Name KEY

Biology Unit 2 Chemistry of Life (Ch. 6) Guided Notes

- I can draw atom models and identify the # protons, # neutrons, and # electrons in an atom.
- I can identify the 6 most common elements that make up living things. C, H, N, O, P, S
- I can differentiate between ionic and covalent bonds.

Atoms are the building blocks of matter. Living & Nonliving things are made of matter.

Atom = Smallest Particle of an element that still retains the same Characteristics of the element; made of Protons, neutrons, electrons

Element = a substance that cannot be broken down into simpler chemical substances; composed of the same type of atoms.

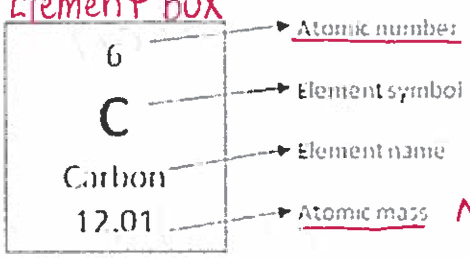
Structure of an ATOM

3 Parts:

1. Protons = + charge and located in the nucleus of an atom.
2. Neutrons = No charge (neutral) and located in the nucleus of an atom.
3. Electrons = − charge and located in the electron cloud of an atom.
   1st energy level can hold a maximum of 2 electrons
   2nd energy level can hold a maximum of 8 electrons
   3rd energy level can hold a maximum of 18 electrons (2,8,8)

The periodic table identifies the atomic number and atomic mass of an element.

Element box



= # Protons

Mass number = 12

Mass number = atomic mass rounded to nearest whole number

The periodic table is arranged in order of increasing atomic number.

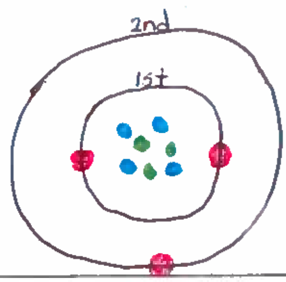
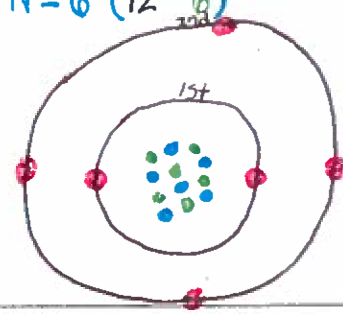
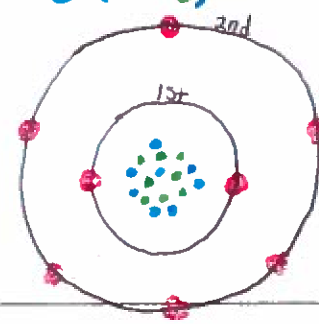
The vertical columns of the periodic table are called groups or families.

The horizontal rows of the periodic table are called Periods.

To calculate how many protons, electrons, and neutrons an atom or given element has use the following:

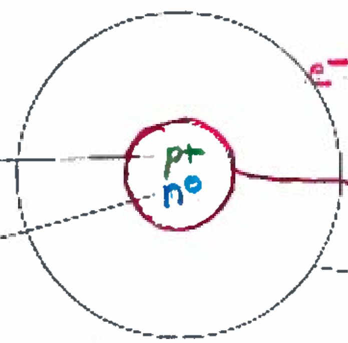
Atomic Number = # of Protons = # Electrons
Atoms are NEUTRAL/have NO CHARGE; therefore # Protons = # Electrons
Neutrons = Atomic Mass (rounded) – Atomic Number

For each element identify the # Protons, # Electrons, # Neutrons, Atomic #, and Atomic Mass (Mass Number). Then, draw and label the atom.

Lithium Li	Carbon C	Oxygen O
Atomic # = 3 Atomic Mass = 6.941 amu (7) • P = 3 • E = 3 • N = 4 (7-3)  	Atomic # = 6 Atomic Mass = 12.011 amu (12) • P = 6 • E = 6 • N = 6 (12 - 6)  	Atomic # = 8 Atomic Mass = 15.999 amu (16) • P = 8 • E = 8 • N = 8 (16 - 8) 

Fill in the diagram and chart below.

electron energy level neutron nucleus proton



1. Proton
2. neutron
3. electron
4. Nucleus
5. energy level

Statement	Electron	Neutron	Proton
Positively charged particle			X
Located outside the nucleus	X		
Can be shared by two atoms	X		
Has no charge (neutral)		X	

Atoms with same # protons but different number of neutrons are called isotopes.

Notice the type of notation used for atoms: ${}^{A}_{Z}X$

X = chemical symbol of the element
Z = "atomic number" = # protons
A = "mass number" = # protons + # neutrons

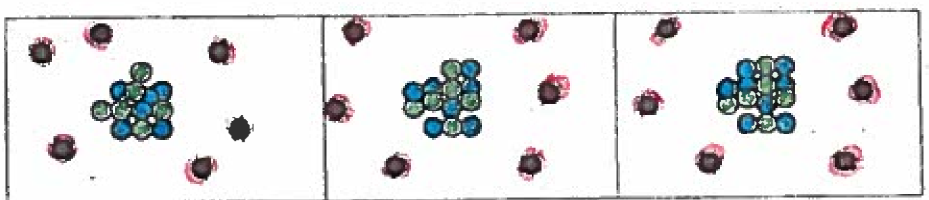
${}^{12}_{6}C$, ${}^{13}_{6}C$, and ${}^{14}_{6}C$ are notations that represent isotopes of carbon atoms.

${}^{1}_{1}H$, ${}^{2}_{1}H$ and ${}^{3}_{1}H$ are notations that represent isotopes of hydrogen atoms.

Note the following symbols: (they are not to scale)

= proton (positive charge)
= electron (negative charge)
= neutron (no charge)

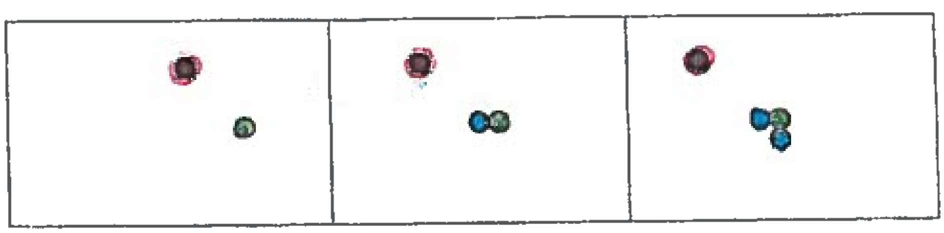
The following three diagrams are carbon atoms:



Carbon Isotopes

${}^{12}_{6}C$ (6 protons, 6 neutrons) ${}^{13}_{6}C$ (6 protons, 7 neutrons) ${}^{14}_{6}C$ (6 protons, 8 neutrons)

The following three diagrams are hydrogen atoms:



Hydrogen Isotopes

${}^{1}_{1}H$ ${}^{2}_{1}H$ ${}^{3}_{1}H$

List the 6 most common elements found in living things.

C arbon
H ydrogen
N itrogen
O xygen
P hosphorus
S ulfur

Why do atoms bond together?

