Introduction to Science
and the Chemistry of Life

I **Nature of Science**

1.Forms

a) Pure Science - study for the pure gain of knowledge

b) Applied Science - directed study to solve a known problem.

2. Procedures of Science - the Scientific Method

a) Observation - measurable, unbiased observations

b) Hypothesis - cause and effect or Null

c) Experimentation - use of control, sufficient numbers, unbiased analysis

d) Theory - a working explaination of cause and effect with predictive value.

e) Law - a proven theory in all measurable situations.

3. Limitations of Science

a) Scientific Domain - must be able to apply the Scientific Method to the area

b) Aims of Science - "to make and use theories"

4. Divisions of Biological Sciences

a) botany - study of plants
b) zoology - study of animals
c) microbiology - study of bacteria, viruses
d) anatomy - study of structure
e) physiology - study of cell and organ chemistry
f) embryology - development of an egg through early development
g) genetics - study of inheritance of traits
h) taxonomy - the grouping of organisms by physical traits
I) cytology - study of cells
j) histology - study of tissues
k) ecology - study of organisms in relationship to their environment.

II Nature of Life

1. Levels of Organization

atoms
molecules
compounds
organelles
cells
tissues
organs
organ systems
organism
population
community
ecosystem
biosphere

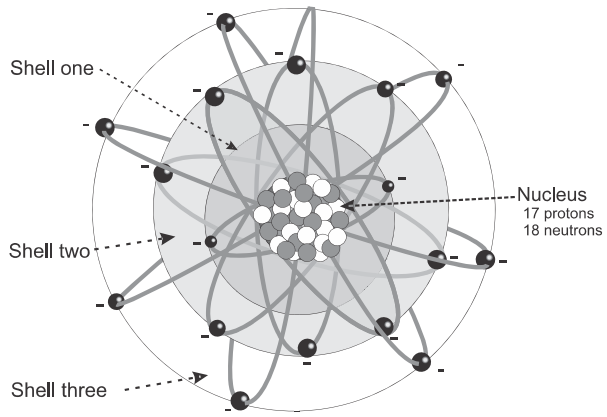
III Chemistry of Life

1. Elements
92 naturally occurring kinds
~ 20 kinds in cells

2. Atom

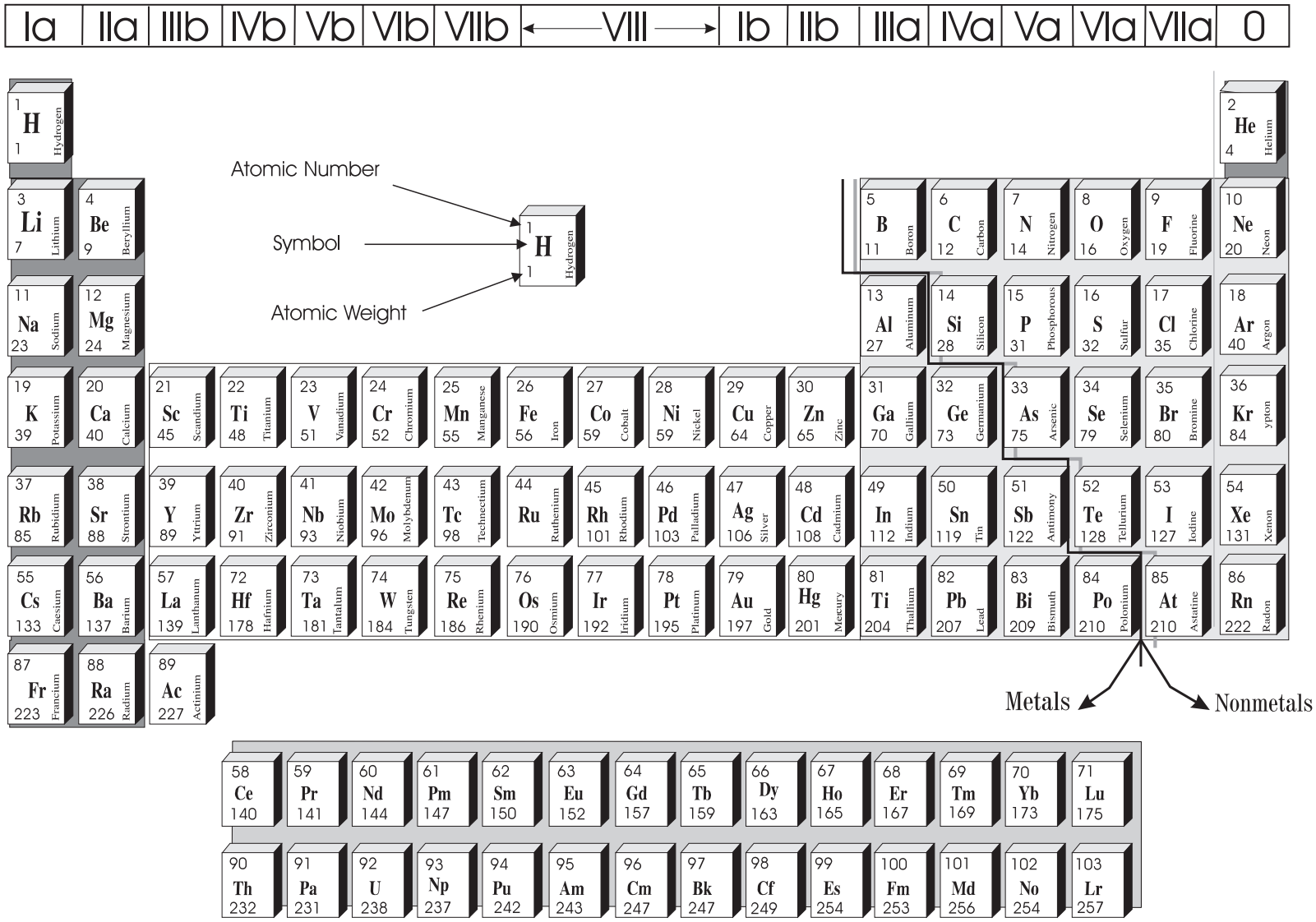
nucleus - center mass
shells - arrangement of electrons

atomic number - number of protons
atomic weight - protons plus neutrons
proton number - determines the element
electron number - equal to the proton #
valence - # of electrons in the outermost shell
isotopes- same # of protons, different # of neutrons.



Hypothetical Atom

Octet rule - all shells have a tendency to have 8 electrons in them except for the first shell which has 2.


