

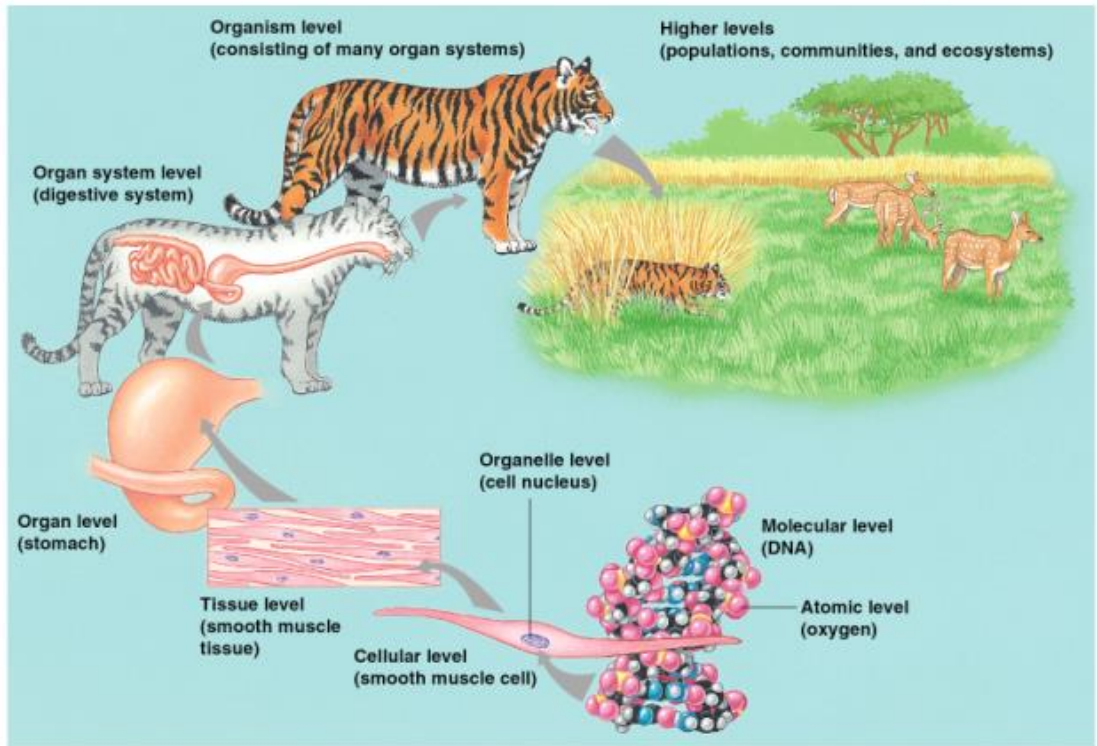
# The Chemistry of Life: The Nature of Matter

Biology

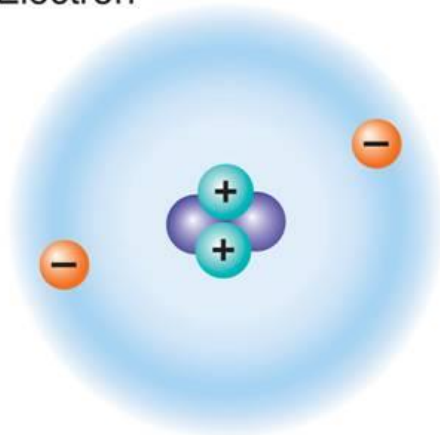
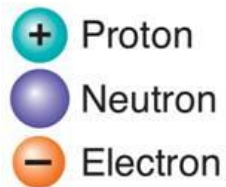
Ch. 2

# Life's Hierarchical Order

- Atom
- Molecule
- Organelle
- Cell
- Tissue
- Organ
- Organ system
- Organism
- Population
- Community
- Ecosystem



# Matter is Made of Atoms



**Helium**

Atomic number = 2

Mass number = 4

- **Atom**—smallest unit of matter
- Made up of
  - protons
  - neutrons
  - electrons

# Elements Are the Simplest Pure Substances

- **Elements**—substance made of only one kind of atom

**Periodic Table of the Elements**

1 1IA 11A	2 IIA 2A											13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	18 VIIIA 8A	
1 <b>H</b> Hydrogen 1.0079													5 <b>B</b> Boron 10.811	6 <b>C</b> Carbon 12.011	7 <b>N</b> Nitrogen 14.00674	8 <b>O</b> Oxygen 15.9994	9 <b>F</b> Fluorine 18.998403	10 <b>Ne</b> Neon 20.1797
3 <b>Li</b> Lithium 6.941	4 <b>Be</b> Beryllium 9.01218												11 <b>Al</b> Aluminum 26.981539	12 <b>Si</b> Silicon 28.0855	13 <b>P</b> Phosphorus 30.973762	14 <b>S</b> Sulfur 32.065	15 <b>Cl</b> Chlorine 35.4527	16 <b>Ar</b> Argon 39.948
11 <b>Na</b> Sodium 22.989768	12 <b>Mg</b> Magnesium 24.305	3 IIIB 3B	4 IVB 4B	5 VB 5B	6 VIB 6B	7 VIIB 7B	8 VIII 8	9 VIII 9	10 VIII 10	11 IB 1B	12 IIB 2B		17 <b>Ga</b> Gallium 69.723	18 <b>Ge</b> Germanium 72.64	19 <b>As</b> Arsenic 74.9216	20 <b>Se</b> Selenium 78.96	21 <b>Br</b> Bromine 79.904	22 <b>Kr</b> Krypton 83.80
19 <b>K</b> Potassium 39.0983	20 <b>Ca</b> Calcium 40.078	21 <b>Sc</b> Scandium 44.95591	22 <b>Ti</b> Titanium 47.88	23 <b>V</b> Vanadium 50.9415	24 <b>Cr</b> Chromium 51.9961	25 <b>Mn</b> Manganese 54.938	26 <b>Fe</b> Iron 55.847	27 <b>Co</b> Cobalt 58.9332	28 <b>Ni</b> Nickel 58.6934	29 <b>Cu</b> Copper 63.546	30 <b>Zn</b> Zinc 65.39		31 <b>Ga</b> Gallium 69.723	32 <b>Ge</b> Germanium 72.64	33 <b>As</b> Arsenic 74.9216	34 <b>Se</b> Selenium 78.96	35 <b>Br</b> Bromine 79.904	36 <b>Kr</b> Krypton 83.80
37 <b>Rb</b> Rubidium 85.4678	38 <b>Sr</b> Strontium 87.62	39 <b>Y</b> Yttrium 88.90585	40 <b>Zr</b> Zirconium 91.224	41 <b>Nb</b> Niobium 92.90638	42 <b>Mo</b> Molybdenum 95.94	43 <b>Tc</b> Technetium 98.9062	44 <b>Ru</b> Ruthenium 101.07	45 <b>Rh</b> Rhodium 102.9055	46 <b>Pd</b> Palladium 106.42	47 <b>Ag</b> Silver 107.8682	48 <b>Cd</b> Cadmium 112.411	49 <b>In</b> Indium 114.818	50 <b>Sn</b> Tin 118.71	51 <b>Sb</b> Antimony 121.760	52 <b>Te</b> Tellurium 127.6	53 <b>I</b> Iodine 126.90447	54 <b>Xe</b> Xenon 131.29	
55 <b>Cs</b> Cesium 132.90545	56 <b>Ba</b> Barium 137.327	57-71 Lanthanide Series	72 <b>Hf</b> Hafnium 178.49	73 <b>Ta</b> Tantalum 180.9479	74 <b>W</b> Tungsten 183.85	75 <b>Re</b> Rhenium 186.207	76 <b>Os</b> Osmium 190.23	77 <b>Ir</b> Iridium 192.22	78 <b>Pt</b> Platinum 195.08	79 <b>Au</b> Gold 196.9665	80 <b>Hg</b> Mercury 200.59	81 <b>Tl</b> Thallium 204.3833	82 <b>Pb</b> Lead 207.2	83 <b>Bi</b> Bismuth 208.98037	84 <b>Po</b> Polonium (209, 9824)	85 <b>At</b> Astatine 209, 9871	86 <b>Rn</b> Radon 222, 0176	
87 <b>Fr</b> Francium 223, 0167	88 <b>Ra</b> Radium 226, 0554	89-103 Actinide Series	104 <b>Rf</b> Rutherfordium (261)	105 <b>Db</b> Dubnium (262)	106 <b>Sg</b> Seaborgium (266)	107 <b>Bh</b> Bohrium (264)	108 <b>Hs</b> Hassium (269)	109 <b>Mt</b> Meitnerium (268)	110 <b>Ds</b> Darmstadtium (269)	111 <b>Rg</b> Roentgenium (272)	112 <b>Cn</b> Copernicium (277)	113 <b>Uut</b> Ununtrium unknown	114 <b>Uuq</b> Ununquadium (289)	115 <b>Uup</b> Ununpentium unknown	116 <b>Uuh</b> Ununhexium (288)	117 <b>Uus</b> Ununseptium unknown	118 <b>Uuo</b> Ununoctium unknown	
		57 <b>La</b> Lanthanum 138.9055	58 <b>Ce</b> Cerium 140.115	59 <b>Pr</b> Praseodymium 140.90765	60 <b>Nd</b> Neodymium 144.24	61 <b>Pm</b> Promethium 144.9127	62 <b>Sm</b> Samarium 150.36	63 <b>Eu</b> Europium 151.9655	64 <b>Gd</b> Gadolinium 157.25	65 <b>Tb</b> Terbium 158.92534	66 <b>Dy</b> Dysprosium 162.50	67 <b>Ho</b> Holmium 164.93032	68 <b>Er</b> Erbium 167.26	69 <b>Tm</b> Thulium 168.93421	70 <b>Yb</b> Ytterbium 173.04	71 <b>Lu</b> Lutetium 174.967		
		89 <b>Ac</b> Actinium 227, 0278	90 <b>Th</b> Thorium 232, 0381	91 <b>Pa</b> Protactinium 231, 0382	92 <b>U</b> Uranium 238, 0286	93 <b>Np</b> Neptunium 237, 0287	94 <b>Pu</b> Plutonium 244, 0282	95 <b>Am</b> Americium 243, 0281	96 <b>Cm</b> Curium 247, 0281	97 <b>Bk</b> Berkelium 247, 0281	98 <b>Cf</b> Californium 251, 0286	99 <b>Es</b> Einsteinium 252, 0288	100 <b>Fm</b> Fermium 257, 0288	101 <b>Md</b> Mendelevium 258, 0289	102 <b>No</b> Nobelium 259, 106	103 <b>Lr</b> Lawrencium 262		
		Alkali Metal	Alkaline Earth	Transition Metal	Basic Metal	Semimetals	Nonmetals	Halogens	Noble Gas	Lanthanides	Actinides							

# Atoms Can Bond Together

- **Chemical compound**—substance made of 2 or more *different* elements



sodium +

chlorine

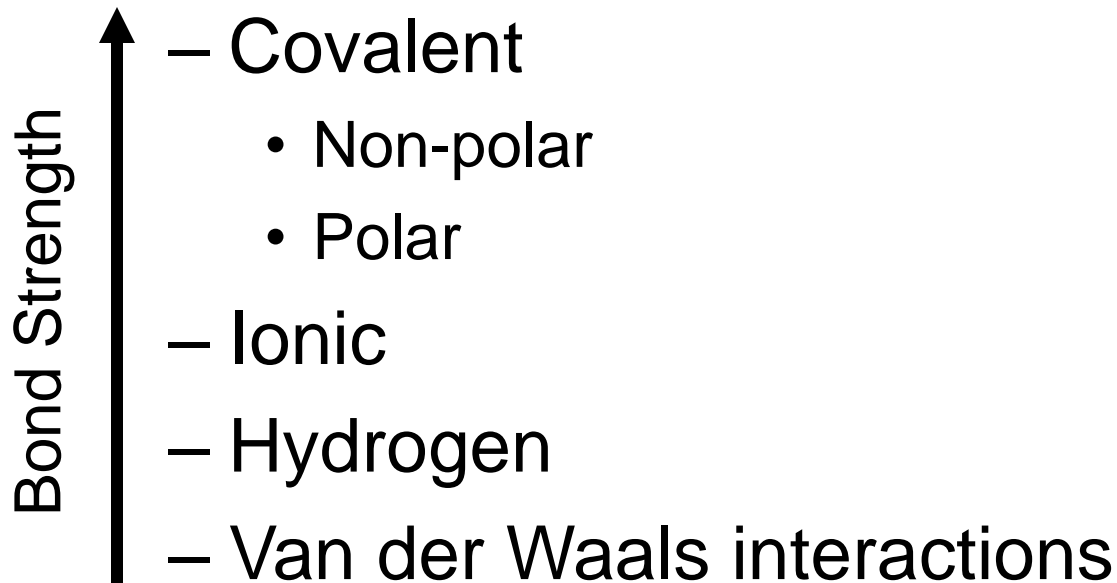
→

sodium  
chloride

Benjamin  
Cummings

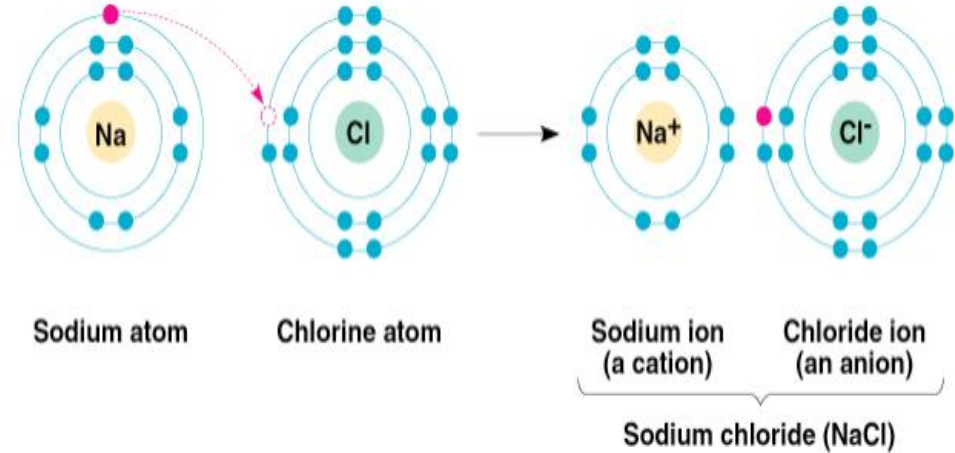
# Atoms Can Bond Together

- Compounds linked together by **chemical bonds**

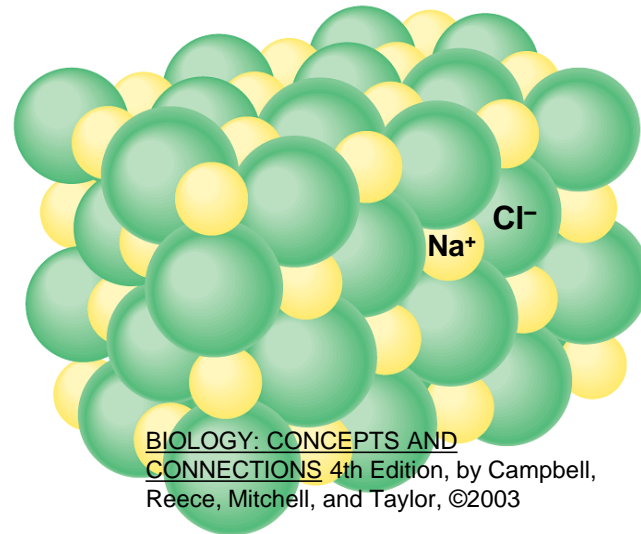


# Ionic Bonding

- Elements give and take electrons
- Electron transfer creates **ions** (charged atoms)
  - **Cation** (positive ion)
  - **Anion** (negative ion)