Atoms bond together to fill their valence (outer) electrons to become Stable.
When atoms bond together they form Compounds and/or molecules.

Compound = two or more different elements chemically combined Ex. NaCl

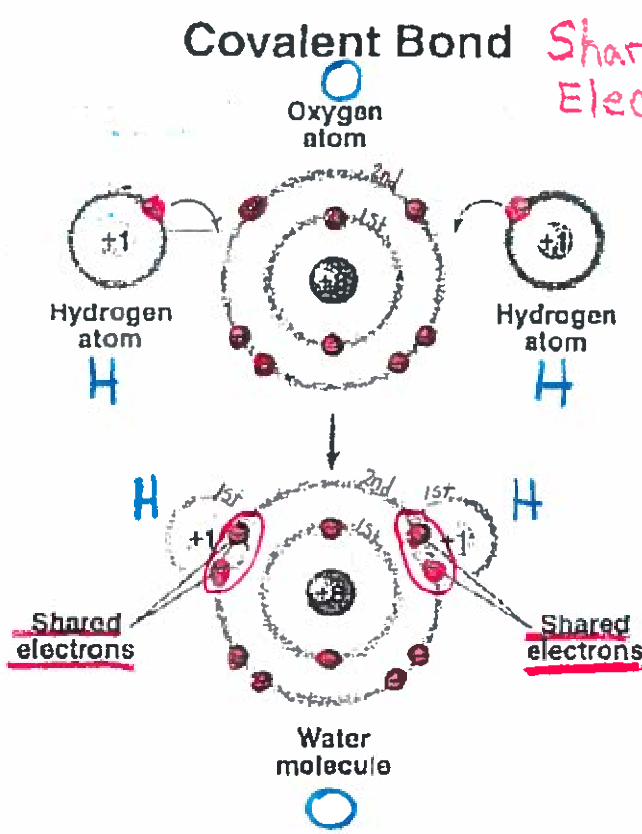
Molecule = group of atoms held together by covalent bonds Ex. O_2

TYPES OF BONDING

1. Covalent bonding is when two or more atoms Share electrons to form molecules. Example: Water (H_2O)

Sharing outer (valence) Electrons

Nonmetal atoms



H_2O

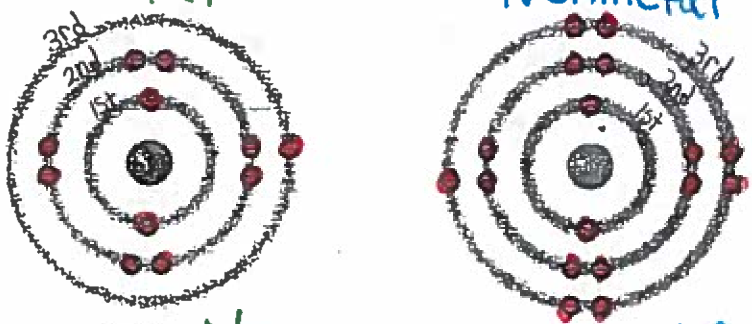
2. Ionic bonding is the attractive force between two ions of opposite charge to form compounds. Example: NaCl (table salt)

Neutral Atoms (# Protons = # Electrons)

Overall Charge is Zero on Atom

Metal

Nonmetal



Na Atom
1st = 2 e^-
2nd = 8 e^-
3rd = 1 e^-

+11 Protons
−11 Electrons
= 0 overall Charge

Sodium atom Na

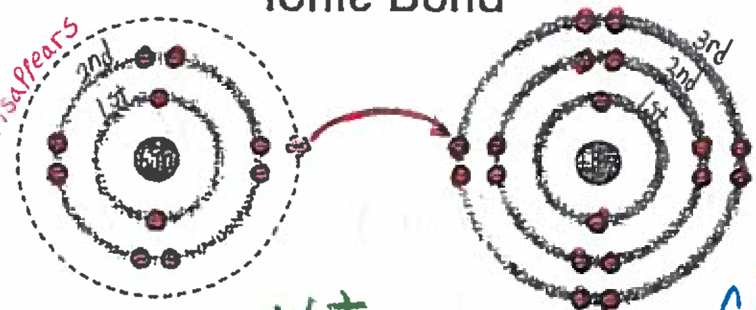
Chlorine atom Cl

Cl Atom
1st = 2 e^-
2nd = 8 e^-
3rd = 7 e^-

+17 Protons
−17 Electron
= 0 overall Charge

Needs 1 e^- to be filled and Stable

Ionic Bond



Na^+ Ion
1st = 2 e^-
2nd = 8 e^-
3rd = ~~0 e^-~~

+11 Protons
−10 Electrons
+1 overall Charge

Sodium Ion (+) Na^+
(loses an electron)

Giver of e^-
Cation (+)

Chloride Ion (−) Cl^-
(gains an electron)

Taker of e^-
Anion (−)

Cl^- Ion
1st = 2 e^-
2nd = 8 e^-
3rd = 8 e^-

Filled and Stable

+17 Protons
−18 Electrons
−1 Overall Charge

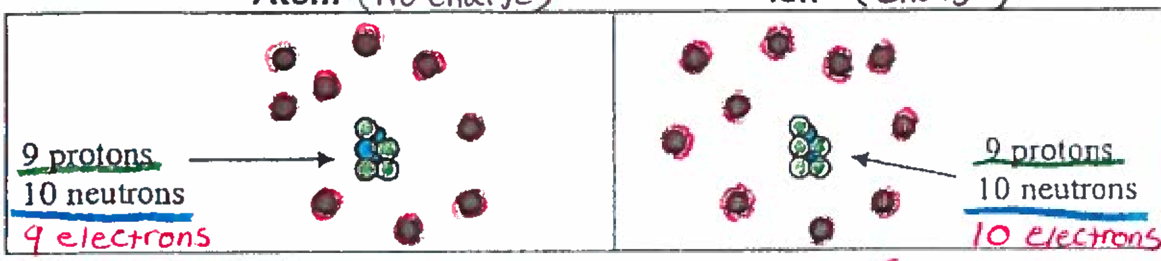
Atom becomes positively charged ion when it gives / loses electron(s).

Atom becomes negatively charged ion when it gains / accepts / takes electron(s).

The atomic mass unit (amu) is a special unit for measuring the mass of very small particles such as atoms. The relationship between amu and grams is the following: 1.00 amu = 1.66×10^{-24} g
Note the following diagrams comparing atoms and ions.

Atom (No charge) | **Ion** (Charge)

+9
−9
0
No charge
Neutral



+9
−10
−1
Overall Charge

$^{19}_{9}F$

Atomic mass = 18.9980 amu
Mass Number = 19 amu

$^{19}_{9}F^{(-1)}$ ← Charge

Atomic mass = 18.9985 amu
Mass Number = 19 amu

How many protons, neutrons, and electrons does the Fluorine ATOM have?

