Saturday, October 3, 2020

BIO1109: Midterm 1 – October 19, 2020

Chapter 1: Introduction

BIOLOGY

Scientific extension of the human tendency to feel connected to and curious about all forms of life. Innate attraction to life in its diverse forms: biophilia

Biology leads us to different kinds of environments

Ecosystems

Laboratories

Microscopic world

History and

Evolution of life

•Chapter 1: Themes in the study of life

Inquiring about life

•Life is best defined by several basic characteristics shared by all organisms. Like nonliving things, organisms are composed of chemical elements.

•Organisms obey the same laws of chemistry and physics that govern every thing within the universe.

•The characteristics of life, will provide great insight into the unique nature of organisms and will help us distinguish living things from nonliving things.

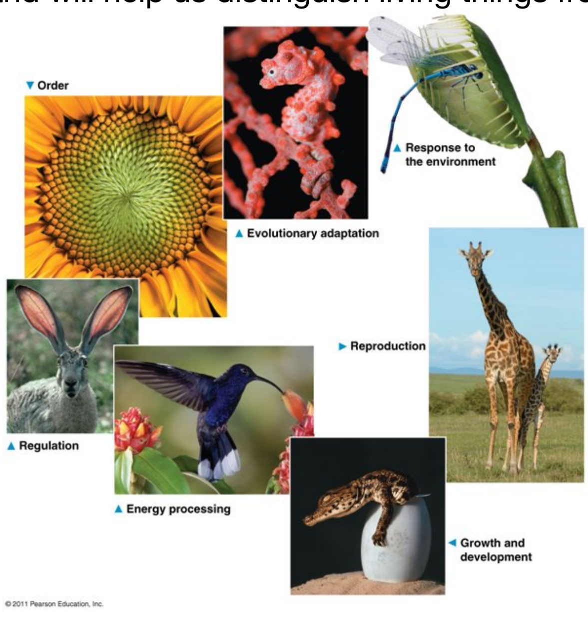


FIGURE 1.3: Some properties of life

Living things are organized

•The cell is the basic unit of structure and function of all living things:

–It is autonomous and uses energy (metabolism);

–It is present in all organisms:

•in Unicellulars: cells live independently

•in Multicellulars: cells combined to form tissues

–It can reproduce and grow.

All characteristics of living things can be observed at the cellular level

Levels of biological organization

atom

molecule

cell

tissue

organ

organ system

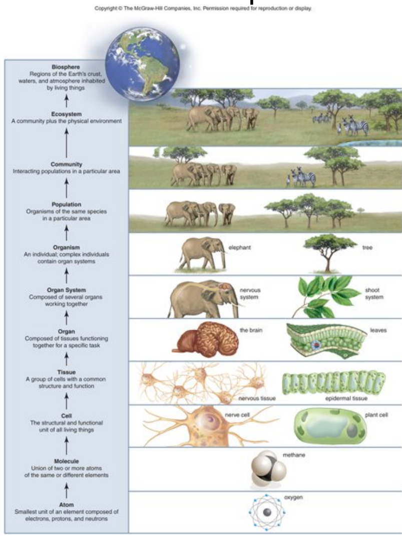
organism

population

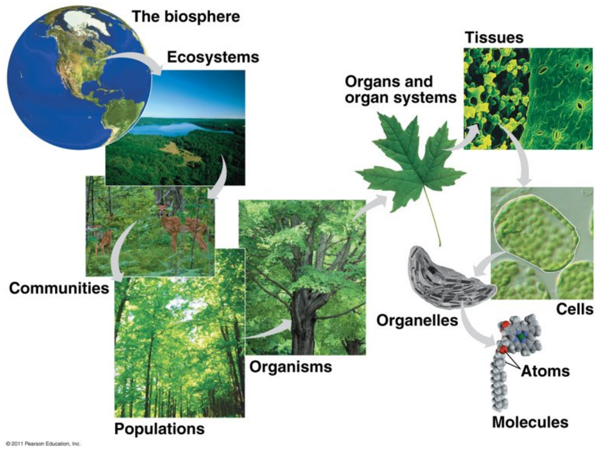
community

ecosystem

biosphere



LEVELS OF BIOLOGICAL ORGANIZATION



Living things acquire materials and energy

•Material (matter)

–Everything that takes up space and has mass;

–Outside source of nutrients.

•Energy

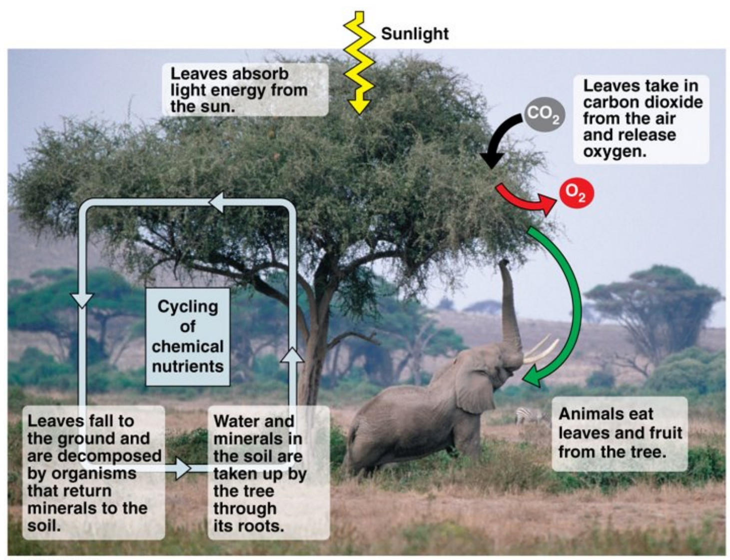
–Capacity to do work, which is needed to maintain organization of the cell and the organism.

•Metabolism

–All chemical reactions (degradation or synthesis) that occur in a cell.

•Photosynthesis

–Process by which solar energy is transformed into chemical energy of organic nutrient molecules



Interaction of tree with other organisms

Homeostasis:

state of biological balance

•Homeostasis is not just a static state:

–This is the capacity to maintain a dynamic equilibrium within a tolerance range and it is achieved through a variety of automatic mechanisms that compensate for internal and external changes

-Many biological factors must remain within a tolerance range, despite

changes in the environment:

- body temperature
- blood pH
- sap composition
- blood pressure
- moisture level
- level of glucose and calcium...

Homeostasis also exists in ecosystems:

Ex.: rodent populations remaining constant by the action of predators (snakes, coyotes, foxes and hawks)

Example of homeostatic mechanism

in a small ecosystem (human body)

After a meal:

blood glucose

insuline secretion (pancreas)

absorption of glucose by the liver and muscles

blood glucose

Insuline secretion

Living things respond

•Response

–Ability to detect changes in the environment and react to these changes:

•It allows organisms to interact with their environment as well as with other organisms:

–Examples:

»In unicellulars, the beating of microscopic tails moving them away from light or chemicals;

»In multicellulars: 1) a vulture detecting food kilometers away; 2) a butterfly sensing the approach of fall and flying south where food is still abundant; 3) leaves of a land plant turning toward the sun; 4) a deer darting toward safety;

•It helps ensure survival and allows to carry on daily activities

–All activities are termed behavior: searching for food and shelter; mating; hunting; defense

Living things reproduce and develop

•Reproduction is the ability to make another organism similar to itself:

–Unicellulars (Bacteria and Protists) simply split in two (binary fission);

–Multicellulars (Most Fungi, Plants and Animals) reproduce by pairing a sperm from one partner and an egg from the other partner:

•The union leads to a zygotic cell (fertilized egg) and is followed by many cell divisions. This results in an immature stage, which grows and develops through various stages to become an adult.

•An embryo develops into a specific organism because of the bleueprint inhirited from its parents:

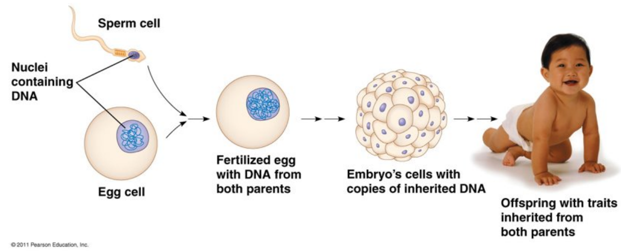
–This blueprint for an organism's metabolism and organization is encoded in genes

•Genes are segments of long molecules of DNA:

–Genes can be passed on to the next generation;

–Unique collection of genes ensures unique characteristics. of an individual;

–DNA can undergo mutations (changes) which may be passed on to the next generation which helps create a huge diversity of life



Inherited DNA directs development of an organism

Living things have adaptation

•Adaptations

–Modifications (in structure, function and behavior) that make organisms better able to function in a particular environment.

•Evolution

–Long process by which populations of organisms change over the course of many generations to become more suited

to their environment.

•Natural selection: the natural environment selects organisms, so that only those who are able to modify are able to survive and reproduce —> fitness

•Species

–Group of individuals capable of interbreeding and producing fertile offspring.

•When two populations become so different under modifications of the environment, they make two different species

A population of organisms is the product of evolution and will constantly change

Natural selection

- Following changes in the environment;

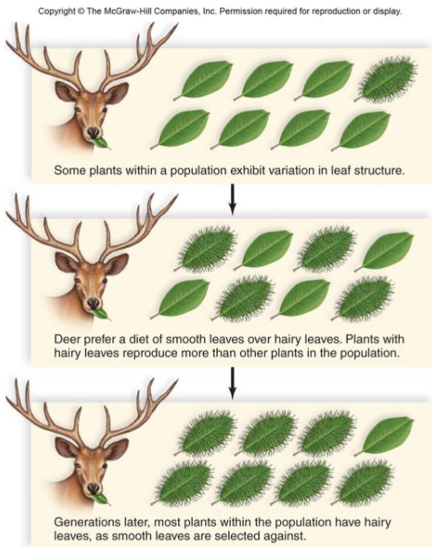
- Way by which the natural environment selects the organisms: those who are better adapted are able to survive and reproduce

- structure

- function

- behavior

New characters are brought about by genetic variation and mutations and can be passed on to the offspring.



Examples of adaptation: modification in structure under a predation stress

Form fits function

Examples

Aerodynamically efficient shape of a bird's wing

- With appropriate external contours;
- With a skeleton contributing to flight: bones that are strong and at the same time have a light honeycomb structure.

Long extensions of the neurons (nervous cells)

-Which rapidly transmit nervous impulses to glands or muscles, making these cells well structured for communication.

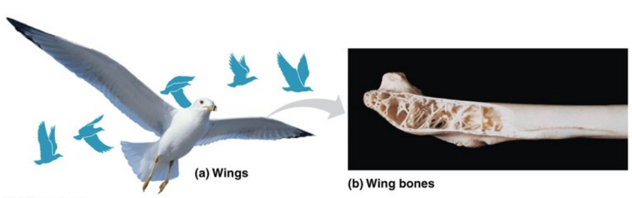
Inner membrane of a mitochodrion (site of cellular respiration)

-Which has many infoldings: many molecules (among which are enzymes) are embedded in this inner membrane and can carry out many of the steps in cellular respiration: more enzymes are packed in a minute container compared to an inner membrane without infoldings

Figure 1.7 (first canadian edition)

Form fits function in a gull's wing

a) The shape of a bird's wing and b) the structure of its bone make flight possible



The cells: basic units of structure and function

-All cells are capable or reproduction

-Cells are autonomous and capable of performing all activities of life

(growth, metabolism, homeostasis…)

-All organisms are composed of cells (uni- or multicellular organisms)

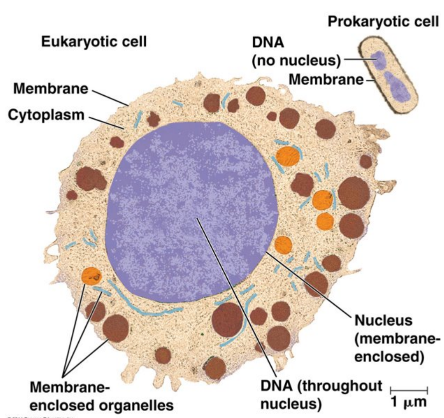
The two major kinds of cells

Eukaryotic cells

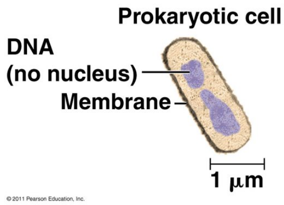
- Complex structure
- Enclose many kinds of membrane-bounded organelles
- DNA associated with proteins (histones)
- True nucleus surrounded by a nuclear envelope

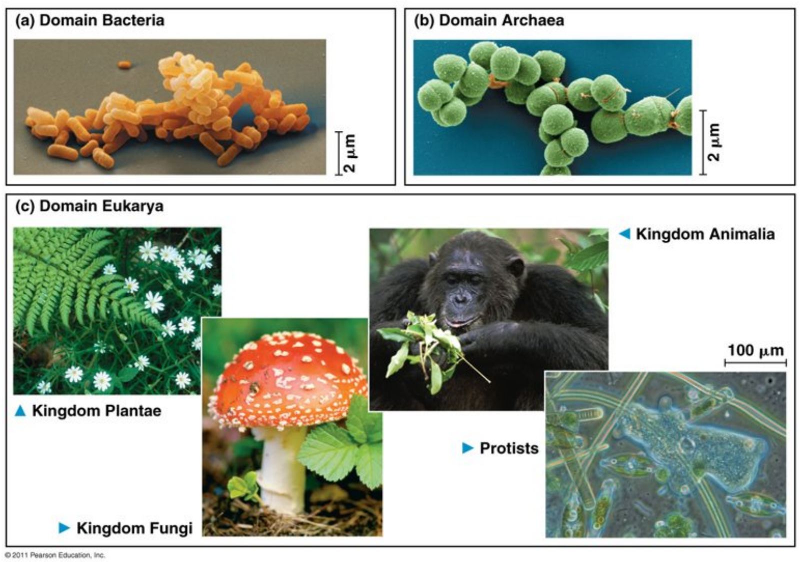
Prokaryotic cells

- Simple structure
- Do not enclose many kinds of membrane-bounded organelles but have ribosomes
- DNA not associated with proteins
- Do not have a true nucleus (no nuclear envelope)

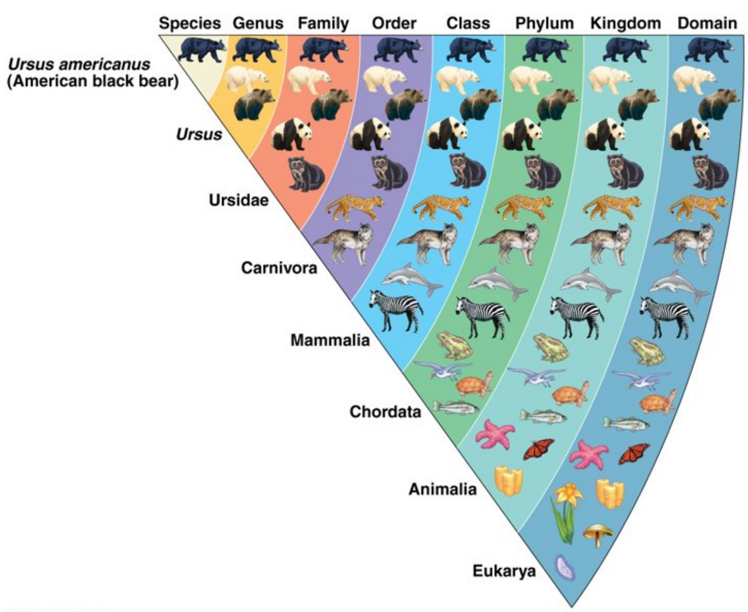


Contrasting prokaryotic and eukaryotic cell in size and complexity





The three domains of life



Classifying life: species that are closely related are place in a same group

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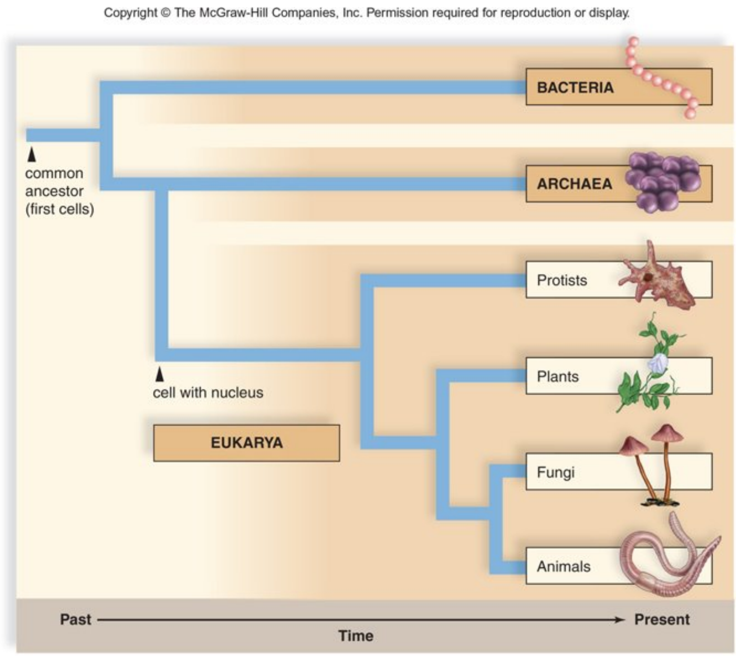

Development of new lineages from a common ancestor

Table 1.1 Levels of Classification

Category	Human	Corn
Domain	Eukarya	Eukarya
Kingdom	Animalia	Plantae
Phylum	Chordata	Anthophyta
Class	Mammalia	Monocotyledones
Order	Primates	Commelinales
Family	Hominidae	Poaceae
Genus	*Homo*	*Zea*
Species*	*H. sapiens*	*Z. mays*

**To specify an organism, you must use the full binomial name, such as* Homo sapiens.

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Chapter 2: Chemical context of life

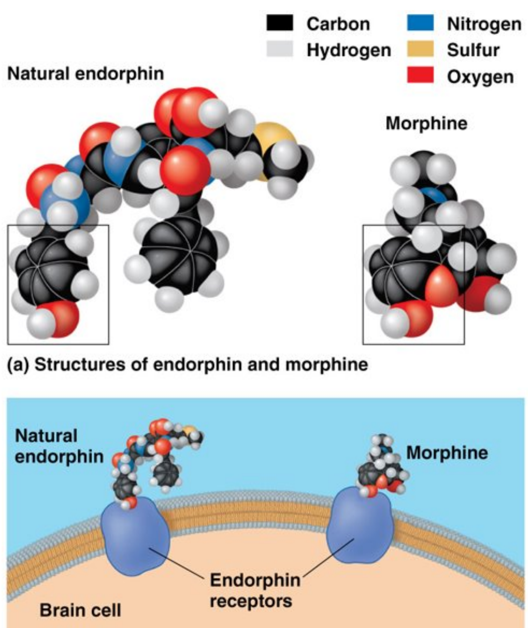
-Why studying basic concepts of chemistry?

-To better know about phenomenons that occur at the level of organisms.

-We might want to know why opiates (such as morphine) and endorphins has similar effects:

-<u>Endorphins</u>: signaling molecules produced by the pituitary gland that bind to brain receptors, releiving pain and producing euphoria during times of stress (Ex.: intense exercise);

-<u>Morphine</u>: 1) affects pain perception and emotional state by mimicking the brain's natural endorphins; releives pain and alter mood by weakly binding to specific receptor molecules on the surface of brain cells.



