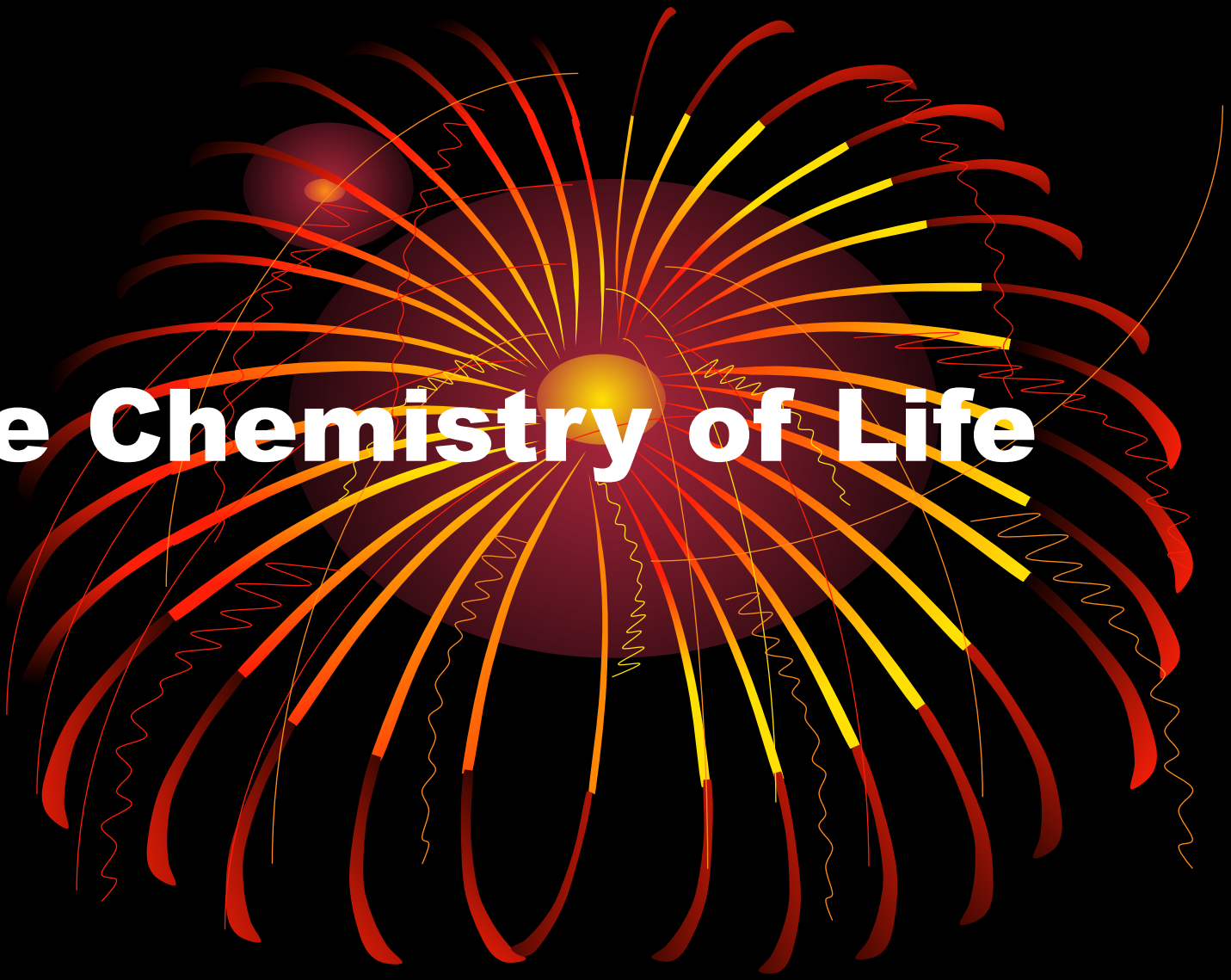
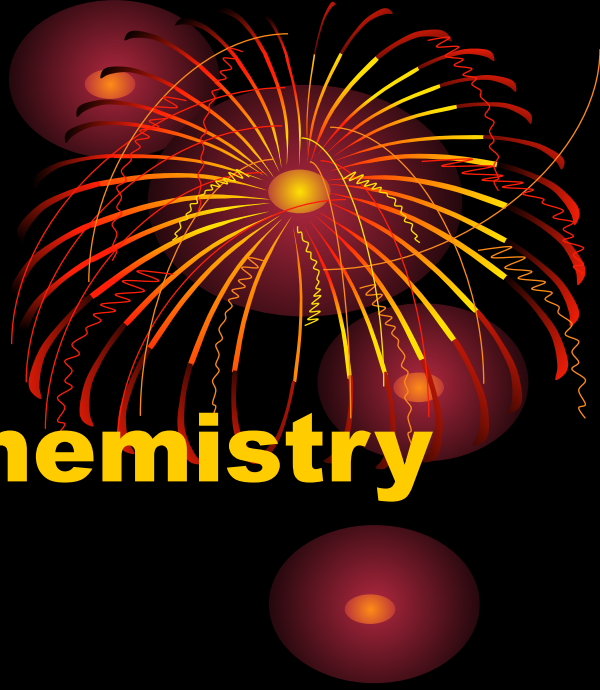
# The Chemistry of Life



# Learning Target

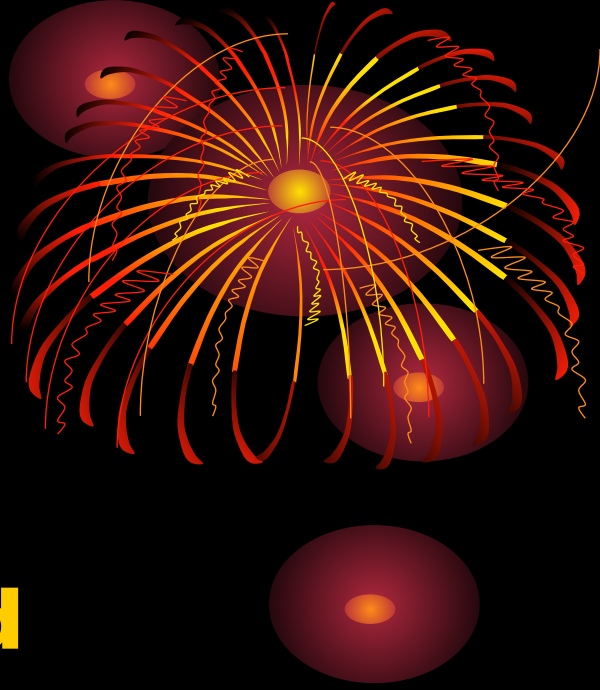


- I can review basic chemistry properties and characteristics:
  - Atoms
  - Subatomic particles
  - Ions
  - Chemical bonding
  - Water

# The Nature of Matter

- An atom is the basic unit of matter.
- Protons and neutrons are in the nucleus
- Electrons surround the nucleus

