

Chemical Basis of Life

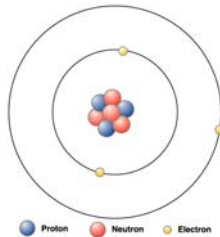
Chapter 2

Introduction

- **Matter** - anything that has mass
 - Made of **elements**
 - Substance that cannot be broken down to other substances by chemical reactions
 - **Atom** – the smallest unit of matter that is unique to a particular element
 - Each element has a **chemical symbol**

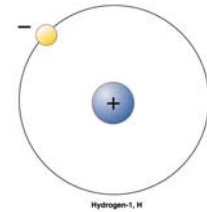
Atomic Structure

- Atoms of all elements contain **subatomic particles**
 - 3 kinds
 - Protons
 - Neutrons
 - Electrons



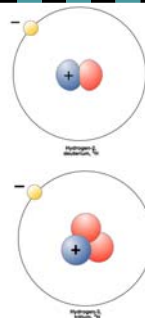
Atomic Structure

- **Protons**
 - Found in the nucleus
 - Carry a positive charge
 - Number of protons = number of electrons (usually)
 - Numbers do not vary
 - Numbers are specific for each element



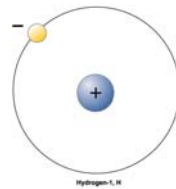
Atomic Structure

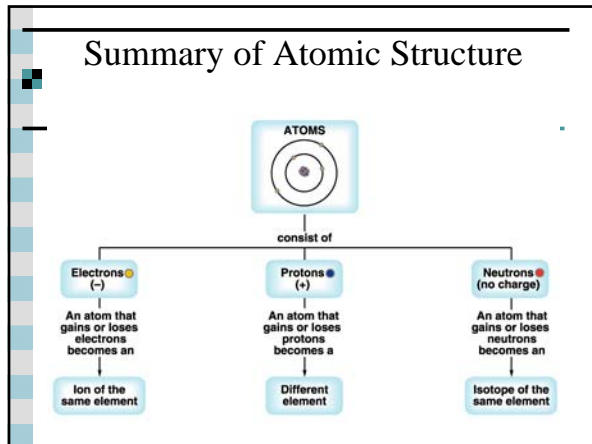
- **Neutrons**
 - Found in the nucleus
 - Electrically neutral
 - Numbers can vary
 - **Isotope**
 - **Radioactive isotope**



Atomic Structure

- **Electrons**
 - Orbit the nucleus
 - Carry a negative charge
 - Number of electrons = number of protons (usually)
 - Numbers can vary
 - **Ion**





Chemical Bonding

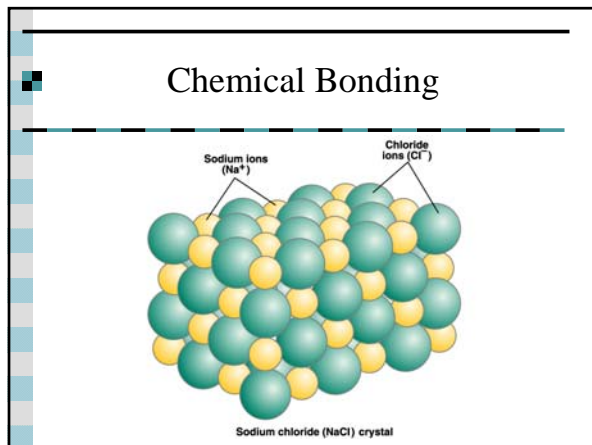
- **Chemical bonds form molecules**
 - 2 or more atoms
 - Elements
 - Compounds
- **Chemical formula**
 - Represents kinds and numbers of molecules
- **Structural formula**
 - Shows location of bonds
 - Atoms of each element will form a specific number of bonds

Step 1: Sodium gives up its one weakly held electron to chlorine.

Step 2: The sodium and chloride ions both have stable outer shells that are filled with electrons.