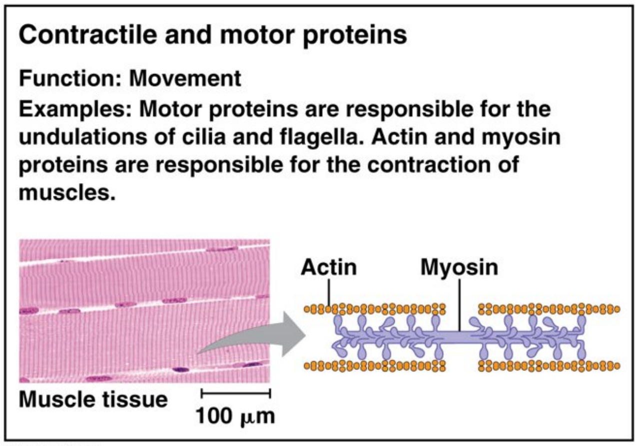
(a) Structures of endorphin and morphine

(b) Binding to endorphin receptors

A molecular mimic
Morphine affects pain perception and emotional state by mimicking the brain's natural endorphins.

- We might want to know how muscles contract. To do so, we must take into account the interaction between actin and myosin molecules (which are proteins) within myofilaments. These are essential components of the muscles.

-All organisms are composed of atoms and molecules: their organization is responsible for the unique properties of living things that cannot be found in nonliving things.



2.1) Matter and chemical elements

-All organisms are composed of matter (any substance taking up space and having mass).

-Ex:

- Sheep wool is a matter;
- Tree bark is a matter;
- Phospholipid molecules in cell membranes are matter.
- Matter only exists in three distinct states:
- Solid, liquid and gas
- All matter, living or nonliving, is composed of basic substances called elements:
- An element is a substance that cannot be broken down to simpler substances with different properties (density, solubility, melting point, reactivity).
- There are 92 naturally elements that serve as building blocks of matter (nitrogen, sulfur, phosphorus…).
- Both Earth'crust and all organisms are composed of elements.
  - but they differ as to which ones are common

Elements that are basic to life and make up about 95% of the body weight of organisms

Table 2.1 Elements in the Human Body

Element	Symbol	Percentage of Body Mass (including water)	
Oxygen	O	65.0%	96.3%
Carbon	C	18.5%	
Hydrogen	H	9.5%	
Nitrogen	N	3.3%	
Calcium	Ca	1.5%	3.7%
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 (less than 0.01% of mass): 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), zinc (Zn)

Elements	Biological property
C carbon	Makes up the backbone of organic molecules; may bind to 4 atoms; responsible for the tridimensional shape of a molecule
H hydrogen	Takes part in more chemical reactions than any other elements
N nitrogen	Component of all proteins and nucleic acids
O oxygen	Essential for aerobic cellular respiration
P phosphorus	Component of nucleic acids, membrane lipids and some proteins
S sulfur	Component of many proteins

2.2) Element properties and atomic structure

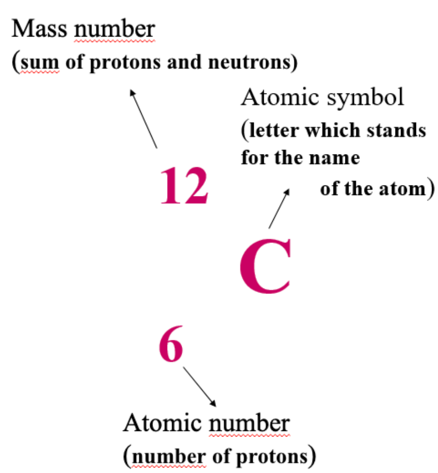
-Atoms are made up of subatomic particules (electrically charged):

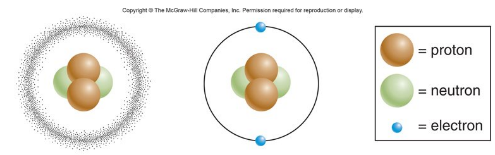
-proton (nucleus, +)
-neutron (nucleus, 0)
-électron (electron shell, -)

-All atoms have:

-An atomic symbol

-An atomic number
-A mass number





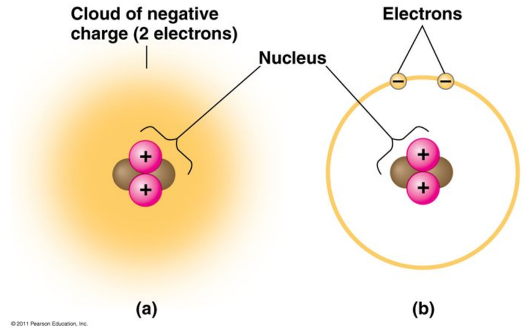
a. b.

Subatomic Particles			
Particle	Electric Charge	Atomic Mass Unit (AMU)	Location
Proton	+1	1	Nucleus
Neutron	0	1	Nucleus
Electron	−1	0	Electron shell

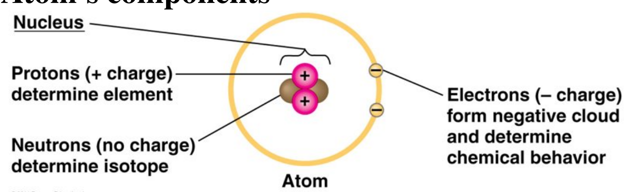
c.

Figure 2.4 Simplified models of a helium (He) atom

The helium nucleus consists of 2 neutrons and 2 protons. Two electrons exist outside the nucleus



Atom's components



Atom that has more neutrons than other atoms of the same element and therefore has a greater mass;
in nature, an element exists as a mixture of its isotopes.

Ex: Carbon exists as C-12 (6 protons and 6 neutrons) 99%
C-13 (6 protons and 7 neutrons) 1%
C-14 (6 protons and 8 neutrons) much rarer

Radioactive isotope: isotope in which the nucleus decays spontaneously, giving off particles and energy.

Periodic table

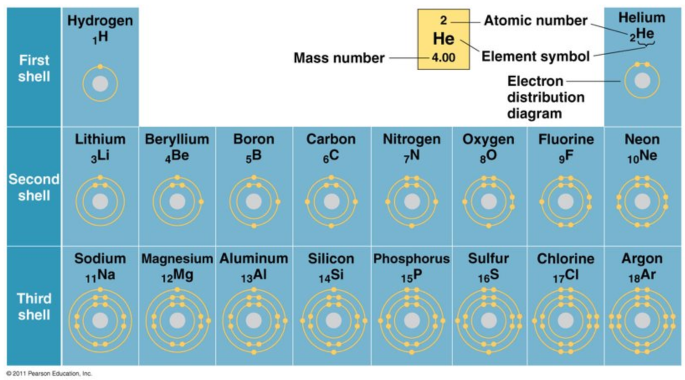
The periodic table is a way to group the elements, and therefore atoms, according to their characteristics. Two rules are to be considered

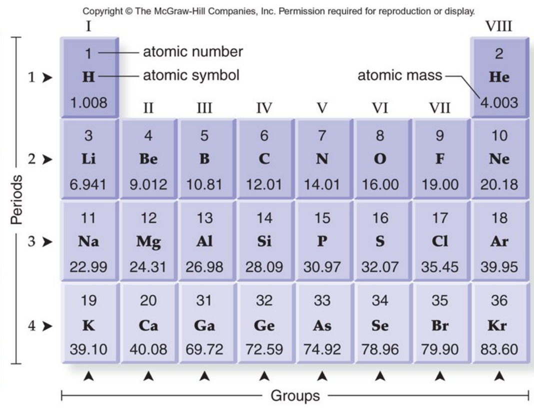
- Number of electric shells
  tells that an atom is in a particular period(horizontal row)
- Number of electrons on the last shell
  tells that an atom is in a particular group(vertical column)

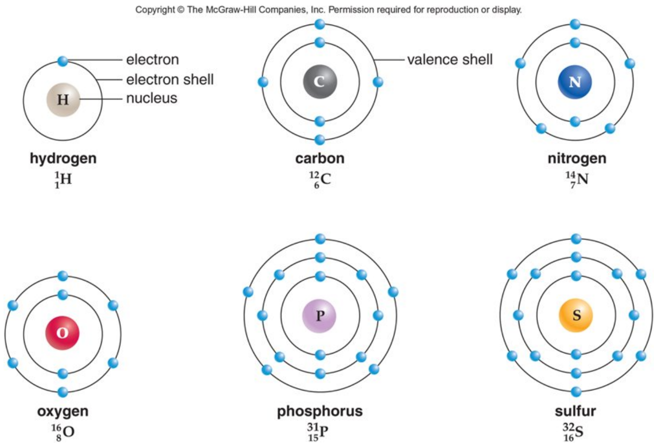
Figure 2.7

Electron distribution diagram for the first 18 elements in the periodic table

-Helium is presented in the inset;
-Electrons are presented as yellow dots and electrons shells as concentric circles;
-Elements are arranged in row, each representing the filling of an electron shell;
-As electrons are added, they occupy the lowest available shell.







Electrons and energy

Electron shells about the nucleus represent energy levels. Why for?

- Negatively charged electrons are attracted to the positively charged nucleus and it takes energy to push them away and keep them in their own shell.

When we'll study photosynthesis, we'll realize that:

when atoms (of chlorophyll molecule photosynthetic pigment within plant leaves) absorb the energy from the sun, electrons are boosted to a higher energy level. Later as the electrons return to their original energy level, energy is released and transformed into chemical energy (organic molecules). The chemical energy supports all life on Earth and therefore our very existence is dependent on energy of electrons.

- cellular respiration takes advantage of this very energy released from organic molecules.

Photosynthesis is a process by which solar energy is converted into chemical energy trapped in organic molecules (glucids, lipids, proteins).
It particularly takes place in Algae and Plants.

Energy from the sun

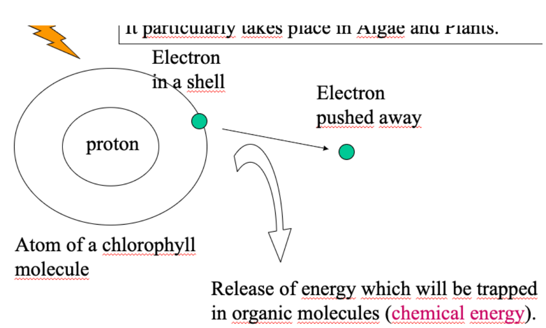
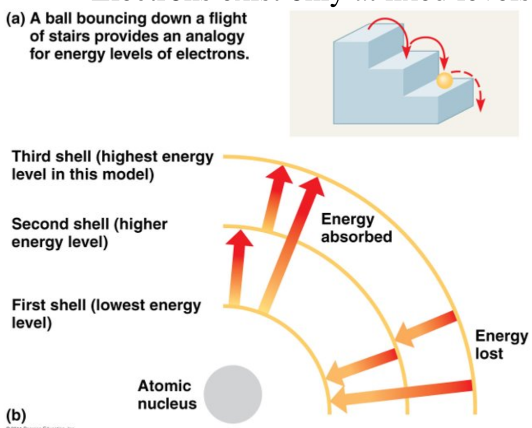


Figure 2.6
Energy levels of an atom's electrons

Electrons exist only at fixed levels of potential energy called electrons shells



Octet rule
The outer shell is most stable when it has eight electrons

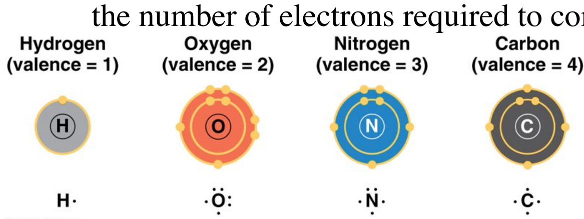
-Noble gases have 8 electrons on their outer shell. They gain stability and do not ordinarily react with other atoms.

-Many atoms have less that 8 electrons on their outer shell. They are not stable and use the electrons in their outer shell to undergo reaction with other atoms, in such a way that after the reaction , each has a stable outer shell.

According to their valence shell, they can give up, accept or share electrons to acquire 8 electron s in the outer shell.

Figure 4.4
Valence of the major elements of organic molecules

-Valence = number of covalent bonds an atom can form; generally equal to the number of electrons required to complete the outermost shell.



2.3)
Molecules and chemical bondings between atoms

Ionic bonding	Covalent bonding	Hydrogen bonding
Stong attraction between a negatively charged ion and a positively charged ion.	Strong attraction that results when two atoms share electrons in such a way that each atom has an octet of electrons in the outer shell	Weak attraction between the hydrogen (electropositive) of a molecule and the oxygen or nitrogen (electronegative) in another molecule represented by ...
Bonding between Na+ and Cl- resulting in NaCl (sodium chloride or table salt);	Bonding between two atoms of hydrogen (H-H), of oxygen (O=O) or between an atom of carbon and hydrogen (C-H); Covalent bonding are symbolized by a line between the two atoms	Bonding between two molecules of water; Although a hydrogen bond is more easily broken that a covalent bond, many hydrogen bonds taken together are quite strong; Particularly important when two strands of DNA must join together.

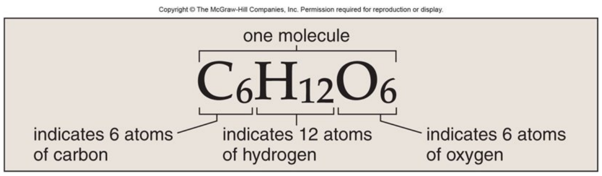
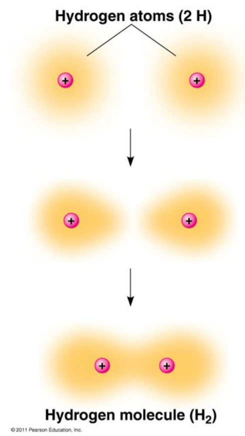


Figure 2.9
Formation of a covalent bond resulting in a complete molecule.



Ionic bonding

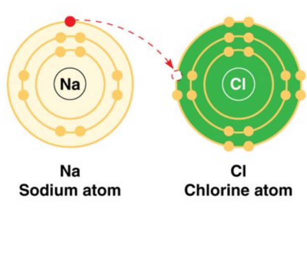
Salts are solid substances that can separate and become ions in water) .

Ex.: NaCl —> Na+ + Cl-

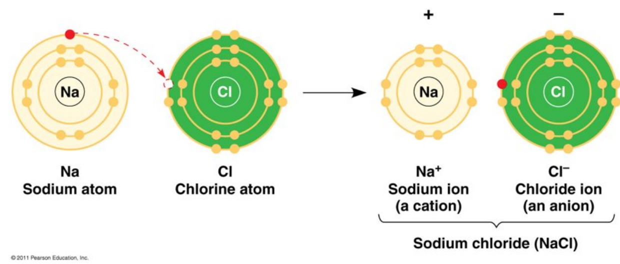
In biological systems (70 to 90% of water), ionic compounds exist as individual ions.

Figure 2.12
Electron transfer and ionic bonding: attraction between oppositively charged atoms or ions.

1o The lone valence electron of a sodium atom is transferred to join the 7 valence electrons of a chlorine atom.



2o Each resulting ion has a completed valence shell.
An ionic bond can form between the oppositively charged ions



Covalent bonding

Organic molecule have a tridimensional form:

- carbon is responsible for the backbone of a molecule;

The tridimensional form is responsible for structure and function of all living matter:

Ex.:

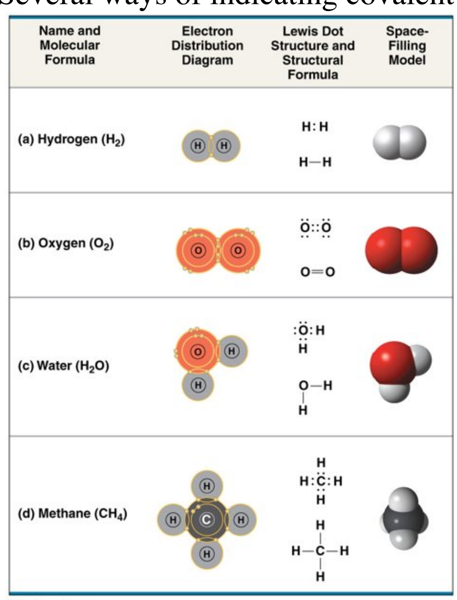
-hormones have specific shape that can be recognized by their targets (Ex.: growth hormone being recognized by children bone and muscle cells);

- some receptors on WBCs have a specific shape allowing them to bind with HIV viruses: this receptor-virus complex allows the virus to be taken into the cell, reproduce into it and destroy it.

Figure 2.10

Covalent bonding in four molecules

Several ways of indicating covalent bonds.



Types of covalent bonds

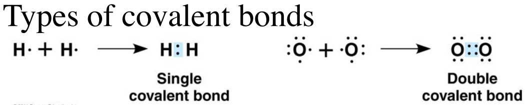
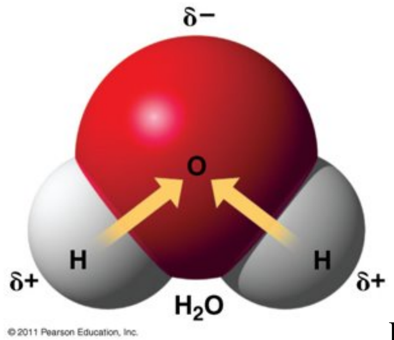


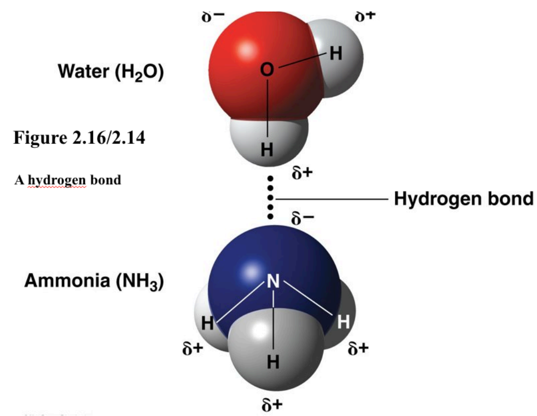
Figure 2.11: Polar covalent bonds in a water molecule

A polar molecule is one that has a partially negative portion and a partially positive portion

Oxygen is partially negative



Hydrogen is partially positive



Hydrogen bonding
The partial positive charge on a hydrogen atom that is covalently bonded to an electronegative atom allows the hydrogen to be attracted to a different electronegative atom nearby.

Non polar molecules vs polar molecules

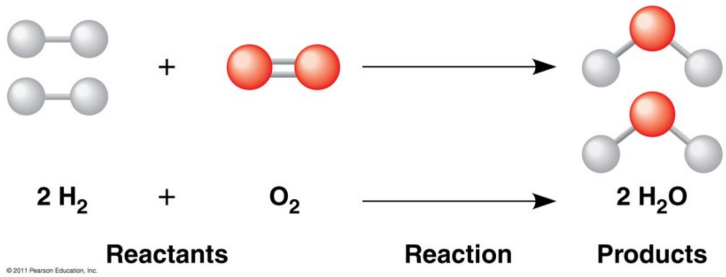
- -Non polar
  - -Within the molecule, electron sharing is equal among atoms;
  - -No atom is more electronegative nor electropositive than any other atom
    - -CH4, O2
- -Polar
  - -Within the molecule, electron sharing is unequal among atoms:
    - -one atom attracts more electrons than another atom does, and dominates the association;

  -In a covalent bonding, electronegativity is the attraction of electrons by one atom: this one is called: electronegative atom.

    -In a water molecule, O is more electronegative than H and attracts the pair of electrons. Oxygen in a molecule of H2O has a slight negative charge (-) and hydrogens have a slight positive charge (+). Then, water molecule is said to be polar.

    -A polar covalent bonding is one whithin which the electron sharing is unequal.

2.4) Chemical reactions
A chemical reaction is the making and breaking of chemical bonds, leading to changes in the composition of matter.



+
2 H_2
+
O_2
2 H_2O
Reactants
Reaction
Products
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Chapter 4: Carbon and molecular diversity

Structure of organic molecules account for function of all cells in any type of organism.