Ia IIa IIIb IVb Vb VIb VIIb ← VIII → Ib IIb IIIa IVa Va VIa VIIa 0
Atomic Number
Symbol
Atomic Weight
1 H 1 Hydrogen
2 He 4 Helium
3 Li 7 Lithium
4 Be 9 Beryllium
5 B 11 Boron
6 C 12 Carbon
7 N 14 Nitrogen
8 O 16 Oxygen
9 F 19 Fluorine
10 Ne 20 Neon
11 Na 23 Sodium
12 Mg 24 Magnesium
13 Al 27 Aluminum
14 Si 28 Silicon
15 P 31 Phosphorous
16 S 32 Sulfur
17 Cl 35 Chlorine
18 Ar 40 Argon
19 K 39 Potassium
20 Ca 40 Calcium
21 Sc 45 Scandium
22 Ti 48 Titanium
23 V 51 Vanadium
24 Cr 52 Chromium
25 Mn 55 Manganese
26 Fe 56 Iron
27 Co 59 Cobalt
28 Ni 59 Nickel
29 Cu 64 Copper
30 Zn 65 Zinc
31 Ga 70 Gallium
32 Ge 73 Germanium
33 As 75 Arsenic
34 Se 79 Selenium
35 Br 80 Bromine
36 Kr ypton 84
37 Rb 85 Rubidium
38 Sr 88 Strontium
39 Y 89 Yttrium
40 Zr 91 Zirconium
41 Nb 93 Niobium
42 Mo 96 Molybdenum
43 Tc 98 Technecium
44 Ru Ruthenium
45 Rh 101 Rhodium
46 Pd 103 Palladium
47 Ag 106 Silver
48 Cd 108 Cadmium
49 In 112 Indium
50 Sn 119 Tin
51 Sb 122 Antimony
52 Te 128 Tellurium
53 I 127 Iodine
54 Xe 131 Xenon
55 Cs 133 Caesium
56 Ba 137 Barium
57 La 139 Lanthanum
72 Hf 178 Hafnium
73 Ta 181 Tantalum
74 W 184 Tungsten
75 Re 186 Rhenium
76 Os 190 Osmium
77 Ir 192 Iridium
78 Pt 195 Platinum
79 Au 197 Gold
80 Hg 201 Mercury
81 Ti 204 Thallium
82 Pb 207 Lead
83 Bi 209 Bismuth
84 Po 210 Polonium
85 At 210 Astatine
86 Rn 222 Radon
87 Fr 223 Francium
88 Ra 226 Radium
89 Ac 227 Actinium
Metals
Nonmetals
58 Ce 140
59 Pr 141
60 Nd 144
61 Pm 147
62 Sm 150
63 Eu 152
64 Gd 157
65 Tb 159
66 Dy 163
67 Ho 165
68 Er 167
69 Tm 169
70 Yb 173
71 Lu 175
90 Th 232
91 Pa 231
92 U 238
93 Np 237
94 Pu 242
95 Am 243
96 Cm 247
97 Bk 247
98 Cf 249
99 Es 254
100 Fm 253
101 Md 256
102 No 254
103 Lr 257

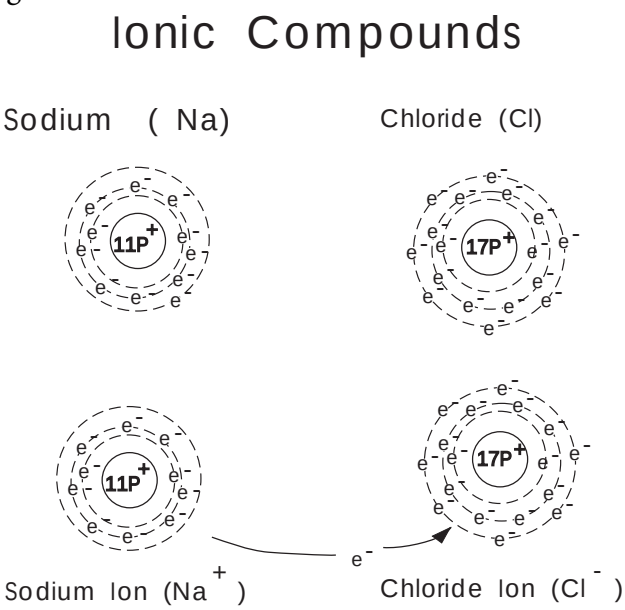
3. Bonding

Ionic Bonding vs Covalent Bonding

a) Ionic Bonding

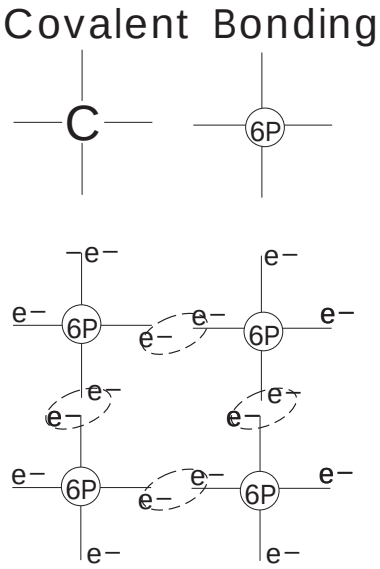
b) Covalent Bonding

c) Hydrogen Bonding



Ionic Bonds

Covalent Bonding: Single, Double and Triple.



