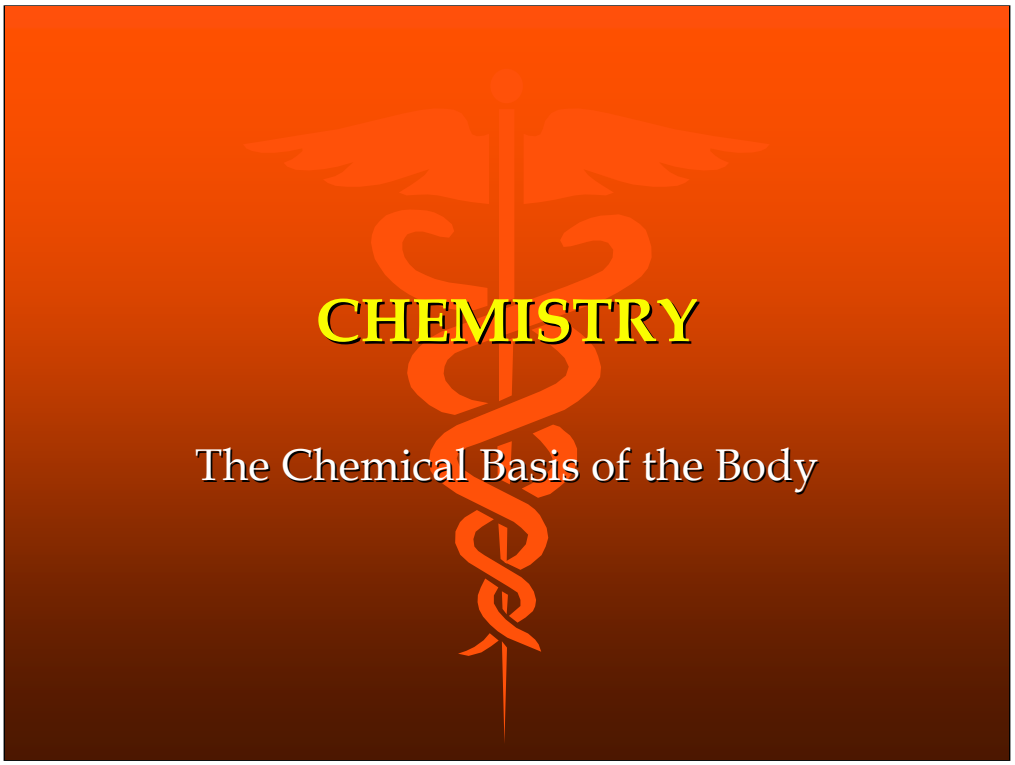

CHEMISTRY
The Chemical Basis of the Body

MATTER

- Anything that has mass and occupies space
- Three states: solid - liquid - gas
- Made up of chemical building blocks called ELEMENTS

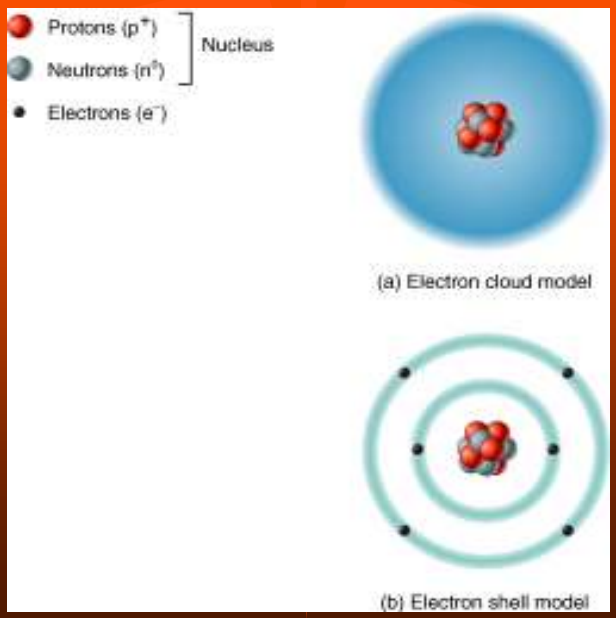
Elements

- Composed of the same atoms.
- Cannot be broken down into simpler substances by ordinary chemical means.
- 109 Elements (92 occurring naturally).
- 26 Elements found in the human body.
- C, H, O, N - 96% of the human body.
- S and P make up 99% of the body.