Example: In Human, a modification in hemoglobin structure
(a red blood cell protein) can cause sickle-cell anemia,
a disease that can strike one out of every 1000 African Americans:

- this disease is caused by genetic mutation which results in the production of hemoglobin that contains only one incorrect amino acid. This defect alters the tri-dimensional structure of the hemoglobin molecule causing RBCs to transform from biconcave disks into sickle-shaped cells :

Consequences: - decrease in the levels of oxygen in capillaries
- lost of RBCs flexibility within capillaries
- blockage of blood flow in lungs, heart and brain
———> (life-threatening)

Organic molecules

Distinction between inorganic molecules and organic molecules

- Inorganic molecules usually contain:
  - Positive and negative ions
  - Ionic bondings
  - Small number of atoms (small molecules)
  - Often associated with nonliving matter

  - Organic molecules usually contain:
  - Carbon and hydrogen
  - Covalent bondings
  - Many atoms (molecules often quite large)
  - Often associated with living matter

Table 3.1 Inorganic Versus Organic Molecules

Inorganic Molecules	Organic Molecules
Usually contain positive and negative ions	Always contain carbon and hydrogen
Usually ionic bonding	Always covalent bonding
Always contain a small number of atoms	Often quite large, with many atoms
Often associated with nonliving matter	Usually associated with living organisms

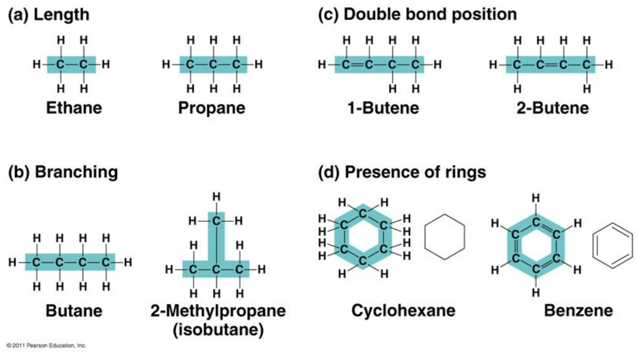
Carbon atom

- What is there about carbon that makes organic molecules the same and also different?
    - Carbon is small with a total of 6 electrons;
    - In order to acquire 4 electrons in the outer shell (octet rule), it always shares electrons with:
        - C H N O P S
            - These are the elements that make up most of the weight of living things.
- Carbon can share with as many as 4 other elements and this spells diversity of biomolecules;
- Carbon can share electron with another carbon atom (C-C)

and the result is carbon chains that can be quite long:

- When chains of carbon atoms are bonded exclusively to hydrogen, they are c alled ***hydrocarbons***:
    - The chain may be either linear or cyclic

Figure 4.5 : Four ways that carbon skeletons can vary



Carbon skeleton and functional groups

The carbon chain of an organic molecule

is called: ***carbon skeleton*** (or backbone)and has:

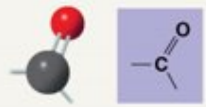
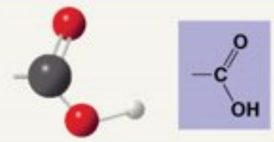
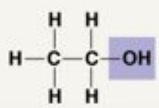
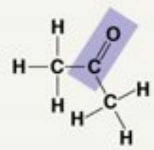
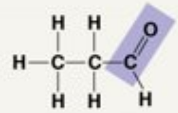
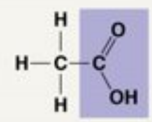
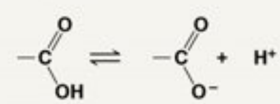
> -A functional group: Specific combination of bonded atoms
> that always react the same way; takes part in biochemical reactions
>
> -A remainder of the molecule indicated by the letter **R:** Does not change as a biochemical reaction occurs; **does not** take part in the reaction)

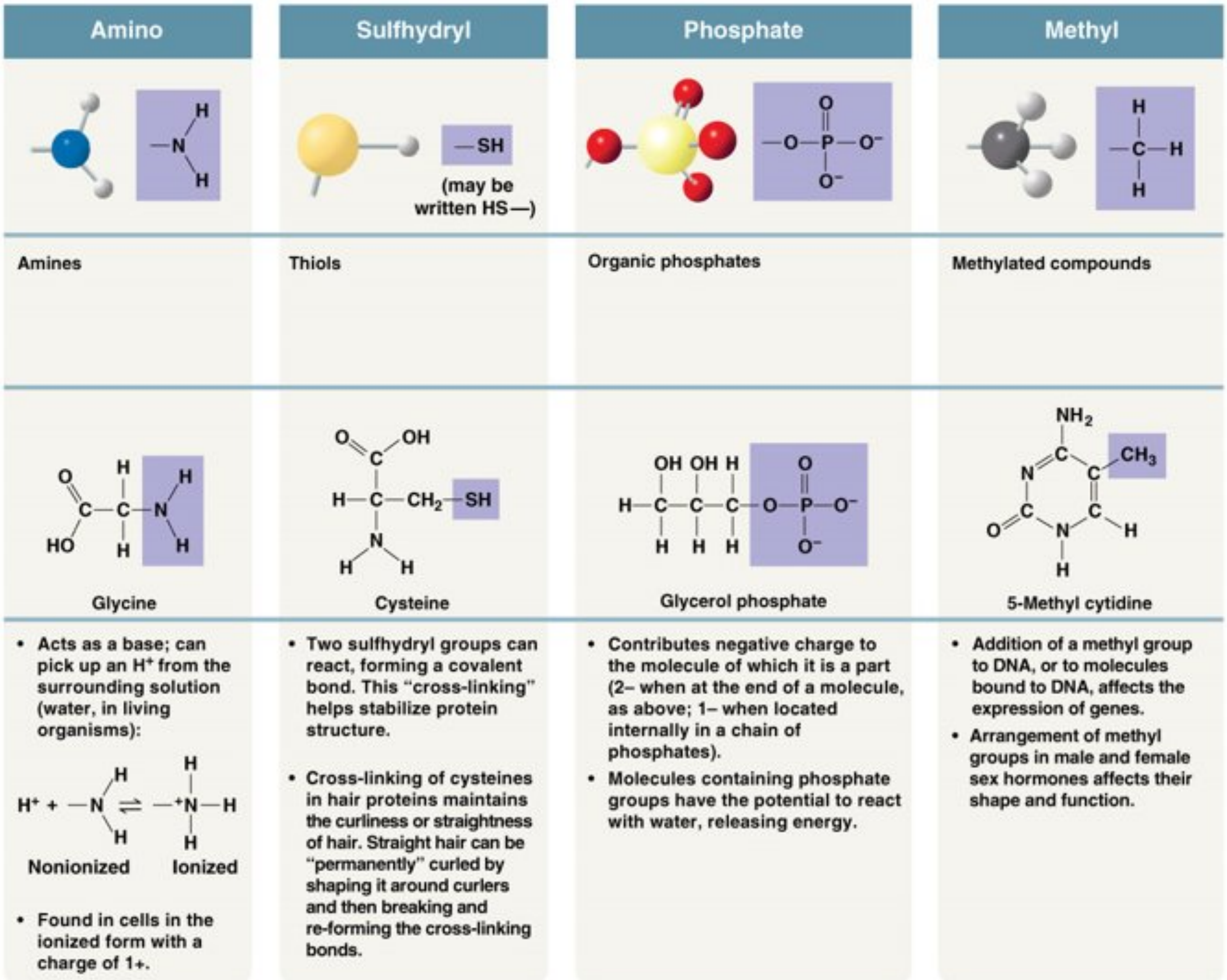
Functional groups

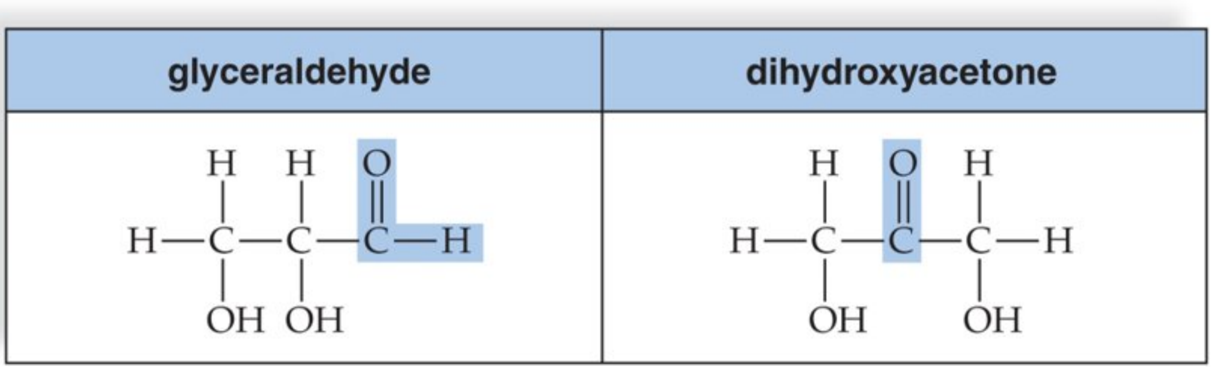
> Hydroxyl (alcohol function): - OH amino acids, sugars
>
> Carbonyl(aldehyde function or ketone function): - CHO - C=O sugars
>
> Carboxyl (acidic function): - COOH and fatty acids amino acids
>
> Amino: - NH_2 amino acids
>
> Sulfhydril: - SH amico acids
>
> Phosphate: - PO_4H_2 lipids, amino acids, nucleic acids

Figure 4.9 : Some biologically important chemical groups

Saturday, October 3, 2020

CHEMICAL GROUP	Hydroxyl	Carbonyl	Carboxyl
STRUCTURE	 (may be written HO—)		
NAME OF COMPOUND	Alcohols (Their specific names usually end in *-ol*.)	Ketones if the carbonyl group is within a carbon skeleton Aldehydes if the carbonyl group is at the end of the carbon skeleton	Carboxylic acids, or organic acids
EXAMPLE	 Ethanol	 Acetone  Propanal	 Acetic acid
FUNCTIONAL PROPERTIES	• Is polar as a result of the electrons spending more time near the electronegative oxygen atom. • Can form hydrogen bonds with water molecules, helping dissolve organic compounds such as sugars.	• A ketone and an aldehyde may be structural isomers with different properties, as is the case for acetone and propanal. • Ketone and aldehyde groups are also found in sugars, giving rise to two major groups of sugars: ketoses (containing ketone groups) and aldoses (containing aldehyde groups).	• Acts as an acid; can donate an H^+ because the covalent bond between oxygen and hydrogen is so polar:  Nonionized Ionized • Found in cells in the ionized form with a charge of 1– and called a carboxylate ion.


Amino
Sulfhydryl
Phosphate
Methyl
(may be written HS—)
Amines
Thiols
Organic phosphates
Methylated compounds
Glycine
Cysteine
Glycerol phosphate
5-Methyl cytidine
• Acts as a base; can pick up an H+ from the surrounding solution (water, in living organisms):
Nonionized
Ionized
• Found in cells in the ionized form with a charge of 1+.
• Two sulfhydryl groups can react, forming a covalent bond. This "cross-linking" helps stabilize protein structure.
• Cross-linking of cysteines in hair proteins maintains the curliness or straightness of hair. Straight hair can be "permanently" curled by shaping it around curlers and then breaking and re-forming the cross-linking bonds.
• Contributes negative charge to the molecule of which it is a part (2– when at the end of a molecule, as above; 1– when located internally in a chain of phosphates).
• Molecules containing phosphate groups have the potential to react with water, releasing energy.
• Addition of a methyl group to DNA, or to molecules bound to DNA, affects the expression of genes.
• Arrangement of methyl groups in male and female sex hormones affects their shape and function.


glyceraldehyde
dihydroxyacetone

Chapter 5: Structure and function of biomolecules

5.1) Polymers built from monomers

5.2) Carbohydrates (sugars)

-Polymers of monosaccharides

5.3) Lipids

-Polymers of fatty acids

5.4) Proteins

-Polymers of amino acids

5.5) Nucleic acids

-Polymers of nucleotides; ATP (nucleotide)

Biomolecules of cells

When a digestion occurs, large molecules (polymers)
are broken down into smaller molecules (monomers)

Ex.: digestion of proteins in meat releases amino acid molecules

When a synthesis occurs, the
body takes these small molecules and builds from them large molecules

Ex.: cells take small molecules of amino acids to make up membrane components

Monomers

-These are small subunits which bond to one another and contribute to building up larger molecules.

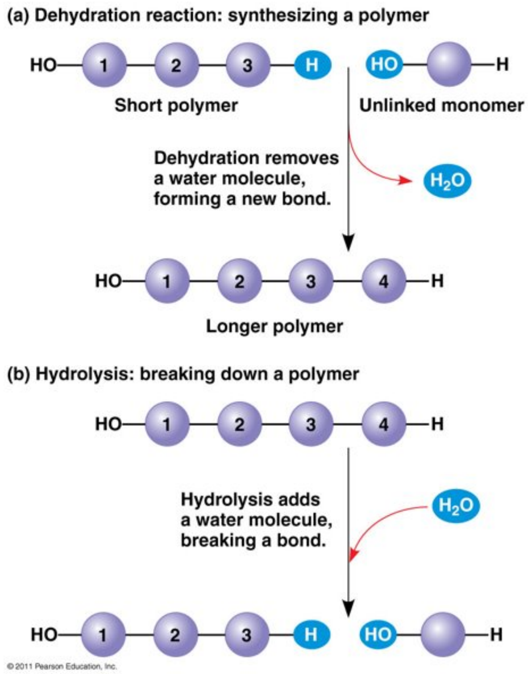
Ex.: -glucose is a monomer of cellulose
-amino acids are monomers of proteins

Polymers

-These are large molecules which are constructed by linking together a large number of small subunits.

Ex: -cellulose is a polymer of glucose
-proteins are polymers of amino acids

Figure 5.2: Synthesis and breakdown of polymers from monomers



Condensation vs Hydrolysis

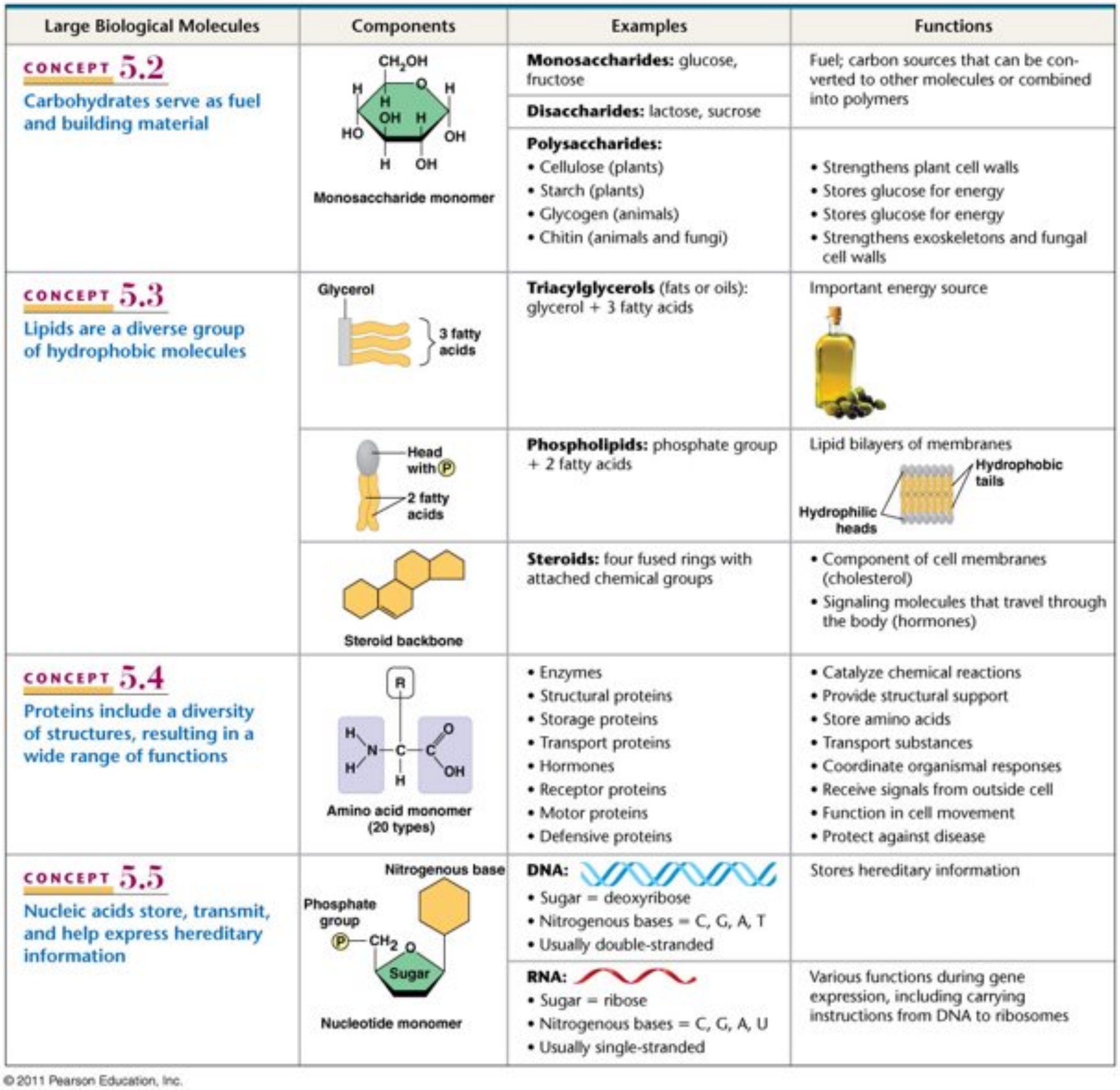
-Condensation reactions are synthesis reactions (build up) where subunits bond to one another by removal of H2O: this kind of reaction is called: dehydration

-One monomer looses an -OH while the other looses an –H; Water is produced.

