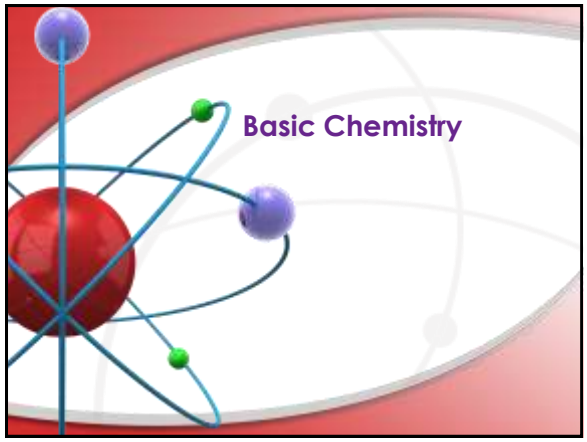


Basic Chemistry

Atomic Particles

Isotopes

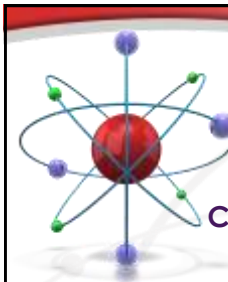
- atoms with equal numbers of protons but different numbers of neutrons

Elements in the Body

Element	% Body Weight	Element	% Body Weight
O	65	Na	0.2
C	18.6	Cl	0.2
H	9.7	Mg	0.06
N	3.2	S	0.04
Ca	1.8	Fe	0.007
P	1.0	I	0.0002
K	0.4		

Trace Elements

- Si
- F
- Cu
- Mn
- Zn
- Se
- Co
- Mo
- Co
- Cr
- Sn
- Al
- B



Chemical Bonding

Chemical Bonding

- Chemical bond - a physical connection or attraction that links two or more atoms.
- Bonding involves **only** valence (outer) electrons

7

The Octet Rule

- Atoms are stable once they have a full outer level:
  - 1st level→ 2 electrons
  - 2nd level (and higher) → 8 electrons

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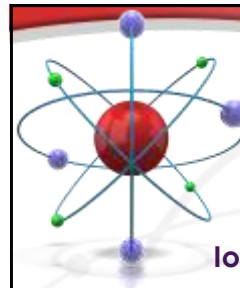
The Octet Rule

Atoms can do three things to get to eight valence electrons:

1. Gain electrons
2. Lose electrons
3. Share electrons

9



Ionic Bonding

10

Ions

- Ions - atoms of the same element that have an overall electrical charge.

1. cation - positive ion
   - more protons than electrons; LOSES ELECTRONS
2. anion - negative ion
   - more electrons than protons; GAINS ELECTRONS.

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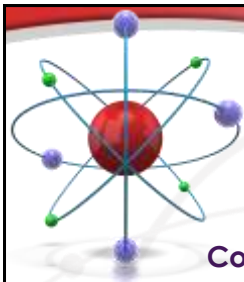
Ionic Bonds

- electrostatic attraction between oppositely charged IONS.
- Each atom needs to follow Octet Rule

12

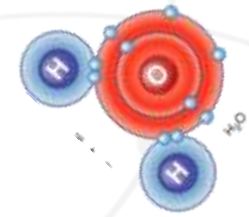


Covalent Bonding

13

Covalent Bonds

- Atoms share PAIRS of electrons (THINK: Joint custody)



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Types of Covalent Bonds

1. Non-polar covalent bonds
   - electrons are evenly shared between atoms
2. Polar covalent bonds
   - electrons are not evenly shared between atoms
   - creates areas of negative charge where electrons gather

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Covalent Bonds

- Still following The Octet Rule.
- Form compounds specifically called molecules
  - Definite and predicable shapes
  - Very strong

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Double and Triple Bonds

- Atoms can share more than one pair of electrons:
  - Double bond→ sharing 4 electrons (2 pairs)
  - Triple bond→ sharing 6 electrons (3 pairs)

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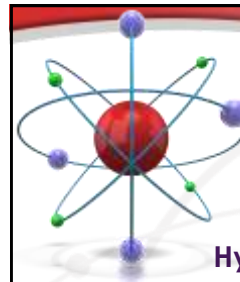


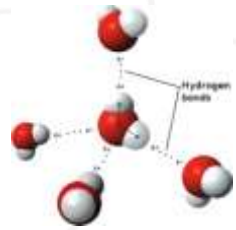
Hydrogen Bonding

18

Hydrogen Bonds

- Extremely weak bonds formed between a hydrogen (that is bound with nitrogen or oxygen) and another electron hungry atom
- Can occur between molecules

  or
- Within a single molecule
  - 3-d shape



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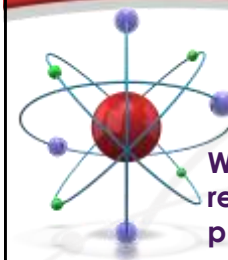

Why are chemical reactions important to physiology?