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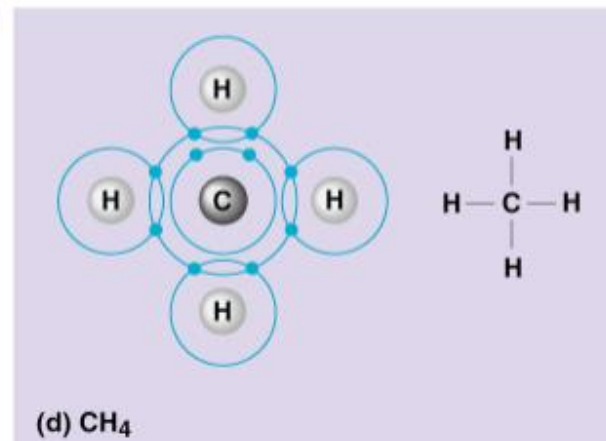
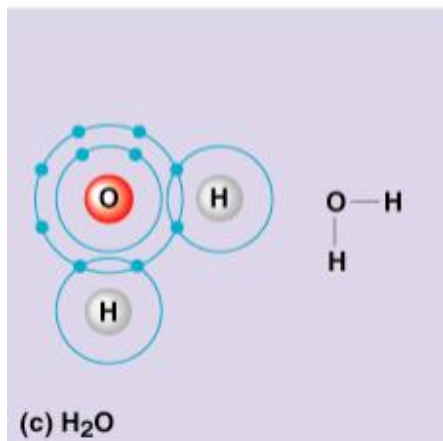
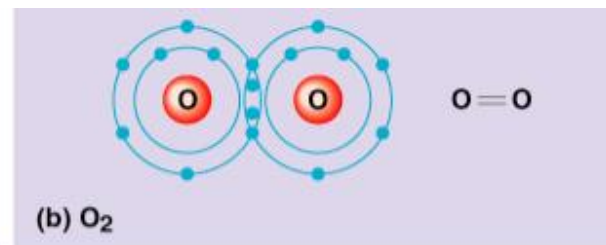
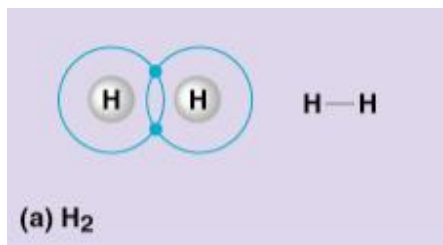


<http://www.sacbee.com/static/weblogs/health-and-fitness/Salt%20Shaker.jpg>

BIOLOGY: CONCEPTS AND CONNECTIONS 4th Edition, by Campbell, Reece, Mitchell, and Taylor, ©2003

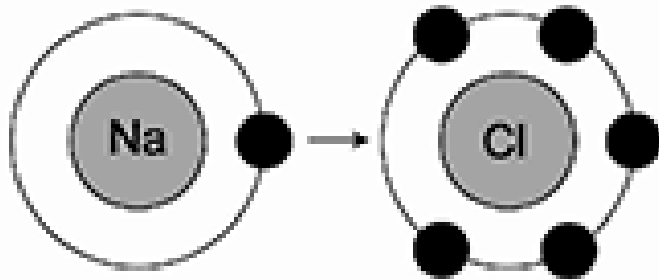
# Covalent Bonding

- Electrons are shared by atoms

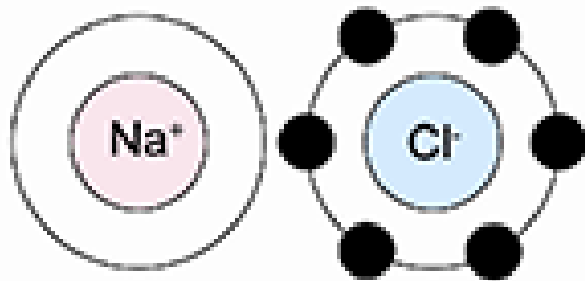




## Ionic bond

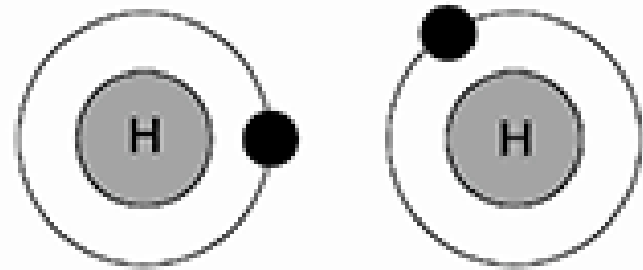


(a) The electron moves from Na to Cl

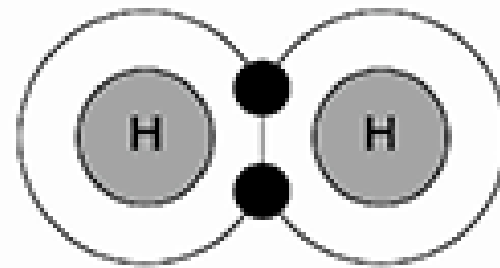


(b) Positively charged Na and negatively charged Cl attract each other and are electronically bonded together

## Covalent bond

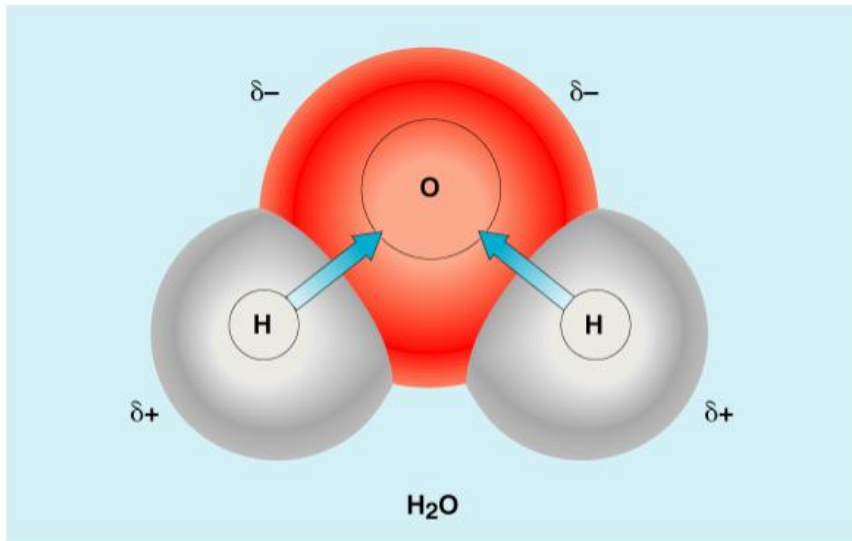


(c) Electrons cannot move independently



(d) The atoms form bonds by sharing electrons.

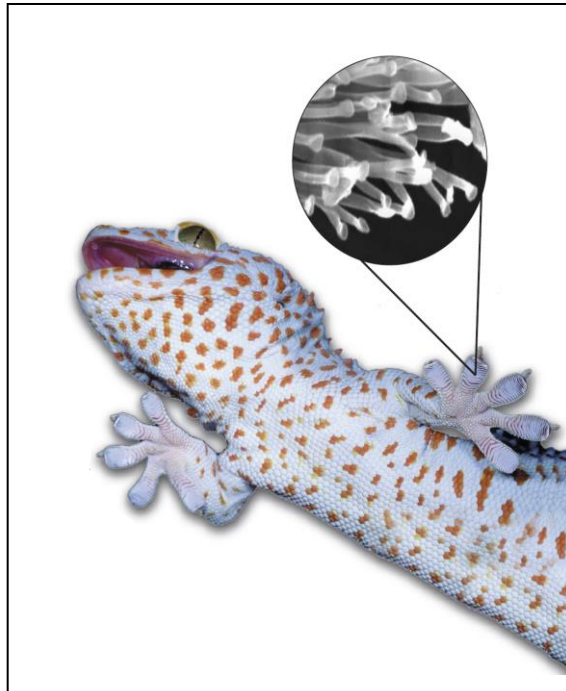
# Covalent Bonds



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- **Nonpolar Covalent**
  - Electrons are shared evenly
- **Polar Covalent**
  - One atom more electronegative than the other (charged)
  - water

# Van der Waals Forces

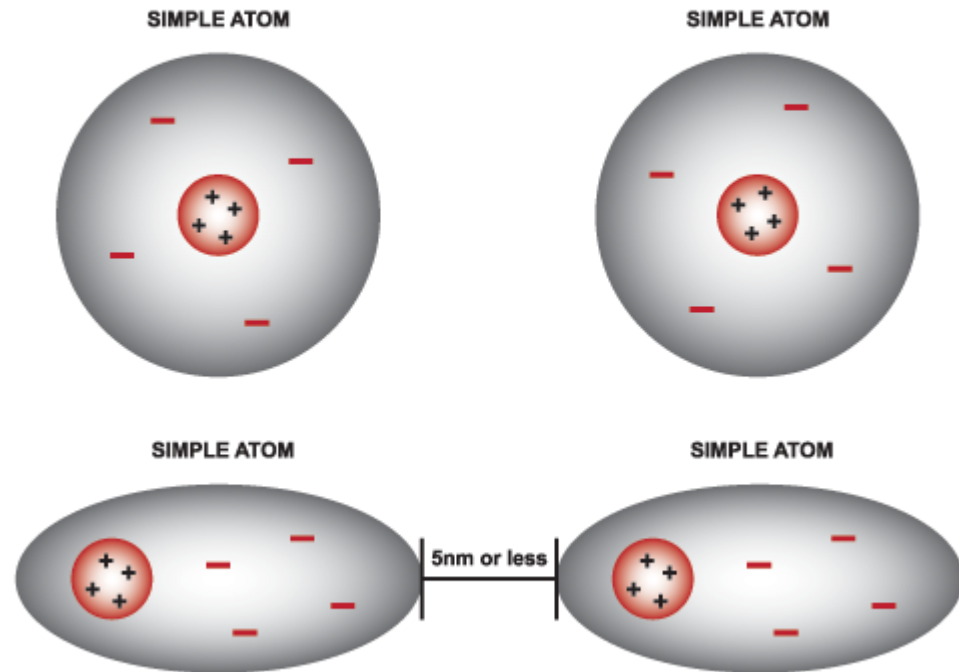


VAN DER WAALS' FORCES (VDW)  
DIAGRAM

**KEY**

+ POSITIVE NUCLEUS

- NEGATIVE CHARGED ELECTRON CLOUD

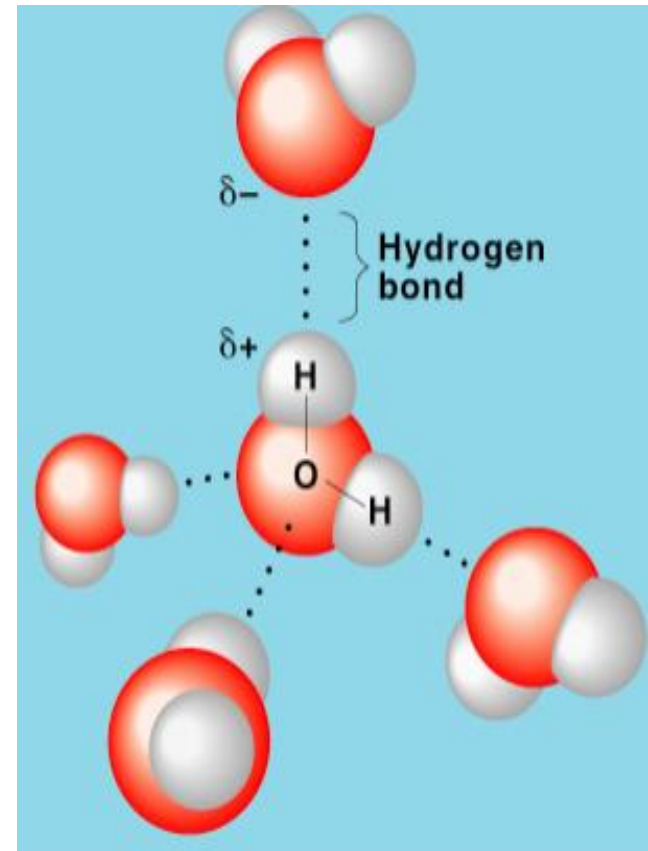
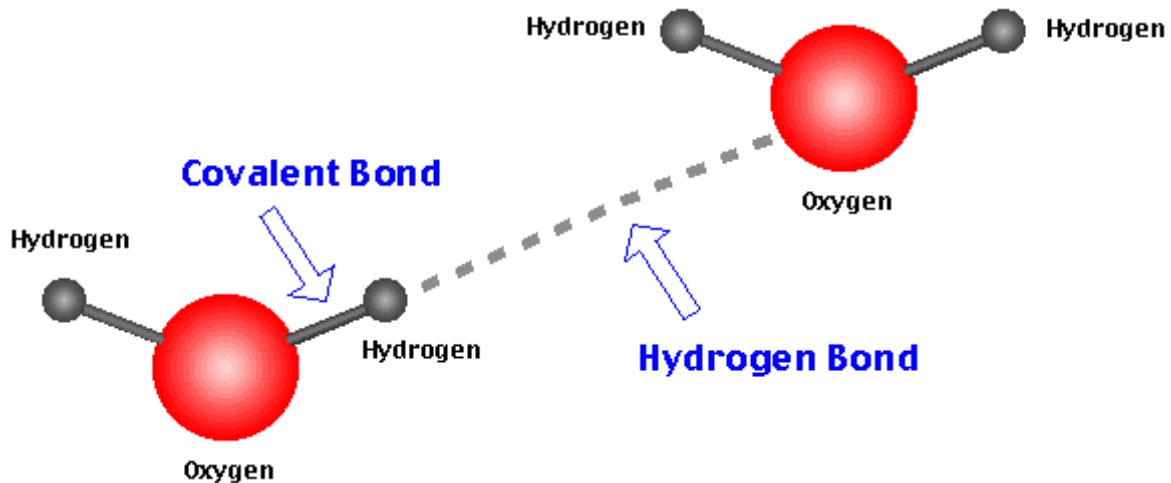


When two atoms come within 5 nanometers of each other, there will be a slight interaction between them, thus causing polarity and a slight attraction.