-Hydrolysis reactions are degradation reactions (break down) where subunits separate from each other by addition of H2O: this is the opposite of dehydration:

-An -OH from water attaches to one subunit while an

-H from water attaches to the other subunit. Water is required



Large Biological Molecules	Components	Examples	Functions
CONCEPT 5.2 Carbohydrates serve as fuel and building material	CH_2OH, H, O, H, H, OH, H, HO, OH, H, OH Monosaccharide monomer	**Monosaccharides:** glucose, fructose	Fuel; carbon sources that can be converted to other molecules or combined into polymers
		Disaccharides: lactose, sucrose	
		Polysaccharides: • Cellulose (plants) • Starch (plants) • Glycogen (animals) • Chitin (animals and fungi)	• Strengthens plant cell walls • Stores glucose for energy • Stores glucose for energy • Strengthens exoskeletons and fungal cell walls
CONCEPT 5.3 Lipids are a diverse group of hydrophobic molecules	Glycerol 3 fatty acids	**Triacylglycerols** (fats or oils): glycerol + 3 fatty acids	Important energy source
	Head with Ⓟ 2 fatty acids	**Phospholipids:** phosphate group + 2 fatty acids	Lipid bilayers of membranes Hydrophobic tails Hydrophilic heads
	Steroid backbone	**Steroids:** four fused rings with attached chemical groups	• Component of cell membranes (cholesterol) • Signaling molecules that travel through the body (hormones)
CONCEPT 5.4 Proteins include a diversity of structures, resulting in a wide range of functions	R, H, N, C, C, O, H, H, OH Amino acid monomer (20 types)	• Enzymes • Structural proteins • Storage proteins • Transport proteins • Hormones • Receptor proteins • Motor proteins • Defensive proteins	• Catalyze chemical reactions • Provide structural support • Store amino acids • Transport substances • Coordinate organismal responses • Receive signals from outside cell • Function in cell movement • Protect against disease
CONCEPT 5.5 Nucleic acids store, transmit, and help express hereditary information	Nitrogenous base Phosphate group Ⓟ—CH_2 O Sugar Nucleotide monomer	**DNA:** • Sugar = deoxyribose • Nitrogenous bases = C, G, A, T • Usually double-stranded	Stores hereditary information
		RNA: • Sugar = ribose • Nitrogenous bases = C, G, A, U • Usually single-stranded	Various functions during gene expression, including carrying instructions from DNA to ribosomes

5.2) Carbohydrates - sugars
- These are molecules having many hydroxyle groups (-OH). They are divided into two groups:
    - those having aldehyde function (-CHO and coming from glyceraldehyde) **or**
    - those having a ketone function (-C=O and coming from dihydroxyacetone).
- They are soluble in water (hydropohilic).
- They are composed of :
    - simple sugars (monosaccharides)
    - double sugars (disaccharides)
    - long-chain sugars (polysaccharides)

General molecular formula of glucids is: Cn(H2)nOn

Autotroph organisms (plants) and heterotroph organisms (animals) are interconnected through carbohydrates

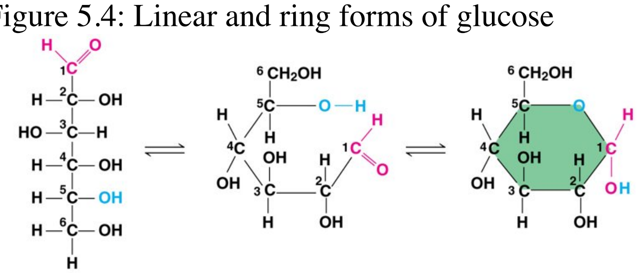
Photosynthesis reaction
$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$

Cellular respiration reaction
$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$

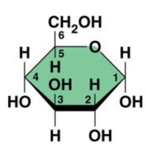
Monosaccharides: ready energy; simple sugars
Glucose
- -hexose (with 6 carbon atoms); $C_6H_{12}O_6$
- -major source of cellular fuel and carbon for metabolism
- -transported in the blood of Animals
- -its breaking down leading to ATP molecules

Ribose and deoxyribose
- -pentose (with 5 carbon atoms)
- -are found in nucleic acids:
  - -ribose: RNA (ribonucleic acid)
  - -deoxyribose: DNA (deoxyribonucleic acid)

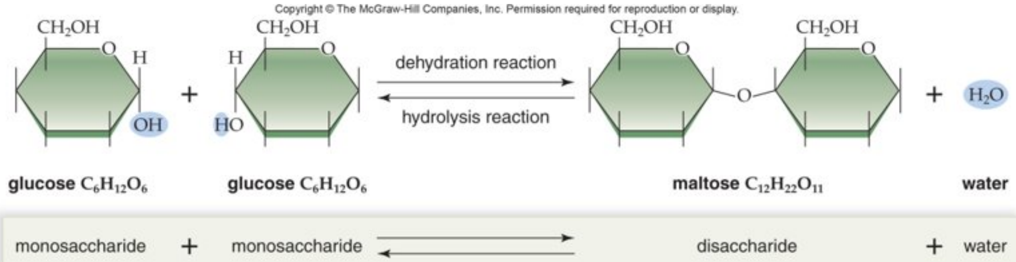
Figure 5.4: Linear and ring forms of glucose



(a) Linear and ring forms



(b) Abbreviated ring structure

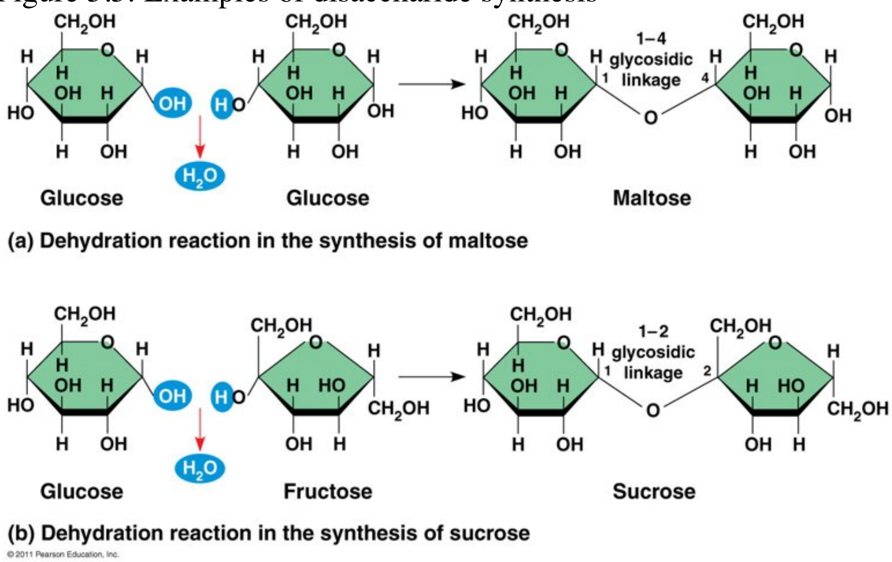


Disaccharides: varied uses; made of two monosaccharides
Maltose
- Digestive role:
  - Comes from digestion of starch and leads to two glucose molecules
  - glucose + glucose

Sucrose
- table sugar (used to sweeten food)
- form in which sugar is transported in plants
- glucose + fructose

Lactose
- found in milk
- glucose + galactose

Figure 5.5: Examples of disaccharide synthesis



Formation and hydrolysis of the osidic bonding (between two sugars)

Formation (condensation) releasing of a molecule of water
Ex.: synthesis of maltose from two molecules of glucose

Hydrolyse (degradation) addition of a molecule of water
Ex.: degradation of maltose into two molecules of glucose

Polysaccharides: energy storage molecules; polymers of monosaccharides (glucose)
Starch
- Exclusively found in plants
- Two forms of starch:
  - amylose: nonbranched & amylopectin: branched

Glycogen

-Exclusively found in animals (liver ans muscles)

-Even more branched than starch

Figure 5.6:
Storage polysaccharides of plants and animals
Starch and glycogen are composed entirely of glucose monomers;

Angle of the 1-4 linkages is responsible for the helice form of the polymer chains, in unbranched regions.

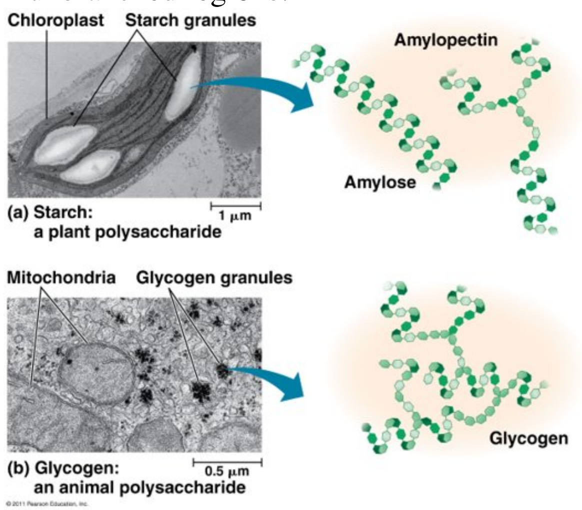
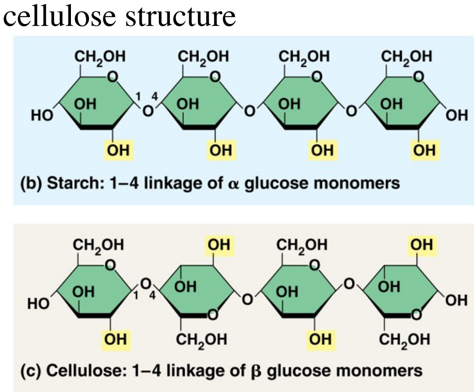


Figure 5.7 : Starch and cellulose structure



Polysaccharides: structural molecules

Cellulose

-In plants

-The most abundant carbohydrate on Earth

-Abundant in plant cell wall

-Nonbranched

-In ruminants, microbes break down cellulose in a special pouch before the cud is returned to the mouth for

more chewing and reswallowing.)
-In non ruminants
(as humans) there is no means of digesting cellulose, although it is a dietary fiber.

Chitin

-In animals and fungi
-Found in fungal cell wall and in the exoskeleton of Arthropods (Ex.: Insects, crabs, lobsters, scorpions, spiders…)
-Glucose attached to an amino group
-Cannot be digested by animals

Figure 5.6 : The arrangement of cellulose in plant cell walls

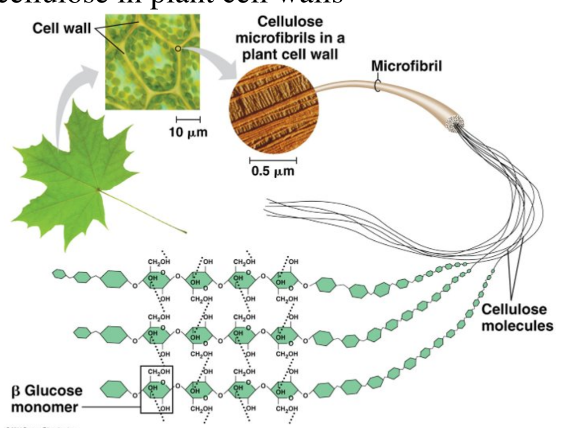
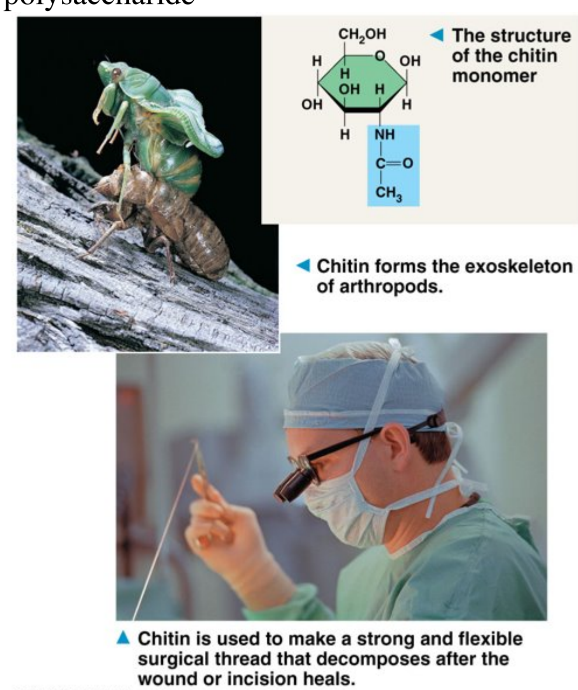


Figure 5.8 : Chitin, a structural polysaccharide



5.3) Lipids

-Organic compounds that are insolube in water (hydrophobic) due to their long hydrocarbon chains but soluble in organic solvants such as benzene.

-Hydrophobic nature is due to fatty acids (long carbon chains):

- Fatty acids often bind to glycerol.

-Important lipids are: - triglycerides (fats and oils),
- phospholipids (in cell membranes),
- steroids (cholesterol and sexual hormones),
- waxes (in plants and animals)

Table 3.3 Lipids

Type	Functions	Human Uses
Fats	Long-term energy storage and insulation in animals	Butter, lard
Oils	Long-term energy storage in plants and their seeds	Cooking oils
Phospholipids	Component of plasma membrane	—
Steroids	Component of plasma membrane (cholesterol), sex hormones	Medicines
Waxes	Protection, prevent water loss (cuticle of plant surfaces), beeswax, earwax	Candles, polishes

Triglycerides

-Composed of two types of subunit molecules

-one glycerol

-three fatty acids

-The name triglyceride is due to three fatty acids attached to one glycerol.

Importance to living things:

-Insulation (in animals);

-Long-term energy storage (in plants and animals).

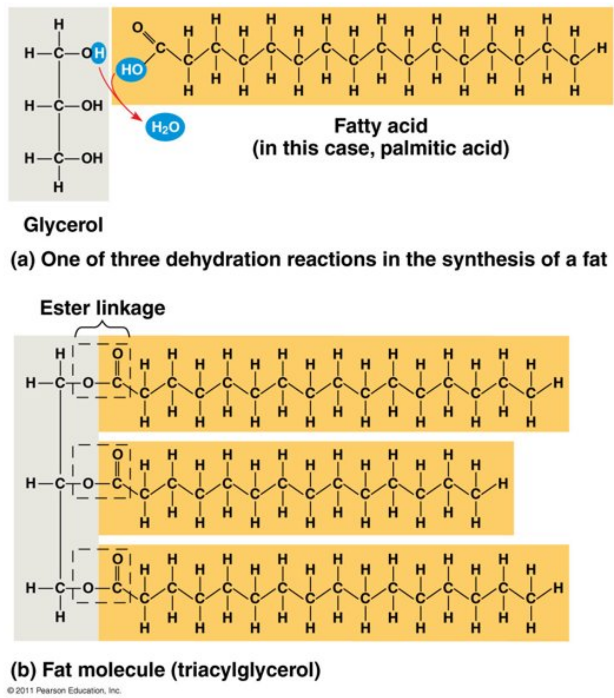
Figure 5.9

The synthesis and structure of a fat (triacylglycerol)

Building block of a fat:

-one molecule of glycerol

-three molecules of fatty acids.



(a) One of three dehydration reactions in the synthesis of a fat

(b) Fat molecule (triacylglycerol)

Notes on fatty acids
Definition

- subunits (monomers) of lipids
- contain:
- a long hydrocarbon chain
    - saturated or unsaturated
- a functional group at one end
    - COOH

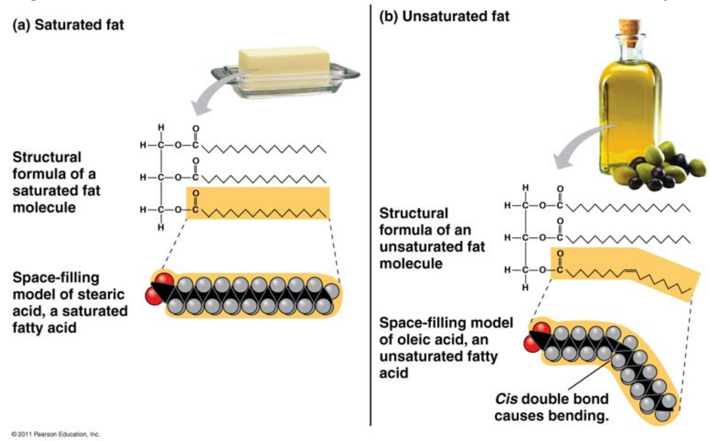
Space structure

- saturated and unsaturated : zigzag chain   All carbons are saturated with H.   There are double bounds in the carbon chain; not all carbons are saturated with H
- unsaturated: each double bond creating a kink

Distinction between fats and oils
Fats:
1- solid at room temperature
2- contain primarily saturated fatty acids
3- melt at higher temperatures
4- most often in animals

Oils:
1- liquid at room temperature
2- contain primarily unsaturated acids
3- melt at lower temperatures
4- most often in plants

Figure 5.10 : Saturated and unsaturated fats and fatty acids



Phospholipids
-They are composed of four subunit molecules:
- -one glycerol
- -two fatty acids
- -one phosphate group
- -one remainder R

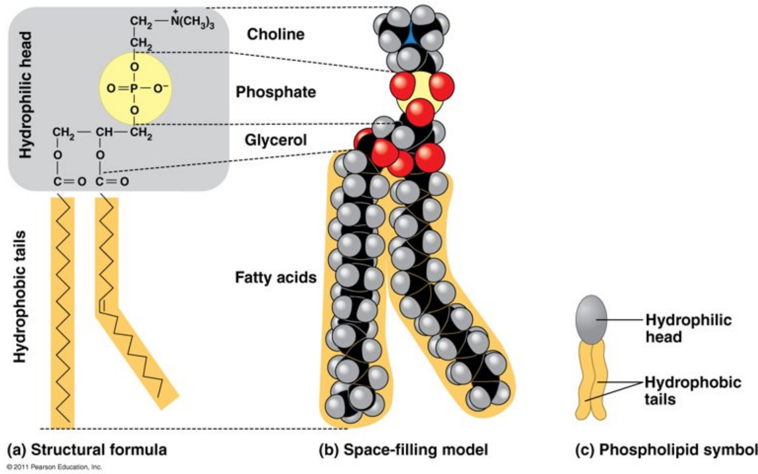
-Each molecule has:
- -A hydrophilic polar head
- -A hydrophobic nonpolar tail

The plasma membrane that surrounds
cells consists primarily of a phospholipid bilayer.

-because phospholipids have hydrophilic heads and hydrophobic tails, they tend to arrange themselves so that only the polar heads are adjacent to a watery medium.

-when surrounded by water, phospholipids become a bilayer (double layer) in which hydrophilic heads project outward and the hydrophobic tails project inward

Figure 5.11
Structure of a phospholipid
- -A hydrophilic polar head
- -Two hydrophobic nonpolar tails
- -The kink in one of the tail is due to a cis double bond



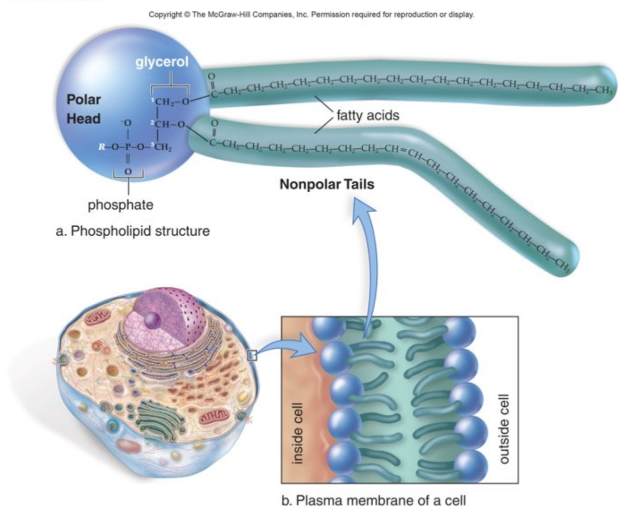
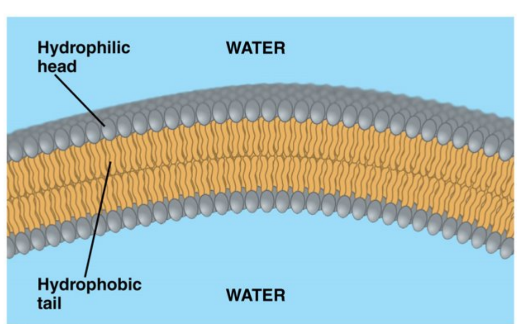


Figure 5.11
Bilayer structure formed by self-assembly of phospholipids in an aqueous environment

-The bilayer is the main fabric of biological membrane:

- hydrophilic heads being in contact with water;
- hydrophobic tails being in contact which each other and remote from water

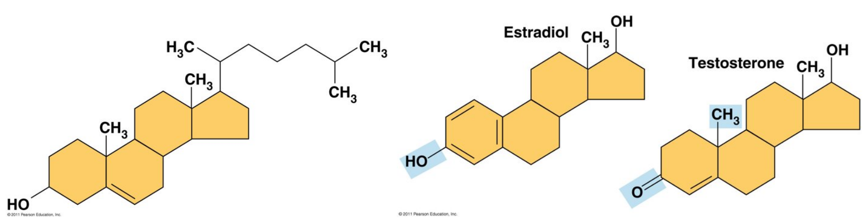


Steroids
-They have a skeleton of four fused carbon rings.
-Two major types of steroids:
- -Cholesterol
  - -Essential component of animal cell's plasma membrane (for physical stability);
  - -Precursor of several other steroids among which are sex hormones.
- -Sex hormones
  - -Essential for regulation and reproduction
  - Ex.: testosterone (in testes) & estrogen (in ovaries)

These two hormones differ only by a few atoms attached to the carbon skeleton and yet have their own profound effect on the body and behavior

Figure 5.12
Cholesterol
Molecule from which other steroids are synthesized.

