

Chapter 2

Fundamentals of Chemistry

Chemical Building Blocks

Atom

✓ the smallest chemical unit of matter that can take part in a chemical reaction.

Element

✓ least complex of substances; matter that is composed of only one kind of atom.

For example, a diamond is made of the element carbon and consists of many carbon atoms. Each atom retains the properties of the element carbon.

Atom, element, compound, and Mixture

Atom
(element)



Oxygen (O)

Smallest unit that still has the properties of an element

Molecule
(element)



Oxygen (O₂)

Stable assembly of two or more atoms

Compound



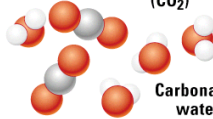
Water (H₂O)



Carbon dioxide (CO₂)

Substances forged in chemical reactions from two or more different elements

Mixture

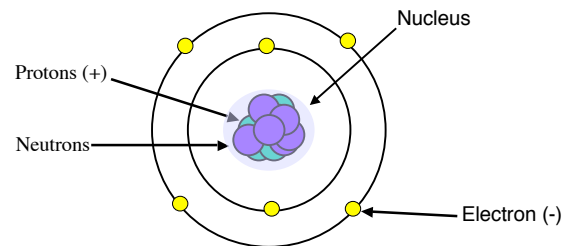


Carbonated water

Different compounds combined together

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Atomic Structure



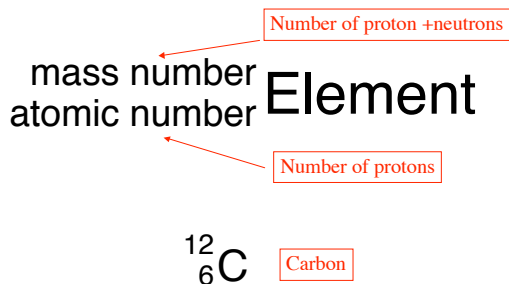
Atomic particles

<u>Particle</u>	<u>Mass</u>	<u>Charge</u>
Proton	1 amu	+1
Neutron	1 amu	0
Electron	1/1836 amu	-1

Atomic Number

- ✓ The atomic number of an element is the number of protons the nucleus of the atom.
- ✓ Carbon has an atomic number of 6 and has 6 protons in the nucleus.
- ✓ The number of protons in the nucleus does not change.

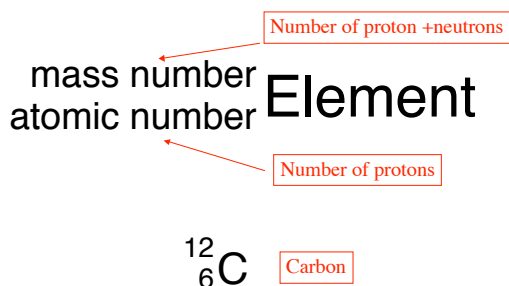
Properties of an atom



Mass Number

- ✓ This is the sum of the mass of the protons and the mass of the neutrons.
- ✓ Since the mass of both of these atomic particles is 1 amu, then the mass number is also equal to the number of protons plus the number of neutrons.

Properties of an atom



First three periods of the Periodic Table

Chemical symbol	Hydrogen H									Helium He						
First shell																
Atomic number	1	Atomic mass								2	4					
	Lithium Li	Beryllium Be	Boron B	Carbon C	Nitrogen N	Oxygen O	Fluorine F	Neon Ne								
Second shell																
	3	7	4	9	5	11	6	12	7	14	8	16	9	19	10	20
Third shell																
	Sodium Na	Magnesium Mg	Aluminum Al	Silicon Si	Phosphorus P	Sulfur S	Chlorine Cl	Argon Ar								
	11	23	12	24	13	27	14	28	15	31	16	32	17	35	18	40

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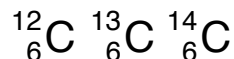
Molecular weight

