

### The Structure of Atoms

- **Chemistry** is the study of interactions between atoms and molecules
- The **atom** is the smallest unit of matter that enters into chemical reactions
- Atoms interact to form **molecules**
- Atoms are composed of
  - **Electrons**: Negatively charged particles
  - **Protons**: Positively charged particles
  - **Neutrons**: Uncharged particles
- Protons and neutrons are in the nucleus
- Electrons move around the nucleus

### Chemical Elements

- Each chemical element has a different number of protons
- Isotopes of an element are atoms with different numbers of neutrons. Isotopes of oxygen:

### Electronic Configurations

- Electrons are arranged in electron shells corresponding to different energy levels

### How Atoms Form Molecules

- Atoms combine to complete the outermost shell
- The number of missing or extra electrons in this shell is known as the **valence**
- Molecules hold together because the valence electrons of the combining atoms form attractive forces, called **chemical bonds**, between the atomic nuclei

### Chemical Bonds

- A compound contains different kinds of atoms  
H<sub>2</sub>O

### Ionic Bonds

- The number of protons and electrons is equal in an atom
- Ions are charged atoms that have gained or lost electrons
- **Ionic bonds** are attractions between ions of opposite charge. One atom loses electrons, and another gains electrons.

### Covalent Bonds

- **Covalent bonds** form when two atoms share one or more pairs of electrons

### Hydrogen Bonds

- **Hydrogen bonds** form when a hydrogen atom that is covalently bonded to an O or N atom is attracted to another N or O atom in another molecule

### Molecular Weight and Moles

- The sum of the atomic weights in a molecule is the **molecular weight**
- One **mole** of a substance is its molecular weight in grams

### Chemical Reactions

- **Chemical reactions** involve the making or breaking of bonds between atoms
- A change in **chemical energy** occurs during a chemical reaction
- **Endergonic** reactions absorb energy
- **Exergonic** reactions release energy

### Synthesis Reactions

- Occur when atoms, ions, or molecules combine to form new, larger molecules
- **Anabolism** is the synthesis of molecules in a cell

### Decomposition Reactions

- Occur when a molecule is split into smaller molecules, ions, or atoms
- **Catabolism** is the decomposition reactions in a cell

### Exchange Reactions

- Are part synthesis and part decomposition

### Reversible Reactions

- Can readily go in either direction
- Each direction may need special conditions

### Important Biological Molecules

- **Organic compounds** always contain carbon and hydrogen
- **Inorganic compounds** typically lack carbon

### Water

- Inorganic
- Polar molecule
- Solvent
  - Polar substances dissociate, forming solutes
- H<sup>+</sup> and OH<sup>-</sup> participate in chemical reactions
- H bonds absorb heat
  - Makes water a temperature buffer

### Acids

- Substances that dissociate into one or more H<sup>+</sup>  
 $\text{HCl} \rightarrow \text{H}^+ + \text{Cl}^-$

### Bases

- Substances that dissociate into one or more OH<sup>-</sup>  
 $\text{NaOH} \rightarrow \text{Na}^+ + \text{OH}^-$

### Salts

- Substances that dissociate into cations and anions, neither of which

is H<sup>+</sup> or OH<sup>-</sup>



### Acid-Base Balance

- The amount of H<sup>+</sup> in a solution is expressed as **pH**
- $\text{pH} = -\log[\text{H}^+]$
- Increasing [H<sup>+</sup>], increases acidity
- Increasing [OH<sup>-</sup>] increases alkalinity
- Most organisms grow best between pH 6.5 and 8.5

### Structure and Chemistry

- The chain of carbon atoms in an organic molecule is the **carbon skeleton**
- **Functional groups** are responsible for most of the chemical properties of a particular organic compound.

### Functional Groups

- Identify the functional groups in an amino acid:

### Organic Compounds

- Small organic molecules can combine into large macromolecules
- **Macromolecules** are polymers consisting of many small repeating molecules
- The smaller molecules are called **monomers**

### Polymers

- Monomers join by **dehydration synthesis** or **condensation reactions**

### Carbohydrates

- Cell structures and energy sources
- Consist of C, H, and O with the formula (CH<sub>2</sub>O)<sub>n</sub>
- **Monosaccharides** are simple sugars with 3 to 7 carbon atoms
- **Disaccharides** are formed when 2 monosaccharides are joined in a

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- dehydration synthesis
- Disaccharides can be broken down by hydrolysis
- Oligosaccharides** consist of 2 to 20 monosaccharides
- Polysaccharides** consist of tens or hundreds of monosaccharides joined through dehydration synthesis
  - Starch, glycogen, dextran, and cellulose are polymers of glucose that are covalently bonded differently
  - Chitin is a polymer of 2 sugars repeating many times

### Lipids

- Primary components of cell membranes
- Consist of C, H, and O
- Are nonpolar and insoluble in water

### Simple Lipids

- Fats** or **triglycerides**
- Contain glycerol and fatty acids; formed by dehydration synthesis
- Saturated fat**: No double bonds
- Unsaturated fat**: One or more double bonds in the fatty acids
  - cis*: H atoms on the same side of the double bond
  - trans*: H atoms on opposite sides of the double bond

### Complex Lipids

- Contain C, H, and O + P, N, or S
- Membranes are made of phospholipids

### Steroids

- 4 carbon rings with an -OH group attached to one ring
- Part of membranes

### Proteins

- Are essential in cell structure and function

- Enzymes are proteins that speed chemical reactions
- Transporter proteins move chemicals across membranes
- Flagella are made of proteins
- Some bacterial toxins are proteins

### Amino Acids

- Proteins consist of subunits called **amino acids**
- Exist in either of two **stereoisomers**: D or L.
- L-forms are most often found in nature.

### Peptide Bonds

- Peptide bonds** between amino acids are formed by dehydration synthesis

### Levels of Protein Structure

- The **primary structure** is a polypeptide chain
- The **secondary structure** occurs when the amino acid chain folds and coils in a regular helix or pleats
- The **tertiary structure** occurs when the helix folds irregularly, forming disulfide bonds, hydrogen bonds, and ionic bonds between amino acids in the chain
- The **quaternary structure** consists of 2 or more polypeptides.
- Conjugated proteins consist of amino acids and other organic molecules
  - Glycoproteins
  - Nucleoproteins
  - Lipoproteins

### Nucleic Acids

- Consist of **nucleotides**
- Nucleotides consist of a
  - Pentose
  - Phosphate group
  - Nitrogen-containing (**purine** or **pyrimidine**) base
- Nucleosides** consist of a

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- Pentose
- Nitrogen-containing base

### **DNA**

- **Deoxyribonucleic acid**
- Has deoxyribose
- Exists as a double helix
- **A** hydrogen bonds with **T**
- **C** hydrogen bonds with **G**

### **RNA**

- **Ribonucleic acid**
- Has ribose
- Is single-stranded
- **A** hydrogen bonds with **U**
- **C** hydrogen bonds with **G**

### **ATP**

- **Adenosine triphosphate**
- Has ribose, adenine, and 3 phosphate groups.
- Is made by dehydration synthesis
- Is broken by hydrolysis to liberate useful energy for the cell