MEDAVIE HealthEd
College of Paramedicine

ÉduSanté
Collège de formation paramédicale

Chemistry, Matter and Life

Advanced Care Paramedicine

Module: 01
Section: 10

Overview

- Chemistry
  - Science that deals with the structure of matter
  - Essential when studying human anatomy
- Life is based on
  - Atomic interactions
  - Molecular interactions
  - Chemical interactions

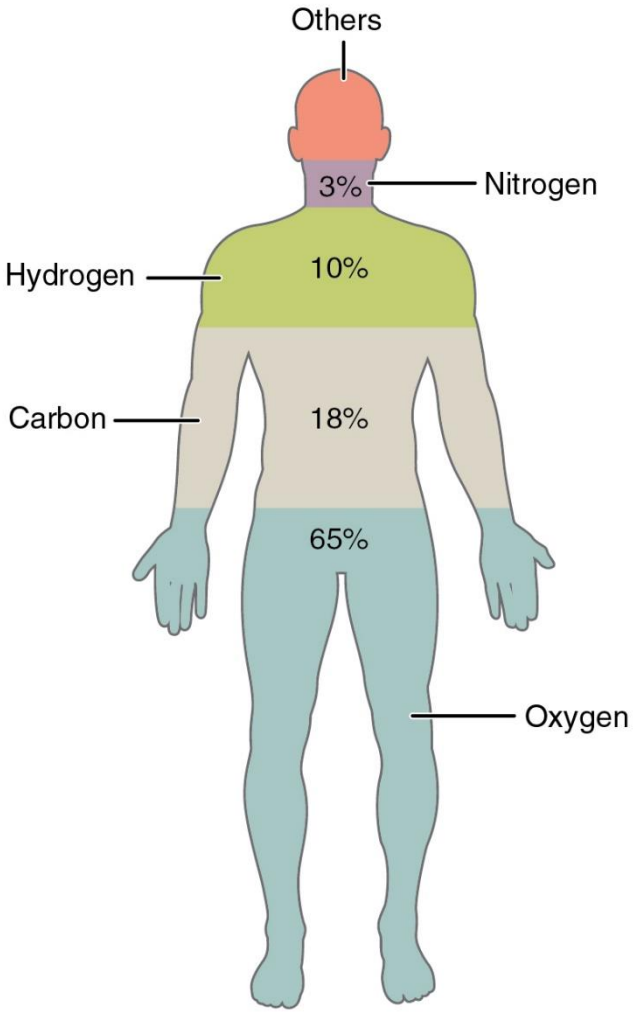
Matter

- Defined as anything that has mass and occupies space
- Includes
  - Solids
    - definite shape, definite volume
  - Liquids
    - indefinite shape, definite volume
  - Gases
    - indefinite shape, indefinite volume

Elements

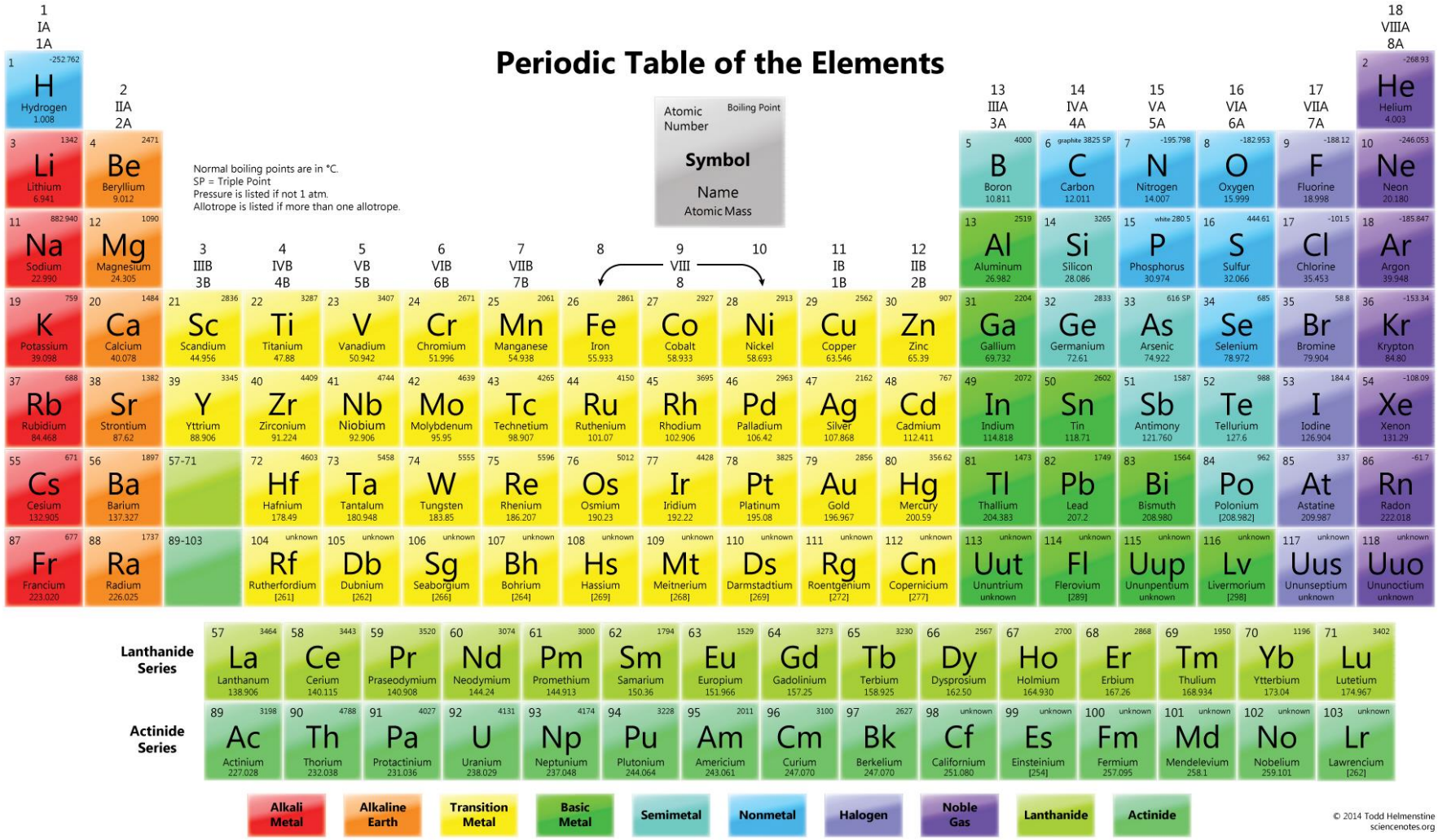
- Simple form of matter, a substance that cannot be broken down into two or more different substances
  - There are 26 elements in the human body
  - There are 11 “major elements,”
    - Four of which (carbon, oxygen, hydrogen, and nitrogen) make up 96% of the human body
      - Hydrogen H (9.5 %)
      - Carbon C (18.5 %)
      - Oxygen O (65.0 %)
      - Nitrogen N (3.3 %)
  - There are 15 “trace elements” that make up less than 2% of body weight

Elements



Element	Symbol	Percentage in Body
Oxygen	O	65.0
Carbon	C	18.5
Hydrogen	H	9.5
Nitrogen	N	3.2
Calcium	Ca	1.5
Phosphorus	P	1.0
Potassium	K	0.4
Sulfur	S	0.3
Sodium	Na	0.2
Chlorine	Cl	0.2
Magnesium	Mg	0.1
Trace elements include boron (B), chromium (Cr), cobalt (Co), copper (Cu), fluorine (F), iodine (I), iron (Fe), manganese (Mn), molybdenum (Mo), selenium (Se), silicon (Si), tin (Sn), vanadium (V), and zinc (Zn).		less than 1.0

Periodic Table



Atoms

- Smallest particle of an element that maintains the properties of the element
- Contain several different kinds of subatomic particles; the most important are the following:
  - Protons (+ or p) – found in nucleus
  - Neutrons (n) – found in nucleus
  - Electrons (- or e) – found in electron cloud

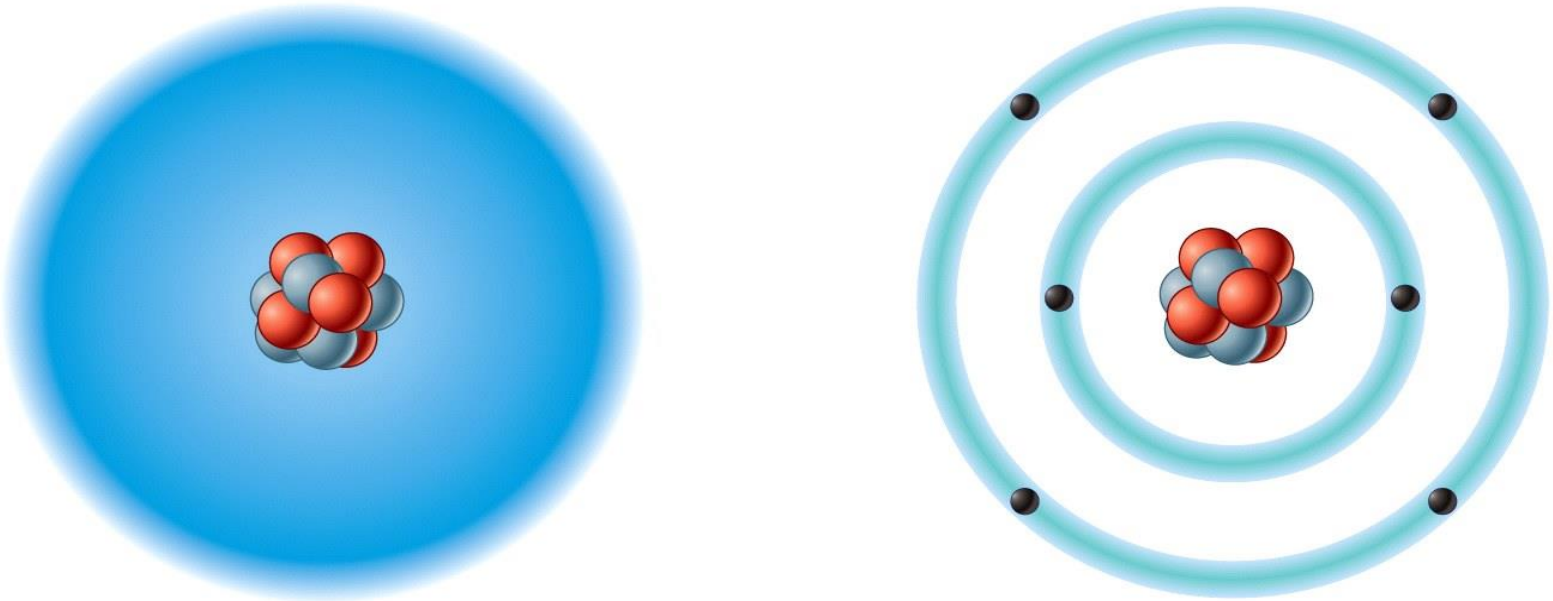
Atoms

Protons (p^+)

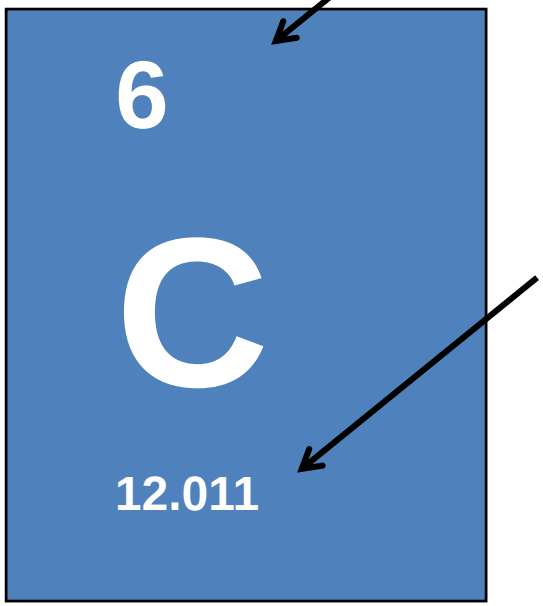
Neutrons (n^0)

Nucleus

Electrons (e^-)

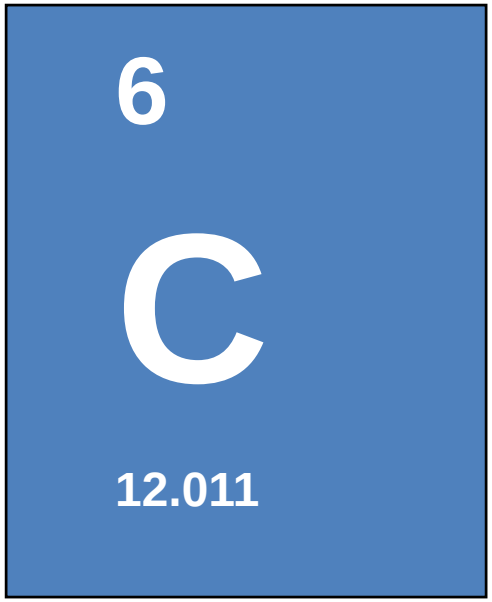


Atomic Structure



- Atomic number
  - The number of protons in an atom's nucleus
  - The atomic number is critically important; it identifies the kind of element
- Atomic weight
  - The mass of a single atom
  - It is equal to the number of protons plus the number of neutrons in the nucleus (p + n)

