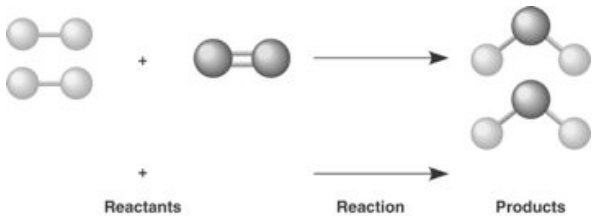
Topics

- Introduction to Organic Chemistry
  - Hydrocarbons
  - Functional groups
- Macromolecules
  - Carbohydrates
  - Lipids

Understanding acids and bases

		$[H_3O^+]$	pH	$[OH^-]$
MORE BASIC	BASIC	1.0×10^{-15}	15.00	1.0×10^{1}
		1.0×10^{-14}	14.00	1.0×10^{0}
		1.0×10^{-13}	13.00	1.0×10^{-1}
		1.0×10^{-12}	12.00	1.0×10^{-2}
		1.0×10^{-11}	11.00	1.0×10^{-3}
		1.0×10^{-10}	10.00	1.0×10^{-4}
		1.0×10^{-9}	9.00	1.0×10^{-5}
		1.0×10^{-8}	8.00	1.0×10^{-6}
	NEUTRAL	1.0×10^{-7}	7.00	1.0×10^{-7}
MORE ACIDIC	ACIDIC	1.0×10^{-6}	6.00	1.0×10^{-8}
		1.0×10^{-5}	5.00	1.0×10^{-9}
		1.0×10^{-4}	4.00	1.0×10^{-10}
		1.0×10^{-3}	3.00	1.0×10^{-11}
		1.0×10^{-2}	2.00	1.0×10^{-12}
		1.0×10^{-1}	1.00	1.0×10^{-13}
		1.0×10^{0}	0.00	1.0×10^{-14}
		1.0×10^{1}	−1.00	1.0×10^{-15}

Chemical reactions



$H_20 + NaOH + HCl \rightleftharpoons Na^+ + Cl^- + 2H_20$

Physiological Buffers

(equal at pH 6.1)

$CO_2 + H_20 \rightleftharpoons H_2CO_3 \rightleftharpoons HCO_3^- + H^+$

Buffer	pKa (pH it likes)
Carbonate	6.1
Phosphate	7.2

CO_2 acts as an important **physiological buffer**. It is constantly being replenished by cellular metabolism

Buffers in Human blood

The body maintains the pH of blood at around 7.4

Serious health consequences result from changes of just a few tenths of a unit.

A decrease in blood ph is called **acidosis**, an increase is called **alkalosis**

Buffers maintain pH by binding H^+ or OH^- ions.

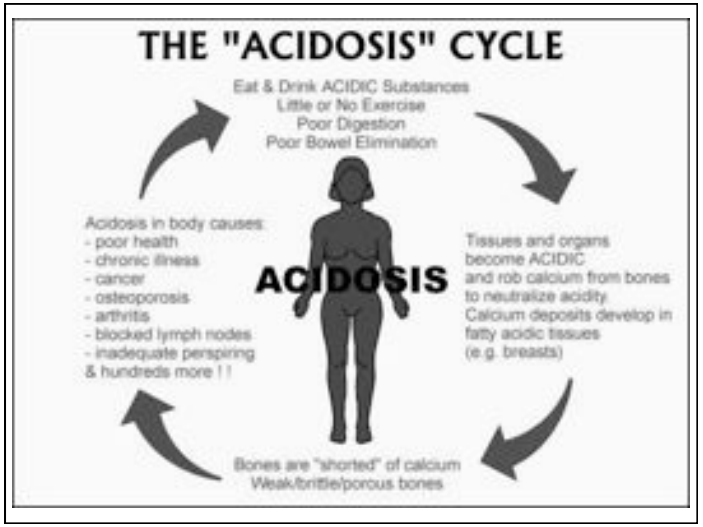
Buffers are most effective in a pH range near its pK_a.