Step 3: The Na+ and Cl- ions are attracted to each other because of their opposite charges.

Sodium chloride (NaCl) molecule



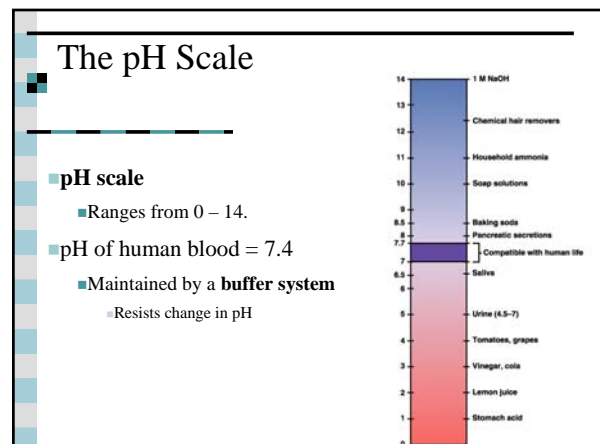
Chemical Properties

- **Determined by:**
 - Arrangement of atoms
 - Numbers of atoms
 - Types of atoms
- Eg. Sugar = C₆H₁₂O₆

glucose

Acids and Bases

- **Acid** – a substance that, when put into water, gives up H⁺
 - Donates H⁺ to a solution
- **Base** – a substance that, when put into water, gives up ions that will combine with H⁺
 - Takes H⁺ out of solution



Chemical Organization

- Four of the most widely distributed elements on earth are:
 - Oxygen
 - Carbon
 - Hydrogen
 - Nitrogen
- Inorganic compounds**
- Organic compounds** are compounds of carbon

Carbon

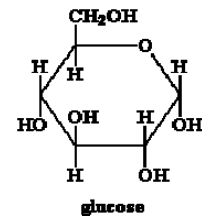
- Carbon is unusual
 - Atoms of most elements can bond to like atoms
 - Number of atoms so bondable is usually limited
 - Carbon atom – much more versatile
 - Can form as many as 4 bonds with other atoms, including other C atoms
 - More or less long chains of carbon atoms can form this way
 - C atoms can be joined into rings and other shapes
 - C – C combinations introduce tremendous complexity and variety into molecular structure

Categories of Organic Compounds

- Four categories form the basis of living matter.
 - Carbohydrates**
 - Lipids**
 - Proteins**
 - Nucleic acids**

Carbohydrates

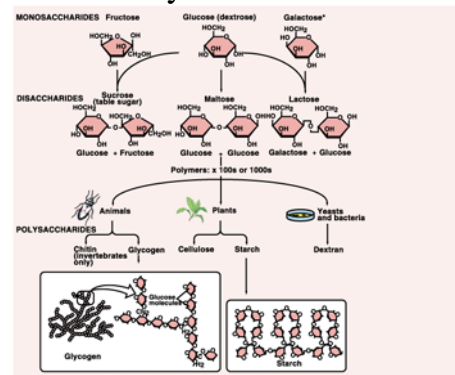
- Contain C, H, O
- Function: structural building blocks, source of energy
- Sugars and starches



Carbohydrates

- Types
 - Monosaccharides** – simple sugars
 - Disaccharides** – 2 simple sugars bonded together = a double sugar
 - Form a larger molecule
 - Polysaccharides** – many sugars bonded together
 - Eg. Starches

Carbohydrate Structure



Lipids

- Contain C, H, O
- Function: food storage, structural component, source of energy
- Fats and oils

$$\begin{array}{c}
 \text{O} \\
 \parallel \\
 \text{C} - \text{O} - \text{C} - \text{H} \\
 | \\
 \text{H}
 \end{array}$$

$$\begin{array}{c}
 \text{O} \\
 \parallel \\
 \text{C} - \text{O} - \text{C} - \text{H} \\
 | \\
 \text{H}
 \end{array}$$

$$\begin{array}{c}
 \text{O} \\
 \parallel \\
 \text{C} - \text{O} - \text{C} - \text{H} \\
 | \\
 \text{H}
 \end{array}$$

