Basics of Life Science

Waseda SILS LE204

Thursdays 9-10:30

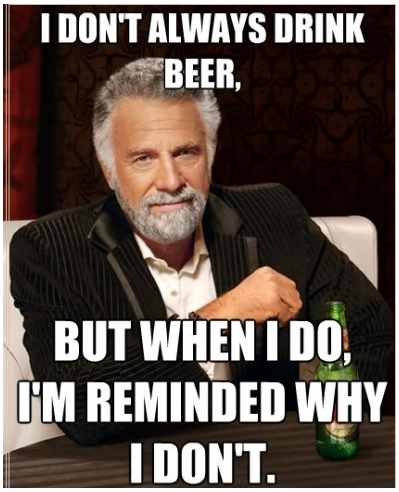
Ray Luo, Anthony DeCostanzo

Know Thyself

Some issues facing SILS studies that require biological knowledge.

- Global warming / climate change.
- Genetic engineering / cloning.
- Diseases and disease treatments.
- Human and societal behavior.
- Population control / poverty.
- Ethics in using stem cells.
- Ethics in scientific and social research.

I don't usually set class "rules", but when I do, I prefer "study guides."



Study guides to help you succeed in life… at least Life Science 204 class.

☑ Don't take too much notes, just listen.

Study guides to help you succeed in life… at least Life Science 204 class.

- ☑ Don't take too much notes, just listen.
- ☑ Ask me at ANY time ANY question.

Study guides to help you succeed in life… at least Life Science 204 class.

- ☑ Don't take too much notes, just listen.
- ☑ Ask me at ANY time ANY question.
- ☑ Try to answer my questions.

and .....

Study guides to help you succeed in life… at least Life Science 204 class.

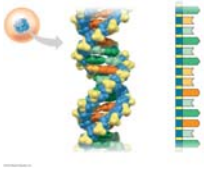
- ☑ Don't take too much notes, just listen.
- ☑ Ask me at ANY time ANY question.
- ☑ Try to answer my questions.

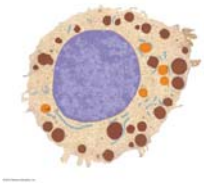
and .....

✓ Laugh at my jokes (if they are funny).

Biology is the study of what makes who we are.

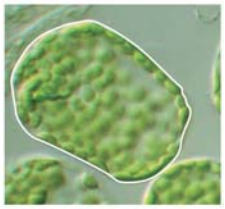
4-7: Chemistry





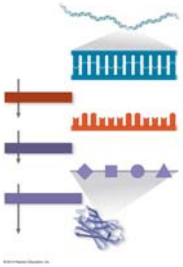
4-14: Organelles

4-21: Cell cycles



Biology is the study of what makes who we are.

4-28: Creating Life

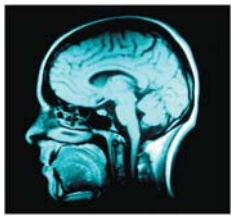


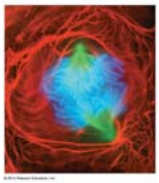
5-12: Genetics

5-19: Sensory Motor

Biology is the study of what makes who we are.

5-26: Nervous System





6-9: Cell Physiology

6-16: Evolution

Biology is the study of what makes who we are.

6-23, 30: Diseases

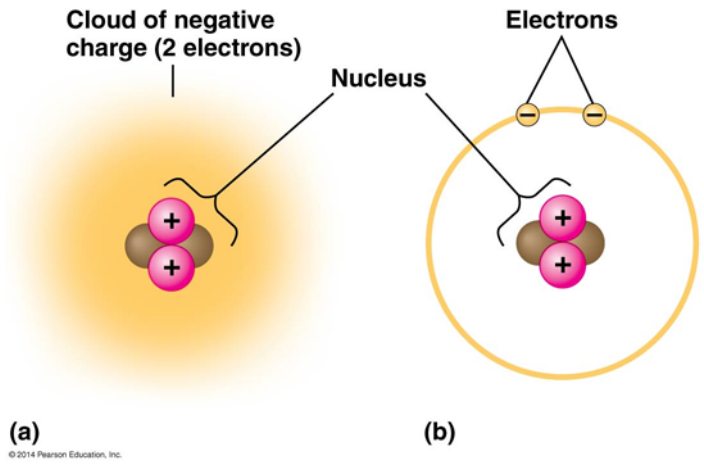
7-7: Gene Therapy

7-14: Ethics, Policy

Everything in life and elsewhere are made up of atoms.

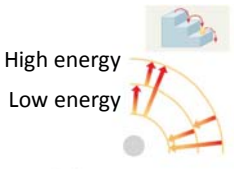
- We are made up mostly of elements oxygen, carbon, hydrogen, and nitrogen (96%).
- Compounds are combinations of elements: water H_2O, salt NaCl, methane (gas) CH_4.
- Atom is an unit of matter of a single element.
- Question: The human body, which has $7x10^{27}$ atoms, is composed mostly of which element?