Covalent Bond

4. pH: Acid - Base Relationships

pH Value	**Log**	**Number of Hydrogen Ions**	
pH 1	10^{-1}	.1	H^+
pH 2	10^{-2}	.01	H^+
pH 3	10^{-3}	.001	H^+
pH 4	10^{-4}	.0001	H^+
pH 5	10^{-5}	.00001	H^+
pH 6	10^{-6}	.000001	H^+
pH 7	10^{-7}	.0000001	H^+
pH 8	10^{-8}	.00000001	H^+
pH 9	10^{-9}	.000000001	H^+
pH 10	10^{-10}	.0000000001	H^+
pH 11	10^{-11}	.00000000001	H^+
pH 12	10^{-12}	.000000000001	H^+
pH 13	10^{-13}	.0000000000001	H^+
pH 14	10^{-14}	.00000000000001	H^+

Strong acids and bases vs. weak acids and bases

$HCl \Rightarrow H^{+}\,{}^{-}Cl$ (Hydrochloric Acid) Strong Acid

$H_3C\text{-}COOH \Rightarrow H_3C\text{-}COO^{-}\ {}^{+}H$ (Acetic Acid) Weak Acid

$NaOH \Rightarrow Na^{+}\,{}^{-}OH$ (Sodium Hydroxide) Strong Base

$NH_4OH \Rightarrow NH_4^{+}\,{}^{-}OH$ (Ammonium Hydroxide) Weak Base

Buffers - Will tend to modify the acidity or alkalinity of a solution to keep it stablized

Composed of a Weak Acid or Weak Base

$H_2CO_3 \rightleftarrows H^+ + HCO_3$ (Carbonic Acid)

5. Types of Chemical Changes in Cells

a) Synthesis

$CO_2 + H_2O \Rightarrow H_2CO_3$ (Carbonic Acid)

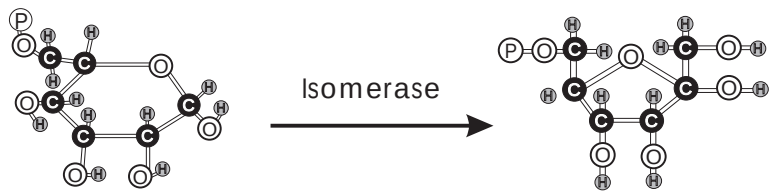
b) Decomposition

$H_2CO_3 \Rightarrow CO_2 + H_2O$

c) Exchange

$HCl + NaOH \Rightarrow HOH + NaCl$

d) Rearrangement



6. Catalyst

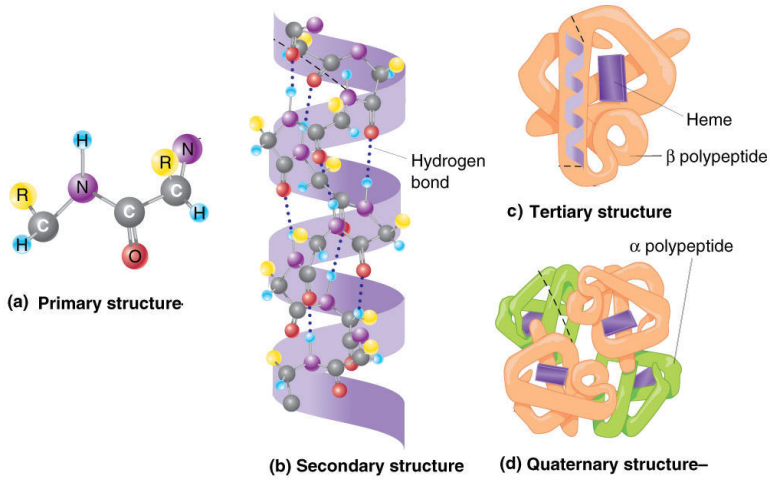
a) Definition : Speeds up reaction, determines direction, takes place of external heat, and not used up in the reaction.

b) Biological Catalysis - Enzymes (proteins)

c) Lock and Key model theory of enzyme activity

d) Enzyme characteristics

1) Temperature
2) pH
3) concentration
4) heavy metals
5) pressure



7. Important Biological Compounds

a) Water H_2O

1) Universal Solvent
2) Cohesive and Adhesive Properties
3) High Specific Heat
4) High Boiling Point
5) Coolant
6) Less dense as solid than as a liquid.

