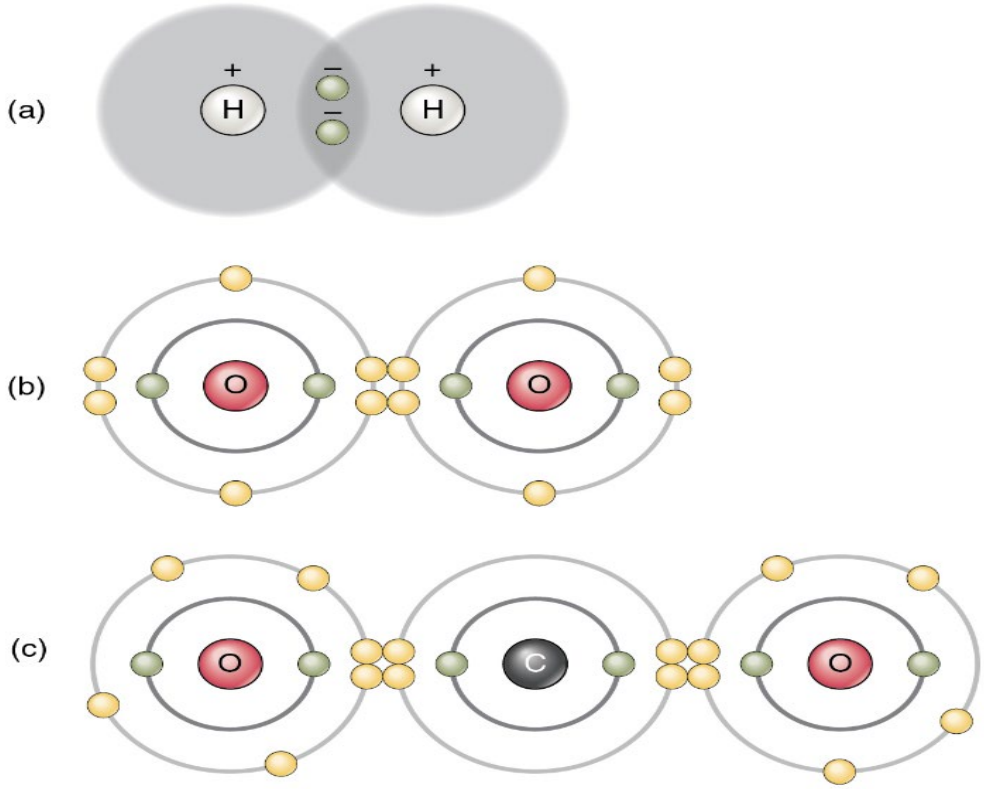
BIOLOGY 1103/1109
Human Anatomy and Physiology I

Unit 1
Atoms and molecules



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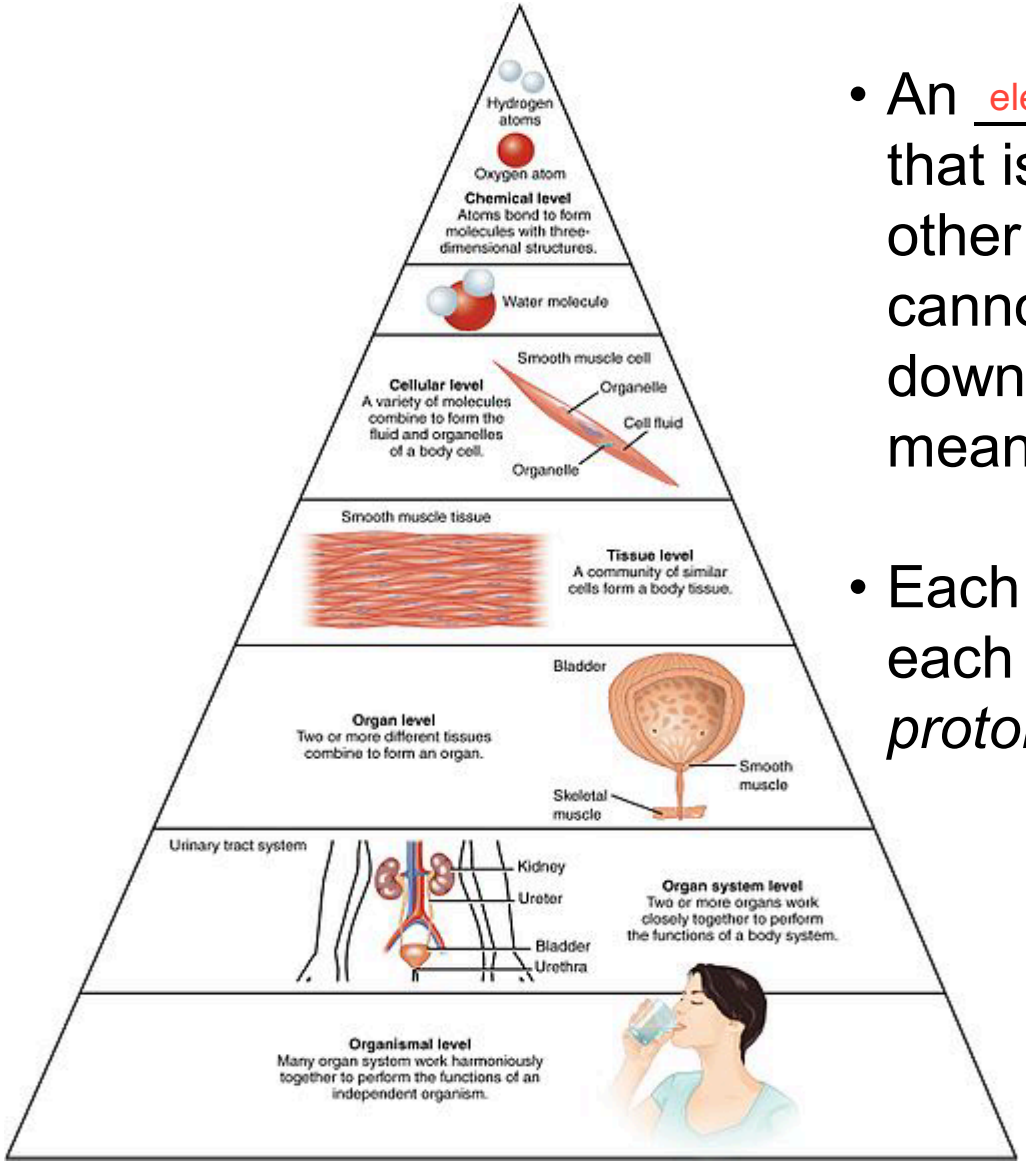
Atoms and molecules

Objectives

1. Define the term “chemical element”, specify the name and symbol for the four most common chemical elements in the body, and describe the importance of each.
2. Define the term “atom” and describe the structure of an atom.
3. Define the terms “molecule” and “compound”.
4. Describe the formation of an ion and of an ionic bond.
5. Describe the formation of a covalent bond.
6. Distinguish between organic and inorganic molecules.
7. Describe the composition of organic molecules, specify two characteristics of organic molecules that make them useful to living organisms, and give examples of organic molecules.
8. Specify the chemical and physical properties of water .

Levels of structural organization of the body



- An element is a pure substance that is distinguished from all other matter by the fact that it cannot be created or broken down by ordinary chemical means.
- Each element is made of atoms, each with a constant number of *protons.*

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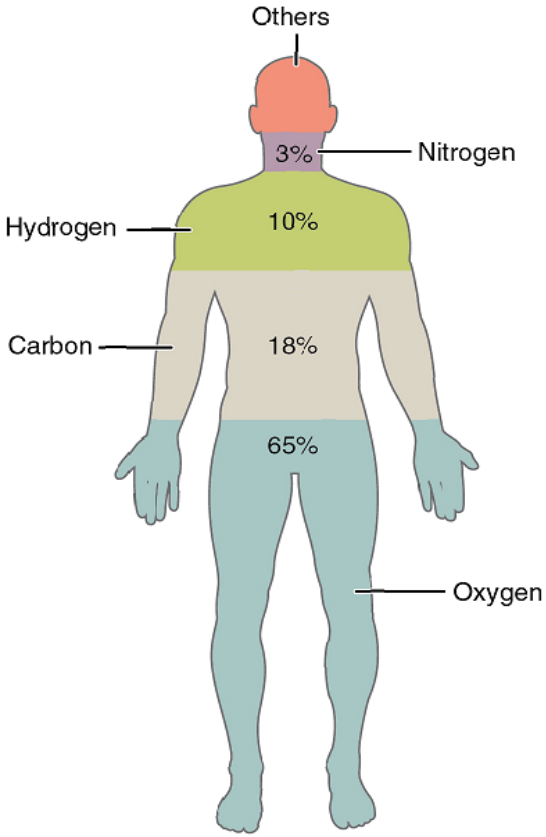
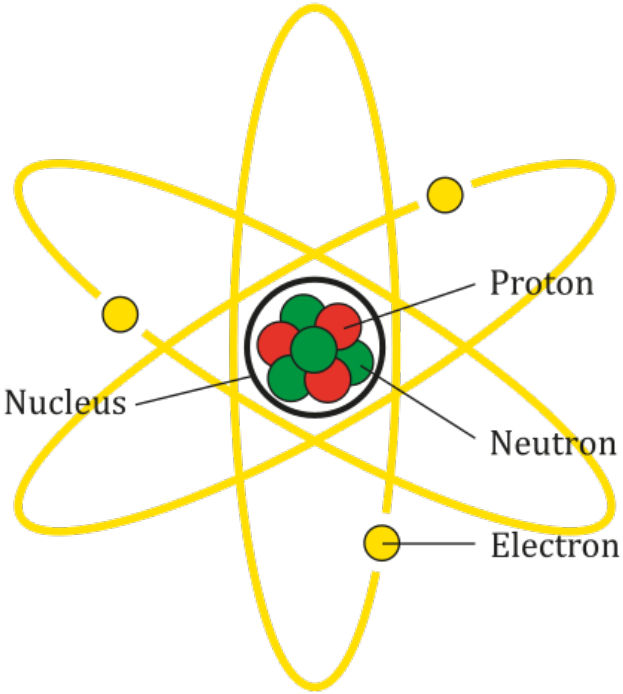
The most common chemical elements in the human body



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

- Chemical element is a pure substance that cannot be broken down any further by chemical mean

Atoms make up elements



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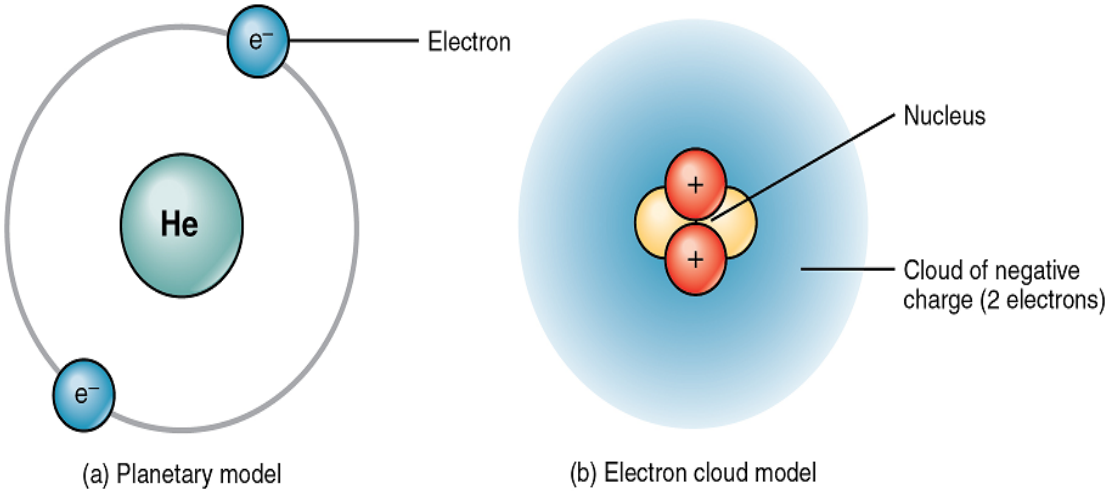
- An *atom* is the smallest component of an element that retains all the chemical properties of that element.
- At the most basic level, all organisms are made of a combination of *elements.*
- Except for Hydrogen, all atoms contain protons (p), electrons, *and neutrons.*

Structure of the atom:
Protons + Neutrons + Electrons

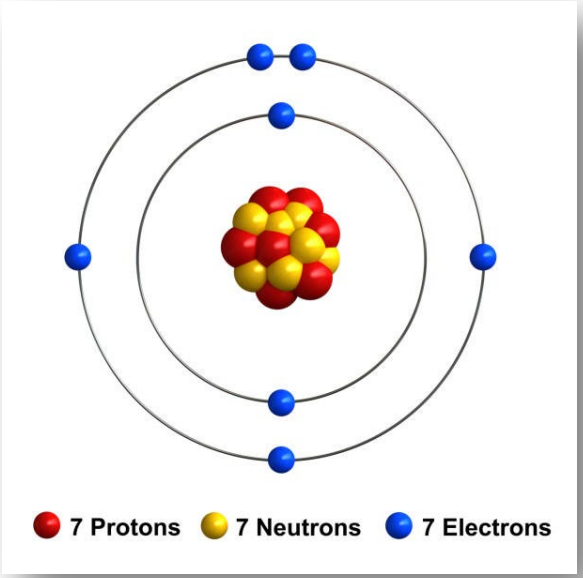
Basic atomic structure
Atom = Proton(s) + Neutron(s) + Electron(s)



Sub-atomic particles	
Proton (p^+):	*positive charge*
Neutron (n^0):	*no charge*
Electron (e^-):	*negative charge*

- A *proton* is a particle that resides in the atomic nucleus and has a mass of 1 and a charge of +1.
- An *electron* is a particle that travels in the space around the atomic nucleus and has almost no mass and a charge of -1.
- A *neutron* is a particle that resides in the atomic nucleus and has a mass of 1 and no charge.
- In a *neutral atom*, the positive and negative charges balance each other out.

Atomic properties



- *Nitrogen,* as pictured above, has an atomic number of 7 and an atomic mass of 14.
- The atomic *number* is equal to the number of protons that element contains.
- The mass *number* is the number of protons plus the number of neutrons.
- Thus, it is possible to determine the number of neutrons by subtracting the number of protons from the mass number.

- Since protons and neutrons each have a mass of 1, *the mass of any atom is equal to the number of protons and neutrons of that atom.*
- The number of electrons does not factor into the mass of an atom.
- Each atom contains a different number of protons and neutrons.

Can you draw Na (atomic number = 11) an Cl (atomic number = 17)?

Look at the drawing in the practice paper

Molecule *vs.* compound

Molecule: Made up of two or more of the same atoms joined together by chemical bonds.

O_2

Compound: Made up of atoms from two or more different elements joined together by chemical bonds.