Energy

- Energy: is needed for all cell/system tasks.
  - the ability to do work
- Work:
  - a change in mass or distance

Forms of Energy

- Kinetic energy:
  - energy of motion
- Potential energy:
  - stored energy
- Chemical energy:
  - potential energy stored in chemical bonds

Break Down, Build Up

- Decomposition reaction (catabolism):
  - AB →A + B
- Synthesis reaction (anabolism):
  - A + B → AB
- Exchange reaction (reversible):
  - AB + C↔AC + B
  - AB + CD ↔ AD + CB

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Water In, Water Out

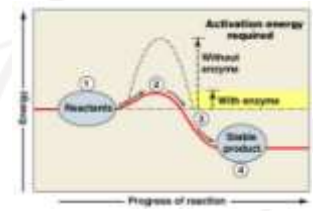
- Hydrolysis:
  - A-B-C-D-E + H_2O → A-B-C-H + HO-D-E
- Dehydration synthesis (condensation):
  - A-B-C-H + HO-D-E → A-B-C-D-E + H_2O

Energy In, Energy Out

- Exergonic reactions (exothermic):
  - produce more energy than they use
- Endergonic reactions (endothermic):
  - use more energy than they produce

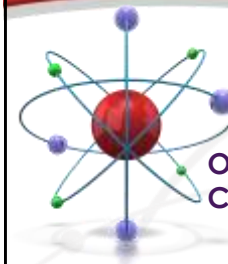
Activation Energy

- Chemical reactions in cells cannot start without help (slow)
- Activation energy gets a reaction started



Activation Energy

- Enzymes:
  - proteins that lower activation energy of a reaction
  - →Speed up reactions



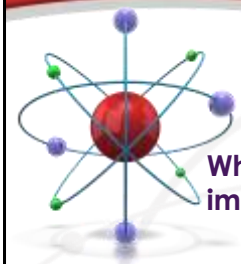
Organic and Inorganic Compounds

Organic and Inorganic Molecules

- Organic:
  - molecules based on carbon and hydrogen
  - Made by living things
- Inorganic:
  - molecules not based on carbon and hydrogen

Essential Molecules

- Nutrients:
  - essential molecules obtained from food
- Metabolites:
  - molecules made or broken down in the body



Why is water so important?

Hydrogen Bonds

- Hydrogen bonds between H_2O molecules cause surface tension

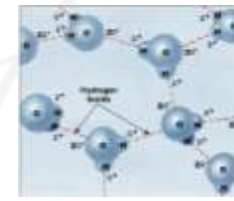


Figure 2-6

Properties of Water

- Solubility:
  - water's ability to dissolve a solute to make a solution
- Reactivity:
  - most body chemistry uses or occurs in water

Properties of Water

- High heat capacity:
  - water's ability to absorb and retain heat
- Lubrication:
  - to moisten and reduce friction

Aqueous Solutions

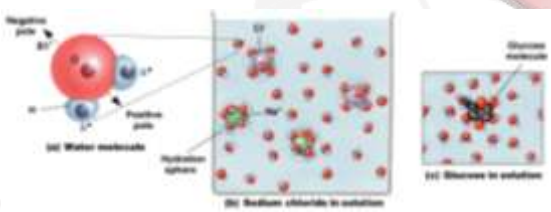


Figure 2-8

Electrolytes

- Inorganic ions which conduct electricity in solution
- Electrolyte imbalance seriously disturbs vital body functions

Electrolytes

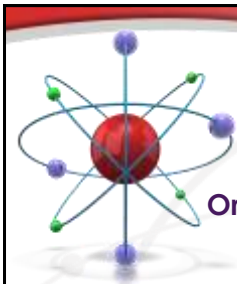
TABLE 2–3 Important Electrolytes That Dissociate in Body Fluids

Electrolyte		Ions Released
NaCl (sodium chloride)	⟶	$Na^+ + Cl^-$
KCl (potassium chloride)	⟶	$K^+ + Cl^-$
$CaPO_4$ (calcium phosphate)	⟶	$Ca^{2+} + PO_4^{3-}$
$NaHCO_3$ (sodium bicarbonate)	⟶	$Na^+ + HCO_3^-$
$MgCl_2$ (magnesium chloride)	⟶	$Mg^{2+} + 2Cl^-$
Na_2HPO_4 (disodium phosphate)	⟶	$2Na^+ + HPO_4^{2-}$
Na_2SO_4 (sodium sulfate)	⟶	$2Na^+ + SO_4^{2-}$