Atoms are made up of neutrons, protons (+), and electrons (-).

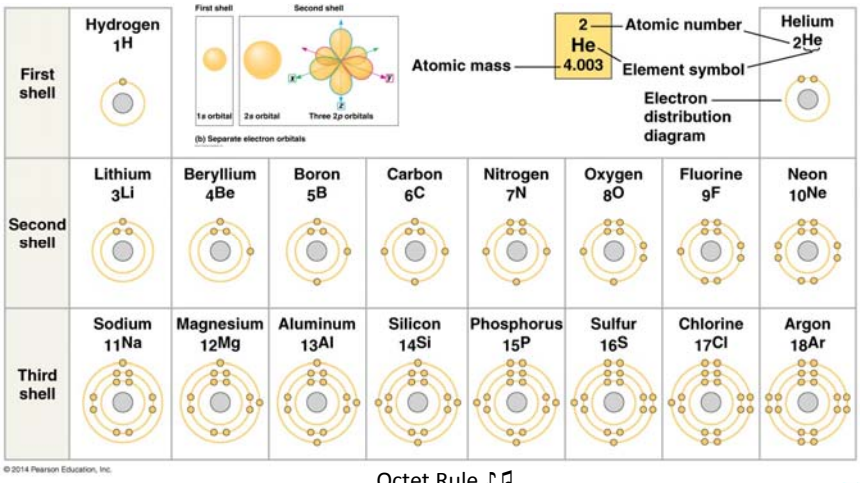


Atoms are made up of neutrons, protons (+), and electrons (-).

- Atomic mass = # protons + # neutrons.
- Atomic number = # protons = # electrons.
- Isotopes have the same atomic number but different atomic mass (carbon 13).
- Radioactive isotopes used for dating.
- Electrons occupy different levels of energy.

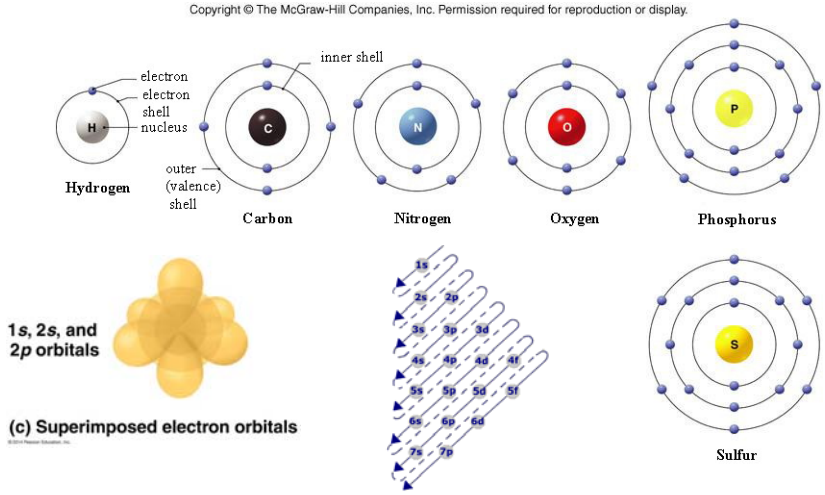


Chemistry is determined by number of protons and distribution of electrons.



Octet Rule ♪♫

The Octet rule governs reactivity of most chemical elements.

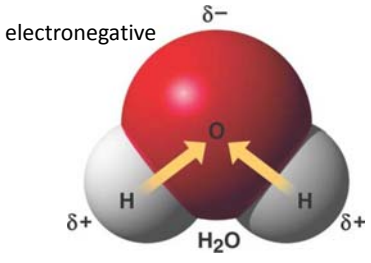


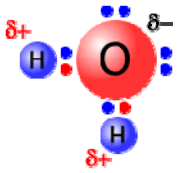
Things to ponder while lining up to get ramen (aka review).

- Question: titanium has atomic number 22, an isotope of titanium with mass of 48 has how many neutrons?
- Question: how many electrons does chlorine (atomic number 17) have in its outermost (valence) shell?

Chemical reactivity is dependent on the number of valence shell electrons.

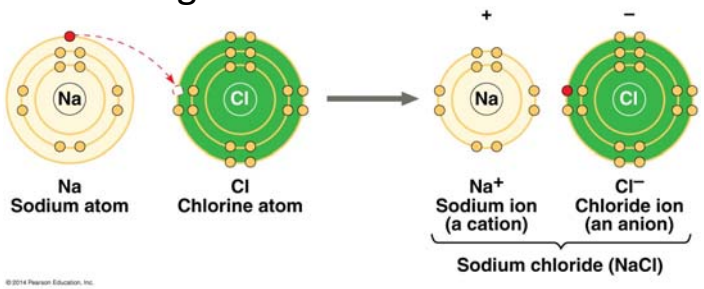
- **Covalent bonds** are made up of atoms sharing valence shell electrons in a molecule (H-H single bond, O=O double bond).
- Water: oxygen - two single bonds - hydrogen.