H_2O

Organic *vs.* inorganic compounds

Organic COMPOUNDS

- Small and simple
- Substance that does not contain carbon-hydrogen bonds (except CO_2)
- Often contain ionic bonds

Examples

Salts: KCl, $NaNO_3$

Acids: HCl, H_2SO_4

Bases: NaOH, $Ca(OH)_2$

Other: H_2O, CO_2

Inorganic COMPOUNDS

- Large and complex
- Compounds that always contain carbon-hydrogen bonds
- Carbon as the main elemetn
- Contain covalent bonds

Examples

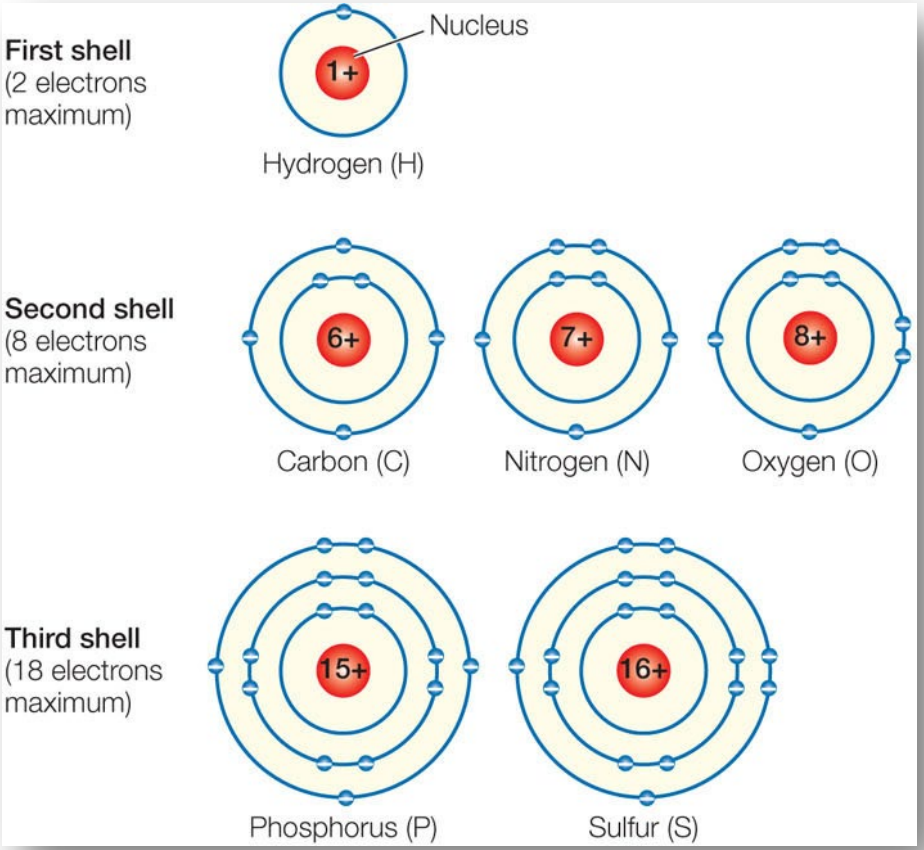
Carbohydrates: $C_6H_{12}O_6$

Lipids: $C_{18}H_{38}O$

Proteins: $(CHON)_n$

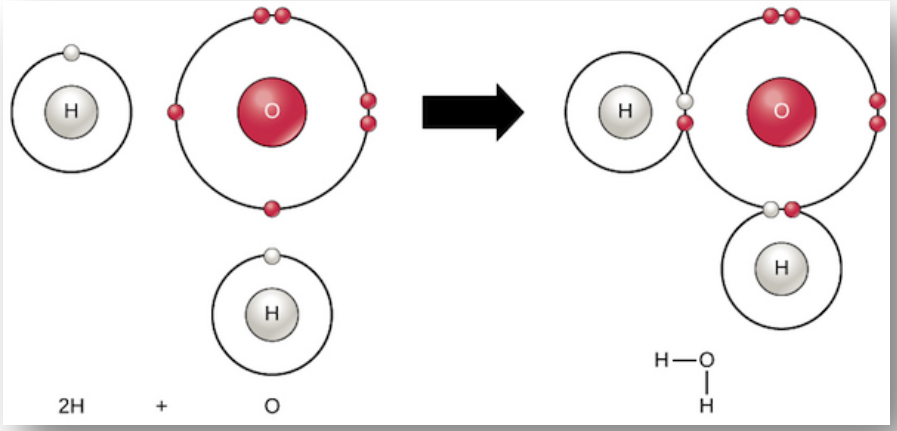
Nucleic acids: $(CHONP)_n$

Chemical bonds; it's all about electrons

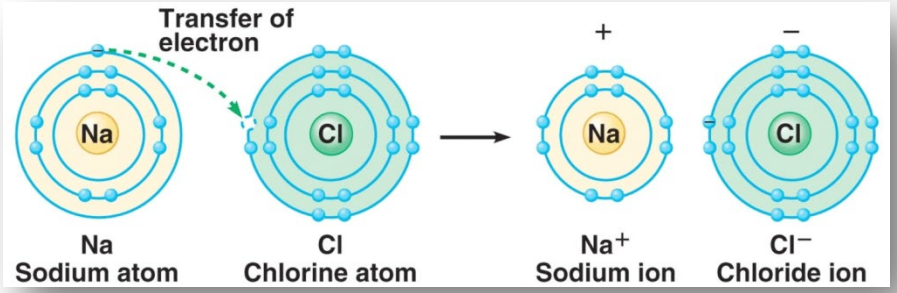


- Electrons exist at energy levels that form shells around the nucleus.
- The closest shell can hold two electrons and is always filled with electrons first.
- The second and third energy levels have shells that can hold up to eight electrons that are arranged in four pairs - one position in each pair is filled with an electron before any pairs are completed.

The octet rule



When water is formed, *electrons are shared* between an oxygen atom and two hydrogen atoms, filling the outer electron shells of all three atoms.

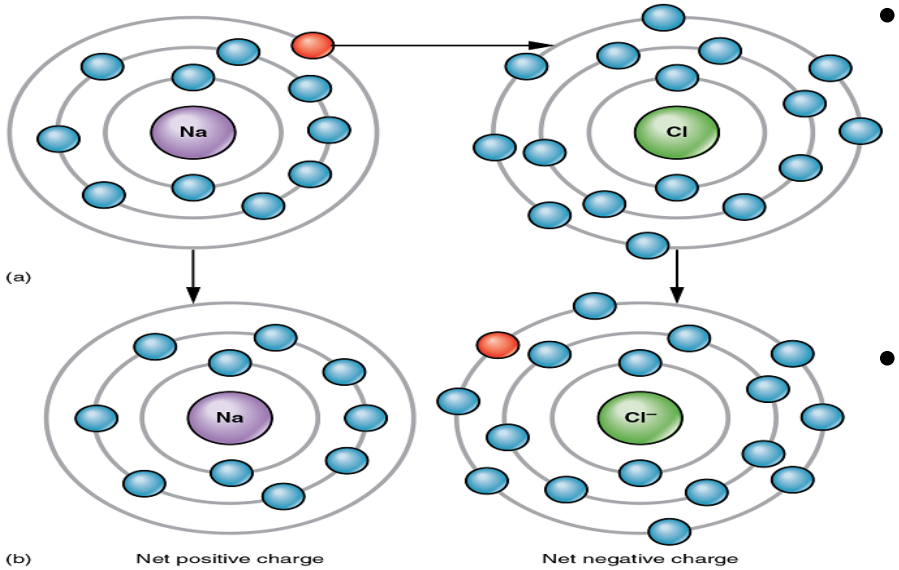


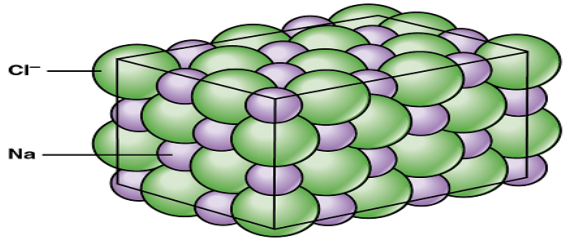
When table salt is formed, *an electron is transferred* from a sodium atom to a chlorine atom, filling the outer electron shells of both atoms.

- An atom is at its most stable when all electron positions in the outermost shell are filled.
- *Chemical bonds* are formed between atoms to fill their outer electron shells, achieve stability, and form molecules.
- This is accomplished by sharing electrons, accepting electrons from another atom, or donating electrons to another atom.
- Because the outermost shells of elements with low atomic numbers (rows 2 and 3 in the periodic table) can hold eight electrons, this is referred to as the octet *rule.*

Ions and ionic bonds:

transfer of electrons

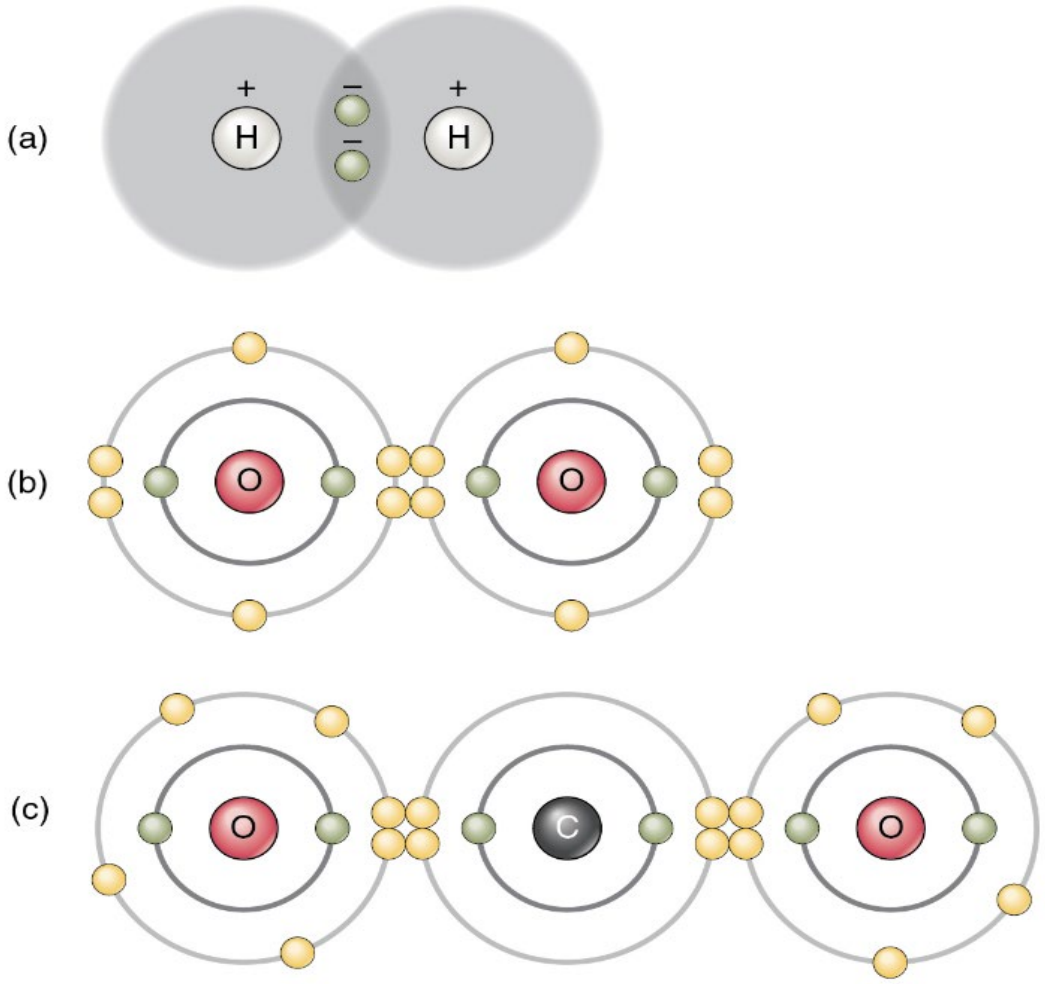




- When the number of electrons does not equal the number of protons, the atom will have a net charge and is called an ion.
- Atoms with one or two extra or missing electrons in the outer shell are more likely to accept or donate electrons to become stable.
- Positive ions are called *cations* and are formed by an atom losing one or more electrons.
- Negative ions are called *anions* and are formed by gaining one or more electrons.
- The two oppositely charged ions are held together by their electrostatic attraction - *this attraction is the ionic bond.*

Covalent bonds:

sharing electrons



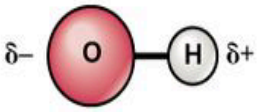
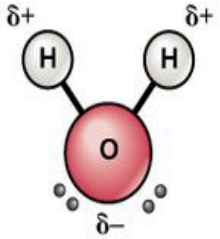
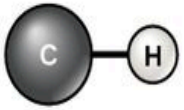
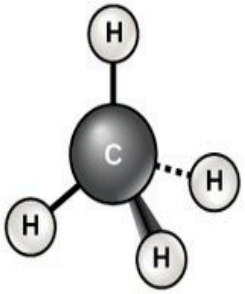
- Another type of strong chemical bond is a *covalent bond*, formed when a pair of electrons is shared between two elements.
- The electrons spend their time orbiting the atomic nuclei of each atom in the partnership, satisfying both outer shell requirements.
- Covalent bonds are the strongest and most common form of chemical bond in living organisms.

Examples of covalent bonds:

sharing electrons: polar vs nonpolar

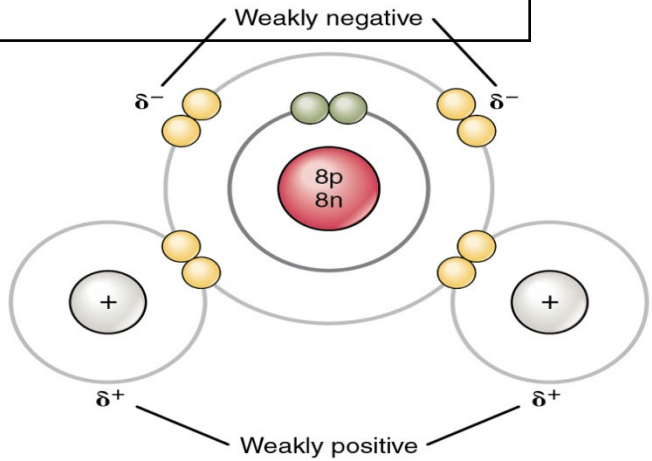
- A nonpolar covalent bonds are electrically balanced, no region of the molecule is either more positive or more negative than any other.

- A polar molecule is a molecule that contains regions that have opposite electrical charges. Polar molecules occur when atoms share electrons unequally, in polar covalent bonds.

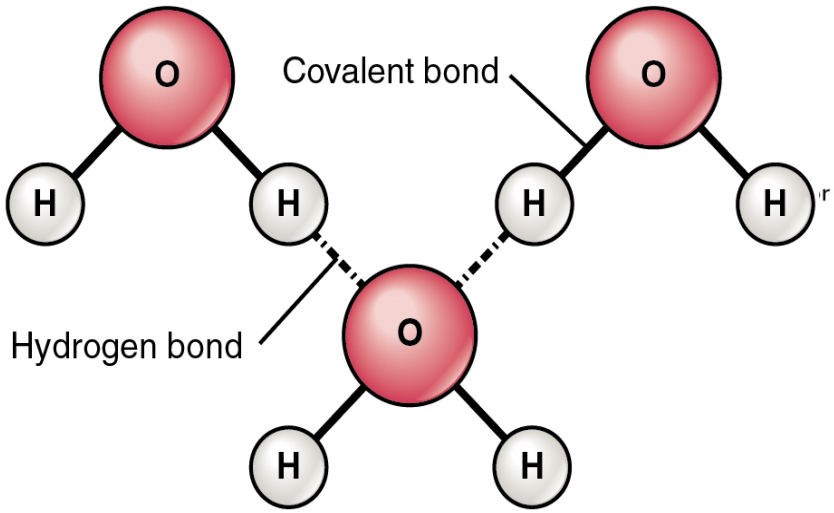
	Bond type	Molecular shape	Molecular type
Water	 Polar covalent	 Bent	Polar
Methane	 Nonpolar covalent	 Tetrahedral	Nonpolar

Main structural characteristics
- Inorganic compound - 2 covalent bonds - Polar

Hydrogen bonds



(a) Planetary model of a water molecule



- Water is two Hydrogen covalently linked to an Oxygen. These bonds in one water compound are polar covalent bonds.

- A hydrogen bond is formed when a weakly positive hydrogen atom already bonded to one electronegative atom is attracted to another electronegative atom from another molecule.

