

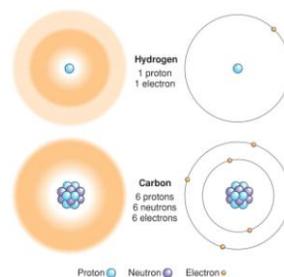
Chapter 2 Outline

- ▶ Atoms
- ▶ Chemical Bonds
- ▶ Acids, Bases and the pH Scale
- ▶ Organic Molecules
 - ▶ Carbohydrates
 - ▶ Lipids
 - ▶ Proteins
 - ▶ Nucleic Acids

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Atoms

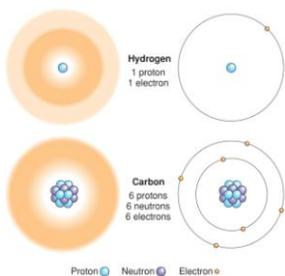
- ▶ Are smallest units of the chemical elements
- ▶ Composed of protons, neutrons and electrons
- ▶ Nucleus contains protons (+ charge) and neutrons (no charge)
- ▶ Electrons (- charge) occupy orbitals or shells outside nucleus



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Atoms

- ▶ Atomic mass is sum of protons and neutrons in an atom
- ▶ Atomic number is number of protons in an atom
- ▶ Electron shells or orbitals .
 - ▶ Number of shells depends on atomic number
 - ▶ First shell = 2 electrons
 - ▶ Second = up to 8 electrons
 - ▶ Electrons in distant shells have higher energy



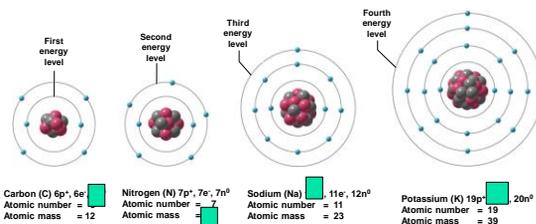
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Atoms - Electron Shells

- ▶ Valence electrons are those in outermost shell
 - ▶ Participate in chemical reactions and form bonds
- ▶ Isotopes: different forms of same atom
 - ▶ Atomic number is the same, but atomic mass is different
 - ▶ Different numbers of neutrons!

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Planetary Models of Elements



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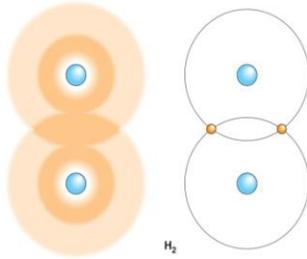
Chemical Bonds

- ▶ Molecules form by chemical bonding between valence electrons of atoms
 - ▶ Number of bonds determined by number of electrons needed to complete outermost shell

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Covalent Bonds

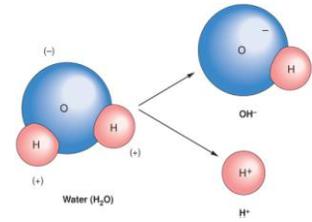
- ▶ Occur when atoms **share** valence electrons
- ▶ In **nonpolar covalent** bonds electrons are shared equally
 - ▶ e.g. in H_2 or O_2



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Covalent Bonds

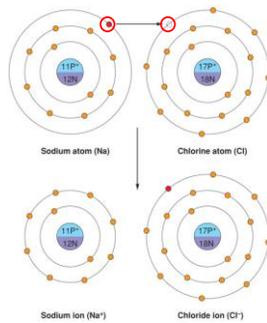
- ▶ In **polar** bonds electrons are shared **unequally**
 - ▶ Have + and - poles
- ▶ Tend to form polar molecules
 - ▶ e.g. H_2O



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Ionic Bonds

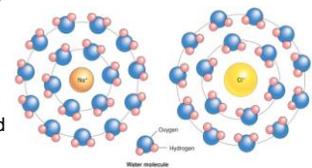
- ▶ Electrons are transferred from one atom to another
- ▶ One gives and one receives
- ▶ Forming charged atoms (**ions**)
- ▶ Atom that loses electrons + **cation** (+ charged)
- ▶ Atom that gains electrons = **anion** (- charge)