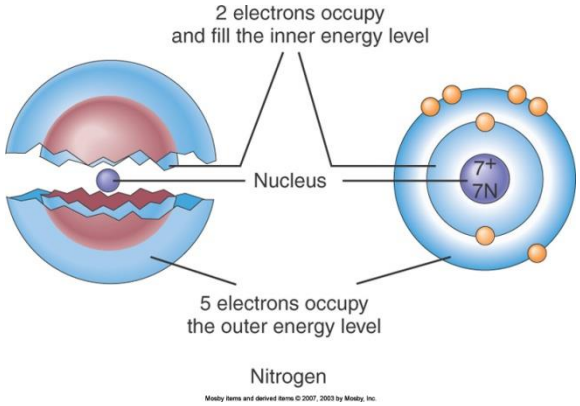
Atomic Structure



- Atomic mass
  - Average mass of all the isotopes of an atom
  - Approximately equivalent to the number of protons and neutrons in the atom
    - Or to the average number allowing for the relative abundances of different isotopes

Basic Chemistry

- Energy levels
  - The total number of electrons in an atom equals the number of protons in the nucleus (in a stable atom)
  - The electrons form a “cloud” around the nucleus

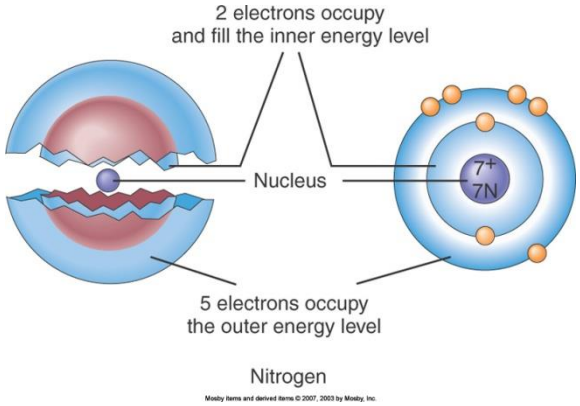


Basic Chemistry

- Energy levels
  - "Bohr model"—a model resembling planets revolving around the sun, useful in visualizing the structure of atoms
    - Exhibits electrons in concentric circles showing relative distances of the electrons from the nucleus
    - Each ring or shell represents a specific energy level and can hold only a certain number of electrons
    - The number and arrangement of electrons determine if an atom is chemically stable
    - An atom with eight, or four pairs of, electrons in the outermost energy level is chemically inert
    - An atom without a full outermost energy level is chemically active

Basic Chemistry

- Energy levels
  - Octet rule
    - Atoms with fewer or more than eight electrons in the outer energy level will attempt to lose, gain, or share electrons with other atoms to achieve stability



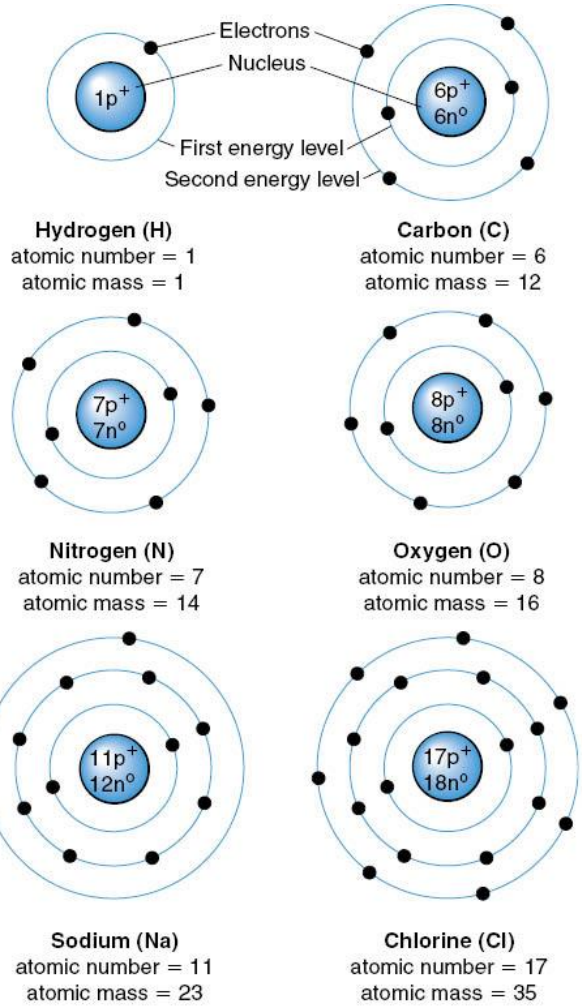
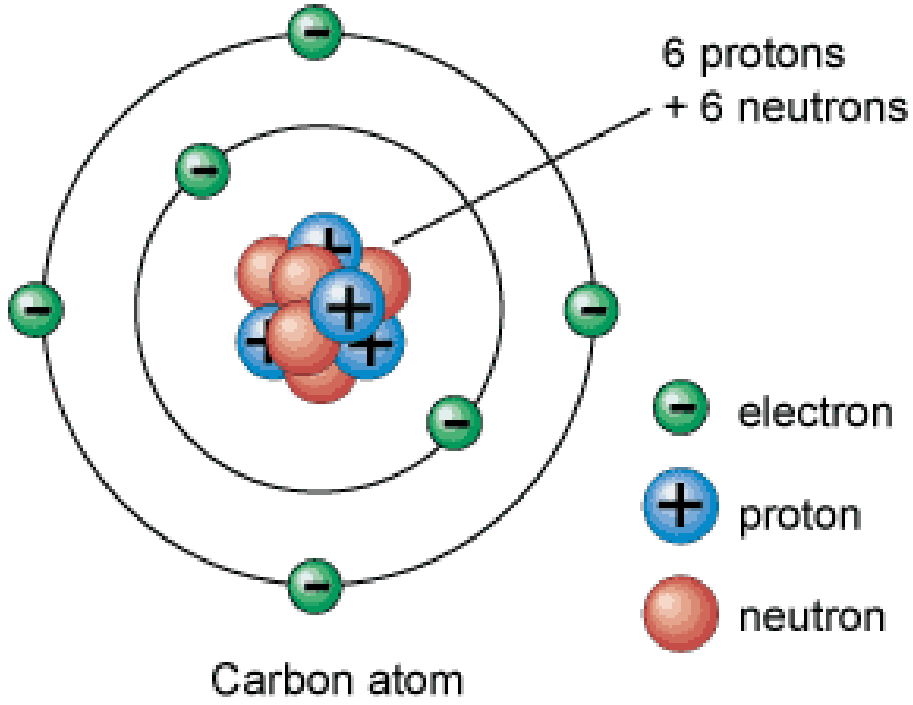
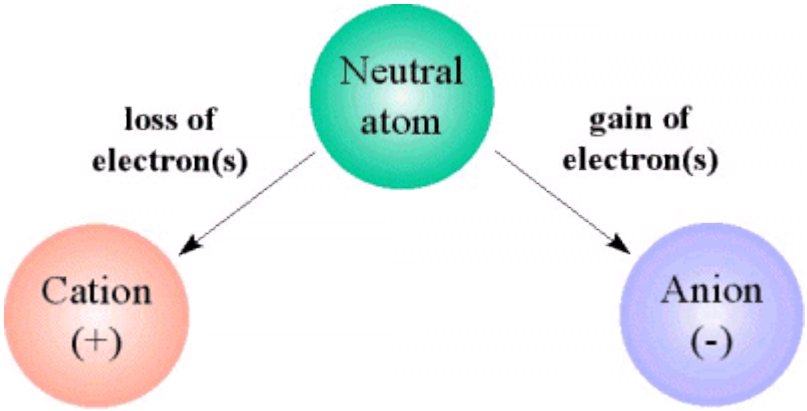


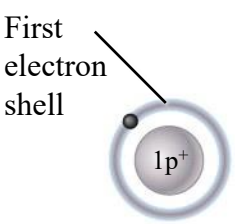
Figure 2-2 *Diagrams of the atomic structure of some biologically important elements—hydrogen, carbon, nitrogen, oxygen, sodium, and chlorine.*



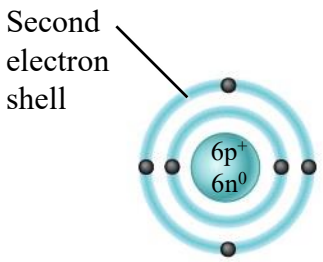
Ion

- Ions are atoms or molecules in which the total number of electrons is not equal to the number of protons
  - If an atom loses one or more electrons it has a net positive charge (Cation)
  - If an atom gains electrons then it has a net negative charge (Anion)

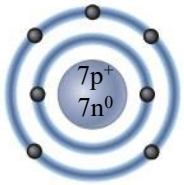




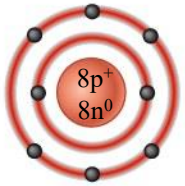
Hydrogen (H)
Atomic number = 1
Mass number = **1 or 2**
Atomic mass = 1.01



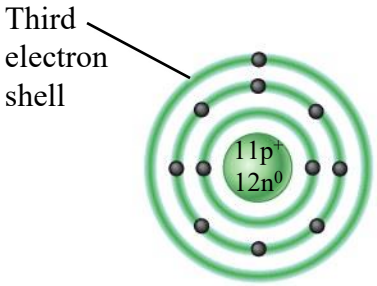
Carbon (C)
Atomic number = 6
Mass number = **12 or 13**
Atomic mass = 12.01



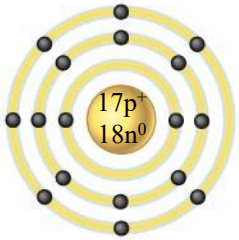
Nitrogen (N)
Atomic number = 7
Mass number = **14 or 15**
Atomic mass = 14.01



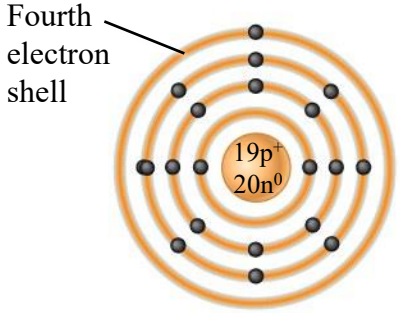
Oxygen (O)
Atomic number = 8
Mass number = **16, 17, or 18**
Atomic mass = 16.00



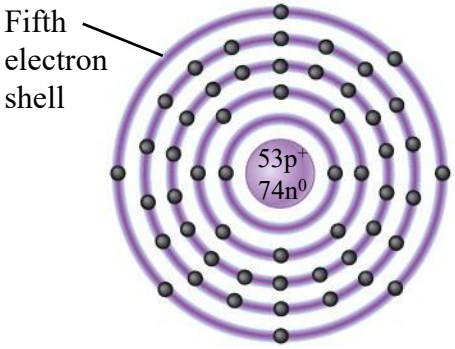
Sodium (Na)
Atomic number = 11
Mass number = **23**
Atomic mass = 22.99



Chlorine (Cl)
Atomic number = 17
Mass number = **35 or 37**
Atomic mass = 35.45



Potassium (K)
Atomic number = 19
Mass number = **39, 40, or 41**
Atomic mass = 39.10

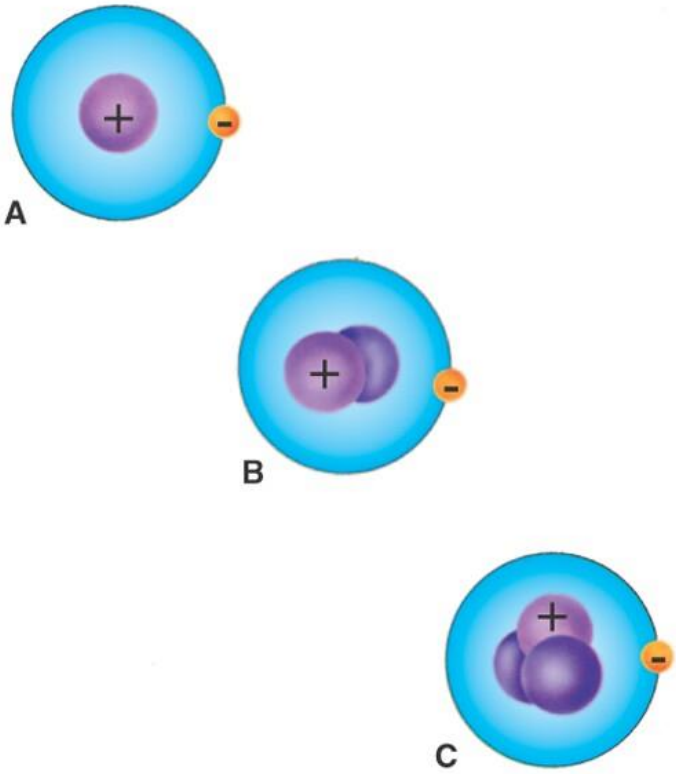


Iodine (I)
Atomic number = 53
Mass number = **127**
Atomic mass = 126.90

Atomic number = number of protons in an atom
Mass number = number of protons and neutrons in an atom (boldface indicates most common isotope)
Atomic mass = average mass of all stable atoms of a given element in daltons