- Page 39
- Q1,3,5,6

# The Water Molecule

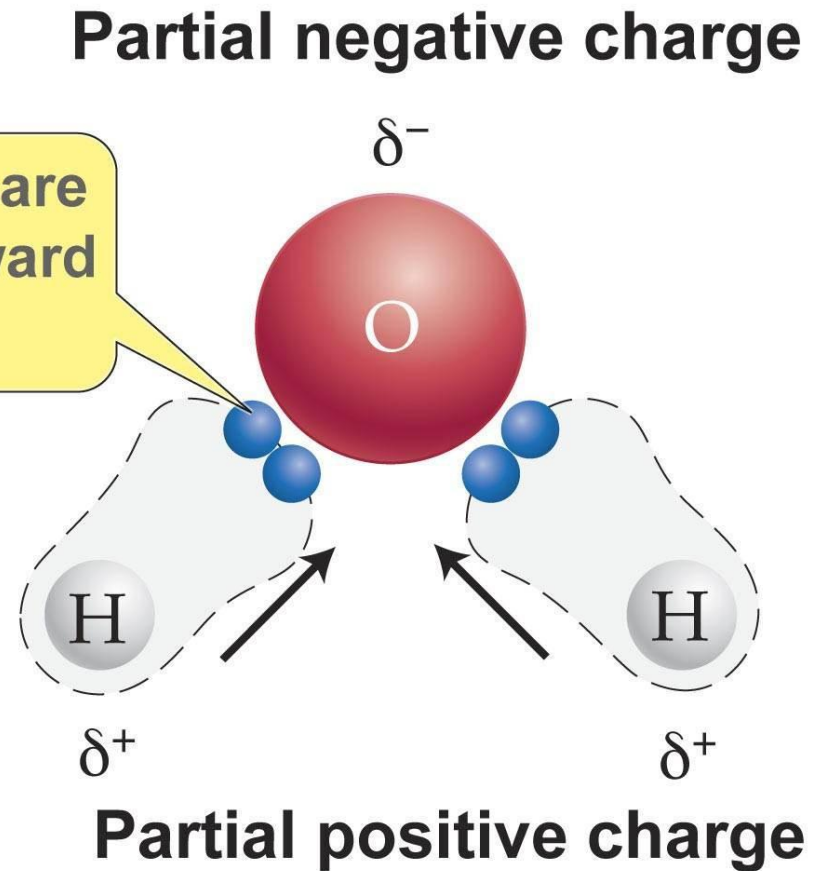
- Hydrogen bond: attraction between polar molecules



# The Water Molecule

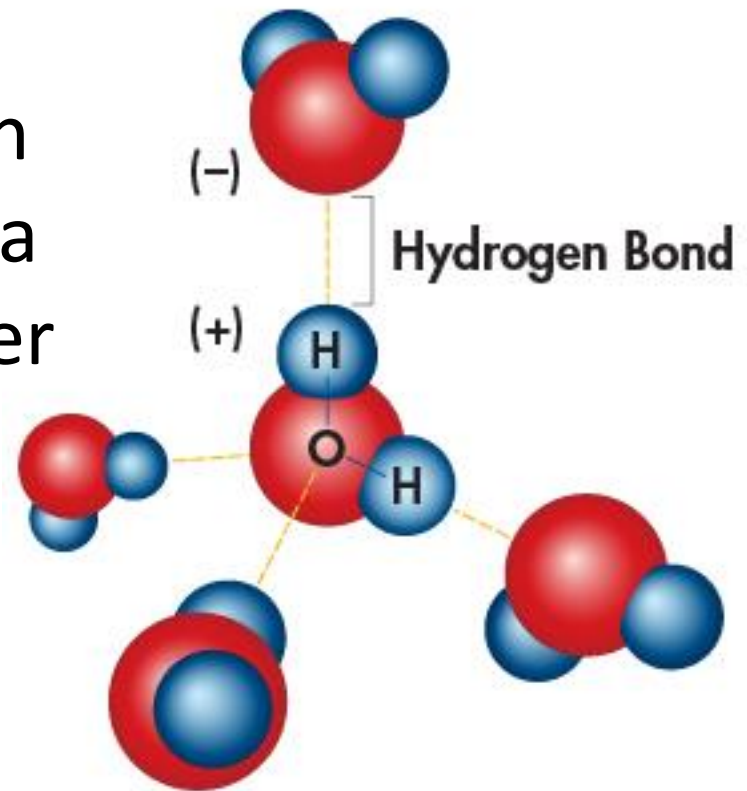
- Polarity: the property of having poles or being polar

Electrons are pulled toward oxygen.



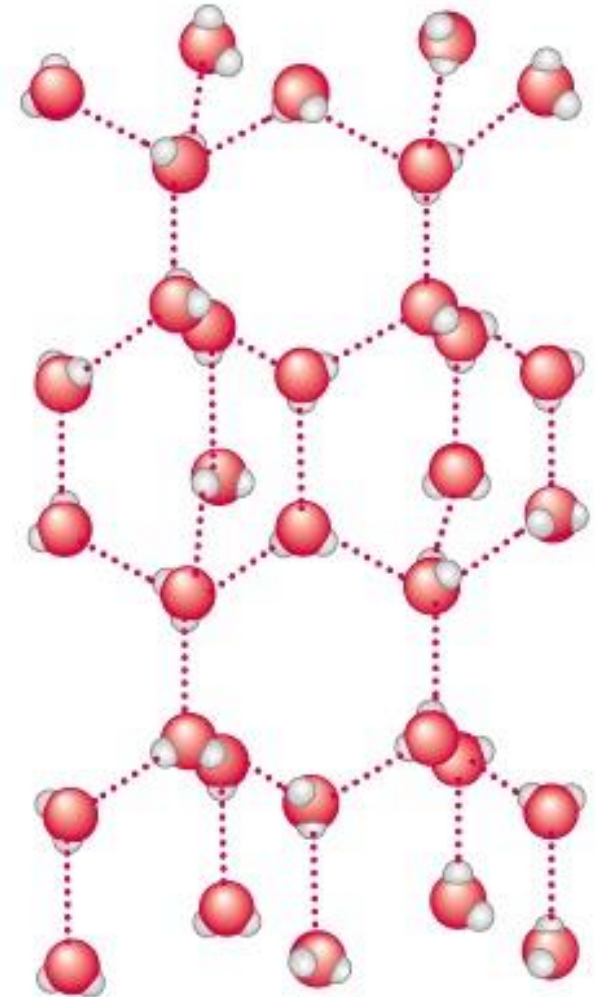
# The Water Molecule

- Hydrogen Bonds: Weak chemical **bond** between an electronegative atom and a **hydrogen** bound to another electronegative atom

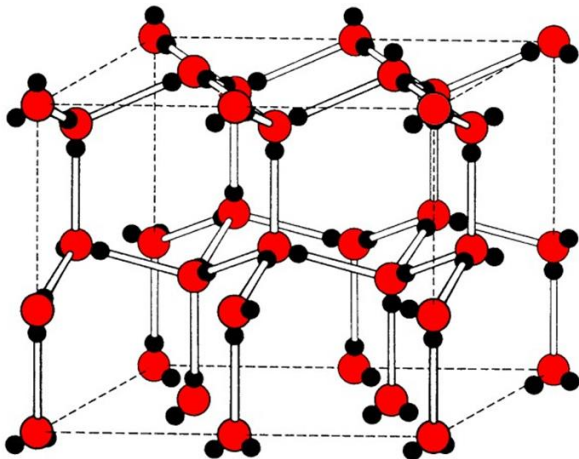


# The Water Molecule

(a) Solid water (ice)



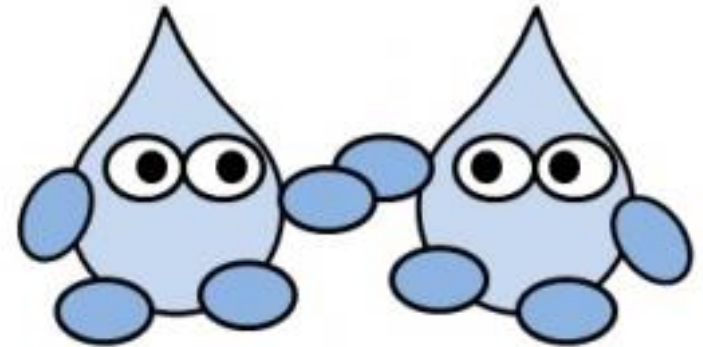
- Hydrogen Bonds: Weak chemical **bond** between an electronegative atom and a **hydrogen** bound to another electronegative atom



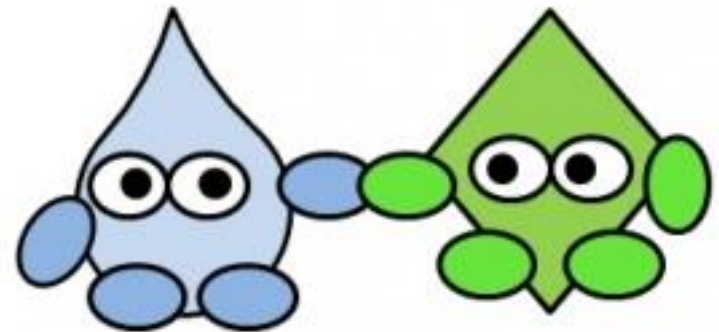


# The Water Molecule

- **Cohesion:** attraction between molecules of the same substance.
- **Adhesion:** an attraction between molecules of different substances.



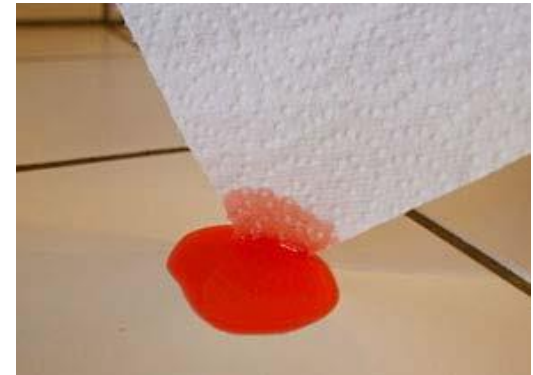
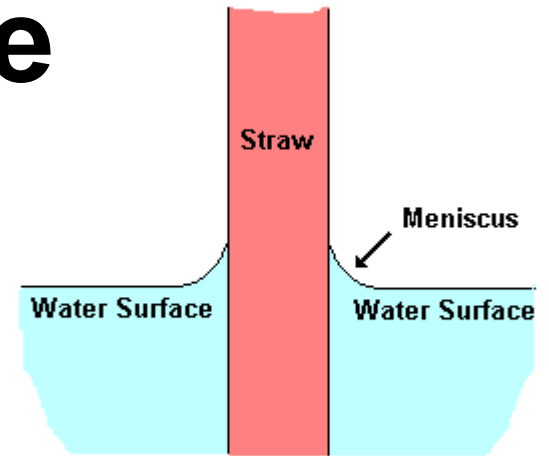
cohesion



adhesion

# The Water Molecule

- **Cohesion:** attraction between molecules of the same substance.
- **Adhesion:** an attraction between molecules of different substances.



# The Water Molecule

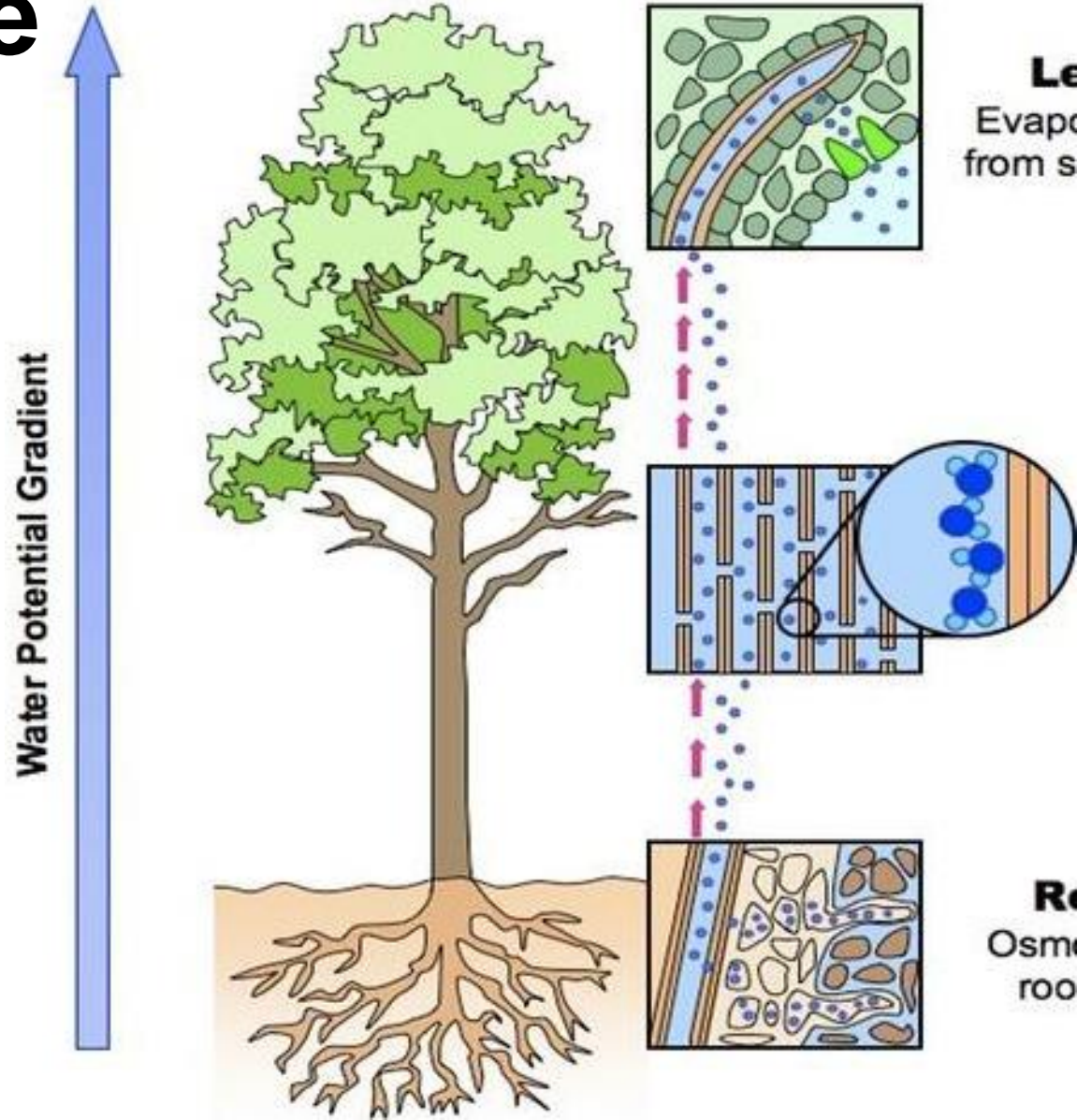


- **Cohesion:** attraction between molecules of the same substance.
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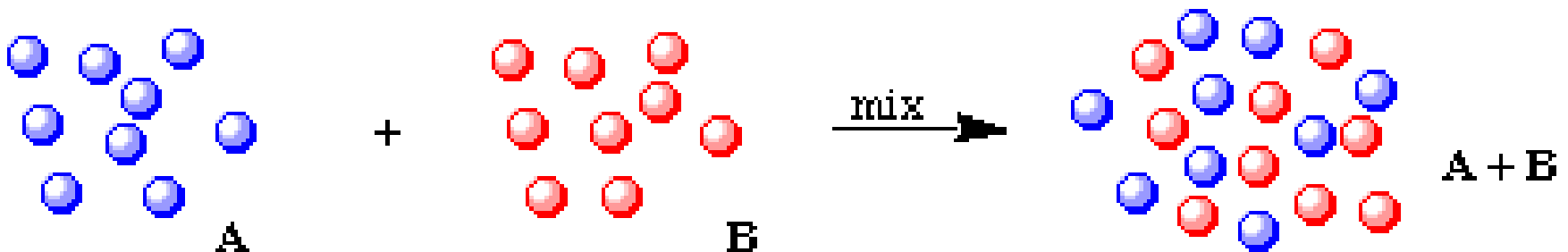
# The Water Molecule

- **Cohesion:** attraction between molecules of the same substance.
- **Adhesion:** an attraction between molecules of different substances.