# Atoms



- Protons are + charged
- Electrons are – charged
- Neutrons have 0 charge

- Have equal numbers of protons and electrons

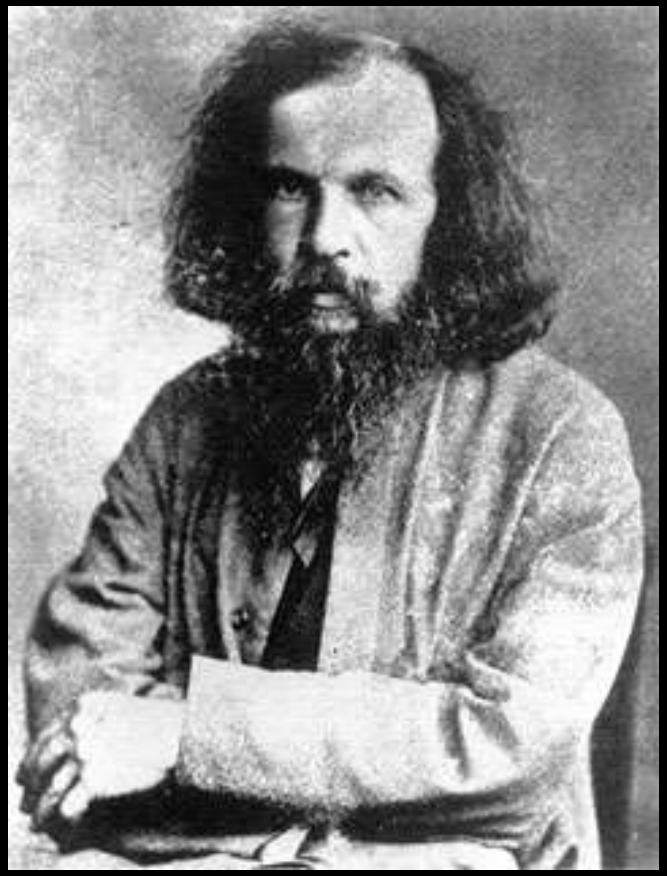
# Elements

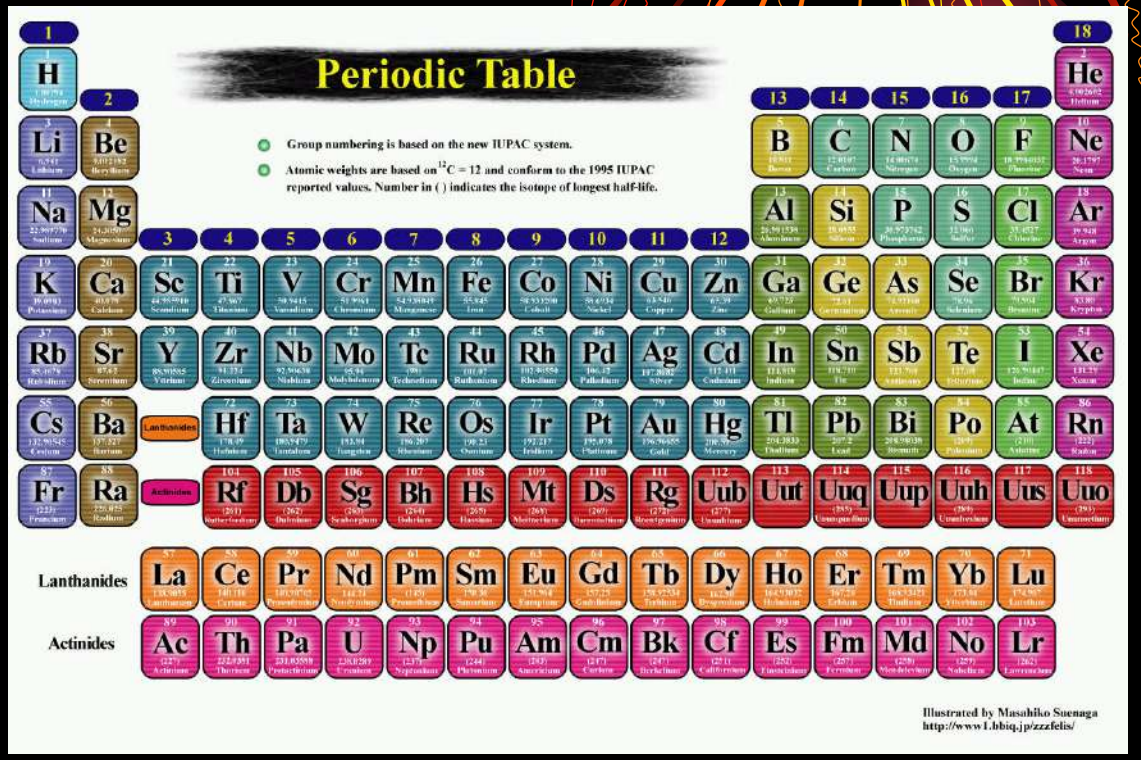
- A pure substance that is made of only one type of atom
- Over 100 are known
- 90 or so are natural
- About 24 are found in living organisms

# Elements

- Represented by a one or two letter symbol
  - H is hydrogen
  - Na is sodium
- All elements are arranged on the Periodic Table of Elements

# I am Dmitri Mendeleev!



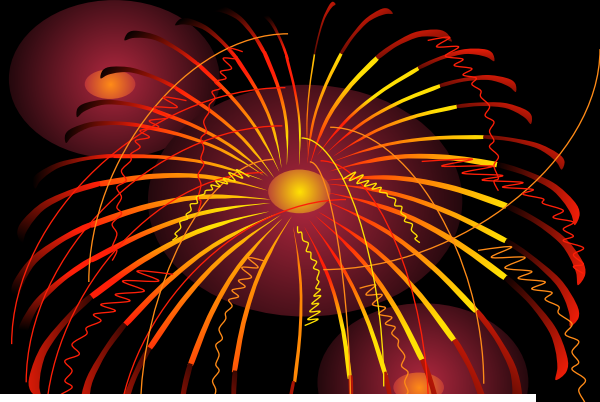


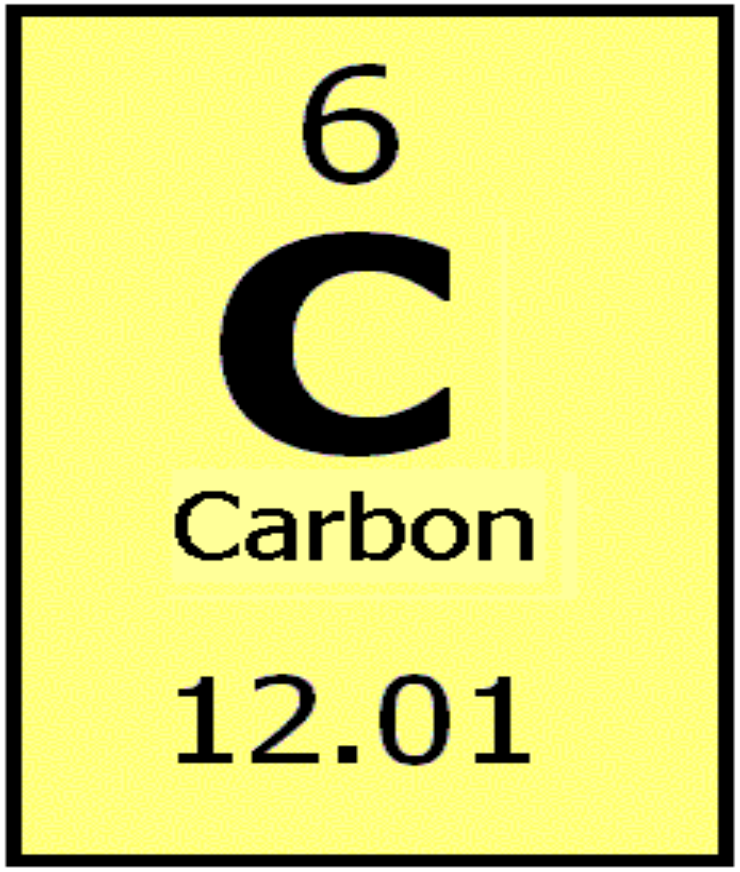

# I made the PERIODIC TABLE !

# What is the PERIODIC TABLE?

- Shows all known elements in the universe.
- Organizes the elements by chemical properties.

# How do you read the PERIODIC TABLE?





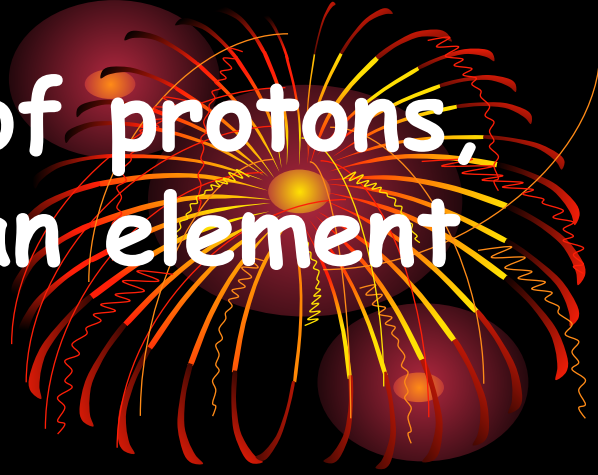

— Atomic number

— Symbol

— Name

— Atomic Weight

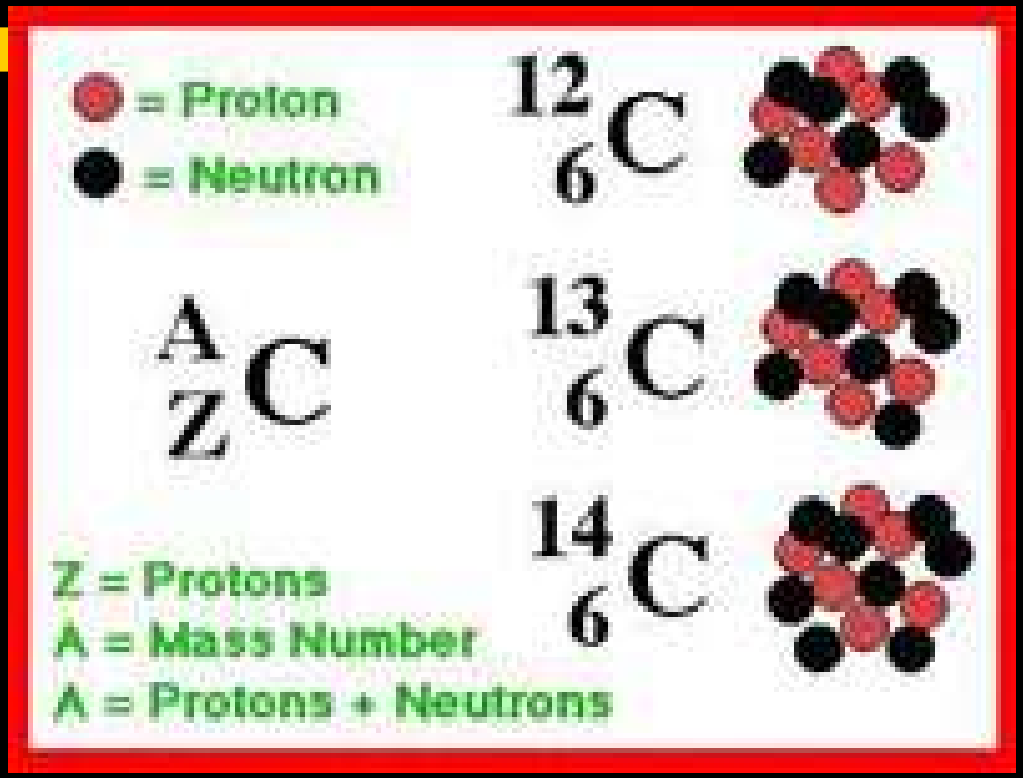
How do I find the number of protons, electrons, and neutrons in an element using the periodic table?