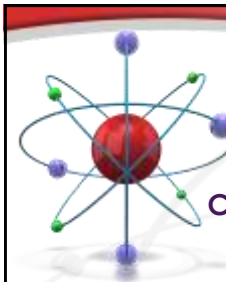
Table 2-3

Molecules and Water

- Hydrophilic:
  - hydro = water, philos = loving
  - reacts with water
- Hydrophobic:
  - phobos = fear
  - does not react with water



Organic Molecules



Carbohydrates

Carbohydrates

- quick energy sources
- components of membranes

Monosaccharides and Disaccharides

- Monosaccharides:
  - simple sugars with 3 to 7 carbon atoms (glucose)
  - Monomers
- Disaccharides:
  - 2 simple sugars condensed by dehydration synthesis (sucrose)

Simple Sugars

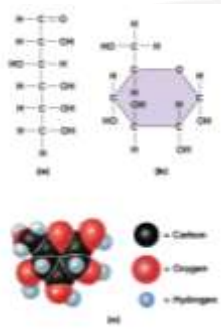


Figure 2-10

Polysaccharides

- Chains of many simple sugars (glycogen)

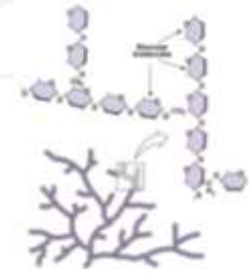
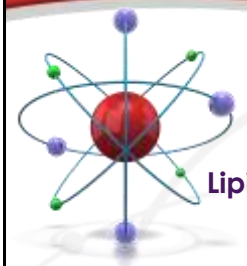


Figure 2-12



Lipids

Lipids

- Mainly hydrophobic molecules such as fats, oils, and waxes
  - Phospholipids - hydrophilic & hydrophobic
- Made mostly of carbon and hydrogen atoms
- Lipids have many functions, including membrane structure and energy storage

Fatty Acids

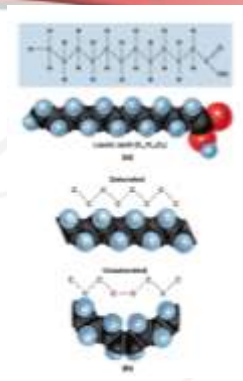


Figure 2-13

Saturated and Unsaturated

- Fatty acids may be:
  - saturated with hydrogen (all single covalent bonds)
  - unsaturated (1 or more double/triple bonds)

Combination Lipids

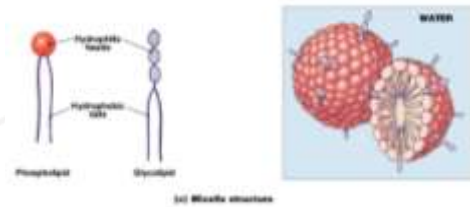
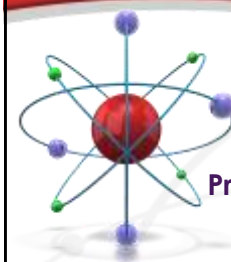


Figure 2-17c



Protein

Proteins

- control anatomical structure and physiological function
- determine cell shape and tissue properties
- perform almost all cell functions

Protein Functions

- 7 major protein functions:
  1. support:
     - structural proteins
  2. movement:
     - contractile proteins
  3. transport:
     - transport proteins

Protein Functions

4. buffering: regulation of pH
5. metabolic regulation:
   - enzymes
6. coordination and control:
   - hormones
7. defense:
   - antibodies

Protein Structure

- Proteins are the most abundant and important organic molecules
- Basic elements:
  - carbon (C), hydrogen (H), oxygen (O), and nitrogen (N)
- Basic building blocks:
  - 20 amino acids