Water

Physical properties

All related to the hydrogen bonds between water compounds:

- Density; ice (solid state) is actually less dense than water (liquid state).
- Boiling point; the actual boiling point of water is 100ºC.
- Surface tension; like small insects walking on the surface of a pond. This physical property is important in the human body

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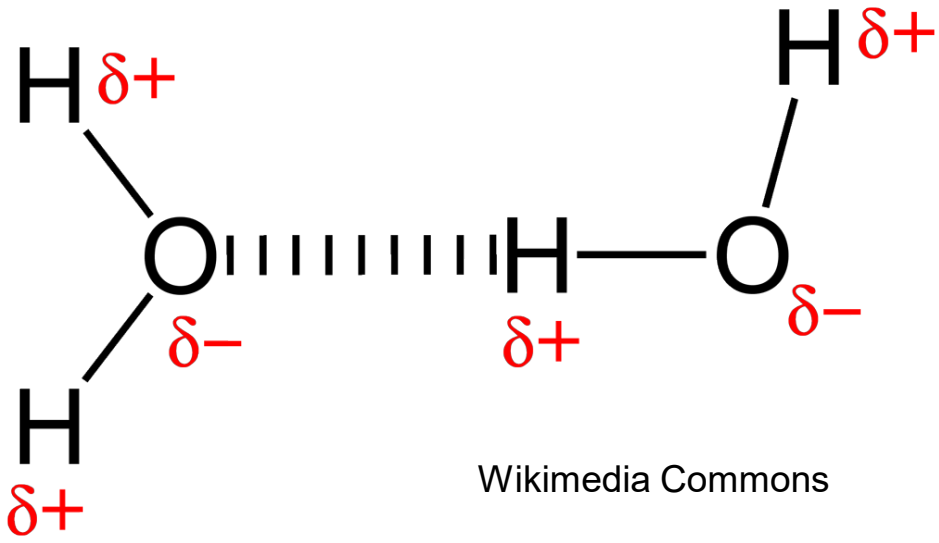
Human Anatomy and Physiology I

Unit 2

The chemistry of water



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The chemistry of water

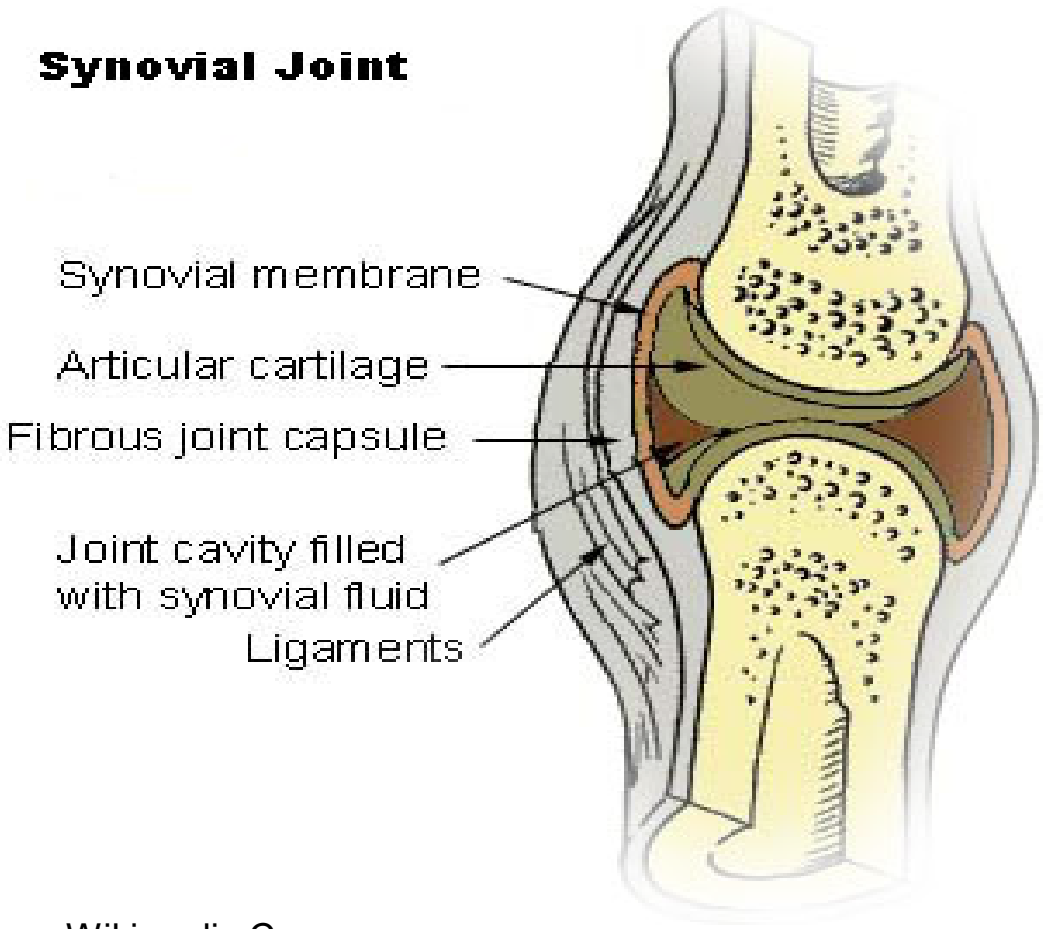
Objectives

1. Explain the biological importance of water.
2. Specify the percentage of body weight that is composed of water and estimate the amount of body water you contain in liters.
3. Describe the distribution of body water.

Water

Biological importance

1. Water as a lubricant and cushion



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- Lubricates body joints, lungs, digestive tract and other organs
- Cushions the brain, eyes and developing fetus

Water

Biological importance

2. Water as a heat sink; it absorbs and dissipates heat but does not experience a corresponding increase in temperature

High specific heat

Evaporative cooling


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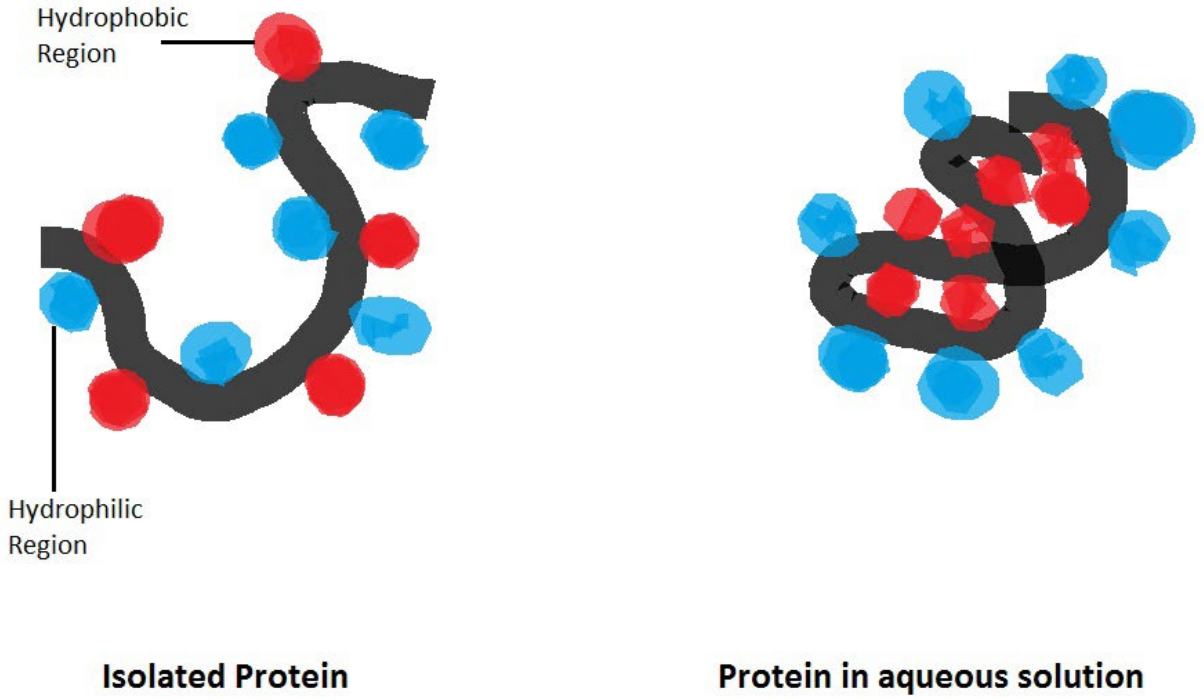
Main characteristics
- Resistant to changes in temperature
- Can absorb/release large amounts of heat
- Absorbs heat when it evaporates

Water

Biological importance

3. Water as a component of liquid mixtures



Isolated Protein **Protein in aqueous solution**

- A mixture is a combination of two or more substances, each of which maintains its own chemical identity

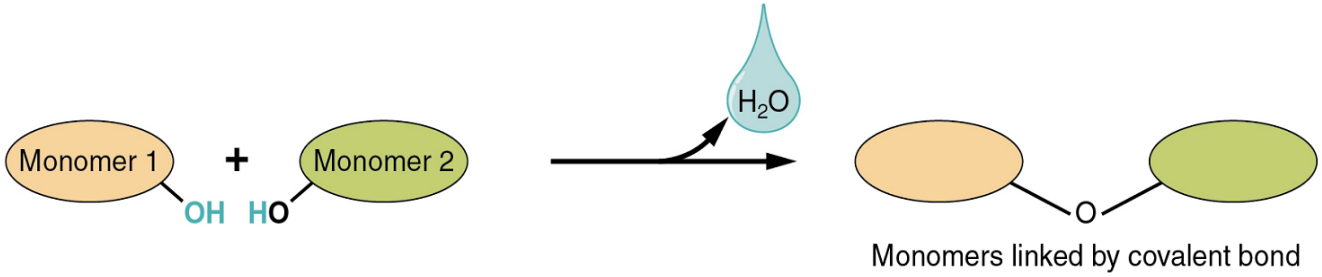
Water

Biological importance

4. The role of water in chemical reactions

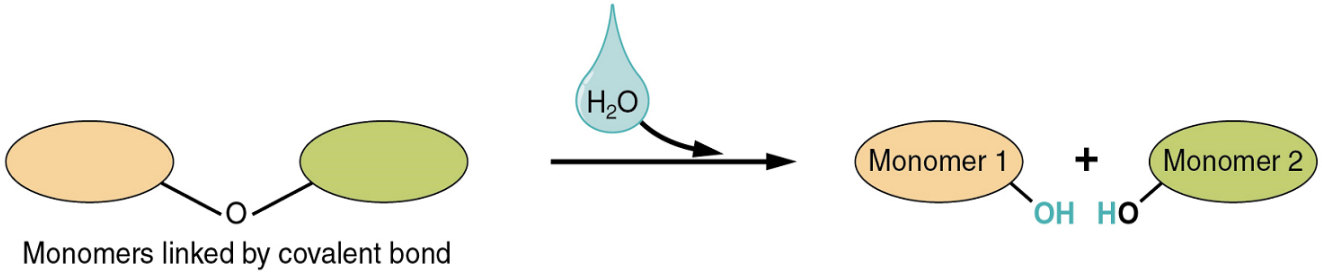
(a) Dehydration synthesis

Monomers are joined by removal of OH from one monomer and removal of H from the other at the site of bond formation.



(b) Hydrolysis

Monomers are released by the addition of a water molecule, adding OH to one monomer and H to the other.

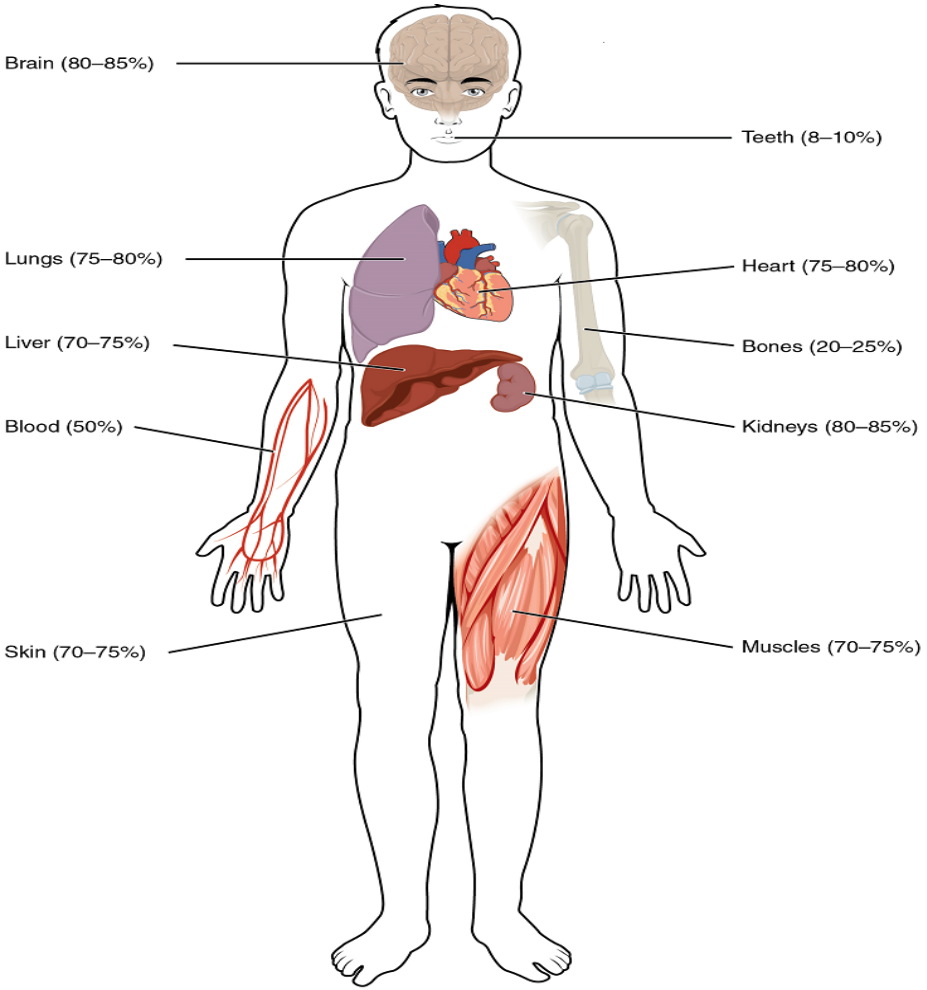


Water

Water content

Water Content in the Human Body (as % of weight)

- Infant: 75%
- Adult: 60%
  - Women= 50 % , Man= 60 %
- Senior: 45% (lowest found)

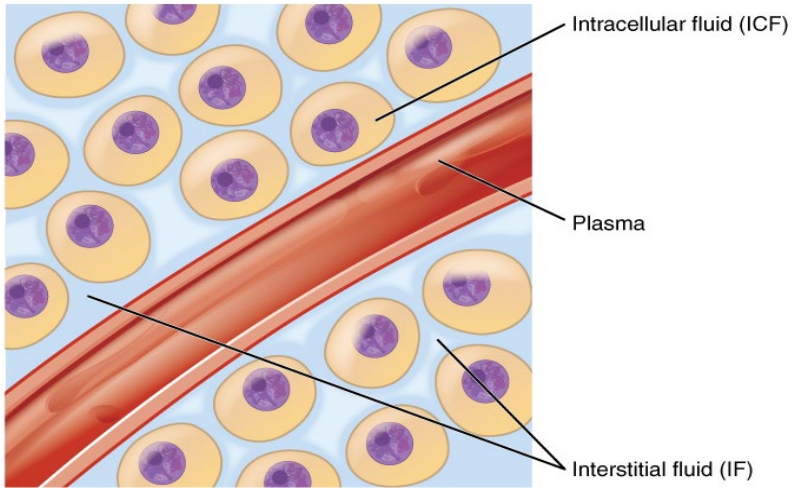


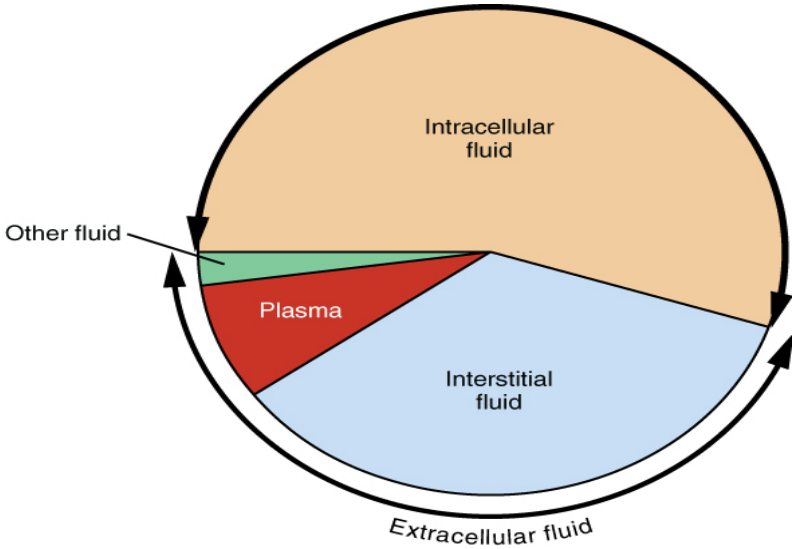
How many liters of water does your body contain?

1 L weighs 1 Kg
1 lb = 0.45 Kg

Water

Distribution





- The intracellular fluid (ICF) lies within cells and makes up about 60 percent of the total water in the human body
- The extracellular fluid (ECF) is outside cells as plasma and interstitial fluid (the fluid in between cells).
- ECF accounts for the other 33% of the body's water content.

The chemistry of water

Objectives

1. Explain the biological importance of water.
2. Specify the percentage of body weight that is composed of water and estimate the amount of body water you contain in liters.
3. Describe the distribution of body water.

