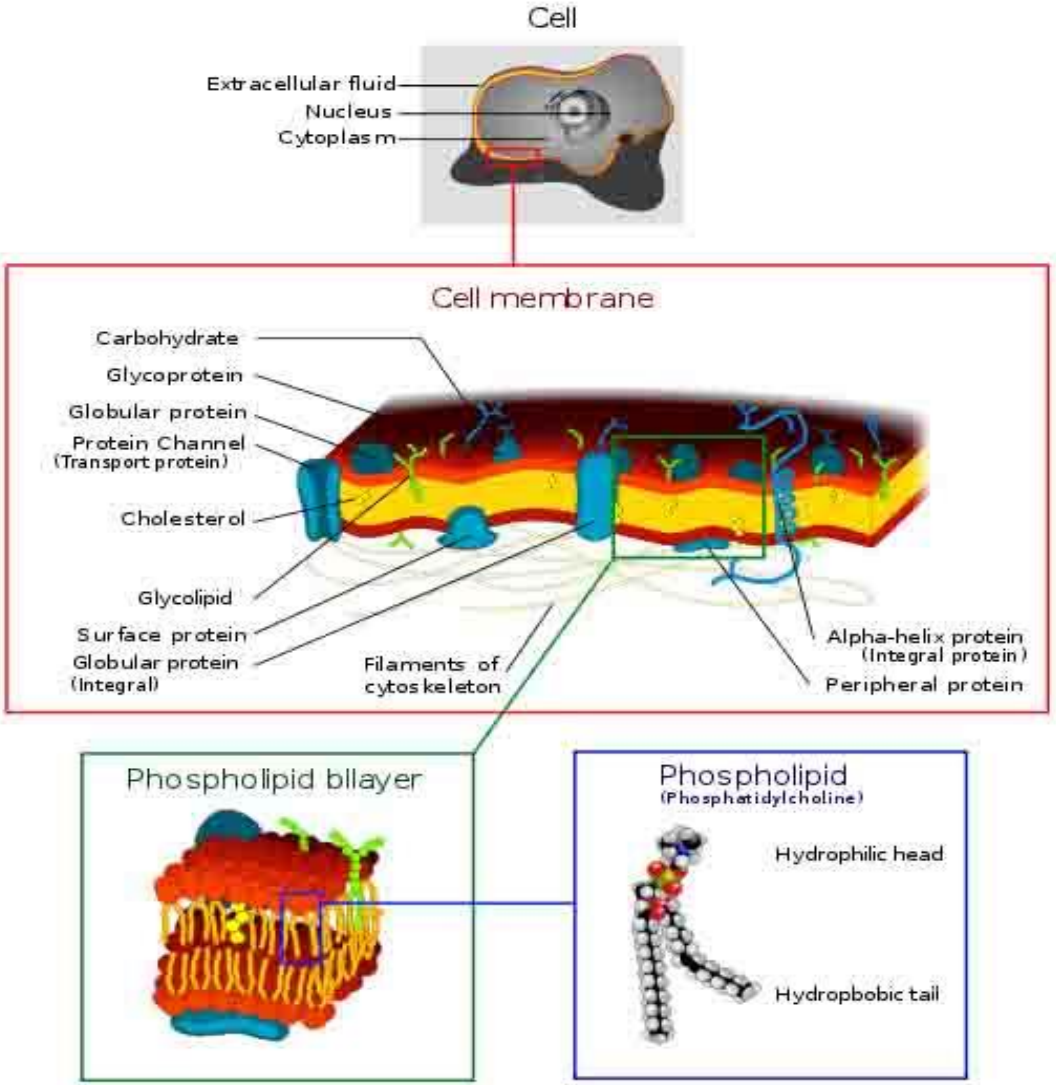
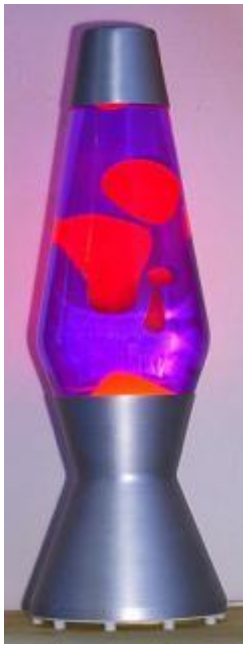


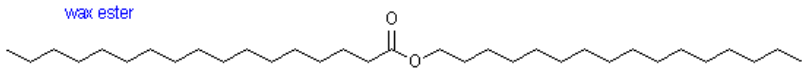
Image: Cell Membrane, Wiki;

Organic Molecules – Lipids

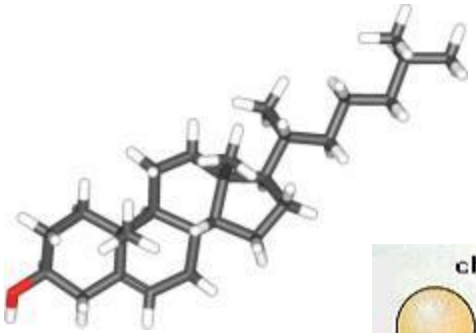
*(Fats, Phospholipids, **Waxes & Steroids**)*



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.