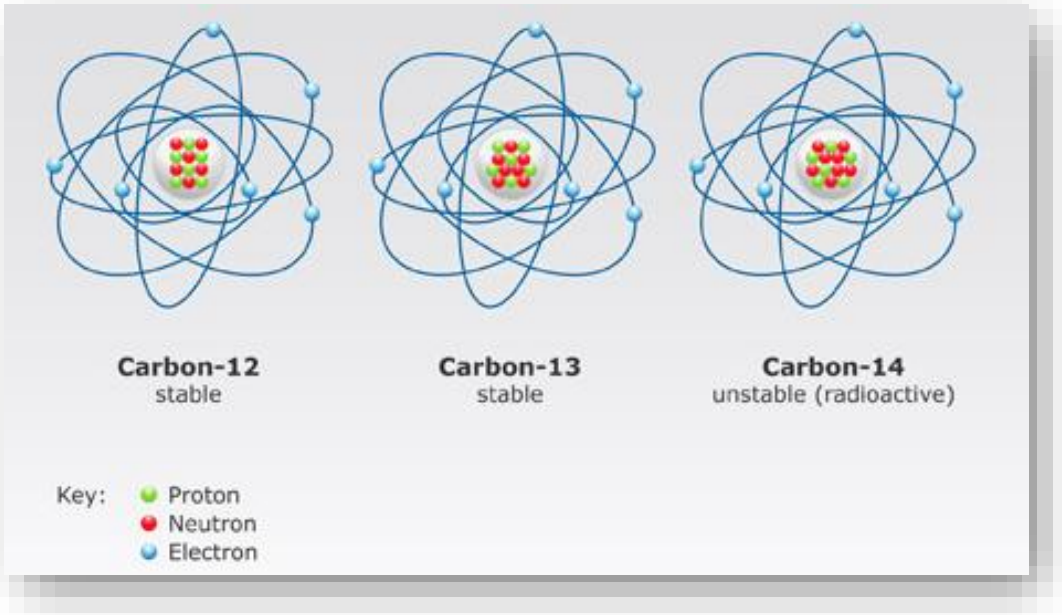
Isotopes

- Atoms of one element
- Contain:
  - Same number of protons
  - Different numbers of neutrons
- May be radioactive



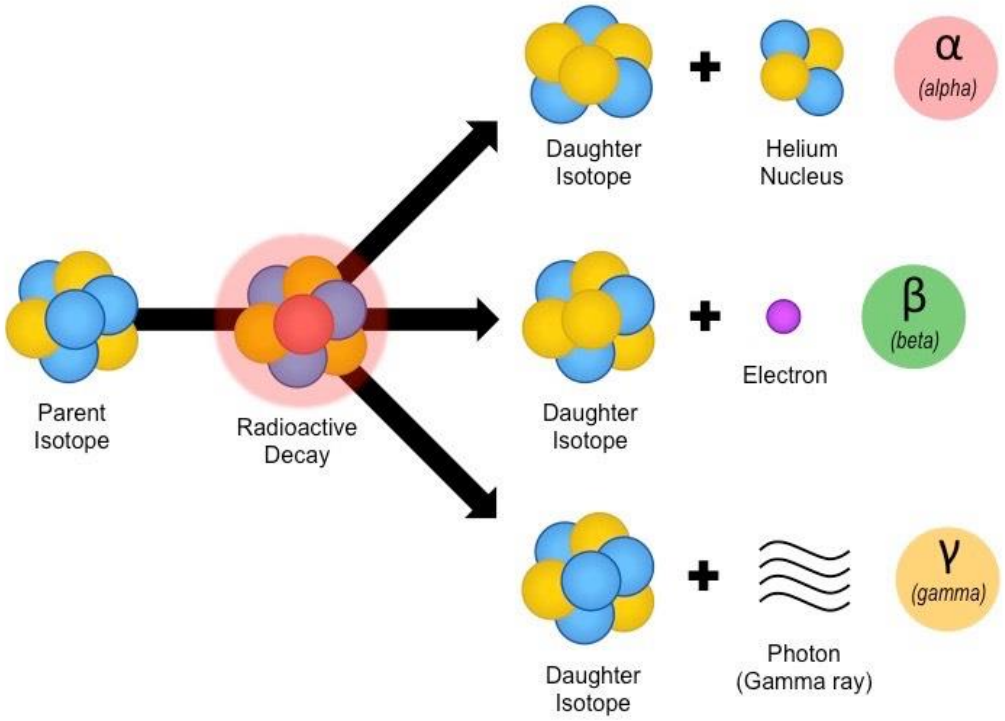
Radioisotopes

- Radiation
  - Emission of energetic particles, due to instability of atomic nuclei
- Nuclei spontaneously emit subatomic particles or radiation, in measurable amounts



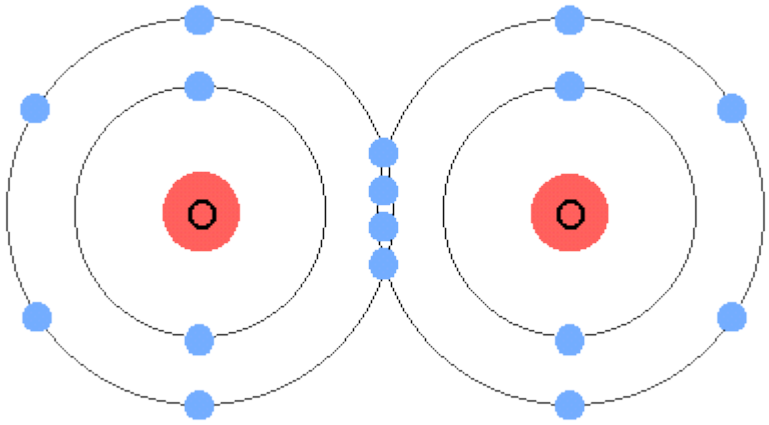
Radioisotopes

- Radioactive decay: process of emitting radiation
- Three common forms of radiation
  - Alpha
  - Beta
  - Gamma



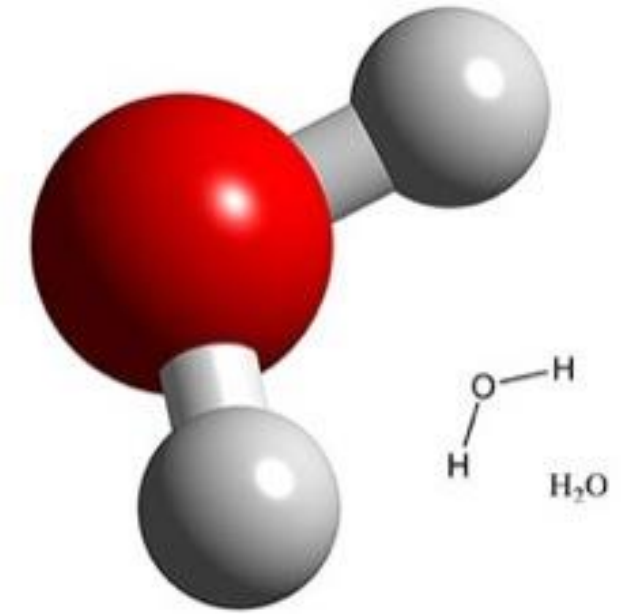
Molecule

- Smallest unit of a compound
- A combination of two or more of the **same** atoms combine by chemical bonding
- Examples:
  - 2 elements of oxygen bond to form an oxygen molecule (O_2)



Compounds

- Atoms of two or more **different** elements joined to form chemical combinations
- Combine in a fixed ratio to form a new substance
  - NaCl
  - H_2O
  - $C_6H_{12}O_6$



Chemical Bonds

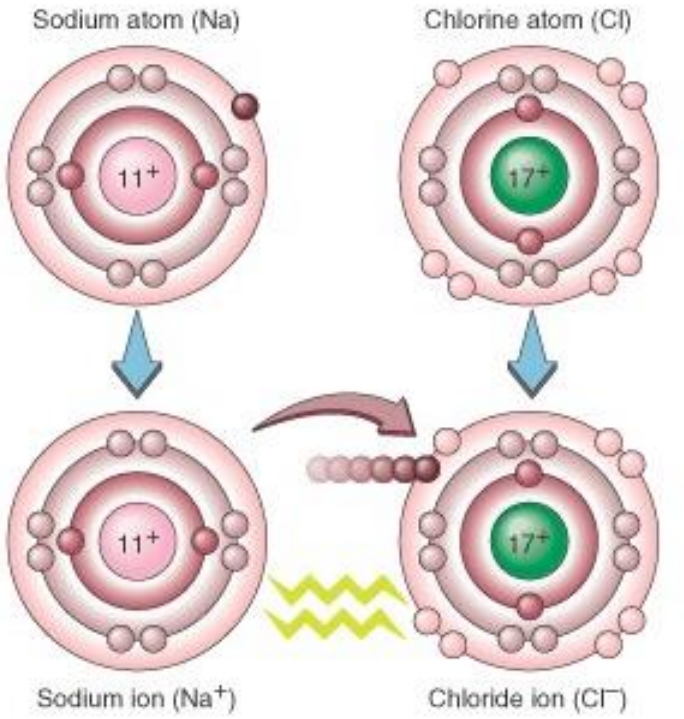
- Attractions between atoms
  - Chemical reaction
    - interaction between two or more atoms that occurs as a result of activity between electrons in their outermost energy levels

Chemical Bonds

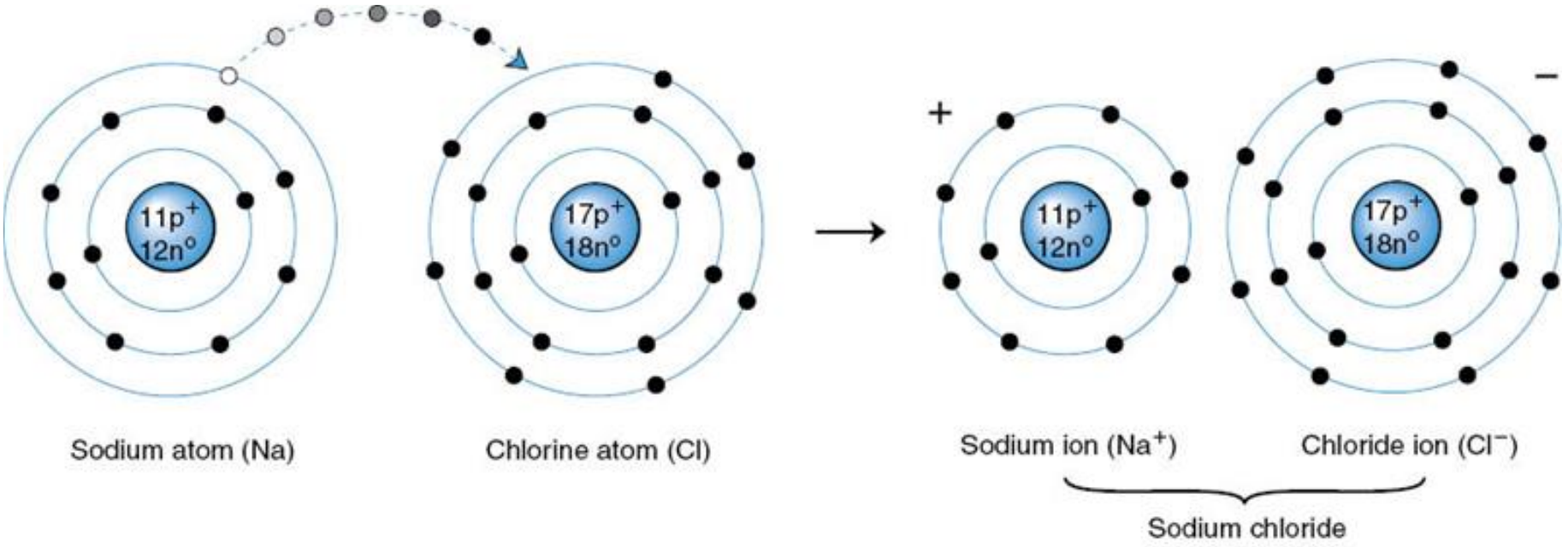
- Chemical bonds are forces that hold atoms together
- Determined largely by the Electrons
- Atoms have a tendency to share electrons to maintain a stable configuration
- 3 Types
  - Ionic
  - Covalent
  - Hydrogen

Ionic Bonds

- Ionic, or electrovalent, bond
  - formed by transfer of electrons; strong electrostatic force that binds positively and negatively charged ions together
- Changed particles that result are called Ions
  - positively charged (Cation)
  - negatively charged (Anion)

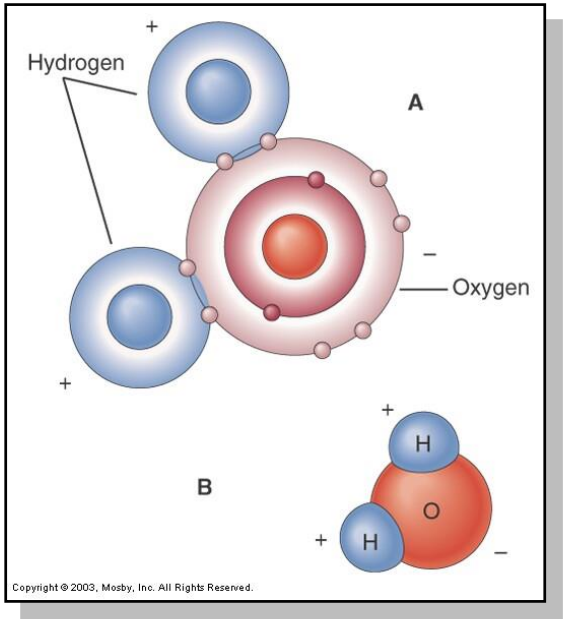


Ionic Bonds

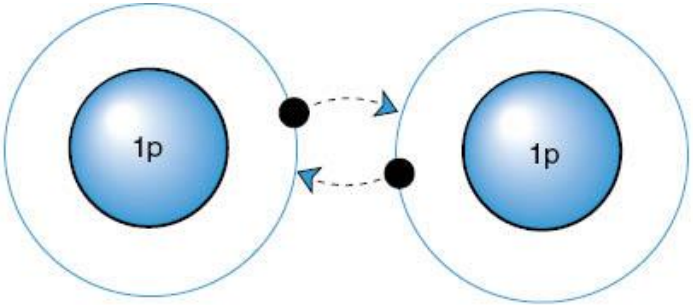

11p+
12n°
17p+
18n°
+
11p+
12n°
17p+
18n°
−
Sodium atom (Na)
Chlorine atom (Cl)
Sodium ion (Na+)
Chloride ion (Cl−)
Sodium chloride