- ✓ The molecular weight of a substance the sum of the atomic mass units of atoms in the molecule.
- ✓ Water (H_2O) has *two* molecules of hydrogen ($\text{amu} = 1$) and *one* atom of oxygen ($\text{amu} = 16$).
 $2(1) + 1(16) = 18$;

So, 18 is the molecular weight of water

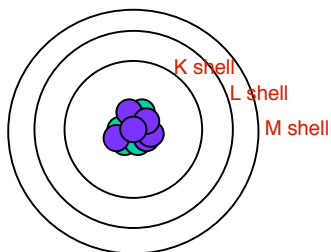
Isotopes

- ✓ Atoms that have the same number of protons but a different number of neutrons are called isotopes.



- ✓ All of these are isotopes of the element carbon.

Electrons are found in shells



Only a certain number of electrons can be found in a shell.
In K there are 2 electrons; in L there are 8, and in M there are 18.

Octet Rule or Rule of Octets

- ✓ Atoms need to fill the outer shell with a maximum of 8 electrons to attain and maintain stability.

Chemical Bonds

- ✓ The process by which the octet of electrons in the outer shell is obtained.
 - ⇐ Sharing of electrons.
 - ⇐ Donating/accepting of electrons

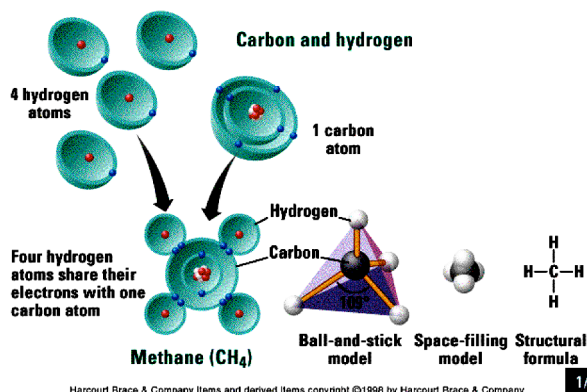
How are molecules held together (Chemical Bonds)?

- ✓ Strong bonds
 - ⇒ Covalent bonds
 - Sharing of electrons.
 - ⇒ Ionic bonds
 - Donating/accepting of electrons between two atoms
- ✓ Weak bonds
 1. Hydrogen bonds - an attraction between molecules due to partial charges
 2. van der Waals - attraction between close molecules - very weak

Covalent Bond

- ✓ Formed by the sharing of electrons.
- ✓ Two electrons are shared per covalent bond.
- ✓ Strong bond.
- ✓ SPONCH (sulfur, phosphorus, oxygen, nitrogen, carbon, hydrogen)

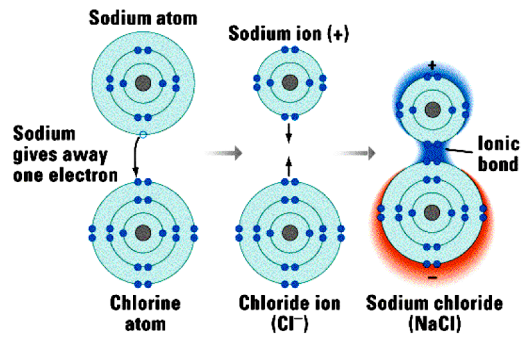
Covalent bonding in hydrogen and carbon



Ionic Bond

- ✓ Formed by the donating and accepting of electrons by two atoms.
- ✓ Strong bond.
- ✓ Atoms that have nearly full or nearly empty shells tend to form ions.
 - ⇒ Positively-charged ions are called cations.
 - ⇒ Negatively-charged ions are called anions.