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Ionic Bonds

- ▶ Ionic bonds are formed by attraction of + and - charges
- ▶ Ionic bonds are weaker than polar covalent bonds
- ▶ Dissociate when dissolved in H_2O
 - ▶ Because H_2O forms hydration spheres around ions
 - ▶ e.g. $NaCl$



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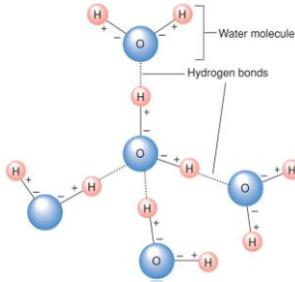
Ionic Bonds

- ▶ **Hydrophilic** molecules (polar) are soluble in water
 - ▶ Readily form hydration spheres
 - ▶ e.g. glucose and amino acids
- ▶ **Hydrophobic** molecules (nonpolar), cannot form hydration spheres (water soluble)

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Hydrogen Bonds

- ▶ When H forms polar bond with another atom it takes on a slight + charge
- ▶ Making it attracted to any nearby negatively charged atoms
- ▶ Called **hydrogen bonds**
 - ▶ e.g., bond between adjacent H₂O's
 - ▶ **surface tension**



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Acids and Bases

- ▶ **Acids** release protons (H⁺) in a solution (proton donor)
- ▶ **Bases** lower H⁺ levels of a solution (proton acceptor)

Table 2.2 Common Acids and Bases

Acid	Symbol	Base	Symbol
Hydrochloric acid	HCl	Sodium hydroxide	NaOH
Phosphoric acid	H ₃ PO ₄	Potassium hydroxide	KOH
Nitric acid	HNO ₃	Calcium hydroxide	Ca(OH) ₂
Sulfuric acid	H ₂ SO ₄	Ammonium hydroxide	NH ₄ OH
Carbonic acid	H ₂ CO ₃		

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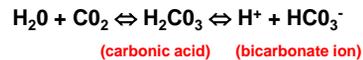
pH

- ▶ Is symbol for **H⁺ concentration of a solution**
- ▶ pH scale runs from 0 to 14
- ▶ $\text{pH} = \log \frac{1}{[\text{H}^+]}$
- ▶ Pure H₂O is neutral and has pH = 7
- ▶ Acids have a pH < 7 (pH 0 - 7)
- ▶ Bases have a pH > 7 (pH 7 - 14)

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Buffers

- ▶ Molecules that slow changes in pH by either combining with or releasing H⁺s
- ▶ e.g. the **bicarbonate buffer system** in blood:



- ▶ buffers pH because reaction can go in either direction depending upon concentration of H⁺s

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Blood pH

- ▶ Normal range of pH is 7.35 – 7.45
 - ▶ Maintained by buffering action
 - ▶ **Acidosis** occurs if pH < 7.35
 - ▶ **Alkalosis** occurs if pH > 7.45

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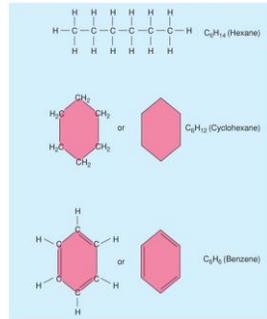
Organic Molecules

- ▶ Those molecules that contain carbon and hydrogen
- ▶ Carbon has 4 electrons in outer shell
 - ▶ Bonds covalently to fill outer shell with 8 electrons

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Organic Molecules

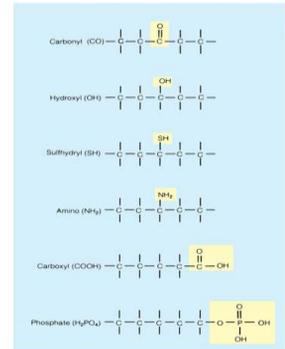
- ▶ In body, carbons are linked to form chains or rings
- ▶ Serve as “backbone” to which more reactive **functional groups** are added



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Organic Molecules

- ▶ Functional groups:
- ▶ Carbonyl group forms **ketones** and **aldehydes**
- ▶ Hydroxyl group forms **alcohols**
- ▶ Carboxyl group forms **organic acids** (lactic and acetic acids)



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- ▶ **Isomers** – molecules with identical molecular formulae but different arrangement of their atoms