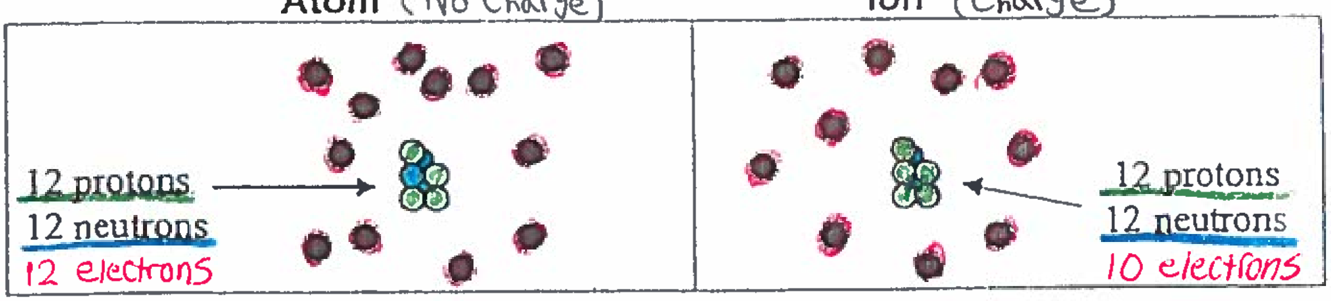
9 10 9

What is different in the Fluorine ION? 9 10 10

Fluorine ion has one more electron (10) instead of 9, Creating an overall charge of −1 on the ion.

Atom (No charge) | **Ion** (Charge)

+12
−12
0
No charge
Neutral



+12
−10
+2
Overall Charge

$^{24}_{12}Mg$

Atomic mass = 23.9978 amu
Mass Number = 24 amu

$^{24}_{12}Mg^{(+2)}$ ← Charge

Atomic mass = 23.9968 amu
Mass Number = 24 amu

How many protons, neutrons, and electrons does the Magnesium ATOM have?

12 12 12

What is different in the Magnesium ION? 12 12 10

Magnesium ion has two less electrons (10) instead of 12, Creating an overall charge of +2 on the ion.

KEY

Chemical Reactions & Enzymes

- I can differentiate between reactants and products in a chemical reaction.
- I can summarize the functions of enzymes.
- I can create a model showing how enzymes function.
- I can explain how pH, temperature, and other substances affect enzyme function.

Physical change = a change in which the physical form (__Shape__ or __appearance__) of a substance is changed, but not what it is made of.
Ex. Water changing states from solid (ice) to liquid to gas (vapor), cutting paper, painting a house

Chemical change = a change in which a substance is converted into a __new__ substance with __different__ composition and properties.
- Involves chemical reactions that break the __Chemical__ __bonds__ of __reactants__ to rearrange and make new __products__.

Ex. Photosynthesis, cellular respiration, combustion of methane (natural gas)

PHOTOSYNTHESIS CHEMICAL REACTION

REACTANTS (left side) $\xrightarrow{\text{Yield}}$ PRODUCTS (right side)

coefficient

Subscript

$$6CO_2 + 6H_2O \xrightarrow{\text{Light}} C_6H_{12}O_6 + 6O_2$$

Carbon dioxide + Water → Sugar (Glucose) + Oxygen

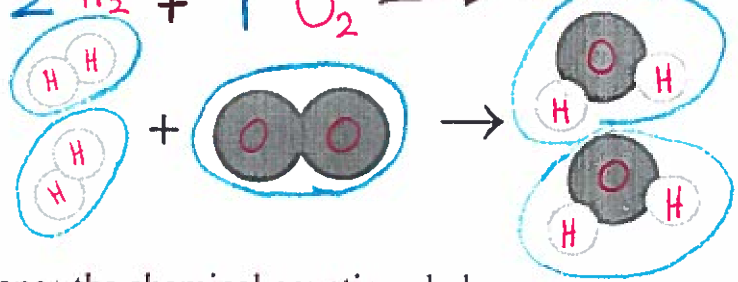
Chemical Reactions

- Written as chemical formulas using symbols.
- Atoms from the reactants (left side of arrow) are the atoms that form the products (right side of arrow).
- Subscripts (numbers below and to right of symbol) identify how many of that atom are in the compound/molecule.
- Coefficients (numbers in front of compound/molecule) identify the number of that compound/molecule.
- Reactions must be balanced to show conservation of matter.
- NEVER CHANGE SUBSCRIPTS WHEN BALANCING CHEMICAL REACTIONS! ONLY CHANGE THE COEFFICIENTS TO BALANCE CHEMICAL REACTIONS! Use whole #'s
- An arrow shows the reaction (breaking and making of chemical bonds). → = Yields
- Activation energy is needed for reactants to become products.
- Reactions are either endothermic (absorb energy) or exothermic (release energy).

Circle the subscripts and underline the coefficients in the following chemical reaction.

$2\ H_2 + 1\ O_2 \rightarrow 2\ H_2O$

$2\ H_2 + 1\ O_2 \longrightarrow 2\ H_2O$



Elements	# atoms left	→	# atoms right
O	2	=	2
H	4	=	4

Practice: Add the correct coefficient to balance the chemical equations below.

1. $\underline{2}\ N_2 + \underline{1}\ O_2 \rightarrow \underline{2}\ N_2O_1$ Subscript = 1

Elements	# atoms left	→	# atoms right
N	4	=	4
O	2	=	2

law of Conservation of Matter

atoms left = # atoms righ

2. $\underline{2}\ H_2O_2 \rightarrow \underline{2}\ H_2O + \underline{1}\ O_2$

Elements	# atoms left	→	# atoms right
O	4	=	4
H	4	=	4

3. $\underline{1}\ N_2 + \underline{3}\ H_2 \rightarrow \underline{2}\ NH_3$

Elements	# atoms left	→	# atoms right
N	2	=	2
H	6	=	6

4. $\underline{1}\ CH_4 + \underline{2}\ O_2 \rightarrow \underline{1}\ CO_2 + \underline{2}\ H_2O$

Elements	# atoms left	→	# atoms right
C	1	=	1
H	4	=	4
O	4	=	4

5. Sodium (solid) + Chlorine (gas) → Sodium Chloride (solid)

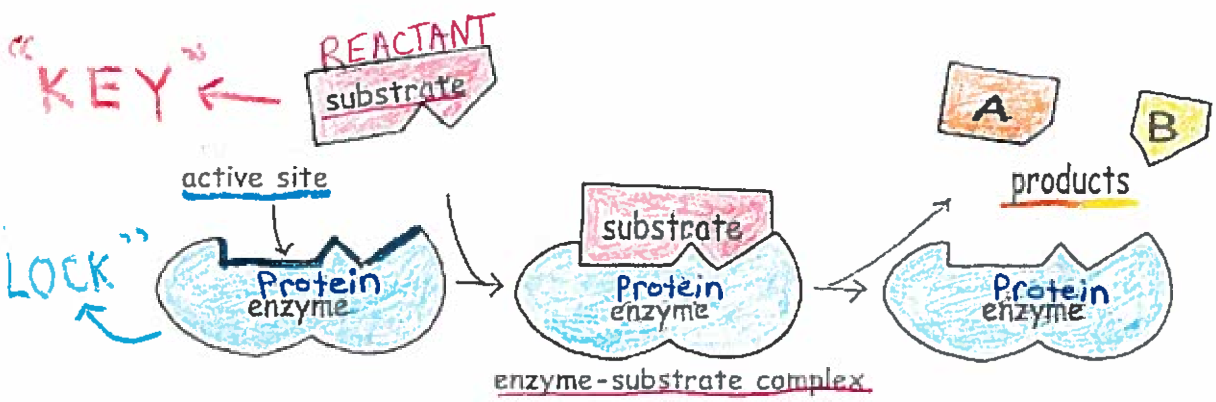
$\underline{2}\ Na_{(s)} + \underline{1}\ Cl_{2\,(g)} \longrightarrow \underline{2}\ NaCl_{(s)}$