Covalent Bonds

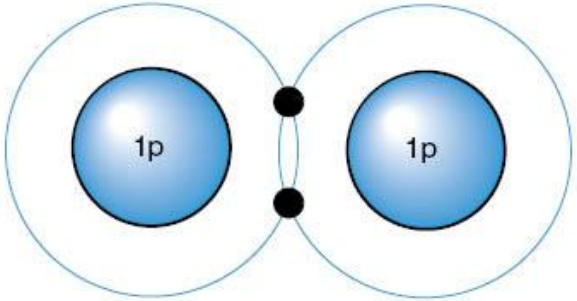
- Formed when 2 atoms share a pair of electrons
  - Single covalent
  - Double covalent
- Non-polar Covalent Bond
  - Electrons shared equally between the two atoms
- Polar Covalent Bond
  - Electrons spend more time around one end of the atom then the other (H_2O)
  - Stronger than Ionic bonds



Covalent Bonds

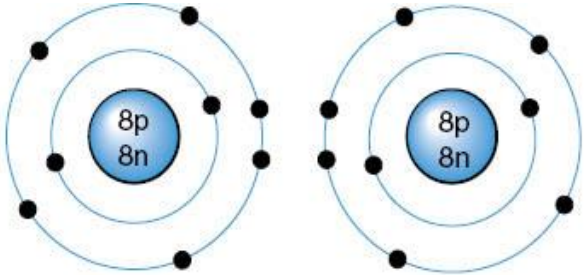


Two hydrogen atoms each with one proton in the nucleus and one electron in the energy shell

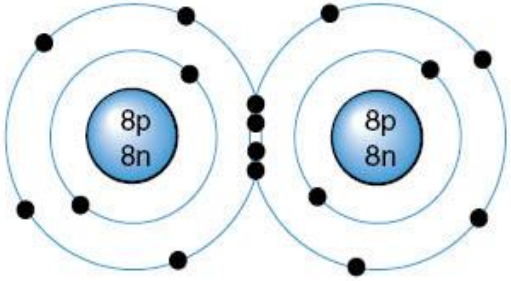


A molecule of hydrogen gas, H–H (H_2)
The two hydrogen atoms share an electron pair to form a single covalent bond

Figure 2-5 *Single covalent bond in hydrogen gas.*



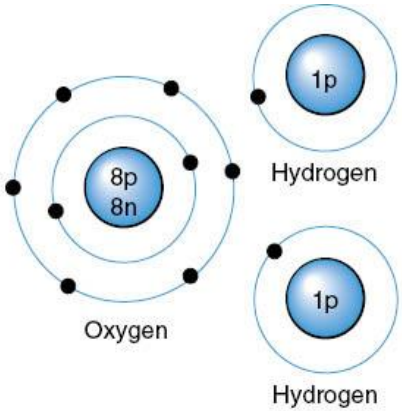
Two atoms of oxygen, each with eight protons and eight neutrons in the nucleus and six electrons in the outer energy level.



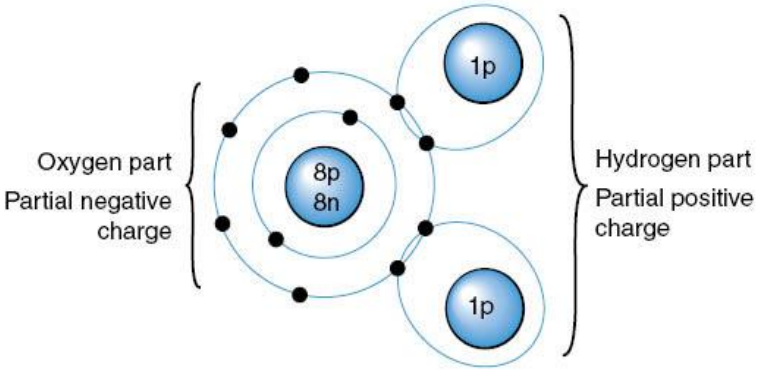
A molecule of oxygen gas.
Each oxygen atom shares two electrons to form a double covalent bond.

Figure 2-7 *Double covalent bond in oxygen gas.*

Covalent Bonds



One oxygen and two hydrogen atoms

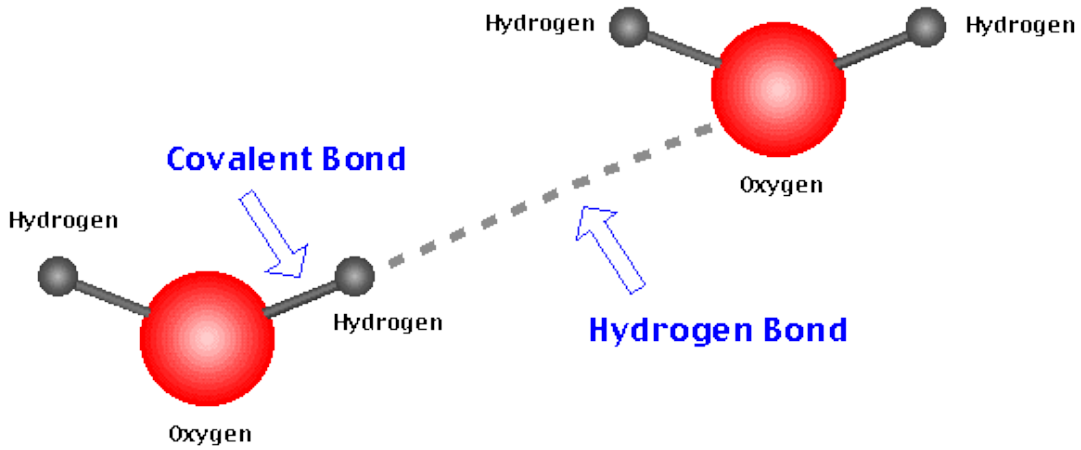


Water molecule (H_2O) with polar covalent bonds

Figure 2-10 *Polar covalent bonds between oxygen and hydrogen.*

Hydrogen Bonds

- Where ionic and covalent bonds hold atoms to atom to form a molecule, Hydrogen bonds hold molecule to molecule
- Result from the weak electrical attraction between the positive end of one molecule and the negative end of another.
- Individually these bonds are very weak, although taken in a large enough quantity, the result is strong enough to hold molecules together or in a three-dimensional shape.



Hydrogen Bonds

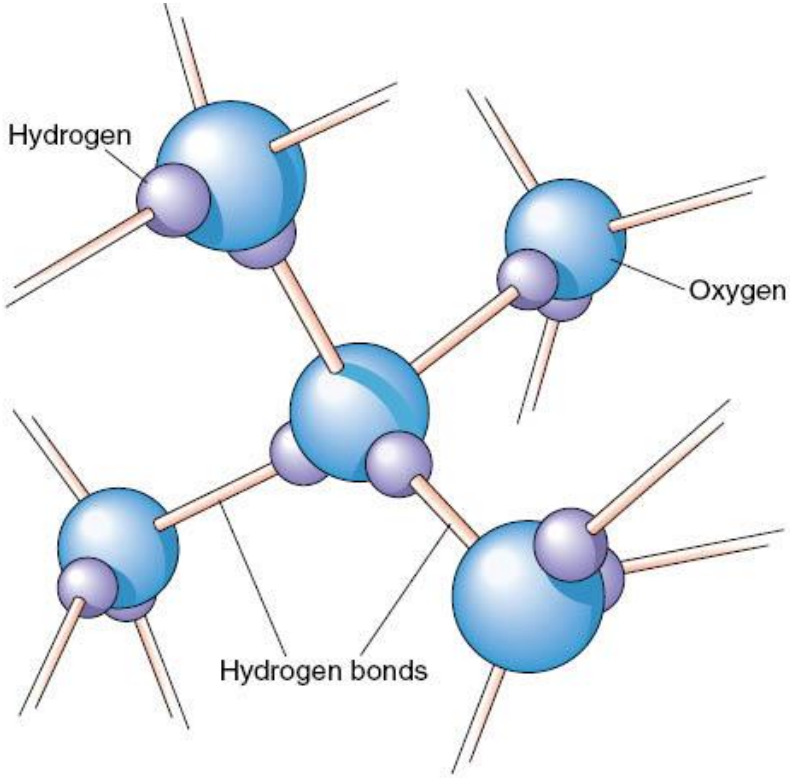


Figure 2-11 *Intermolecular hydrogen bonds in water. The electropositive hydrogen end of a water molecule has a weak attraction for the electronegative oxygen end of other water molecules to form hydrogen bonds.*

Formulas

- Molecular Formula
  - Short hand way to write the compound
  - $C_6H_{12}O_6$

- Structural Formula
  - Represents how atoms are arranged and joined together
  - H-O-H

Chemical Equations

- Abbreviated method of showing the compounds involved in the reaction and the resulting compounds

Reactants → Products

Basic Chemistry

- Chemical reactions
  - Involve the formation or breaking of chemical bonds
  - There are three basic types of chemical reactions involved in physiology:
    - Synthesis reaction
    - Decomposition reaction
    - Exchange reaction
    - Reversible reaction

Types of Chemical Equations

- Synthesis

$$A + B \rightarrow AB$$

$$2H_2 + O_2 \rightarrow 2H_20$$

- Decomposition

$$AB \rightarrow A + B$$

$$2H_20 \rightarrow 2H_2 + O_2$$

Types of Chemical Equations

- Exchange Reactions
  - Single Replacement

$$A + BC \rightarrow AC + B$$

$$Cl_2 + 2NaBr \rightarrow 2NaCl + Br_2$$

  - Double Replacement

$$AB + CD \rightarrow AD + CB$$

$$\text{H-lactate} + NaHCO_3 \rightarrow \text{Na-lactate} + \text{H-}HCO_3$$

Lactic Acid + Sodium Bicarbonate → Sodium Lactate + Carbonic Acid

Chemical Equations

- Exergonic Reactions
  - more energy is stored in reactants than in the products
  - therefore energy is released

$$ATP + H_2O \rightarrow ADP + P + Energy$$

(Hydrolysis)

Chemical Equations

- Endergonic Reactions
  - more energy is stored in products than in the reactants
  - therefore energy is required

$$ADP + P + Energy \rightarrow ATP + H_2O$$

(dehydration)

  - lipid, carbohydrate and protein molecules are synthesized this way

Reversible Reactions

- Many reactions are able to react in either direction

$$A + B \rightleftarrows AB$$

$$CO_2 + H_2O \rightleftarrows H_2CO_3 \rightleftarrows H^+ + HCO^{3-}$$

Carbonic Anhydrase

Reaction Rates

- All reactions occur at different rates
- Items that affect the reaction rate:
  - Temperature effects rate
  - Catalyst
  - Concentration
  - Surface area

Reaction Rates

- Temperature effects rate
  - To hot → fast reactions
  - To cold → slow reactions
- Catalyst
  - Substance that changes the reaction rate without being changed itself
  - Enzymes are an example in the human body

Reaction Rates

- Concentration
  - higher the concentration → fast reactions
- Surface area
  - greater the surface area → fast reactions

Le Chatelier's Principle

- A principle to predict the result that occurs following changes made to a reaction already at equilibrium
- Reactions want to return to equilibrium, therefore when a change occurs, the reaction shifts to return to equilibrium

Le Chatelier's Principle

- An increase in concentration of the reactants (A or B) will cause a “shift” to the right and more product (AB) to form

OR

- An increase in concentration of the product (AB) will cause a “shift” to the left and more reactants (A and B) to form

$$A + B \rightleftharpoons AB + Heat$$

Le Chatelier's Principle

- As well, since Heat is a product, if we increase the temperature, we are adding more product (Heat) so the reaction “shifts” to the left and produces more reactants (A & B)

$$A + B \rightleftharpoons AB + Heat$$

Le Chatelier's Principle

- The same is true if we remove reactants or products

Ex: by removing product AB, equilibrium will "shift" to form more product to fill void and return to equilibrium

$$A + B \rightleftharpoons AB + Heat$$

Mixtures, Solutions and Suspensions

- Solute
  - The substance that dissolves to form a solution
- Solvent
  - The substance in which a solute dissolves
- Solution
  - Solute dissolved in a solvent

Mixtures, Solutions and Suspensions

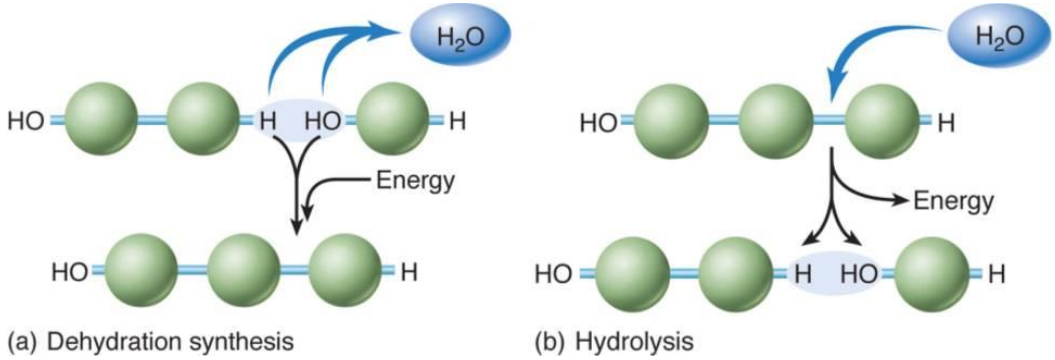
- Mixture
  - Consists of 2 or more substances that can be physically separated (sugar and water)
- Suspensions
  - Particles settle if left undisturbed (sand and water)

Mixtures, Solutions and Suspensions

- Colloidal Suspension
  - Particles so small they do not dissolve
  - Cytoplasm in the cell is an example
- Tincture
  - When the solute is dissolved in a solvent of alcohol