3 Fatty Acids + Glycerol
Triglyceride (a fat molecule)

Saturated vs. Unsaturated Fats

- **Saturated fat**
 - H bonded to all C atoms
- **Unsaturated fat**
 - C double bonded
 - **Polyunsaturated**
 - Many C = C bonds

Saturated

Unsaturated

http://www.nature.com/horizon/livingfrontier/background/images/fat_f2.jpg

Proteins

- Contain C, H, O, N
- Function: structural component, energy source, **enzymes**, etc.
- Structure: chains of **amino acids**
 - Sequence of amino acids determines protein's shape
 - Shape determines how functional a protein is
- Animal cells usually contain 23 types of amino acids
- Basis of Life

http://www.berkeley.edu/news/media/releases/2003/02/18_table.shtml

Amino Acid Structure

Model amino acid

$$\begin{array}{c}
 \text{COOH} \\
 | \\
 \text{H} - \text{C} - \text{R} \\
 | \\
 \text{NH}_2
 \end{array}$$

Amino Acid Structure

Isoleucine

$$\begin{array}{c}
 \text{COOH} \\
 | \\
 \text{H} - \text{C} - \text{C} - \text{C} - \text{C} - \text{H} \\
 | \quad | \quad | \quad | \\
 \text{NH}_2 \quad \text{CH}_3 \quad \text{H} \quad \text{H}
 \end{array}$$

Protein Molecules

AMINO ACIDS

can be categorized as

Essential

Nonessential

and can link together to form

Peptides (2-9 amino acids)

Polypeptides (10-100 amino acids)

Proteins (>100 amino acids)

have

1^o structure

Sequence of amino acids

2^o structure

α-helix

β-pleated sheet

3^o structure

Fibrous proteins

Globular proteins

4^o structure

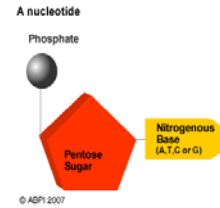
Multiple subunits

Variations in Protein Structure

- 100's of a.a. units may be joined together in a single protein molecule
 - Structurally can vary in almost unlimited fashion
- Possible for no 2 organisms to have exactly the same types of proteins
 - The difference in life between organisms is the arrangement of amino acids
 - Proteins are very specific for each organism

Nucleotides

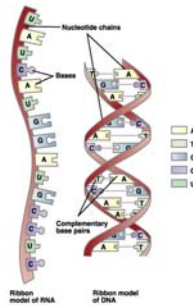
- Contain C, H, O, N, P
- Consist of 3 units
 - Phosphate group - P
 - 5-C sugar
 - Nitrogen base
- Function as genetic systems (DNA) and energy carriers (ATP)



<http://www.abpiscschools.org.uk/res/coResourceImport/modules/genome/en-images/nucleotide.gif>

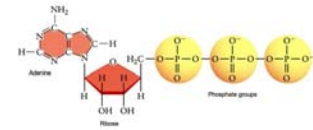
Genetic Systems - Nucleic Acids

- Structure: **nucleotides** bonded together to form long chains
- DNA**
 - Stores information that controls all cell activities
 - Double stranded
 - Held together by bonds between nitrogen bases
 - Base pairs
- RNA**
 - Tells the cell how to construct proteins



Energy carriers - ATP

- Nucleotides are able to link up with 1 or 2 additional phosphate groups
 - Form **high energy bonds**



ATP

http://www.griffined.com/images/ATP_molecule.jpg

Sample Exam Questions

- A substance that cannot be broken down to other substances by chemical reactions is a (an)
 - A. Atom
 - B. Molecule
 - C. Element
 - D. Compound
- The two strands of DNA are held together by
 - A. Bonds between nitrogen bases
 - B. Bonds between sugar and phosphate molecules
 - C. Bonds between amino acids
 - D. Bonds between lipids