# Solutions and Suspensions

- **Mixture:** physically mixed together but not chemically combined.
- **Solution:** molecules of mixture are evenly distributed



# Comparing a Mixture and Solution

Mixture



sand

+



water

You can separate the sand from the water by filtering.



Solution



sugar

+



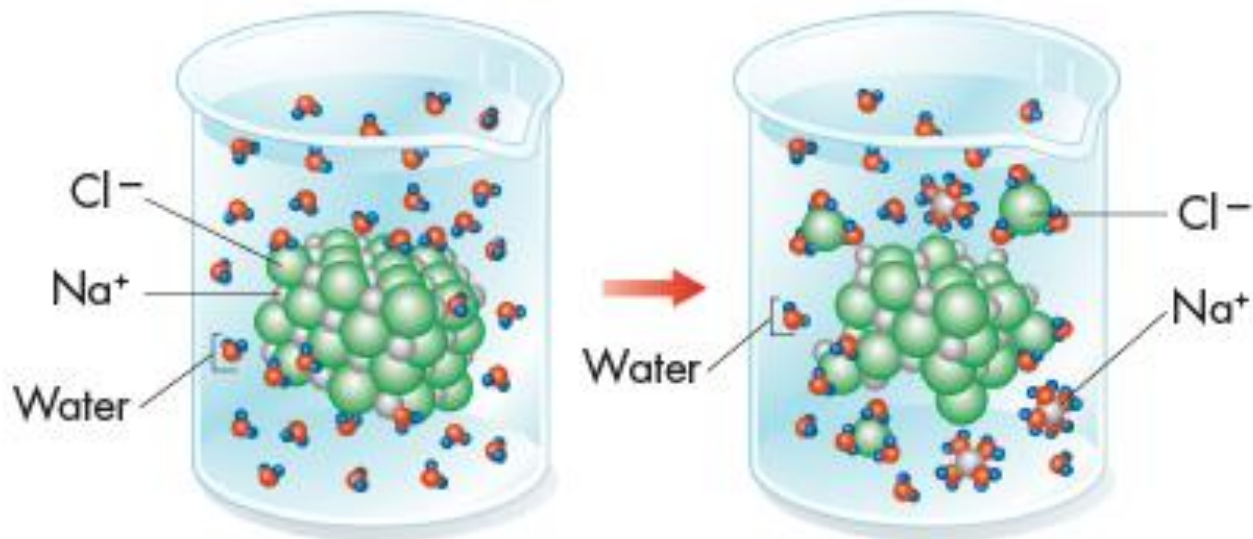
water

The sugar is dissolved in the water. The sugar particles are evenly distributed in the water.



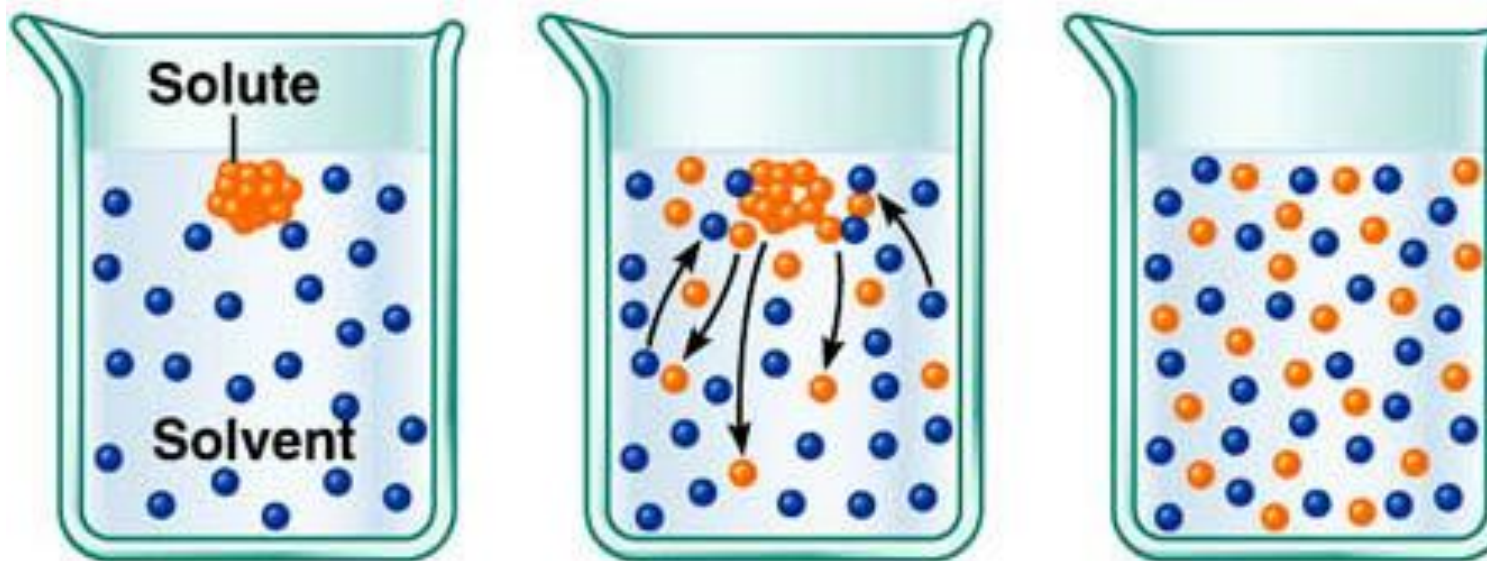
# Solutions and Suspensions

- Solution is made of a Solute and Solvent
- Solute: substance that dissolves
- Solvent: substance a solute dissolves in



# Solutions and Suspensions

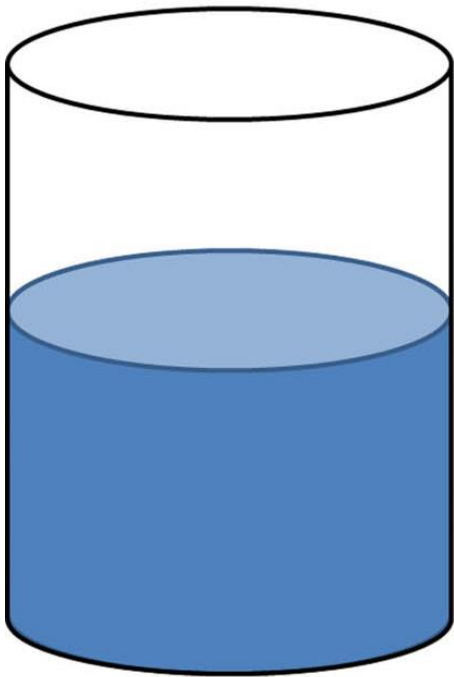
- Solution is made of a Solute and Solvent
- Solute: substance that dissolves
- Solvent: substance a solute dissolves in



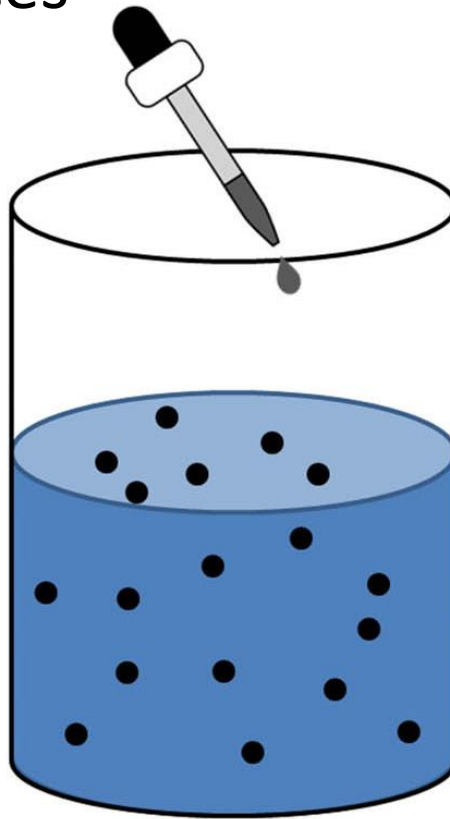


# Suspensions

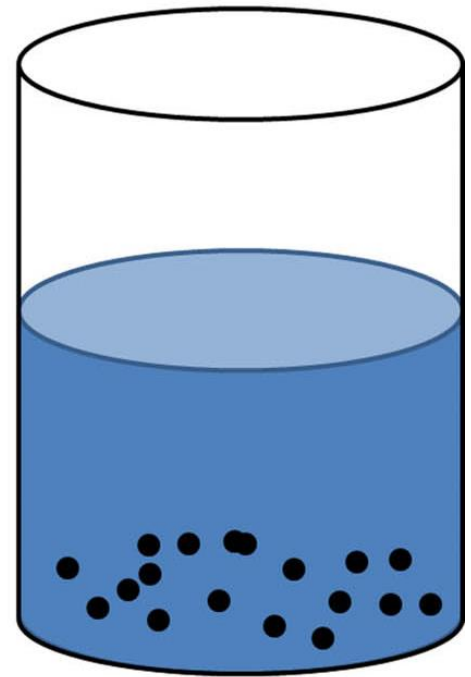
- Don't dissolve
- Separate into pieces
- Non dissolved



**Solution**



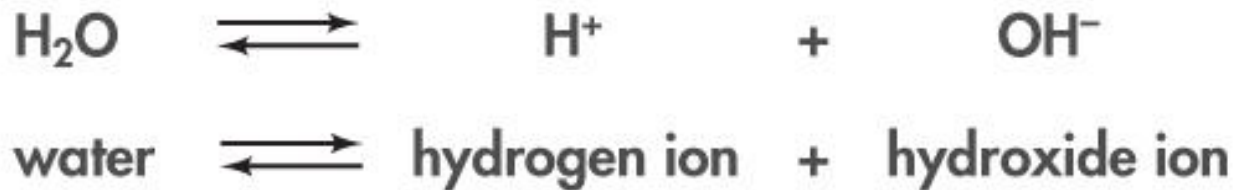
**Suspension**



**Precipitation**

# Acids, Bases, and pH

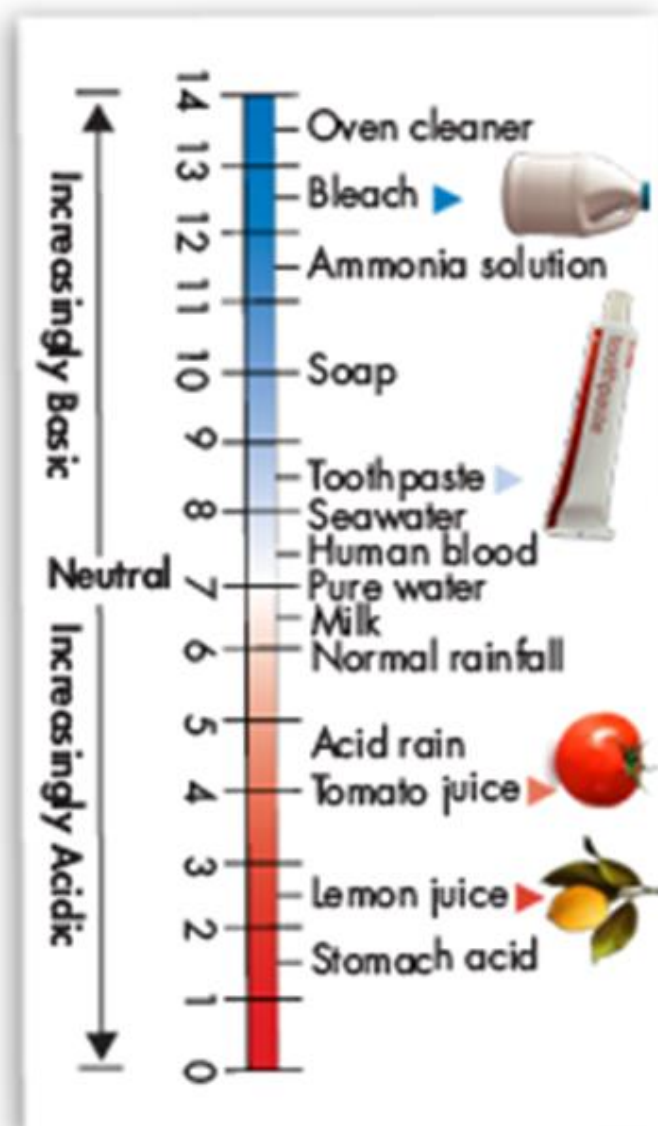
- Water molecules can split
- Water has is pH natural because  $H^+ = OH^-$



# Acids, Bases, and pH

- **The pH Scale**

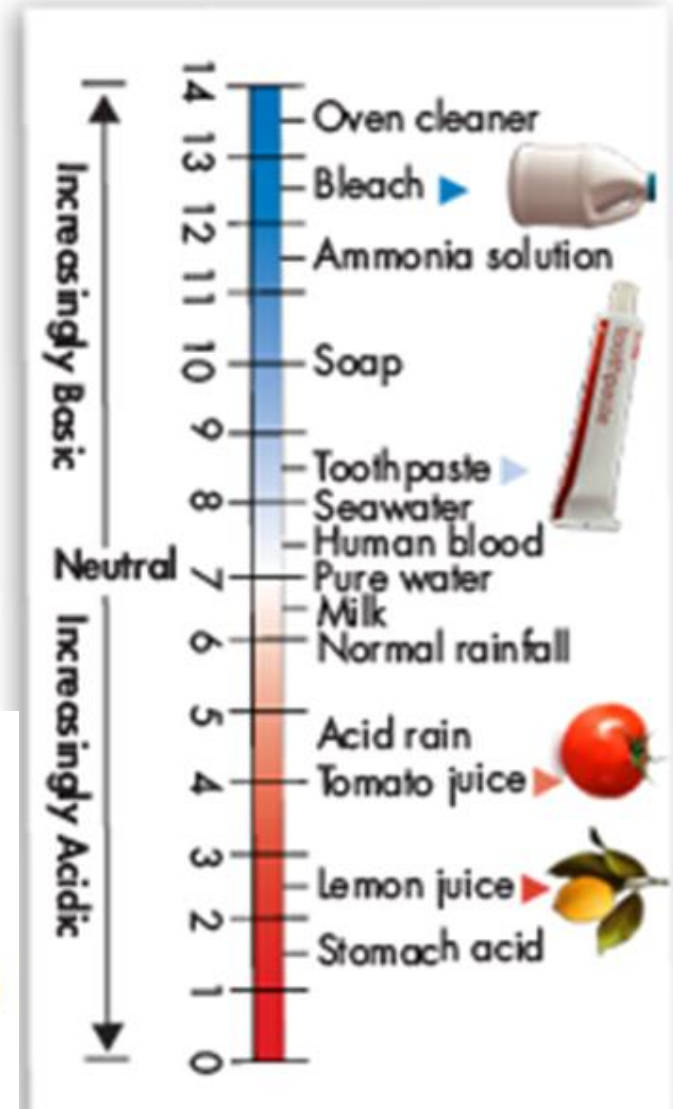
- indicate the concentration of  $H^+$  ions in solution
- At a pH of 7, the concentration of  $H^+$  ions and  $OH^-$  ions is equal. Pure water has a pH of 7