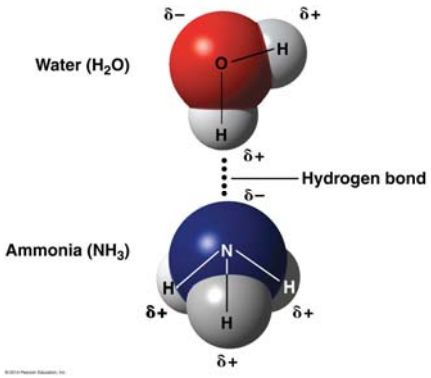


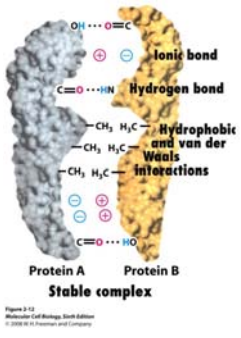
Chemical reactivity is dependent on the number of valence shell electrons.

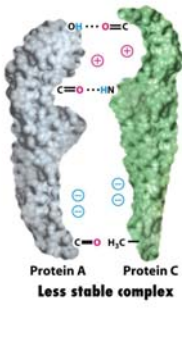
- **Ionic bonds** are formed from atoms with such differing electronegativity that one pulls electron away from the other and both become charged.



Other chemical interactions hold biological molecules together.

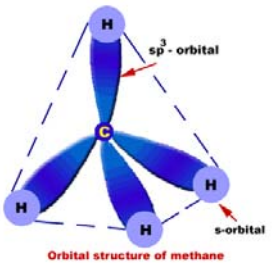




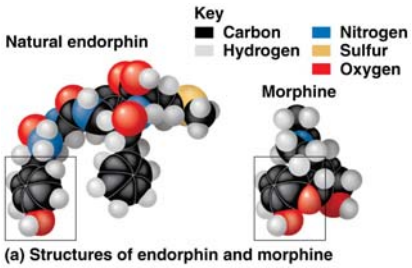


Hydrogen Bonds | Hydrophobic Interactions | Van der Waals forces

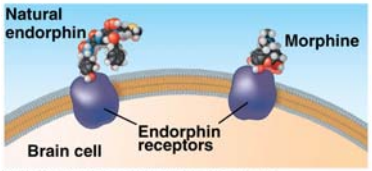
The 3D shape of molecules determines their biological reactivity.



Orbital structure of methane



(a) Structures of endorphin and morphine



(b) Binding to endorphin receptors

Chemical reactions preserve the number of atoms of each element.

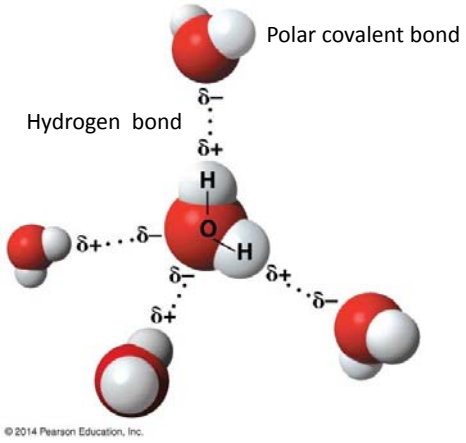
- Acid-Base:

  $HCl + KOH \rightarrow KCl + H_2O$
- Combustion:

  $C_3H_8 + 5O_2 \rightarrow 4H_2O + 3CO_2 + energy$
- Photosynthesis:

  $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + energy$
- Question: X and Y are? $2H_2 + XO_2 \rightarrow YH_2O$

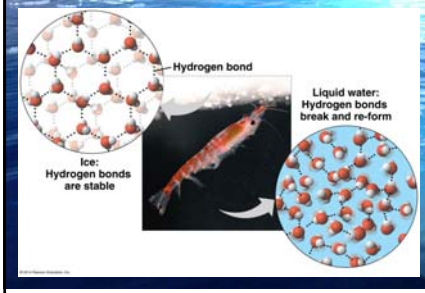
The polarity of the water molecule gives rise to hydrogen bonds.



Properties of water sustain life on Earth.

- Adhesion to water allows transport up thin vesicles; surface tension allows floatation.
- Water can absorb heat when it's hot and release heat when it's cold; high specific heat.
- Water that evaporates as steam leaves behind a cooler reservoir of liquid to prevent overheating; high heat of vaporization 580 cal.