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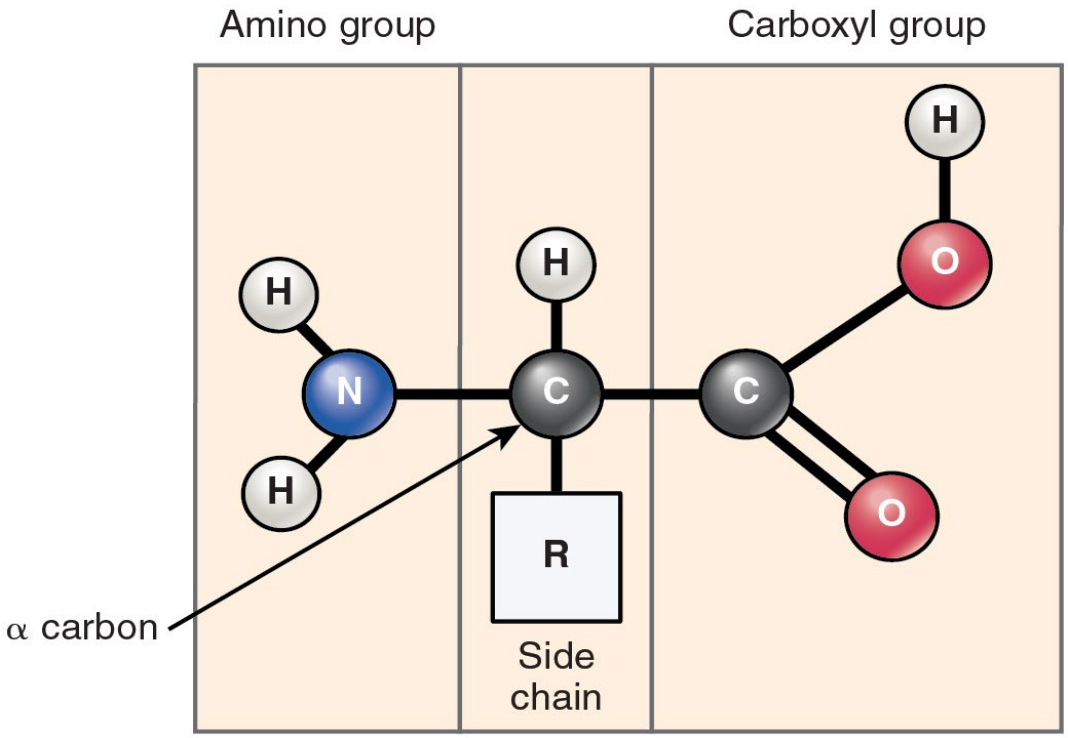
Human Anatomy and Physiology I

Unit 3 Biochemistry



Biochemistry

Objectives

1. Describe the chemistry of carbon.
2. Describe the structure and function of carbohydrates.
3. Describe the structure and function of lipids.
4. Describe the structure and function of proteins.
5. Describe the structure and function of nucleic acids.

Chemistry of carbon

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- Four electrons to share
- Long chains
- Carbon-hydrogen = hydrocarbons
- Can bond to functional groups

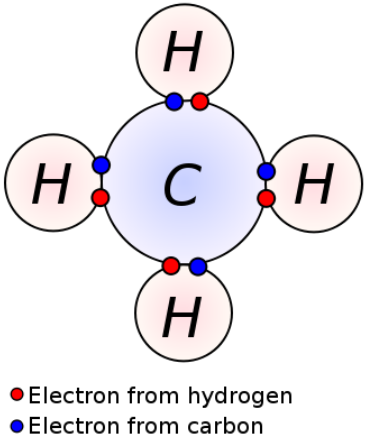


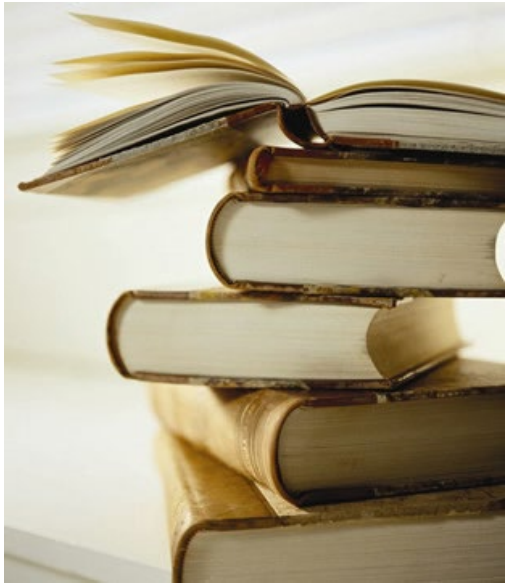
Table 1: Functional Groups Important in Human Physiology

Functional group	Structural formula	Importance
Hydroxyl	—O—H	Hydroxyl groups are polar. They are components of all four types of organic compounds discussed in this chapter. They are involved in dehydration synthesis and hydrolysis reactions.
Carboxyl	O—C—OH	Carboxyl groups are found within fatty acids, amino acids, and many other acids.
Amino	—N—H_2	Amino groups are found within amino acids, the building blocks of proteins.
Methyl	—C—H_3	Methyl groups are found within amino acids.
Phosphate	—P—O_4^{2-}	Phosphate groups are found within phospholipids and nucleotides.

1. Carbohydrates:

"Watery carbon"

Sucrose



Cellulose

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IMPORTANT FACTS
- Common in diet
- Synthesized by body

General Formula:

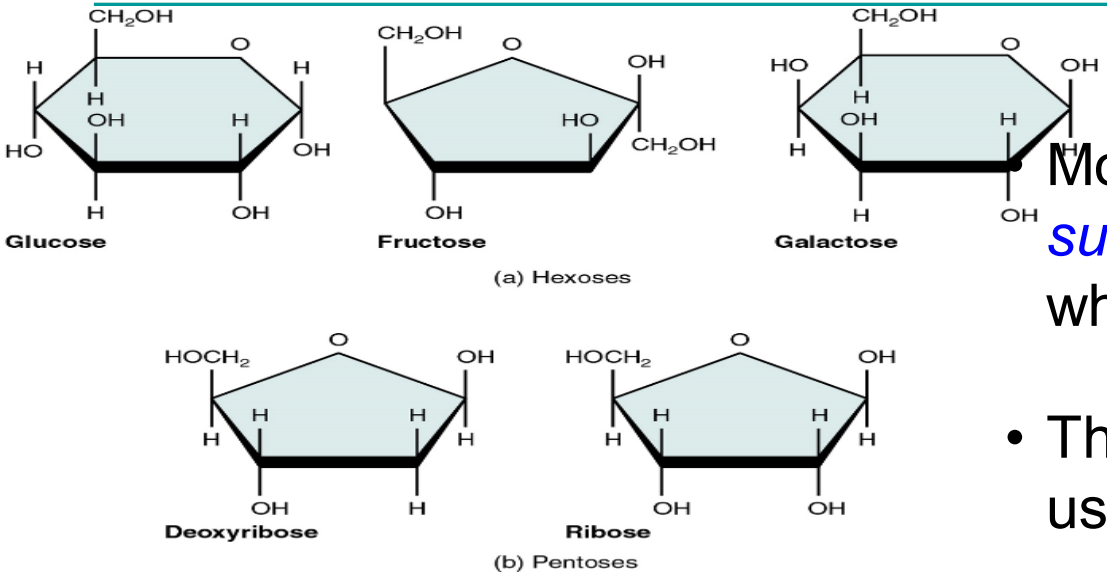
$$C_n(H_2O)_n$$

Function
- Source of energy
- Structural components of body

C:H:O = 1:2:1(ratio)

a. monosaccharides:

the building blocks of all carbohydrates

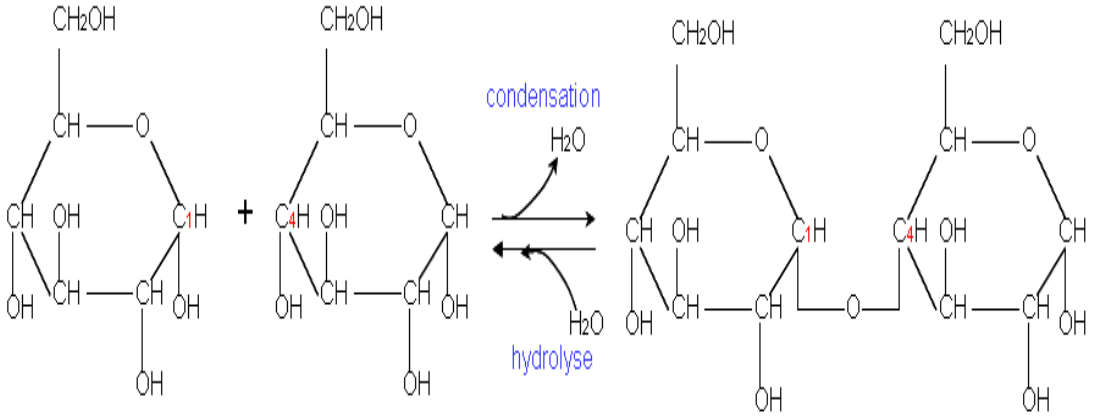


Glucose is the main energy supplying molecule of the body and the sugar carried in your blood

- Monosaccharides are *simple sugars,* the most common of which is glucose ($C_6H_{12}O_6$).
- The number of carbon atoms usually ranges from 3 to 6.
- May exist as a linear chain or as a ring-shaped molecule.
- Although *glucose, galactose, and fructose* all have the same chemical formula ($C_6H_{12}O_6$), they differ structurally and chemically.

b. disaccharides:

two monosaccharides linked by a covalent bond



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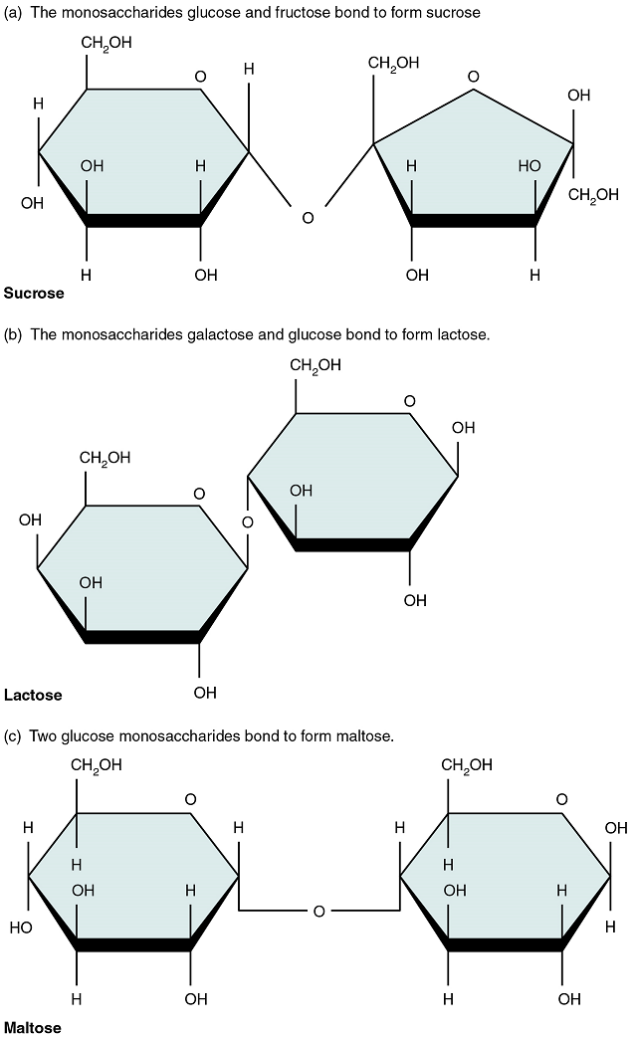
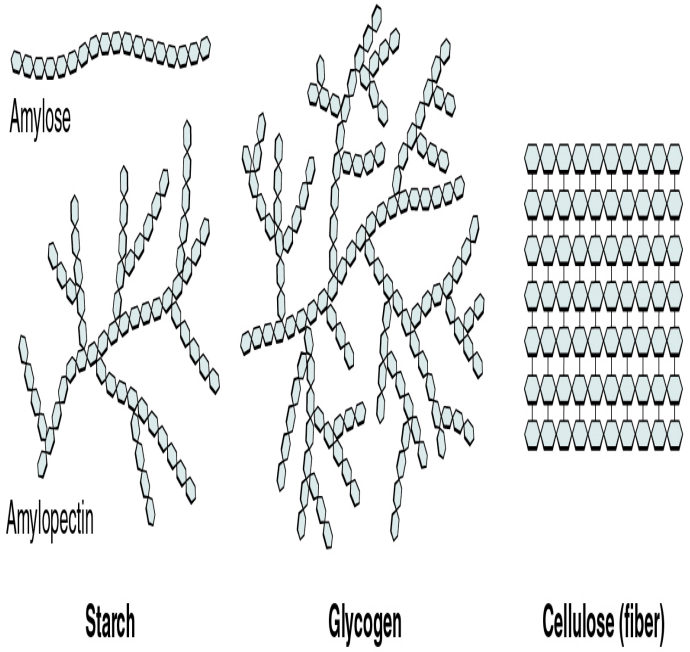


- Disaccharides are formed via dehydration synthesis, and the bond linking them is referred to as a glycosidic bond

- Includes sucrose, lactose and maltose

c. polysaccharides:

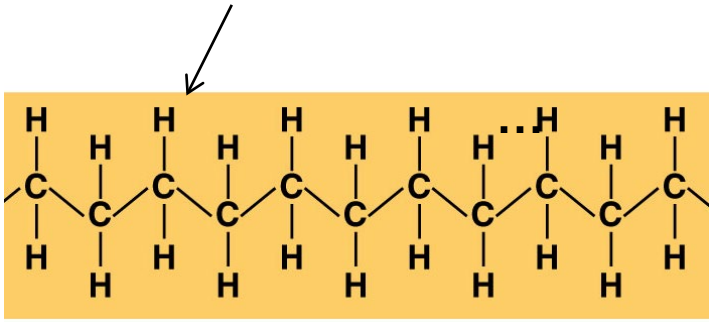
hundreds of monosaccharides linked by covalent bonds



- A long chain of monosaccharides linked together is known as a *polysaccharide.*
- *Starch* is a storage polysaccharide in plants, made up entirely of glucose subunits.
- Glycogen is a storage polysaccharide in in humans and other vertebrates, made up entirely of glucose subunits.
- *Cellulose,* one of the most abundant natural biopolymers, is a structural polysaccharide in plants, made up entirely of glucose subunits.
- *Chitin* is a structural polysaccharide in some animals and fungi, made up of nitrogenous monosaccharides.

2. Lipids:
general properties

- Large vs. small
- Most are insoluble in H_2O (hydrophobic) because of their nonpolar hydrocarbons
- Common in diet & synthesized by body
- Mostly consist of hydrocarbon chains