The most important buffer for maintaining acid-base balance in the blood is the carbonic-acid-bicarbonate buffer.
The equilibrium reaction is:

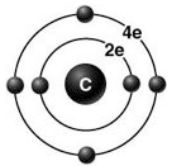
$$H_2O + CO_2 \rightleftharpoons H_2CO_3 \rightleftharpoons HCO_3^- + H^+$$

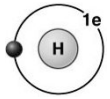
H_2CO_3: Weak acid

HCO_3^-: "conjugate base"



Carbon- the BACKBONE of life

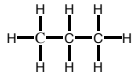




- Carbon is unique. It always forms four bonds and it exclusively forms covalent bonds.
- Is found in all organic molecules
- Carbon-Carbon chains found in many biological molecules
- Carbon-Carbon and Carbon-Hydrogen are nonpolar

Chemistry Shorthand

- Covalent bonds are represented by lines
- In *shorthand* the Carbon-Carbon bonds are represented only by a line, and hydrogens are <u>assumed</u>



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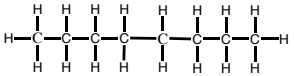

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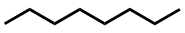
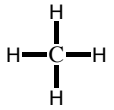
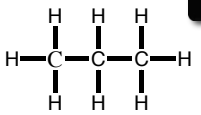