# Acids, Bases, and pH

## • The pH Scale

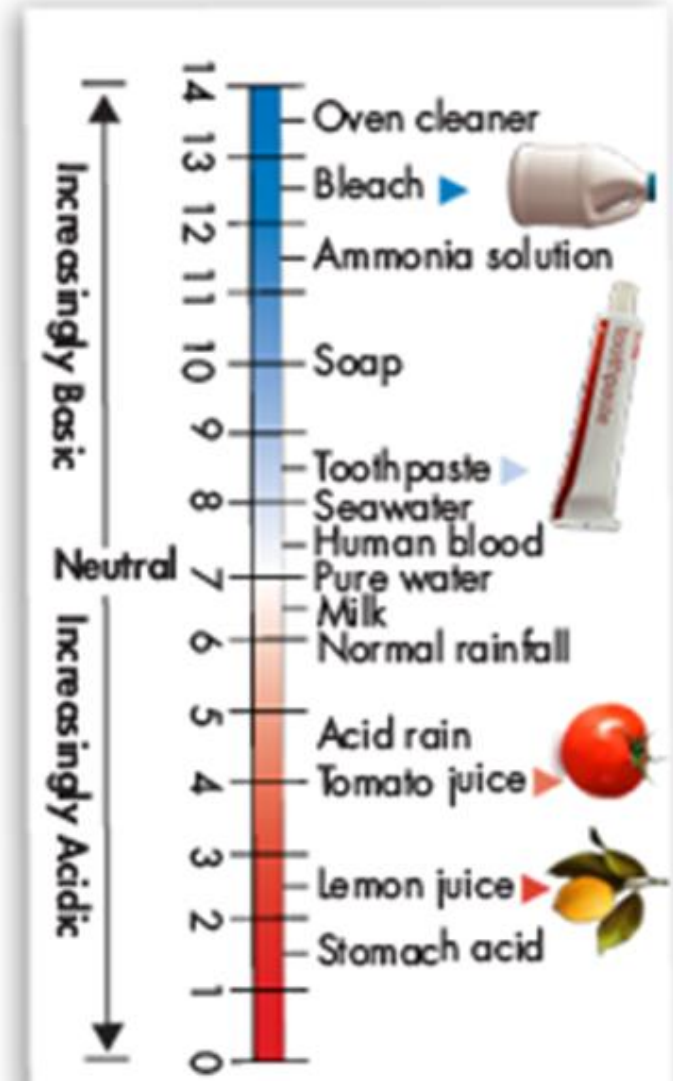
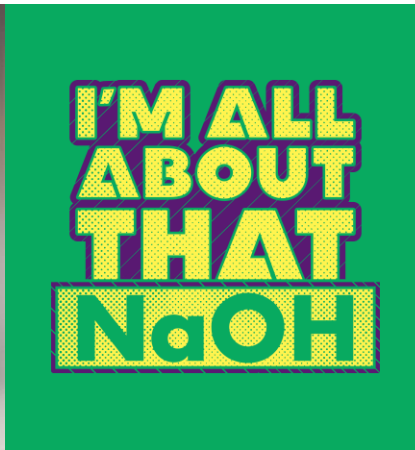
- Acids:
- forms  $H^+$  ions in solution
- Solutions with a pH below 7
- more  $H^+$  ions than  $OH^-$  ions.



# Acids, Bases, and pH

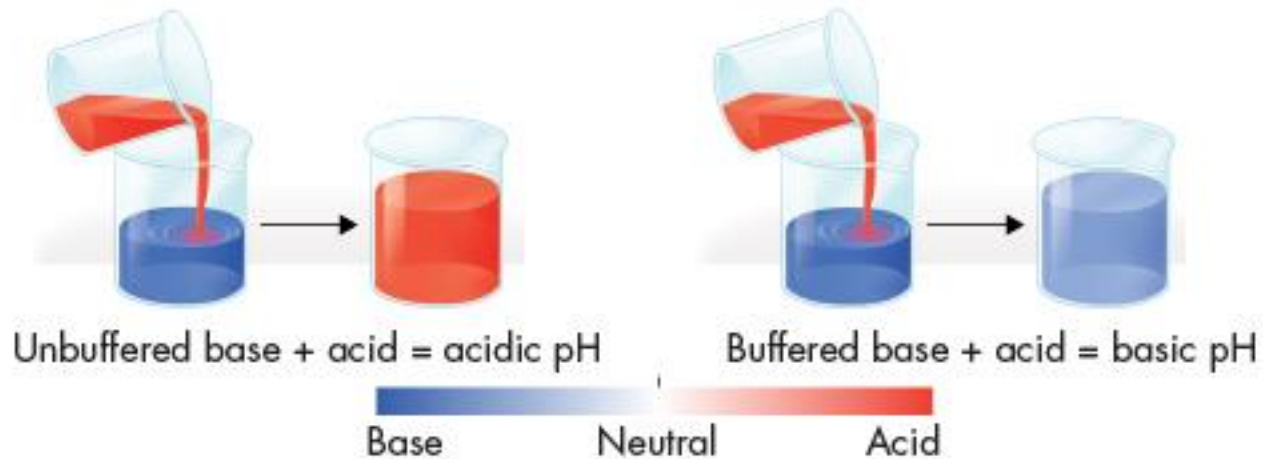
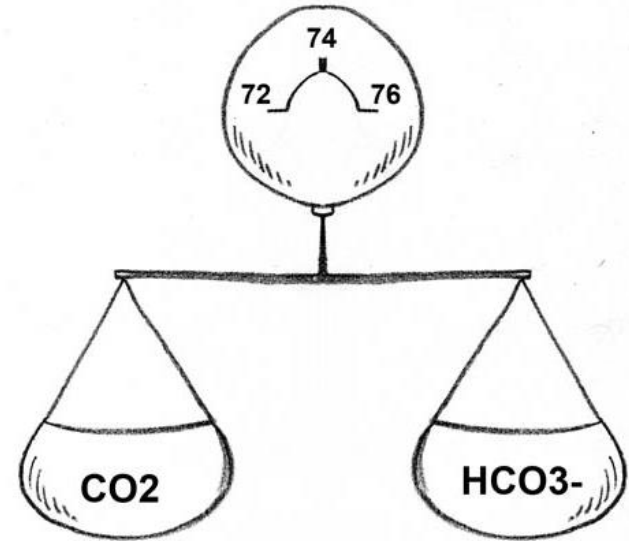
- The pH Scale

- Bases:
- produces hydroxide ( $\text{OH}^-$ ) ions in solution
- Solutions with a pH above 7
- more  $\text{OH}^-$  ions than  $\text{H}^+$  ions.



# Buffers

- weak acids or bases that can react with strong acids or bases to prevent changes in pH.



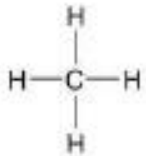
- Text book
- Page 43
- Q1,2,3,4,5,

# 2-3 Carbon Compounds

Carbon is very versatile. Two reasons are

- Carbon atoms have four valence electrons
- Form bonds with other carbon atoms

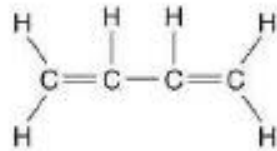
**Figure 2-11 Carbon Compounds**



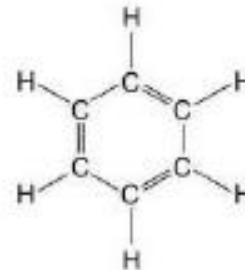
Methane



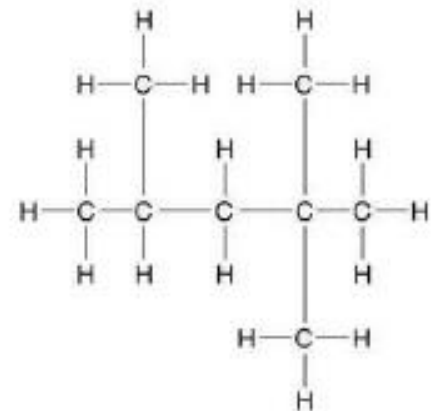
Acetylene



Butadiene



Benzene



Isooctane



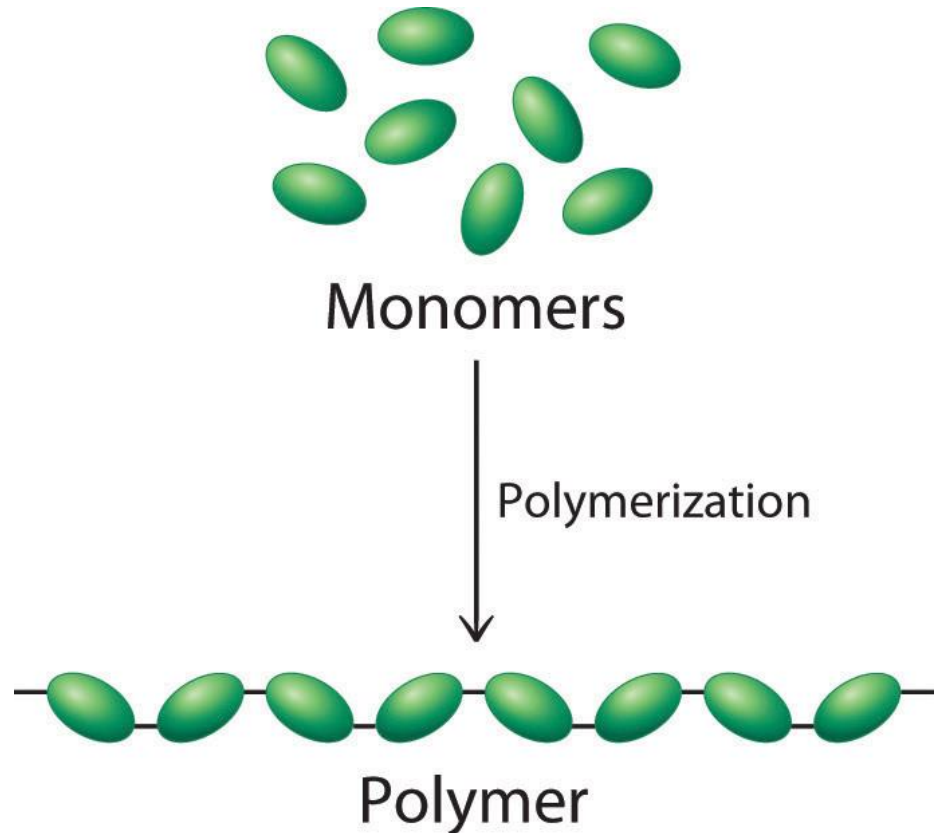
# 2-3 Carbon Compounds

## Macromolecules

- macro = big
- Macromolecules are many small molecules put together to make one big one.

## Polymerization

- Making macromolecules
  - Join lots of monomers to make a polymer



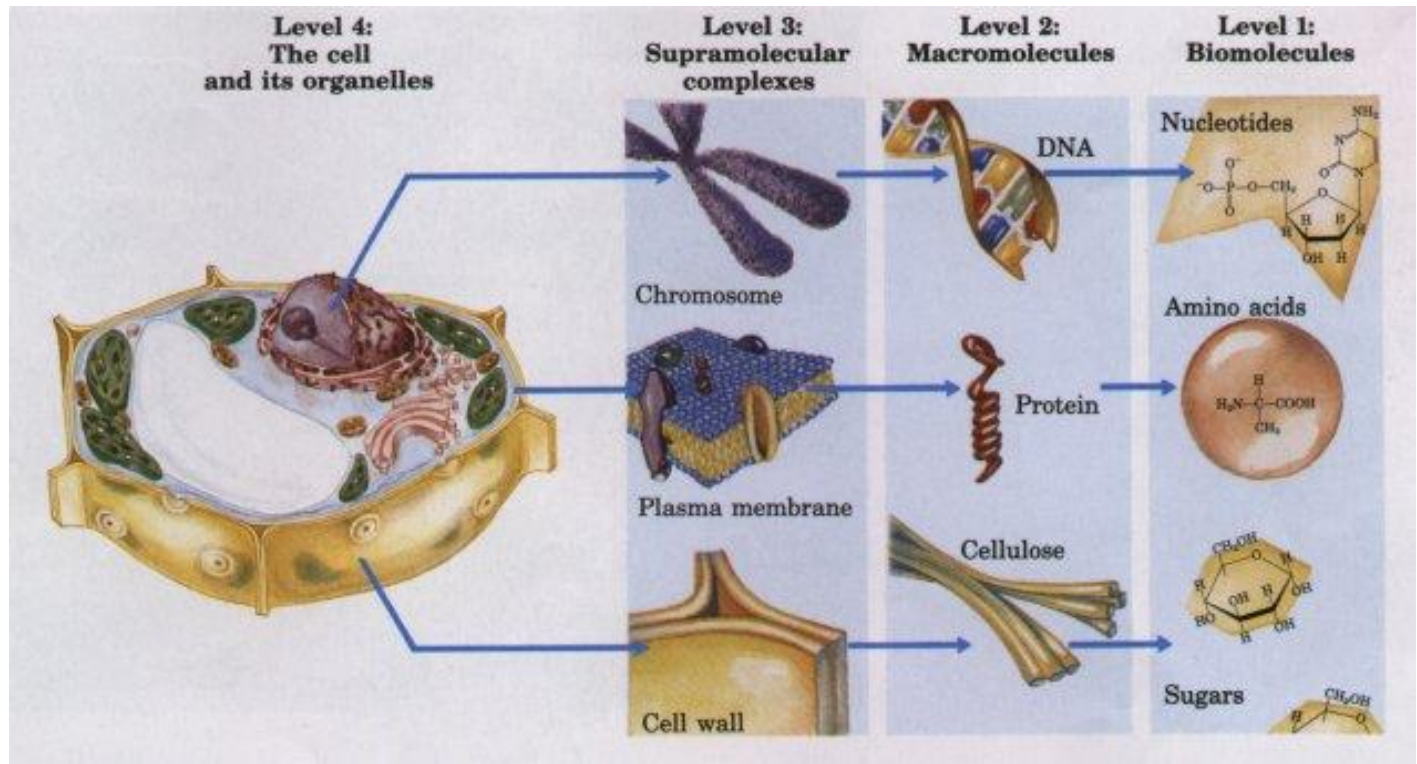
# 2-3 Carbon Compounds

## Macromolecules

- macro = big
- Macromolecules are many small molecules put together to make one big one.