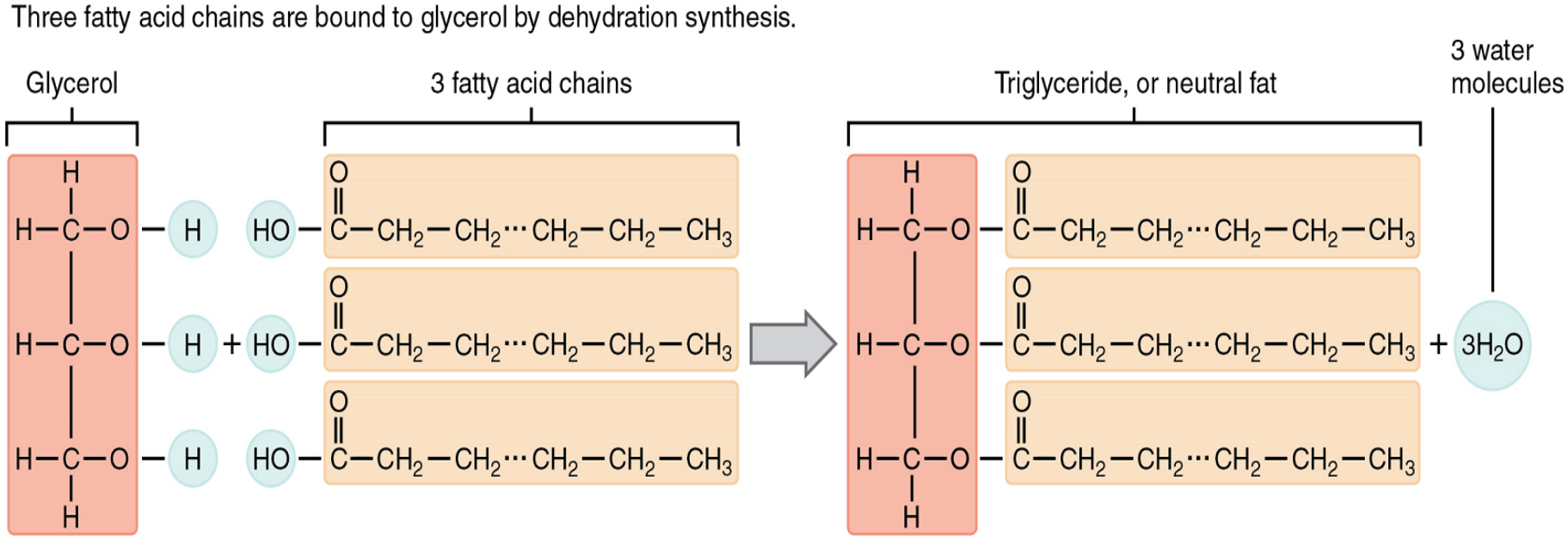


Lipid Properties

1. Composition: CHO (very little O)
2. Water-insoluble because hydrophobic

a. triglycerides

synthesis by dehydration reaction

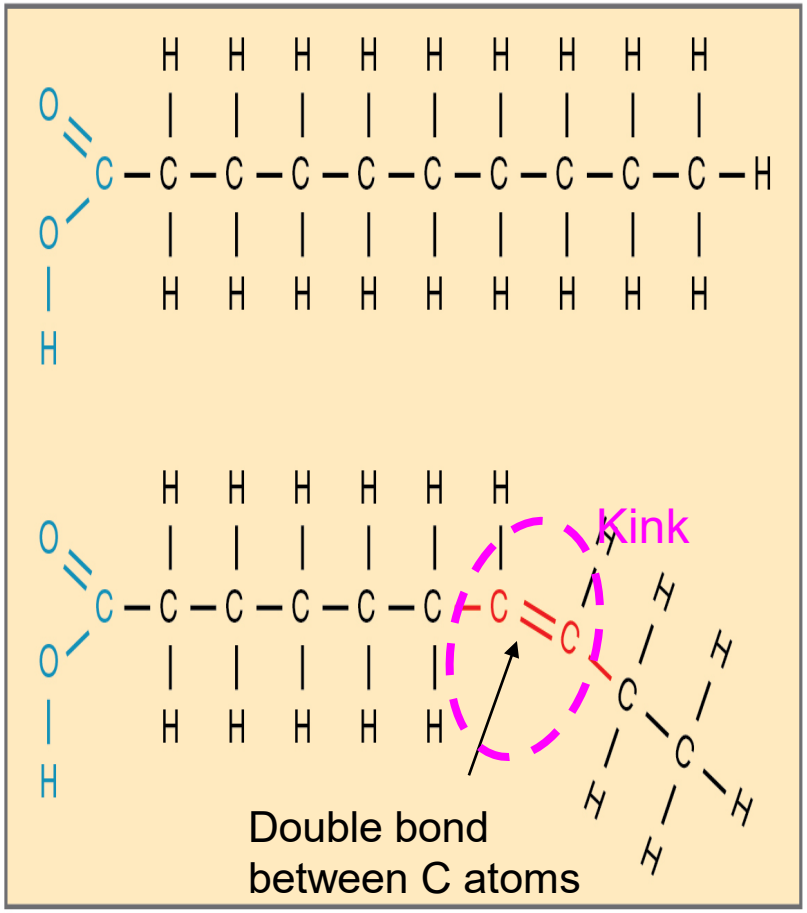


- Most common lipids in your body & diet
- Major lipid storage form in mammals
- Commonly found in adipose tissue
- Great source of energy

- *Triglycerides* consist of a glycerol molecule covalently bonded to three fatty acids.
- Glycerol is an organic compound with three carbon atoms while fatty *acids* have a long chain of hydrocarbons with an acidic carboxyl group on the end.

Saturated *vs.* unsaturated fats

Based upon whether all bonds of carbons are filled with H



Saturated **fatty acid**

Single covalent bonds between carbon atoms.

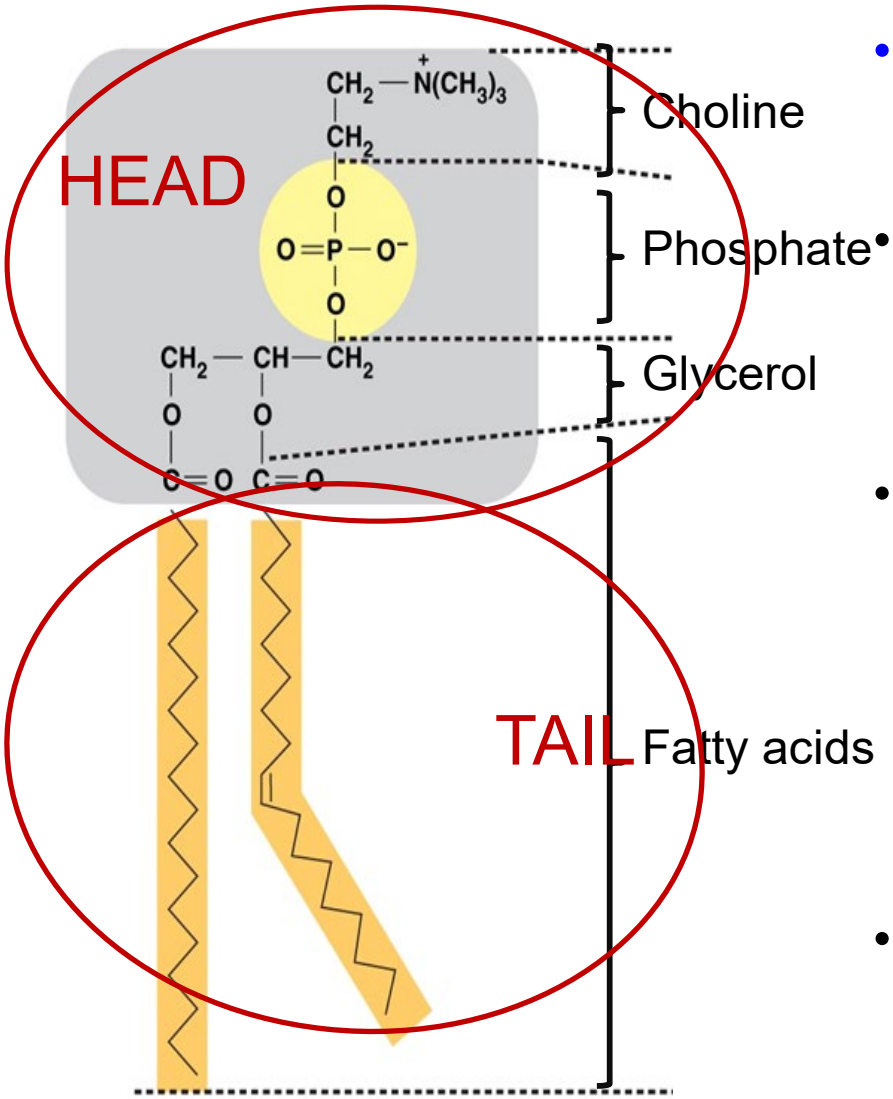
Un**saturated fatty acid**

Single + at least one double covalent bond between carbon atoms.

- Monounsaturated:
  Single C=C double bond & kink
- Polyunsaturated:
  >1 C=C double bond & kink

b. phospholipids:

major components of cell membranes



- *Phospholipids* are the major constituent of the plasma membrane.
- They are composed of a *glycerol* molecule covalently bound to *two fatty acid chains* and a phosphate *group.*
- A phospholipid has a region that is polar and attracts water, called the *hydrophilic* head where the phosphate group is located (other polar groups can be attached to the phosphate group as well).
- A phospholipid also has a *hydrophobic* tail region that are not attracted to water where the fatty acid tails are located.

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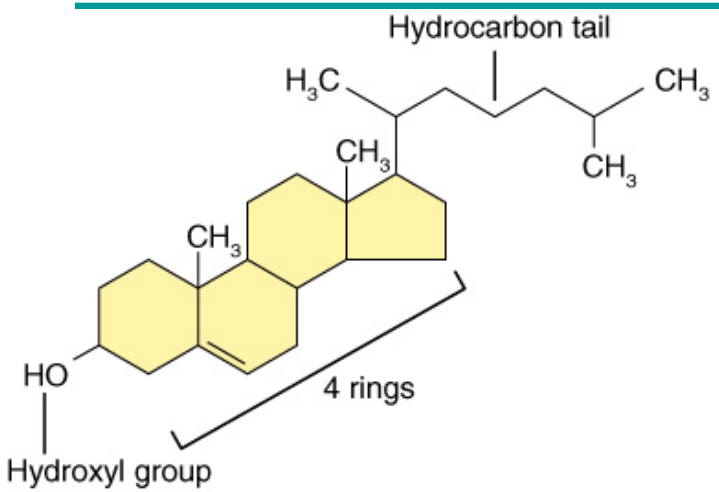
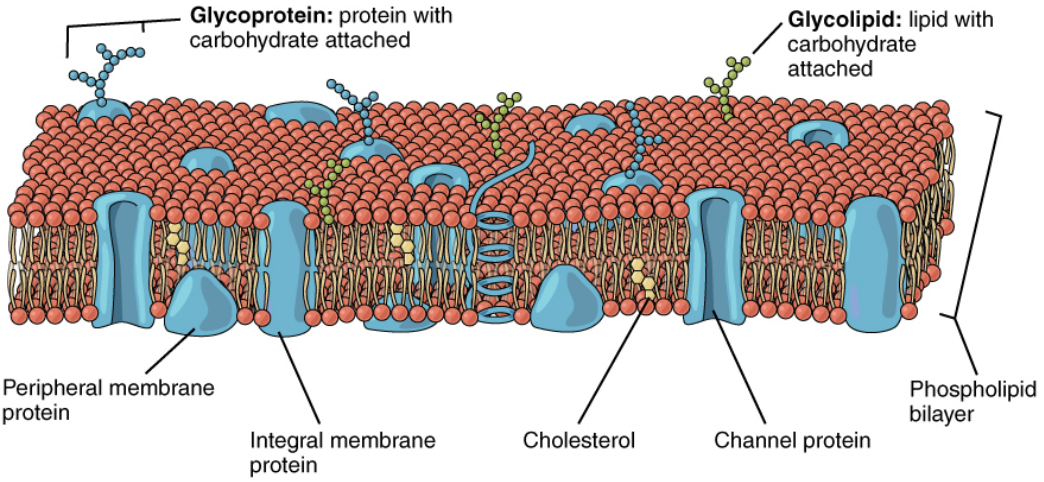
c. steroids:

cholesterol and hormones



(a) Cholesterol



Cholesterol within the animal cell membrane

- Unlike phospholipids and triglycerides, *steroids* have a ring structure.
- Steroids are considered lipids because they are hydrophobic.
- All steroids have *four, linked carbon* rings and several of them have a short hydrocarbon tail.
- Many steroids function as hormones, such as *testosterone* and *estradiol*.

general chemical composition

Carbon	C	present in all proteins
Hydrogen	H	
Oxygen	O	
Nitrogen	N	
Sulphur	S	present in many, but not all proteins
Phosphorus	P	

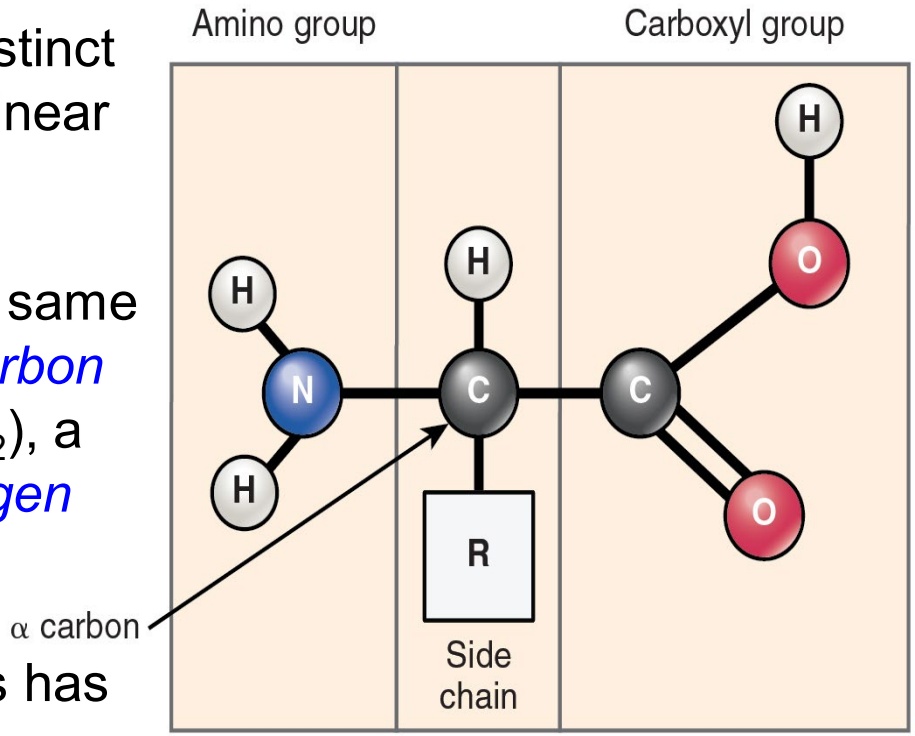
GENERAL CHARACTERISTICS

- Complex organic molecules
- Widely distributed in body
- Different levels of structural organization

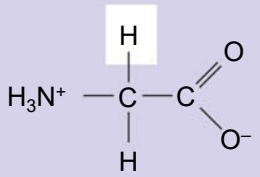
Proteins

amino acids as building blocks

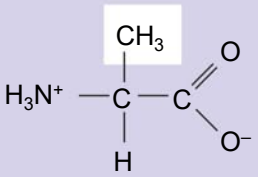
- All proteins are polymers of *amino acid* monomers.
- There are 20 different chemically distinct amino acids that get arranged in a linear sequence.
- Each of the 20 amino acids has the same fundamental structure - a *central carbon atom* bound to an amino *group* (-NH_2), a carboxyl *group* (-COOH), and a *hydrogen atom* (-H).
- Each of the 20 different amino acids has a unique variable *reactive group (*R *Group),* the only structural difference between them.



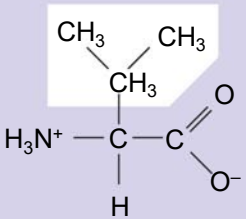
9 non-polar amino acids



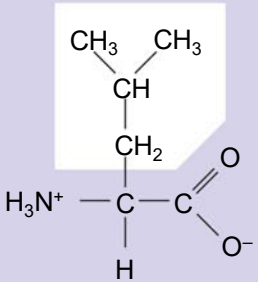
Glycine (Gly)



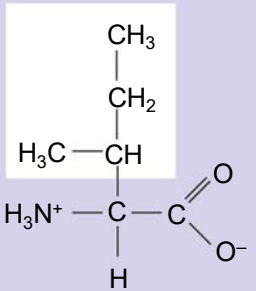
Alanine (Ala)



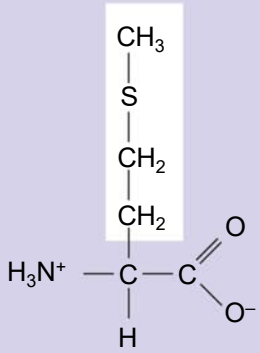
Valine (Val)



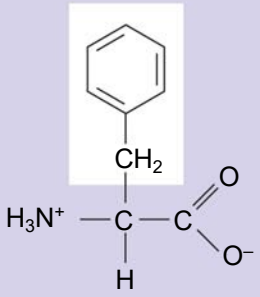
Leucine (Leu)



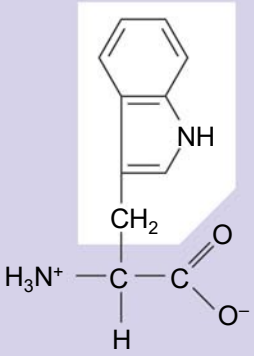
Isoleucine (Ile)



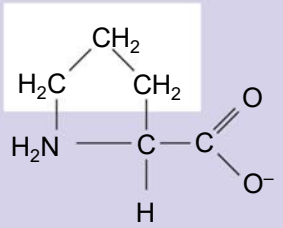
Methionine (Met)



Phenylalanine (Phe)