b) Carbon

1) Covalence of four

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    |
-- C --
    |
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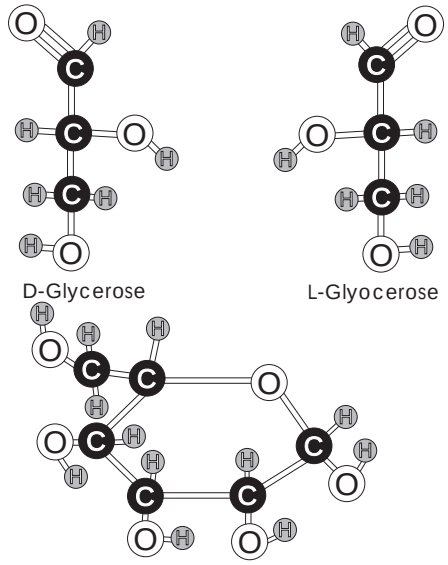
2) Can bond with C, H, O, N
3) Form chains and rings

c) **Carbohydrates** $(C_nH_{2n}O_n)$

1) Monosaccharide

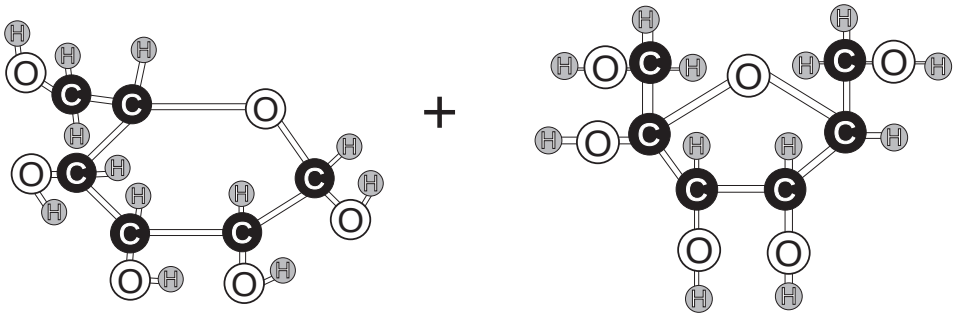
Monosaccharides



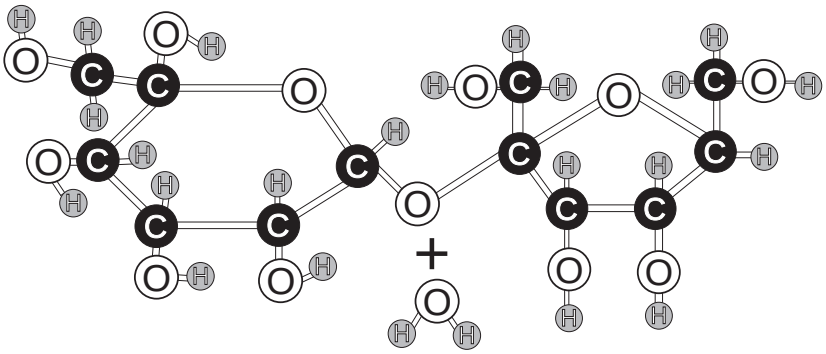
2) Disaccharide

3) Polysaccharide

