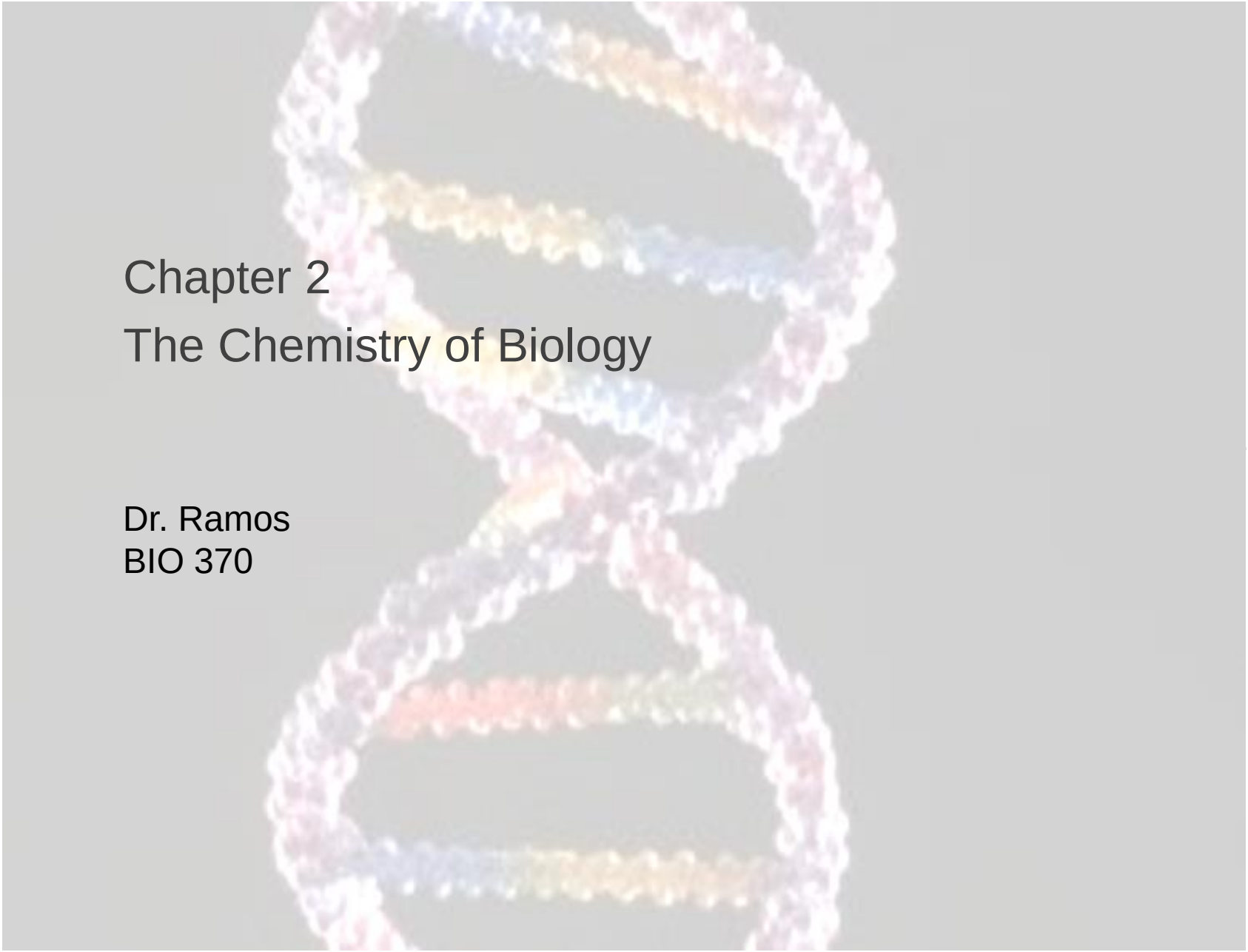


Chapter 2
The Chemistry of Biology

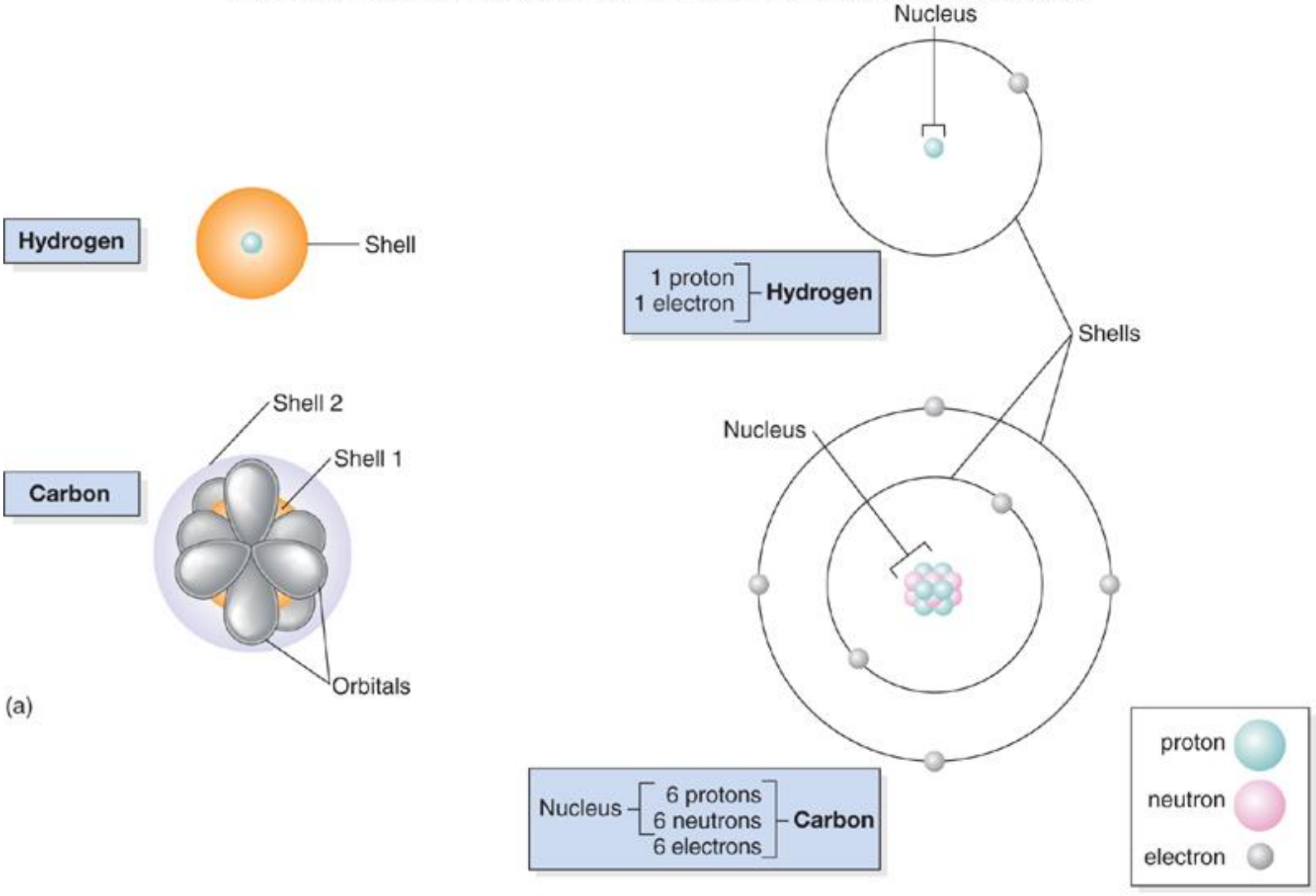
Dr. Ramos
BIO 370

Atoms, Bonds, and Molecules

- **Matter** - all materials that occupy space and have mass

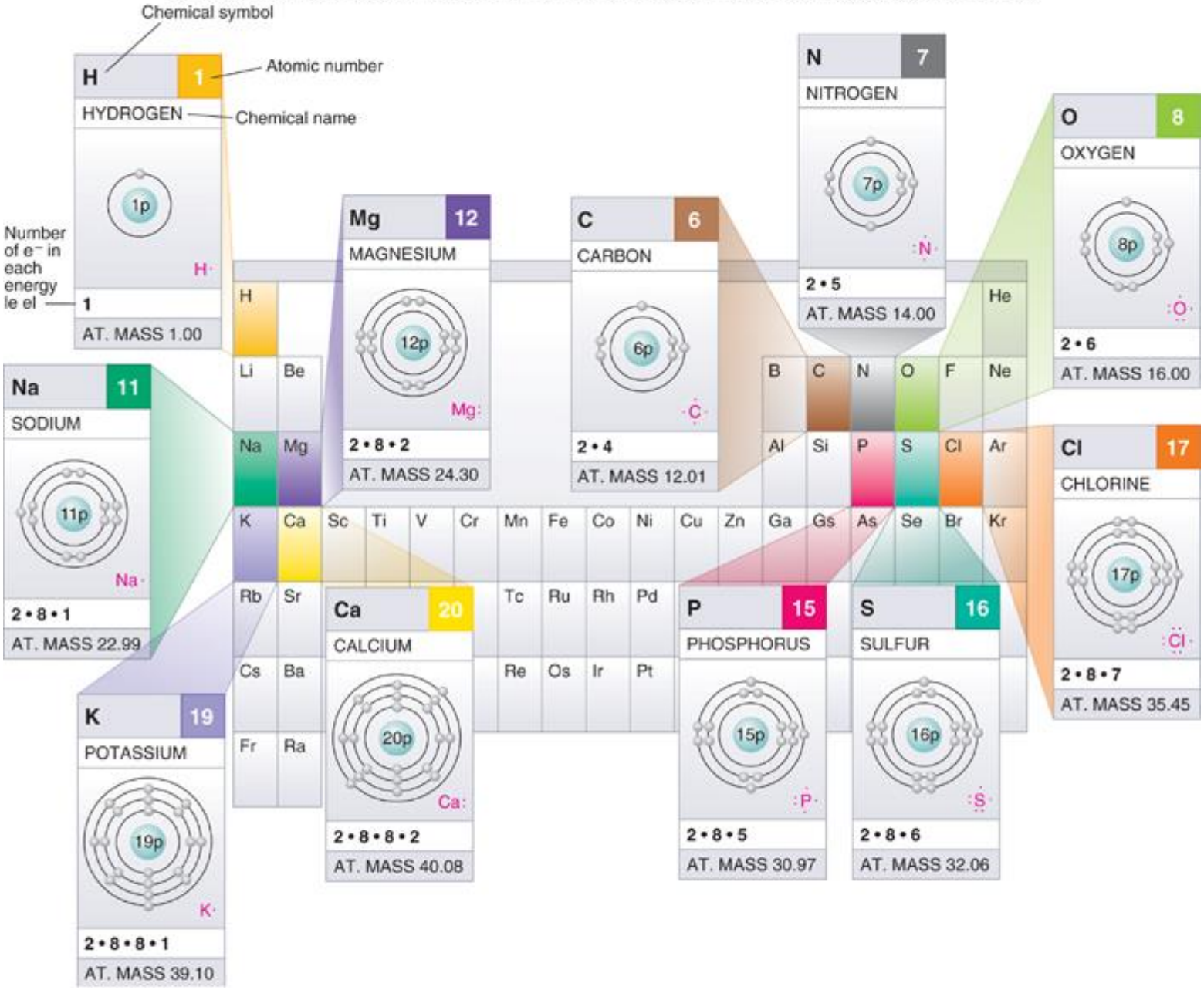
- Matter is composed of **atoms.**
  - **Atom** – simplest form of matter not divisible into simpler substances
  - Composed of **protons, neutrons, and electrons**

- **Element –** pure substances with a characteristic number of protons, neutrons, and electrons and predictable chemical behaviors



Characteristics of elements

- **Atomic number** – number of protons
- **Mass number** – number of protons and neutrons
- **Isotopes** – variant forms of an element that differ in mass number
- **Atomic weight** – average of the mass numbers of all of the element's isotopic forms
- **Electron orbitals** – volumes of space surrounding the atomic nucleus where electrons are likely to be found