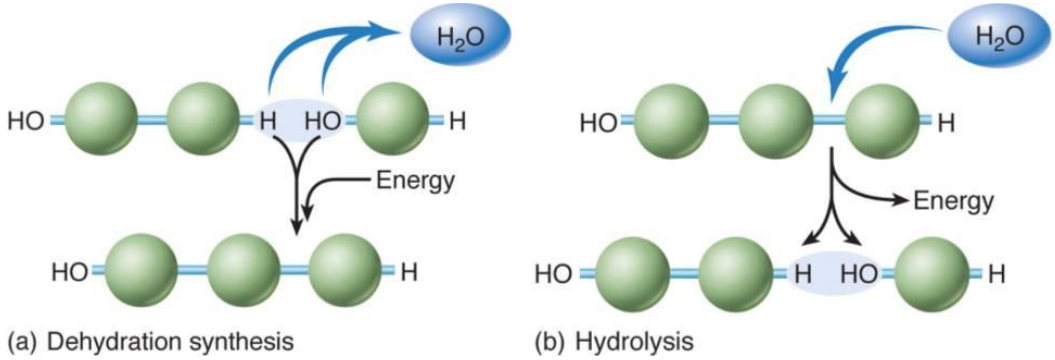
Metabolism

- Describes all chemical reactions that occur in the body cells.
  - Catabolism
    - Break down complex compounds into simpler ones
    - Releases energy
    - Hydrolysis
    - End products are CO_2, H_2O and other waste
    - More then half the energy release is transferred to ATP



Metabolism

- Describes all chemical reactions that occur in the body cells.
  - Anabolism
    - Joins simple molecules to form more complex biomolecules (carbs, lipids, proteins and nucleic acids)
    - Requires energy
    - Dehydration synthesis



Organic and Inorganic Compounds

- Inorganic compounds—few have carbon atoms and none have C–C or C–H bonds
- Organic molecules
  - Have at least one carbon atom and at least one C–C or C–H bond in each molecule
  - Often have functional groups attached to the carbon-containing core of the molecule

Inorganic Compounds

- Water
  - The body's most abundant and important compound
  - Properties of water
    - Polarity allows water to act as an effective solvent; ionizes substances in solution
    - The solvent allows transportation of essential materials throughout the body

Inorganic Compounds

- Properties of water (cont.)
  - High specific heat
    - water can lose and gain large amounts of heat with little change in its own temperature; enables the body to maintain a relatively constant temperature
  - High heat of vaporization
    - water requires absorption of significant amounts of heat to change water from a liquid to a gas, allowing the body to dissipate excess heat

Inorganic Compounds

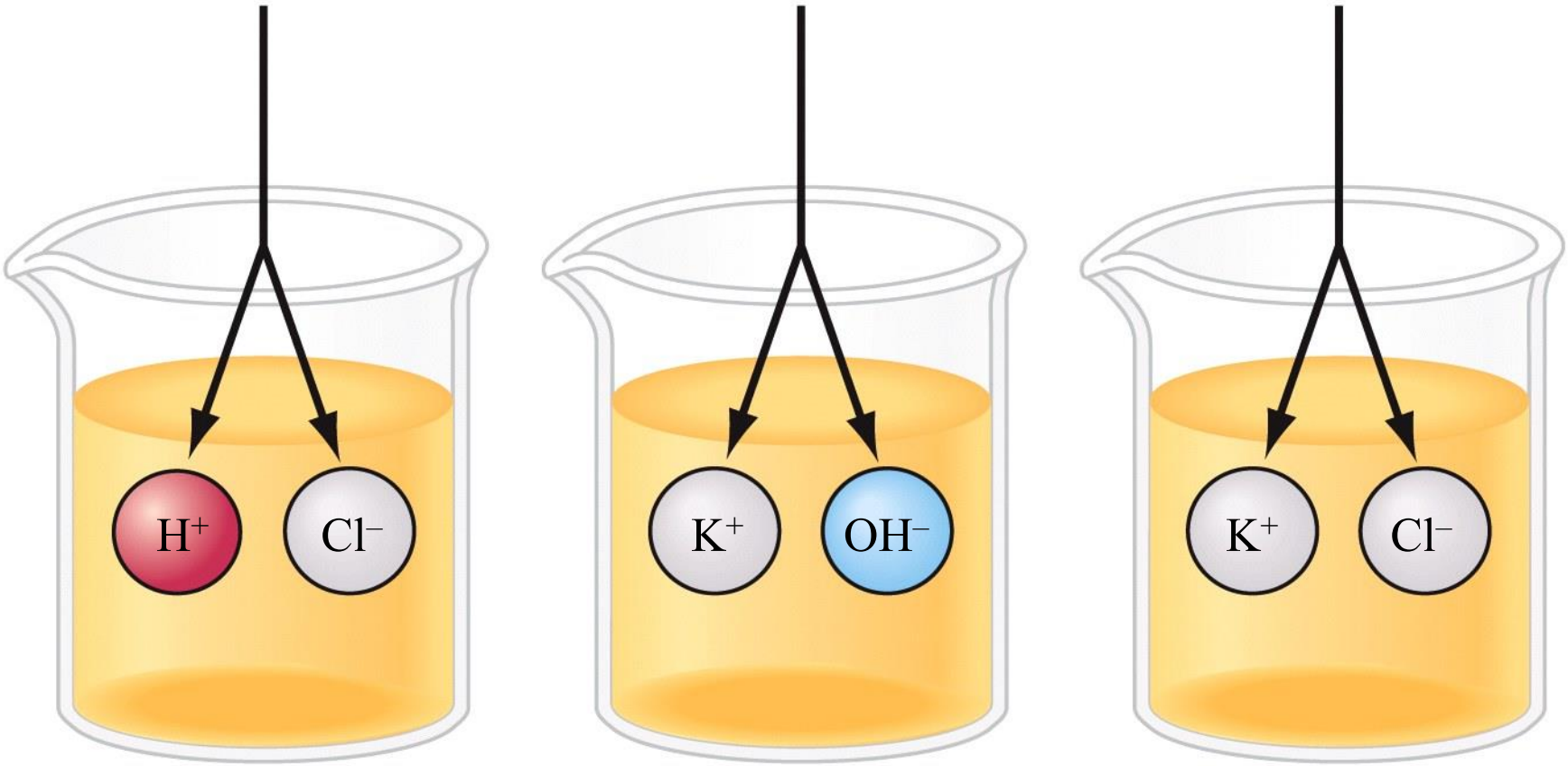
- Oxygen and carbon dioxide
  - closely related to cellular respiration
    - Oxygen
      - required to complete decomposition reactions necessary for the release of energy in the body
    - Carbon dioxide
      - produced as a waste product, also helps maintain the appropriate acid-base balance in the body

Inorganic Compounds

- Electrolytes
  - Large group of inorganic compounds, which includes acids, bases, and salts
  - Substances that dissociate in solution to form ions
  - Positively charged ions are cations; negatively charged ions are anions

Inorganic Compounds

- Electrolytes (cont.)
  - Acids and bases
    - Common and important chemical substances that are chemical opposites
    - Acids
      - Any substance that releases a hydrogen ion (H+) when in solution; “proton donor”
      - Level of “acidity” depends on the number of hydrogen ions a particular acid will release
    - Bases
      - Electrolytes that dissociate to yield hydroxide ions (OH–) or other electrolytes that combine with hydrogen ions (H+)
      - Described as “proton acceptors”



(a) Acid (b) Base (c) Salt

Neutralizing Reaction

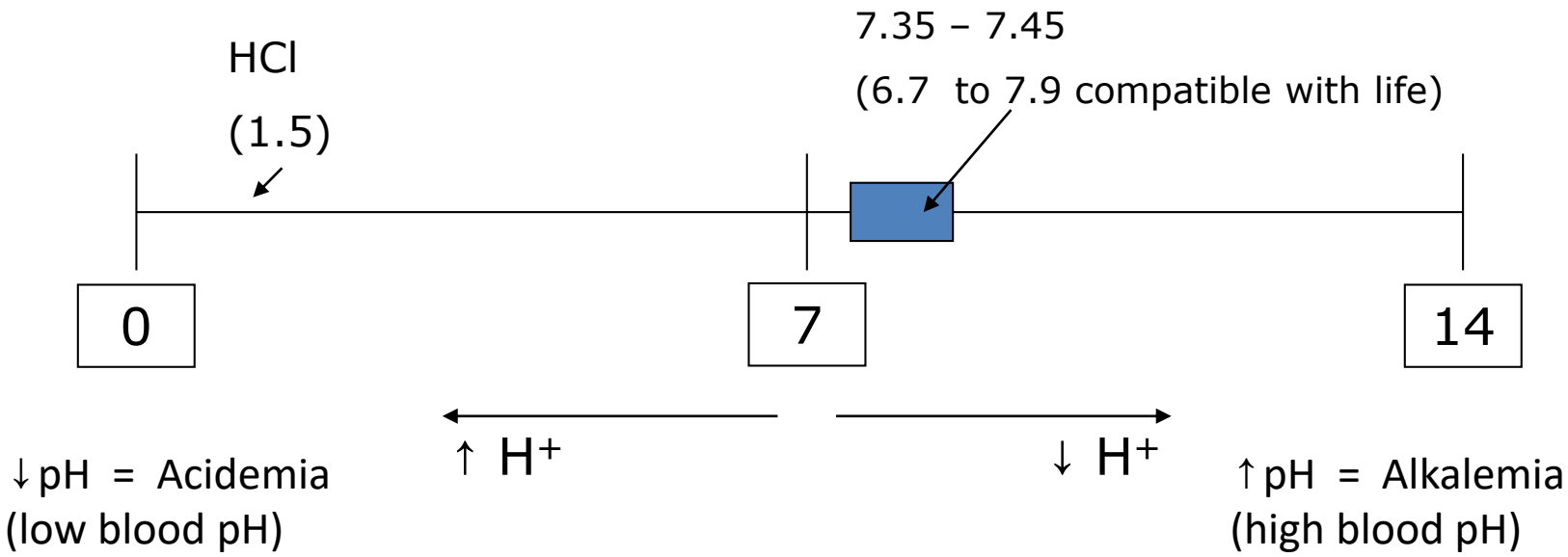
Base + Acid = Salt + Water

$HCl + NaOH \rightarrow NaCl + H_2O$

(Neutralizing Reaction)

Acid / Base

- pH Scale



Acid / Base

- Buffer
  - Resists change to pH when either and acid or a base is added
  - Act as a 'Reservoir' for H^+ ions and donate or accept H^+ ions to maintain a constant pH

- Acid $HCl + NaHCO_3 \rightarrow H_2CO_3 + NaCl$
- Base $NaOH + H_2CO_3 \rightarrow NaHCO_3 + H_2O$

Inorganic Compounds

- Salts
  - Compounds that result from chemical interaction of an acid and a base
  - Reaction between an acid and a base to form a salt and water is called a neutralization reaction

Organic Compounds

- Originally referred to compounds formed by a living process
- Contain C–C or C–H bonds
  - Carbohydrates
  - Monosaccharides
  - Disaccharides
  - Polysaccharides

Carbohydrates

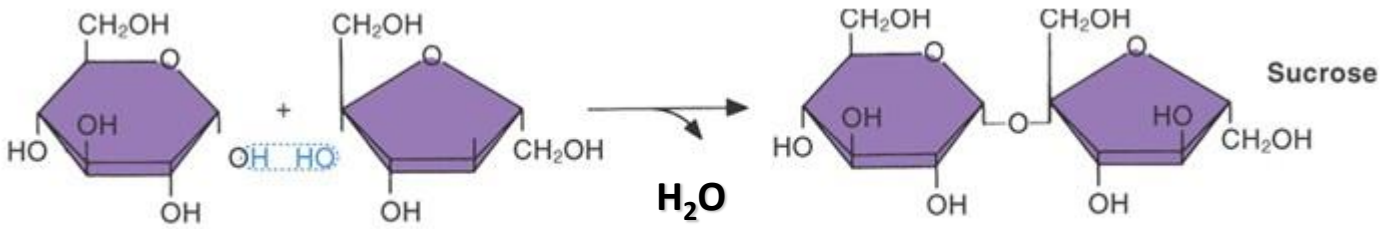
- Molecules composed of C, H and O in a set ratio of 1:2:1
- Commonly call Sugars and Starches
- Range from small to very large
- Functions
  - important energy source in the body
  - contribute to the structure of some cellular components
  - form a reserve supply of stored energy

Carbohydrates

- Monosaccharides (simple sugars)
  - Simplest form of carbohydrates
  - Glucose
    - is most important type ($C_6H_{12}O_6$)
  - Fructose and Galactose
    - have same molecular formula but are arranged differently
    - when ingested they are converted into glucose in the liver

Carbohydrates

- Disaccharides
  - Formed when 2 monosaccharide's are linked by dehydration synthesis
  - Sucrose (Table sugar) 1 glucose - 1 fructose
  - Maltose (Malt sugar) 2 glucose
  - Lactose (Milk sugar) 1 glucose - 1 galactose



Carbohydrates

- Polysaccharides
  - long chains of monosaccharides
  - Starch
  - Cellulose — “roughage” - not digestible
  - Glycogen — storage form of carbohydrates and is found in the liver and muscle