Elements	# atoms left	→	# atoms right
Cl	2	=	2
Na	2	=	2

Enzymes

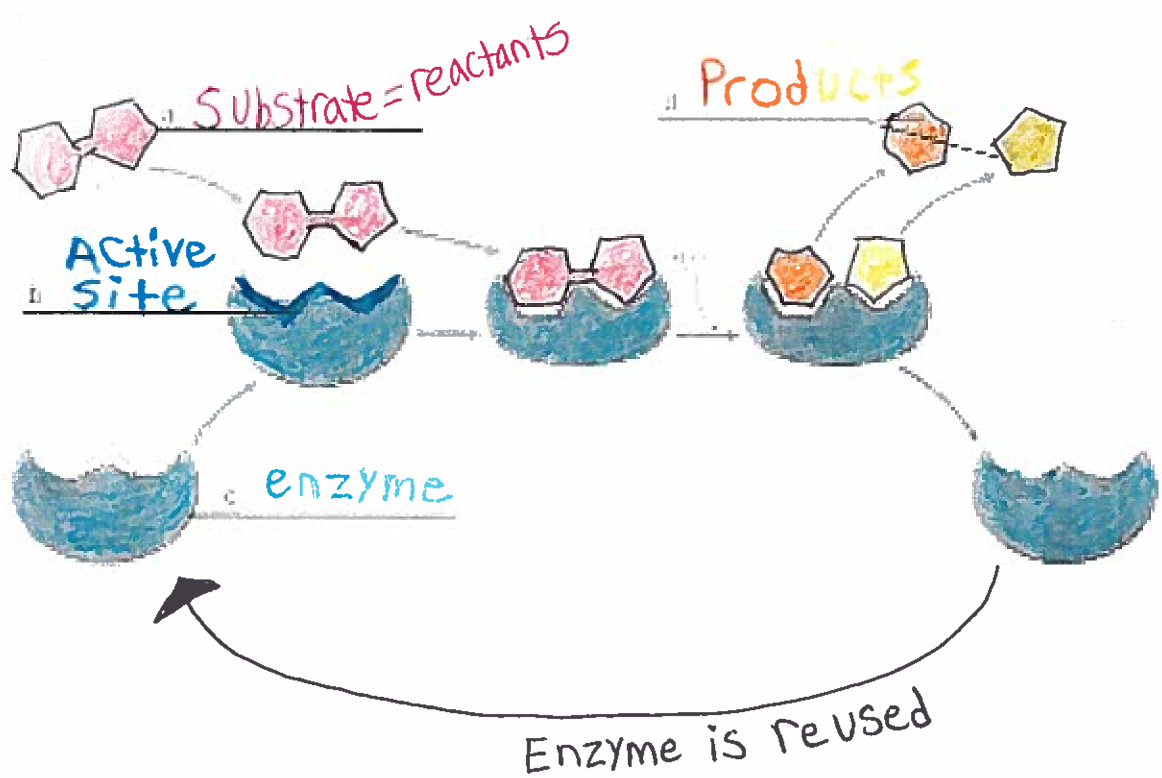
- Proteins that speed up chemical reactions by lowering/decreasing activation energy.
- Biological catalysts ending in -ase. Ex. lactase, catalase, amylase
- Involved in Metabolism (energy needed for all the chemical reactions in your body.
- Are reusable and do not get used up during the chemical reaction.
- Changes to factors such as pH, temperature, and other substances affect an enzyme's ability to work.
- When an enzyme changes shape and loses its function, it becomes denatured.

Label and briefly describe what is happening at each step in the chemical reaction above.

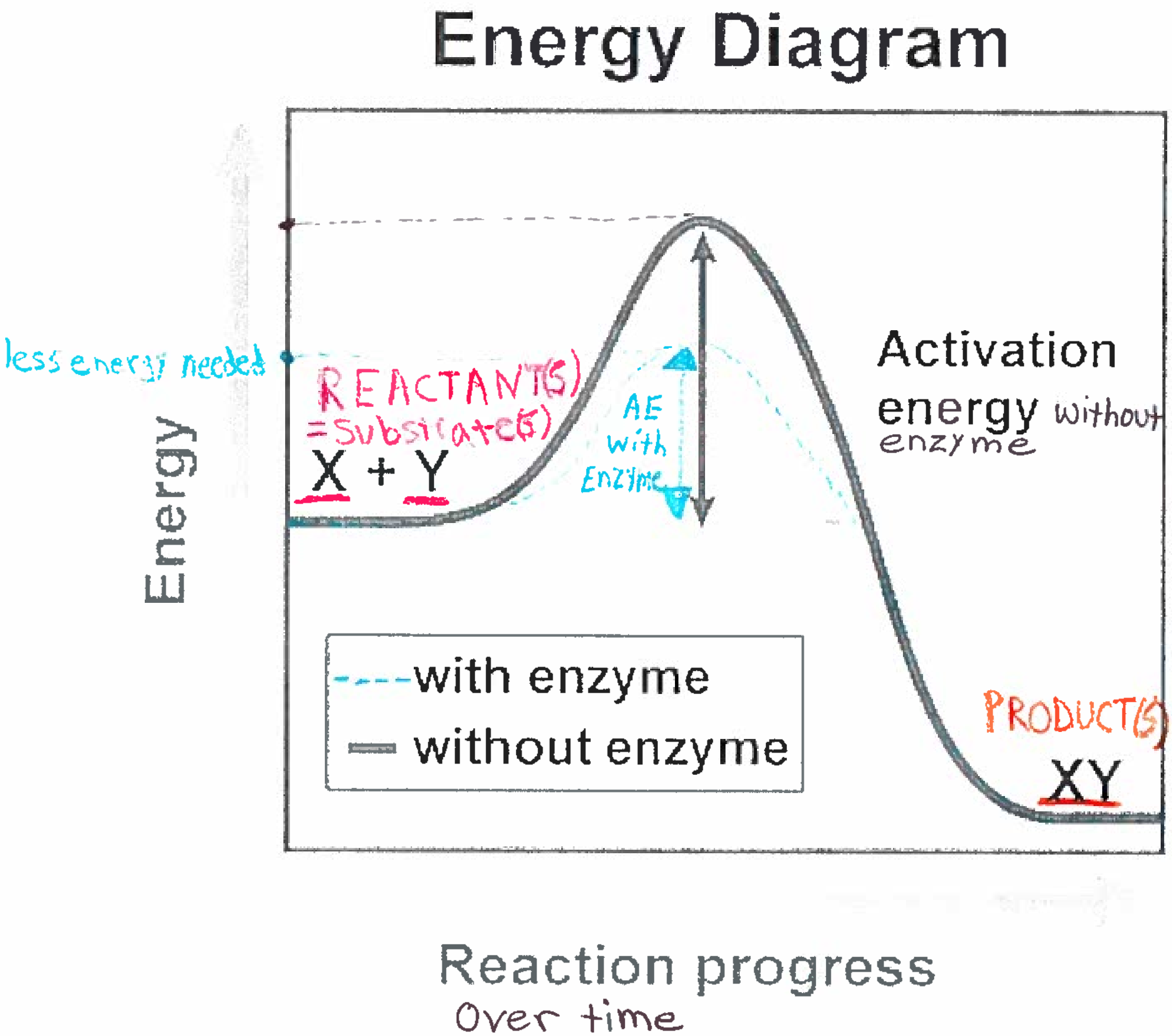


Substrate is broken down into Products A & B

Label the diagram below.