- # of PROTONS = ATOMIC NUMBER
- # of ELECTRONS = ATOMIC NUMBER
- # of NEUTRONS = ATOMIC WEIGHT _ ATOMIC NUMBER

# Isotopes

- Atoms of the same element with different numbers of neutr



# Isotopes

- Some are radioactive
- The nuclei are unstable and break down at a constant rate
- Carbon dating
- Medical procedures

# Chemical Compounds

- A substance formed by the chemical combination of two or more elements
  - $H_2O$
  - NaCl
- Physical and chemical properties of the compound are very different from the individual elements


# Chemical Bonds

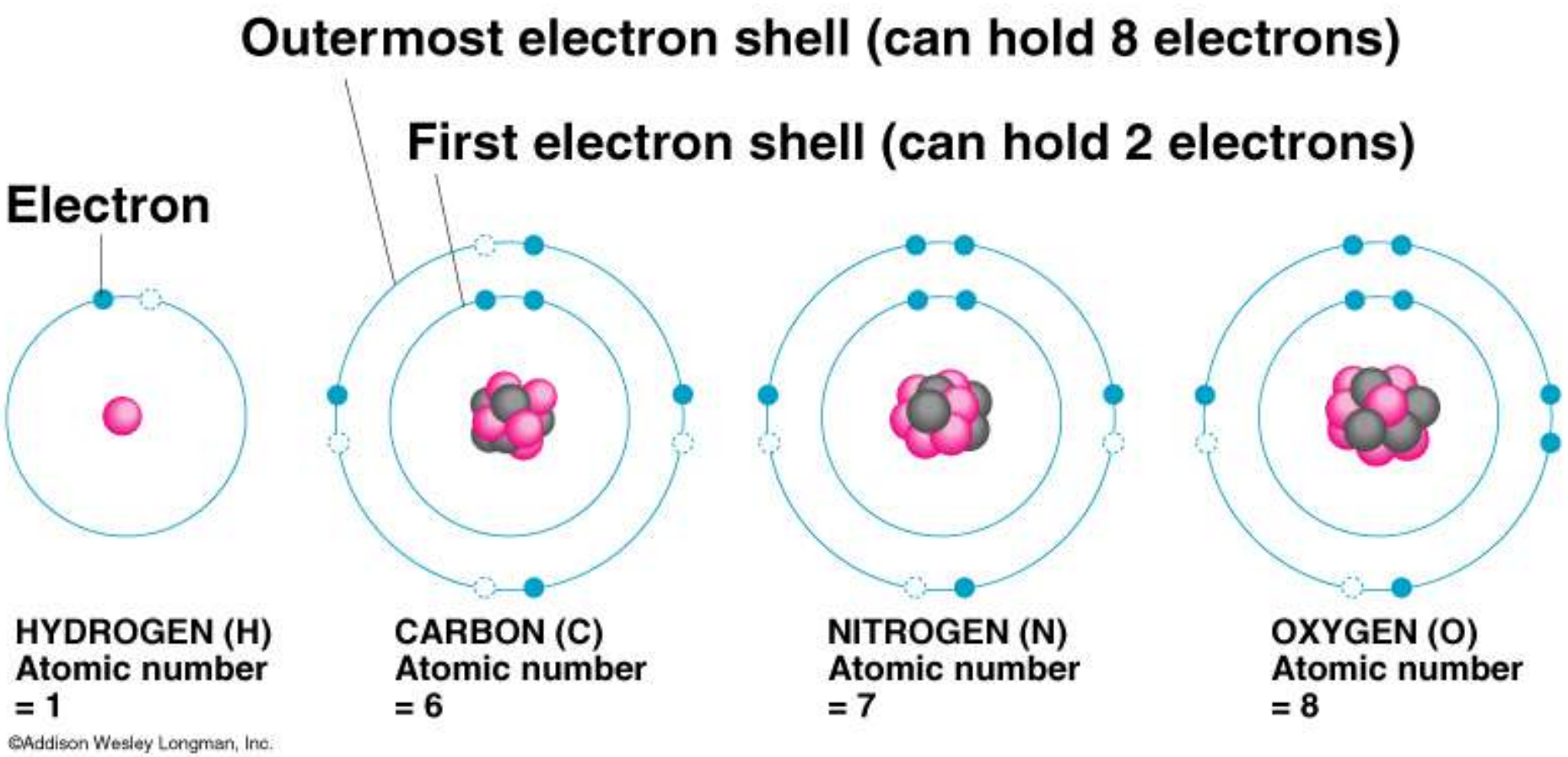
# Electron Shells

**Electrons vary in the amount of energy they possess, and they occur at certain energy levels or electron shells.**

**Electron shells determine how an atom behaves when it encounters other atoms**

# Electrons are placed in shells according to rules:

**The 1st shell can hold up to two electrons, and each shell thereafter can hold up to 8 electrons.**

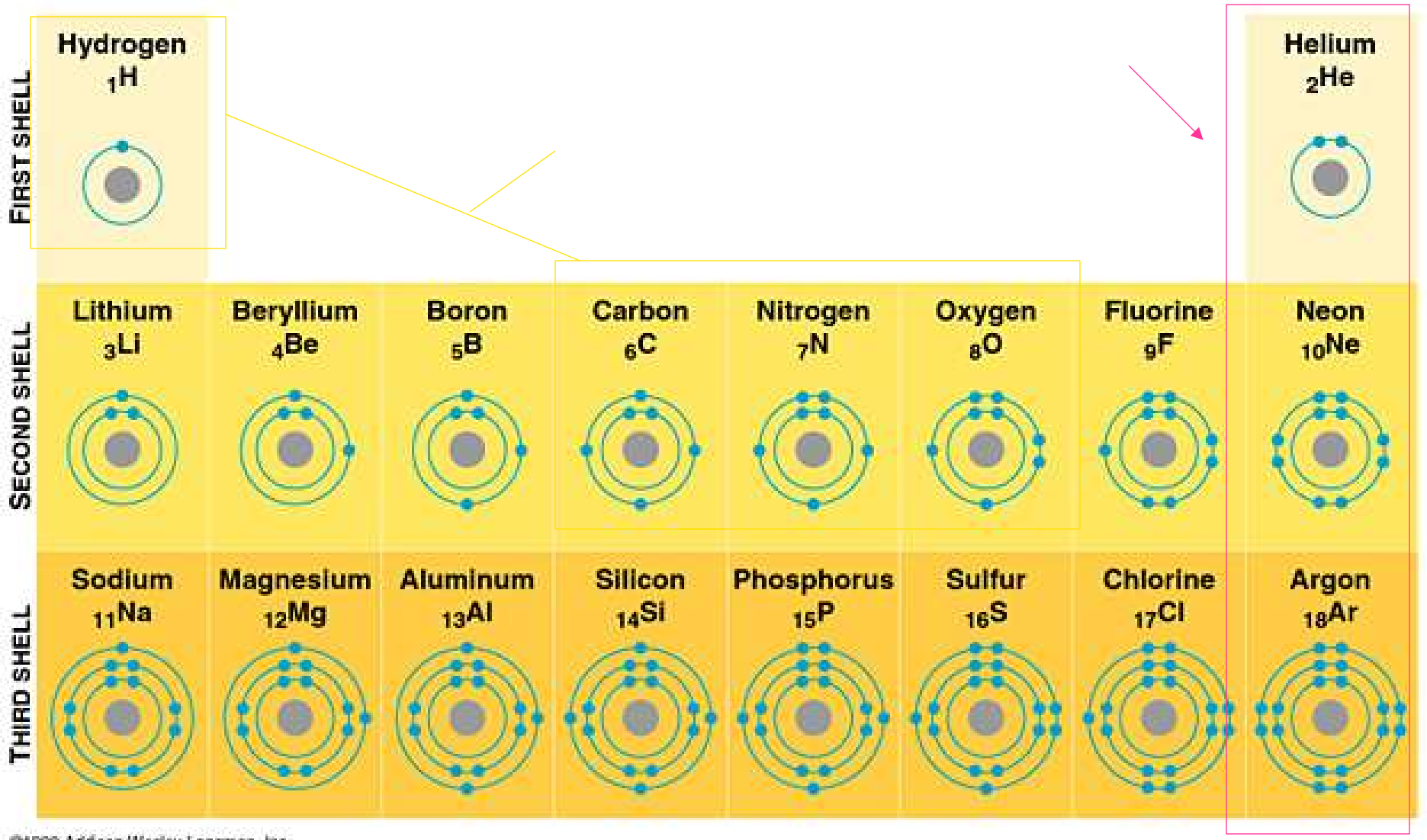



Octet Rule = atoms tend to gain, lose or share electrons so as to have 8 electrons