Atoms

- The smallest unit of matter that can enter into chemical reactions.
- Composed of two basic components:
  - Nucleus
  - Outer energy levels or clouds

Structure of an Atom



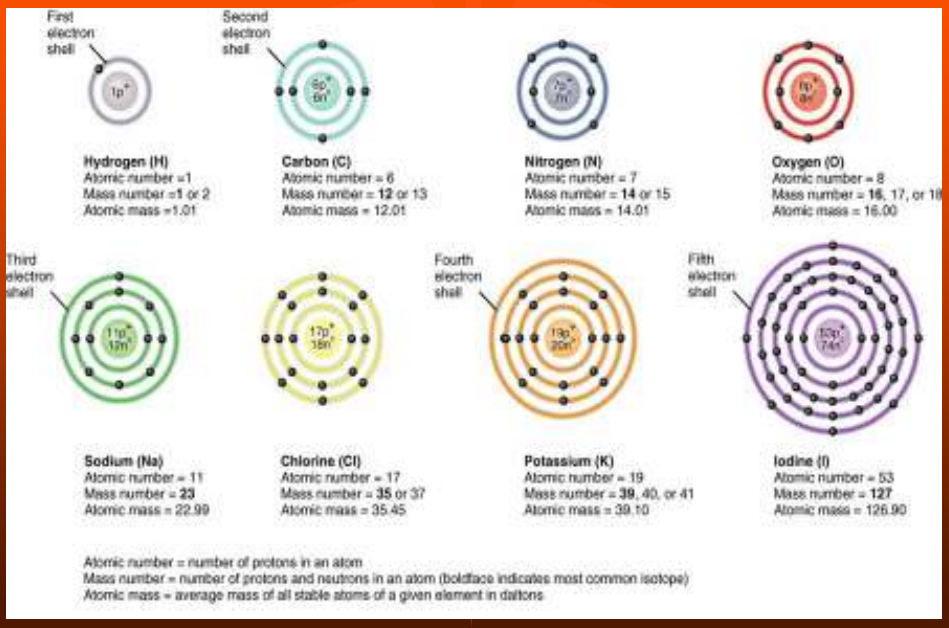
Nucleus

- Protons (+ charge)
  # of protons is element's atomic number
- Neutrons (uncharged)
- # of protons plus # of neutrons form the element's atomic weight

Electrons

- Negatively charged particles that orbit around the nucleus.
- # of electrons always equals the # of protons in an atom.

Atoms


First electron shell
Second electron shell
Third electron shell
Fourth electron shell
Fifth electron shell
Hydrogen (H)
Atomic number =1
Mass number =1 or 2
Atomic mass =1.01
Carbon (C)
Atomic number = 6
Mass number = 12 or 13
Atomic mass = 12.01
Nitrogen (N)
Atomic number = 7
Mass number = 14 or 15
Atomic mass = 14.01
Oxygen (O)
Atomic number = 8
Mass number = 16, 17, or 18
Atomic mass = 16.00
Sodium (Na)
Atomic number = 11
Mass number = 23
Atomic mass = 22.99
Chlorine (Cl)
Atomic number = 17
Mass number = 35 or 37
Atomic mass = 35.45
Potassium (K)
Atomic number = 19
Mass number = 39, 40, or 41
Atomic mass = 39.10
Iodine (I)
Atomic number = 53
Mass number = 127
Atomic mass = 126.90
Atomic number = number of protons in an atom
Mass number = number of protons and neutrons in an atom (boldface indicates most common isotope)
Atomic mass = average mass of all stable atoms of a given element in daltons

Ions (Electrolytes)

- Most atoms have too many or too few electrons in their outermost energy level which is not complete.
- Valance is the number of extra or deficient electrons in outermost orbital.
- Anions - extra electrons in outermost orbital which creates a net negative charge.
- Cation - deficient electrons in outermost orbital which creates a net positive charge.
- Electrolytes - ions in solution