Draw a dotted line to represent how the chemical reaction would occur with an enzyme. Label the reactants and products on the energy diagram.



Compare *what happens to energy in exothermic and endothermic reactions by completing the diagram below.*

Ex. Hot Packs

Exothermic Reaction — Heat to outside "exit"

During the reaction, energy is released in form of heat or light

As a result, the energy of the product is lower than the energy of the reactants.

Ex. Cold Packs

Endothermic Reaction — Heat to inside

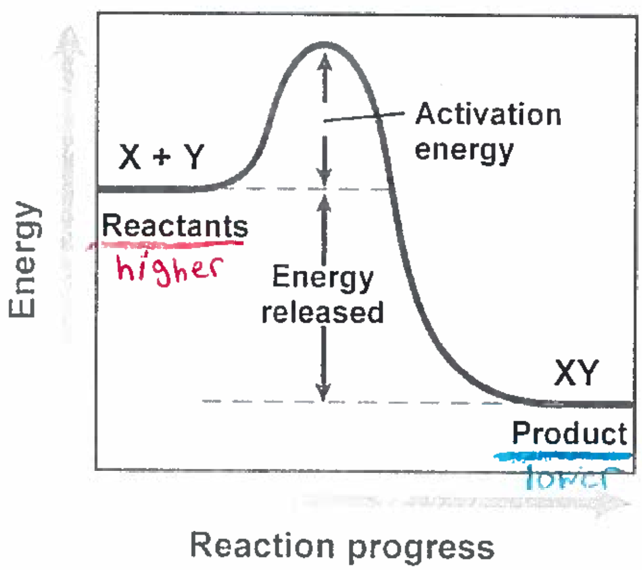
During the reaction, energy is absorbed

As a result, the energy of the product is higher than the energy of the reactants.

Label the type of reaction (exothermic or endothermic) shown by the energy diagrams below and justify your reasoning below the pictures.

Exothermic reaction

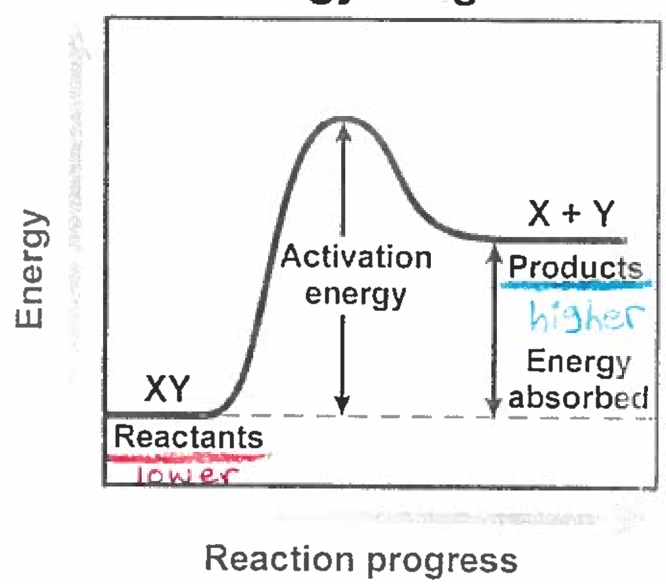
Energy Diagram



- Reactant(s) have more energy than Product(s)
- The energy difference between reactant(s) and Product(s) is released as heat and/or light

Endothermic reaction

Energy Diagram



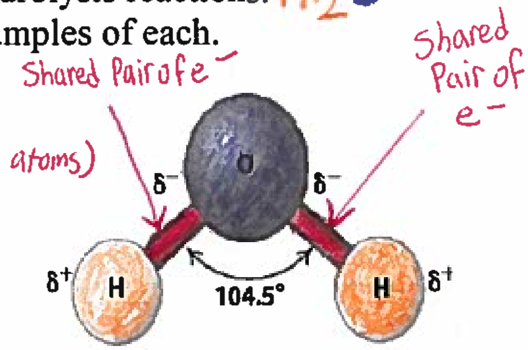
- Reactant(s) have less energy than Product(s)
- The energy difference between reactant(s) and Product(s) is absorbed & Stored in the Chemical bonds of the Product(s)

KEY

Properties of Water, Acids, Bases, & pH

- I can describe the importance of water.
- I can describe the properties of water.
- I can explain why hydrogen bonds form.
- I can describe dehydration synthesis (condensation) and hydrolysis reactions.
- I can differentiate between acids and bases and provide examples of each.

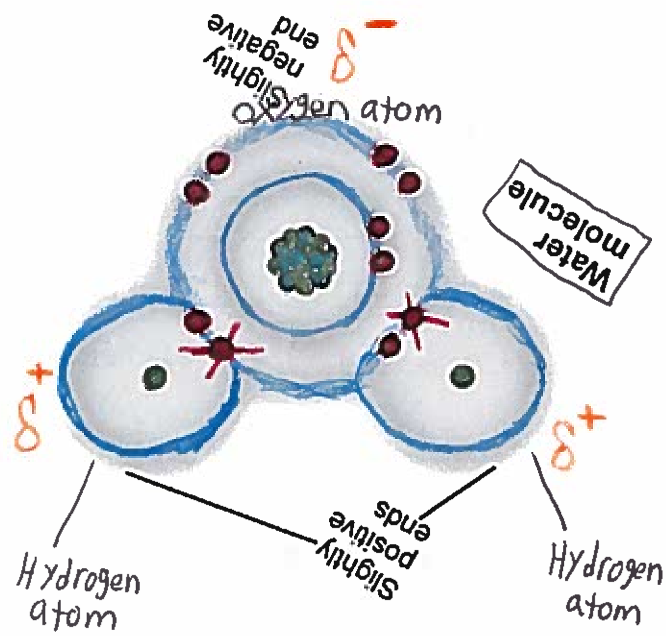
Water H_2O



Water is a compound/molecule formed by Covalent bonds. (Sharing electrons between atoms)

The oxygen atom and hydrogen atoms Share their valence electrons.
(Outer)

Since Oxygen is a very electronegative atom, it DOES NOT share the electrons equally with the two hydrogen atoms in a water molecule.