Molecules and Bonds

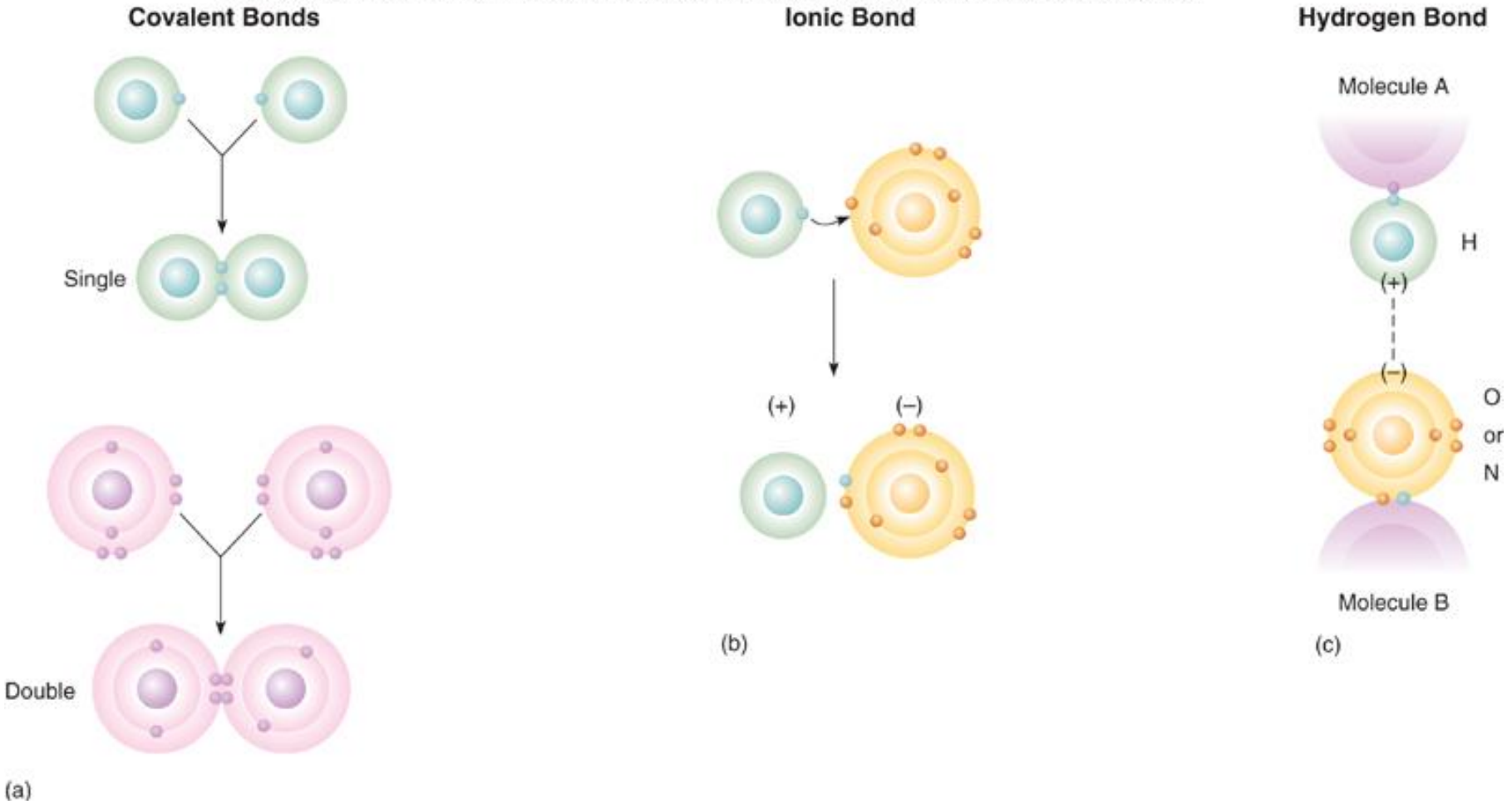
- **Molecule** – distinct chemical substance that results from the combination of two or more atoms.
- **Compounds** – molecules that are combinations of 2 or more different elements.
- **Chemical bonds** – when 2 or more atoms share, donate or accept electrons to form molecules and compounds
  - 3 types: covalent, ionic, and hydrogen

Types of Chemical Bonds

1. **Covalent bonds** – electrons are shared among atoms
   - **polar** covalent bonds– unequal sharing
   - **nonpolar** covalent bonds– equal sharing

2. **Ionic bonds** – electrons are transferred to one atom forming positively charged **cations** and negatively charged **anions**

3. **Hydrogen bonds** – weak bonds between hydrogen and other atoms



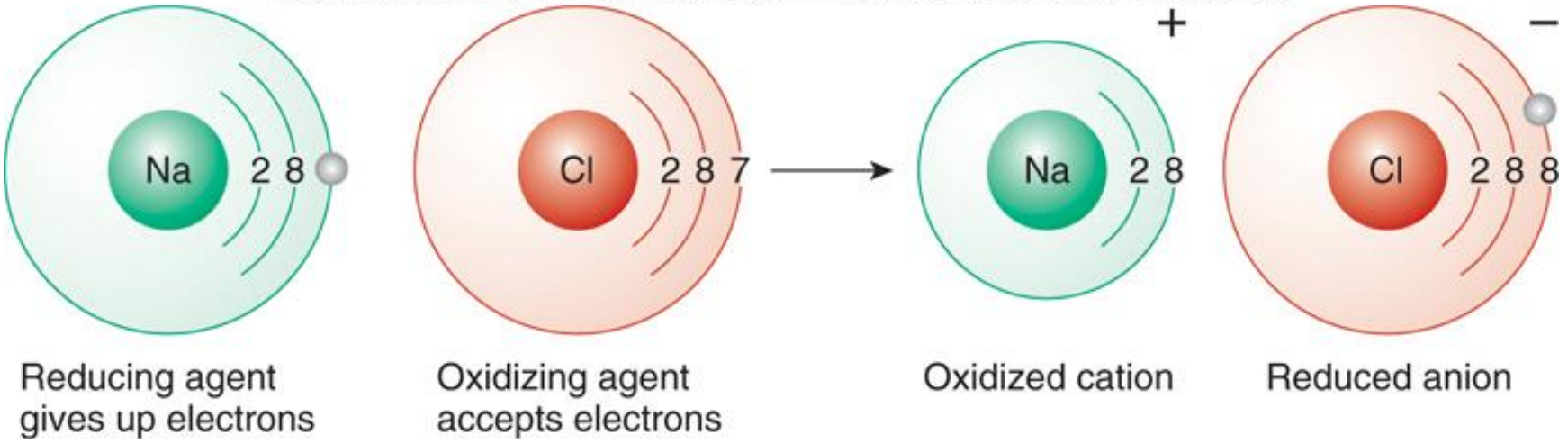
Electron Transfer and Oxidation-Reduction Reactions