Ability of solid ice to float on liquid ice means lakes/seas won't freeze solid.



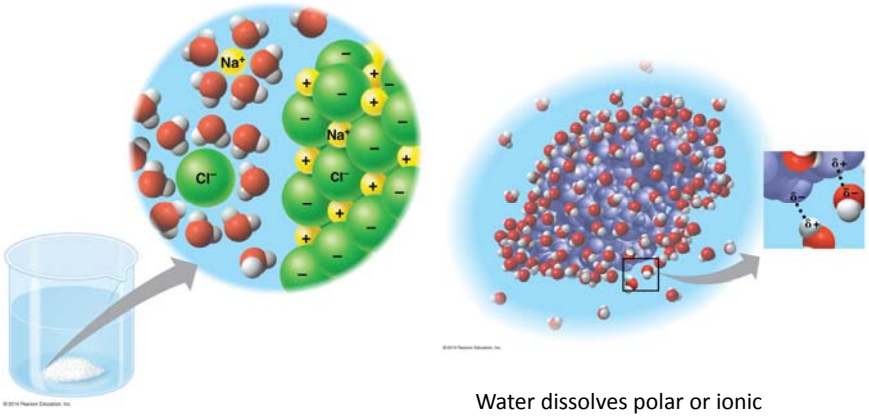
Global warming causes polar ice caps to form later and melt earlier.

- Combustion:

  $C_3H_8 + 5O_2 \rightarrow 4H_2O + 3CO_2 + \text{energy}$
- Impact:

  Sea level rise 1.8mm/yr, increased rain in wet areas, reduced rain in dry areas, heat waves, droughts, ocean acidification, conversion of tropical forests to savannahs, species extinct.

Water can dissolve almost anything due to its weak hydrogen bonding.

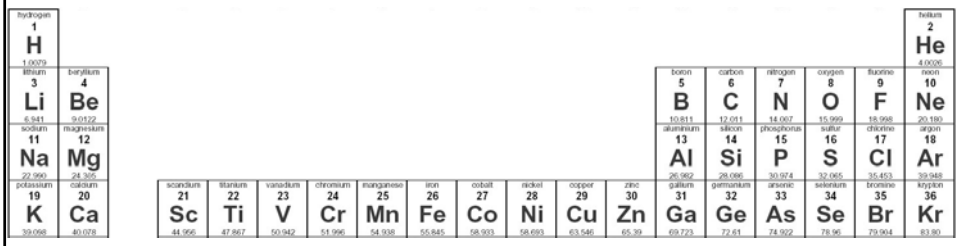


Water dissolves polar or ionic species but not fats.

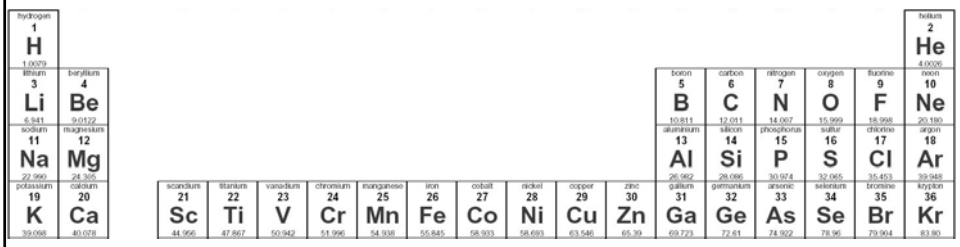
Calculating amount of materials using molar definition of mass.

- A mole of a compound has its molecular mass expressed in grams (for 6.02×10^{23} molecules).
  - One mole of water weighs 18 grams:
  - 2 hydrogens (2 x 1.0079g) + 1 oxygen (15.9994g)
- Concentration is moles per liter of solution.
- Question: How many grams of salt (sodium chloride) should you add to one liter of water to get one molar concentration salt solution?

NaCl is one Na (22.99 g/mol) and
one Cl (35.453 g/mol).

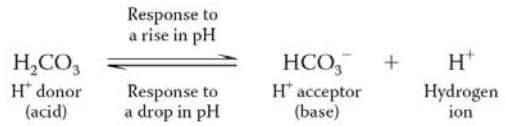


NaCl is one Na (22.99 g/mol) and
one Cl (35.453 g/mol).
So one mol of NaCl is 22.99+35.45 = 58.44 gram,
put that in one liter of water to give you
1M NaCl in H_2O.



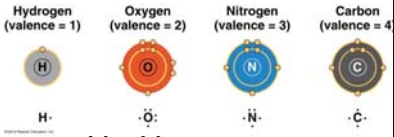
Acidic and basic solutions affect living conditions.