The unequal sharing of electrons results in charged ends (poles) of the molecule. δ⁺ and δ⁻

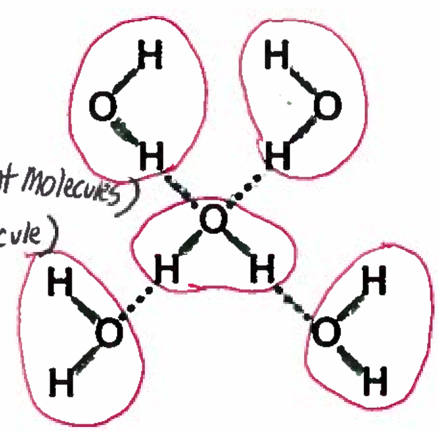
Polar molecules result when atoms do not share electrons equally between atoms.

Water is a Polar molecule.

Water molecules are attracted to one another and form hydrogen bonds. between O and H atoms

Hydrogen bonding is also known as Van der Waal's force.

Circle and count the number of water molecules in the picture to the right. Label the types of bonds that form between the atoms in individual water molecules and between different water molecules.



= Hydrogen bond (between O and H of different molecules)

= Covalent bond (between O and H of same molecule)

Coefficient

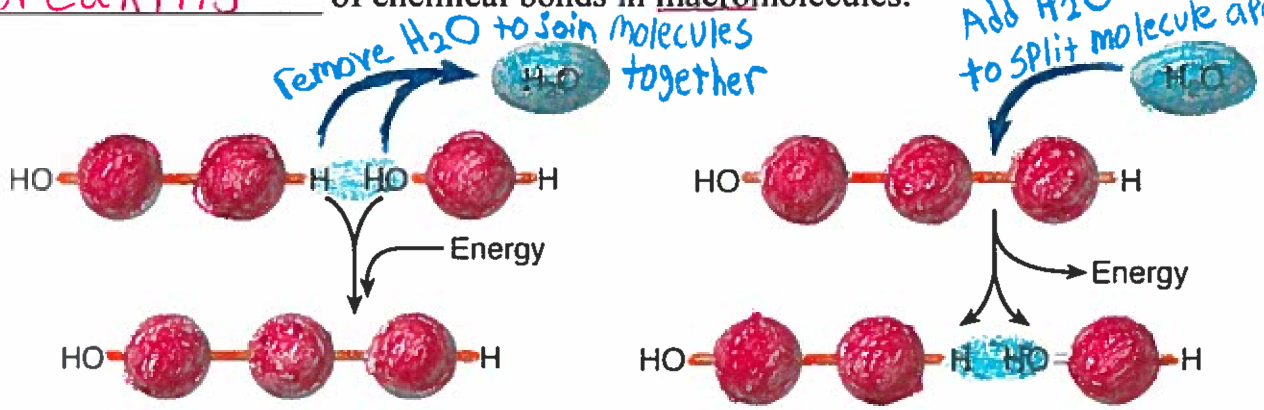
5 Water Molecules

5 H_2O

Properties of Water

Property	Description
+ Polar −	Atoms of water molecule (oxygen & hydrogen atoms) do not share electrons equally. Forms hydrogen bonds as a result.
Universal Solvent	Many substances dissolve in water. Breaks down solutes such as $NaCl \rightarrow Na^+ + Cl^-$
Cohesion	Cohesion results in water molecules being attracted to each other due to hydrogen bonds.
Adhesion	Adhesion results in water molecules being attracted to other surfaces due to hydrogen bonds.
High Surface Tension	Greater attraction of liquid water molecules to each other (due to cohesion) than to molecules in the air (adhesion) Ex. Water striders walk on water
High Heat Capacity	Water resists temperature changes
Density	Water is less dense as a solid and more dense as a liquid, so ice floats.

Water is important in Metabolism. It is involved in Making and breaking of chemical bonds in large macromolecules.



(a) Dehydration synthesis (Condensation) (b) Hydrolysis "to split apart using water"

Acids and Bases

Water dissociates into hydrogen (H^+) and hydroxide (OH^-) ions.

water / Hydrogen ions / Hydroxide ions

$$H_2O \Leftrightarrow H^+ + OH^-$$

Acids release hydrogen (H^+) ions or hydronium (H_3O^+) ions in solution.

Bases release hydroxide (OH^-) ions in solution.

The pH scale is used to measure the concentration of hydrogen (H^+) ions.

The greater the H^+ concentration, the more acidic.

Bases have a low concentration of H^+ ions.

The relationship between H^+, OH^- and pH

$[H^+] = 1 \times 10^{-pH}$

OH^- concentration(mol/l)		pH	H^+ concentration(mol/l)	
1×10^{-14}	0.00000000000001	0	1	1×10^{0}
1×10^{-13}	0.0000000000001	1	0.1	1×10^{-1}
1×10^{-12}	0.000000000001	2	0.01	1×10^{-2}
1×10^{-11}	0.00000000001	3	0.001	1×10^{-3}
1×10^{-10}	0.0000000001	4	0.0001	1×10^{-4}
1×10^{-9}	0.000000001	5	0.00001	1×10^{-5}
1×10^{-8}	0.00000001	6	0.000001	1×10^{-6}
1×10^{-7}	0.0000001	7	0.0000001	1×10^{-7}
		8		1×10^{-8}
1×10^{-5}	0.00001	9	0.000000001	1×10^{-9}
1×10^{-4}	0.0001	10	0.0000000001	1×10^{-10}
1×10^{-3}	0.001	11	0.00000000001	1×10^{-11}
1×10^{-2}	0.01	12	0.000000000001	1×10^{-12}
1×10^{-1}	0.1	13	0.0000000000001	1×10^{-13}
1 x 100	1	14	0.00000000000001	1×10^{-14}

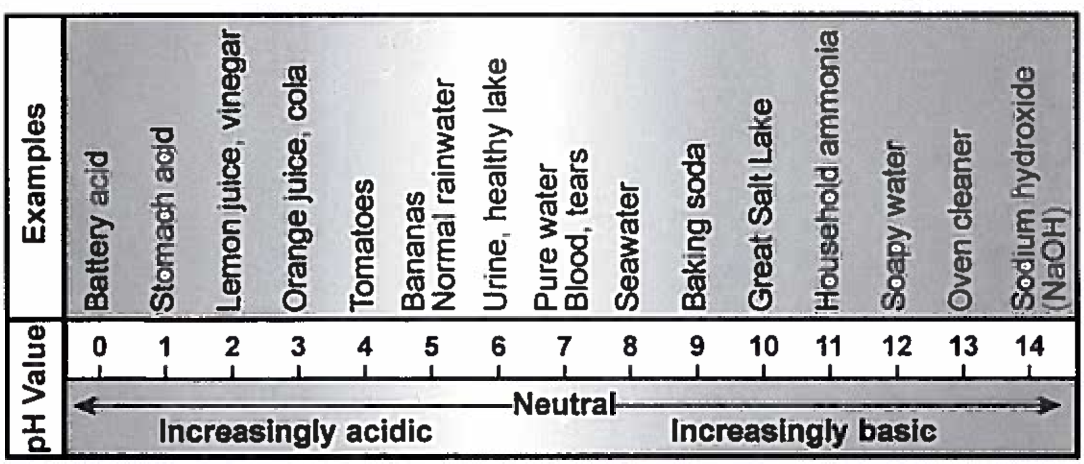
Increasing acidity ↑

Increasing basicity ↓

Identify examples from the pH diagram below to fill in the table.