Energy exchanges in cells is a result of the movement of electrons from one molecule to another.

Oxidation – the loss of electrons

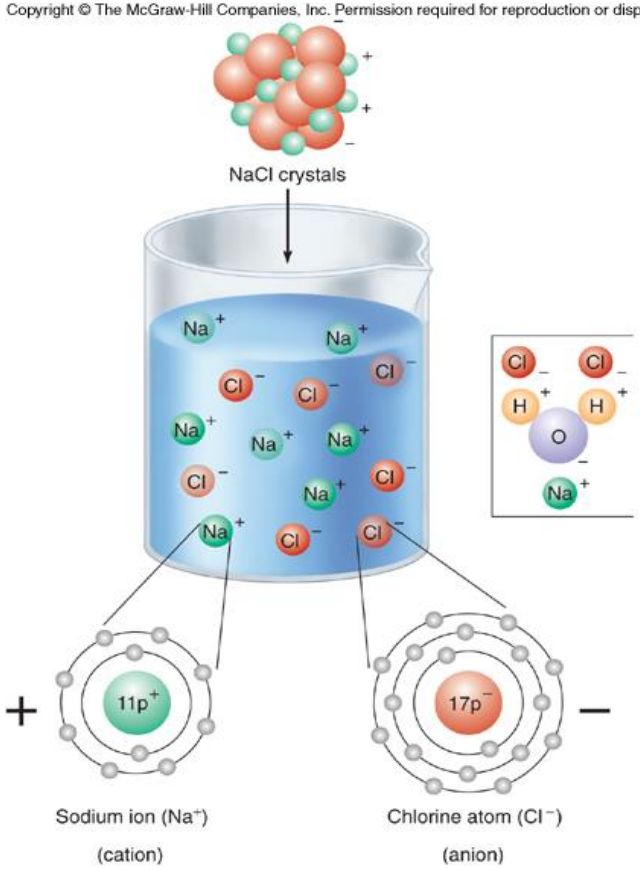
Reduction – the gaining of electrons

Redox reactions – essential to biochemical processes



Solutions: Mixtures of Molecules

Solution – a mixture of one or more substances called **solutes**, dispersed in a dissolving medium called a **solvent**



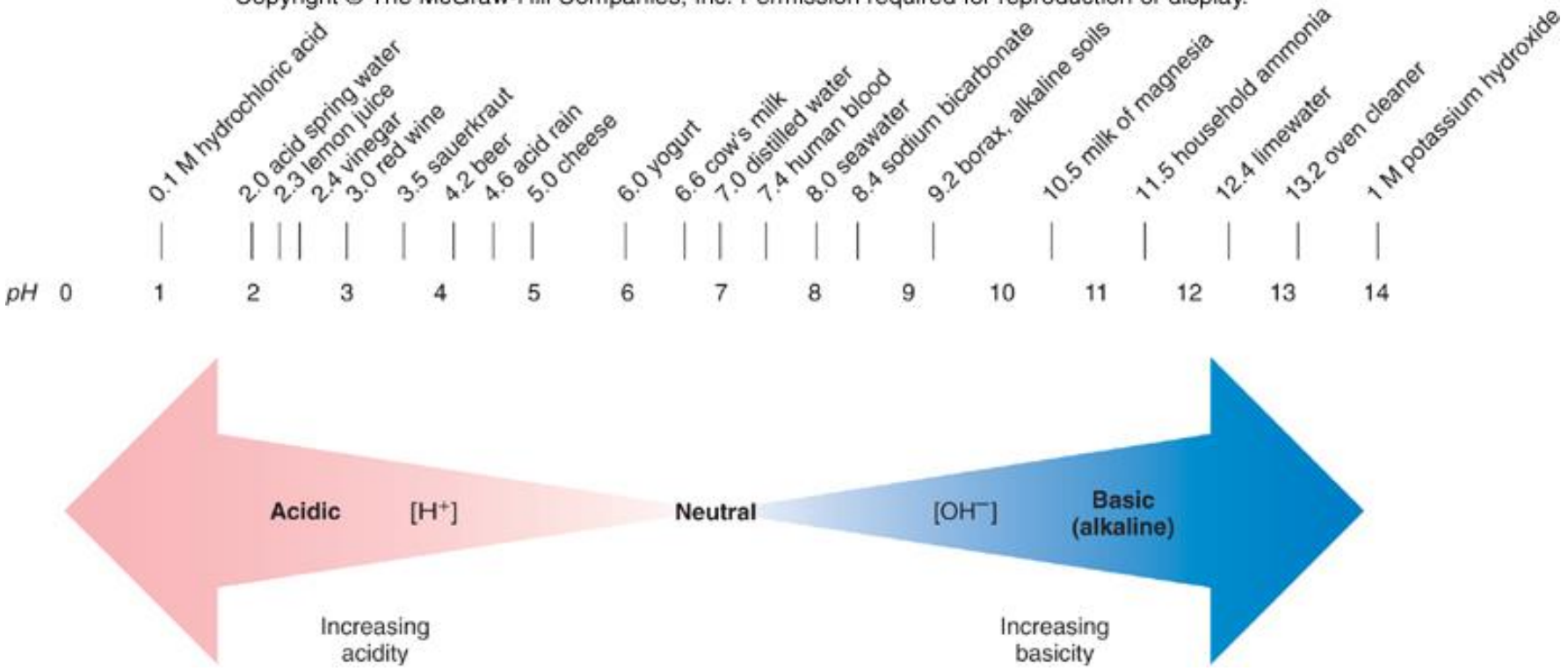
Solutes – Na^+ & Cl^-

Solvent – H_2O

- Most biological activities occur in **aqueous (water-based) solutions.**
- **Hydrophilic** molecules **–** dissolve in water
- **Hydrophobic** molecules – repel water
- **Amphipathic** molecules -have both hydrophilic and hydrophobic properties