C would like to Gain 4 electrons

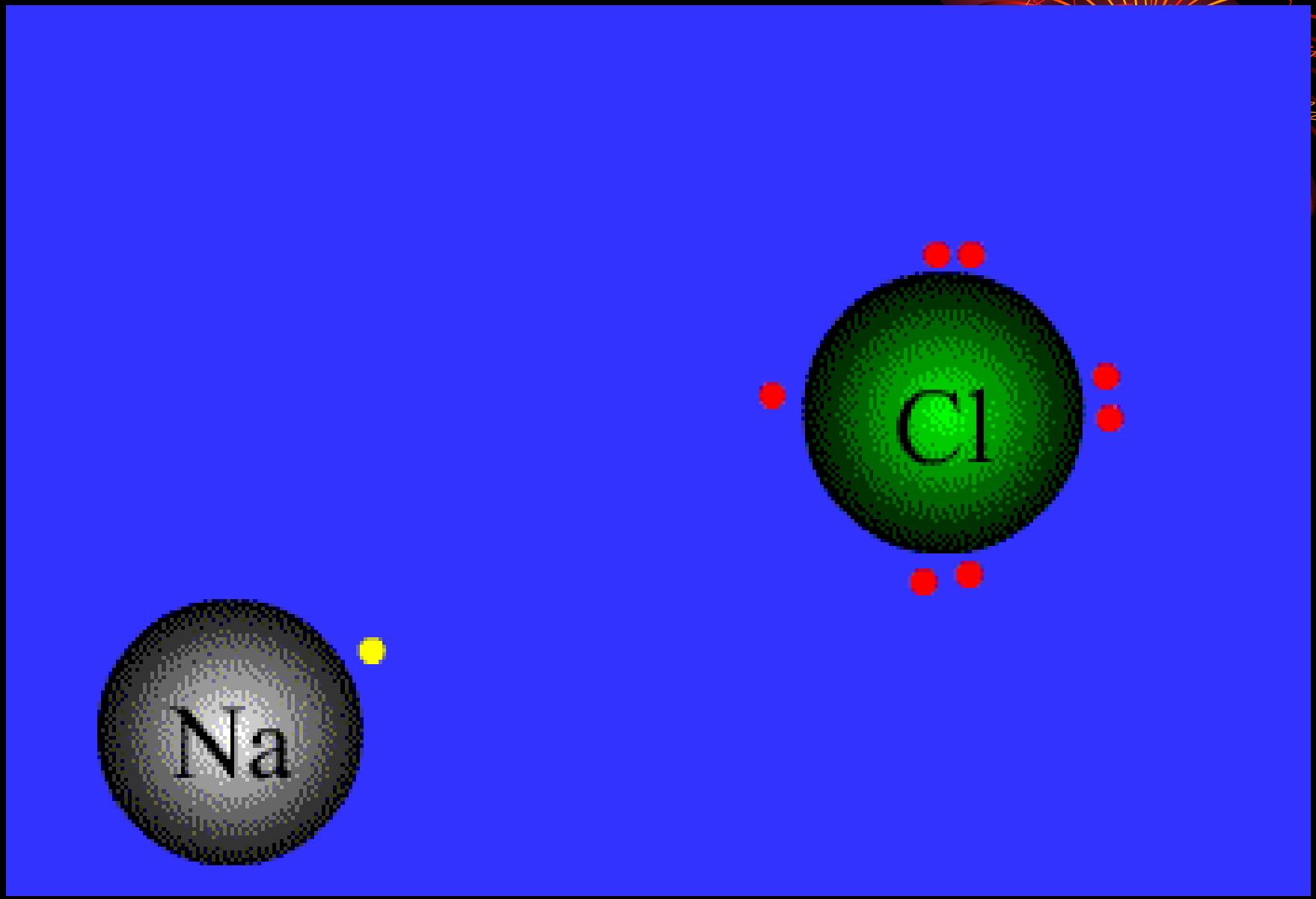
N would like to Gain 3 electrons

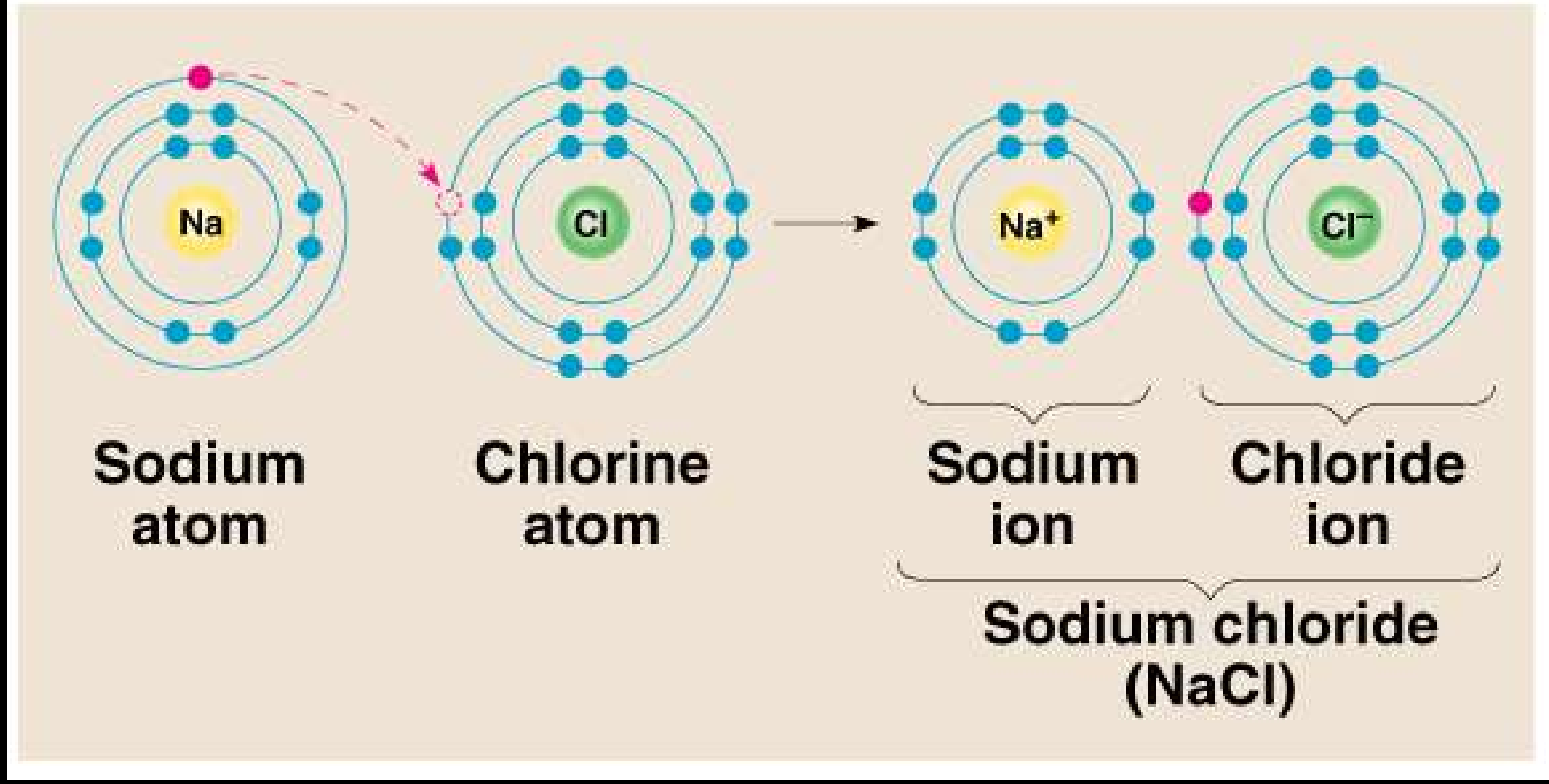
O would like to Gain 2 electrons



# IONIC BOND

**bond formed between two ions by the *transfer* of electrons**


Cl
Na



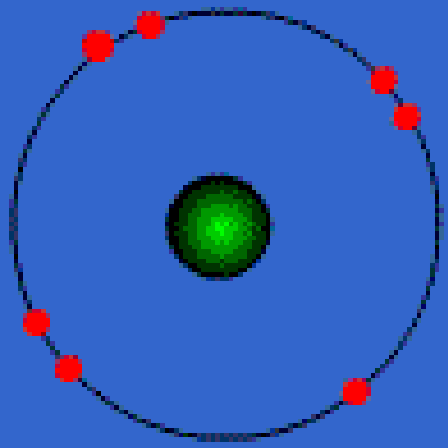

1). Ionic bond – electron from Na is transferred to Cl, this causes a charge imbalance in each atom. The Na becomes (Na+) and the Cl becomes (Cl-), charged particles or ions.