## Types of macromolecules

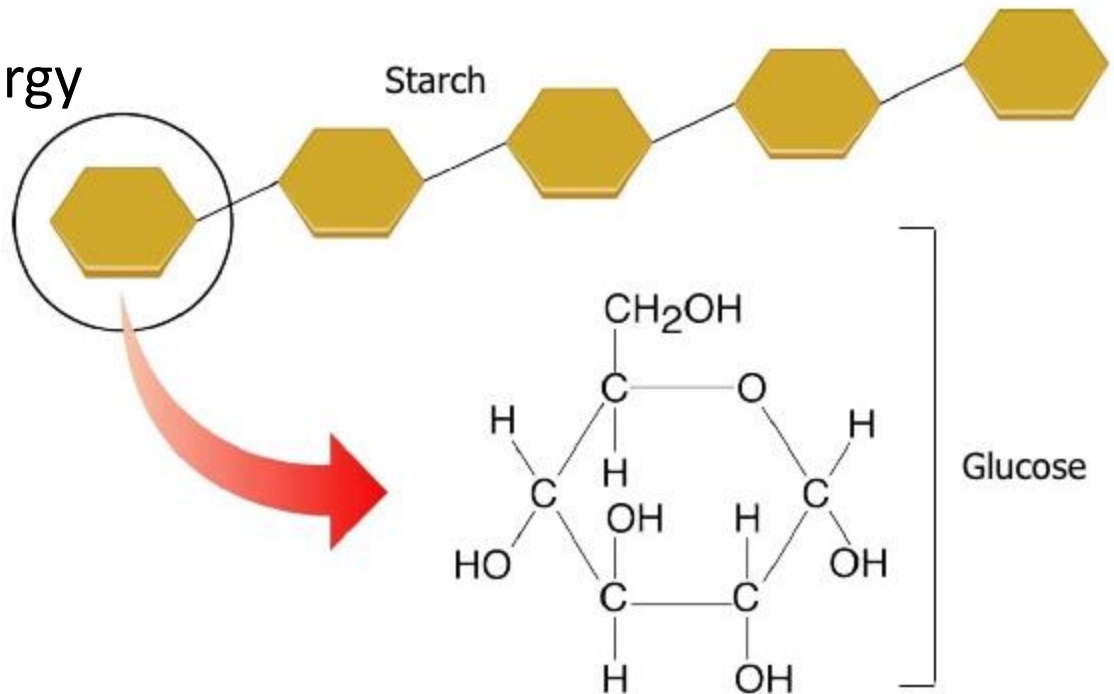
- Carbohydrates
- Lipids
- Nucleic Acids
- Proteins



# 2-3 Carbon Compounds

## CARBOHYDRATES

- Made of C, H and O
- Main source of energy
- Breaking the bonds in a carbohydrate release energy



# 2-3 Carbon Compounds

## Carbohydrates

### Monosaccharide

Glucose  
Fructose  
Galactose



Single sugar  
molecule

### Disaccharide

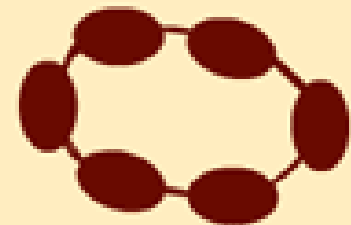
Maltose  
Sucrose  
Lactose



Two sugar  
molecules linked

### Polysaccharide

Starch  
Glycogen  
Cellulose

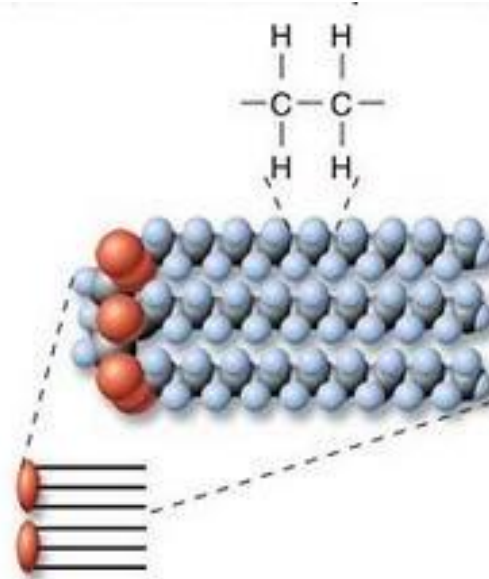


Many sugar  
molecules linked

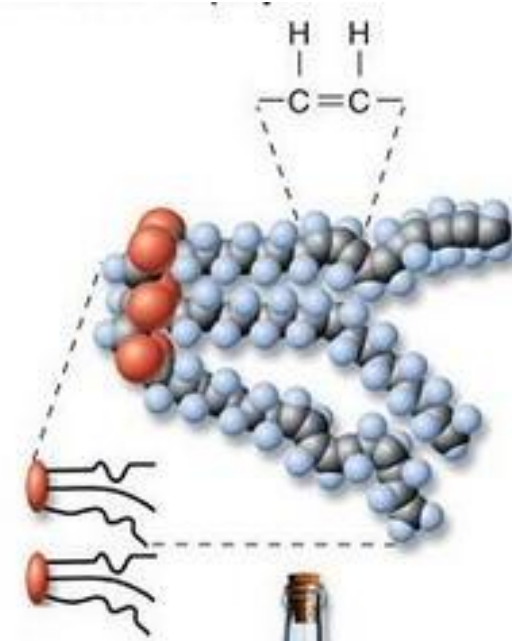
# 2-3 Carbon Compounds

## Lipids

- Not soluble in water
- Mostly made from C & H
- Fats, oils & waxes
- Store energy and make up cell walls.



(b) Hard fat (saturated): Fatty acids with single bonds between all carbon pairs



(c) Oil (unsaturated): Fatty acids that contain double bonds between one or more pairs of carbon atoms

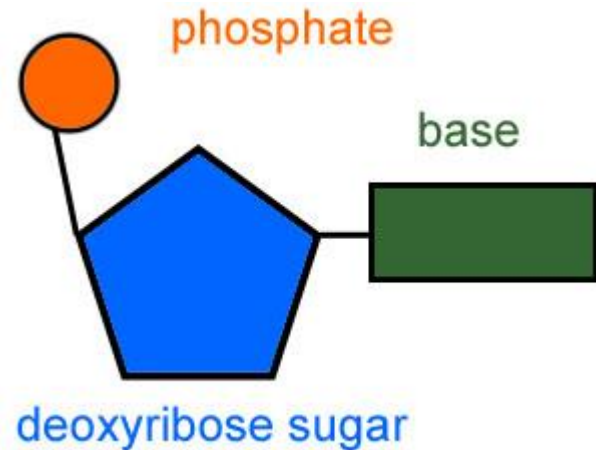
# 2-3 Carbon Compounds

## Nucleic Acids

- Made of H, O, N, C & P
- Nucleic acid = polymer
- Nucleotide = monomer

## Two types

- DNA
- RNA

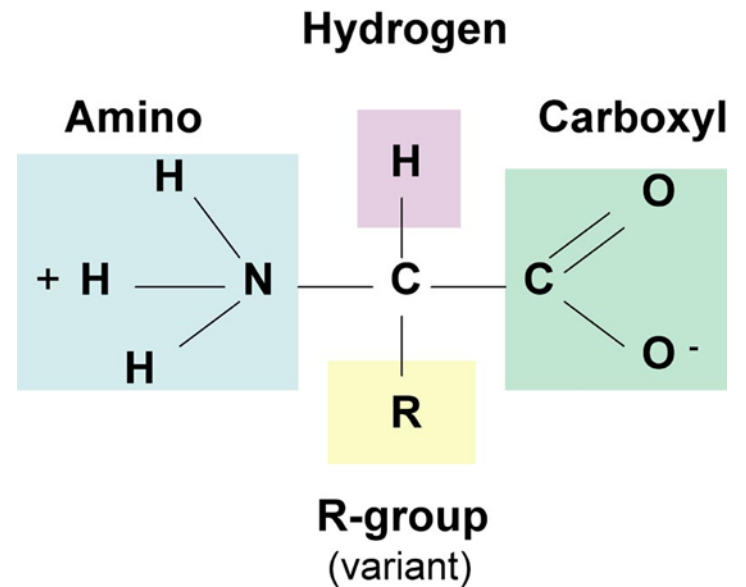


# 2-3 Carbon Compounds

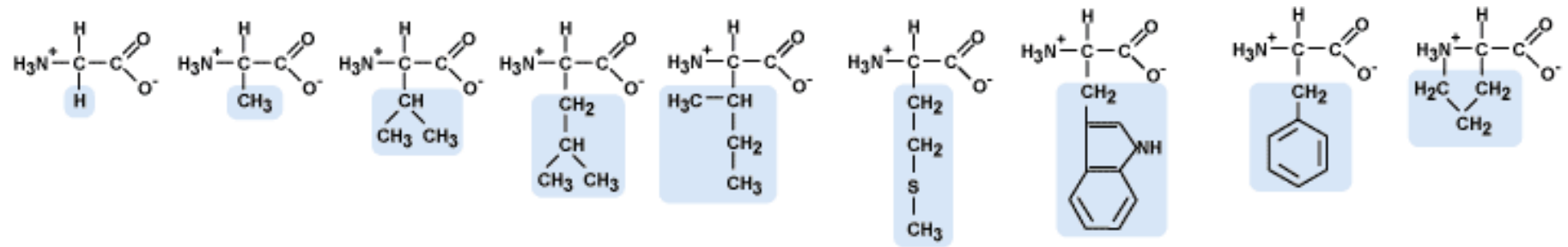
## Protein

- Made of C, H, O & N
- Proteins = polymers
- Amino acids = monomers
- More than 20 different types of amino acids

## Amino Acid Structure

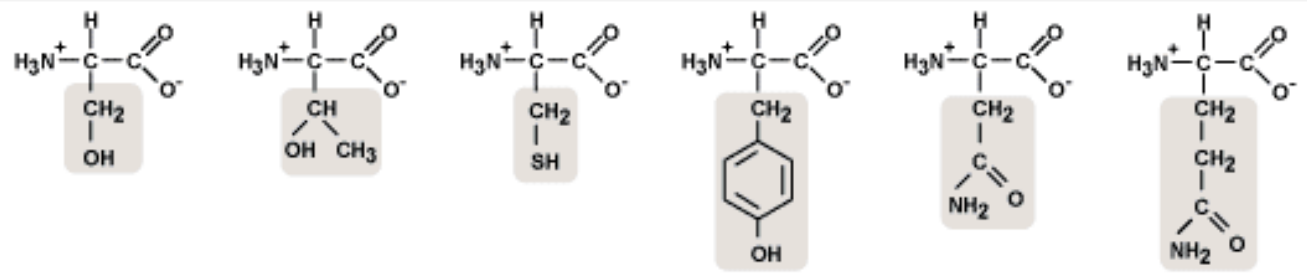


**NONPOLAR**



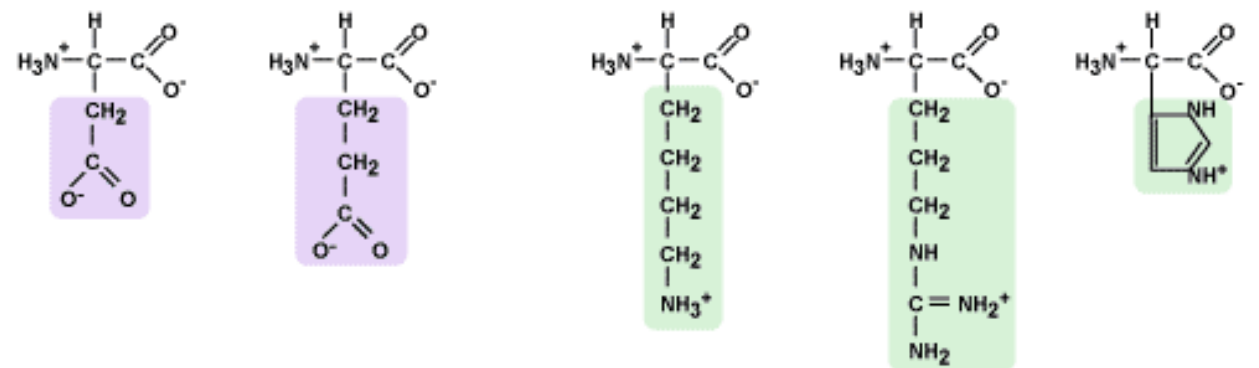
Glycine (Gly)    Alanine (Ala)    Valine (Val)    Leucine (Leu)    Isoleucine (Ile)    Methionine (Met)    Tryptophan (Trp)    Phenylalanine (Phe)    Proline (Pro)

**POLAR**



Serine (Ser)    Threonine (Thr)    Cysteine (Cys)    Tyrosine (Tyr)    Asparagine (Asn)    Glutamine (Gln)

**Electrically Charged**



**Acidic**

Aspartic Acid (Asp)    Glutamic Acid (Glu)

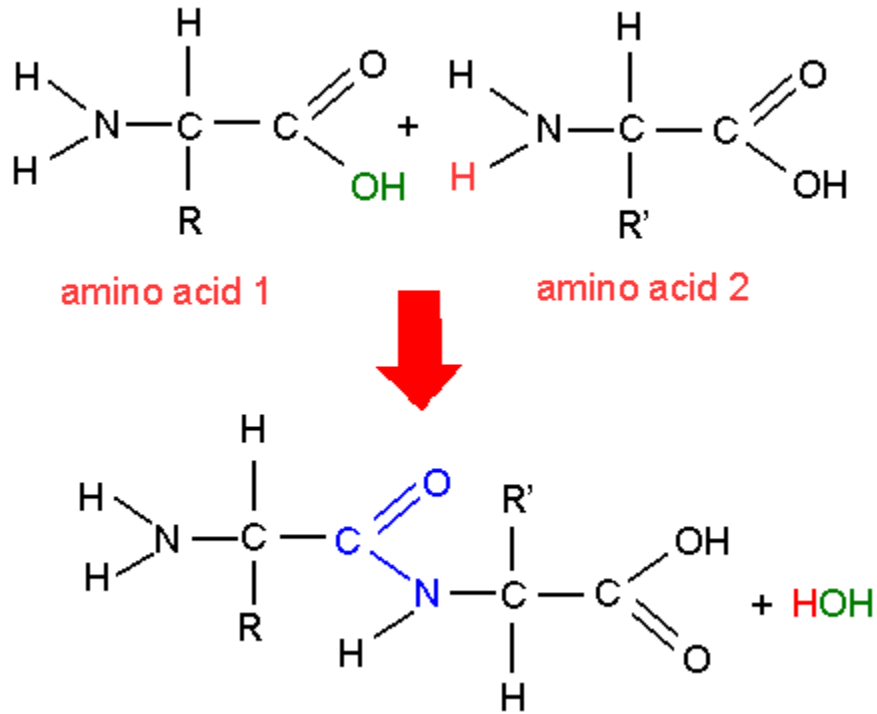
**Basic**

Lysine (Lys)    Arginine (Arg)    Histidine (His)