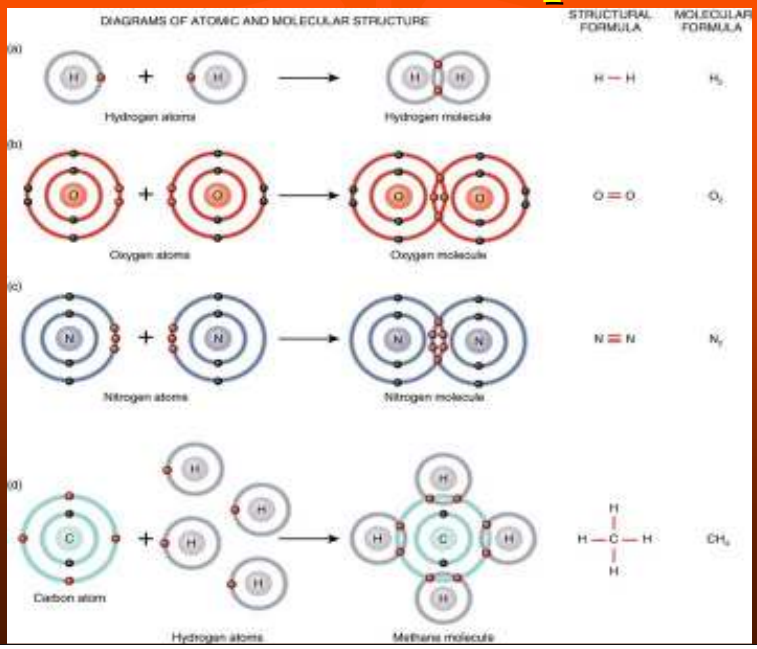
Major Elements in the Body

- The four major elements in the body are:
- C – carbon
- H – hydrogen
- O – oxygen
- N - nitrogen

Molecules

- The combination of two or more elements in a chemical reaction.
  - May be atoms of the same element
    - H_2, O_2, N_2, etc.
  - May be atoms of different elements
    - NaCl, HCl etc.

Molecule Examples



Compounds

- A substance that can be broken down into two or more elements by chemical means.
- Molecules of a compound always contain atoms of two or more different elements.
- ***All compounds are molecules but not all molecules are compounds***

Anions and Cations

- Anions
- An anion is formed when an atom gains an electron or electrons from another atom creating an overall negative charge. Example: Cl^-

- Cations
- Cations are formed when an atom loses an electron or electrons to another atom creating an overall positive charge.
- Example: Na^+

Chemical Bonding

Chemical bonds are formed between atoms when electrons in the outermost orbital are gained, lost, or shared

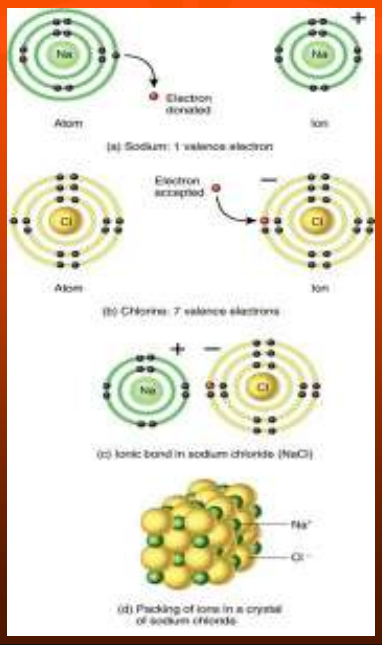
Types of Chemical Bonds

- Ionic Bonding
- Covalent Bonding
- Hydrogen Bonding

Ionic Bonding

- Bonding when one atom gains an electron and another atom loses an electron.
- Transfer electrons from one atom to another.
- Bonds together two oppositely charged ions.
- Strongest type of chemical bonding.

Ionic Bond Example



Covalent Bonding

- Sharing of electron pairs by more than one atom
  - single covalent bond: share one pair of electrons
  - double covalent bond: share two pairs of electrons
  - triple covalent bonds: share three pairs of electrons