Amino Acids

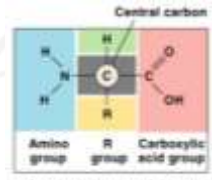


Figure 2-18

Peptides

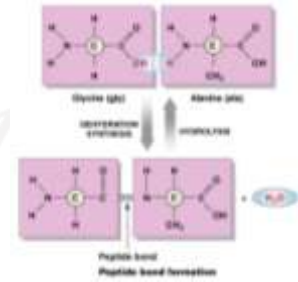


Figure 2-19

Primary Structure

- Polypeptide:
  - a long chain of amino acids

Figure 2-20a

Secondary Structure

- Hydrogen bonds form spirals or pleats

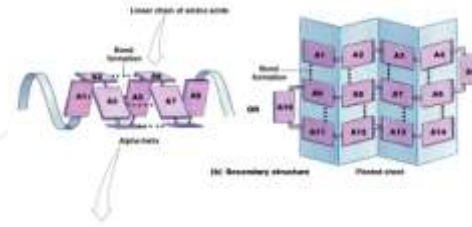


Figure 2-20b

Tertiary Structure

- Secondary structure folds into a unique shape

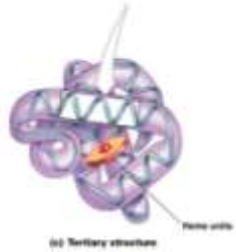


Figure 2-20c

Quaternary Structure

- Final protein shape:
  - several tertiary structures together

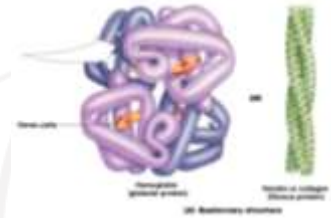


Figure 2-20d

Shape and Function

- Protein function is based on shape
- Shape is based on sequence of amino acids
- Denaturation:
  - loss of shape and function due to heat or pH

Enzymes

- Enzymes are catalysts:
  - proteins that lower the activation energy of a chemical reaction
  - are not changed or used up in the reaction

How Enzymes Work

- Substrates:
  - reactants in enzymatic reactions
- Active site:
  - a location on an enzyme that fits a particular substrate

How Enzymes Work

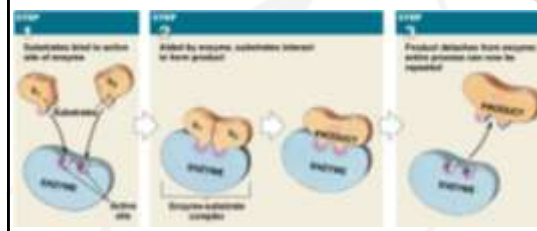
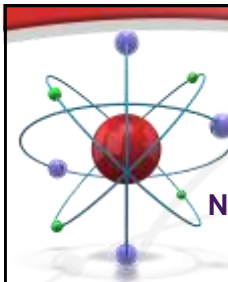


Figure 2-21

Enzyme Characteristics

- Specificity:
  - one enzyme catalyzes one reaction
- Saturation limits:
  - an enzyme's maximum work rate
- Regulation:
  - the ability to turn off and on



Nucleic Acid

Nucleic Acids

- Large organic molecules, found in the nucleus, which store and process information at the molecular level
- DNA and RNA

Deoxyribonucleic Acid (DNA)

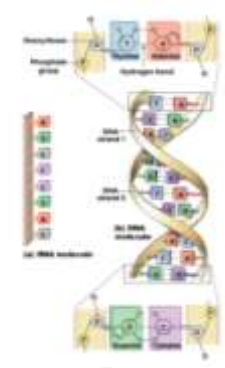
- Nucleus only
- Determines inherited characteristics
- Directs protein synthesis
- Controls enzyme production
- Controls metabolism

Ribonucleic Acid (RNA)

- Codes intermediate steps in protein synthesis

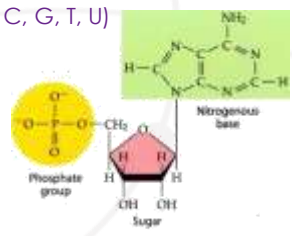
Nucleic Acids

- Assembled from nucleotides



Nucleotides

- Have 3 molecular parts:
  - sugar (deoxyribose/ribose)
  - phosphate group
  - nitrogenous base (A, C, G, T, U)



Complementary Bases

- DNA:
  - adenine (A) and thymine (T)
  - cytosine (C) and guanine (G)
- RNA:
  - uracil (U) replaces thymine (T)

RNA and DNA

- RNA:
  - a single strand
- DNA:
  - a double helix joined at bases by hydrogen bonds

Forms of RNA

- messenger RNA (mRNA)
- transfer RNA (tRNA)
- ribosomal RNA (rRNA)

ADP and ATP

- adenosine diphosphate (ADP):
  - 2 phosphate groups
- adenosine triphosphate (ATP):
  - 3 phosphate groups

The Energy Molecule

- Chemical energy stored in bonds between phosphates

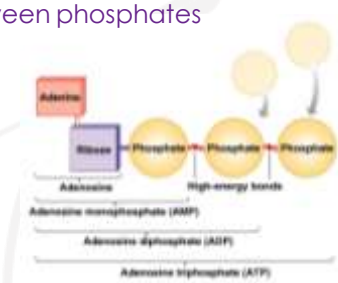


Figure 2-24