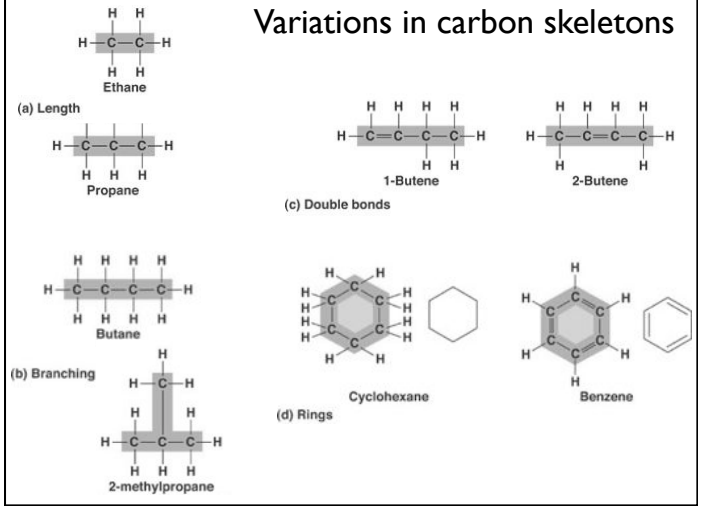
Nomenclature of Hydrocarbons

# of Carbons	Prefix
1	Methyl
2	Ethyl
3	Propyl
4	Butyl
5	Pentyl
6	Hexyl
7	Septyl
8	Octyl
9	Nonyl
10	Decyl



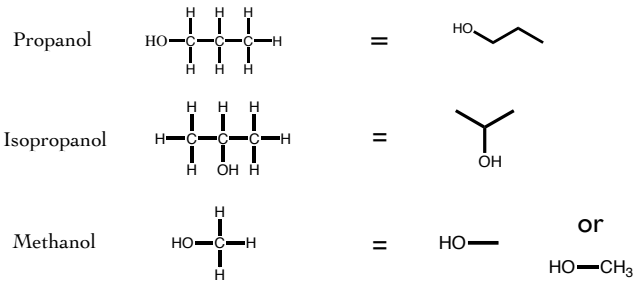


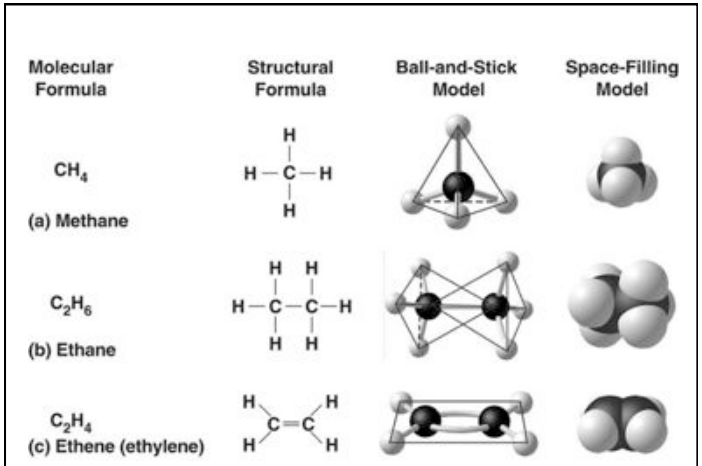
Variations in carbon skeletons



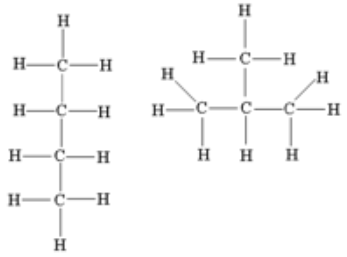
Organic Chemistry Shorthand

- **All** other atoms, and their bonds, are fully drawn out





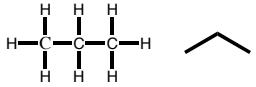
***Isomers*:** compounds with the same molecular formula but different structural formulas.
Isomers do not necessarily share similar properties



n-Butane Isobutane

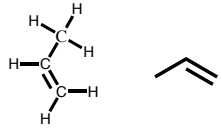
Saturation of Hydrocarbons

- Hydrocarbon chains that contain the maximum number of hydrogens and therefore have no C-C double covalent bonds are **saturated**.



Propane

(Saturated)

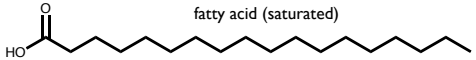


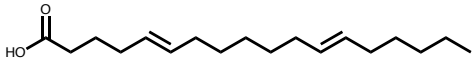
Propyl*ene*

(unsaturated)

Saturation of Hydrocarbons

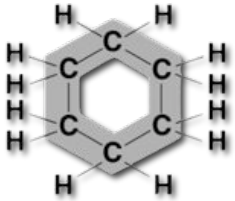
- Hydrocarbon chains with more than one *unsaturated* bonds are called **polyunsaturated**



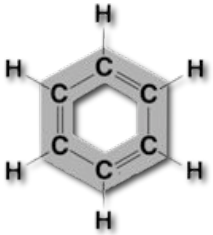


(polyunsaturated)

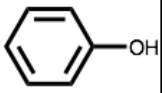
Carbon Structures Can Also Form Rings



Cyclohexane



Benzene

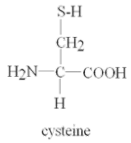


Phenol

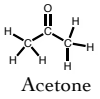
C-O Functional Groups

Functional Group	Example	Where Else Found
Hydroxyl (or "Alcohol") –OH	Ethanol 	Carbohydrates
Aldehyde 	 Glucose	Carbohydrates, formaldehyde

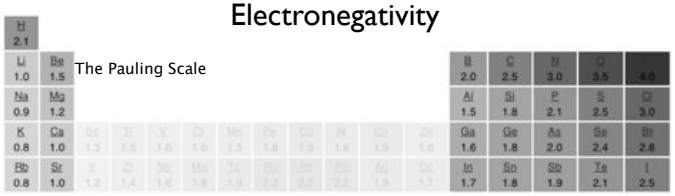
C-O Functional Groups

Functional Group	Example	Where Else Found
Sulfhydryl –SH	 cysteine	Proteins
Methyl –CH3	H3COH methanol	Carbohydrates, Nucleic acids, proteins

C-O Functional Groups

Functional Group	Example	Where Else Found
Ketone 	 Acetone	Carbohydrates, Fat breakdown
Carboxyl 	 Acetic Acid (vinegar)	Amino acids, fatty acids