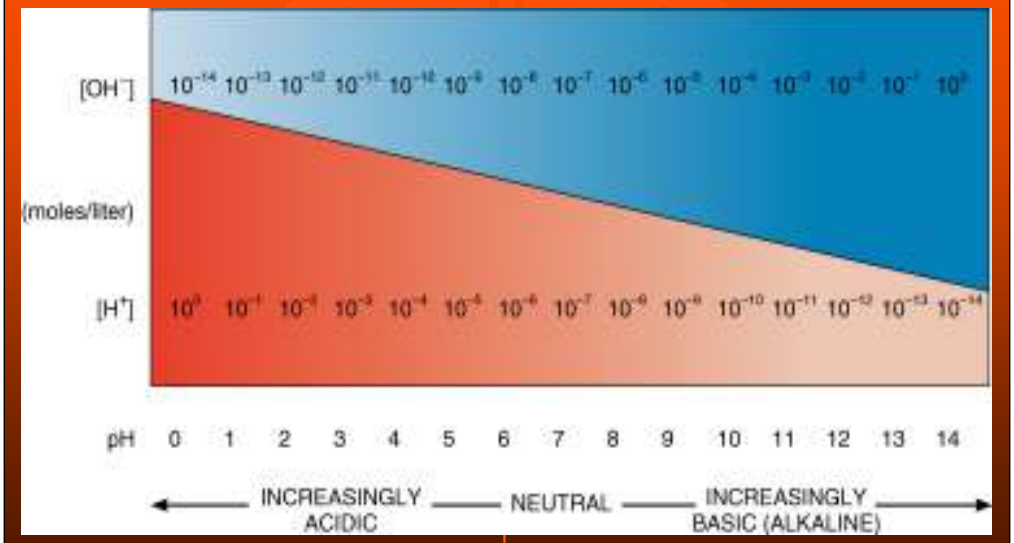
Hydrogen Bonds

- A hydrogen atom covalently bonded to another atom.
- Very weak bond.
- Often serves as a bridge between molecules.
- Many large molecules can contain hundreds of these bonds.

pH Scale

- A scale used to describe the degree of acidity or alkalinity (basicity) of a solution.
- Expressed on a logrhythmic base 10 scale that runs from 0 - 14 with 7 being a neutral pH:
  - > 7 is a basic or alkaline solution
  - < 7 is a acidic solution
- Actually represents the number of H+ ions or OH- ions in solution.

pH Scale


[OH⁻]
(moles/liter)
[H⁺]
pH 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
INCREASINGLY ACIDIC
NEUTRAL
INCREASINGLY BASIC (ALKALINE)

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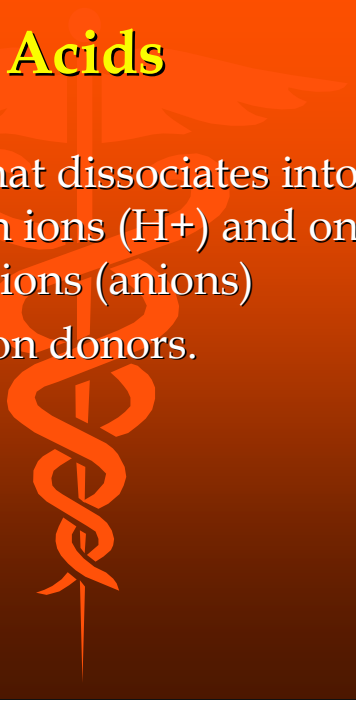
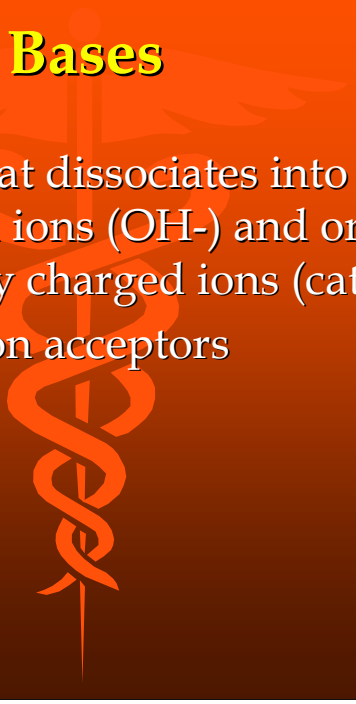
Acids

- A substance that dissociates into one or more hydrogen ions (H+) and one or more negative ions (anions)
- Acids are proton donors.



Bases

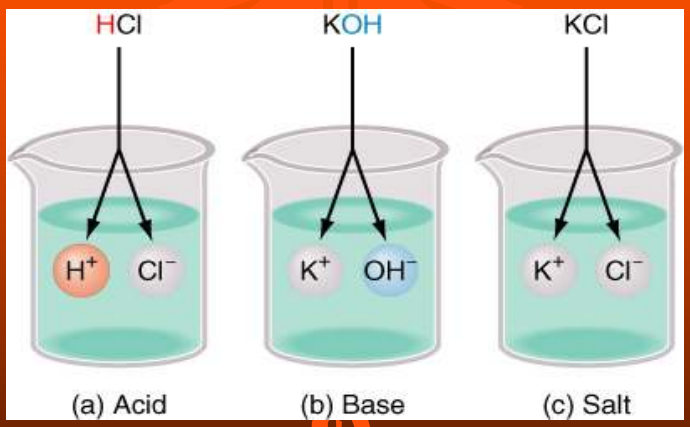
- A substance that dissociates into one or more hydroxyl ions (OH-) and one or more positively charged ions (cations)
- Bases are proton acceptors



Salts

- A substance, that when dissolved in water, dissociates into both anions and cations neither of which is H+ or OH-