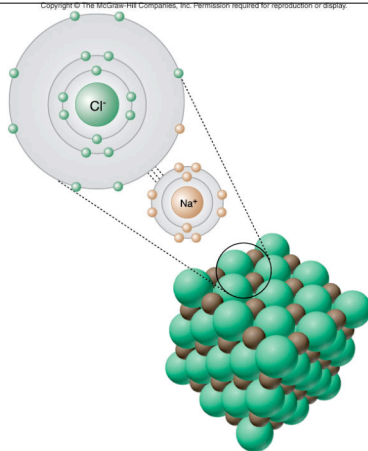
Table salt



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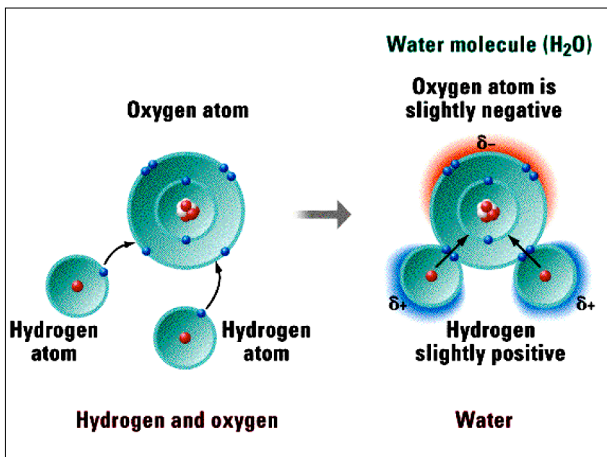
1/2

NaCl

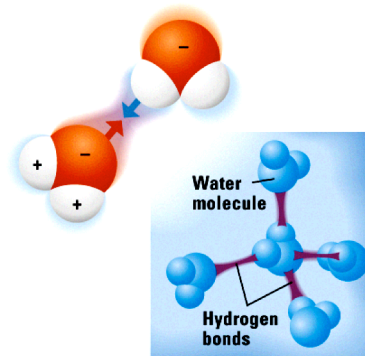


Hydrogen Bond

- ✓ Unequal sharing of electrons between two atoms form partial positive and partial negative charges.
- ✓ The attraction of a partial positive ($\delta+$) and partial negative ($\delta-$) charge in two molecules results in a hydrogen bond.
- ✓ Weak bond.

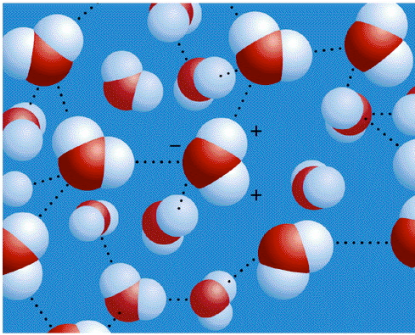


Hydrogen bonds between water molecules



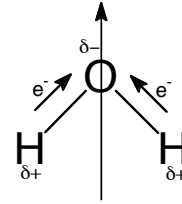
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Hydrogen Bonding in Water Molecules

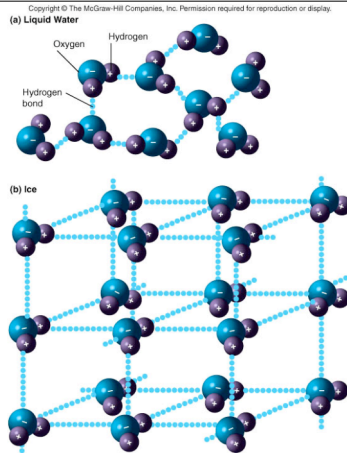


Polarity

✓ Polarity refers to the partial positive and negative charges in an atom.



Water as a solid and liquid



Water

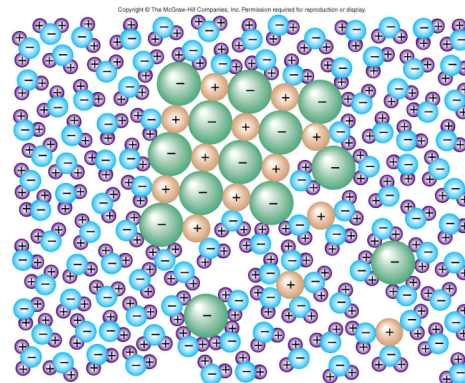
✓ Hydrogen bonds are responsible for many of water's properties.