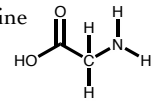
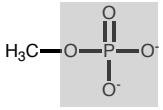
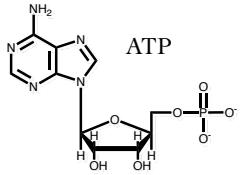
Electronegativity



Element	Strength
F	4.0
O	3.5
N	4.0
S	2.5
C	2.5
H	2.1
P	2.1

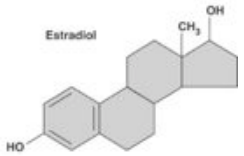
* A difference of less than 0.5 results in mostly ***equal*** sharing (nonpolar)

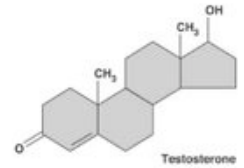
Other Functional Groups

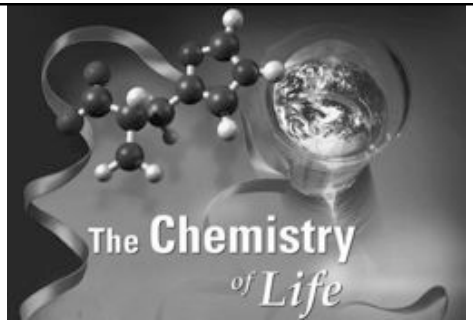
Functional Group	Example	Where Else Found
Amino 	Glycine 	Proteins/ Amino acids
Phosphate 	ATP 	DNA


Female lion


Male lion





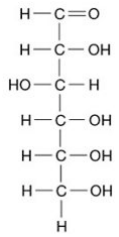


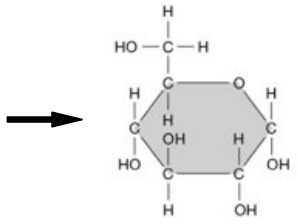
Living tissues: 70% water + <u>30% macromolecules</u>

Carbohydrates
Lipids
Nucleic Acids
Proteins

Carbohydrates

General formula: $C_n(H2O)_n$
Carbon:Hydrogen:Oxygen of 1:2:1
***e.g.* $C_6H_{12}O_6$**

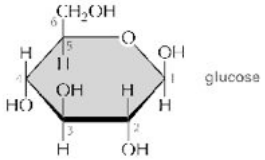

Glucose


Glucose

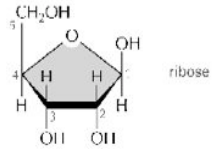
Carbohydrates

Glucose is a **monosaccharide (1:2:1 of C:H:O) ,** a simple sugar.

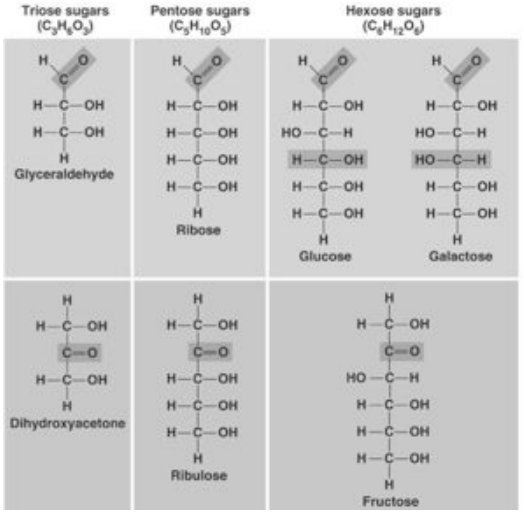
- Monosaccharides have different structures, but still have C:H:O ratio of ~ 1:2:1
- simple molecules with up to 7 carbons



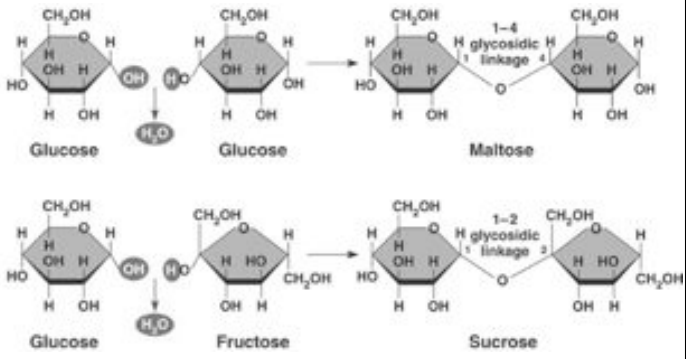
Major metabolic substrate
- 6 carbon ring