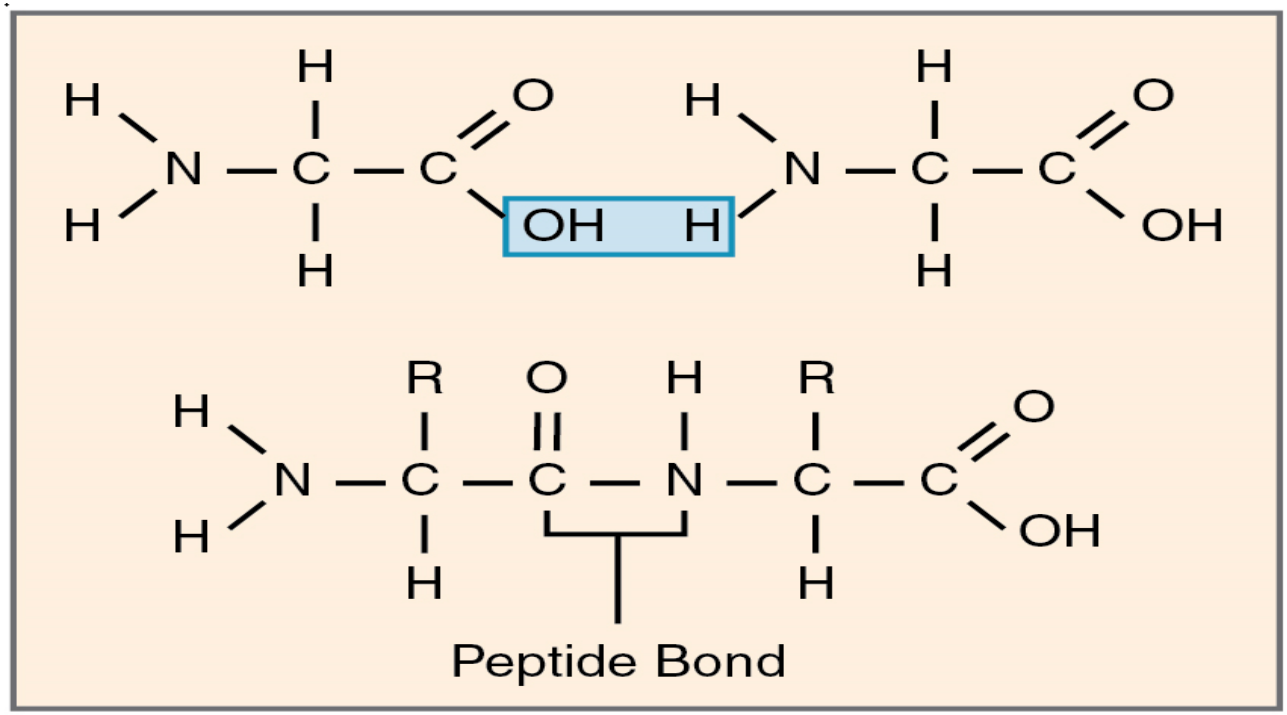
Tryptophan (Trp)



Proline (Pro)

Proteins

amino acids are joined by peptide bonds to make dipeptides

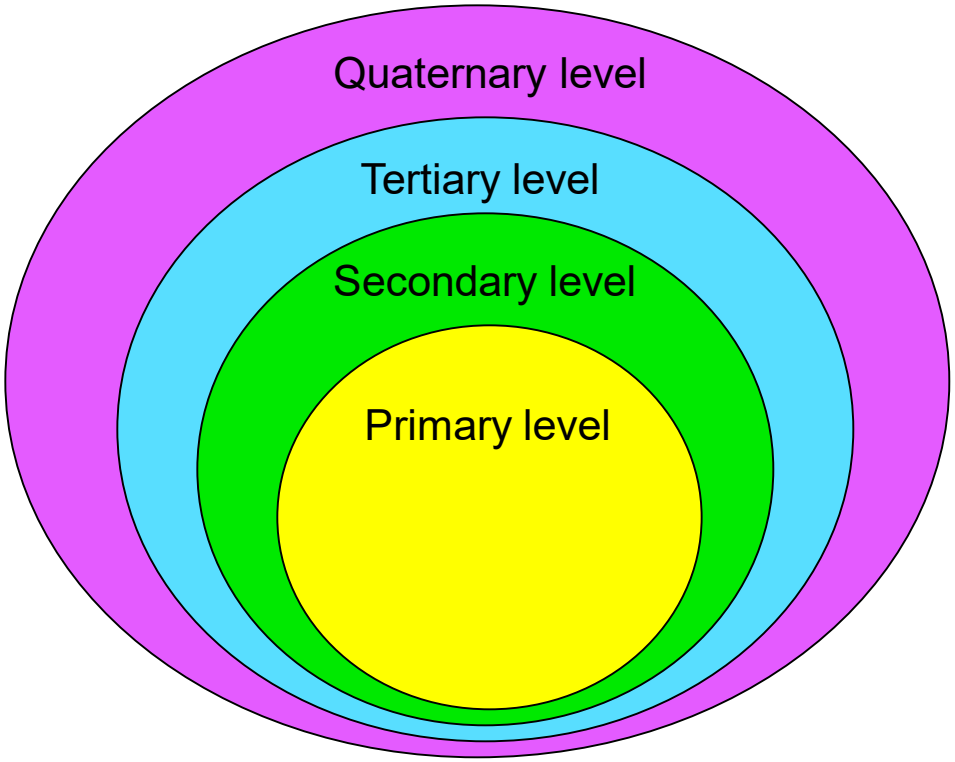


- Bond between two amino acids = peptide bond
- Between carboxyl group of one AA and amine group of another

Protein structure

four levels of organization

Structure determines function.



Proteins

four levels of structural organization

Primary structure = Sequence of amino acids in a polypeptide, which is genetically determined.

Secondary structure = Twisting & folding of a polypeptide into either Alpha Helix or Beta pleated sheets

Tertiary structure = 3D shape, Interactions between neighboring amino acids

Quaternary structure = Overall structure resulting from aggregation of 2 or >2 polypeptides.

Structure is very important for function

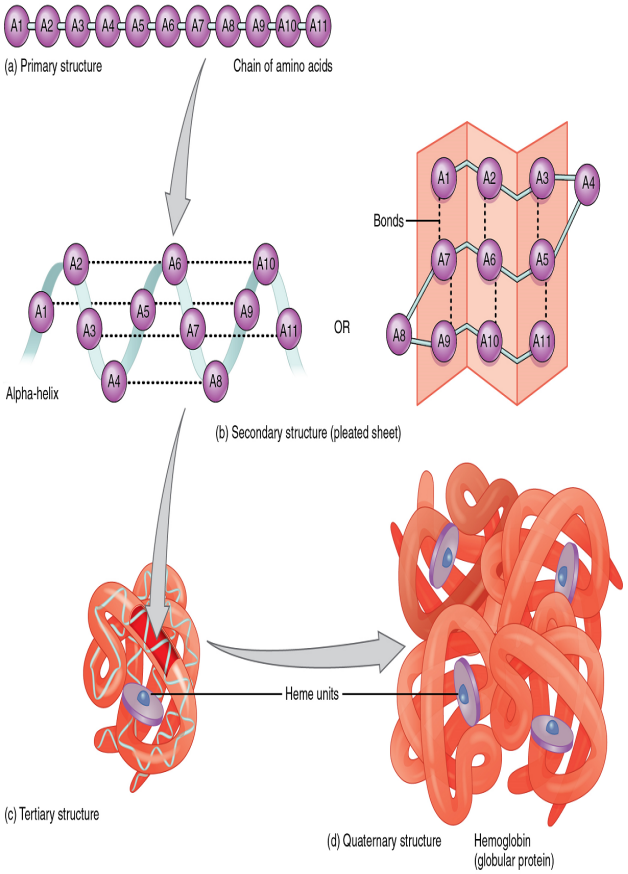


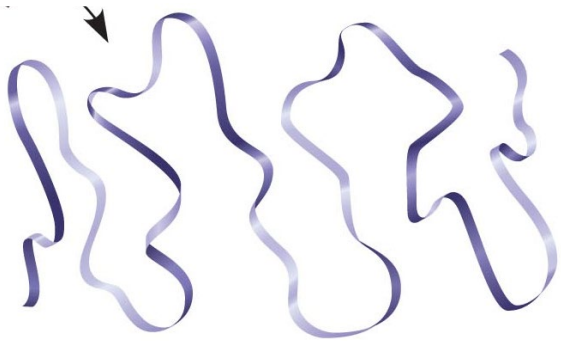
Figure 9

Protein denaturation

Functional protein

Altered environment
(e.g. heat, substances added)

Non-functional protein (denatured)



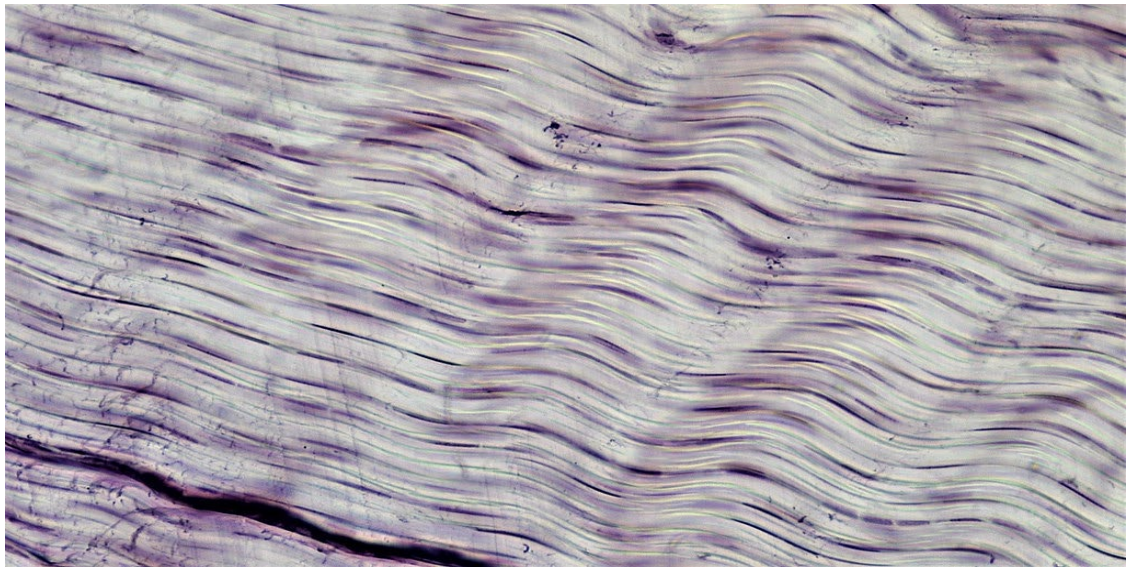
Protein function

Types of Proteins Based on Their Function
I. Structural
II. Regulatory (hormones)
III. Contractile
IV. Immunological
V. Transport
VI. Catalytic
VII. Regulate body fluids
VIII. Molecular chaperones (heat-shock proteins)

Functional groups of proteins

I. Structural i.e. Keratin, collagen

Collagen



Keratin

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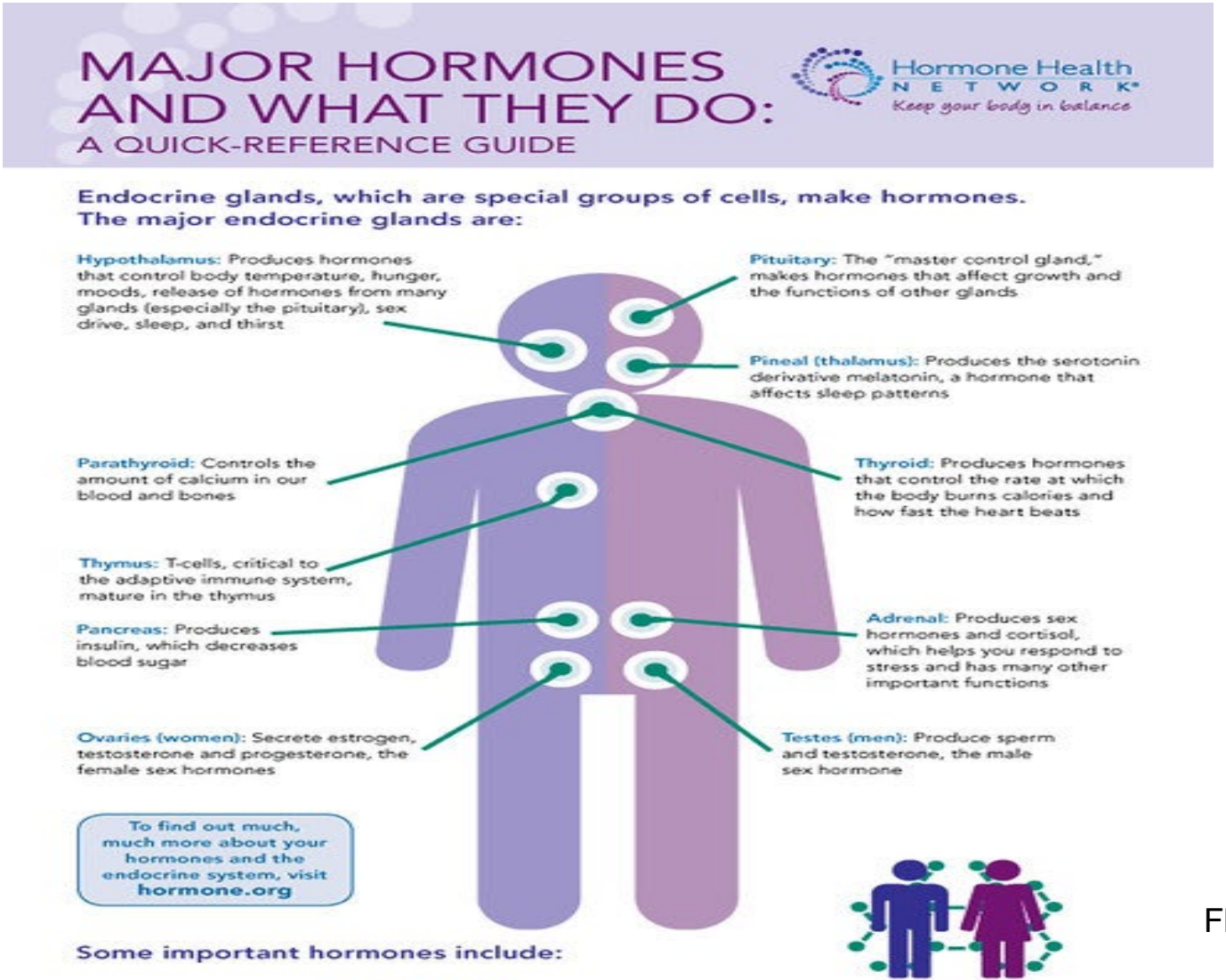
Functional groups of proteins

II. Regulatory (hormones) i.e. Insulin

- Hormones regulate physiological processes



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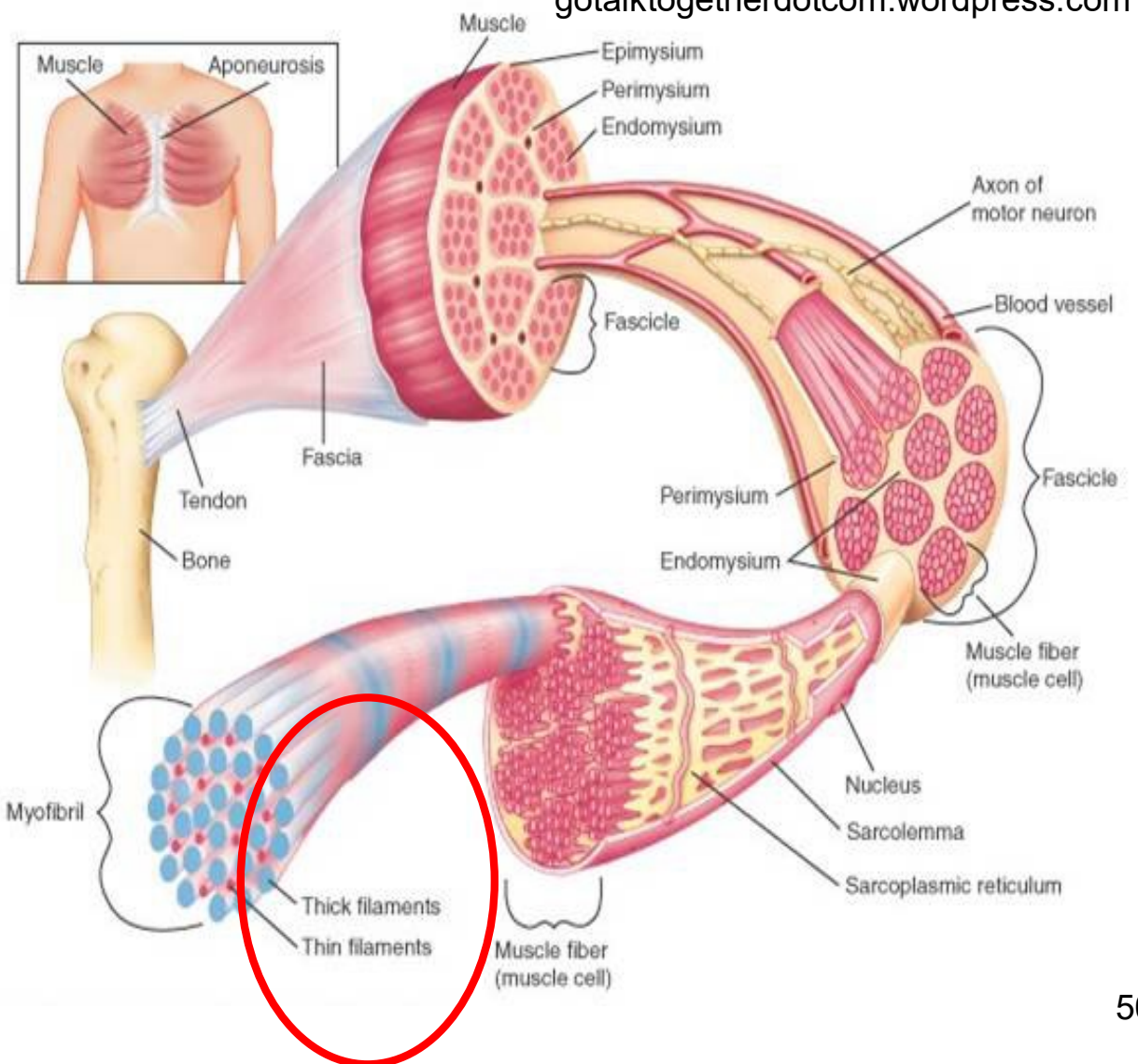
Functional groups of proteins

III. Contractile

i.e. Myosin, actin

- To make movement

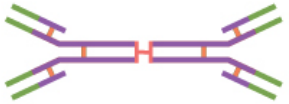
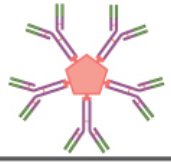
gotalktogetherdotcom.wordpress.com



Functional groups of proteins

IV. immunological (antibodies) i.e. gamma globulin

Examples of Immunoglobulines

Name	Properties	Structure
IgA	Found in mucous, saliva, tears, and breast milk. Protects against pathogens.	
IgD	Part of the B cell receptor. Activates basophils and mast cells.	
IgE	Protects against parasitic worms. Responsible for allergic reactions.	
IgG	Secreted by plasma cells in the blood. Able to cross the placenta into the fetus.	
IgM	May be attached to the surface of a B cell or secreted into the blood. Responsible for early stages of immunity.	