- ⇒ Polar molecule--strong dissolving medium
- ⇒ High surface tension
- ⇒ High specific heat
- ⇒ A medium in which many reactions of the cell occur.

Properties of Water

- ⇒ Denser as liquid than a solid (ice formation)
- ⇒ High heat capacity
 - ⇒ High boiling point
 - ⇒ Good evaporative coolant
- ⇒ Cohesion and surface tension
- ⇒ Adhesion--sticks to everything
 - ⇒ Capillary action
- ⇒ Good solvent (polar medium)
 - ⇒ Solutes (NaCl, sugars, etc.)

Salt dissolving in water



Acids, bases, and pH

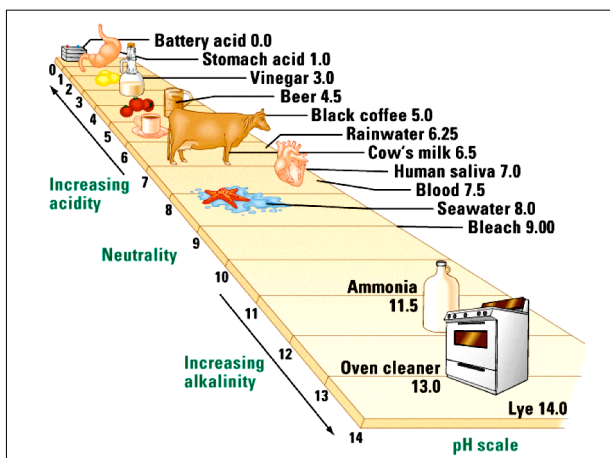
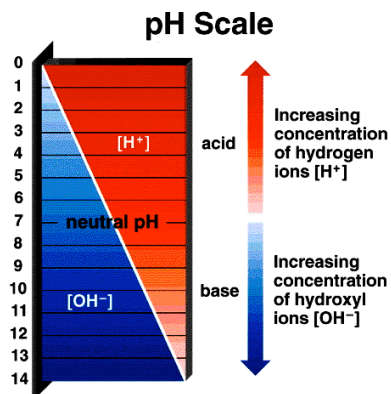
- ✓ Acids are H^+ (proton) donors.
- ✓ Bases are H^+ acceptors.
- ✓ pH is a measure of H^+ in a solution.

⇒ pH 7 is neutral

⇒ pH < 7 is acidic

⇒ pH > 7 is basic

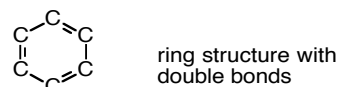
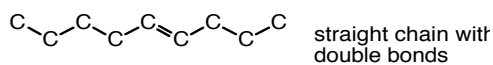
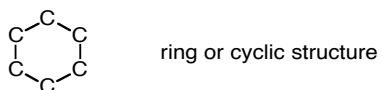
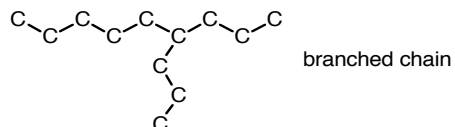
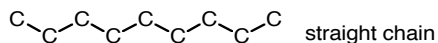
pH is a measure of the hydrogen ion concentration



Organic Chemistry

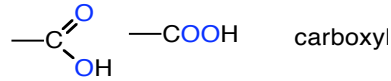
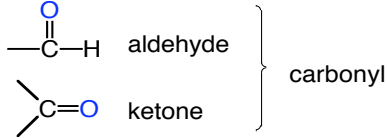
- ✓ Carbon chemistry
 - ⇒ Carbon can make 4 covalent bonds.
 - ⇒ Carbon atoms make carbon skeletons.

Carbon skeletons

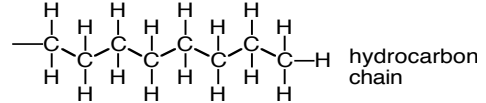
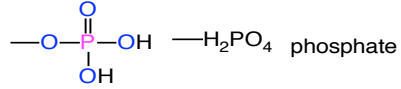
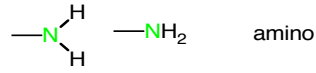


Functional groups give molecules that contain them specific properties.