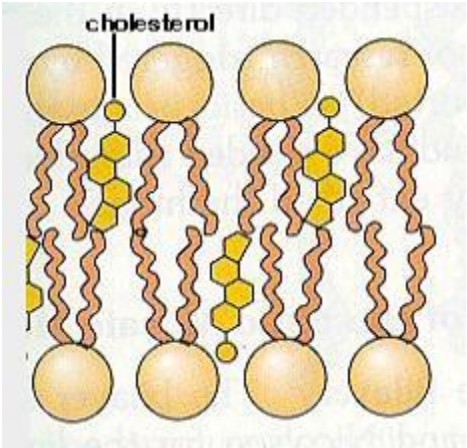


Image: Lava Lamp, Wiki; Cholesterol molecule, Wiki; Phospholipids & Cholesterol, Cytochemistry.net

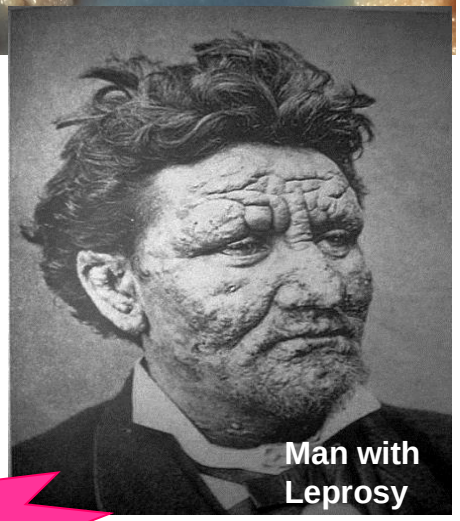
Meet the Microbes: *Mycobacterium*

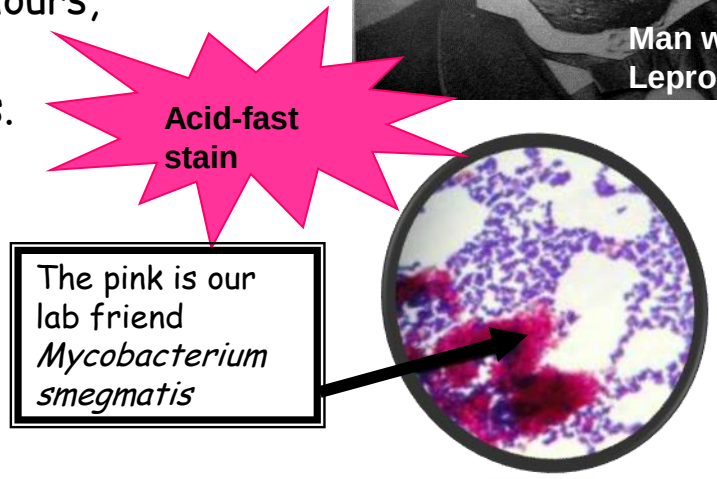
GRAM-variable, obligate aerobe, bacillus-shaped

Q: Why are they considered "Gram variable"?

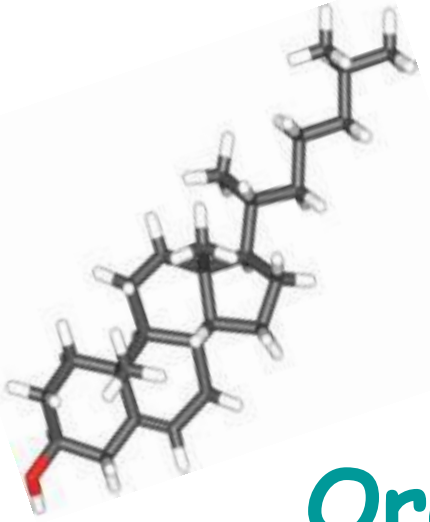
- *M. leprae* and *M. tuberculosis* have plagued mankind for ages.
- Thought that *M. tuberculosis* and *M. leprae* evolved from a soil bacterium that infected cows, then made jump to humans about the time of animal domestication, 10,000 years ago.
- *M. tuberculosis* doubles population every 18-24 hours,
- *M. leprae* doubles population about every 14 days.

Q: What might be the impact of generation time on the course of the infectious diseases these microbes cause?