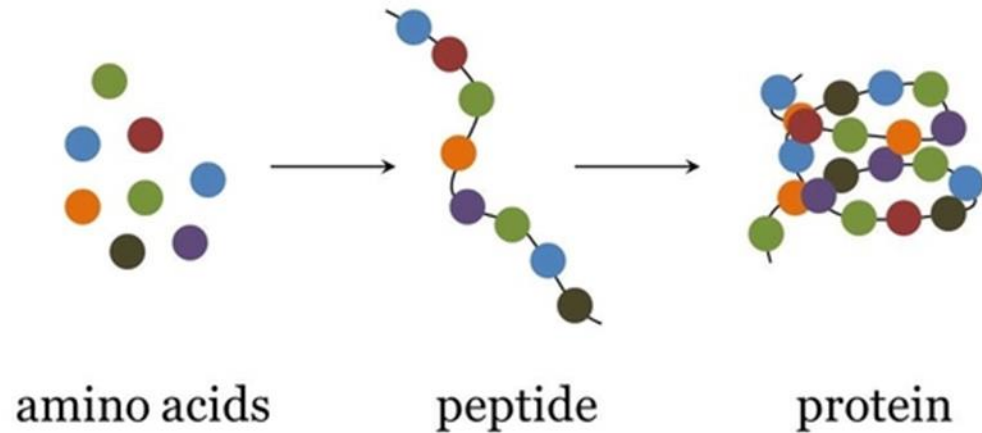


# 2-3 Carbon Compounds

Amino acids join together to make a peptide bond



This makes a polypeptide



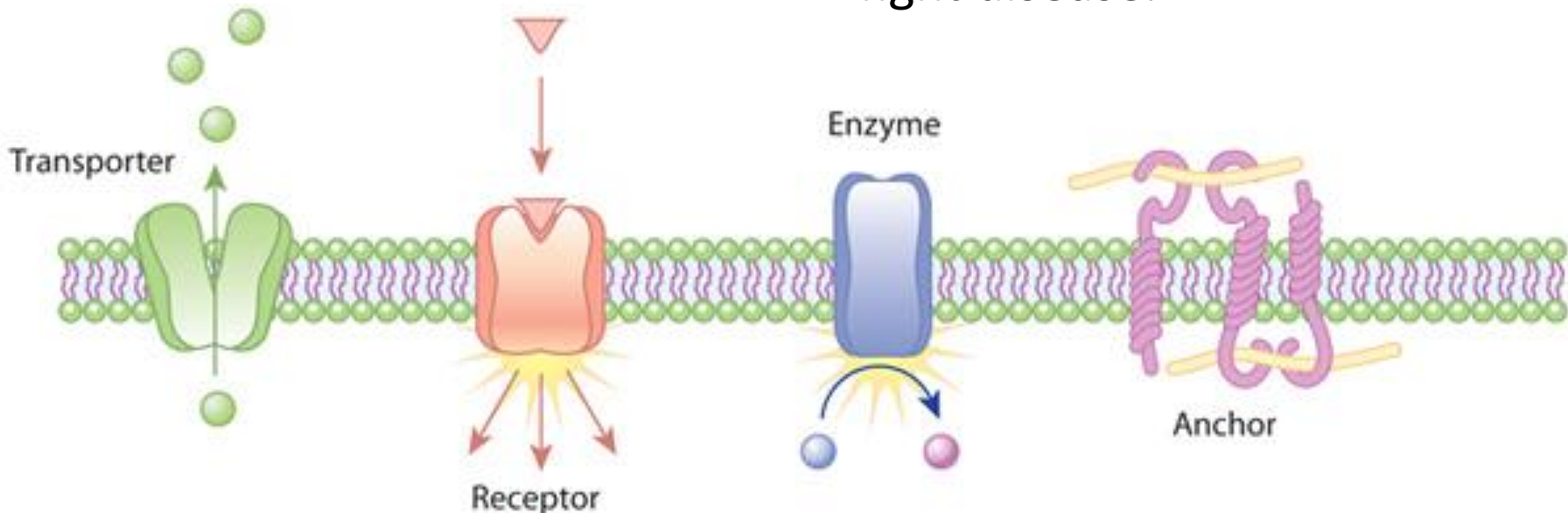
# 2-3 Carbon Compounds

## Lots of types of proteins

- Understand that there are many different types of proteins, each with a unique job or purpose

## Some proteins:

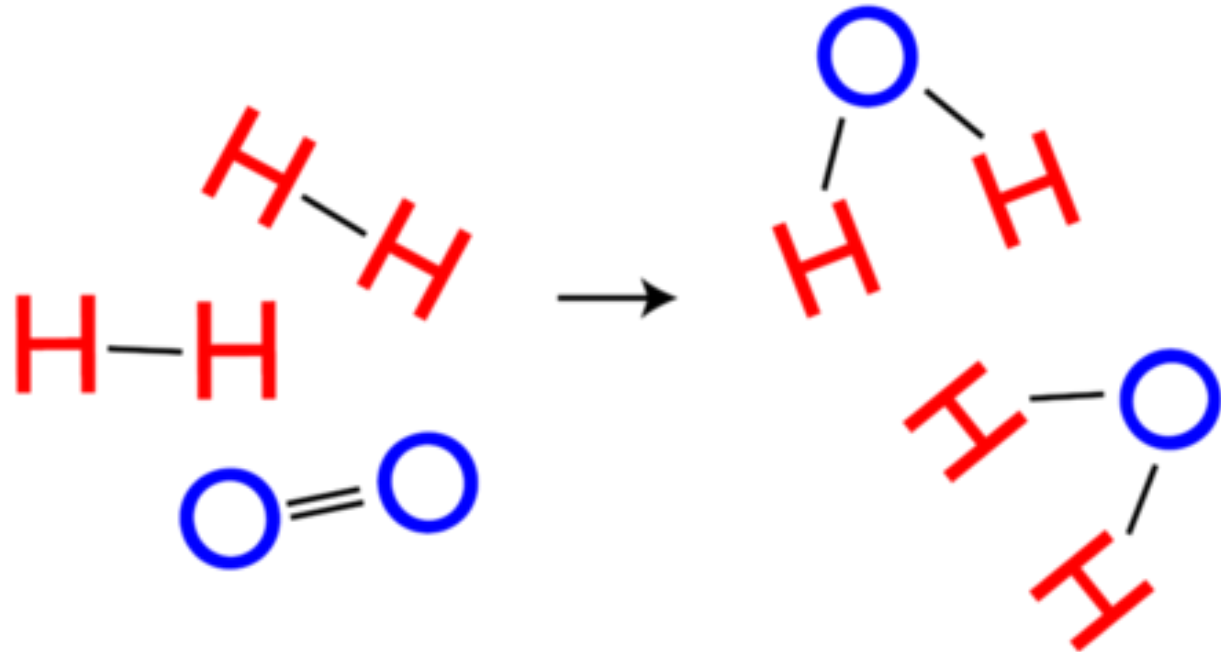
- control the rate of reactions
- regulate cell processes.
- form bones or muscle muscles.
- transport substances into or out of cells.
- fight disease.



# 2-4 Chemical Reactions & Enzymes

## CHEMICAL REACTIONS

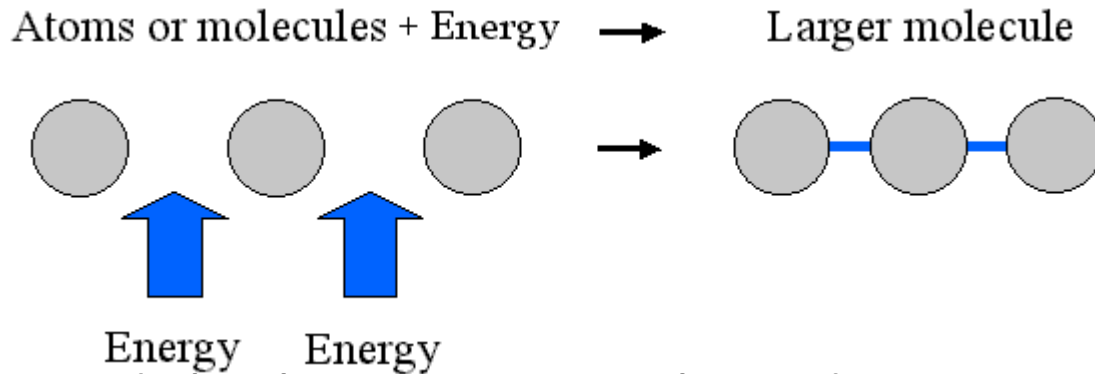
- Change one set of chemicals into another
- Bonds are broken new bonds formed



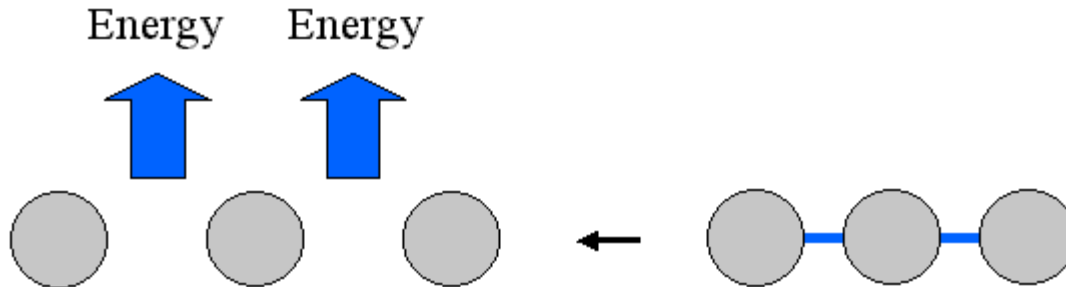
# 2-4 Chemical Reactions & Enzymes

## ENERGY IN REACTIONS

- Bonds formed = energy absorbed



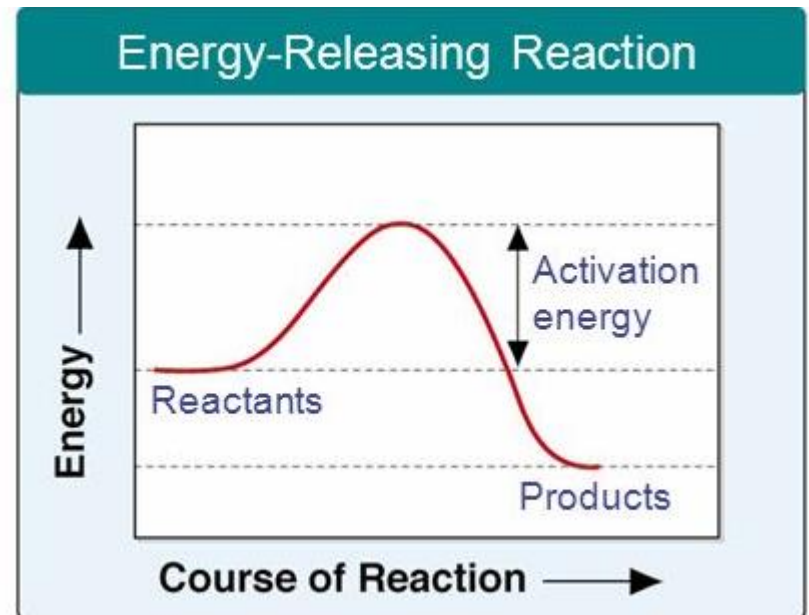
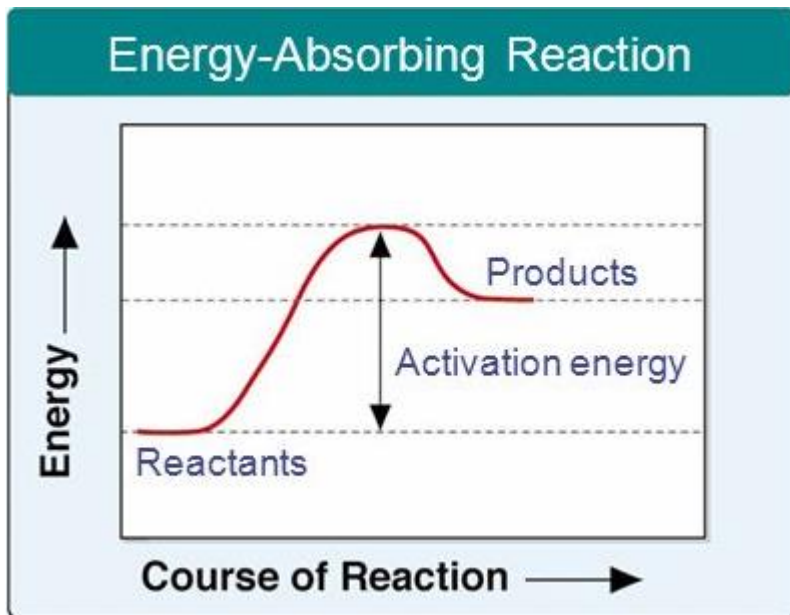
- Bonds broken = energy released