- At 25°C, $[H^+] = 10^{-7}M$, $[OH^-] = 10^{-7}M$.
- pH = - log $[H^+]$, inversely related to hydrogen concentration.
- Neutral solution has pH 7.
- Acidic solution has pH < 7, basic has pH > 7.
- Biological buffers reduce the effect of pH changes:

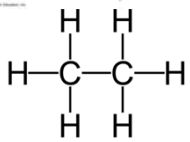


The study of carbon based "life" compounds is organic chemistry.

- **Miller and Urey** (12-11).
- 4 valence electrons of C:

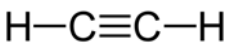


- Single bonds (ethane C_2H_6)

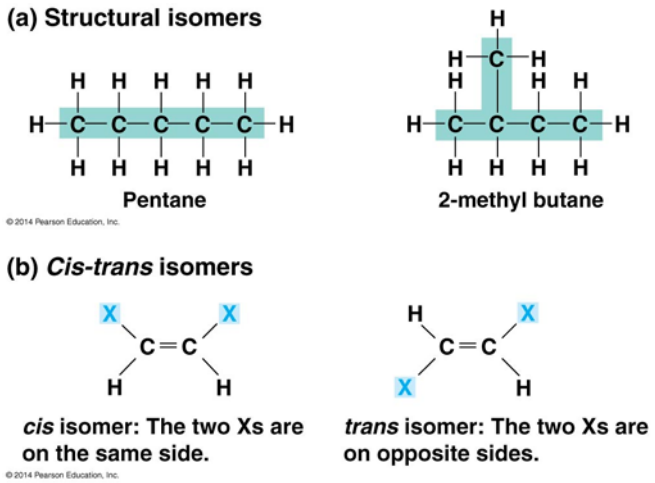


- Double bonds (carbon dioxide CO_2)

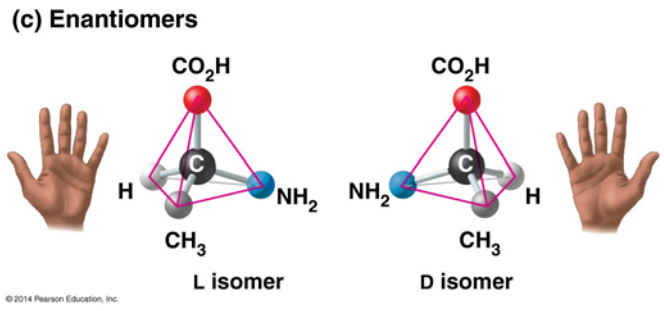
- Triple bonds (acetylene C_2H_2)



Isomers have the same number of atoms of each element.

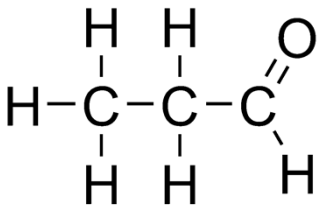


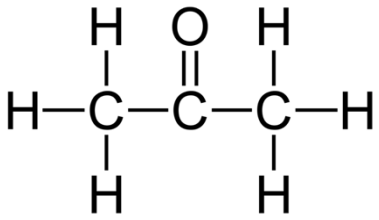
Isomers have the same number of atoms of each element.



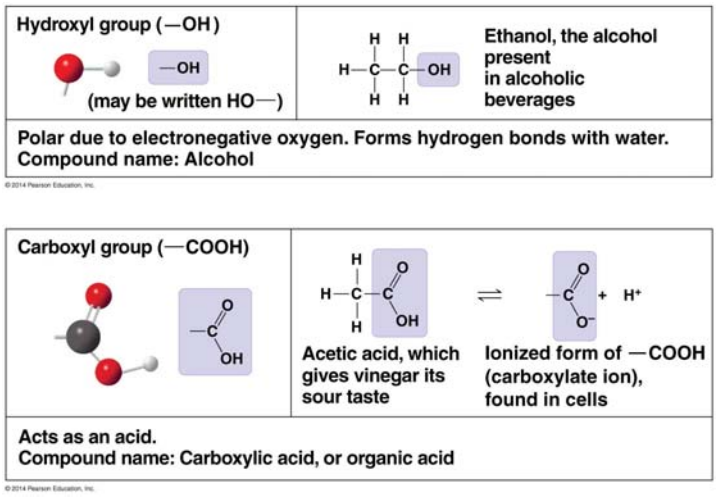
Isomers have the same number of atoms of each element.

- Question: what kind of isomers are propanal and acetone?