Acidity, Alkalinity, and the pH Scale

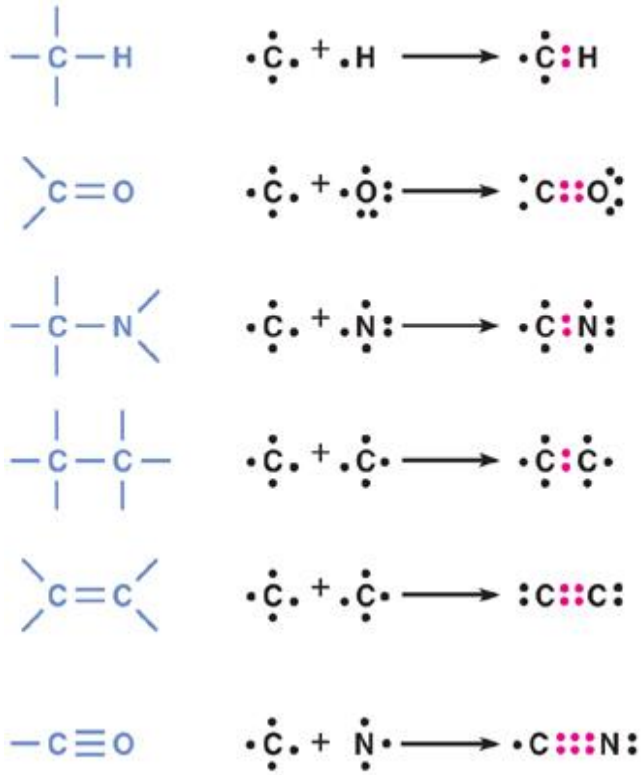
- Ionization of H_2O releases hydrogen ions [H^+] and hydroxyl ions [OH^-]
- pH scale – ranges from 0 to 14, expresses the concentration of H^+ ions
  - pH is the negative logarithm of the concentration of H+ ions.
- pH 6 = 0.000001 moles H^+/ l
- pH 9 = 0.000000001 moles H^+/ l



The Chemistry of Carbon and Organic Compounds

- **Organic chemicals** – compounds containing both carbon and hydrogen atoms.

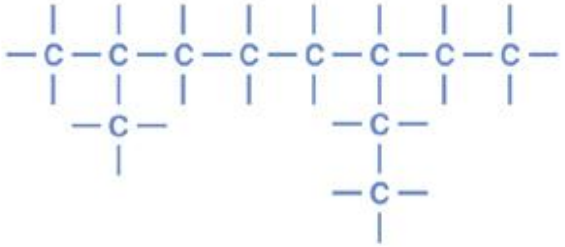
- Carbon is the fundamental element of life
  - contains 4 atoms in its outer orbital
  - can form single, double, or triple covalent bonds
  - can form linear, branched, or ringed molecules



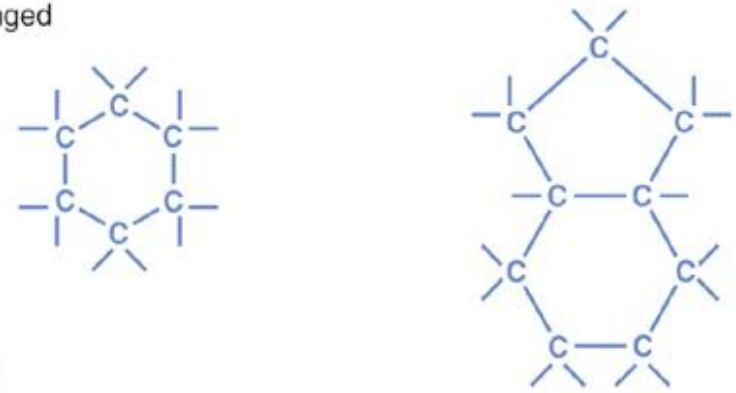
(a)

Linear

Branched



Ringed



(b)

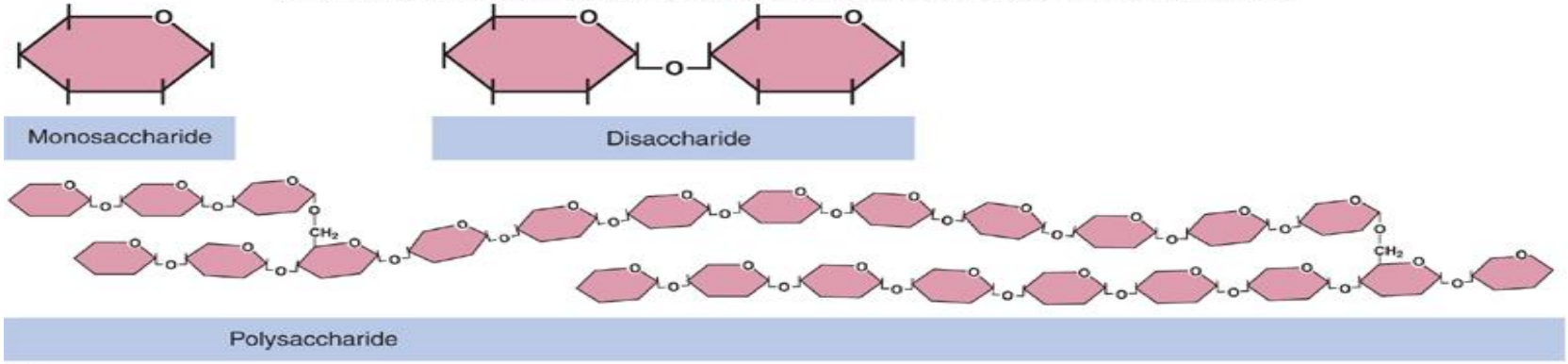
Families of Macromolecules

1. Carbohydrates – monosaccharides, disaccharides, polysaccharides
2. Lipids – triglycerides (fats and oils), phospholipids, steroids
3. Proteins
4. Nucleic acids – DNA, RNA