—OH alcohol, hydroxyl



—SH sulfhydryl



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Table 2.2 Non-Polar and Polar Covalent Bonds

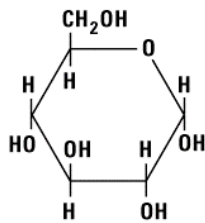
Type of Covalent Bond	Atoms Involved and Charge Distribution
Nonpolar	C—C C and H have equal attractions for electrons, so there is an equivalent charge on each atom. C—H H—H
Polar	O—H The O and N atoms have a stronger attraction for electrons than do C and H, so the O and N have a slight negative charge; the C and H have a slight positive charge. N—H O—C N—C

Four Classes of Biological Molecules

- ✓ Carbohydrates
- ✓ Lipids
- ✓ Proteins
- ✓ Nucleic Acids

✓ Each of these polymers (macromolecules) is made of three or more subunits called monomers.

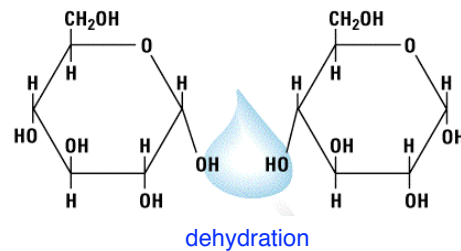
Carbohydrates



Glucose

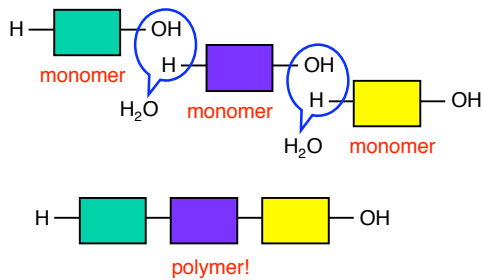
Three types
 Monosaccharide
 Disaccharide
 Polysaccharide

Glycosidic bonds are formed in a dehydration reaction between 2 carbohydrates (disaccharide maltose).



Look at Table 2.4

Monomers to Polymers

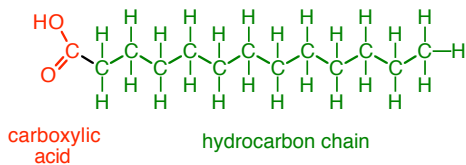


Dehydration synthesis reactions

- ✓ Monosaccharides to polysaccharides
 - ✓ Fatty acids to lipids
 - ✓ Amino acids to proteins
 - ✓ Nucleotides to nucleic acids
- ✓ Each of these reactions produces water in a dehydration synthesis or condensation reaction!

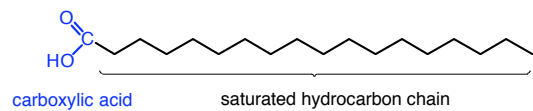
Fatty acids

- ✓ Carboxyl functional group attached to a hydrocarbon chain.



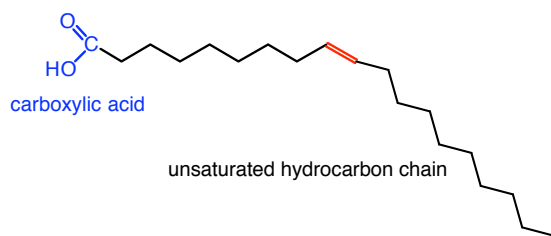
Saturated fatty acid

stearic acid--a saturated fatty acid



Unsaturated fatty acid

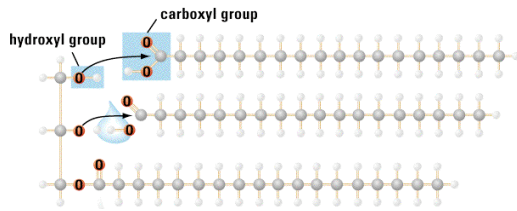
oleic acid--an unsaturated fatty acid



Fatty acids to lipids

- ✓ A bond is formed between glycerol and fatty acids in a **dehydration synthesis** reaction.
- ✓ There are 3 main classes of lipids.
 - ⇒ Triglycerides
 - ⇒ Phospholipids
 - ⇒ Sterols