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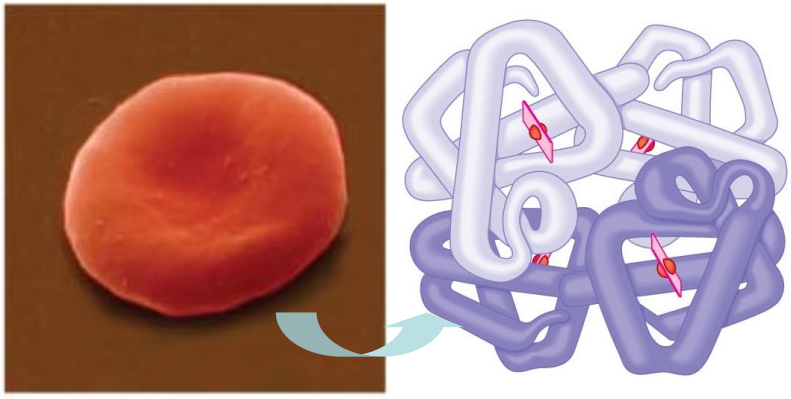
- Aid in your body's response to pathogens

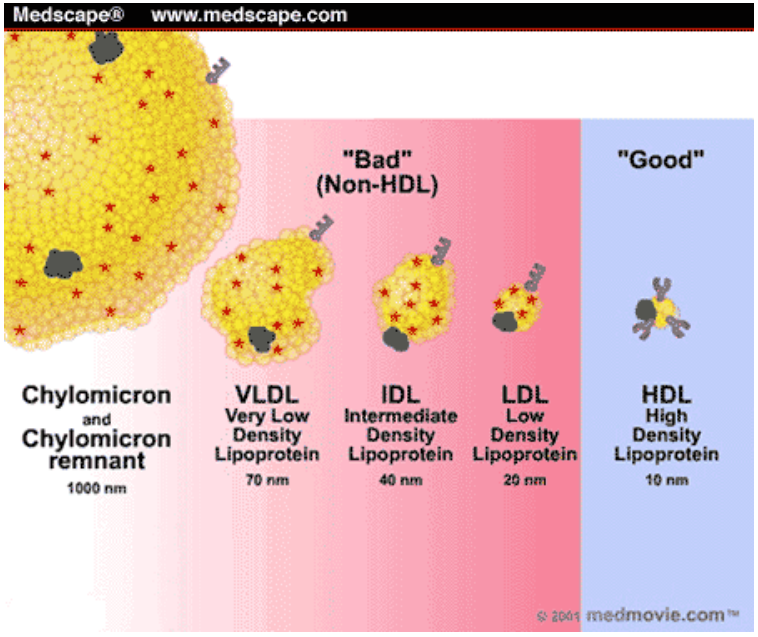
Functional groups of proteins

V. transport i.e. Hemoglobin

Hemoglobin transports oxygen

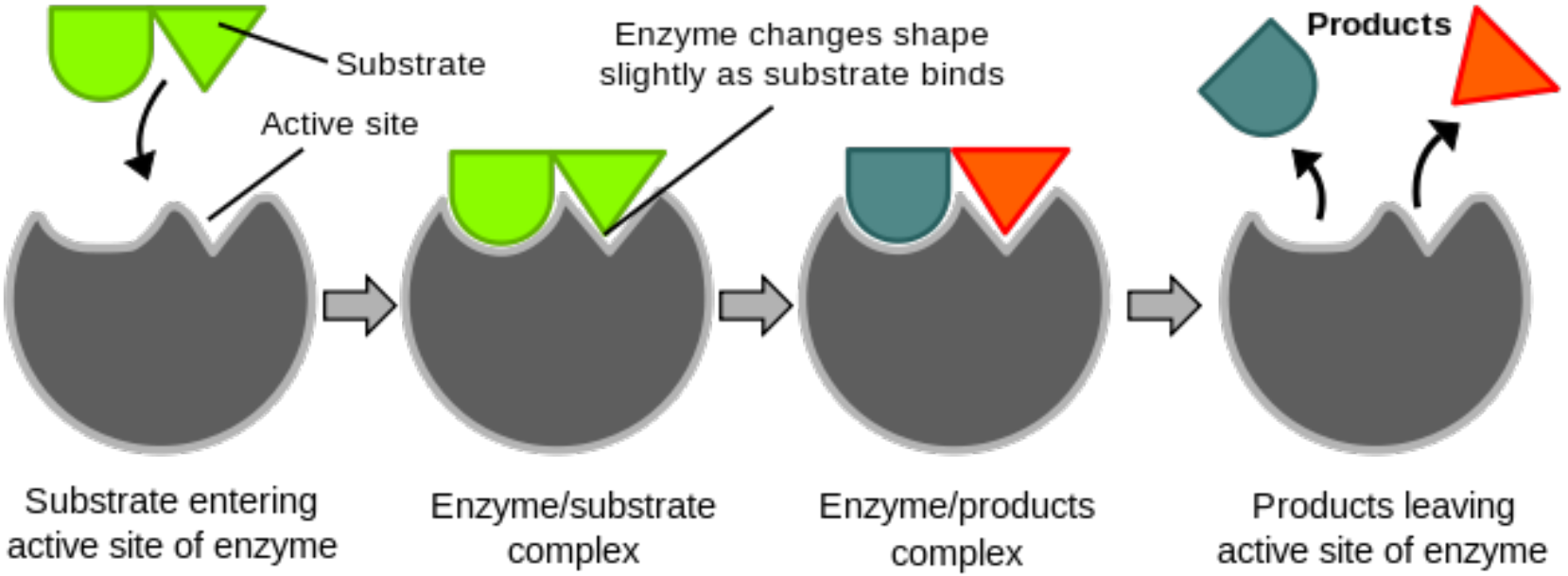


Lipoproteins transport lipids



Functional groups of proteins

VI. catalytic (enzymes) i.e. Amylase, lipase, lactase



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Examples of enzymes [substrates]	
• Sucrase	[sugar]
• Amylase	[starch]
• Lactase	[lactose]
• Lipase	[lipids]

- Most important function; regulate biochemical reactions

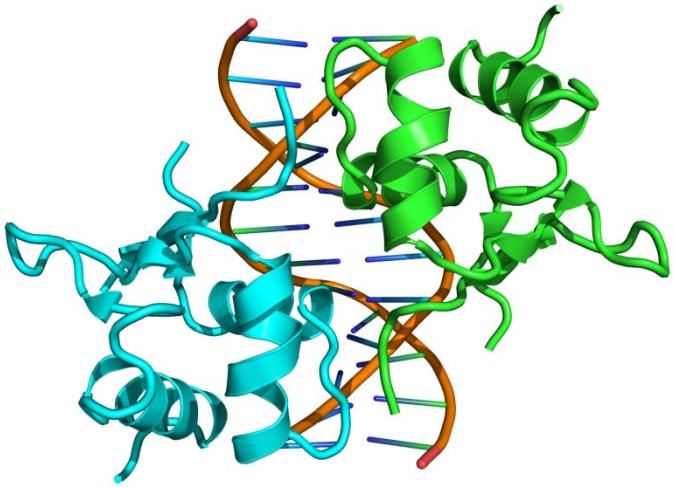
Functional groups of proteins

VII. Regulate body _fluids_ i.e. albumin

Help **regulate body fluid pH** by reversibly functioning as acids or bases, thus acting as buffers

Functional groups of proteins

VIII. Molecular _chaperones_ i.e heat-shock proteins



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Nucleic acid

Always present

C Carbon
H Hydrogen
O Oxygen
N Nitrogen
P Phosphorus

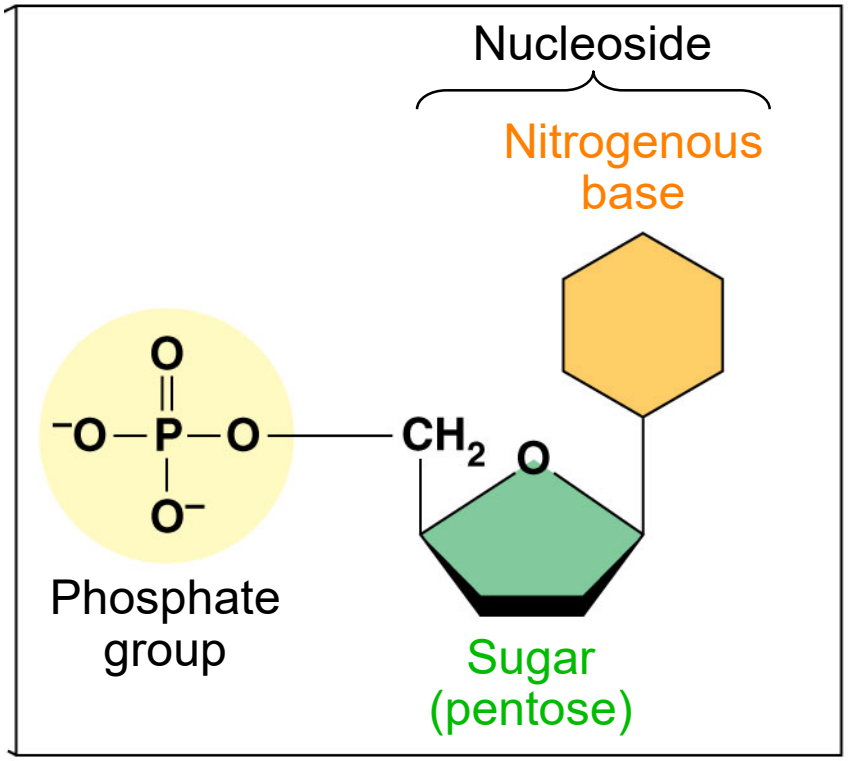
GENERAL CHARACTERISTICS

- Found inside body cells
- Very long chain of nucleotides
- Nucleotides = monomers
- Nucleic acid = polymer

Nucleotide

basic structure

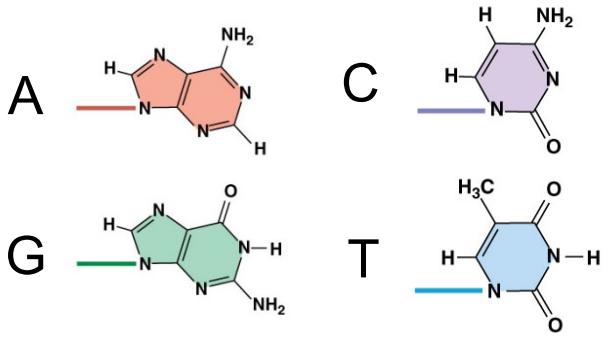
- *Nucleic acids* carry the genetic blueprint of a cell and carry instructions for the functioning of the cell.
- The two main types of nucleic acids are DNA *(deoxyribonucleic acid)* and RNA *(ribonucleic acid).*
- DNA is the genetic material found in all living organisms; it never leaves the nucleus.
- RNA is mostly involved in the synthesis of proteins, being produced in the nucleus and then exiting in order to function.



Types of nucleic acids

Deoxyribonucleic acid (DNA)

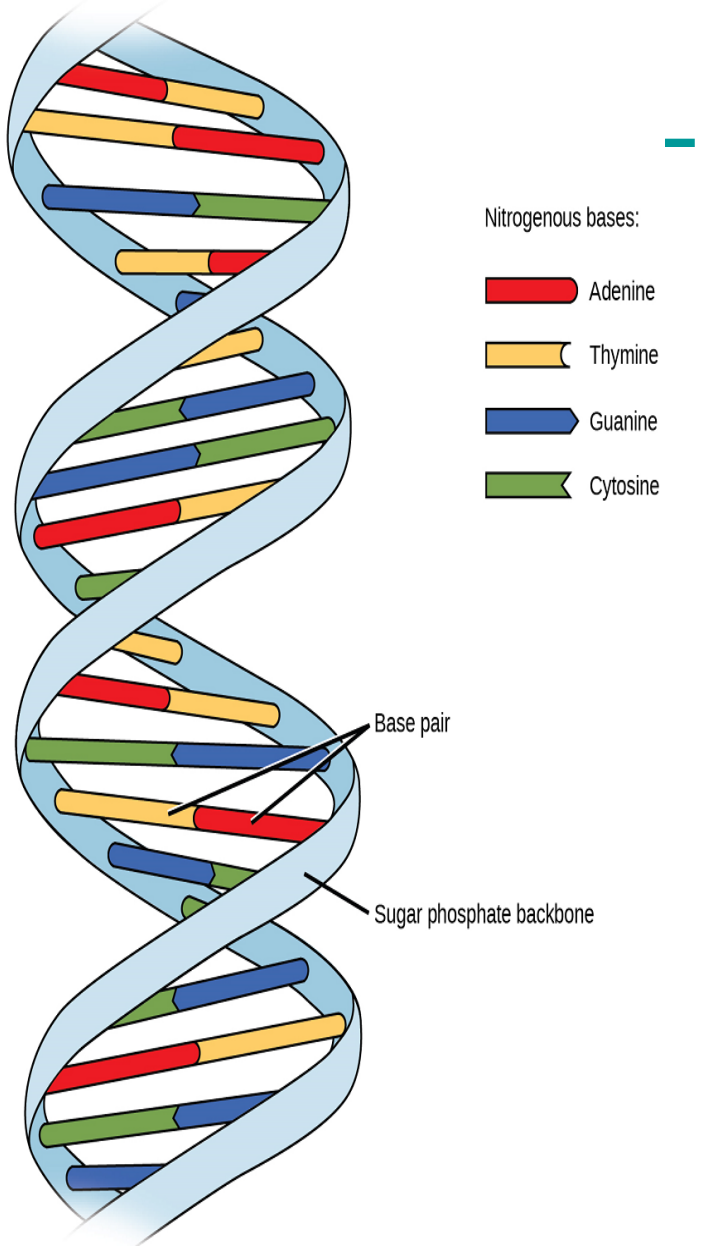
Structure	Role & functions
Double-stranded Sugar: Deoxyribose Bases: A, T, C, G	- Store hereditary material - Contain genes - Blueprint for synthesis of proteins - Direct protein synthesis via RNA



DNA

double helix

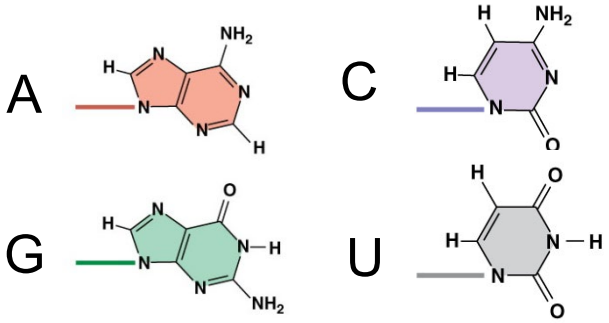
- The structure of DNA is that of a double-helix.
- DNA is composed of two polymers (strands) of nucleotides formed with bonds between phosphate and sugar groups of adjacent nucleotides.
- The _two_ strands are held together by hydrogen bonds between the nitrogenous bases of each strand.
- The two strands coil around one another, explaining the “double-helix” name for the DNA molecule.