Component of RNA/DNA
- 5 carbon ring



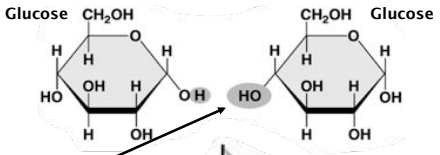
Dehydration reaction



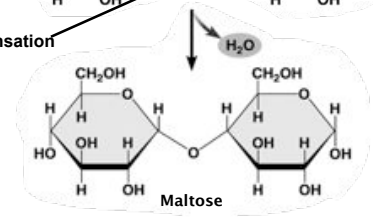
Carbohydrate Polymerization

Glycosidic linkages: covalent bonds between monosaccharides to form complex molecules

Monosaccharides



Condensation



Disaccharide = 2 molecules (vs. oligosccharides, polysaccharides)

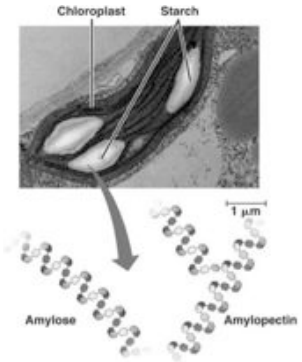
!!!!!!!!! 4 major biochemical roles of carbohydrates !!!!!!!!!

1. Energy storage
   Polysaccharides: starch and glycogen
2. Transport of stored energy
3. Structural molecules to give shape to organisms
   Cellulose
4. Signaling molecules that trigger biological responses