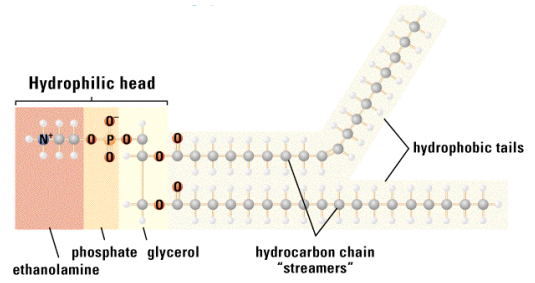
Triglycerol



Glycerol

Three fatty acids

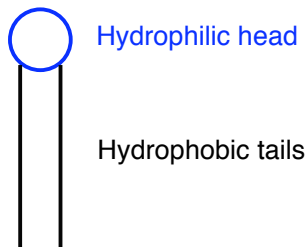
Phospholipids



Phosphate group

2 fatty acids

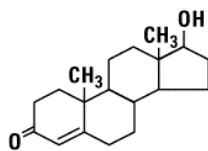
Phospholipids are amphipathic molecules



Phospholipids form micelles and bilayers



Steroids

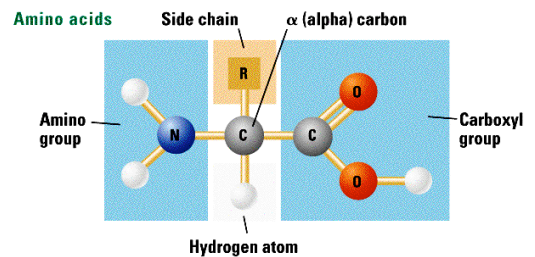


Testosterone

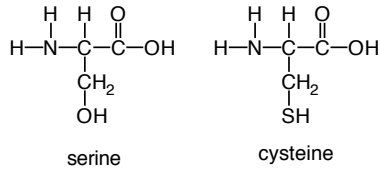
Steroids contain 4 rings of carbon atoms

Others include: cholesterol, progesterone, estradiol, & corticosterone

Basic structure of an amino acid

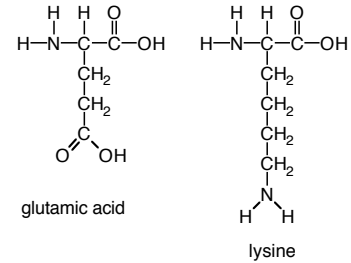


Polar, non-ionizable (non-charged) amino acids



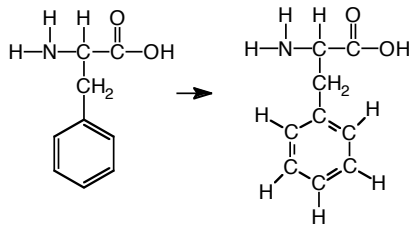
Contain alcohol (-OH), sulfhydryl (-SH) groups

Polar, ionizable (charged) amino acids



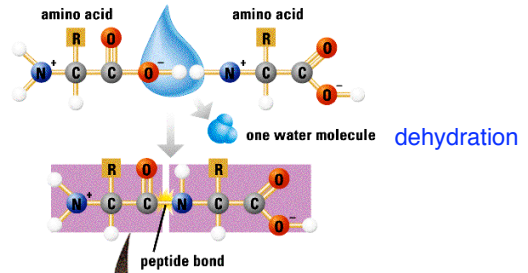
Contain carboxyl (-COOH) or amino (-NH₂) groups