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Carbohydrates

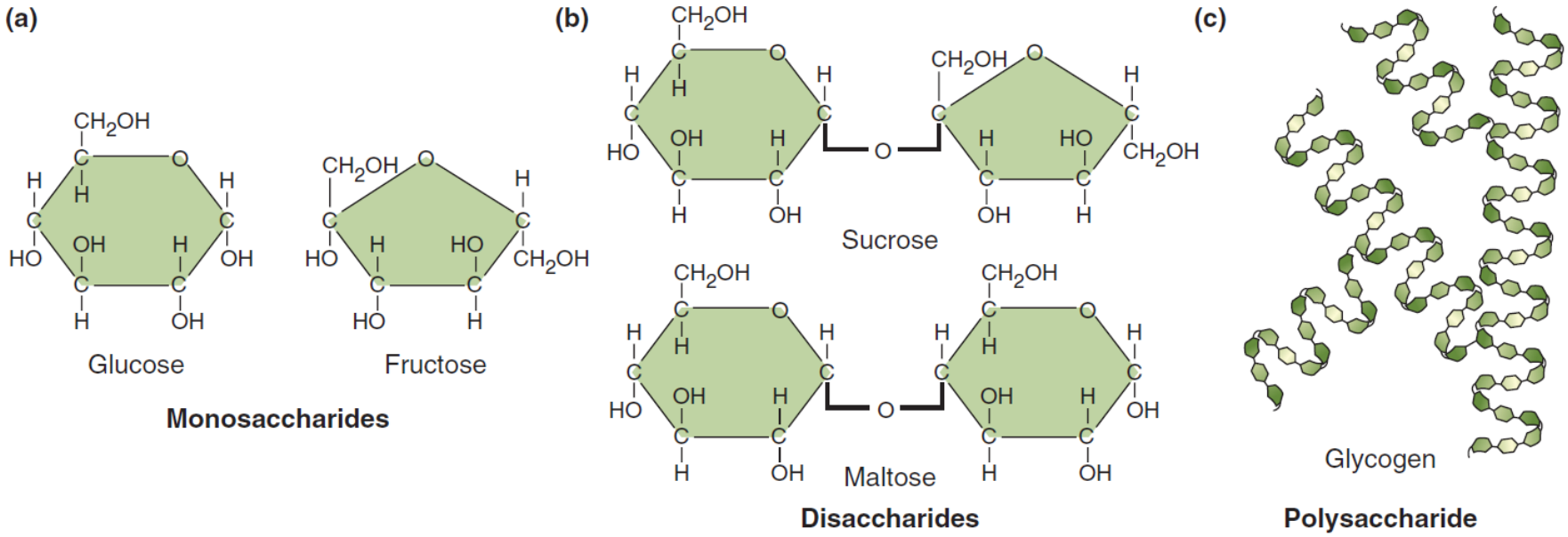


FIGURE 2-7 (A) Monosaccharide, (B) disaccharide, and (C) polysaccharide.

Organic Molecules

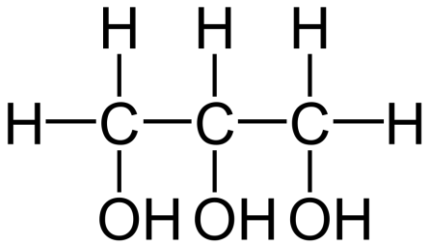
- Two broad categories
  1. Structural proteins form the structures of the body
  2. Functional proteins cause chemical changes in the molecules
     - Shape of a protein's molecules determines its function
       - Denatured proteins have lost their shape and therefore their function
       - Proteins can be denatured by changes in pH, temperature, radiation, and other chemicals
       - If the chemical environment is restored, proteins may be renatured and function normally

Lipids

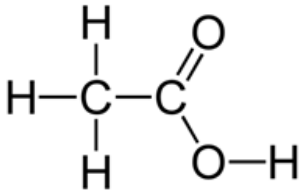
- Contain C, H and O (may contain N or P)
- Differ from Carbohydrates since they have much lower Oxygen concentration
  - i.e glycerol tristerate ($C_{57}H_{110}O_6$)
- Types:
  - Triglycerides (Energy)
  - Phospholipids (Structure)
  - Steroids (Integral part of cell membrane)

Lipids

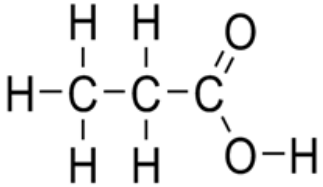
- Are made of:
  - glycerol
    - has hydroxyl group (-OH) on each C



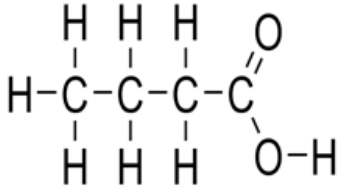
  - fatty acids
    - C chains with a carboxyl group (-COOH) at one end which gives it the acidic properties
    - if all C are connected by single covalent bonds then it is a saturated fatty acid
    - if there are some double covalent bonds then it is a unsaturated fatty acid



Acetic acid (acetate)



Propionic acid (propionate)



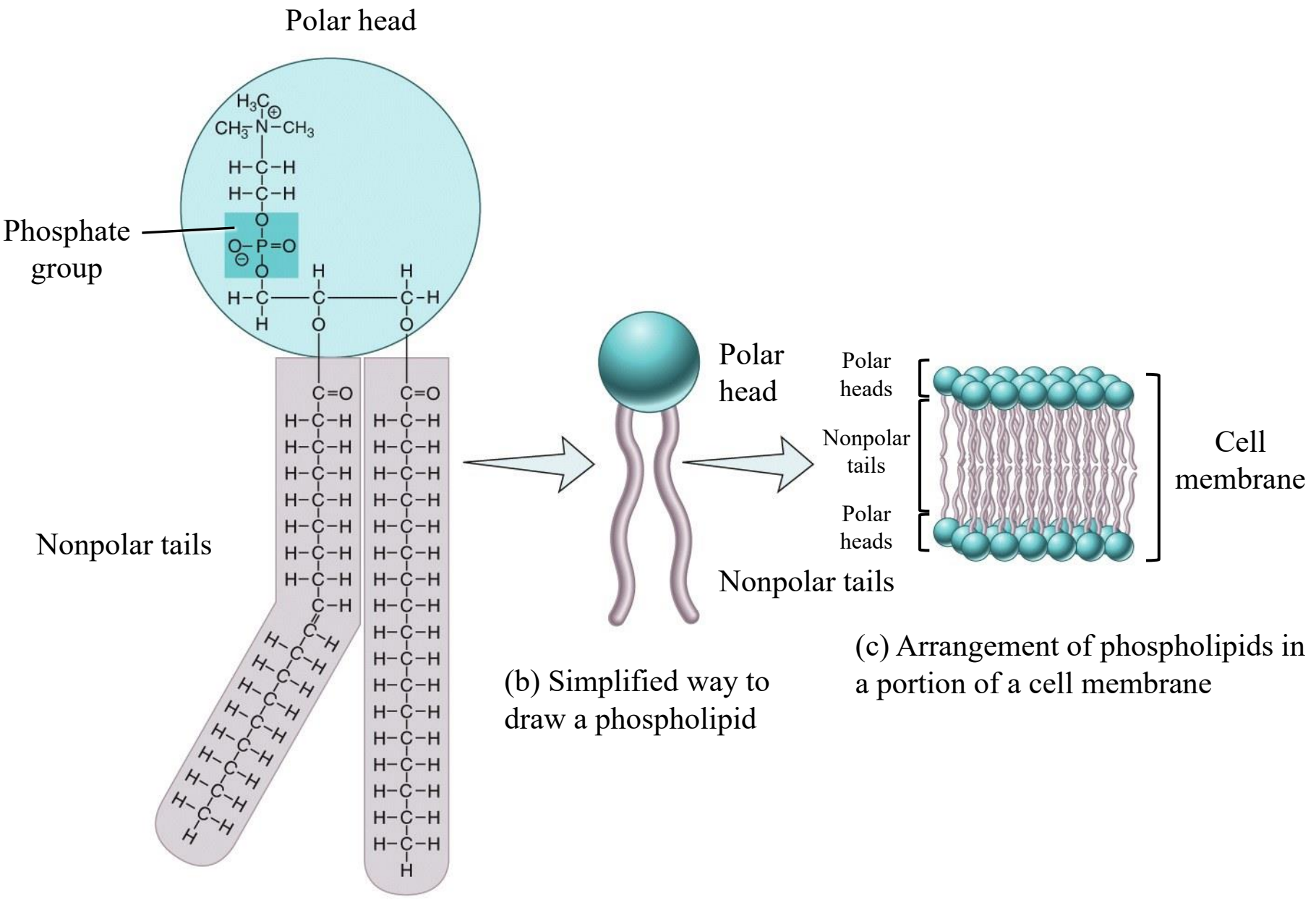
Butyric acid (butyrate)

Lipids

- Triglycerides
  - Most abundant of the lipids
    - Called
      - Fats when solid
      - Oils when liquid
  - Composed of three fatty acids bonded to a glycerol molecule
  - Important functions
      - Most concentrated source of energy
      - Provide protection
      - Padding/Insulation

Lipids

- Phospholipids
  - Similar to triglycerides
    - One end is water-soluble (hydrophilic)
    - One end is fat-soluble (hydrophobic)
  - Contains a phosphate group as well as the glycerol and fatty acids
    - glycerol + phosphate + 2 fatty acids
  - Are important component of the cellular membrane
    - particularly in nerve and muscle cells



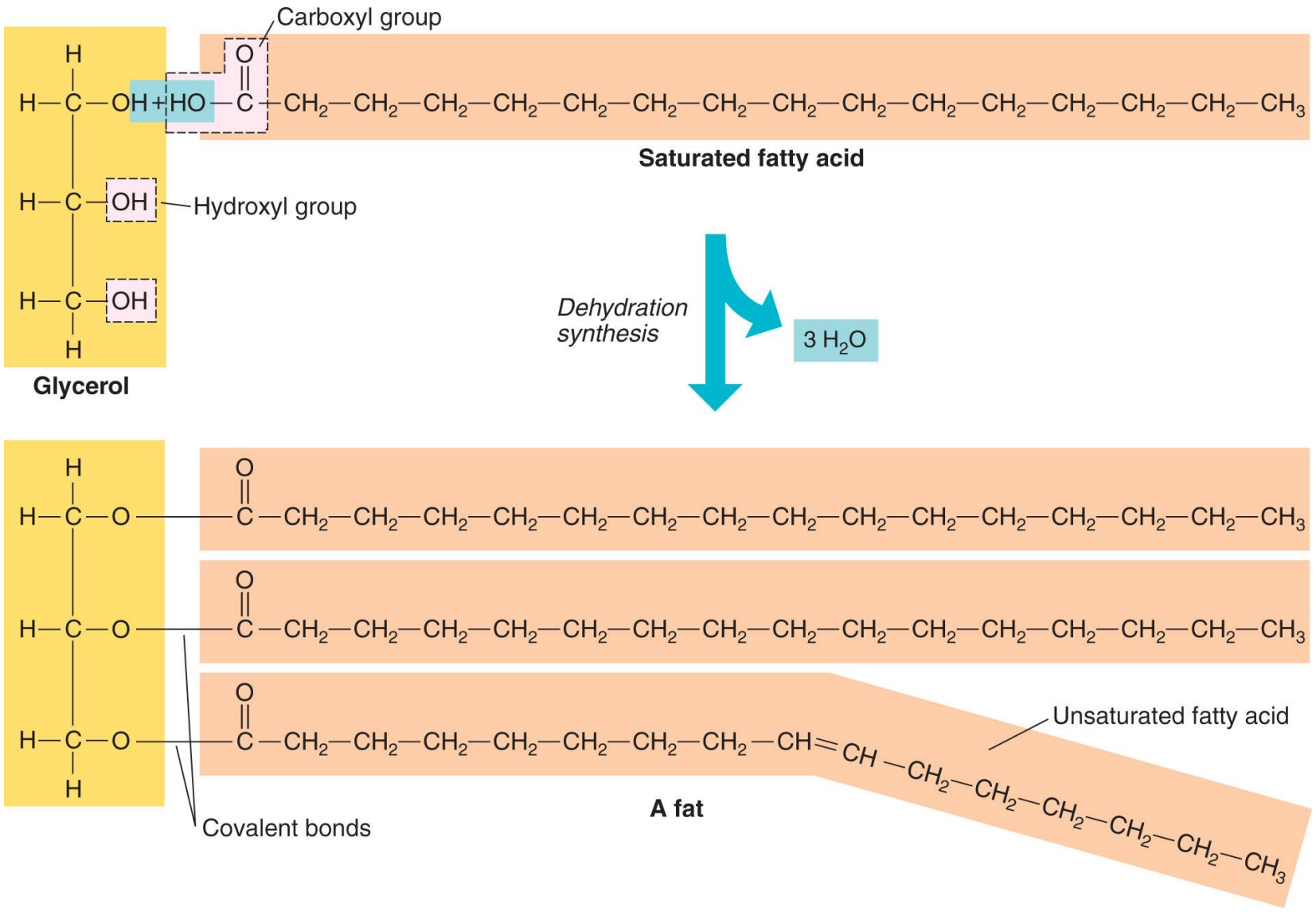
Lipids

- Steroids
  - Large lipid with distinctive carbon framework
    - Main component is steroid nucleus
    - Involved in many structural and functional roles
  - Examples
    - Cholesterol (most common) which is particularly abundant in the brain and nerve tissue
    - Hormones (sex hormones)
      - Estrogen
      - Progesterone
      - Testosterone
      - Cortisol

Saturated and Unsaturated Fats

- Saturated fat
  - Contains carbon atoms bound to as many hydrogen atoms as possible
- Unsaturated fat
  - Has double bonds only
- Polyunsaturated fat
  - Has many double-bonded carbon atoms

Saturated and Unsaturated Fats



Lipids

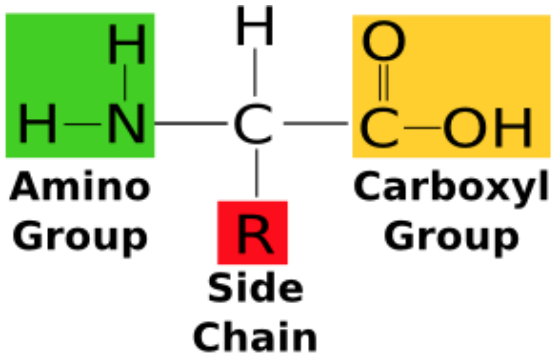
- Prostaglandins
  - "Tissue hormones"; produced by cell membranes throughout the body
    - First discovered in the prostate (hence the name)
  - Formed in the cell and released from the membrane due to stimulus
  - Have very local effects and then become inactive
    - Help regulate effects of hormones
    - Influence BP and gastric secretions
    - Enhance the immune system and inflammatory response
    - Play a role in blood clotting and respiration