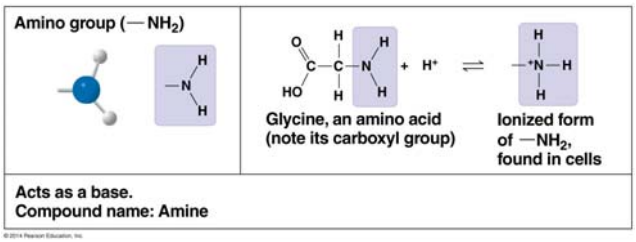


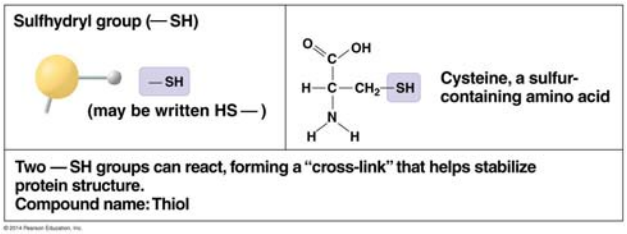


Functional groups give "personalities" to biological molecules.



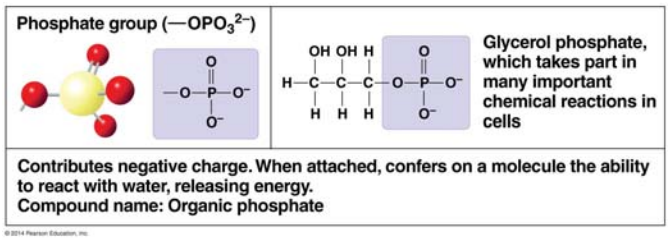
Functional groups give "personalities" to biological molecules.

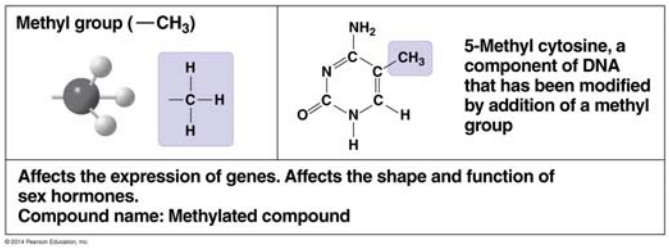




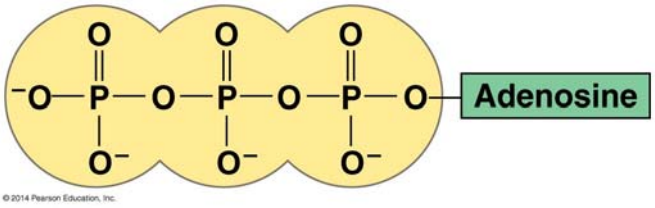
Functional groups give "personalities" to biological molecules.

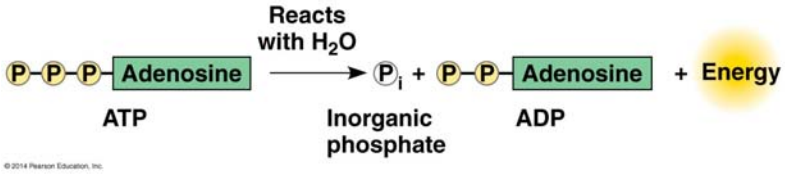
Functional groups joined to Carbon Body via Covalent bonds





ATP is the energy "currency" of the cell.

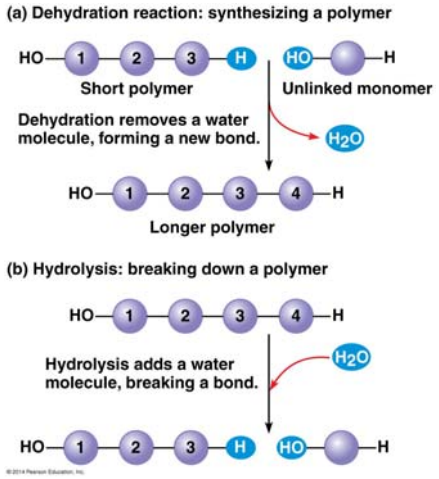




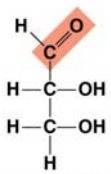
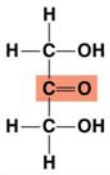
Life has three main classes of macromolecules.

- Carbohydrates store energy (starch, glycogen) and form structures (cellulose, chitin) and make up the backbones of DNA (ribose).
- Proteins catalyze reactions and bind important substrates like oxygen.
- Nucleic acids carry genetic information and information about making proteins (DNA, RNA).

Monomers are built into polymers in dehydration reactions.

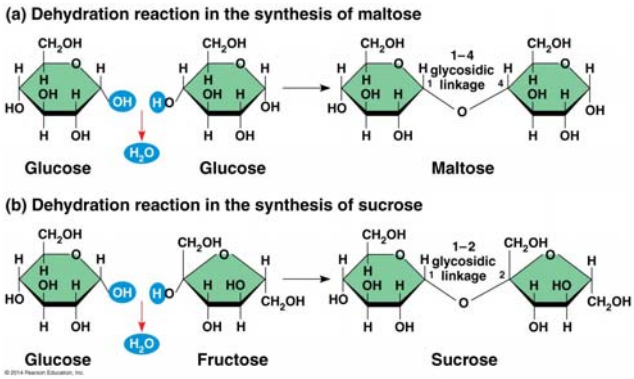


Carbohydrates are chains of sugars with carbonyl and hydroxyl groups.