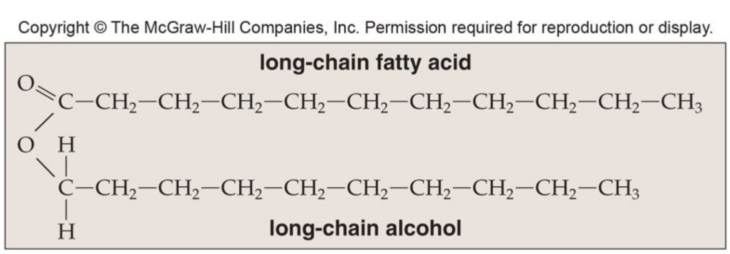
Cholesterol and sex hormones all have four interconnected rings.



Sex hormones

Waxes
Sticky lipids: offering a protective function; solid at normal temperature; hydrophobic; waterproof; resistant to degradtion; found in:
-animals
- -Skin; fur; leathers; wool
- -Waxe of bees
- -Waxe in ears

-Plants
- -Form a protective covering that prevents from loss of water (on leaves, stems, fruits):
  - -this covering is called cuticle.



5.4) Proteins

INTRODUCTION TO PROTEINS

Protein means:
first place or
primary importance
to the structure and function of cells

- 50% of dry weight of most cells contist of proteins
- Over 100 000 proteins have been identified

Importance of proteins
From a quantitative point of view:
- stand for more than half the dry weight of cells

From a qualitative point of view
- structural proteins
- enzymatic proteins
- other proteins

In general
- All proteins contain C, H, O, N;

- Proteins exist in all organisms (bacteria viruses, plants, animals…);

- They are the expression of genetic information (DNA) contained in cell nucleus;

- They are polymers of amino acids.

Functions of proteins:

1- Support: proteins have structural function
ex.: keratin makes up hair and nails;
collagen lends support to ligaments, tendon, skin;

2- Metabolism: enzymes bring reactants together and speed chemical reactions into the cells;
- they are specific to a particular type of reaction;
- they work at body temperature;

3- Transport: involved in transportation of molecules

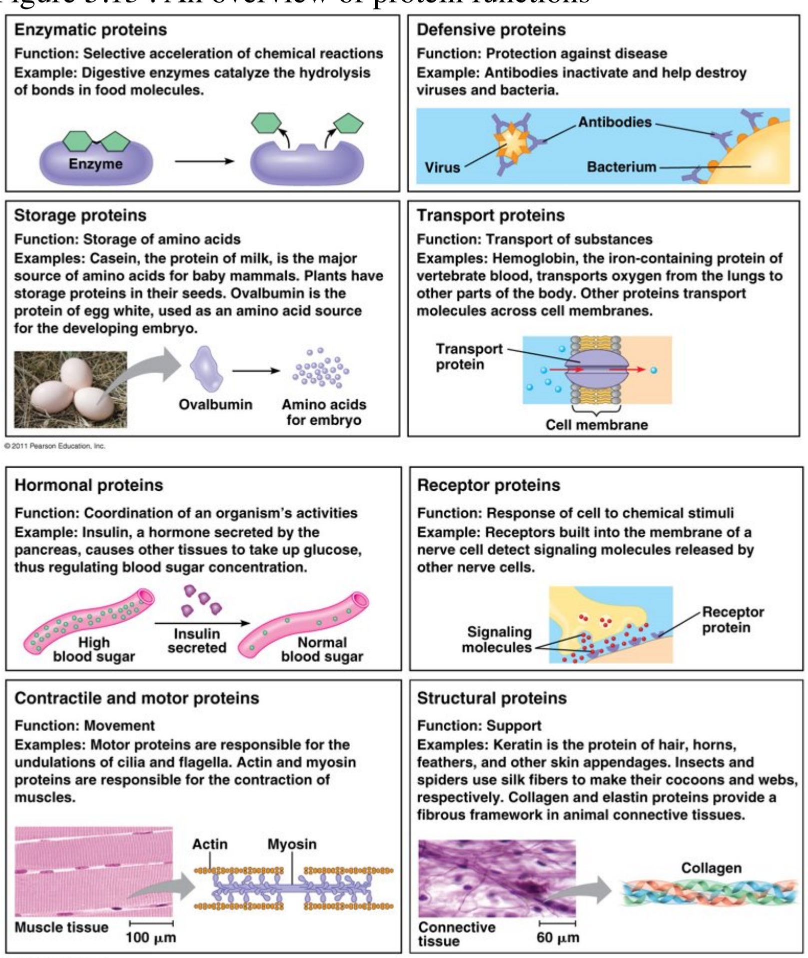
ex.: hemoglobine: transports blood oxygen
plasma membrane proteins allow substances to enter and exit cells.

4- Defense: protect cells agains microbes or harmfull substances
ex.: antibodies: combine with foreign substances (antigens) keeping them from destroying cells;

5- Regulation: make up some hormones
ex.: insuline: regulates blood glucose levels
growth hormone: determines the heigh of individual (regulates growth in children)

6- Motion: make up contractile proteins
ex.: actin and myosin: cause muscles to contract

Figure 5.13 : An overview of protein functions



AMINO ACID: - fundamental subunit of peptide and proteins

PEPTID: - short amino acid chain
- molar mass lower than that of a protein

PROTEIN: - long amino acid chain

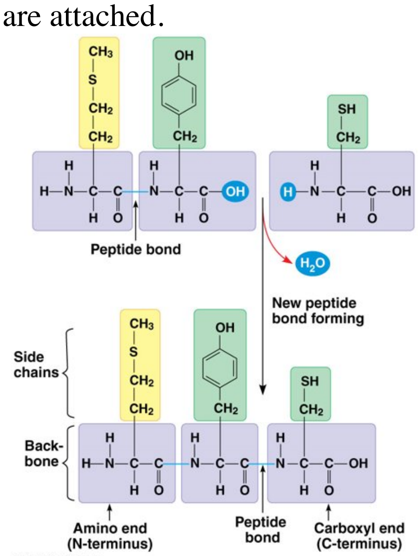
Amino acids
- molecule made of: - a carboxyl group -COOH
- an amino group -NH2

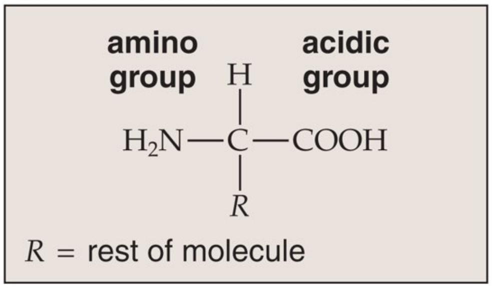
An amino acid differs according to the R group.
It always has an H attached to the central carbon..
- General formula of an amino acid

R-CH-COOH	R-CH-COO-
NH2	NH3+
non ionized.	ionized

Figure 5.15
Making a polypeptide chain
Peptide bonds are formed by dehydration reactions:
- carboxyl group of one amino acid is linked to the amino group of the next.

Peptide bonds are formed one at a time.
The polypeptide has a repetitive backbone to which R groups (side chains) are attached.



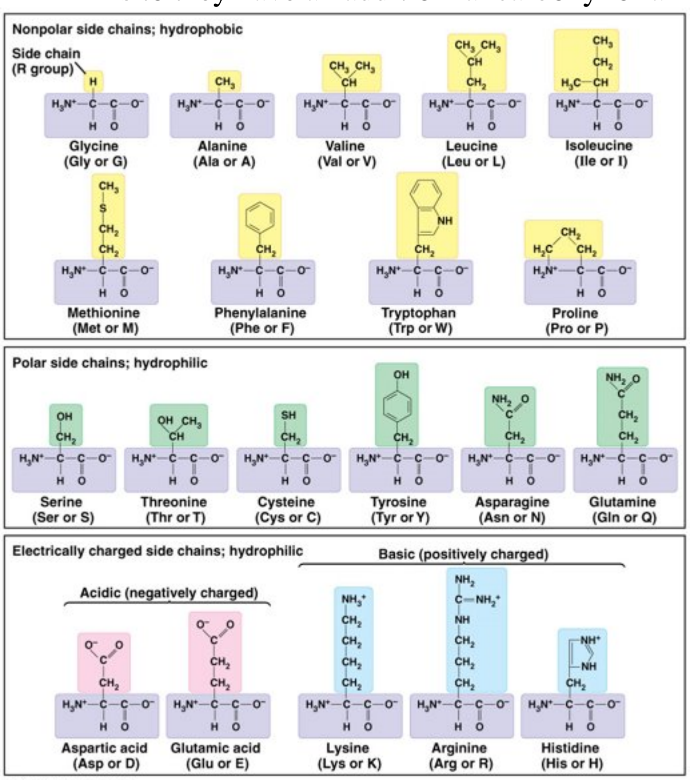


In nature, proteins contain 20 different kinds of amino acids.

These are called: natural amino acids. Each amino acid has: a symbol, a biochemical structure

Figure 5.14
The 20 amino acids of proteins
Amino acids are grouped
according:

- -to their R group (yellow)
- -as to they are nonpolar or polar
- -As to they have an additionnal carboxyl or amino acid function



Functions of amino acids:

1- basic subunits of peptides and proteins;
2- important physiological roles;
3- in Humans, essential amino acids must be included in food.

-Our cells do not have enzymes to build up such important substances: These a. a are : arginine, histidine, isoleucine, leucine lysine, methionine, phenylalanine tryptophane, threonine, valine.

Peptides

Peptides are short chains of amino acids joined by a peptide bond.

The two a. a. join by a dehydration reaction between the carboxyl group of one (-COOH) and the amino group of another (-NH2).

Proteins

-Proteins are polymers (long chains) of many amino acids joined by a peptide bond.

- a protein may contain more thanone polypeptide chain
- a protein is made up from 20 natural amino acids

Average dimension of a protein: 10 000 to 100 000 g/mole

Shape of proteins: levels of complexity

Levels of protein organization

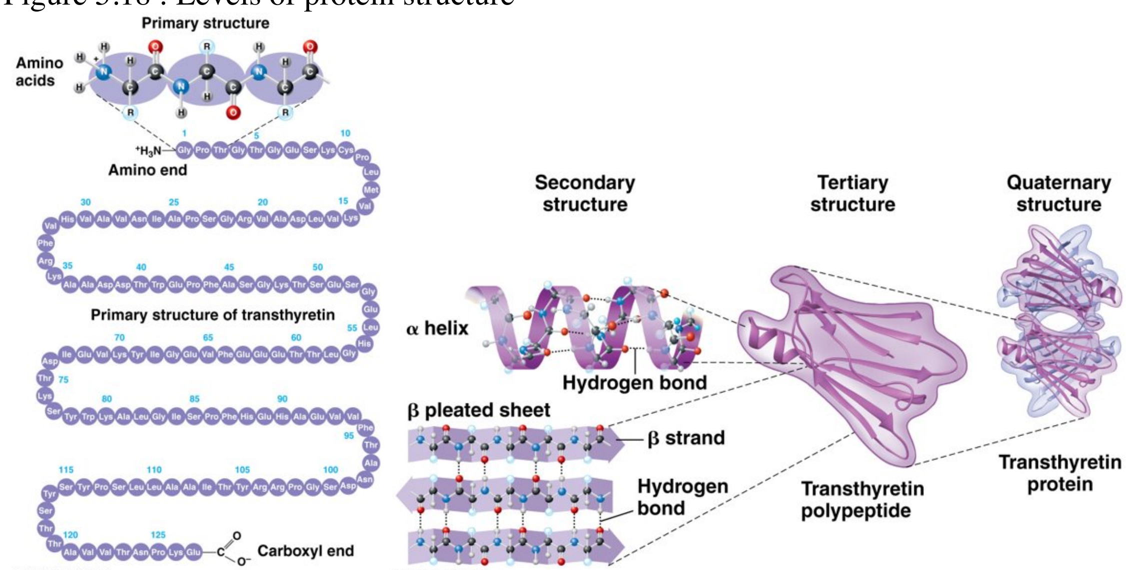
Primary structure: Sequence and number of amino acids

Secondary structure: Alpha helix or pleated sheet

Tertiary structure: Globular shape due to foldings and twistings

Quaternary structure: Two or more proteins joined together

Figure 5.18 : Levels of protein structure



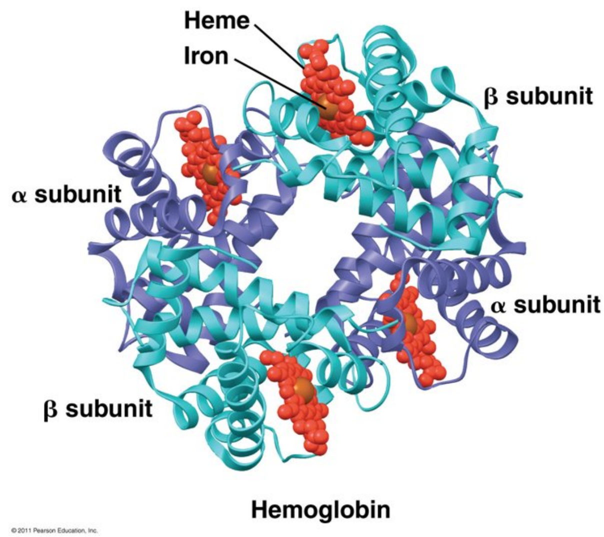
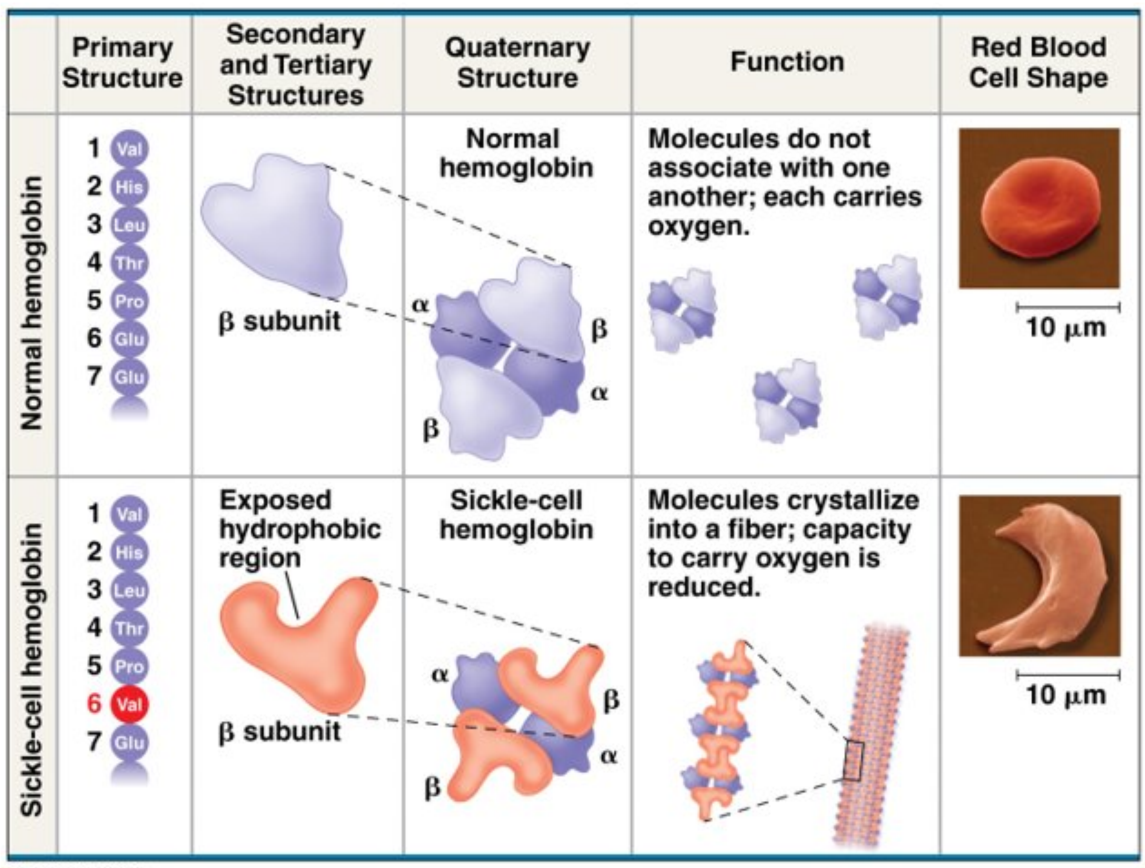
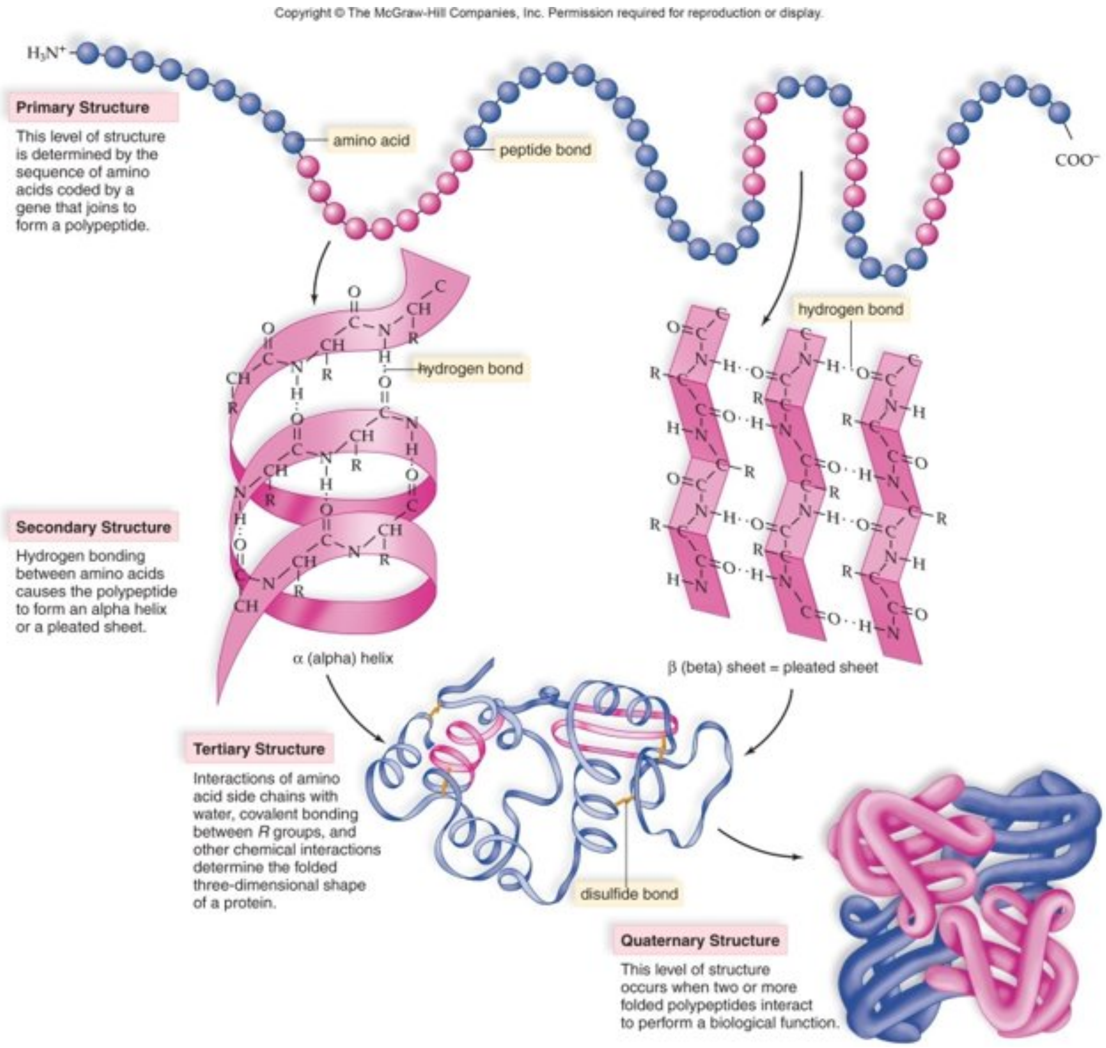


Figure 5.19: A single amino acid substitution in a protein causes a disease called: sickle-cell anemia.