Acids – Bases - Salts



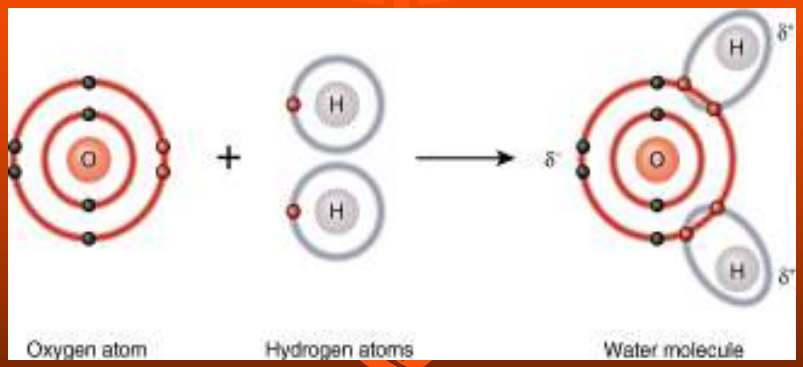
Neutral pH and pH of Blood

- Neutral pH is considered to be 7.0 on the pH scale. This is distilled water which has equal concentrations of H^+ and OH^-.
- The pH of blood is slightly basic (alkaline) ranging from 7.35 to 7.45.

Water

- Universal solvent
- Participates in or is essential in many chemical reactions
- Absorbs and releases heat very slowly
- Important transport medium
- Functions as a lubricant in various regions of the body

Water Molecule



Classification of Chemical Compounds

- Inorganic Compounds
  - Small ionically bonded molecules
  - Generally lack a carbon atom
  - Vital to normal physiological functioning
- Organic Compounds
  - Contains one or more carbon atoms
  - Contains hydrogen atoms
  - Almost exclusively held together by covalent bonds

Inorganic Compounds

- Water
- Acids
- Bases
- Salts

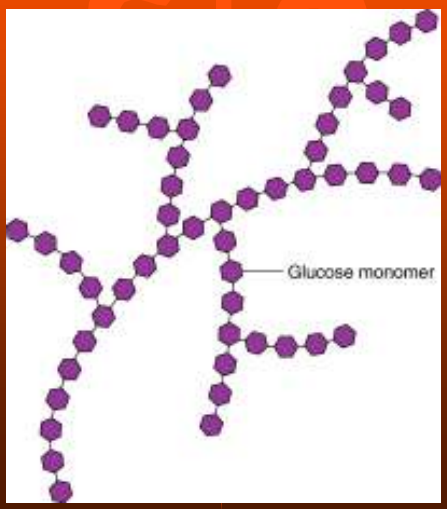
Organic Compounds

- Carbohydrates (sugars & starches)
- Lipids (fats)
- Proteins
- Nucleic Acids (DNA & RNA)

Carbohydrates

- Includes sugars and starches.
- Account for about 2% of body mass.
- Contain C, H, and O molecules in a general formula of $(C H_2 O)n$.
- Functions of carbohydrates:
  - structural units of DNA and RNA
  - energy source (4.5 kcal/gm)
  - only energy source for brain and nerve cells

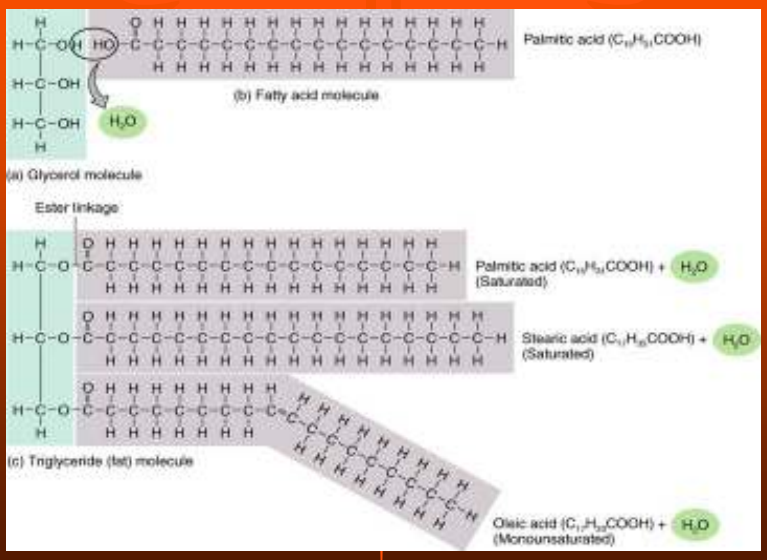
Glucose Molecule
Storage form of Carbohydrates



Lipids (FATS)