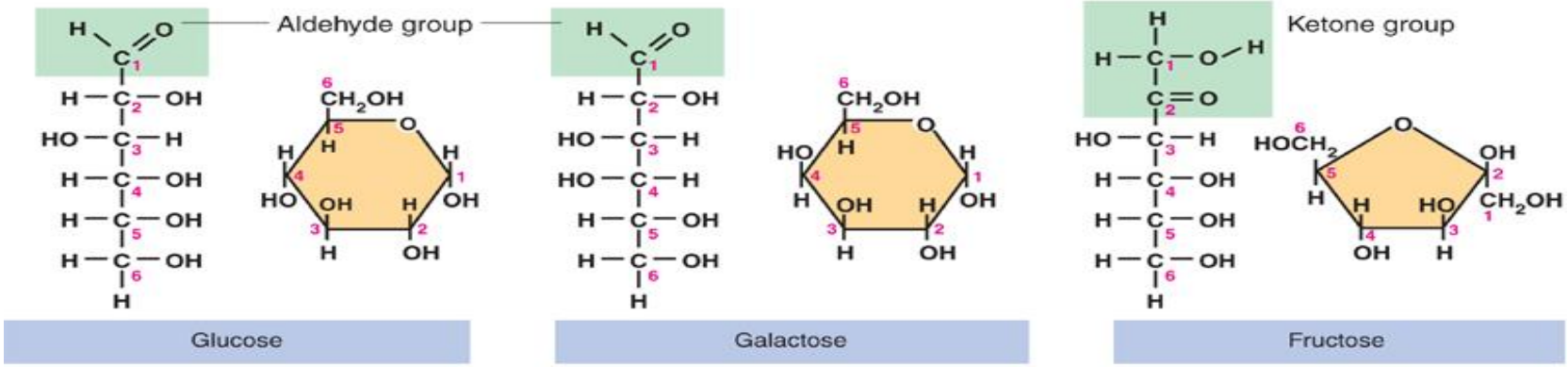
Except for lipids, all are formed by polymerization, where subunits, called **monomers,** are bound into chains called **polymers.**

Carbohydrates

- Sugars and polysaccharides
  - general formula $(\mathbf{CH_2O})_n$
- Monomer – monosaccharide (glucose, fructose)
- Polymer –polysaccharide (starch, cellulose, glycogen)
- Subunits linked by glycosidic bonds
- Functions – structural support, nutrient and energy stores



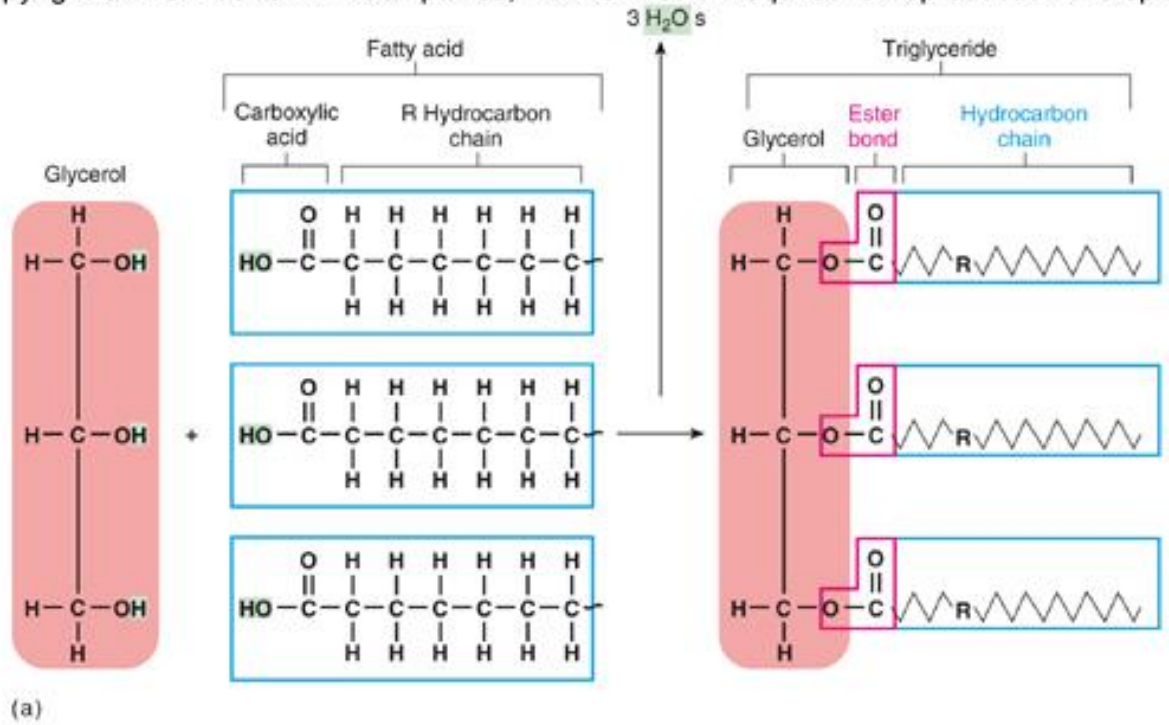
(a)