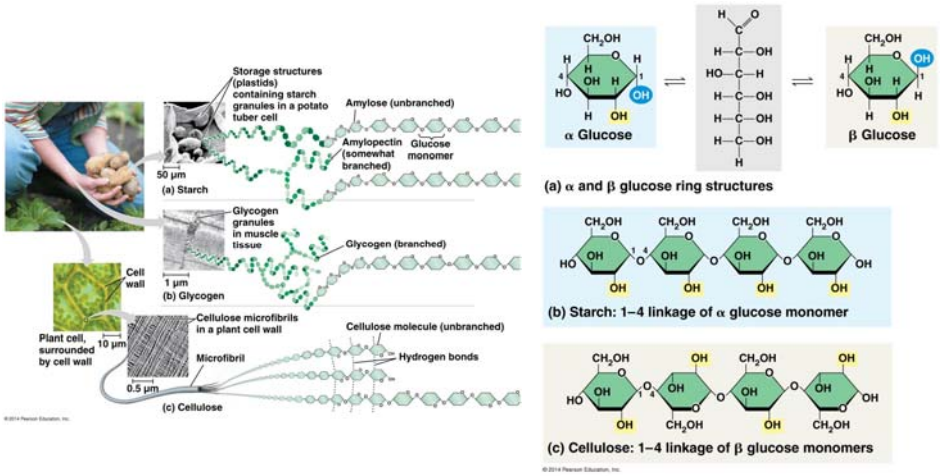
Aldose (Aldehyde Sugar)	Ketose (Ketone Sugar)
Trioses: 3-carbon sugars ($C_3H_6O_3$)	
 Glyceraldehyde	 Dihydroxyacetone

Carbohydrates monomers are joined together by glycosidic bonds.

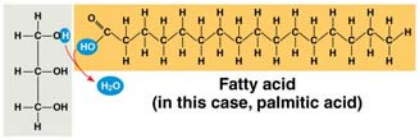
- In solution, each monosaccharide form rings of (usually) 5 or 6 carbons.



Starch (α glucose) and cellulose (β glucose) link monomers differently.

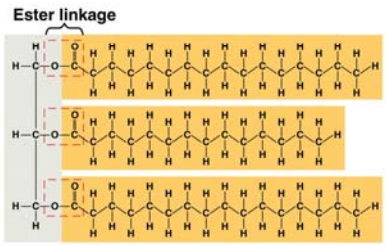


Fats are made up of glycerol and three fatty acids joined together.



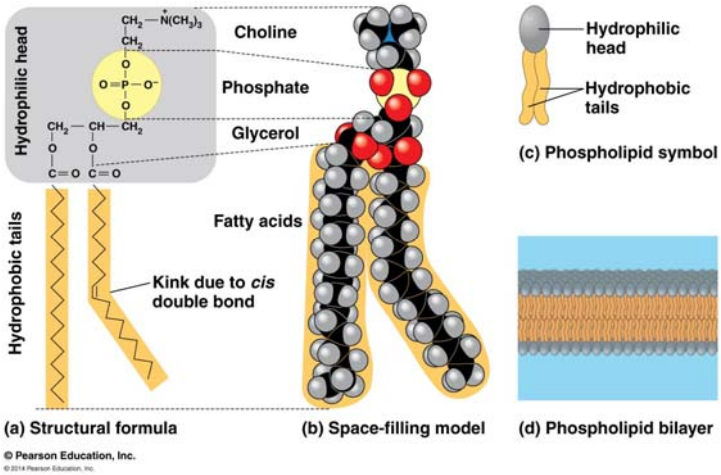
Glycerol

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

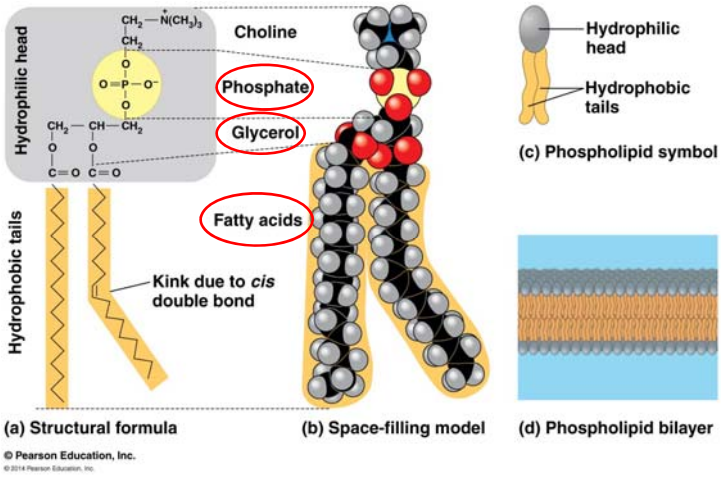


(b) Fat molecule (triacylglycerol)

Phospholipids form the (bilayer) membranes of cells.