- Most are insoluble in water.
- Most highly concentrated source of energy (9.2 kcal/gm).
- Less efficient as a body fuel than carbs.
- Made up of C, H, and O in structural units called fatty acids and glycerols (triglycerides).
- Types of fats determined by the types of hydrogen bonds in the molecule
  - saturated fat
  - unsaturated fat (mono or poly)

Fat Molecules



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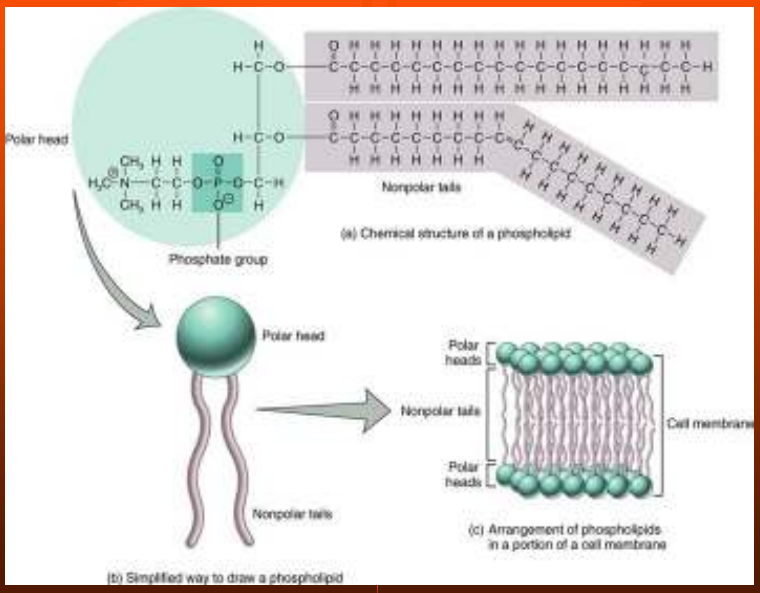
Phospholipid Molecule



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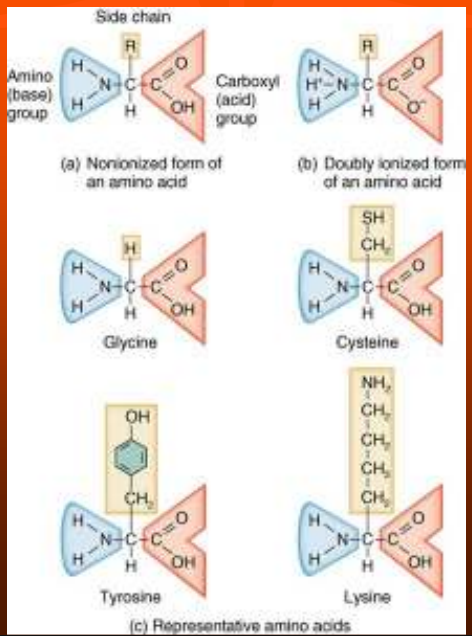
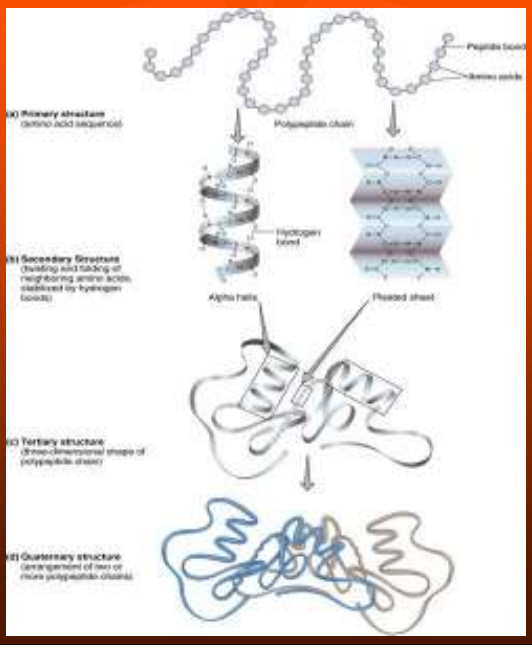
Proteins

- All contain C, H, O, and N (many also contain S and P).
- Composed of molecules called amino acids (20).
- Type of protein is determined by the number and sequence of amino acids.
- Amino acids are joined together at the N atoms in a chemical bond called a peptide bond

Amino Acids


Side chain
Amino (base) group
Carboxyl (acid) group
(a) Nonionized form of an amino acid
(b) Doubly ionized form of an amino acid
Glycine
Cysteine
Tyrosine
Lysine
(c) Representative amino acids