Importante feature: denaturation

Denaturation = collapse of the three-dimensional structure of polypeptide chains due to breaking down of hydrogen bondings between specific portion of the chain

-Denaturing agents: heat, radiations, pH, detergents…

-Biological consequences:

- loss of biological properties (ex.: enzymatic activities)

5.5) Nucleic acids

Nucleic acids (DNA and RNA) are polymers of nucleotides: polynucleotides

-Both have very specific functions in cells

Two types of nucleic acids

DNA: DeoxyriboNucleic Acid

- is the genetic material that stores information regarding its own replication and the order in which amino acids are to be joined to make a protein.

-during cell division, two daughter cells are produced: each one receives the same genetic materi al due to replication.

RNA: RiboNucleic Acid

- is involved in protein synthesis and consequently the expression of genetic information.

Types of RNA:

- messenger RNA (mRNA)
transfer RNA (tRNA)
ribosomal RNA (rRNA)

NUCLEIC ACID AND DIVERSITY

DNA
- Can't go out of nucleus
- Genetic information stored as a sequence of bases

RNA
- Can go out of nucleus and enter cytoplasm

Recall:
50% of dry weight of most cells constist of proteins

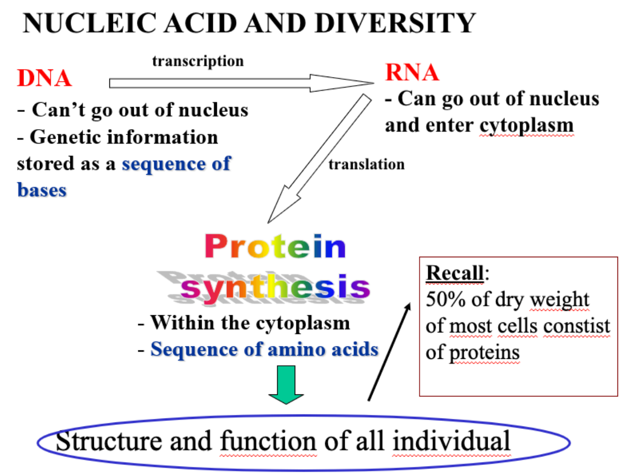
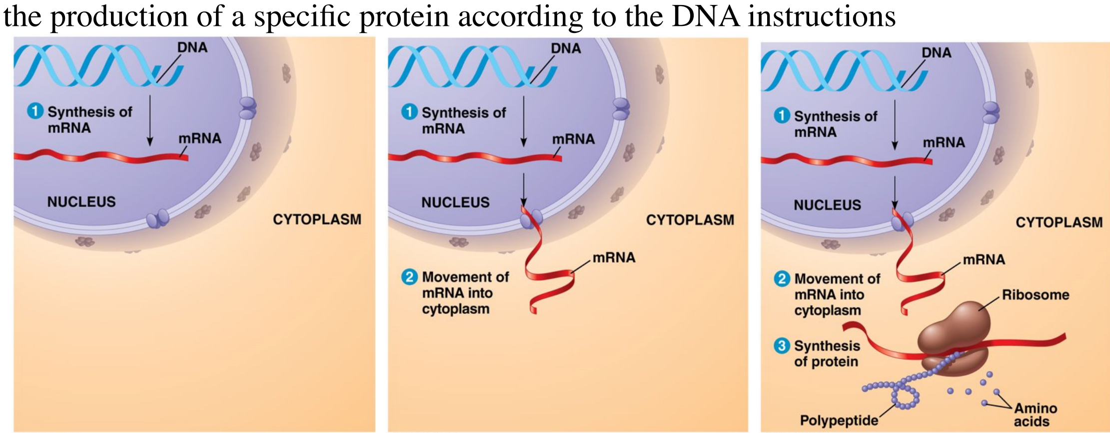


Figure 5.23
DNA transcripted into RNA

RNA translated into a protein
In a Eukaryotic cell, DNA in the nucleus programs protein production in the cytoplasm by dictating the synthesis of a messenger RNA (mRNA).

mRNA exits the nucleus and moves to the cytoplasm where it is now taking part to the production of a specific protein according to the DNA instructions

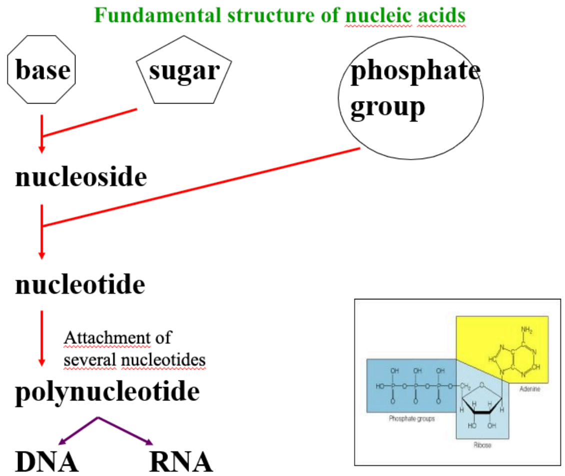


NUCLEIC ACIDS AND ADAPTATION

In addition to the storage of genetic information, nucleic acids allow acdaptation of individuals to stress or variations from the environment

——-> through mutations

Fundamental structure of nucleic acids



Nucleotides
-They are molecular subunits of DNA and RNA:

-To DNA: dATP, dGTP, dCTP, dTTP

-To RNA: ATP, GTP, CTP, UTP

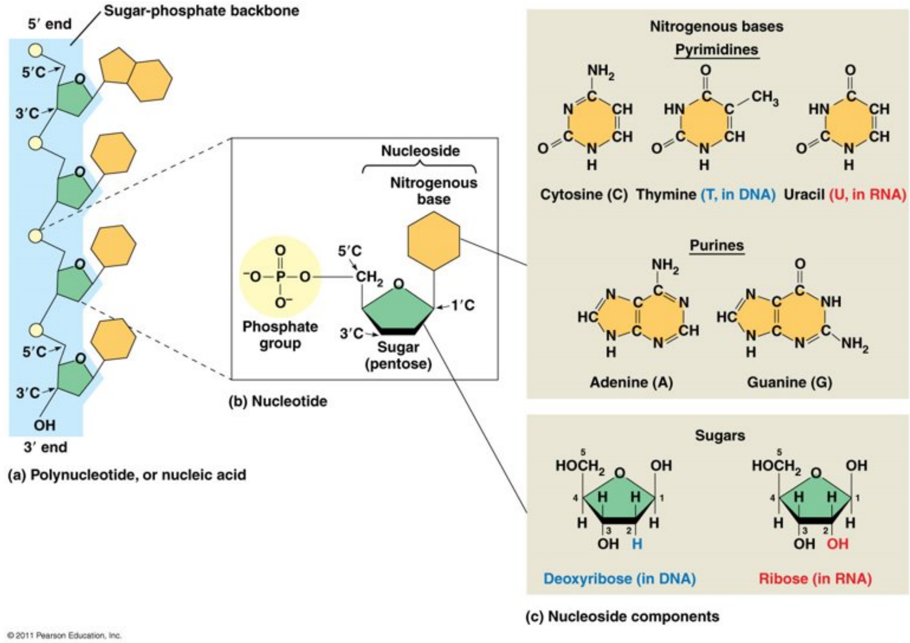
-ATP is a very important nucleotide: 1) is produced during cellular respiration and photosynthesis; 2) stores and provides energy required to cell functions as : synthesis, contraction, transportation; and in plants: fixation of carbone dioxyde into carbohydrates

Figure 5.24
Components of nucleic acids

a) A polynucleotide has a phosphate- sugar backbone with variable appendages, the nirogenous bases.

b) A nucleotide monomer includes: a nitrogenous base, a sugar and a phosphate group.

c) A nucleoside includes: a nitrogenous base (purine or pyrimidine) and a 5-C sugar (ribose or deoxyribose).



Notes on nucleosides
- They are associations of a base with a sugar (B-S);
- They may be of two types according to the nature of the sugar:
  deoxyribonucleoside
  ribonucleoside;
- The linkage between the base and the sugar is said to be N-osidic:
  it is always made between carbon 1 of the sugar and the nitrogen of the base;
-The nucleoside name is due to the base which it is made of.
  -Bases may be:
  adenine guanine cytosine uracil thymine

DNA and RNA structure

Nucleotide
- A nucleotide is a molecular complex of three components:
  - a nitrogen-containing base (A G C U or T),
  - a pentose sugar (deoxyribose ou ribose),
  - a phosphate group
- The phosphate group is attached to the fifth carbon of sugar.

A) Differences between DNA and RNA
DNA
  -sugar = deoxyribose
  -bases = A, G, C, T
  -deoxyribonucleotide as basic subunit
  -double stranded (2 strands)
  -precursors: dATP, dGTP, dCTP, dTTP

RNA

-sugar = ribose
-bases = A, G, C, U
-ribonucleotide as basic subunit
-single stranded (1 strand)
-precursors: ATP, GTP,CTP, UTP

Table 3.4 DNA Structure Compared to RNA Structure

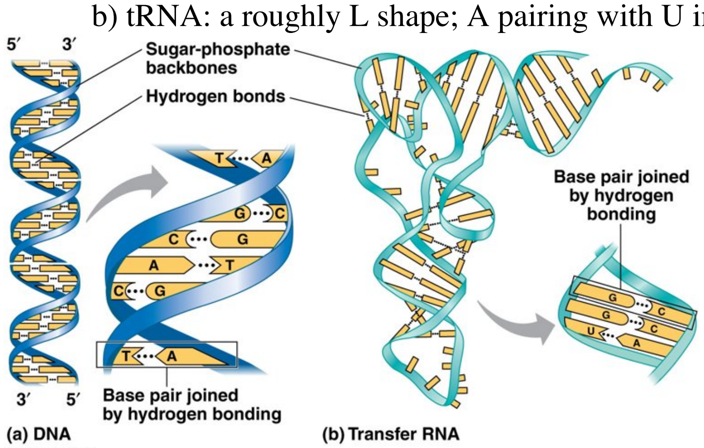
	DNA	RNA
Sugar	Deoxyribose	Ribose
Bases	Adenine, guanine, thymine, cytosine	Adenine, guanine, uracil, cytosine
Strands	Double stranded with base pairing	Single stranded
Helix	Yes	No

Figure 5.25
The structure of DNA and tRNA molecules

a) DNA: a double helix; antiparallel strands; pairs of nitrogenous bases holding the two strands together;

A pairing with T and G pairing with C through hydrogen bonds;

b) tRNA: a roughly L shape; A pairing with U instead of T



Types of nucleotides: vary according to
-Nitrogen-containing bases:

-Purines: adenine and guanine (doublering)

-Found in both RNA and DNA

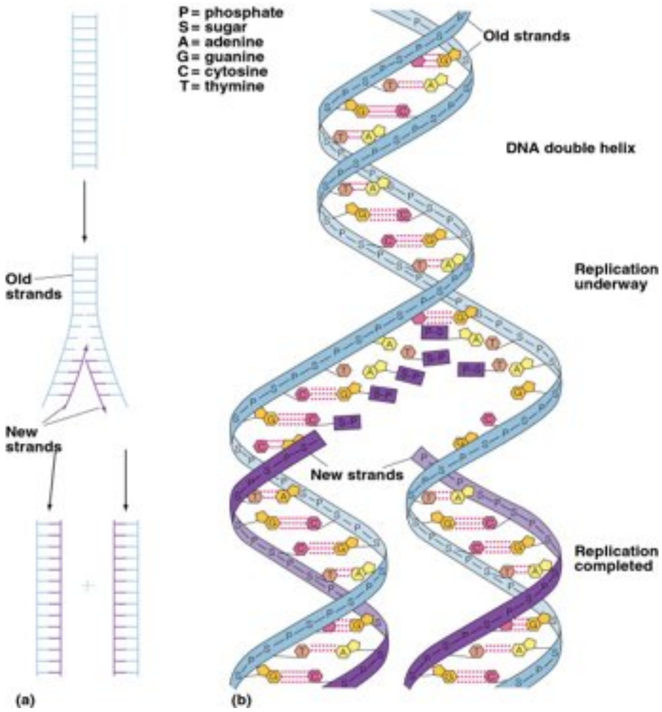
-Pyrimidines: cytosine, thymine et uracil(single ring)

-cytosine in DNA and RNA

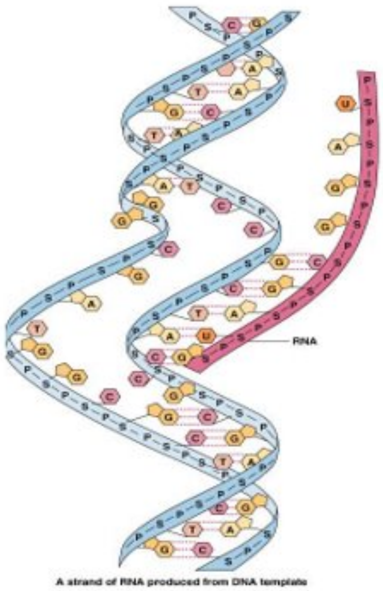
-thymine in DNA only

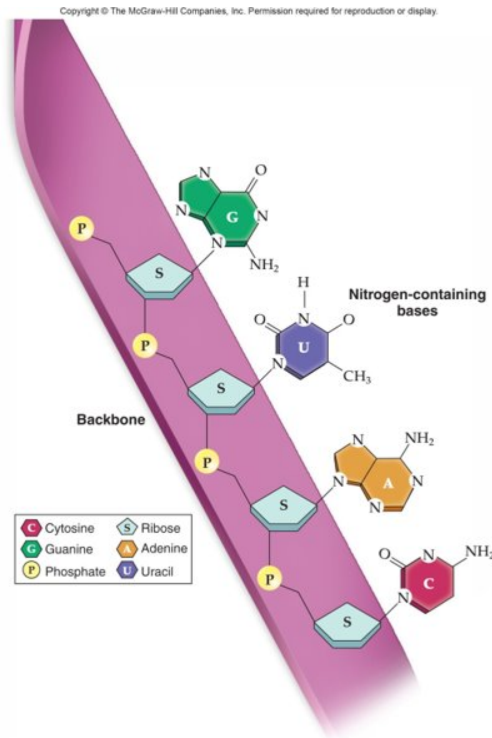
-Uracil in RNA only

DNA
-Produced within the nucleus;
-Composed of many nucleotides (P-S-B);
-Unbranched;
-Very large molecules
-Regular shape;
-Double stranded: double helix.
What does complementary base pairing mean?
-Between strands: T is always paired with ?
? is always paired with G
purines - pyrimidines
A + G = T + C



RNA
-Polymer of ribonucleotides;
-Most often single stranded, except in viruses;

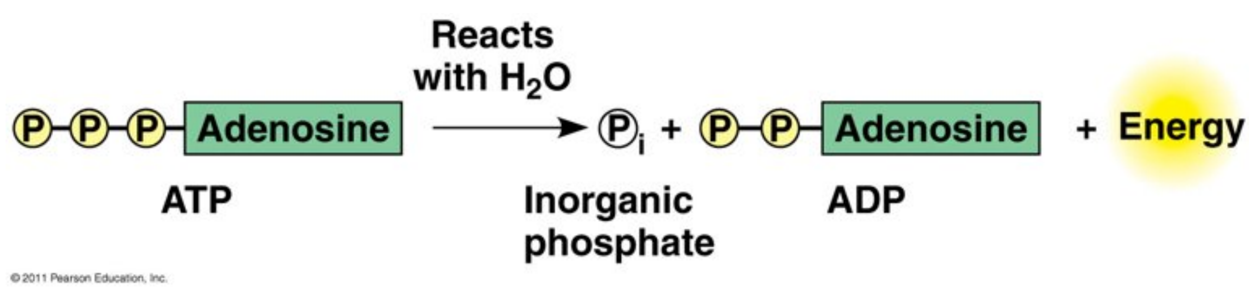




ATP
This is a nucleotide that is called: energy currency of cells (compared to the money we spend when we pay for
a product: cells spend energy when they need something (synthesis, transport, motion))
- It is made up of:
  - One base (adenine)
  - A sugar (ribose)
  - Three phosphate groups

ATP hydrolysis leads to: ADP + Pi
- After hydrolysis, released energy is used to different kinds of work

Page 70
ATP: a nucleotide made with: 3 phosphate group, a sugar (ribose) and a base (adenine)
ATP is an important source of energy for cellular process



Chapter 6: A tour of the cell

Chapter 6: A tour of the cell
6.1) Microscope and biochemistry tools
6.2) Eukaryotic cells and compartmentalization
 -Prokaryotic cells vs eukaryotic cell
 -Panoramic view of the eukaryotic cell

6.1) Microscope and biochemistry tools
 The cell: fundamental unit of life.
What does cell theory tell us?
1) Cells are the smallest unit of living matter
 -Ex.: Various illnesses of the body (diabetes and prostate cancer) are due to a malfunctioning of cells, rather that the organ itself.
2) Cells are capable of self-reproduction
 -Once a cell has reached a given dimension, it divides:
  -binary fission in Prokaryotes and Protists
  - mitosis in many Eukaryotes
3) Every cell comes from a preexisting cell
 - Reproduction of preexisting cells lead to new cells

Cell Theory (follow)
-All organisms are composed of cells:
 -With the exception of Viruses which are composed of proteins and nucleic acids.
-Make a drawing indicating the difference between: an eukaryotic cell a bacteria a virus

Sizes of living things
Proteins
-4 to 10 nm

Viruses
-10 to 100 nm

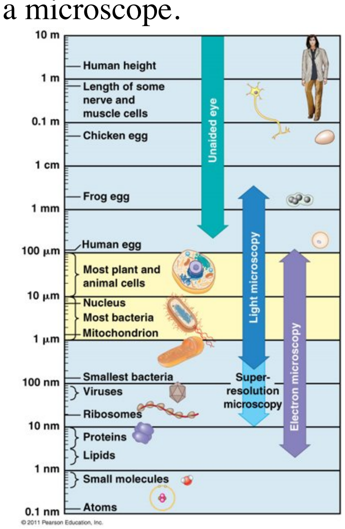
Organelles (Ex.: chloroplasts)
-1 μm

Prokaryotic cells
-1 à 10 μm

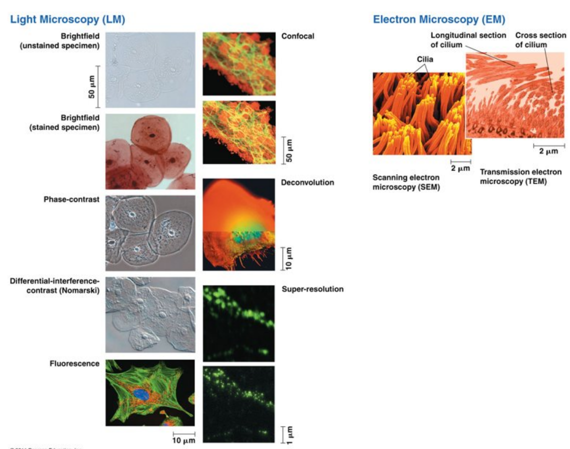
Eukaryotic cells
-10 à 100 μm

Saturday, October 3, 2020

Figure 6.2
The size range of cells
Mostly cells are between
1 and 100 μm in diameter
and are visible only under
a microscope.