# COVALENT BOND

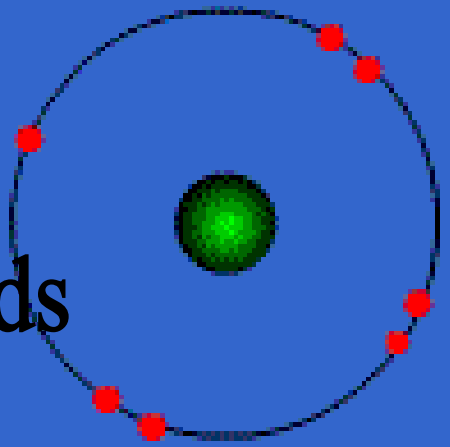
**bond formed by the *sharing* of electrons**

# Covalent Bond

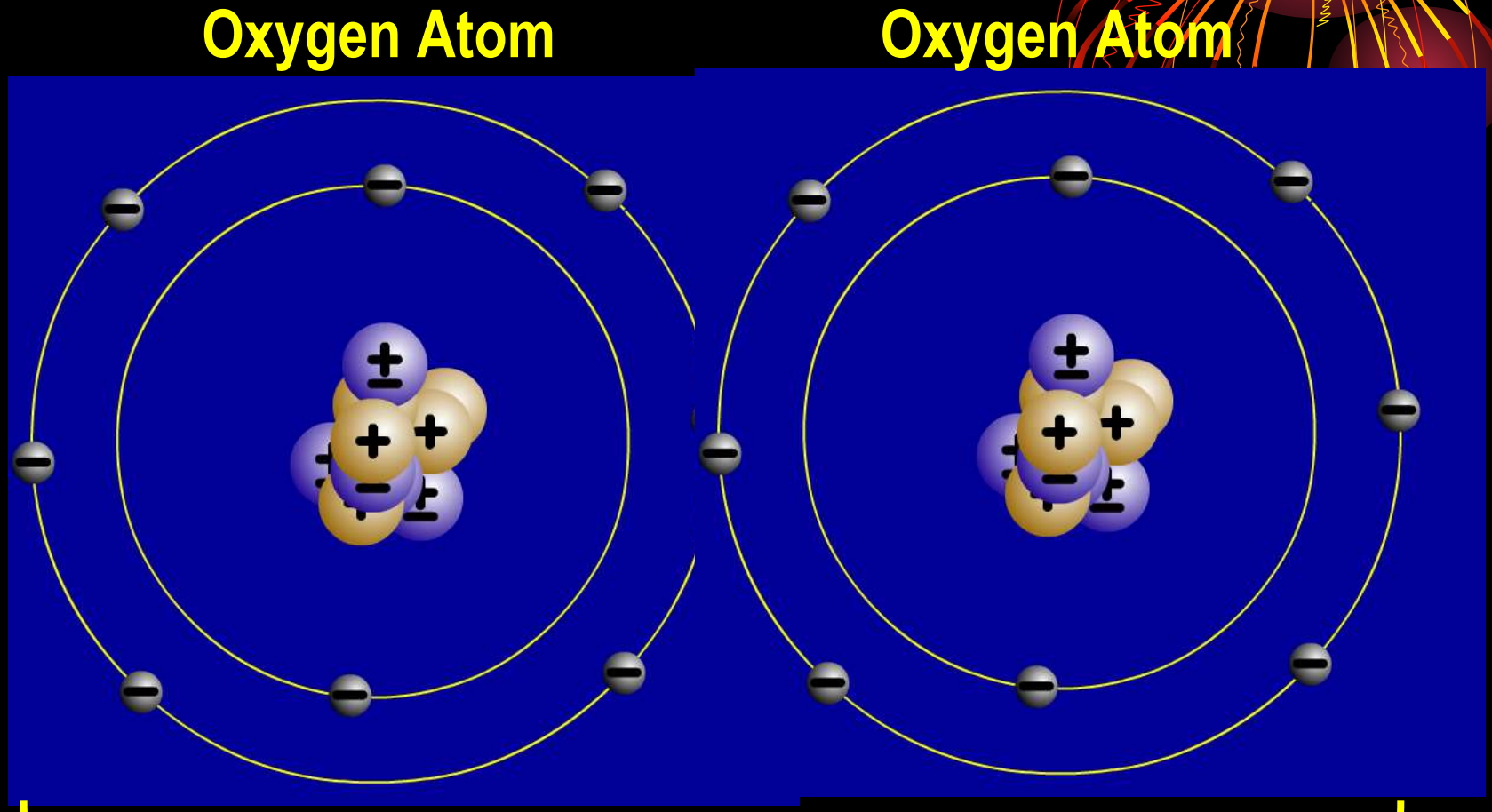
- Between nonmetallic elements of similar electronegativity.
- Formed by sharing electron pairs
- Examples; $O_2$, $CO_2$, $C_2H_6$, $H_2O$, SiC

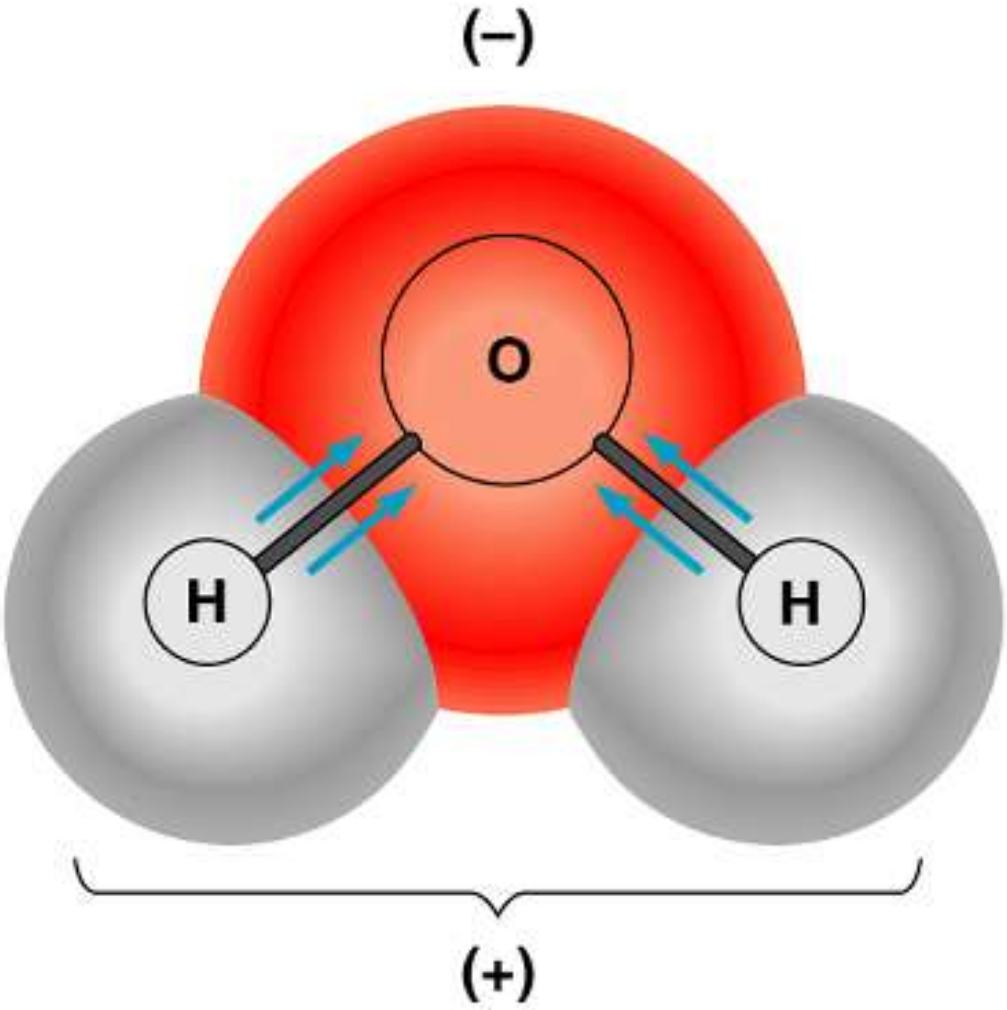


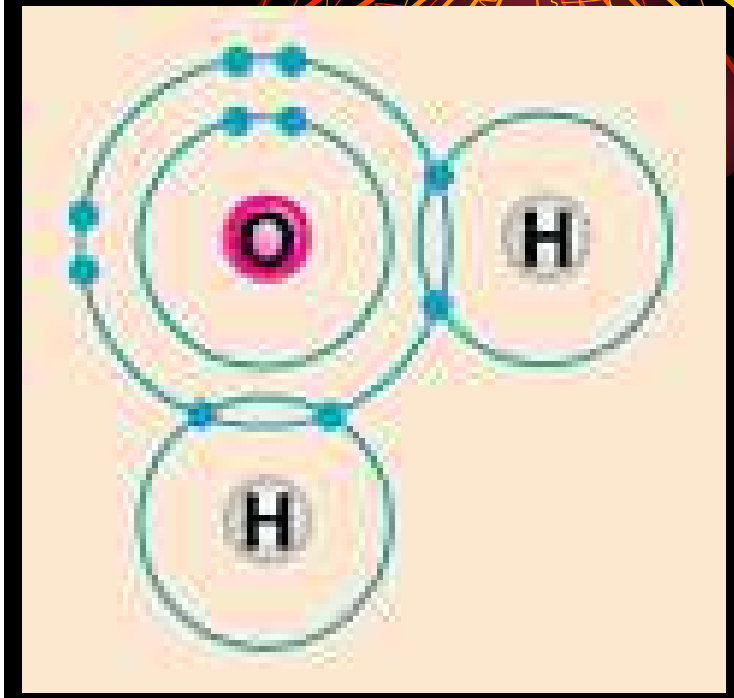
# Covalent Bonds



## 2. Covalent bonds- Two atoms share one or more pairs of outer-shell electrons.





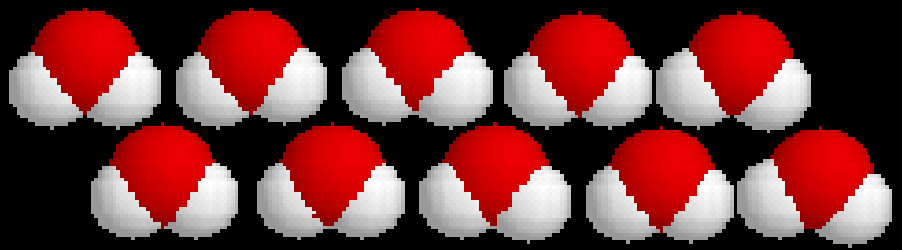



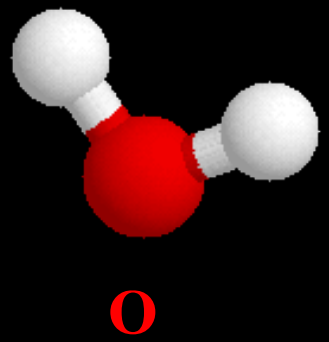

- water is a *polar molecule* because oxygen is more electronegative than hydrogen, and therefore electrons are pulled closer to oxygen.