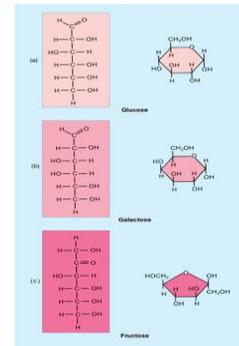
	Structural formulae	Condensed Structural formulae	Molecular formulae
Ethanol		CH ₃ CH ₂ OH	C ₂ H ₆ O
Ethyl ether		CH ₃ OCH ₃	C ₂ H ₆ O

Figure 2.5

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Carbohydrates

- ▶ Organic molecules containing carbon, hydrogen and oxygen in ratio of C_nH_{2n}O_n
- ▶ **Monosaccharides** are simple sugars such as glucose, fructose, galactose



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Carbohydrates

- ▶ **Disaccharides** are 2 monosaccharides joined covalently
- ▶ Include:
 - ▶ **Sucrose** or table sugar (glucose + fructose)
 - ▶ **Lactose** or milk sugar (glucose + galactose)
 - ▶ **Maltose** or malt sugar (2 glucoses)

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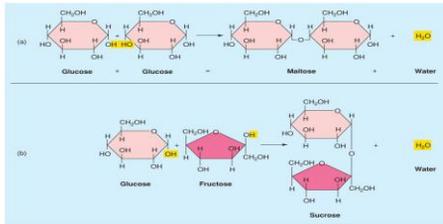
Carbohydrates

- ▶ **Polysaccharides** are many monosaccharides linked together
- ▶ Include **starch** and **glycogen**, which are polymers of thousands of glucoses
- ▶ **Energy storage molecules!!!!!!!**
- ▶ Allows organisms to store thousands of glucoses in 1 polysaccharide molecule!!!!

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Formation of Disaccharides

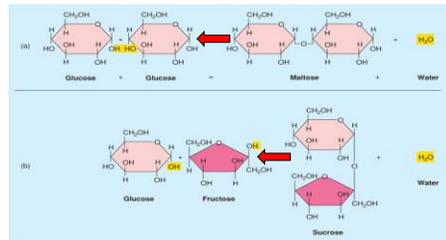
- Occurs by splitting water out of 2 monosaccharides
 - An H^+ and OH^- are removed, producing H_2O
 - Called **dehydration** or **condensation**



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Digestion of Polysaccharides

- Hydrolysis:** Reverse of dehydration synthesis
 - H_2O is split, H^+ added to one monosaccharide, OH^- to other
 - Polysaccharide hydrolyzed into disaccharides, then to monosaccharides



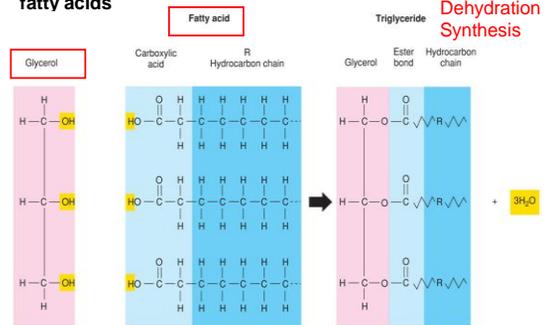
2-33

Lipids

- Are insoluble in polar solvents such as water
 - Hydrophobic
- Consist primarily of hydrocarbon chains and rings

Lipids - Triglycerides

- Formed by dehydration (condensation) of 1 glycerol and 3 fatty acids

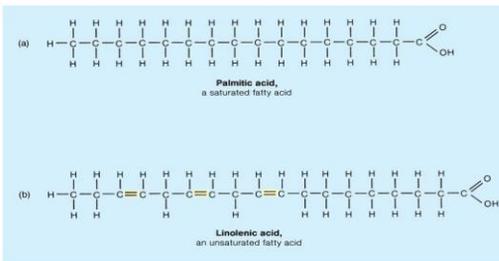


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Lipids - Triglycerides

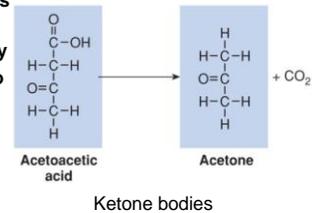
- Are **saturated** if hydrocarbon chains of fatty acids are joined by single covalent bonds
- Are **unsaturated** if there are double bonds within hydrocarbon chains