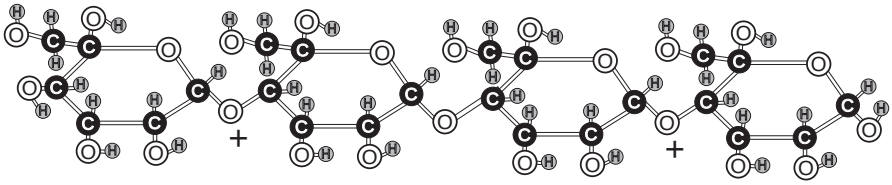
Carbohydrates



Glucose Fructose



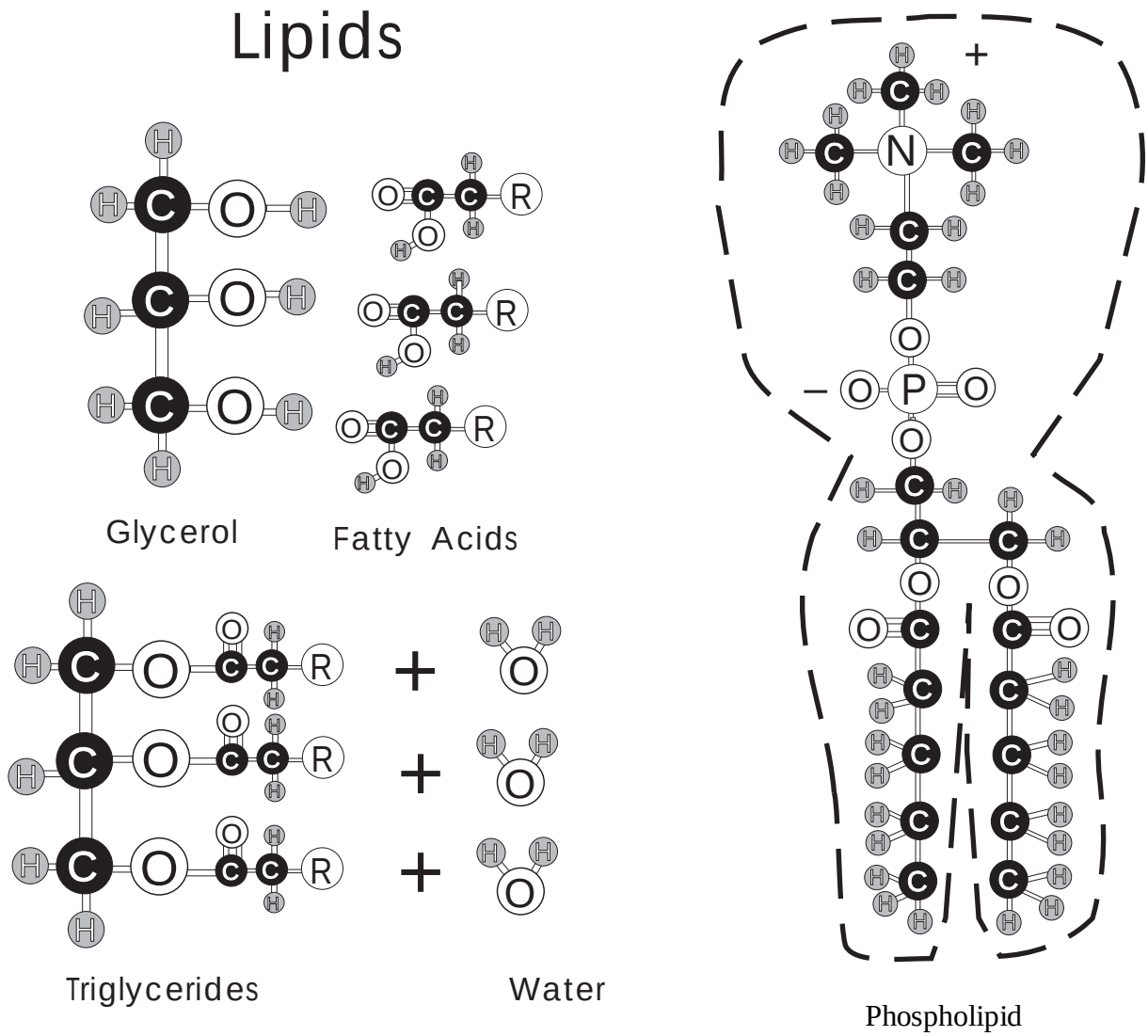
Disaccharides



Polysaccharide

d) **Lipids**

1) glycol- an alcohol- note the "ol" ending on the word.
2) Fatty Acids- note the carboxyl group.
3) Saturated vs. unsaturated
4) Phospholipids: Substitution of a charged phosphate group for third fatty acid chain



Lipids

"R" group - chain of carbon and hydrogen.