# The Extraordinary Properties of Water

# Water

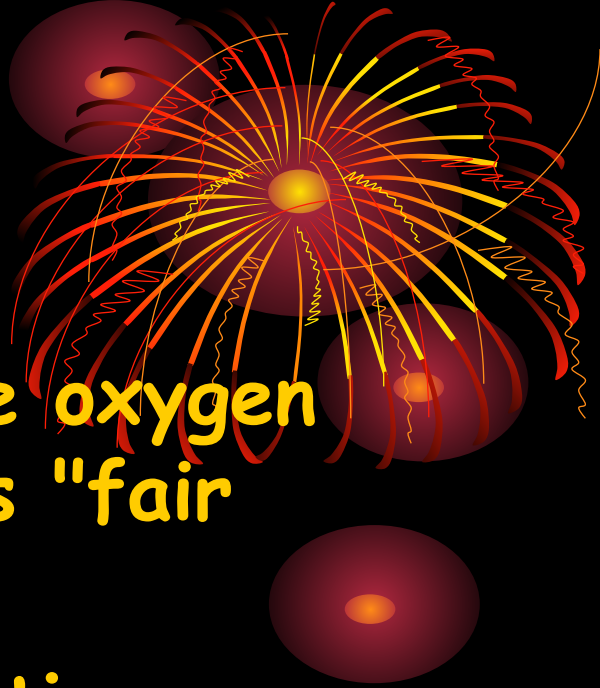
⑩A water molecule ($H_2O$), is made up of three atoms --- one oxygen and two hydrogen.





O

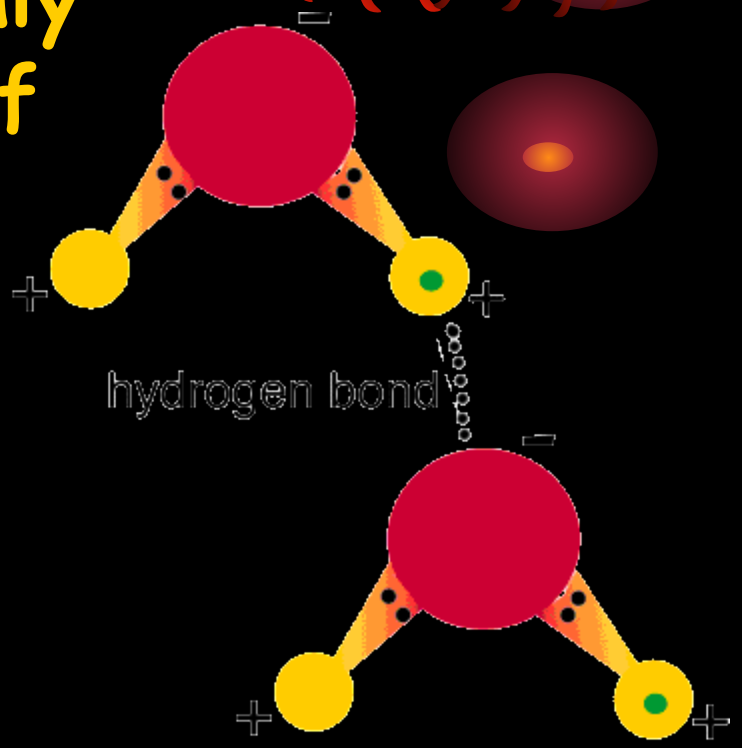
# Water is Polar



- In each water molecule, the oxygen atom attracts more than its "fair share" of electrons
- The oxygen end “acts” negative
- The hydrogen end “acts” positive
- Causes the water to be POLAR
- However, Water is neutral (equal number of e- and p+) --- Zero Net Charge

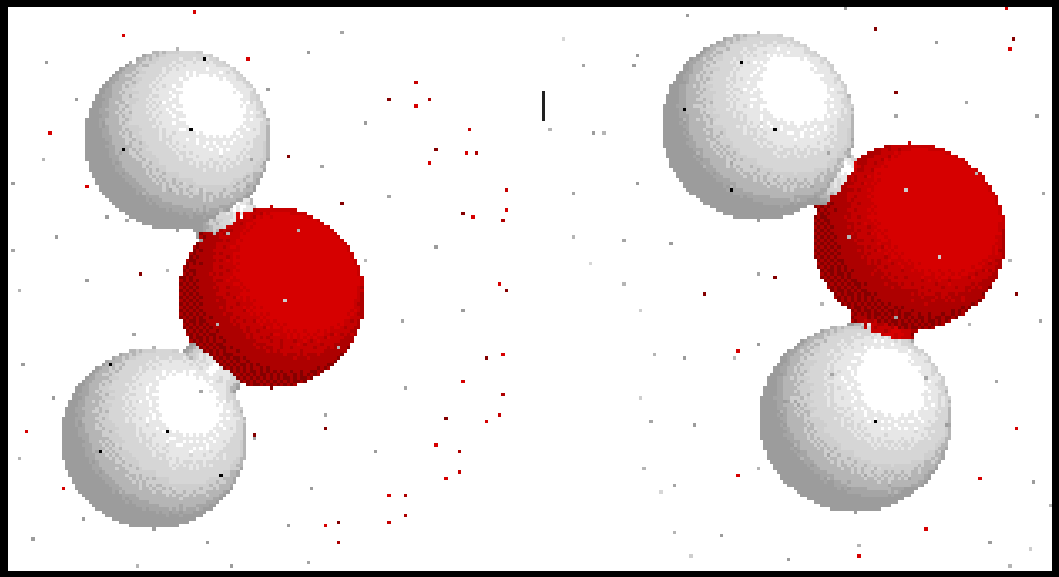
# Hydrogen Bonds Exist Between Water Molecules

- Formed between a highly Electronegative atom of a polar molecule and a Hydrogen
- One hydrogen bond is weak but many hydrogen bonds are strong

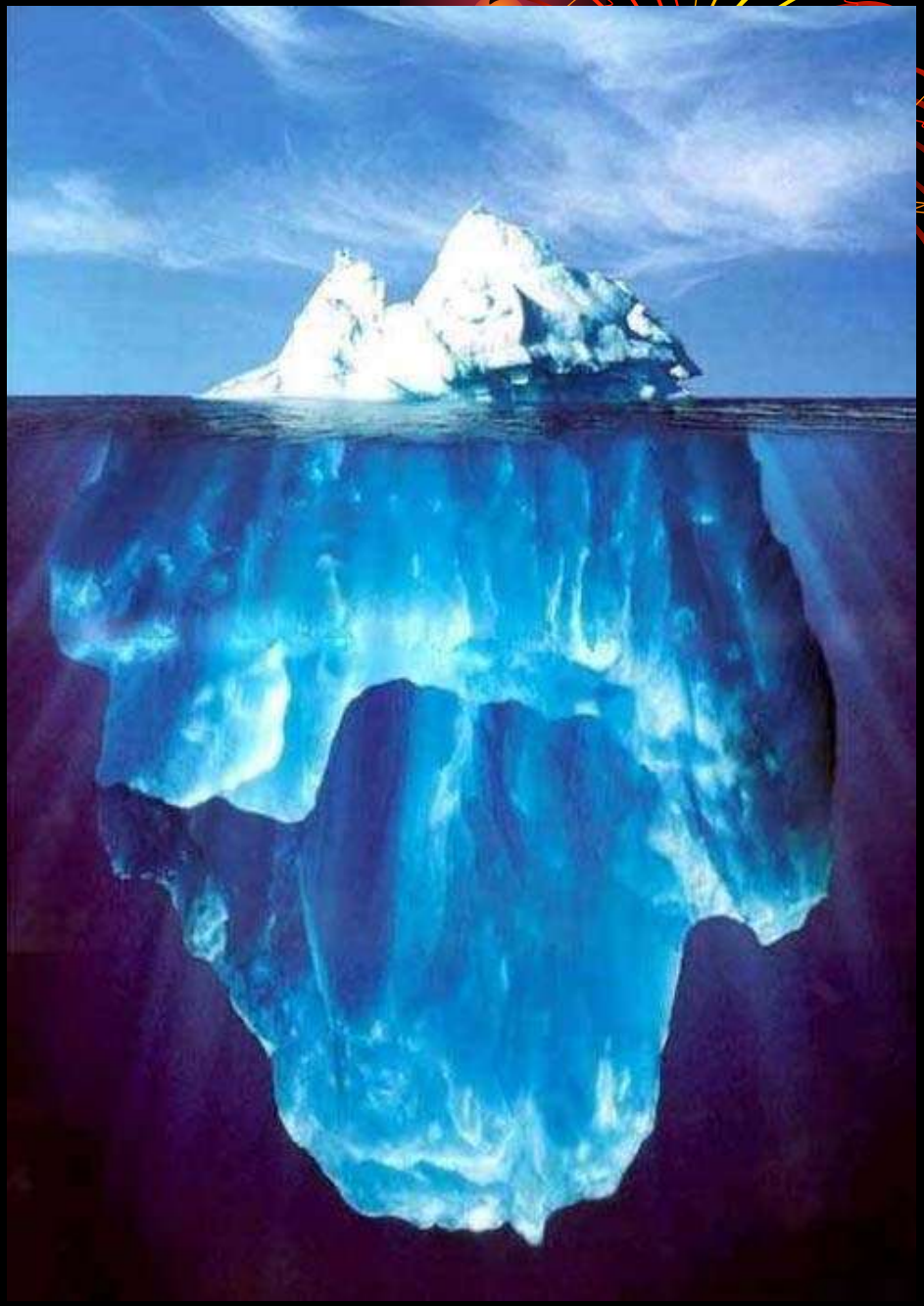


# Interaction Between Water Molecules

Negative Oxygen end of one water molecule is attracted to the Positive Hydrogen end of another water molecule to form a HYDROGEN BOND