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Lipids - Ketone Bodies

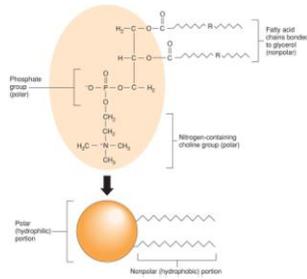
- Hydrolysis of triglycerides releases free fatty acids:
 - can be used for energy
 - or converted in liver to ketone bodies
 - Which are acidic



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Lipids - Phospholipids

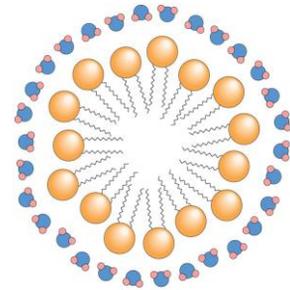
- ▶ Lipids that contain a phosphate group
- ▶ Phosphate part is polar & hydrophilic
- ▶ Lipid part is nonpolar & hydrophobic



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Lipids - Phospholipids

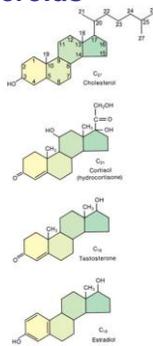
- ▶ Phospholipids aggregate into micelles in water
- ▶ Polar part interacts with water; nonpolar part is hidden in middle



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Lipids - Steroids

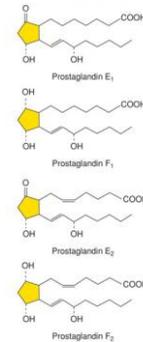
- ▶ Nonpolar and insoluble in water
- ▶ All have **three 6-carbon rings joined to a 5-carbon ring**
- ▶ Cholesterol is:
 - ▶ precursor for steroid hormones
 - ▶ component of cell membranes



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Lipids - Prostaglandins

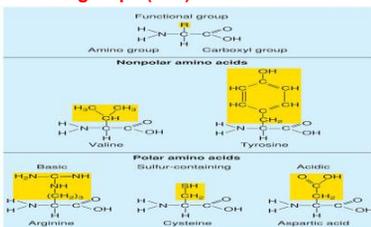
- ▶ Fatty acids with cyclic hydrocarbon group
- ▶ Produced by, and active in most tissues
- ▶ Serve many regulatory functions



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Proteins - Amino Acids

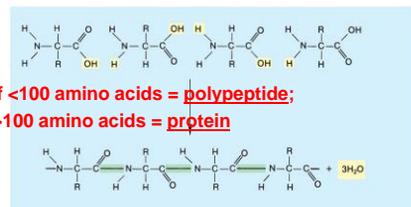
- ▶ Are made of long chains of amino acids
 - ▶ 20 different amino acids can be used
 - ▶ Amino acids contain an **amino group (NH₂)** at one end; **carboxyl group (COOH)** at other end
 - ▶ Differences between amino acids are due to differences in **functional groups ("R")**



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Proteins - Peptides

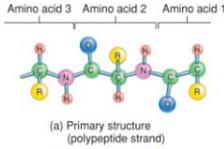
- ▶ Short chains of amino acids
 - ▶ Amino acids are linked by **peptide bonds**
 - ▶ Formed by dehydration reactions



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Proteins - Structure

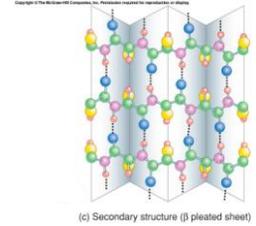
- ▶ Can be described at four levels
- ▶ **Primary structure** is its sequence of amino acids



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Proteins - Structure

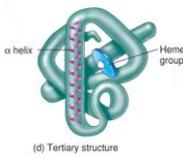
- ▶ **Secondary structure** is caused by weak H bonding of amino acids
- ▶ Results in **alpha helix** or **beta pleated sheet** shapes