Types of nucleic acids

Ribonucleic acid (RNA)

Structure	Role & functions
Single-stranded Sugar: Ribose Bases: A, U, C, G	- Carry genetic information from DNA in nucleus to cytoplasm - Perform protein synthesis on ribosomes - 3 main types with specific roles: *mRNA, rRNA, tRNA*



Role of RNA

Example: messenger RNA (mRNA)

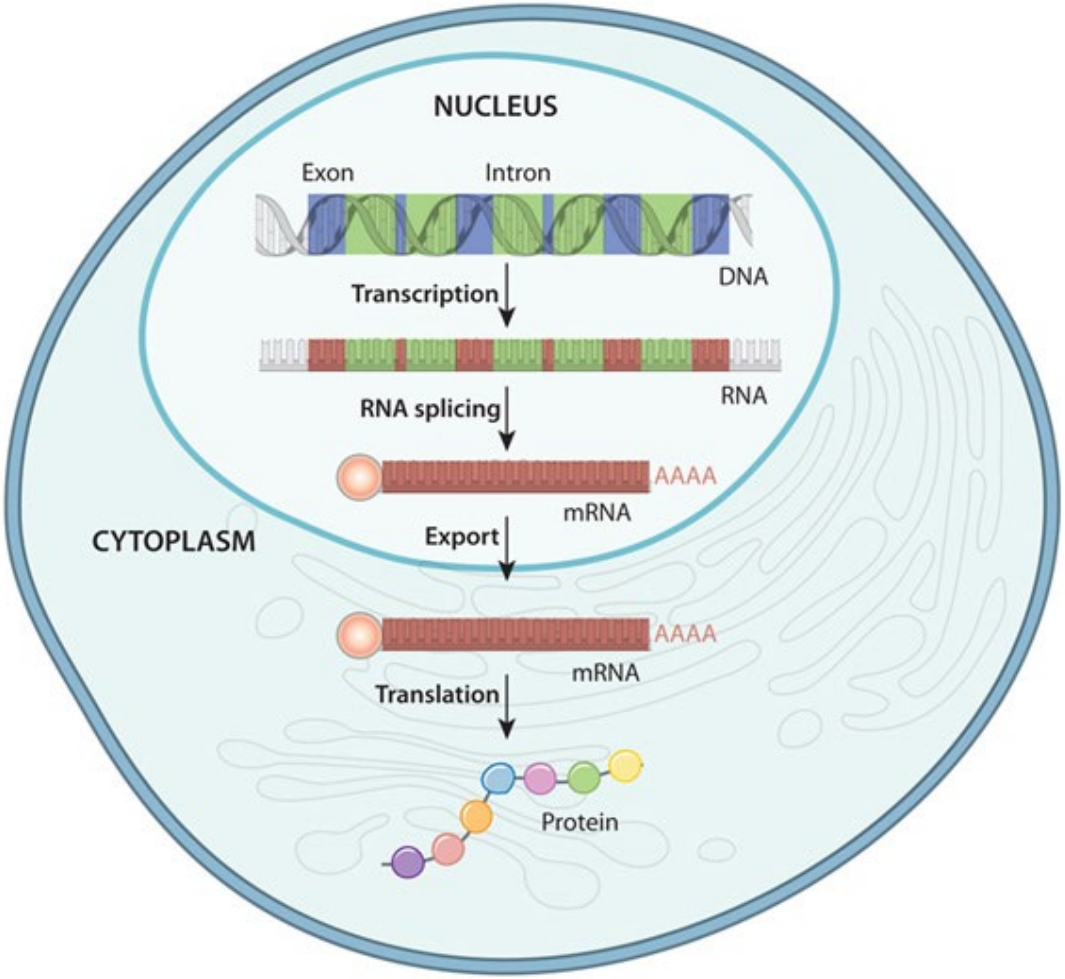
DNA

↓

mRNA

↓

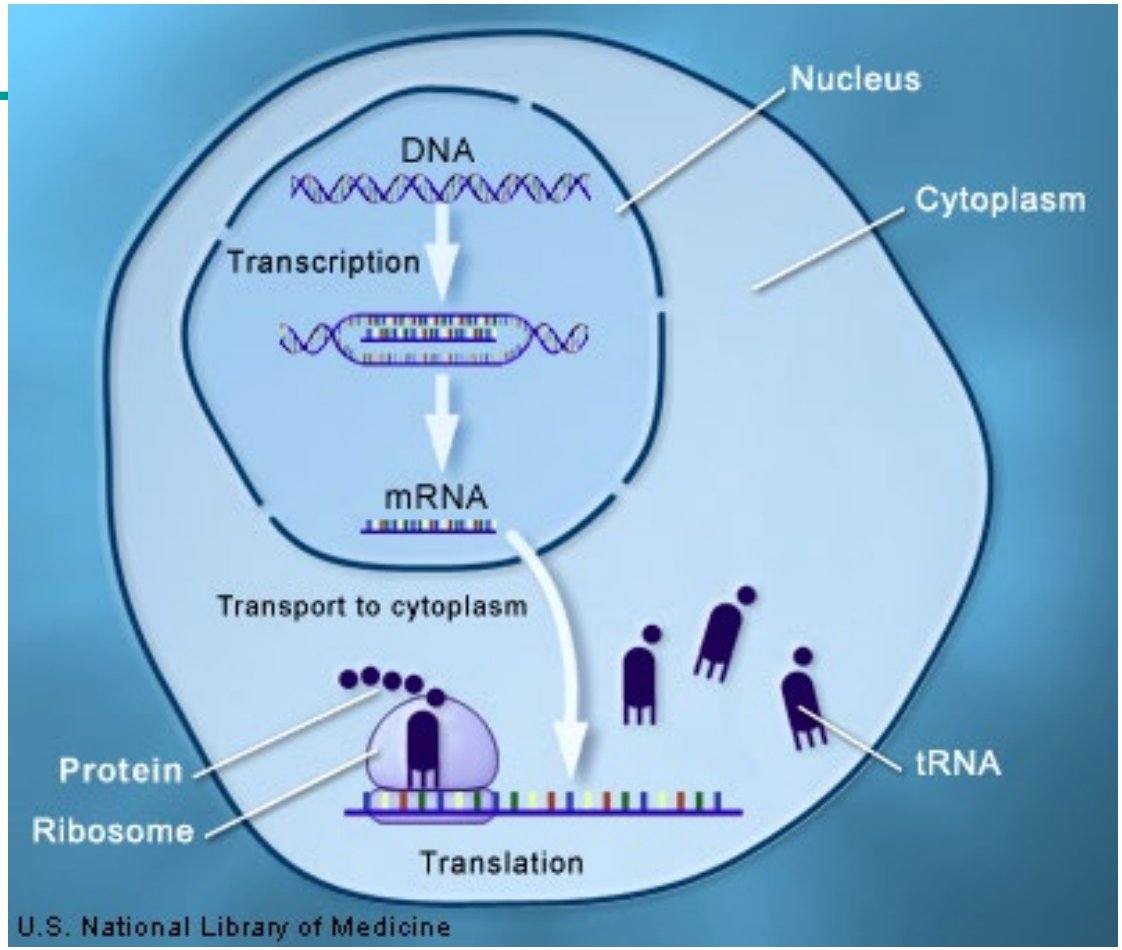
Protein



Nature.org

Function of nucleic acids

how genetic information flows



Main Types of RNA

1. messenger RNA (mRNA)
2. transfer RNA (tRNA)
3. ribosomal RNA (rRNA)

DNA → mRNA →protein

DNA= hereditable material
RNA = moves information, helps to make proteins

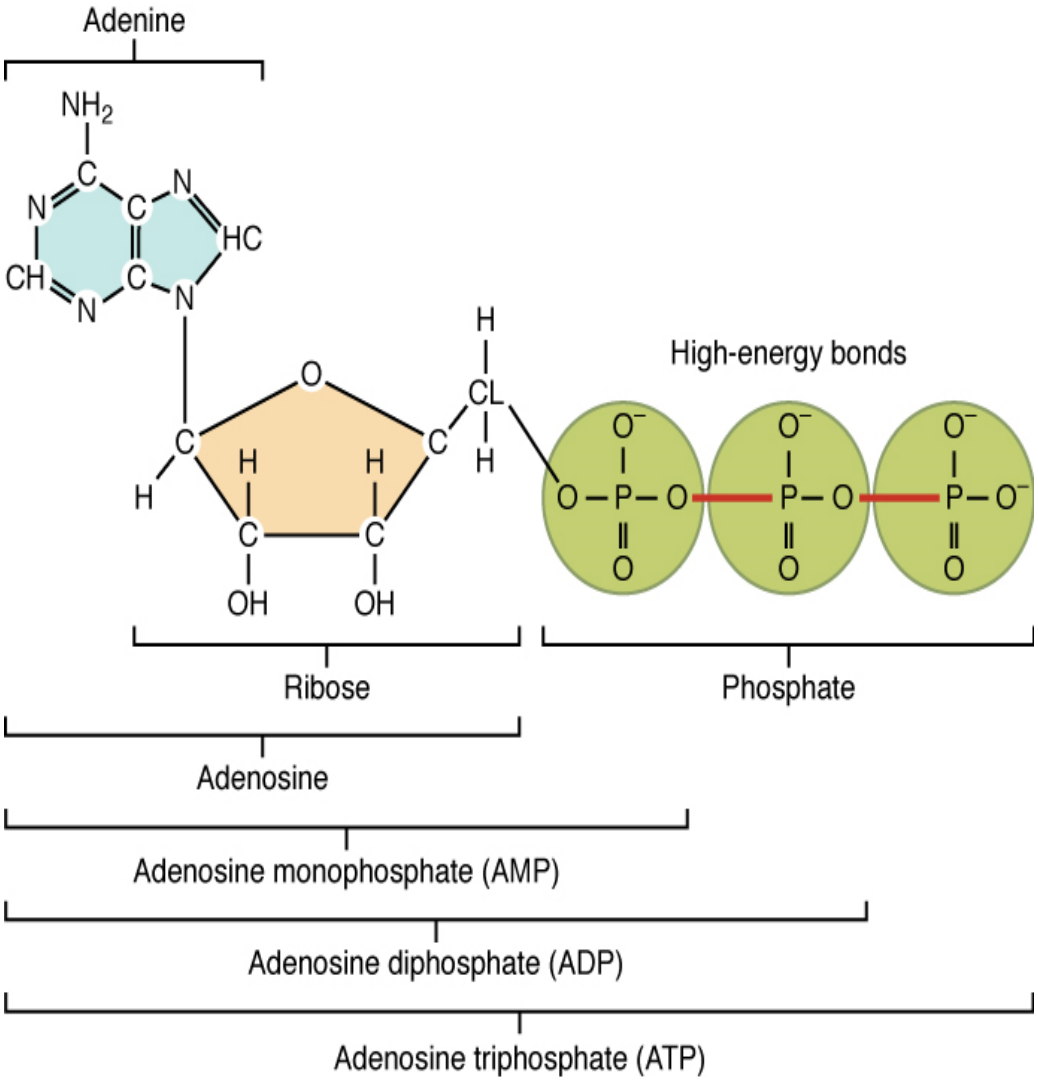
Nucleic acids

RNA and DNA

	Deoxyribonucleic Acid (DNA)	Ribonucleic Acid (RNA)
Pentose Sugar	Deoxyribose	Ribose
Nitrogen bases	Adenine, Guanine, Cytosine, Thymine	Adenine, Guanine, Cytosine, Uracil
Strands	Double-stranded	Single-stranded
Function	Stores genetic information in nucleus	Carries DNA information to cytoplasm

Adenosine triphosphate (ATP)

A nucleotide as energy currency; structure

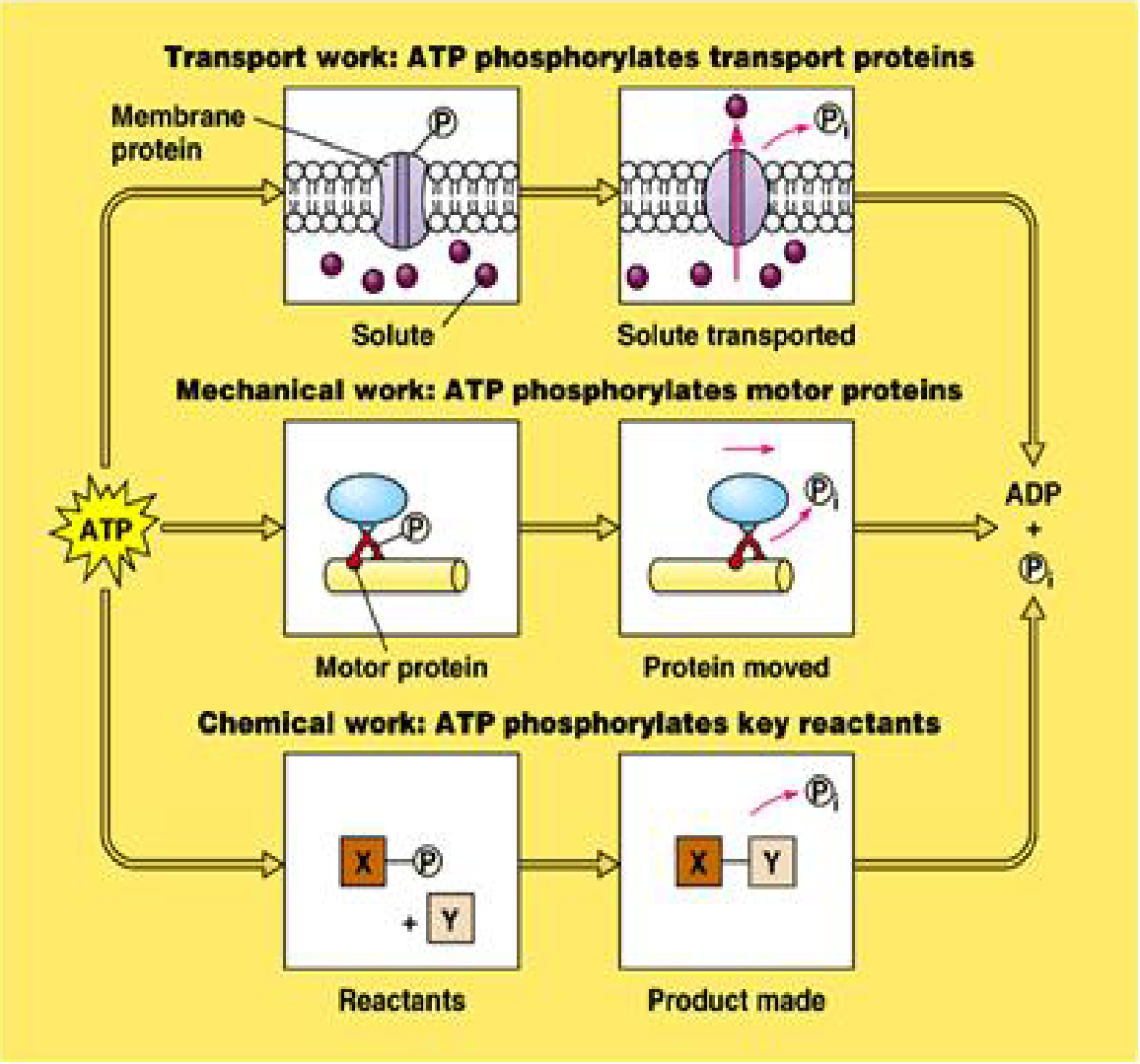


General characteristics

- Our body's energy currency
- Role: temporarily store & transfer energy released by catabolic reactions
- Contains high-energy bonds between phosphate groups

Adenosine triphosphate (ATP)

A nucleotide as energy currency; uses in a cell



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Biochemistry

Objectives

1. Describe the chemistry of carbon.
2. Describe the structure and function of carbohydrates.
3. Describe the structure and function of lipids.
4. Describe the structure and function of proteins.
5. Describe the structure and function of nucleic acids.