Polysaccharides

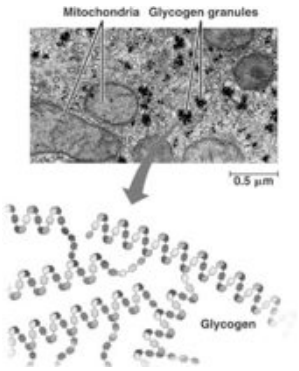
Starch

- Is the major **food storage** form of glucose in plants

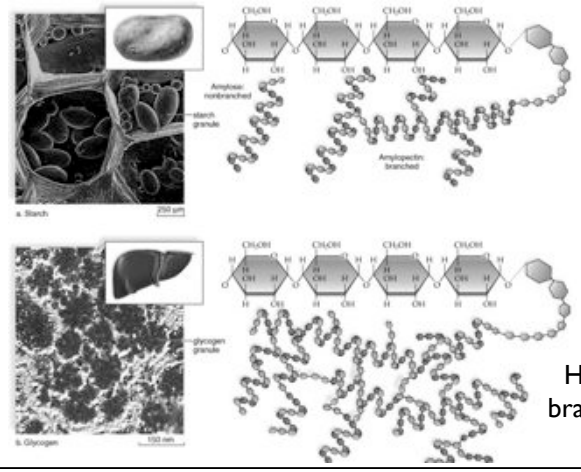


Glycogen

- Is the major **food storage** form of glucose in humans



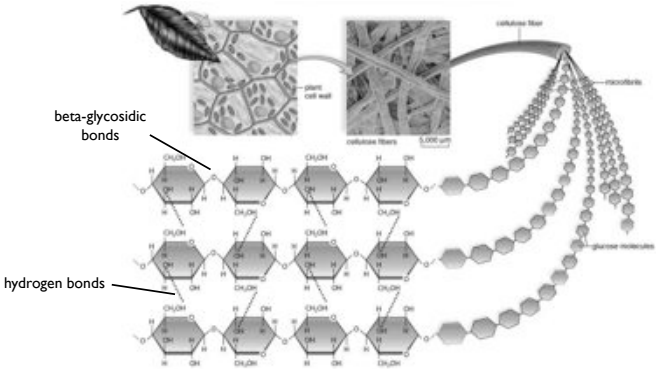
Starch and Glycogen



Highly branched

Structural role of polysaccharides: Cellulose

Is a major component of the tough walls that enclose plant cells

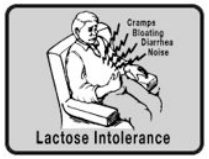


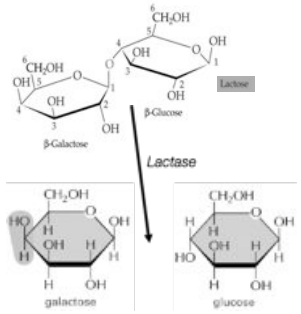
Cellulose

- Cellulose is difficult for mammals to digest
- Cows have microbes in their stomachs to facilitate this process

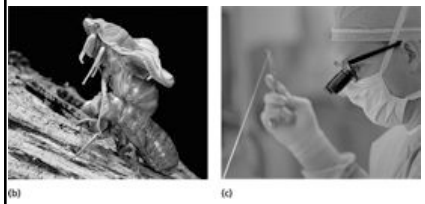
- Why do humans eat cellulose?

Lactose Intolerance





Other Polysaccharides

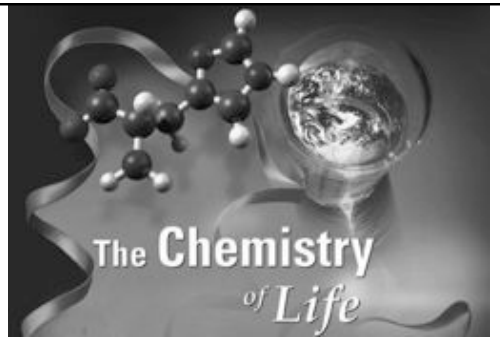


Chitin has repeating units of a **modified glucose** molecule.

An important component of exoskeletons

Peptidoglycan is a polysaccharide with repeating units of a **modified glucose** molecule.

An important component of bacterial **cell walls**



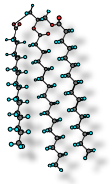
Living tissues: 70% water + 30% macromolecules

- Carbohydrates
- **Lipids**
- Nucleic Acids
- Proteins

Lipids-types and roles

1. Fats and oils

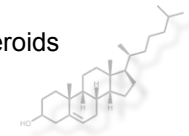
- **Storage of energy**
- **Insulation and protection**



2. Phospholipids

- structural role in cell membranes

3. Steroids

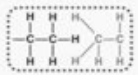


Lipids Mmmmmm…. Lard

- Hydrocarbons that are insoluble in water due to numerous nonpolar covalent bonds.
- Aggregate together, with weak *van der Waals* interactions holding individual moleculues together.
- This forms a macromolecule of individual lipid molecules that are not covalently bonded

Chemical Bonds

TABLE 2.1 Chemical Bonds and Interactions

NAME	BASIS OF INTERACTION	STRUCTURE	BOND ENERGY*
Ionic attraction	Attraction of opposite charges		3–7
Covalent bond	Sharing of electron pairs		50–110
Hydrogen bond	Sharing of H atom		3–7
Hydrophobic interaction	Interaction of nonpolar substances in the presence of polar substances (especially water)		1–2
van der Waals interaction	Interaction of electrons of nonpolar substances		1

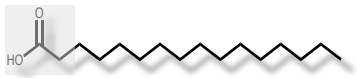
*Bond energy is the amount of energy (Kcal/mol) needed to separate two bonded or interacting atoms under physiological conditions.

PRINCIPLES OF LIFE, Table 2.1

Triglycerides

- Most common unit of lipid is the triglyceride (simple lipid)
- If form solid at room temp = fat liquid = oil
- Composed of 3 fatty acids + 1 glycerol molecule

Fatty acid



Palmitic acid

Glycerol