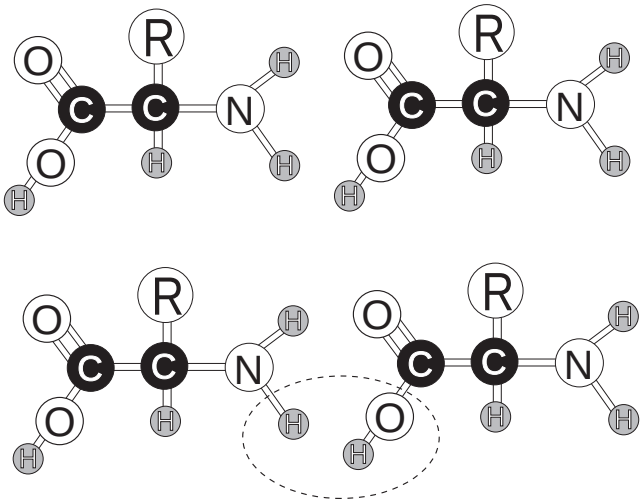
Carboxyl group

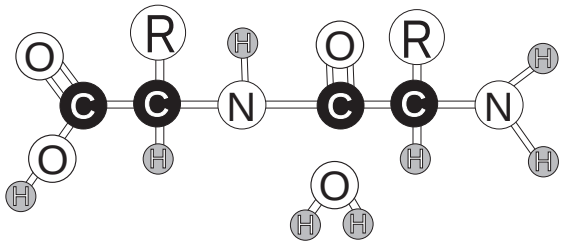
Condensation - combining molecules into larger ones involves the loss of water.

e) **Proteins**

1) Amine groups - $N\text{-}H_2$
2) Carboxyl groups C-OOH
3) Amino acids
4) Peptide bonds - C-N-C
5) 20 amino acids make up all cellular protein and enzymes
6) Primary Structure, Secondary Structure, Tertiary
   hemoglobin
7) Coagulation affected by:
   - heat
   - pressure
   - electricity
   - heavy metals

Proteins: Amino Acids





f) **Nucleic Acids**

1) Nucleic acids = nucleotides

2) nucleotides = nitrogen base + sugar + phosphate complex

3) Nitrogen bases

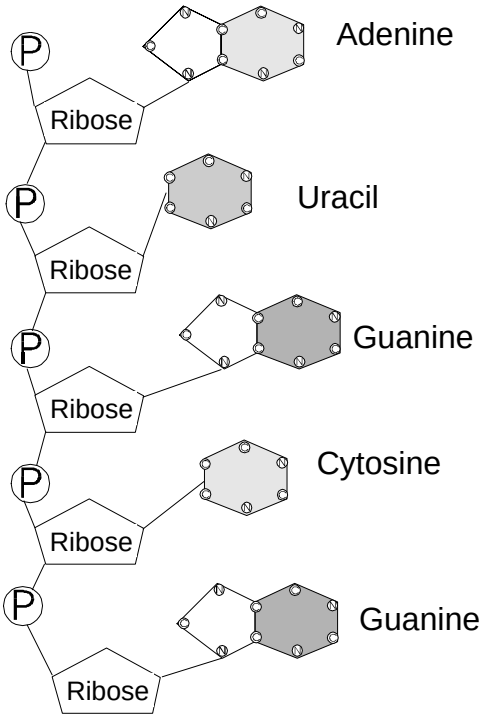
   - adenine
   - guanine
   - cytosine
   - thymine
   - uracil

4) Sugars C_5
   - Deoxyribose
   - Ribose

5) Two kinds of Nucleotides

   - ribose nucleotides
   - deoxyribose nucleotides

6) Ribose nucleotides
   - adenine ribose phosphate
   - uracil ribose phosphate
   - guanine ribose phosphate
   - cytosine ribose phosphate



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