Phospholipids form the (bilayer) membranes of cells.



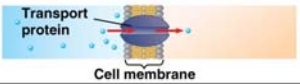
Proteins are required for diverse functions of cells.

Enzymatic proteins
Function: Selective acceleration of chemical reactions
Example: Digestive enzymes catalyze the hydrolysis of bonds in food molecules.

Defensive proteins
Function: Protection against disease
Example: Antibodies inactivate and help destroy viruses and bacteria.

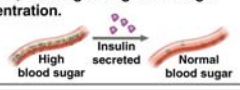
Storage proteins
Function: Storage of amino acids
Examples: Casein, the protein of milk, is the major source of amino acids for baby mammals. Plants have storage proteins in their seeds. Ovalbumin is the protein of egg white, used as an amino acid source for the developing embryo.

Transport proteins
Function: Transport of substances
Examples: Hemoglobin, the iron-containing protein of vertebrate blood, transports oxygen from the lungs to other parts of the body. Other proteins transport molecules across membranes, as shown here.

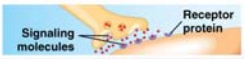


Proteins are required for diverse functions of cells.

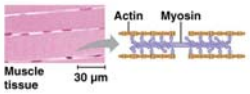
Hormonal proteins
Function: Coordination of an organism's activities
Example: Insulin, a hormone secreted by the pancreas, causes other tissues to take up glucose, thus regulating blood sugar concentration.



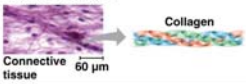
Receptor proteins
Function: Response of cell to chemical stimuli
Example: Receptors built into the membrane of a nerve cell detect signaling molecules released by other nerve cells.



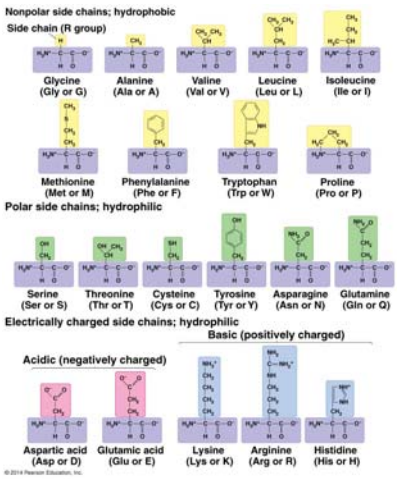
Contractile and motor proteins
Function: Movement
Examples: Motor proteins are responsible for the undulations of cilia and flagella. Actin and myosin proteins are responsible for the contraction of muscles.



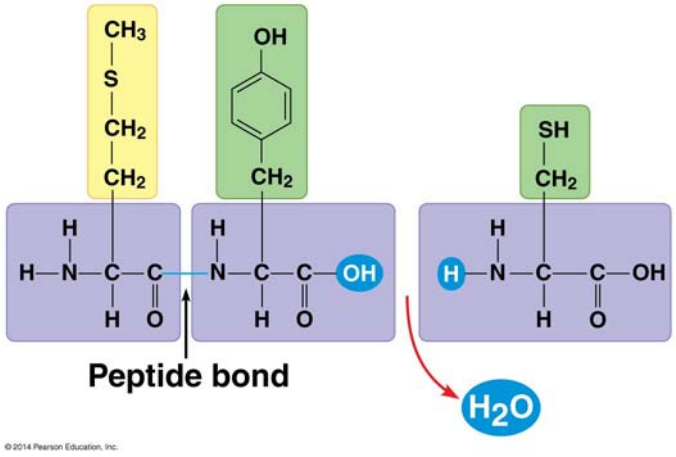
Structural proteins
Function: Support
Examples: Keratin is the protein of hair, horns, feathers, and other skin appendages. Insects and spider use silk fibers to make their cocoons and webs, respectively. Collagen and elastin proteins provide a fibrous framework in animal connective tissues.



Proteins are made up of amino acids characterized by different side chains.



Individual amino acids are joined together by peptide bonds.



Team work.

Which of the following chemicals do you NOT expect to be readily dissolved in water?

- A. Uric acid
- B. Hexane
- C. Glycerol
- D. Ethanol
- E. Potassium chloride

Water has an unusually high specific heat. What does this mean?

- A. At its boiling point, water changes from liquid to vapor.
- B. Ice floats in liquid water.
- C. Floating ice can insulate bodies of water.
- D. More heat is required to raise the temperature of water.