# What are the Properties of Water?

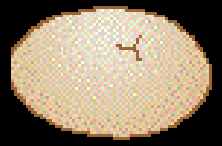


# Properties of Water

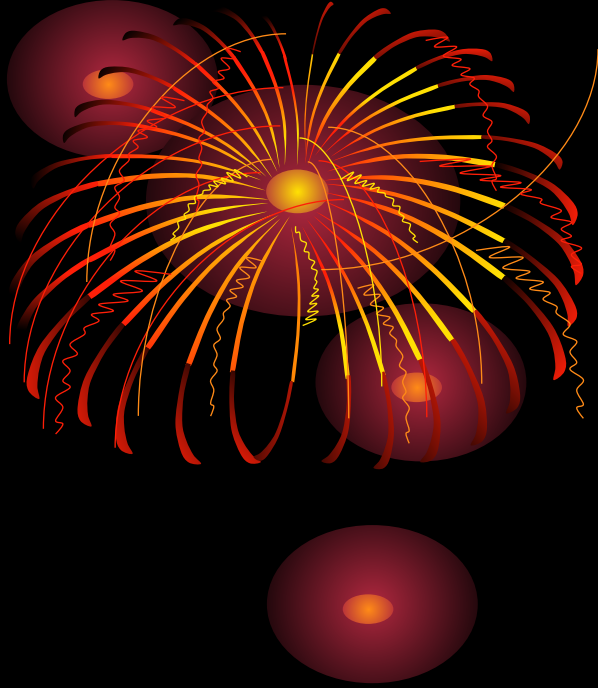
- At sea level, pure water boils at 100 °C and freezes at 0 °C

- The boiling temperature of water decreases at higher elevations (lower atmospheric pressure).

- For this reason, an egg will take longer to boil at higher altitudes

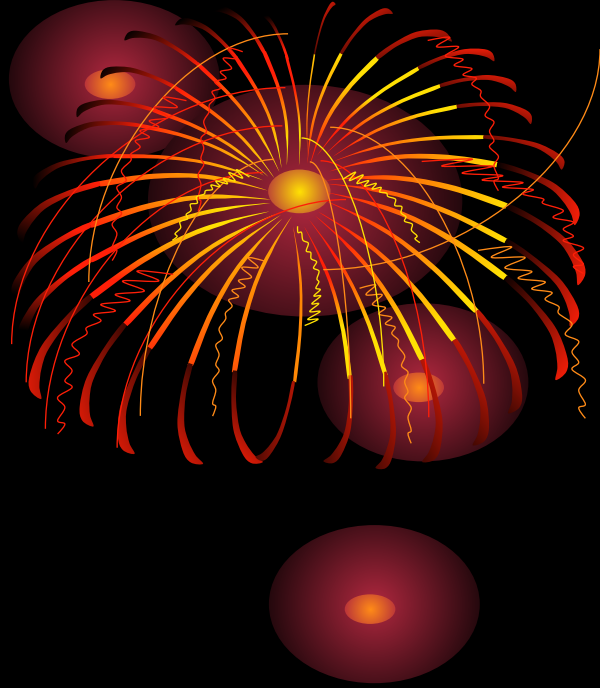


# Properties of Water



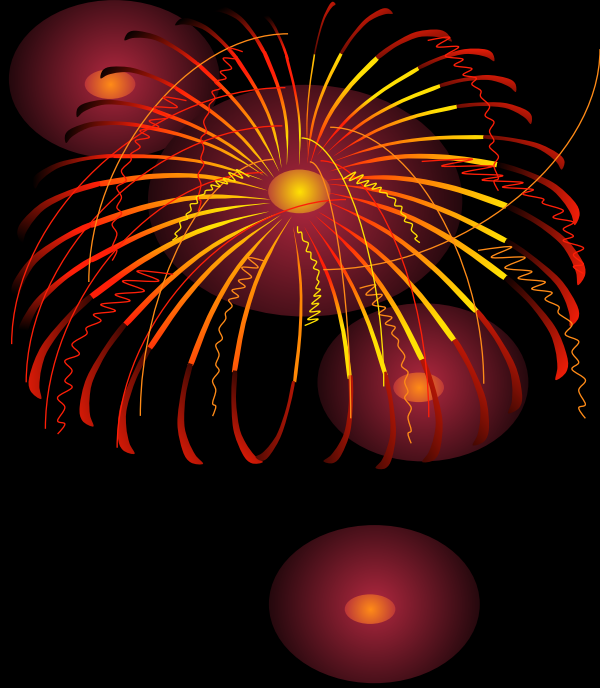
- Cohesion

# Properties of Water



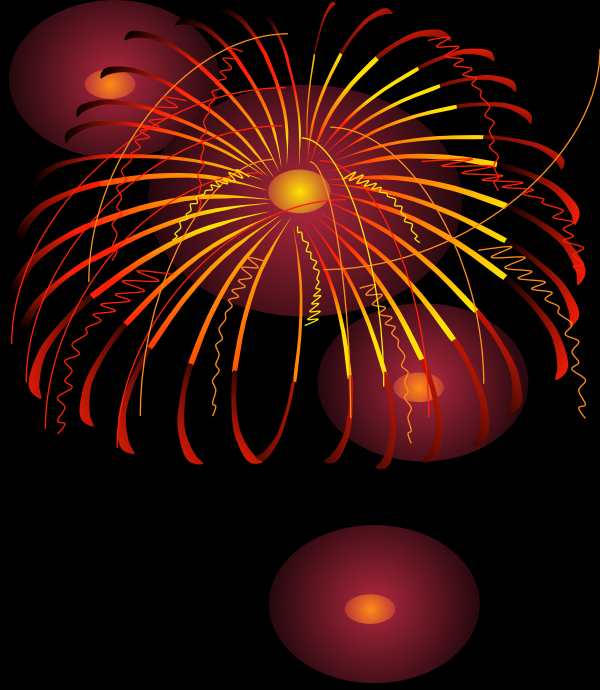
- Cohesion
- Adhesion

# Properties of Water



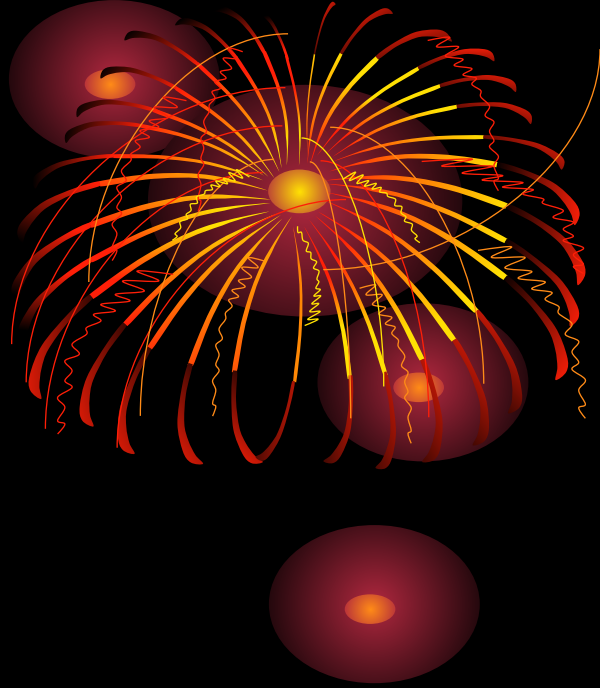
- Cohesion
- Adhesion
- High Specific Heat

# Properties of Water



- Cohesion
- Adhesion
- High Specific Heat
- High Heat of Vaporization

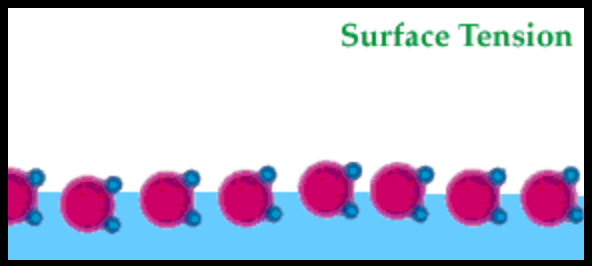
# Properties of Water



- Cohesion
- Adhesion
- High Specific Heat
- High Heat of Vaporization
- Less Dense as a Solid