Other Lipids in the Body

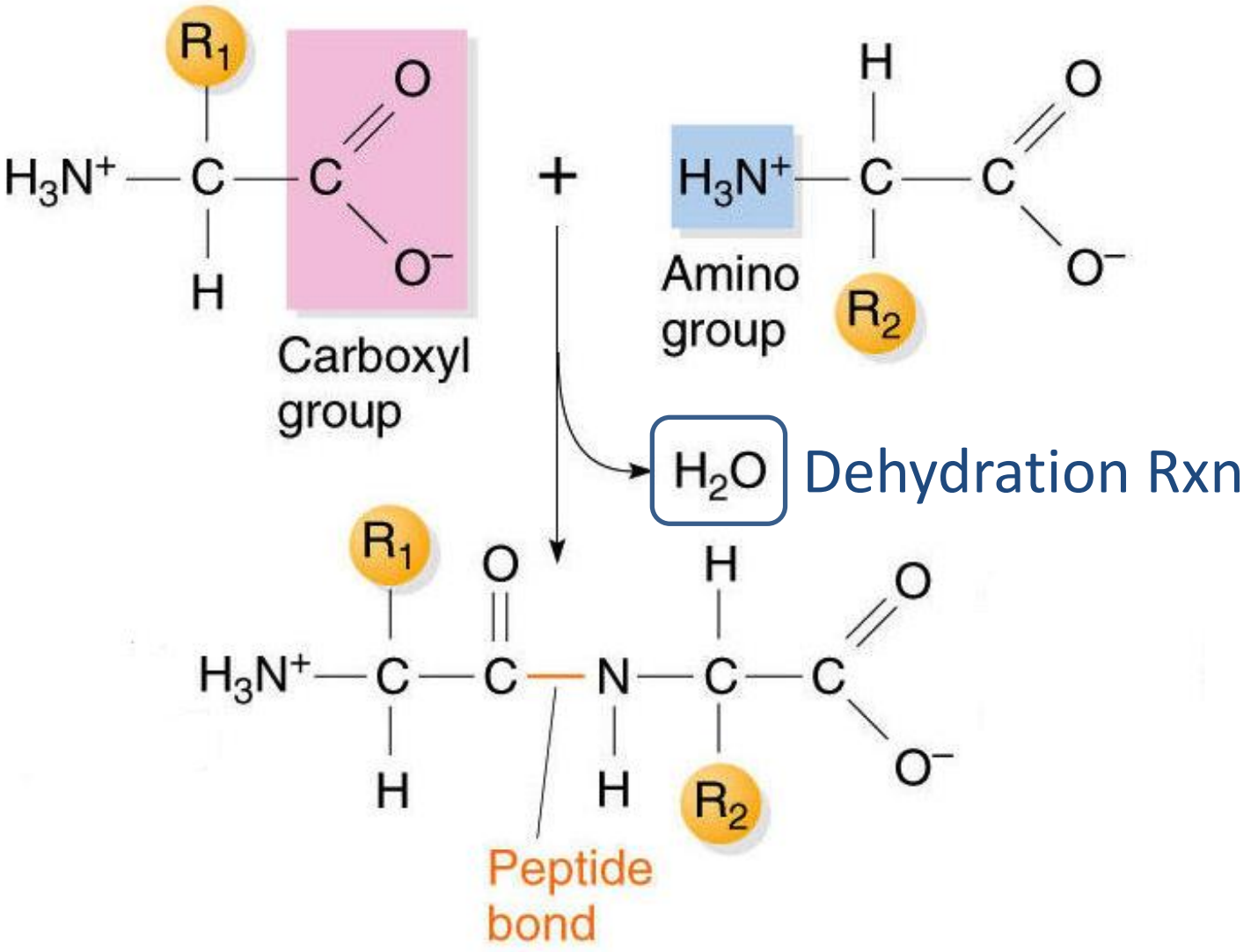
- Fat-soluble vitamins
  - Vitamins A, D, E, and K
- Lipoproteins
  - Transport fats in the blood

Proteins

- All proteins contain C, H, O and N and may contain S, Fe and P
- The building blocks are
  - Amino acid group (-NH_2)
    - Essential amino acids
      - 8 that cannot be produced by the human body
    - Nonessential amino acids
      - 12 amino acids can be produced from molecules available in the human body
  - Carboxyl acid group (-COOH)
- Amino acids are linked together by peptide bonds formed by dehydration synthesis
- Most abundant, highly important organic components of body



Proteins


R1
H3N+
C
C
O
O−
H
Carboxyl group
+
H3N+
C
C
H
O
O−
R2
Amino group
H2O
Dehydration Rxn
R1
H3N+
C
C
O
N
C
C
H
O
O−
H
H
R2
Peptide bond

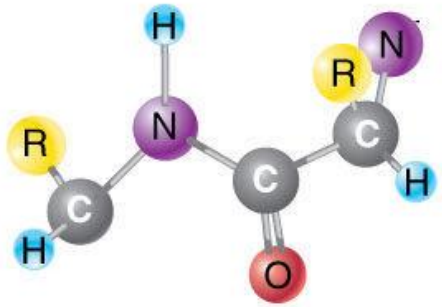
Proteins

- Is the basic structural material of the body
- Performs many important functions:
  - Structural components in cells and tissues
  - Act as antibodies
  - Muscles contain some that are responsible for contraction
  - Receptor sites and identification marks on cells
  - Hemoglobin carries Oxygen in blood
  - Source of energy

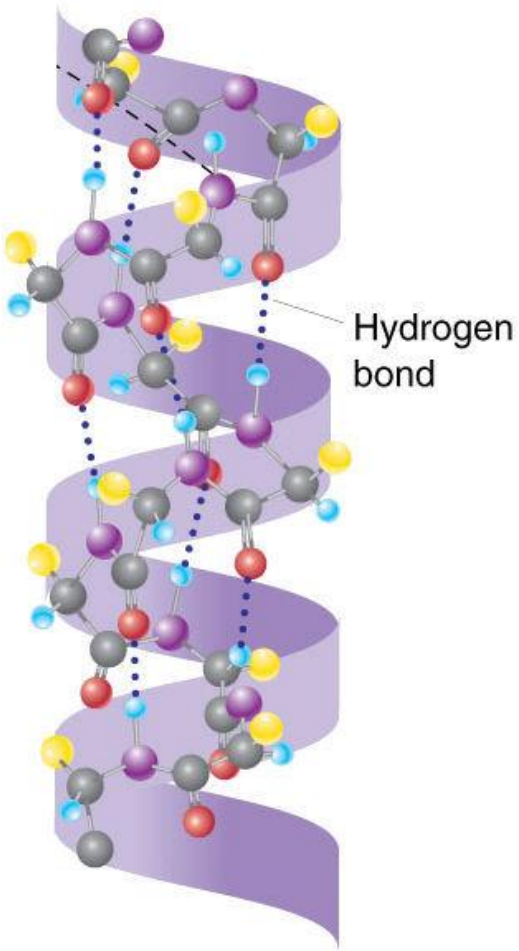
Proteins

- Levels of protein structure
  - Protein molecules are highly organized and show a definite relationship between structure and function
  - There are four levels of protein organization:
    - Primary structure
    - Secondary structure
    - Tertiary structure
    - Quaternary structure

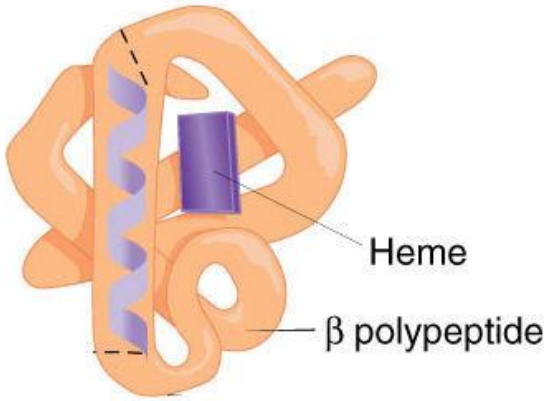
Proteins



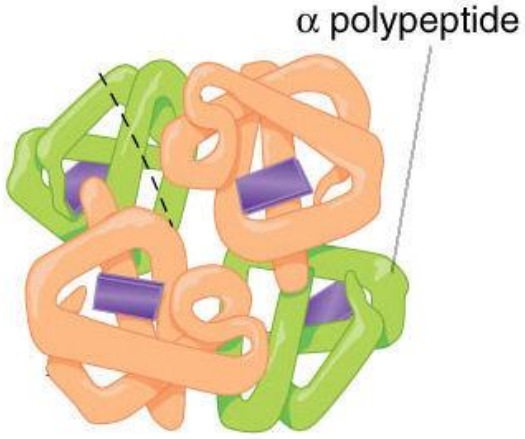
(a) Primary structure



(b) Secondary structure



c) Tertiary structure



(d) Quaternary structure

Enzymes

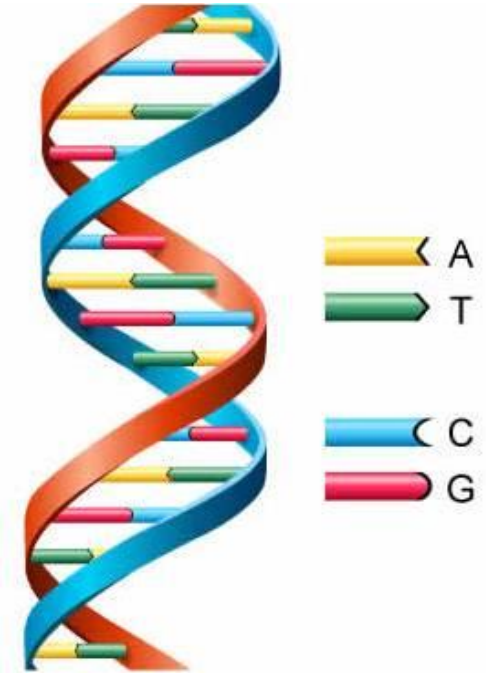
- Globular proteins
  - Promote chemical reactions by lowering activation energy requirements
  - Activation energy must be overcome in order for chemical reactions to occur
- Enzymes act as catalysts
  - Accelerate reactions
  - Are not changed or consumed

Nucleic Acids

- Large, complex, organic compounds that contain C, H, O, N and P
- Nucleotides are the building blocks, which contains a 5-carbon sugar (pentose), a nitrogenous base and a phosphate group
- 2 types
  - Deoxyribonucleic acid DNA
  - Ribonucleic acid RNA
- Found in all living things, cells and viruses

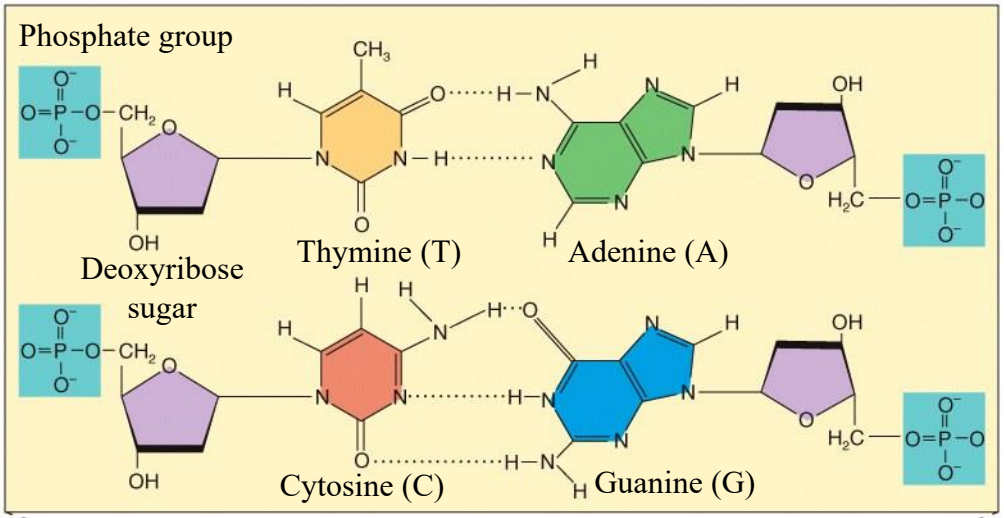
Deoxyribonucleic Acid (DNA)

- Is the genetic material of the cell
  - Sugar: deoxyribose
  - N bases:
    - Adenine
    - Thymine
    - Cytosine
    - Guanine
  - Phosphate group



- The sequence of these gives the genetic code
- Two chains of DNA are loosely joined H Bond are twisted into a double helix

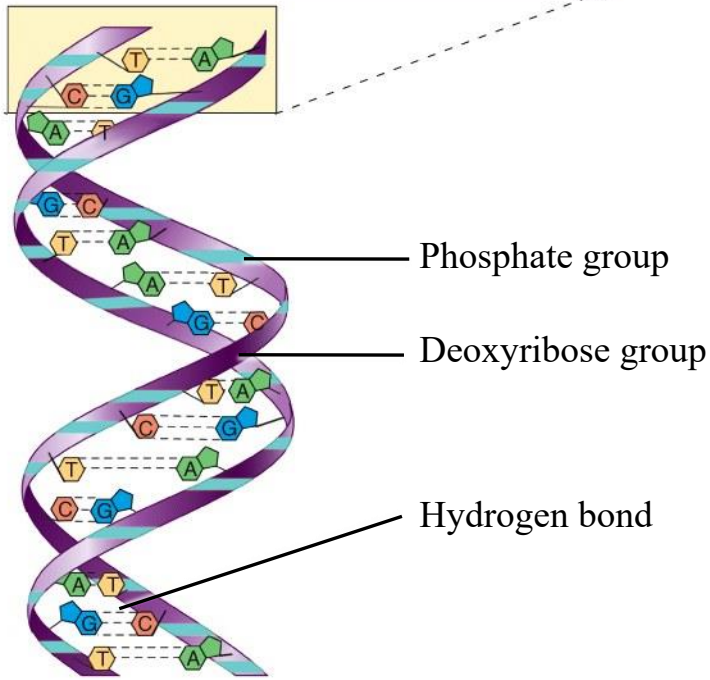
Deoxyribonucleic Acid (DNA)



a) Components of nucleotides

Key to bases:

- = Adenine
- = Guanine
- = Thymine
- = Cytosine



(b) Portion of a DNA molecule

Ribonucleic Acid (RNA)

- Has several functions in the synthesis of proteins in the cell
- Is a single chain
- Three types of RNA
  - Messenger RNA (mRNA)
  - Transfer RNA (tRNA)
  - Ribosomal RNA (rRNA)

- Sugar: ribose
- N bases:
  - Adenine
  - Uracil
  - Cytosine
  - Guanine

DNA and RNA

TABLE 2-4

Characteristics of DNA and RNA

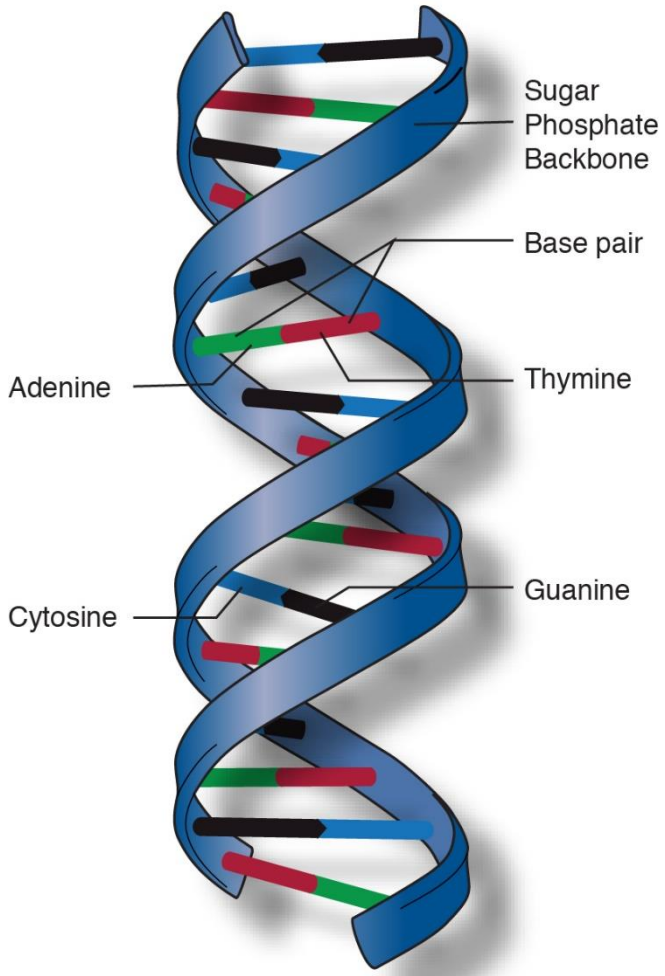
Characteristic	DNA	RNA
Structure	Double stranded and coiled into a *double helix*	Single stranded, either straight or folded
Major functions	Genetic material, direction of protein synthesis; it self-replicates before cell division	Synthesizes proteins based on genetic instructions
Major site in the cells	Nucleus	Cytoplasm (the cell area outside the nucleus)
Sugar	Deoxyribose	Ribose
Bases	Adenosine, cytosine, guanine, thymine	Adenine, cytosine, guanine, uracil

DNA and RNA

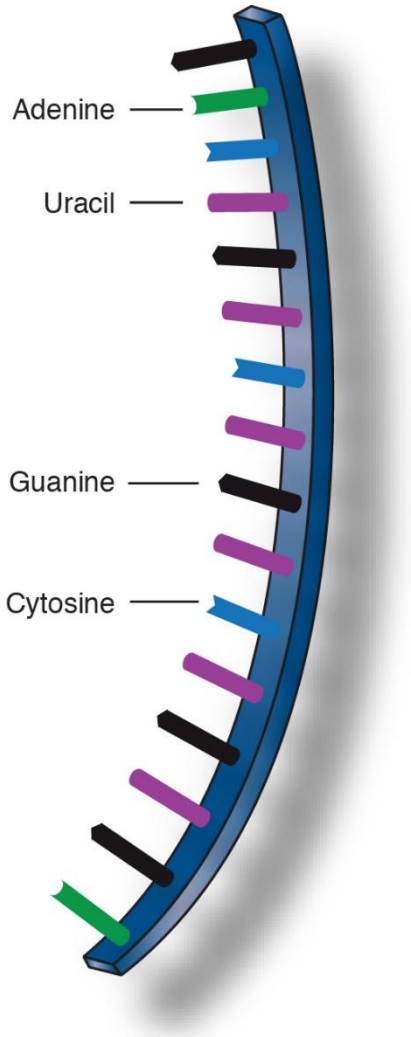
- Some RNA molecules are temporary copies of segments (genes) of the DNA code and are involved in synthesizing proteins
- Some RNA molecules are regulatory, acting as enzymes (ribozymes) or silencing gene expression (RNA interference)

- DNA has the instructions for making proteins
- RNA carries out the process

DNA and RNA



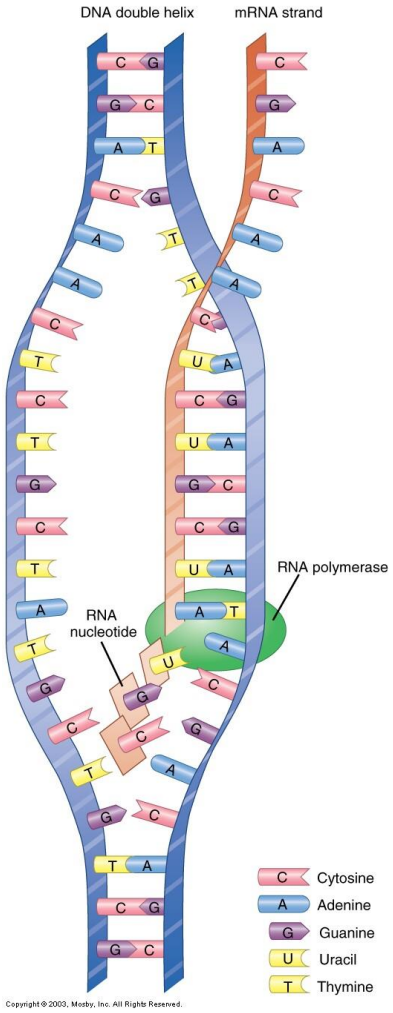
Deoxyribonucleic acid
(DNA)



Ribonucleic acid
(RNA)

Formation of Proteins

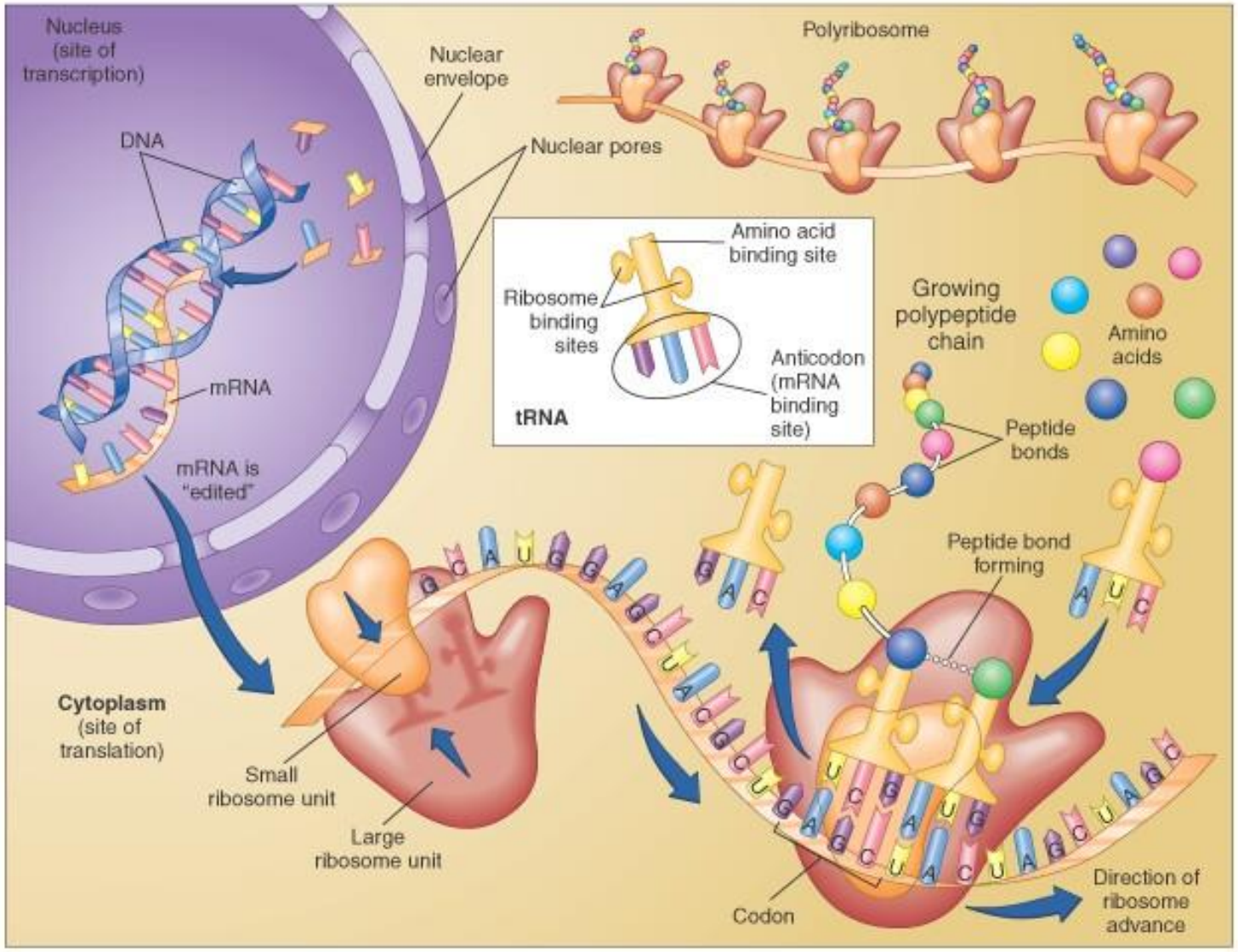
- Transcription
  - Strand of RNA forms along a strand of DNA
  - This RNA becomes mRNA
  - Is released out of nucleus and carries its message to the ribosomes in the cytoplasm



Formation of Proteins

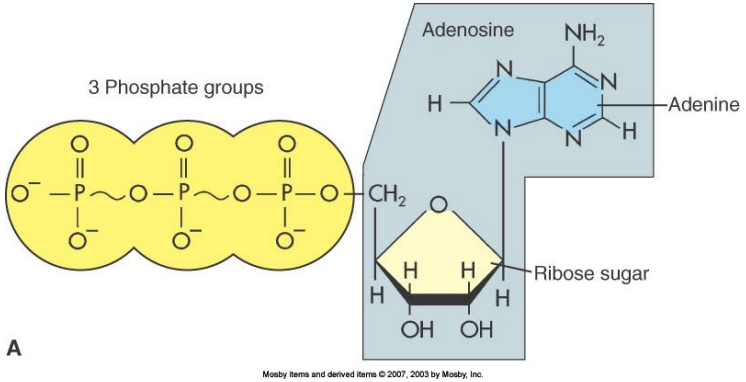
- Translation
  - mRNA attracts small and large ribosome subunits
  - tRNA picks up an amino acid floating freely in the cytoplasm
  - Then attaches in to ribosome/RNA complex in a specific sequence

Formation of Proteins



Organic Molecules

- Nucleic acids and related molecules
  - Nucleotides
    - Nucleotides have other important roles in the body
    - ATP
      - Adenosine
        - » Ribose—a pentose sugar
        - » Adenine—a nitrogen-containing molecule
      - Three phosphate subunits



Organic Molecules

- Nucleotides (cont.)
  - High-energy bonds present between phosphate groups
  - Cleavage of high-energy bonds releases energy during catabolic reactions
  - Energy stored in ATP is used to do the body's work
  - ATP often called the energy currency of cells
  - ATP is split into adenosine diphosphate (ADP) and an inorganic phosphate group by a special enzyme
  - If ATP is depleted during prolonged exercise, creatine phosphate (CP) or ADP can be used for energy

Organic Molecules

- Nucleic acids and related molecules (cont.)
  - NAD and FAD
    - Used as coenzymes to transfer energy-carrying molecules from one chemical pathway to another
  - cAMP (cyclic AMP)
    - Made from ATP by removing two phosphate groups to form a monophosphate
    - Used as an intracellular signal

Organic Molecules

- Combined forms—large molecules can be joined together to form even larger molecules
  - Gives the molecules a completely different function
  - Names of combined molecules reveals what is in them
    - Base word tells which component is dominant
    - Prefix shows the component present in a lesser amount

Organic Molecules

- Combined forms (cont.)
  - Examples:
    - Adenosine triphosphate (ATP)—two extra phosphate groups to a nucleotide
    - Lipoproteins—lipid and protein groups combined into a single molecule
    - Glycoproteins—carbohydrate (glyco, “sweet”) and protein