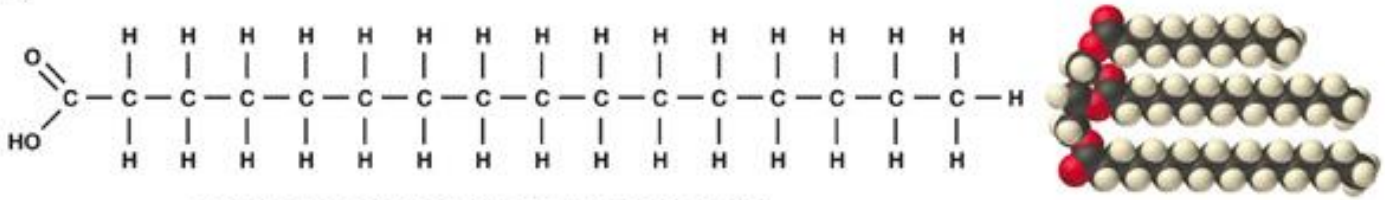
(b)

Lipids

- Long or complex, hydrophobic, C - H chains
- Triglycerides, phospholipids in membranes, steroids like cholesterol
- Functions
  - triglycerides – energy storage
  - phospholipid – major cell membrane component
  - steroids – cell membrane component

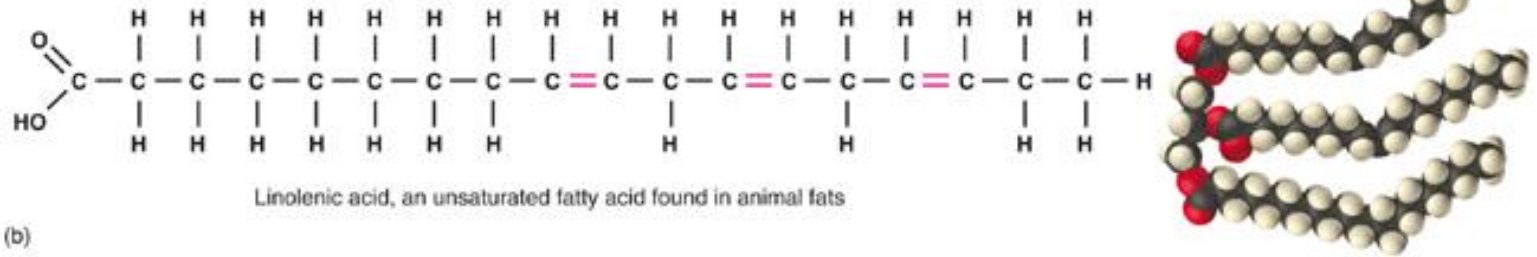


1.



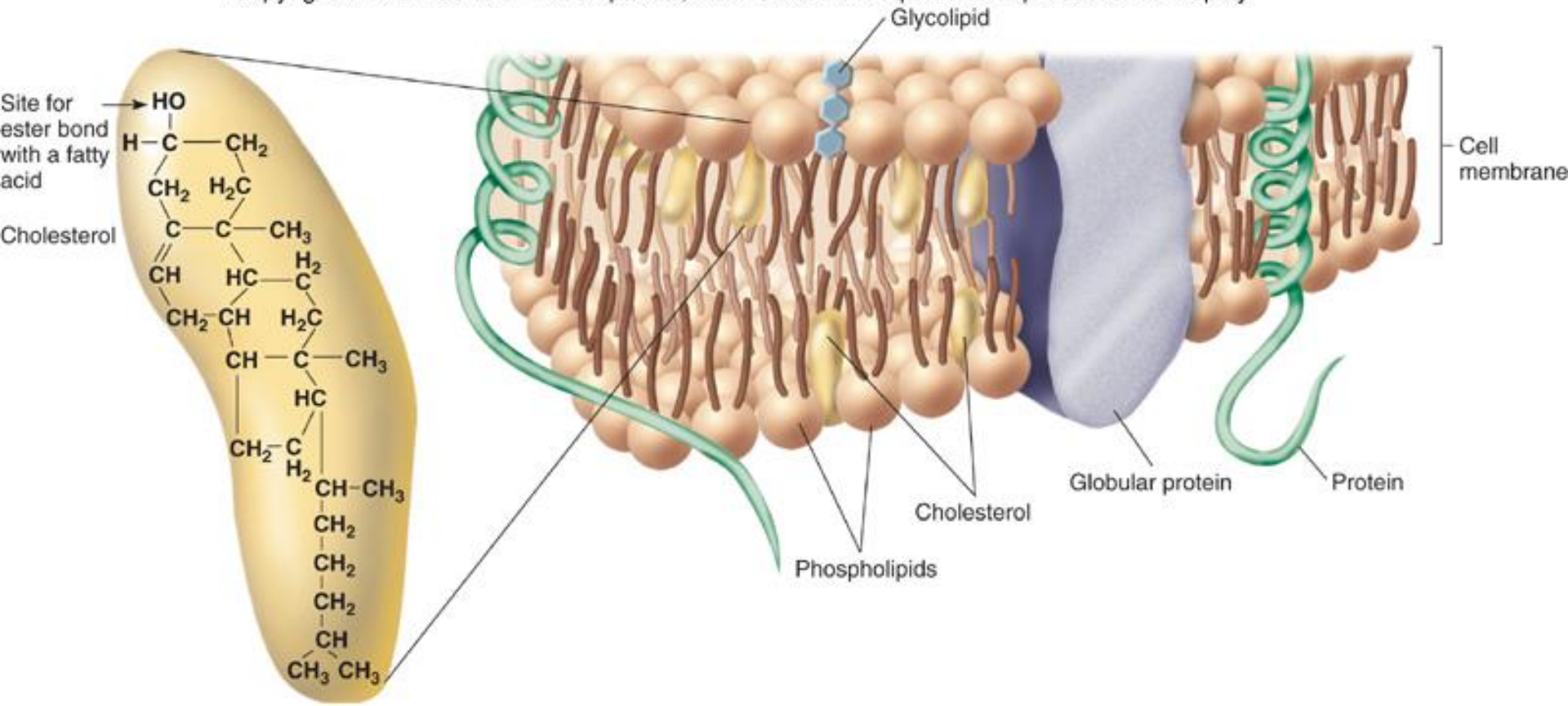
Palmitic acid, a saturated fatty acid found in certain plants

2.