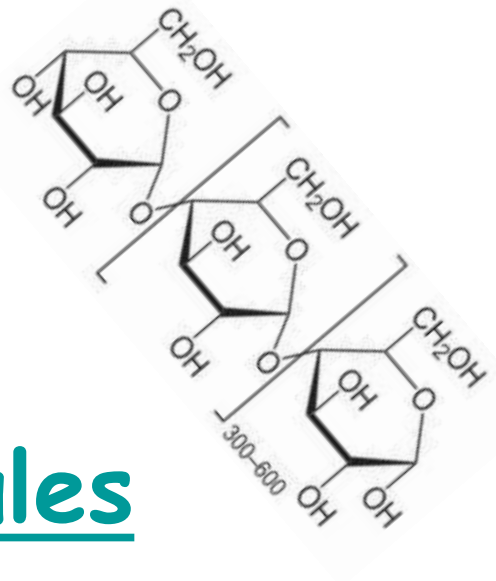




Images: TB Culture, Public Health Image Library (PHIL) #4428, Dr. George Kubica; 24 yo man from Norway, suffering from leprosy; Pierre Arents; Acid fast stain of *Mycobacteria smegmatis* & *Staph*, T. Port

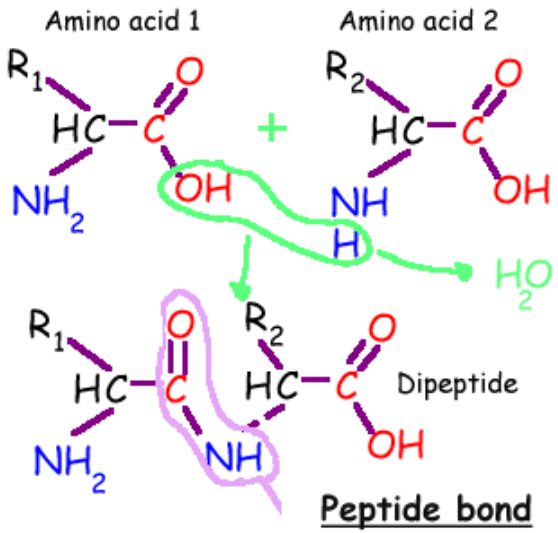


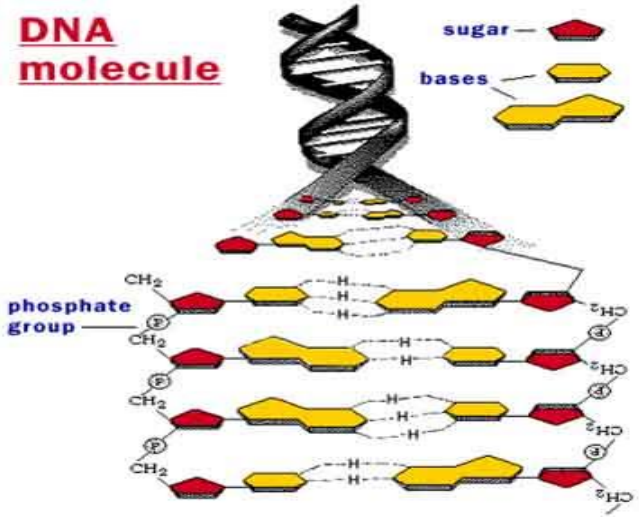
REVIEW!



Animated lessons on

Organic Macromolecules





From the Virtual Microbiology Classroom on ScienceProfOnline.com

Images: Cholesterol, Wiki; Chilesterol; Amino Acids & Peptide Bonds; DNA Molecule, National Science Foundation

Confused?

Here are some links to fun resources that further explain

Inorganic Chemistry:

Smart Links

- Inorganic Chemistry Main Page on the Virtual Cell Biology Classroom of Science Prof Online.
- "She Blinded Me With Science" music video Thomas Dolby.
- "What Kind of Bonds Are These?" song and slide show by Mark Rosengarten.
- Chemical Bond Formation animated science tutorial.
- "Meet the Elements" music video by They Might Be Giants.
- Redox Reactions video lecture by Kahnacademy.
- Chem4Kids website by Rader.
- Neutron Dance ...a so-bad-its-good '80s music video by The Pointer Sisters.

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

Image: Daniel Radcliff by Joella Marano

Confused?

Here are some more links to fun resources that further explain **Organic 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.

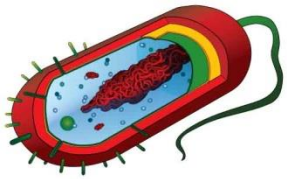
(You must be in PPT slideshow view to click on links.)

Are microbes intimidating you?

Do yourself a favor. Use the…

Virtual Microbiology Classroom *(VMC)* !

The VMC is full of resources to help you succeed, including:



- practice test questions
- review questions
- study guides and learning objectives

You can access the VMC by going to the Science Prof Online website
www.ScienceProfOnline.com

Images: Cholera, *Vibrio cholerae,* Giant Microbes; Prokaryotic cell, Mariana Ruiz