Acids	Bases	Neutral
lake water, Urine, rainwater weak	Seawater, baking soda Weak	Pure water
battery acid, stomach acid strong	NaOH, oven Cleaner strong	blood

Strong acid pH = 0–1



Strong base pH = 13–14

Buffers help neutralize acids and bases to maintain a certain pH level. Many organisms need buffers to maintain a certain pH allowing them to maintain homeostasis.

KEY

Macromolecules

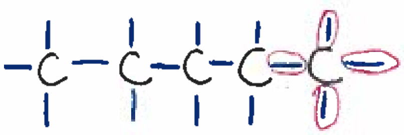
- I can identify the specific elements in each of the organic macromolecules.
- I can identify examples of the organic macromolecules.
- I can summarize the major functions of each organic macromolecule.
- I can recognize the structural formulas of each organic macromolecule.
- I can describe the individual subunits in each of the organic macromolecules.
- I can predict what would happen to my body if certain organic macromolecules were not available.
- I can describe hydrolysis and dehydration reactions.

Life on earth is Carbon - based. = Organic (Contains Carbon)

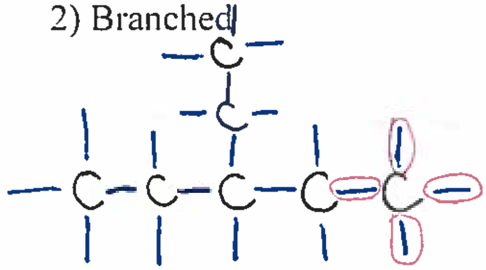
Each carbon atom is special because it forms 4 Covalent bonds.

Carbon joins in ways that it forms large molecules in 3 shapes:

1) Straight chain

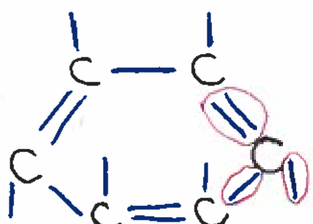


2) Branched



Each Carbon atom has 4 covalent bonds Surrounding it

3) Ring



The six most common elements that make up living things are C, H, N, O, P, S.

Polymers (many parts) - large molecules formed from smaller molecules (monomers) (single part).

4 Major Categories of Organic Macromolecules:

1. Carbohydrates
2. Lipids
3. Proteins
4. Nucleic Acids

Made by Dehydration Synthesis (Condensation) Broken down by Hydrolysis

REACTANTS PRODUCTS

Water is removed *dehydration synthesis* Builds larger Molecule Water is formed as a Product

REACTANTS PRODUCTS

Water is a reactant *hydrolysis* Breaks a larger molecule into 2 or more smaller molecules

(1) Carbohydrates "Sugars and Starches"

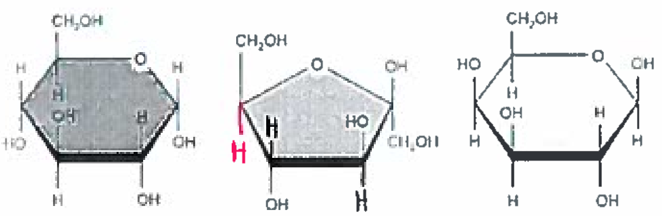
Elements: C, H, O in a 1:2:1 ratio $(CH_2O)_n$

Jobs/Functions:
- Short-term energy source (4 calories/gram)
- energy storage
- Structural support

Examples of Carbohydrates: (simple)

Monosaccharides (subunits of carbohydrates) - Single Sugar

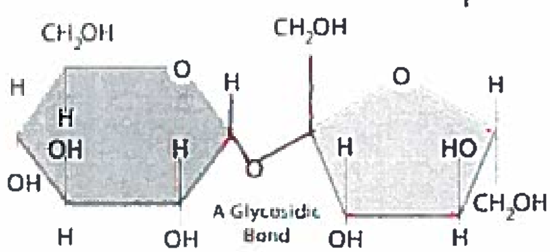
Monosaccharides (3-7 carbon atoms)



Glucose $C_6H_{12}O_6$ | Fructose $C_6H_{12}O_6$ | Galactose $C_6H_{12}O_6$ = Isomers (Same chemical formula, different arrangement of atoms)

Disaccharides - double Sugar (2 monosaccharides)

A Disaccharide Example



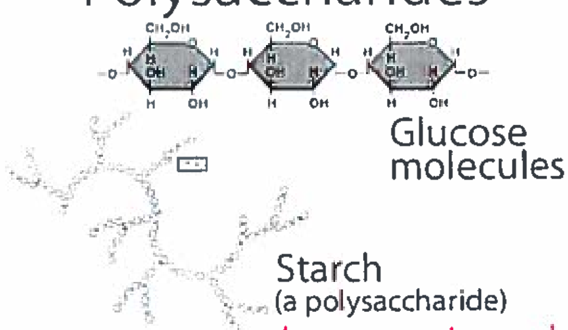
Glucose Fructose

Sucrose $C_{12}H_{22}O_{11}$ (table sugar) + H_2O

Ex. lactose (milk sugar)
maltose (malt sugar)

Polysaccharides - many Sugars

Polysaccharides



(energy storage in Plants)

Ex. glycogen (long-term energy storage in animals)
Cellulose (Plant cell walls)
Chitin (Fungi cell walls)

(2) Lipids "Fats, Oils, and Waxes"

Elements: Mostly C, H and some O

General Structure:

Fatty acids – chain of carbon/hydrogen "tails"

Glycerol – 3-carbon alcohol "backbone"

Other components – phosphate chain (ATP) or 4-carbon rings (steroids)

No true monomer (subunit)

Jobs/Functions:

- Long-term energy storage (9 calories/gram)
- Provide barriers
- hormone production (sex hormones – estrogen & testosterone)
- insulation

Types of Lipids:

1. Phospholipids - chains with phosphate groups (found in cell membrane)
2. Steroids - lipids like cholesterol and sex hormones (estrogen and testosterone)
3. triglycerides (fats) – long-term energy storage

Three Structures of Fatty Acids:

1. Saturated fat
   - No double bonds between carbon atoms in chain [all single bonds (–)]

Examples: butter (butyric acid), Coconut oil (lauric acid), Palm oil (palmitic acid), wax

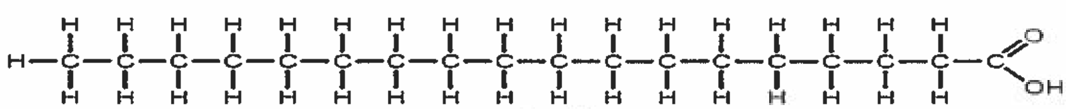
2. Unsaturated fat
   - One double bond (=) between carbon atoms in chain