Protein Structure



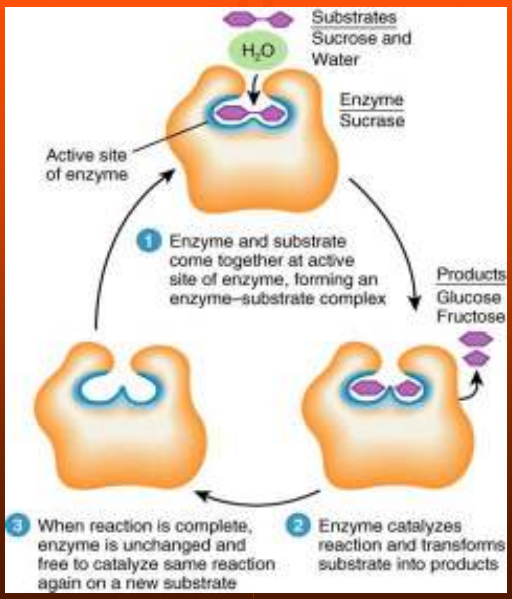
Types and Functions of Proteins

- Structural Proteins
  - Form the structural framework of various body parts (muscle, skin, hair, nails, etc.)
- Regulatory Proteins
  - Function as hormones to control a variety of physiological processes (insulin)
- Contractile Proteins
  - Serve as the contractile elements in muscle tissue (actin and myosin)

Types and Functions of Proteins

- Immunological Proteins
  - Serve as anti-bodies to protect the body (gamma globulin)
- Transport Proteins
  - Transports vital substances throughout the body (hemoglobin)
- Enzymatic Proteins
  - Alter the rate or activation energy of chemical reactions (amylase, lipase, lactase)

Enzyme Function



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Nucleic Acids
DNA and RNA

- Building blocks of life
- All contain C, H, O, N, and P
- Made up of structural units called nucleotides
- DNA contains the genetic code
- DNA and RNA assist with protein synthesis

DNA
Deoxyribonucleic Acid

- Nucleotides are molecules composed of C, H, O, and a nitrogen base of:
  - thymine - adenine
  - guanine - cytosine
- Contains a pentose sugar called deoxyribose
- Contains a phosphate group

Structure of DNA

- A two stranded molecule that twists around each other (double helix).
  - looks like a twisted ladder
- Sides or uprights of the ladder are made of alternating phosphates and the deoxyribose section of the molecule.
- The rungs of the ladder contain the paired nitrogen bases.
  - thymine (T) - adenine (A)
  - guanine (G) - cytosine (C)

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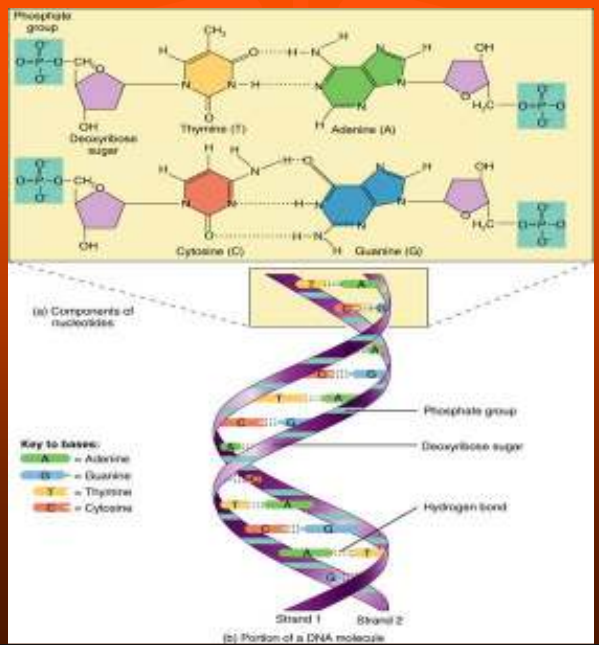
Structure of DNA



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RNA
Ribonucleic Acid

- Molecule is a single strand of nucleotides.
- The sugar portion of the molecule is a pentose sugar, ribose.
- Nitrogen base thymine in DNA is replaced by uracil in RNA.