# 2-4 Chemical Reactions & Enzymes

**Energy Absorbed**

**Energy released**

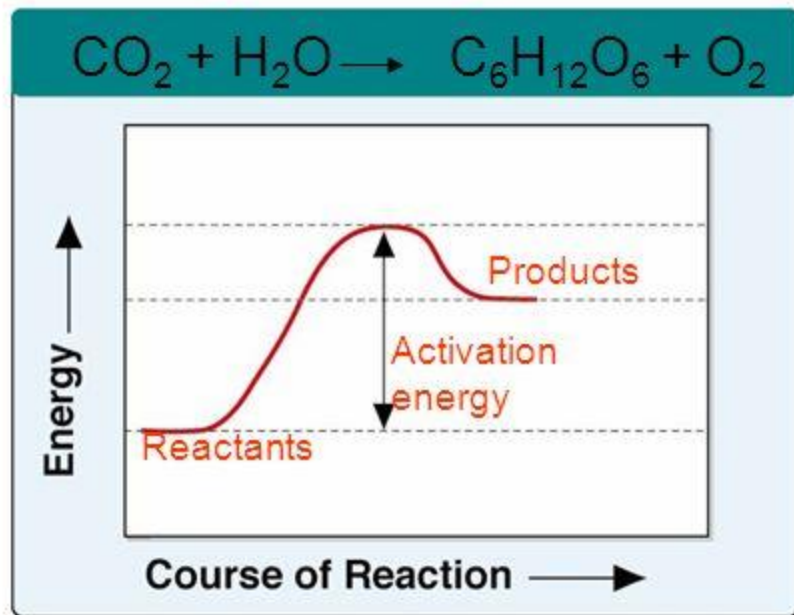


# Chemical Reactions

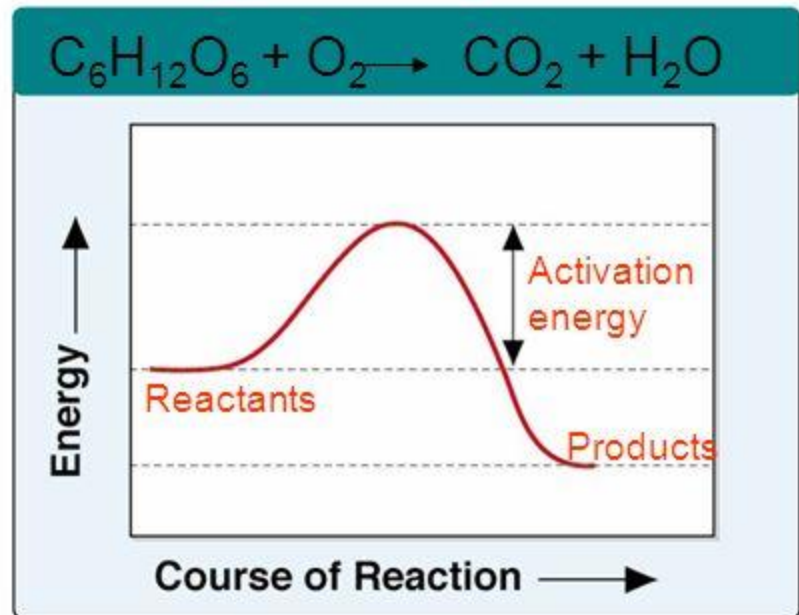
Chemical Reactions -

Metabolism -

Energy-Absorbing Reaction



Energy-Releasing Reaction



Example - Photosynthesis (synthesis)

Reactants =  $\text{CO}_2 + \text{H}_2\text{O}$

Products =  $\text{C}_6\text{H}_{12}\text{O}_6 + \text{O}_2$

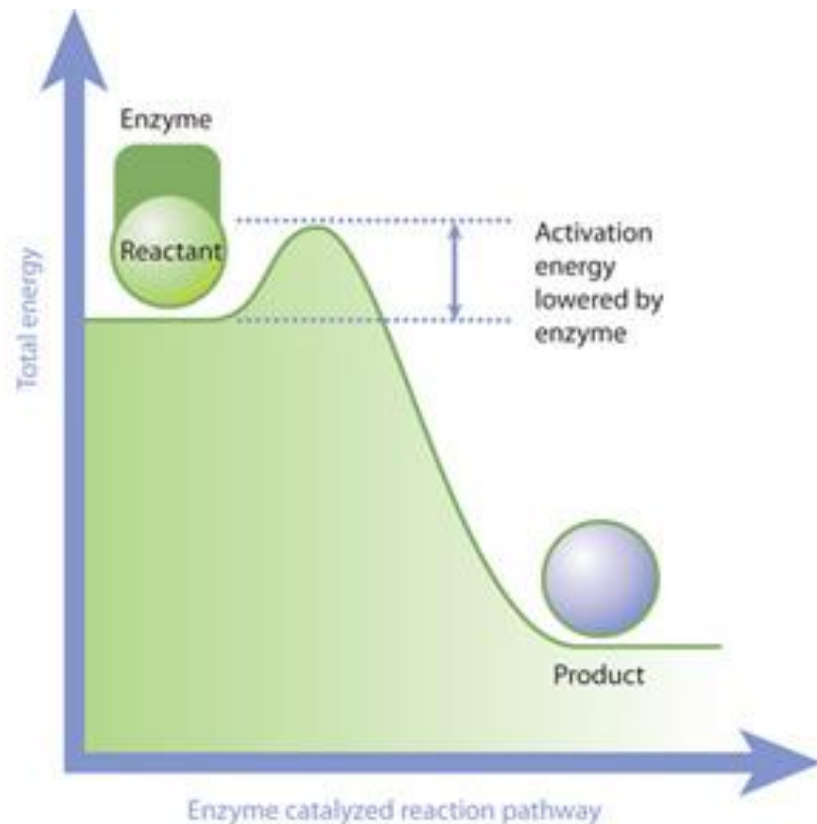
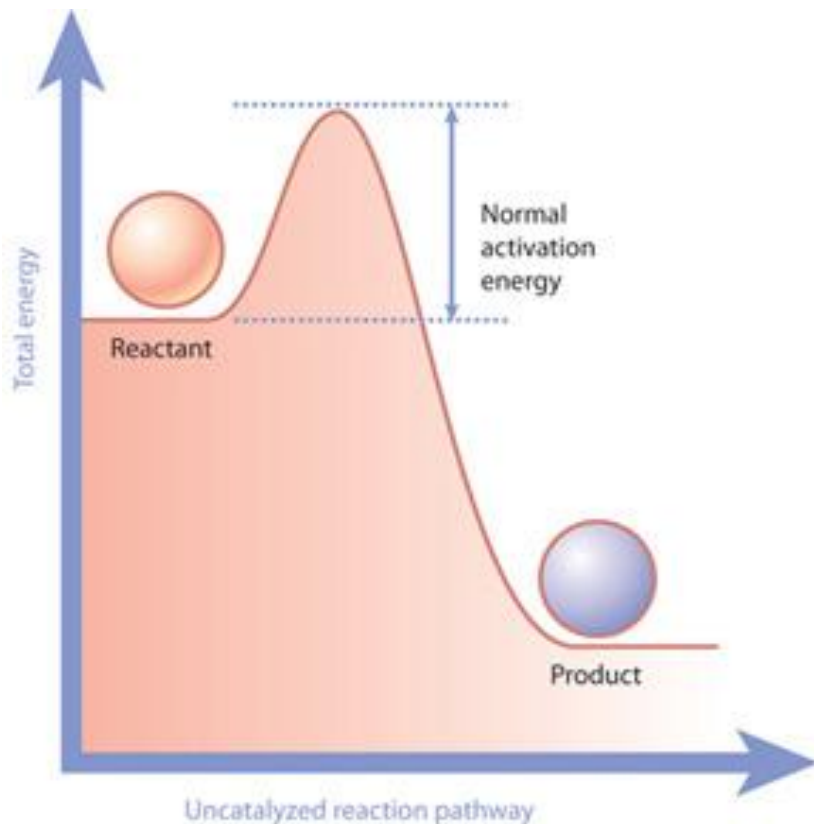
Example - Cell Respiration (decomposition)

Reactants =  $\text{C}_6\text{H}_{12}\text{O}_6 + \text{O}_2$

Products =  $\text{CO}_2 + \text{H}_2\text{O}$

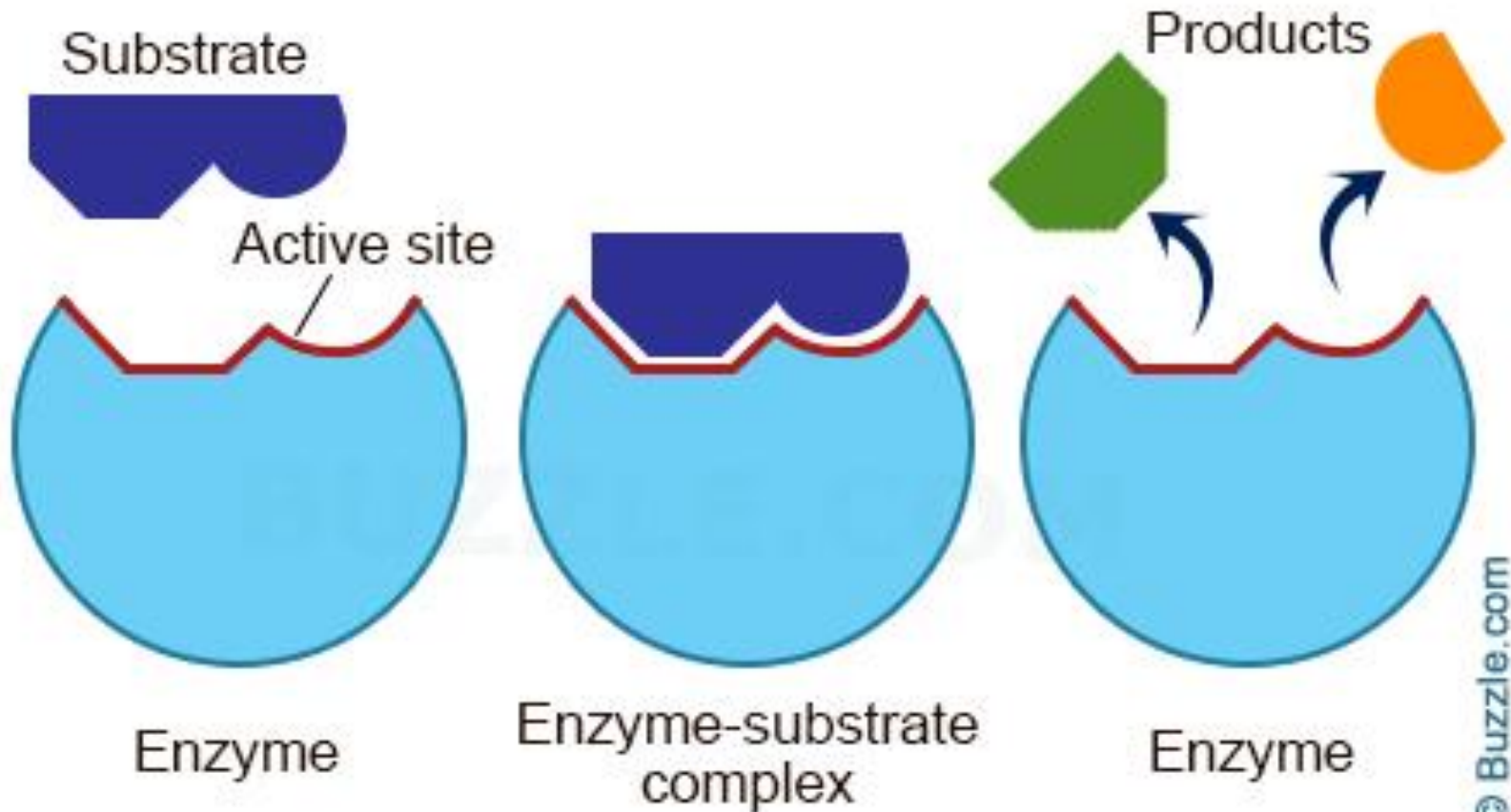
# Enzymes

- Enzymes speed up reactions by lowering the activation energy



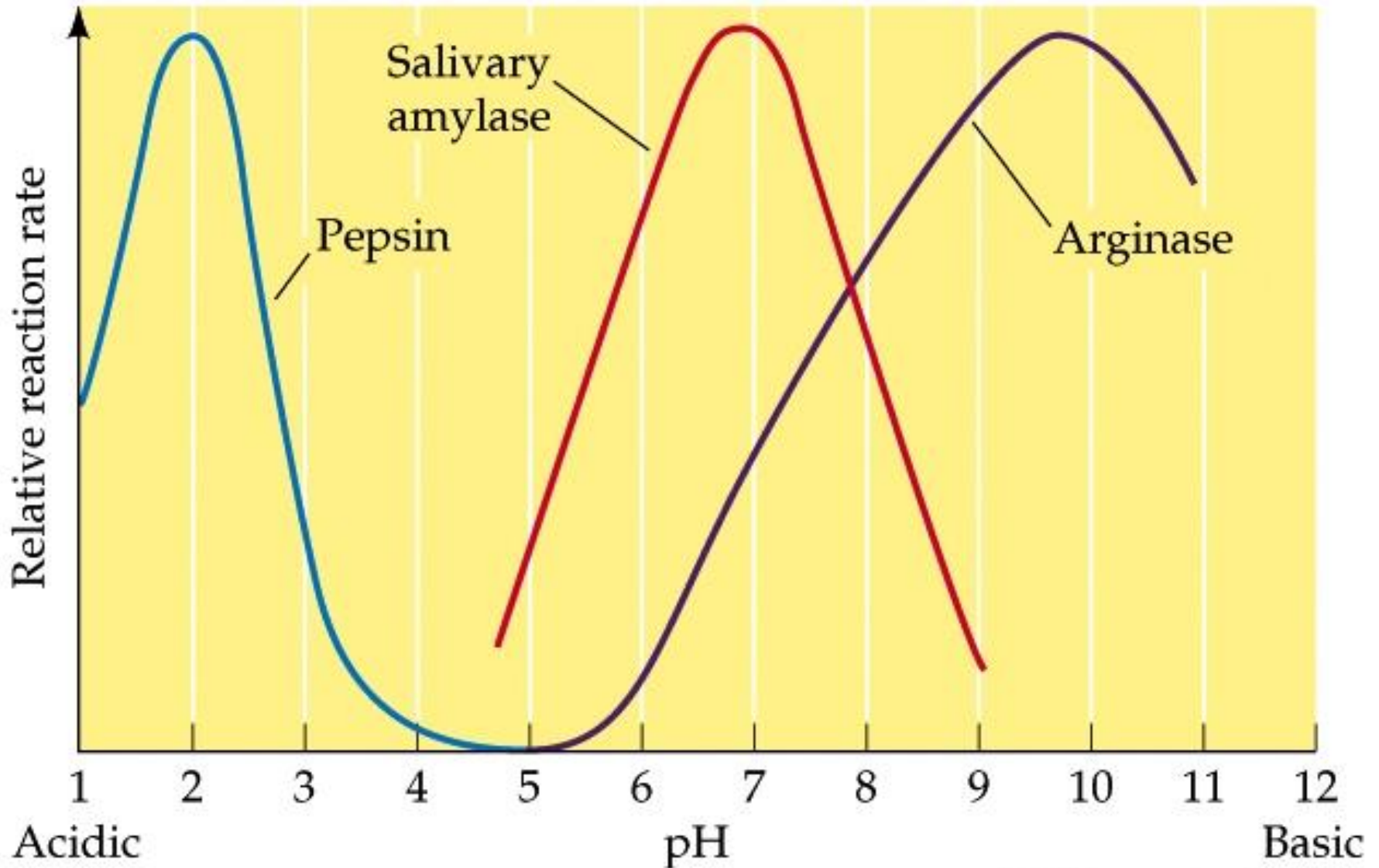
# Enzymes

- Enzymes speed up reactions by lowering the activation energy





# Enzymes



# test

- Types of bonding
  - Covalent
    - Non-polar
    - Polar
  - Ionic
  - Hydrogen
  - Van der Waals interactions
- Solutes and solvents
- Cohesion and adhesion
- pH
- Acid & bases
- Carbon Compounds
  - Carbohydrate
  - Polymerization
  - Monomer
  - Polymer
  - Macromolecule
- Fatty acids
- Nucleic acids
- Proteins
- Experiment
  - What we tested for and how
- Chemical Reactions & Enzymes
  - Energy absorbing and releasing
- Enzymes