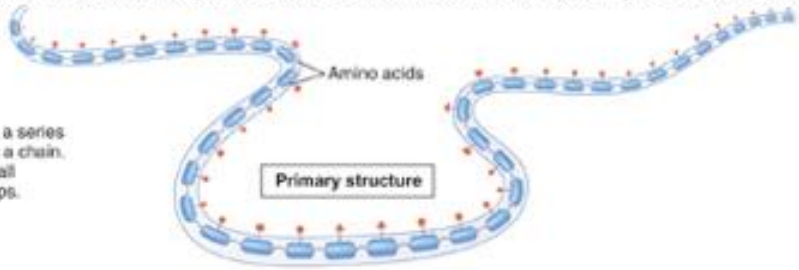
Linolenic acid, an unsaturated fatty acid found in animal fats

(b)

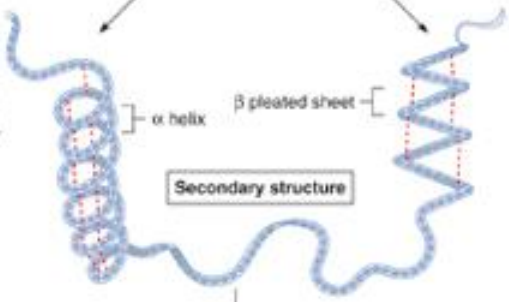


Proteins

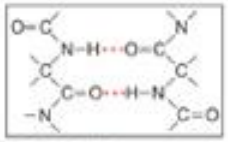
- Predominant molecules in cells
- Monomer – amino acids – 20
- Polymer – peptide, polypeptide, protein
- Subunits linked by peptide bonds
- Fold into very specific 3-D shapes
- Functions - support, enzymes, transport, defense, movement



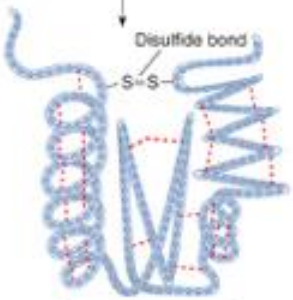
(a) The primary structure is a series of amino acids bound in a chain. Amino acids display small charged functional groups.



(b) The secondary structure develops when polar atoms on adjacent amino acids form hydrogen bonds. This action folds the chain into local configurations called the α helix and β pleated sheet. Most proteins have both types of secondary structures.

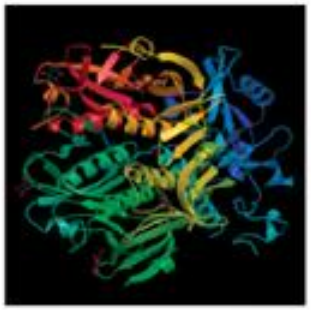


Detail of hydrogen bond



(c) The tertiary structure forms when portions of the secondary structure further interact by forming covalent disulfide and additional hydrogen bonds. It is through this reaction that a stable three-dimensional molecule is formed. Depending on the protein, this may be the final functional state.

Projected 3-D shape (note grooves and projections)

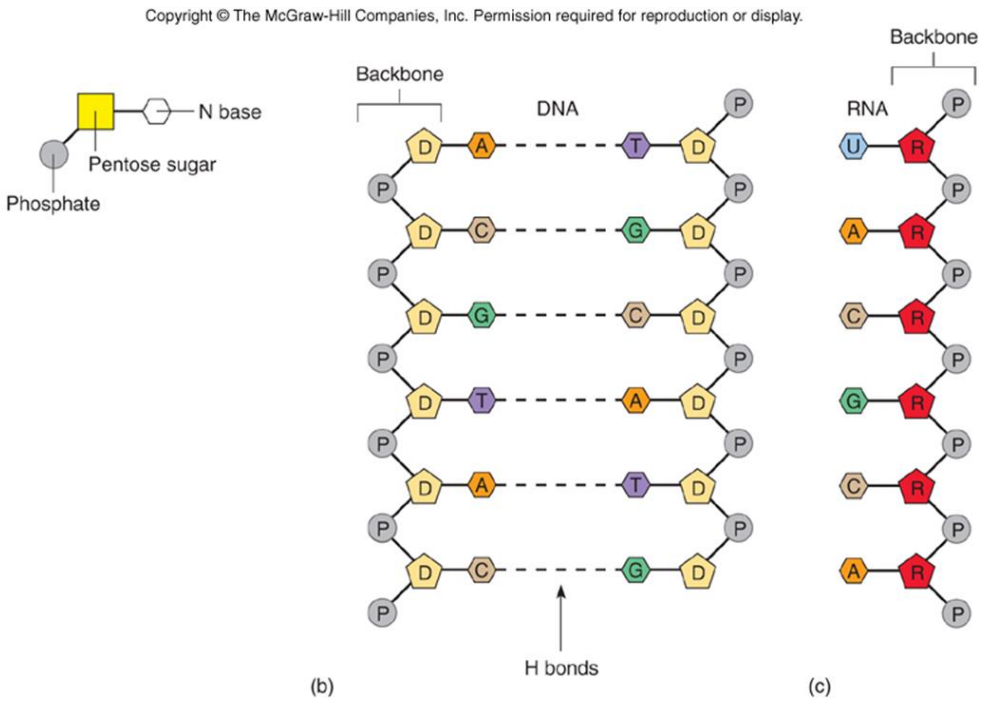


(d) The quaternary structure exists only in proteins that consist of more than one polypeptide chain. Shown here is a model of the cholera toxin, composed of five separate polypeptides, each one shown in a different color.

© Image courtesy RCSB Protein Data Bank.

Nucleic Acids

- DNA and RNA
- Monomer – nucleotide
- DNA – deoxyribonucleic acid
  - A,T,C,G – nitrogen bases
  - double helix
  - function - hereditary materi
- RNA – ribonucleic acid
  - A,U,C,G – nitrogen bases
  - function - organize protein synthesis



ATP: The Energy Molecule of Cells

- Adenosine triphosphate
  - nucleotide - adenine, ribose, three phosphates
- Function – transfer and storage of energy