Exploring microscopy



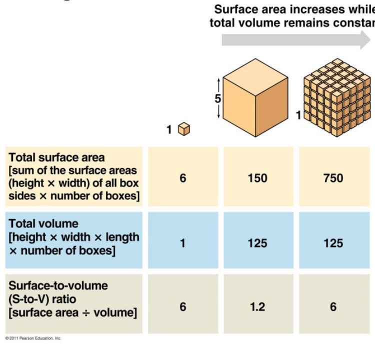
Why are cells so small?
-To increase efficiency:

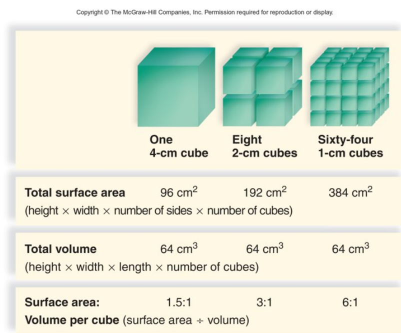
-that is to allow more nutrients to enter the cell and more metabolic wastes to be rid of the cell.

-This higher efficiency is due to an increasing in surface-to-volume ratio.

Figure 6.7
-Geometric relationships between surface area and volume
Cells are represented as boxes.

-Cell’s surface area, volume and surface-to-volume ratio are calculated using arbitrary units of length.
-A high S-to-V ratio is better for exchange of material between a cell and its environment.





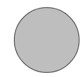
6.2) Eukaryotic cells and comparmentalization
-Two types of cells according to the center of regulation (nucleus):
-Prokaryotes
pro: before karyon: nucleus
-Eukaryotes
eu: true karyon: nucleus

Importance of Bacteria
-They can cause diseases
-Tuberculosis, anthrax, tetanus, throat infections, gonorrhea…
-They decompose remains of dead organisms
-Tree trunks, plant leaves, dead animals…
-They contribute to ecological cycles
-Nitrogen and carbon cycle…
-They are used to manufature many products
-Industrial chemicals, medecine (as insulin), foodstuffs, drugs…

Prokaryotic cells Vs Eukaryotic cells
Prokaryotic cells (Bacteria and Archaea)
-simple
-no membrane-bounded nucleus (DNA packed into a region called: nucleoid)
-about 5 μm
-almost everywhere (air, water, food, soil, skin, digestive tract)
-cytoplasm;
-no complexe organelles

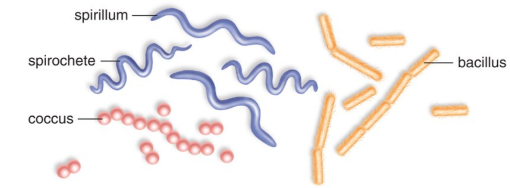
Eukaryotic cells (Protists, Mycetes, Plants, Animals)
-complexe
-membrane-bounded nucleus (DNA associated to histones)
-between 10 to 100 μm
-in smaller quantities

-cytoplasm, cytosol and many types of organelles.

Coccus	Bacillus	Spirillum
Spherical-shaped bacterium 	Rod-shaped bacterium 	Spiral-shaped bacteria 

Structure of Prokaryotes: Bacteria

The three bacterial shapes: according to their cell wall

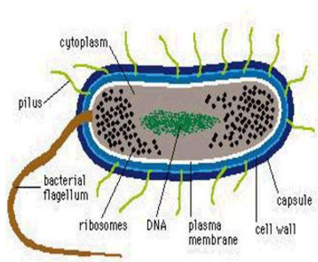


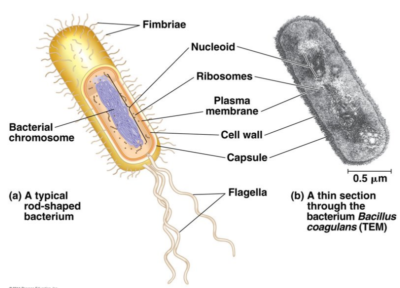
Structure of a generalized bacterial cell

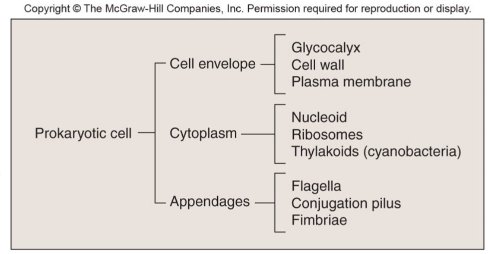
-Cell envelope
- plasma membrane
  - mesosome
- cell wall
- glycocalyx
  - capsule

-Cytoplasm
- nucleoid region
- plasmid
- ribosomes
- inclusions bodies
- thylakoids

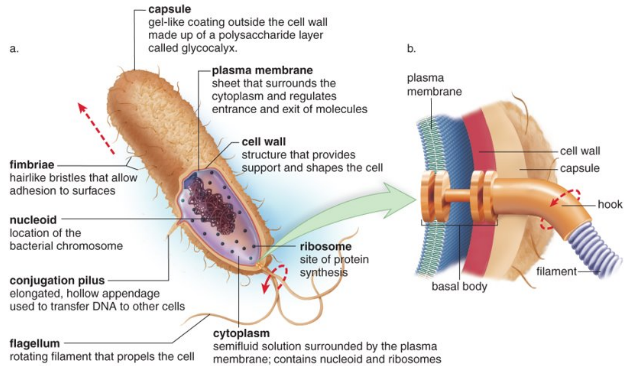
-Appendages
- Flagella
- Fimbriae
- Conjugation pili







What is the distinction between the bacterial cytoplasm and the cytoplasm of a human cell?



Structure of Prokaryotes: Archaea
-Archaeae are more diverse than Bacteria in terms of cell shape:
-coccus, bacillus, spirillum, lobed, flat, irregular shape
-Their DNA and RNA base sequences are different:
-Arhaea nucleic acids are more similar to Eukaryotes's that to Bacteria's
-They live under hard conditions:
-Very high temperature THERMOACIDOPHILES
-Low pH
-High salinity HALOPHILES
-Anaerobic conditions METHANOGENS
-They are the first living forms to appear on Earth

Distinction between Bacteria and Arhaea
-Cell wall composition
-Archaea
polysaccharides and proteins
-Bacteria
peptidoglycans

Plasma membrane composition
-Archaea
glycerol bonded to hydrocarbons
-Bacteria
glycerol bonded to fatty acids

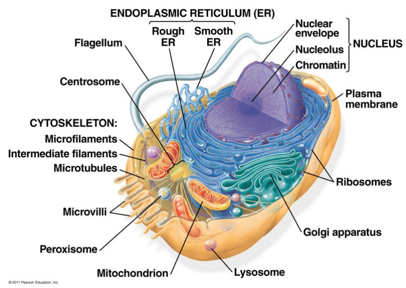
Panoramic view of Eukaryotic cell
-Present in four kingdoms:
-Protists, Mycetes, Plants, Animals
-High efficiency even if surface-volume ratio is reduced compared to Prokaryotes:
-Due to separation of cell into small chambers (compartments)

-Limited by a plasma membrane:

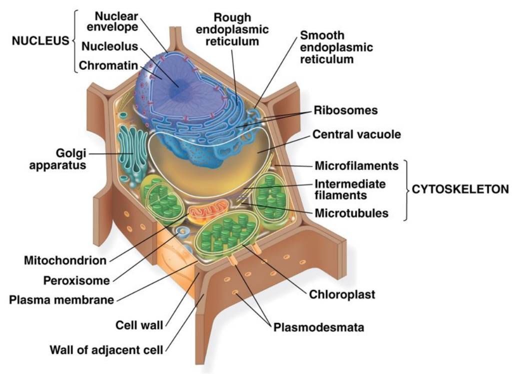
-Made of phospholipids, cholesterol, proteins and sugars

-In Plants, cells are limited by a cell wall made of cellulose

-Cellulose is a sugar



A eukaryotic cell: Animal cell



A eukaryotic cell: Plant cell

Figure 6.6

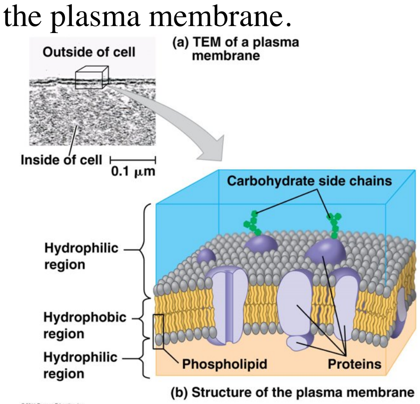
The plasma membrane

-Plasma membrane or organelles' membrane consist of a double layer of phospholipids with various proteins attached to or embedded in it.

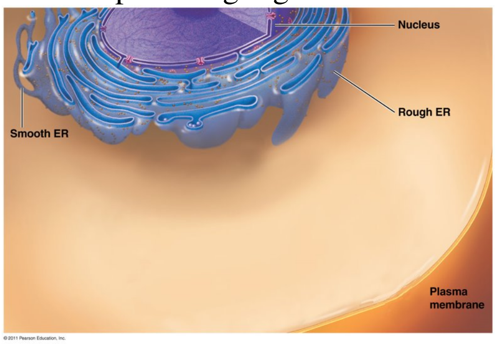
-Hydrophobic parts are found in the interior of the membrane.

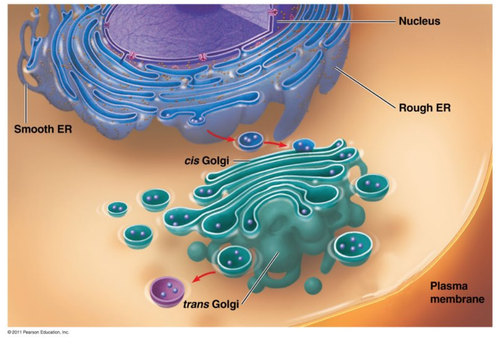
-Hydrophilic parts are in contact with the aqueous solution.

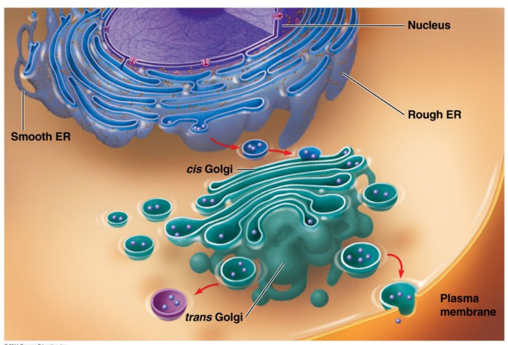
-Carbohydrate side chains may be attached to proteins or lipids on the outer surface of the plasma membrane.



Relationships among organelles







Cell compartments

Definition: Small cell rooms which increase efficency.

-Let us compare a cell to a school:

-a school has classrooms for study work;

-a cell has endoplasmic reticulum for protein synthesis.

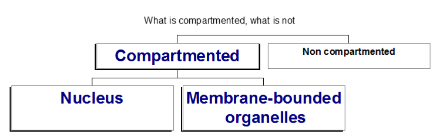
- A school has a registrar office;
- A cell has a nucleus.

-A school has bathrooms;

-A cell has vesicles.

-All small chambers in a cell are surrounded by a membrane the same way as rooms in a school are surrounded by walls, floor, and ceiling.

According to compartmentalization, a cell has two systems



According to compartmentalization, a cell has two systems

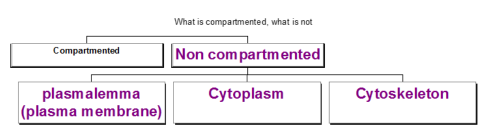


Table 4.1 Comparison of Prokaryotic Cells and Eukaryotic Cells

	Prokaryotic Cells (1–20 μm in diameter)	Eukaryotic Cells (10–100 μm in diameter)	
		Animal	Plant
Cell wall	Usually (peptidoglycan)	No	Yes (cellulose)
Plasma membrane	Yes	Yes	Yes
Nucleus	No	Yes	Yes
Nucleolus	No	Yes	Yes
Ribosomes	Yes (smaller)	Yes	Yes
Endoplasmic reticulum	No	Yes	Yes
Golgi apparatus	No	Yes	Yes
Lysosomes	No	Yes	No
Mitochondria	No	Yes	Yes
Chloroplasts	No	No	Yes
Peroxisomes	No	Usually	Usually
Cytoskeleton	No	Yes	Yes
Centrioles	No	Yes	No
9 + 2 cilia or flagella	No	Often	No (in flowering plants) Yes (sperm of bryophytes, ferns, and cycads)

Chapter 7: Membrane structure and functions

7.1) Fluid mosaics of lipids and proteins

-Structure:
Phospholipid bilayer in which protein molecules are either partially or wholly embedded ; cholesterol and carbohydrates are also components of plasma membrane

-Recall: a phospholipid has both a hydrophilic region and a hydrophobic region. This explains why the plasma membrane is a bilayer.

-Hydrophilic polar heads

- Face the outside and the inside

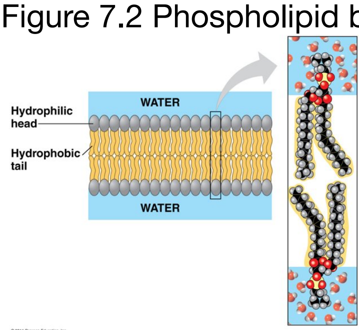
-Hydrophobic nonpolar tails

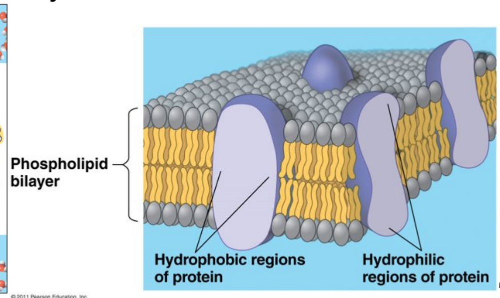
- Face each other

Functions:
-Encloses every cell: thus providing protection and acting as a barrier between its living content and the surrounding environment; thus maintaining the integrity of the cell;
-Regulates what goes into and out of the cell;
-Marks the cell as belonging to the organism;

-Serves as a means of communication 1) between cells and
2) between cells and hormones.

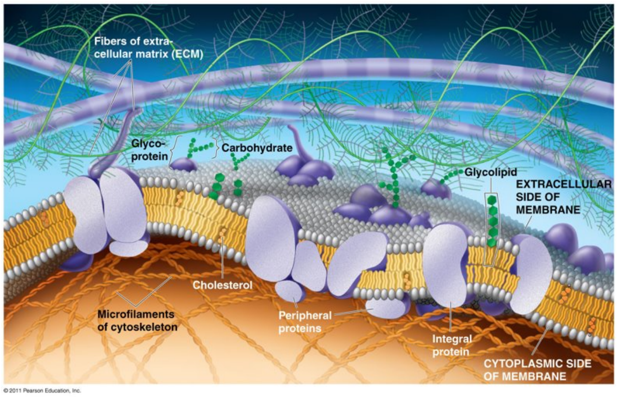
Figure 7.2 Phospholipid bilayer





The original fluid mosaic model for membranes

Figure 7.3 Updated model of an animal cell`s plasma membrane



Phospholipid bilayer
-A phospholipid is an amphipathic molecule: has both a hydrophilic (water-loving) portion and a hydrophobic (water-fearing) portion. Molecules are arranged so that:

-hydrophilic polar heads face the outside and the inside where water is found;
-hydrophobic nonpolar tails face each other thus avoiding water.

Cholesterol
-This is another lipid found in the animal plasma membrane;

Related steroids (as ergosterol) are found in a plant plasma membrane.

Functions:
-Provides stability to membrane;
-At low temperatures, prevents the membrane from freezing by not allowing contact between tails;
-Helps modify the fluidity of the membrane.

Peripheral proteins and integral proteins
-Integral proteins:

They are embedded in the bilayer;
They have both hydrophilic and hydophobic portions:

-Some protrude from only one surface of the bilayer;
-Most span the membrane with a hydrophobic region within the membrane while their hydrophilic heads protrude from both surfaces of the bilayer.

-They are held in place by attachment to protein fibers of the cytoskeleton (inside) and fibers of extracellular matrix (outside)

-Only animal cells have an extracellular matrix (ECM) which contains various protein fibers and complex carbohydrate molecules.

Peripheral proteins:
-They occur only on the cytoplasmic side of the membrane; never embedded in the bilayer

-They are held in place by attachment to protein fibers of the cytoskeleton (inside).

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Glycolipids and glycoproteins

Glycolipids

-associations of lipids and carbohydrates

-Phospholipids attach small carbohydrate chains.

Glycoproteins

-associations of proteins and carbohydrates

-Proteins attach small carbohydrate chains

-Why are the two sides of a plasma membrane not identical?

Carbohydrate chains occur only on the outside surface of the membrane;

-Peripheral proteins occur asymmetrically on one surface or the other.

Small carbohydrate chains

-The glycocalyx is involved in:

Protection to the cell;

Adhesion between cells;

Reception of signal molecules;

Cell-to-cell recognition.

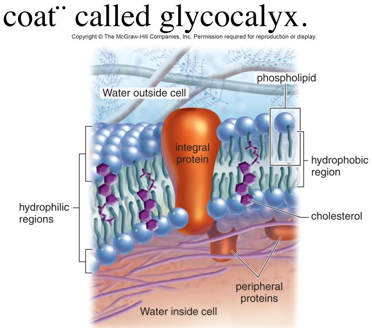
-It is used for determination of A, B and O blood groups and Rh groups.

-It is responsible for rejection of transplanted tissues:

-Each cell of an individual has its own fingerprint, because of these chains.

-A reject may be due because the immune system is able to recognize that the foreign tissues do not have the appropriate carbohydrate chains.

-In animal cells, the carbohydrate chains of proteins give the cell a ¨sugar coat¨ called glycocalyx.



Fluidity of plasma membrane

-The fluidity is due to its lipid composition:

-The greater the concentration of unsaturated fatty acids, the more fluid is the bilayer;

-At body temperature, the phospholipid has a consistency of olive oil;

-Importance of the membrane fluidity:

-Due to fluidity, cells are pliable;

-Allows some enzymes to become active.

Functions of membrane proteins

-Channel proteins

Involved in the passage of molecules or ions through the membrane;

Ex.: hydrogen

-Carrier proteins

Combine with a substance and help it move across the membrane;

Ex.: sodium and potassium

-Cell recognition proteins

-Glycoproteins help the

body recognize foreign substances so that immune system may attack them;

Ex.: pathogens

-Receptor proteins

Have a shape that allows a specific molecule to bind to it. The binding causes the protein to change its shape and brings about a cellular response.

Ex.: hormones

-Enzymatic proteins

Carry out metabolic reactions directly

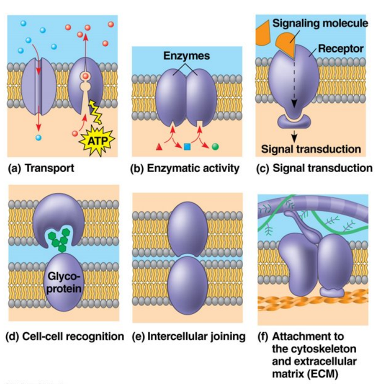
Ex.: ATP metabolism.