Nonpolar amino acids



Contain only carbon (C) and hydrogen (H) atoms

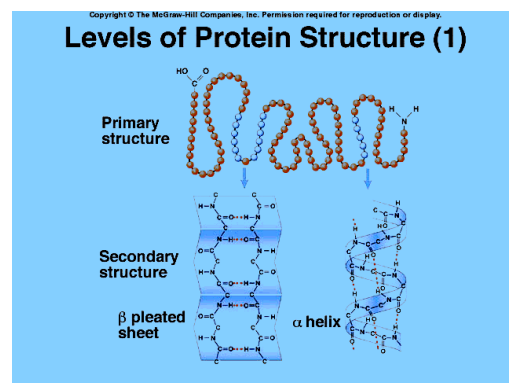
Amino Acids to Proteins



dipeptide
tripeptide
polypeptide

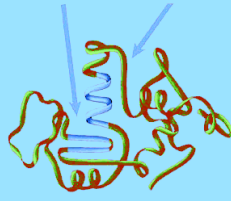
Protein Structure

- ✓ Primary
⇒ Linear arrangement of amino acids.
- ✓ Secondary
⇒ 3-dimensional α-helix and β-pleated sheet.
- ✓ Tertiary
⇒ Hydrophobic, ionic interactions, disulfide bonds
- ✓ Quaternary
⇒ Two or more polypeptides forming a functional protein.



Levels of Protein Structure (2)

Tertiary structure



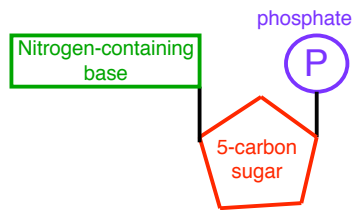
Quaternary structure



Examples of proteins

- ✓ Enzymes
- ✓ Hair
- ✓ Skin
- ✓ Wool
- ✓ Silk
- ✓ Hemoglobin
- ✓ antibodies

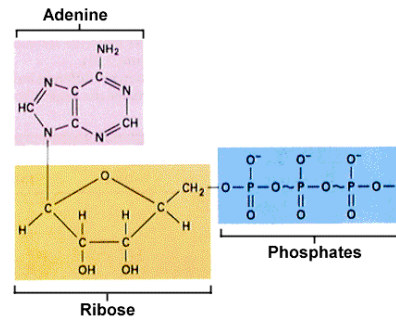
Basic structure of a nucleotide



Functions:

1. Storage of high-energy bonds
2. Form nucleic acids (DNA & RNA)

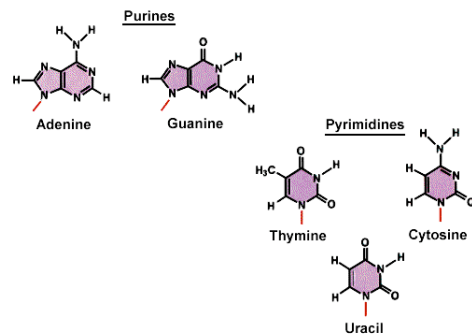
Adenosine triphosphate (ATP)

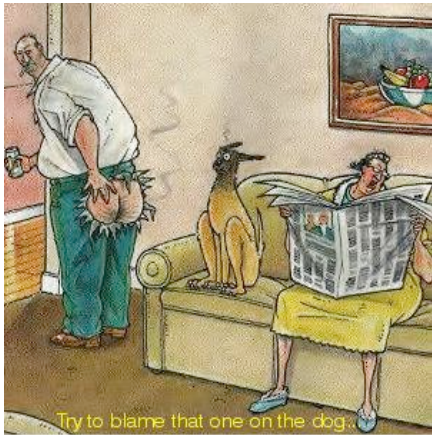


Components of nucleotides

COMPONENT		DNA	RNA
Sugars	Phosphoric acid	X	X
	Ribose		X
	Deoxyribose	X	X
Bases	Adenine	X	X
	Guanine	X	X
	Cytosine	X	X
	Thymine	X	
	Uracil		X

Bases





Try to blame that one on the dog.