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Protein - Structure

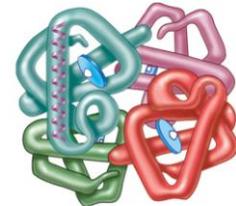
- ▶ **Tertiary structure** caused by bending and folding of polypeptide chains to produce 3-dimensional shape
- ▶ Formed and stabilized by weak bonds between functional groups
- ▶ Not stable; can be **denatured** by heat, pH



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Protein - Structure

- ▶ **Quaternary structure** when a number of polypeptide chains are covalently joined



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Protein - Structure

- ▶ Many proteins are conjugated with other groups
- ▶ **Glycoproteins** contain carbohydrates
- ▶ **Lipoproteins** contain lipids
- ▶ Others, like hemoglobin, contain a pigment

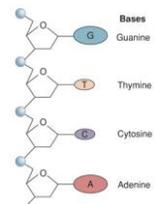
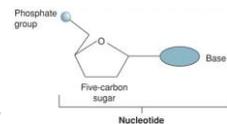
Table 2.4 Composition of Selected Proteins Found in the Body

Protein	Number of Polypeptide Chains	Nonprotein Component	Function
Hemoglobin	4	Heme pigment	Carries oxygen in the blood
Myoglobin	1	Heme pigment	Stores oxygen in muscle
Insulin	2	None	Hormonal regulation of metabolism
Blood group proteins	1	Carbohydrate	Produces blood types
Lipoproteins	1	Lipids	Transports lipids in blood

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Nucleic Acids

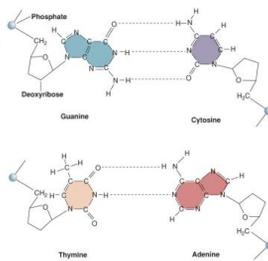
- ▶ Include DNA and RNA
- ▶ Long chains of **nucleotides**
- ▶ Which consist of a **5-carbon sugar, phosphate group, and nitrogenous base**



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Nucleic Acids - DNA

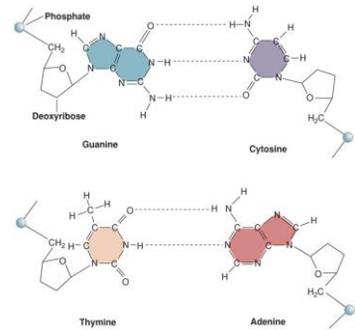
- ▶ Contains genetic code
- ▶ Its **deoxyribose** sugar (5C) is covalently bonded to 1 of 4 bases:
 - ▶ **Guanine** or **adenine** (purines)
 - ▶ **Cytosine** or **thymine** (pyrimidines)
- ▶ Chain is formed by sugar of 1 nucleotide bonding to phosphate of another



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Nucleic Acids - DNA

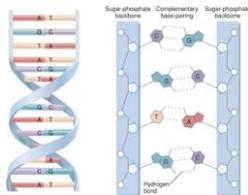
- ▶ Each base can form hydrogen bonds with other bases
 - ▶ This hydrogen bonding holds 2 strands of DNA together



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Nucleic Acids - DNA

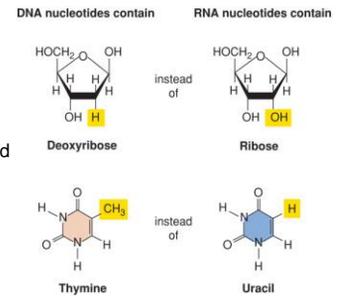
- ▶ The 2 strands of DNA twist to form a **double helix**
- ▶ Number of purines = pyrimidines
 - ▶ Due to **law of complementary base pairing**
 - ▶ adenine pairs only with thymine; cytosine with guanine



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Nucleic Acids - RNA

- ▶ Consists of a long chain of nucleotides joined together by sugar-phosphate bonds
- ▶ Its **ribose** sugar is bonded to 1 of 4 bases:
 - ▶ **Guanine** or **adenine**
 - ▶ **Cytosine** or **uracil** (replaces thymine)
- ▶ Single-stranded



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Nucleic Acids - RNA

- ▶ 3 types of RNA are synthesized from DNA and allow it to direct activities of a cell:
 - ▶ Messenger RNA - **mRNA**
 - ▶ Transfer RNA - **tRNA**
 - ▶ Ribosomal RNA - **rRNA**

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