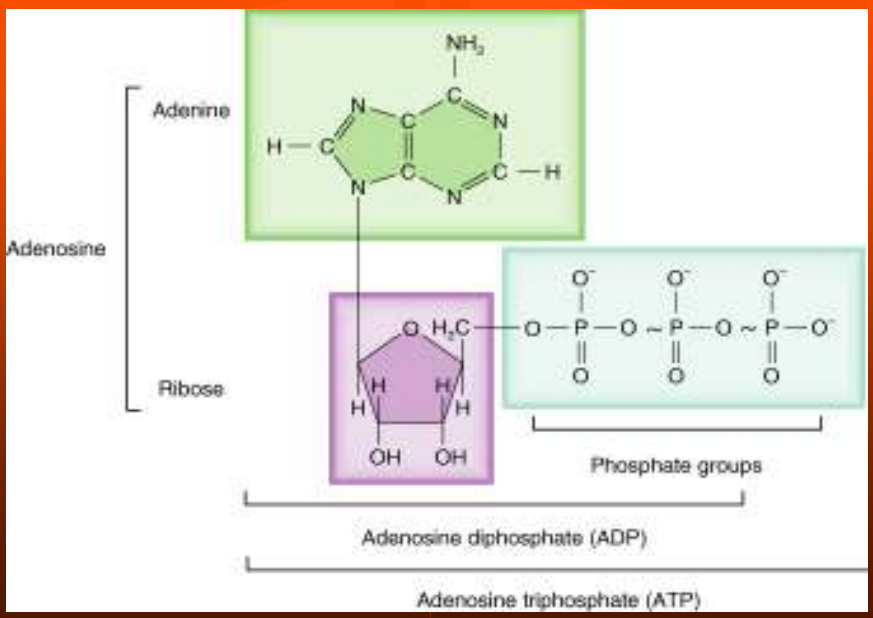
Adenosine Triphosphate (ATP)

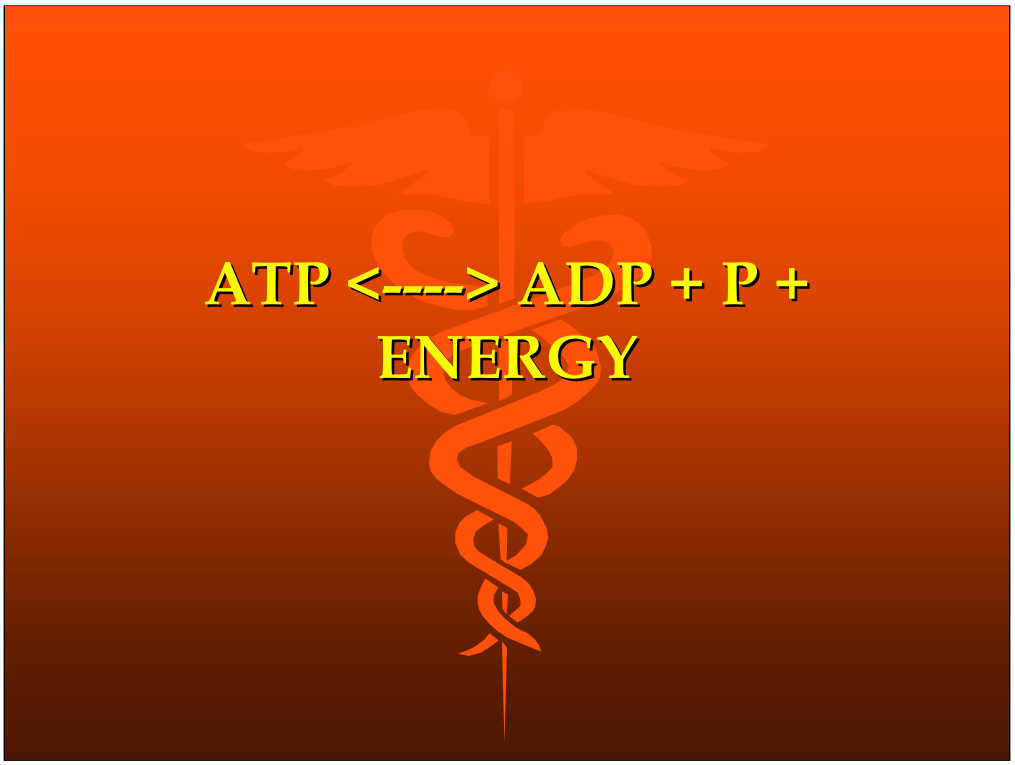
- High energy compound that supplies energy for most chemical reactions.
- Found in all living systems.
- Formed during a process called cellular respiration which takes place in the cytoplasm and the mitochondria of cells.

Structure of ATP

- Adenine unit composed of an adenine molecule and a five carbon sugar (ribose).
- Three phosphate groups attached to the end of the molecule.
- Tremendous amount of energy is released when the terminal phosphate is removed.

Structure of ATP




ATP <----> ADP + P +
ENERGY