Examples: Olive oil, canola oil, Peanut oil, Sunflower oil

3. Polyunsaturated fat
   - Two or more double bonds (=, =) between carbon atoms in carbon chain

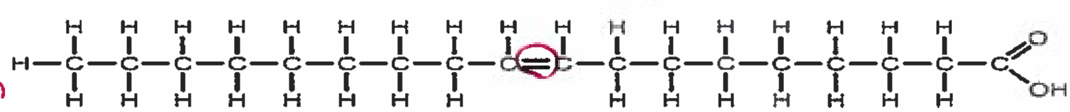
Examples: Soybean oil, corn oil, fish oil

All single Bonds between Carbon atoms



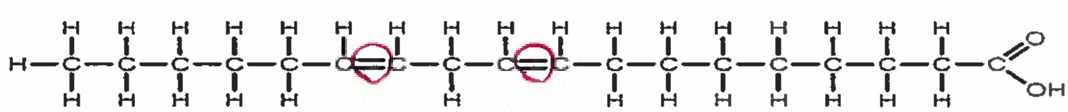
stearic acid
(saturated fatty acid)

One double bond between carbon atoms



oleic acid
(monounsaturated fatty acid)

Two or more double bonds between carbon atoms



linoleic acid
(polyunsaturated fatty acid)

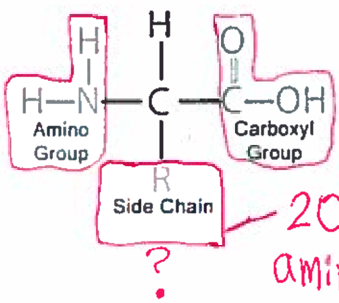
(3) Proteins (Polypeptides)

Elements: C, H, N, O, sometimes S

General Structure:

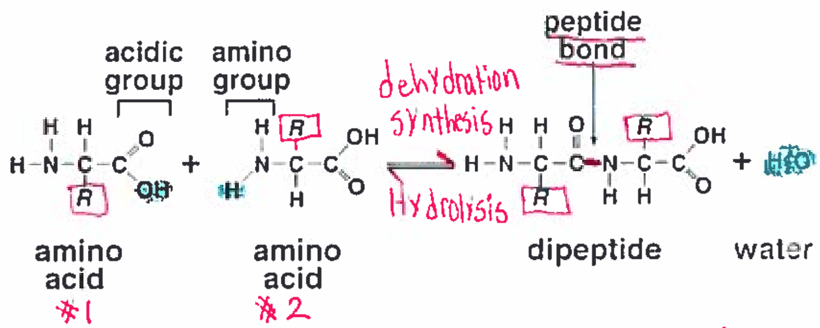
Amino acids - subunits held together by Peptide bonds.

Amino Acid Structure



20 different amino acids

Dipeptide = 2 Amino Acids



Jobs/Functions:

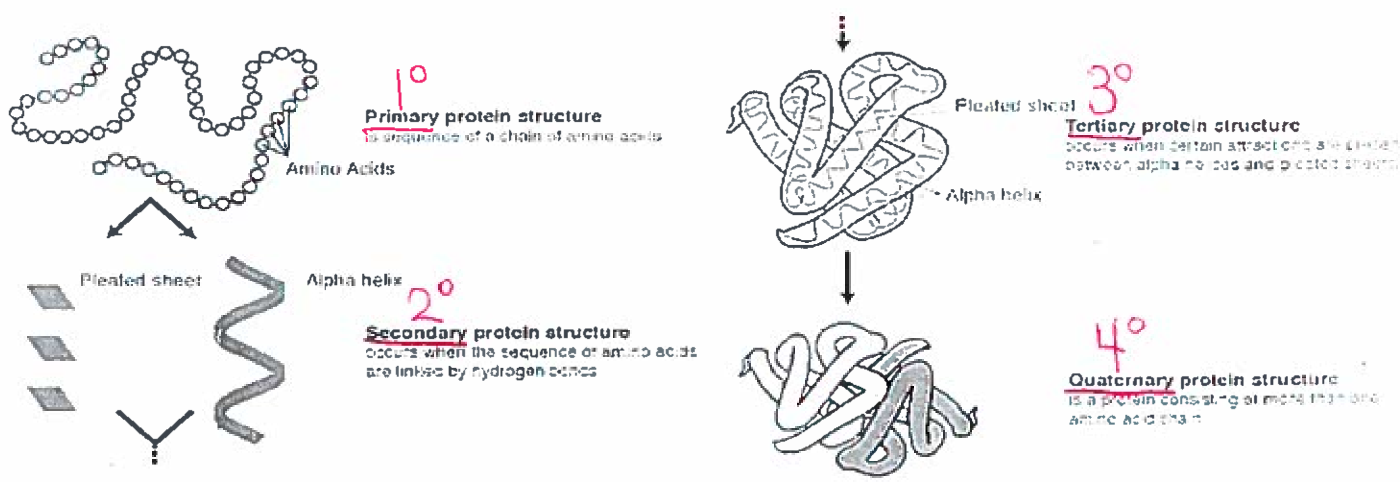
4 calories/gram

- Transport substances
- Speed up chemical reactions (enzymes)
- Provide structural support
- Growth & repair
- Make hormones
- Communication (Cellular messengers)

Examples of Proteins:

Hemoglobin, Collagen, Salivary amylase, muscles, hair, insulin, antibodies, albumin, Pepsin, lipase, rhodopsin, meat, casein, snake venom

Levels of Protein Structure:



(4) Nucleic Acids "Genetic Information"

Elements: C, H, N, O, P

General Structure:

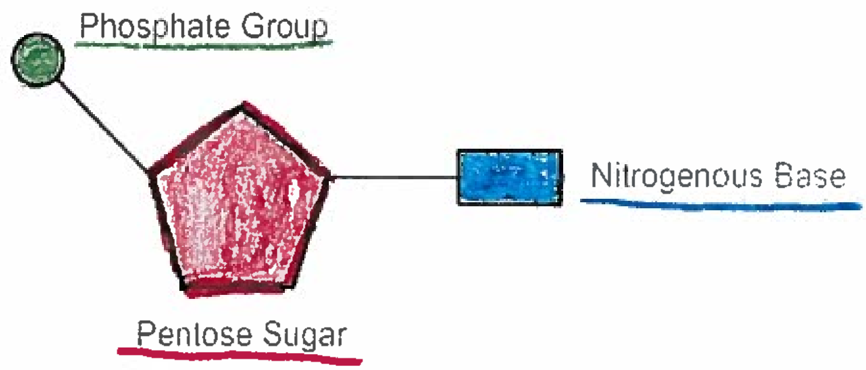
Nucleotides - Monomers - subunits of nucleic acids.

Nucleotides (subunits) are made of 3 parts:

(1) simple sugar

(2) Phosphate group

(3) Nitrogenous base



Jobs/Functions:

- ➢ Storage of genetic information
- ➢ transmission of genetic information
- ➢ instructions (blueprints) for making Proteins

2 Types of Nucleic Acids:

1) DNA = deoxyribonucleic acid

2) RNA = ribonucleic acid