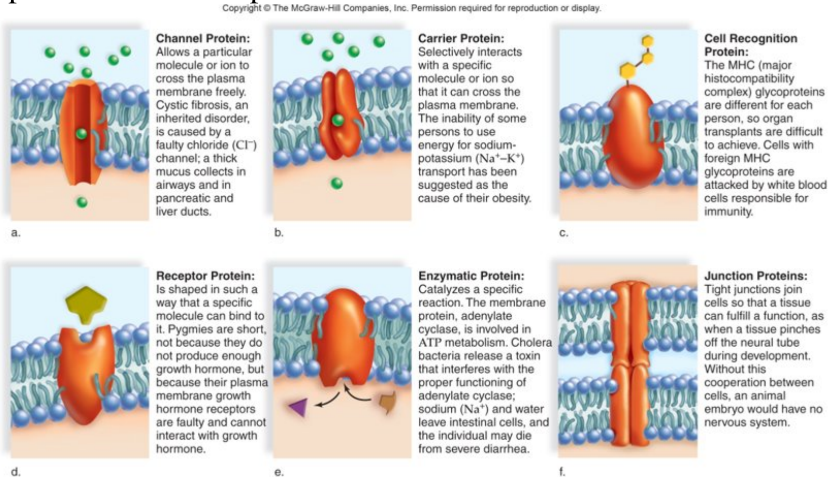
-Junction proteins

Form various types of junction between animal cells

Ex.: Signaling molecules

Figure 7.7 : Some functions of plasma membrane proteins





Return to chapter 6: Modification of cell surfaces
-Extracellular structures take shape from material the cell produces and secretes across its plasma membrane:
    -In plants, prokaryotes, fungi and most algea, the extracellular components of the cell is a fairly rigid cell wall.
-Two types of animal cell surface features:
    1) an extracellular matrix (ECM) observed outside.
    2) junctions occuring between some types of cells.
-Both can connect to the cytoskeleton and contribute to communication between cells, and to tissue formation

Extracellular matrix
-Meshwork of proteins and polysaccharides in close association with the cell that produced them:
- collagen
    - Resists stretching
- elastin
    - Gives resilience
- fibronectin
    - Adhesive protein
- integrin
    - Make connection between ECM and cystoskeleton: playing a role in cell signaling
- proteoglycans (sugar attached to a protein)
    - Resist compression of ECM
    - Assist cell signaling

Junctions between cells:
-Adhesion junction (desmosome)
    Internal cytoplasmic plaques, firmly attached to the cytoskeleton within each cell, are joined by intercellular filaments.
        In heart, stomach, bladder, skin
-Tight junction
    Plasma membrane proteins actually attach to each other producing a zipperlike fastening.
        In the intestine, kidney
-Gap junction
    Two identical plasma membrane channels join: each channel is lined by six plasma membrane proteins; allow small molecules and ions to pass between them.
        In heart, smooth muscles

Plant cell wall

Structure:

-Plant cell covering in addition to the plasma membrane. Cell wall is porous and varies in thickness depending on the age and function of cells; contains cellulose fibrils in which micro fibrils are held together by noncellulose substances (matrix);

Composed of three layers:

-Primary wall

In all plant cells

-Secondary wall

In woody plants

Forms inside the primary wall

Contains lignin (that adds strenght)

-Tertiary wall

Unusual

Functions:

-Protects plant cell;

-Responsible for cell shape;

-Avoid excess of water intake by cell.

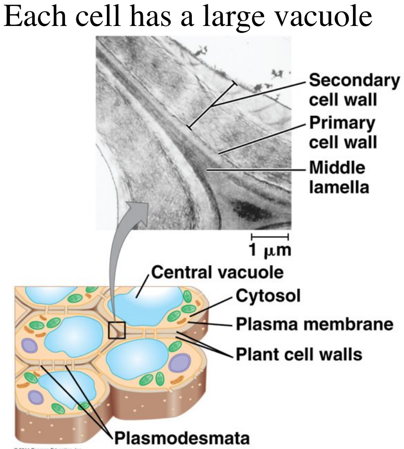
Pectin:

-allows the wall to stretch when the cell is growing

-abundant in the middle lamella: which holds two cells together

Figure 6.27 : Plant cell walls

Each cell has a large vacuole



Chapter 19: Viruses

19.1) Viral structure and types of Viruses; Parasitic nature of Viruses

19.2) Viral infection (entry into host cell and reproduction)

Adenovirus (DNA virus)
Retrovirus (RNA virus)
(Ex.: HIV)

19.3) Viruses, viroids and prions

19.1) Viral structure and types of Viruses

-Viruses are noncellular and do not have any nucleus;
-Viruses are infectious particles,
all having an outer capsid composed of proteins subunits and
an inner core of nucleic acid – either DNA ou RNA, but not both.
-
They cannot produce energy, so that they can reproduce only by using the metabolic m
achinery of a host cell;
-They are associated with a number of plant, animal
and human diseases ((polio, rabies, AIDS, measles, chickenpox, mumps);
-The structural unit is called virion, that is:
protein + nucleic acid

-They are specific and can mutate and evolve.

Table 20.1 Viral Diseases in Humans

Category	Disease
Sexually transmitted diseases	AIDS (HIV), genital warts, genital herpes
Childhood diseases	Mumps, measles, chickenpox, German measles
Respiratory diseases	Common cold, influenza, severe acute respiratory syndrome (SARS)
Skin diseases	Warts, fever blisters, shingles
Digestive tract diseases	Gastroenteritis, diarrhea
Nervous system diseases	Poliomyelitis, rabies, encephalitis
Other diseases	Smallpox, hemorrhagic fevers, cancer, hepatitis, mononucleosis, yellow fever, dengue fever, conjunctivitis, hepatitis C

Viral evolution and mutation

-Evolution (two hypothesis)
-Viruses are derived from the very cell they infect; the nucleic acid of viruses came from their host cell genome!
-Viruses arose early in the origin of life, predating the three domains!

-Mutation (they can modify their genome)
    -This is why it is necessary to have a flu shot every year
        -Antibodies generated from last year's shot are not expected to be effective this year!

Viruses can be cultured in laboratories

-Into live chicken embryos
-Into cultivated cells

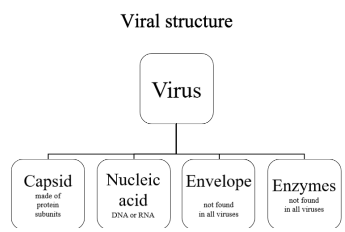
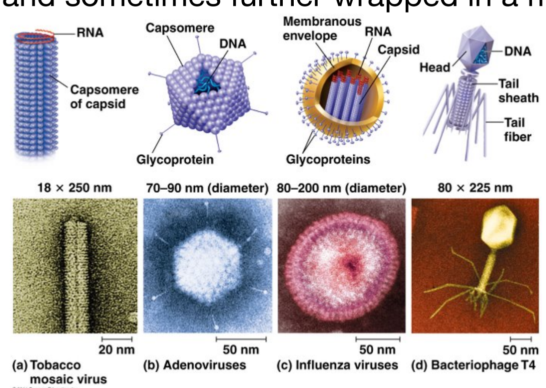
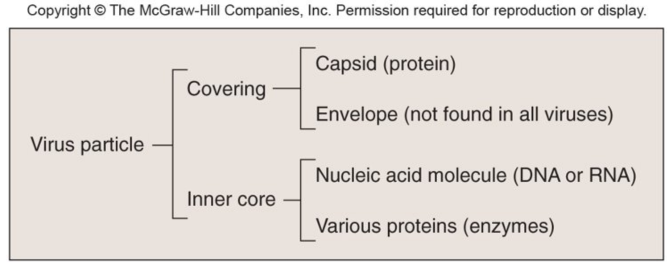


Figure 19.4: Viral structure

Viruses are made of nucleic acids (DNA or RNA) enclosed in a protein coat

and sometimes further wrapped in a membranous envelope.





Genome (involving nucleic acid)

-Few genes:
    Small viruses: have between 4 to 10 genes
    Large viruses: have around 400 genes
-Two types of viruses according to the genome:
    DNA viruses (deoxyribonucleic acid only)
        DNA may be single stranded or double stranded
    RNA viruses (ribonucleic acid only)
        RNA may be single stranded or double stranded
-Human genome: more than 10 000 genes

A virus may have DNA or RNA, but not both!

-Like prokaryotic and eukaryotic cells, viruses have genetic material.
Whereas a cell is capable of copying its own genetic material in order to reproduce, a virus cannot duplicate by itself its genetic material or any of its other components.

-For a virus to reproduce, it must infect a living cell. The infected cell duplicates the viral nucleic acid and other viral parts, including the capsid, the enzymes, and for some viruses, the envelope.

-Viruses do not have their own way of metabolism

Capsid

-Outer covering

-Composed of protein subunits called capsomeres

-Determines the viral shape

Helical	*Polyhedral*	*Complexe*
Helical capsid	**Polyhedral capsid with a fiber at each corner**	**With polyhedral head and helical tail**
- influenza - rabies	- respiratory tract diseases - hepatitis - herpes - polio	- bacteriophages

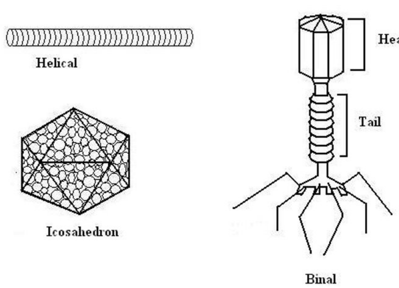
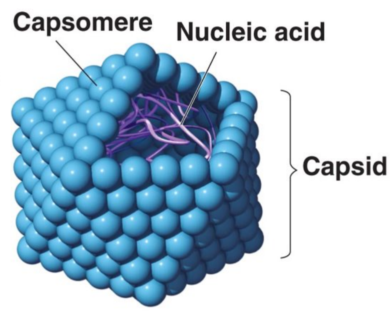
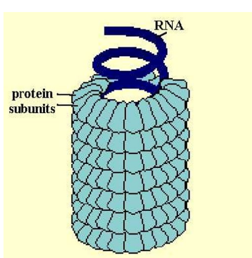


Fig 1. Different shapes of virus capsid

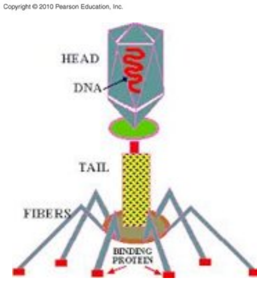


(a) A polyhedral virus

capsomere

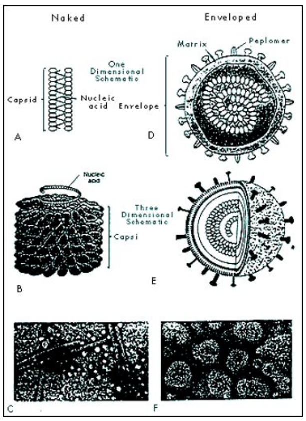


A helical virus

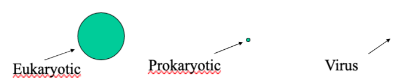


A complex virus

Envelope: typical to almost all viruses that infect Animals
-There are two ways a virus picks up its envelope, when released from the cell:
from the plasma membrane of the host cell;
from nuclear envelope or Golgi apparatus
-Consists of lipids, proteins and carbohydrates from the host cell.
-It is sensitive (to To, Ho, pH…) and this sensitivity determines the way of viral transmission.
Ex.: AIDS virus has an envelope so it has to be directly transmitted from one people to another (through blood, sperm…)



Virus size
10 to 400 nm
-They are much smaller than Bacteria, even more than eukaryotic cell;
-They must be studied by using an electronic microscope



Classification of Viruses according to:
1) the type of nucleic acid
-DNA or RNA viruses
Single stranded or double stranded

2) the shape
-helical, polyhedral, complexe

3) the presence or absence of envelope
-Enveloped viruses
-Naked viruses

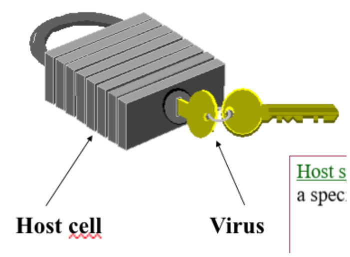
-Some viruses have enzymes needed to produce DNA or RNA

Parasitic nature of Viruses
-Why are Viruses obligate intracellular parasites?
-An isolated virus cannot replicate (multiply itself) outside a host cell;

-A virus does not have enzymes and ribosomes that are essential to its own protein synthesis;
-An isolated virus is only an assembly of genes and proteins.

Viruses infect a variety of cells, but they are host specific.
-A host spectrum is the number of different cell types a virus can infect and parasite.
    -A virus may have a large spectrum (Ex.: Rabies virus) or a small spectrum (Ex.: AIDS virus)

-For a virus to be specific, there must be recognition mechanisms in a lock-and-key manner:
    key: viral (glyco)proteins
    lock: host cell plasma membrane receptors



Host specific: a specific virus can infect a specific organism.
Examples:
- Bacteriophages only infect Bacteria
- Rabies Virus only infects some mammals

19.2) Viral infection (entry - reproduction)
- Viruses are microscopic pirates: commandeering the metabolic activity of a host cell
- Viral infection (entrance and reproduction) occurs into general steps:

1) Attachment
    -In the lock-and-key manner: viral (glyco)proteins bind with a receptor of the host cell’s outer surface;

2) Entry
    -By fusion (for enveloped viruses) or by internal infolding of the plasma membrane (for naked viruses);

3) Uncoating
    -The viral genome (DNA or RNA) becomes free of its covering: the capsid (and in some viruses – the envelope) is removed;

4) Biosynthesis and assembly
    -Relies on host components: enzymes, ribosomes, RNA, ATP, amino acids
        -In the case of DNA virus: DNA can enter the nucleus and directly incorporates to the host DNA: a transcription follows and leads to new viral DNA copies, new viral enzymes and new capsid proteins;
        -In the case of RNA virus: a reverse transcription produces a DNA copy (cDNA) of RNA genes. The cDNA can integrate to the host DNA and furthur transcription leads to new viral components (RNA, enzymes, proteins).

5) Exit
    -By budding (picking up its envelope from the host cell membrane) or by cell lysis (for naked viruses).

-Once subunits of the capsid are made, they gather around the nucleic acid

Figure 19.5 : A simplified viral replicative cycle
Virus is obligate intracellular parasite that uses the equipement and small molecules of its host cell to replicate.

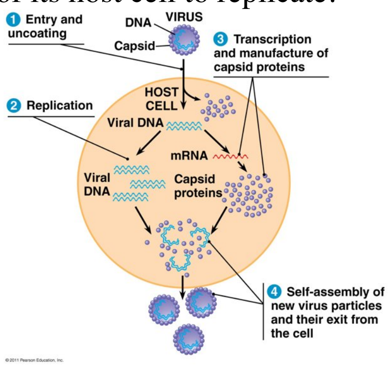


Figure 19.9 : The replicative cycle of an enveloped RNA virus

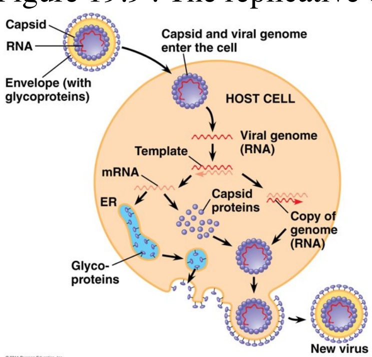
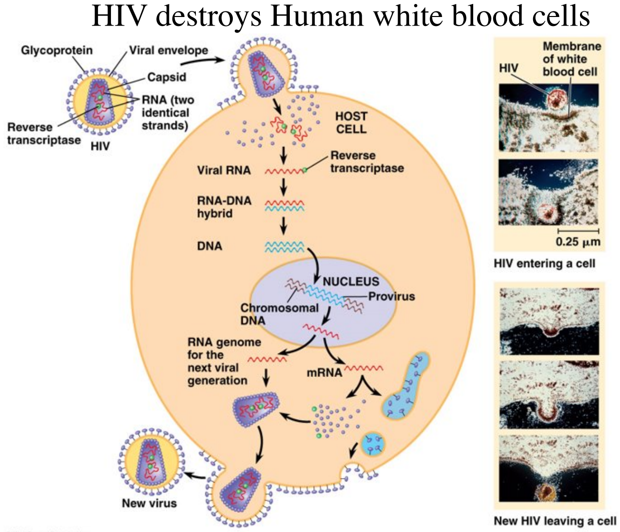
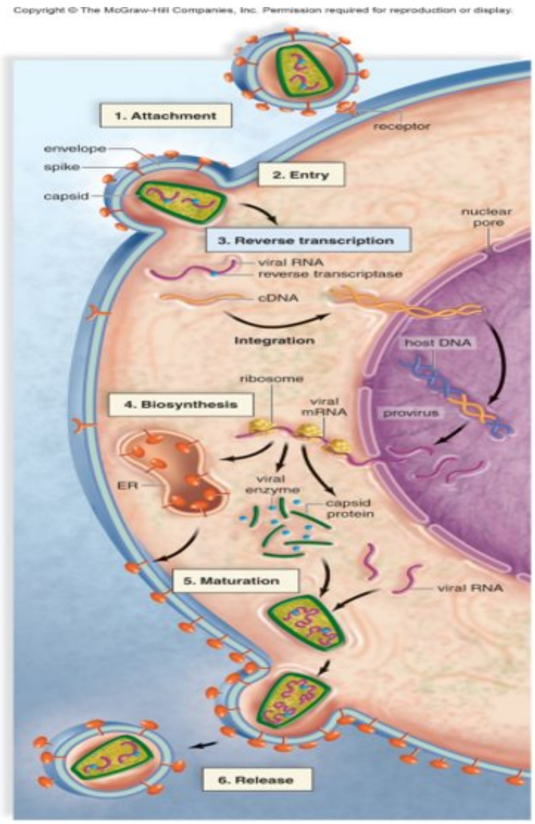
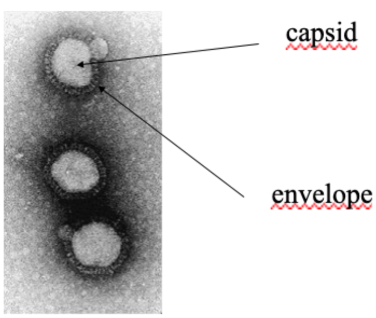


Figure 19.10: The replicative cycle of HIV
A DNA must be synthesized from the viral RNA genome and integrated as a provirus into the host cell chromosomal DNA, a feature unique to RNA viruses (retroviruses).
HIV destroys Human white blood cells





Cold virus:



19.3) Viroid and prions

Viroid

-They are naked strands of RNA not covered by a capsid;

-Many can cause diseases of crops (potatoes, coconuts, citrus);

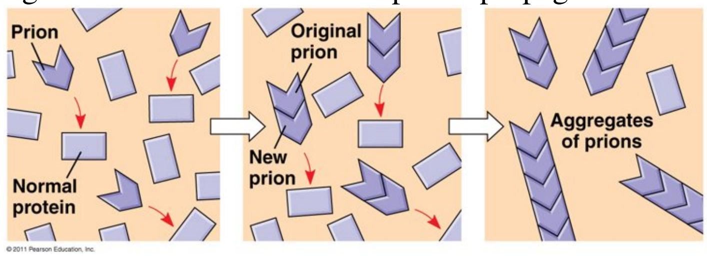
-They also are considered as microscopic pirates.

Prions

-They are particles of infectious proteins

-They can cause fatal brain diseases (Ex.: Mad Cow Disease)

Figure 19. 13 : Model for how prions propagate



Prions are misfolded versions of normal brain proteins . When a prion (PrPsc) contacts a normaly folded version of the same protein (PrPc), it may induce the normal protein to assume the abnormal shape. The resulting chain reaction may continue until high levels of prion aggregation cause cellular malfunction and individual degeneration of the brain