# Cohesion

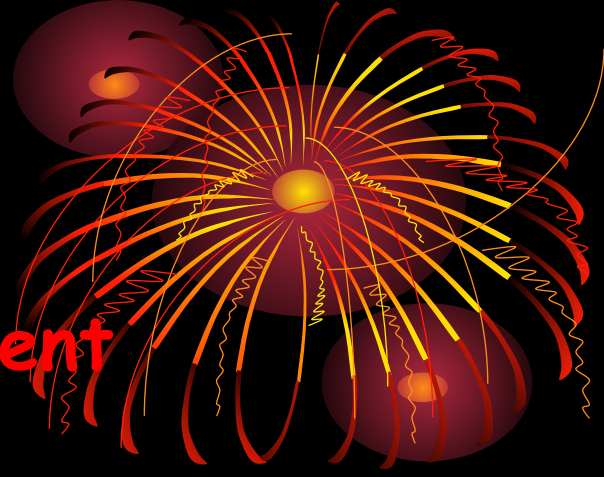
- Attraction between particles of the same substance ( why water is attracted to itself)
- Results in Surface tension (a measure of the strength of water's surface)
- Produces a surface film on water that allows insects to walk on the surface of water



# Cohesion …

Helps insects walk across water

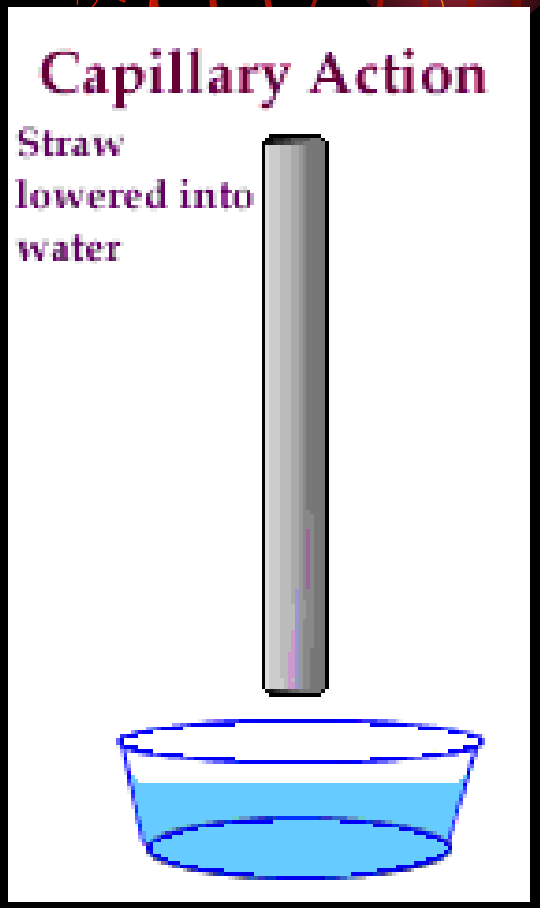
# Adhesion



- Attraction between two different substances
- Water will make hydrogen bonds with other surfaces such as glass, soil, plant tissues, and cotton.
- Capillary action-water molecules will "tow" each other along when in a thin glass tube.
- Example: transpiration process which plants and trees remove water from the soil, and paper towels soak up water.

# Adhesion Causes Capillary Action

Which gives water the ability to "climb" structures



# Adhesion Also Causes Water to …


Form spheres & hold onto plant leaves

Attach to a silken spider web

# High Specific Heat

- **Amount of heat** needed to raise or lower **1g** of a substance **1° C**

- Water **resists temperature change** both for heating and cooling.

- Water can absorb or release large amounts of heat energy with little change in actual temperature.

# High Heat of Vaporization

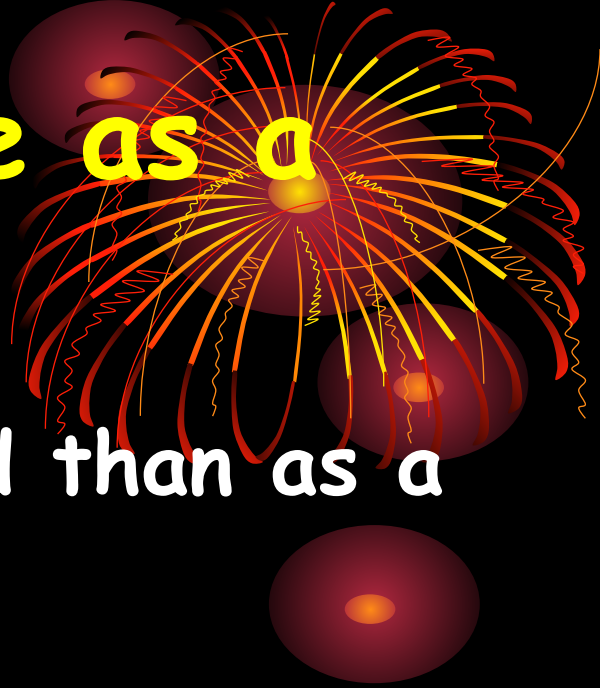
- Amount of energy to convert 1g or a substance from a liquid to a gas
- In order for water to evaporate, hydrogen bonds must be broken
- As water evaporates it removes a lot of heat with it.

# High Heat of Vaporization

- Water's heat of vaporization is 540 cal/g.
- In order for water to **evaporate** each gram must **GAIN 540** calories (temperature doesn't change --- 100°C).
- **As water evaporates** it removes a lot of **heat** with it **(cooling effect)**

- Water vapor forms a kind of global "blanket" which helps to keep the Earth warm
- Heat radiated from the sun warmed surface of the earth is absorbed and held by the vapor

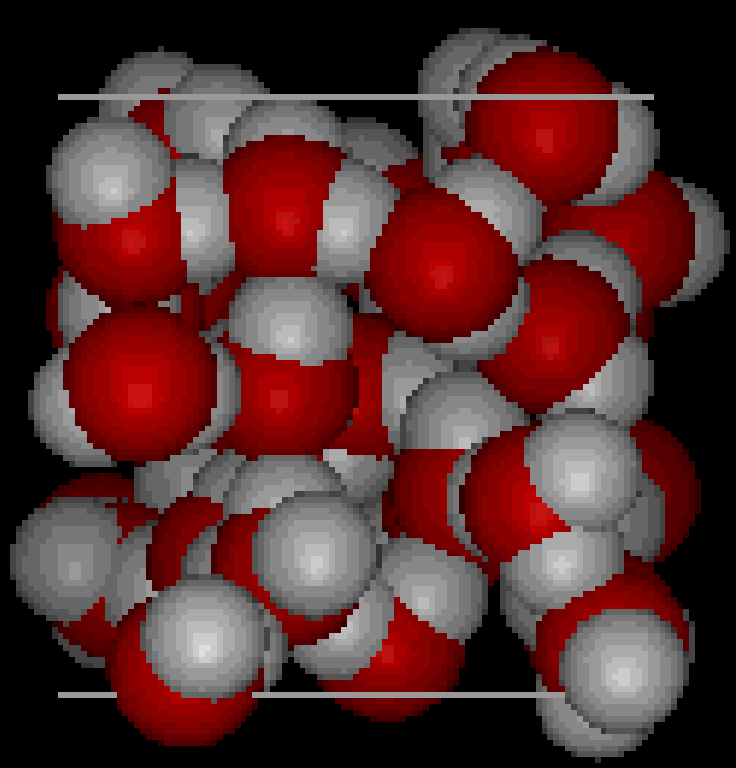
# Water is Less Dense as a Solid

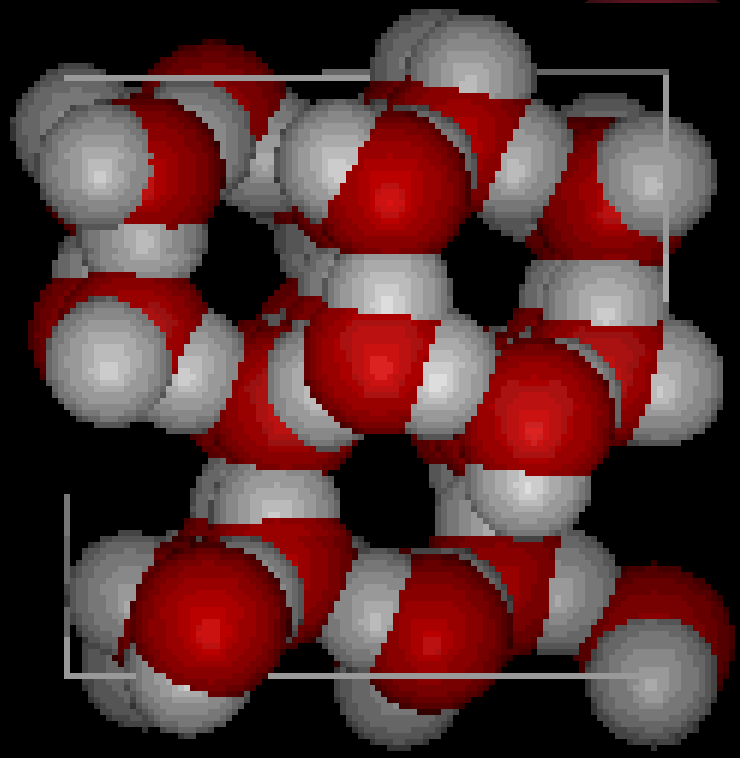


- Ice is less dense as a solid than as a liquid (ice floats)
- Liquid water has hydrogen bonds that are constantly being broken and reformed.
- Frozen water forms a crystal-like lattice whereby molecules are set at fixed distances.

# Water is Less Dense as a Solid

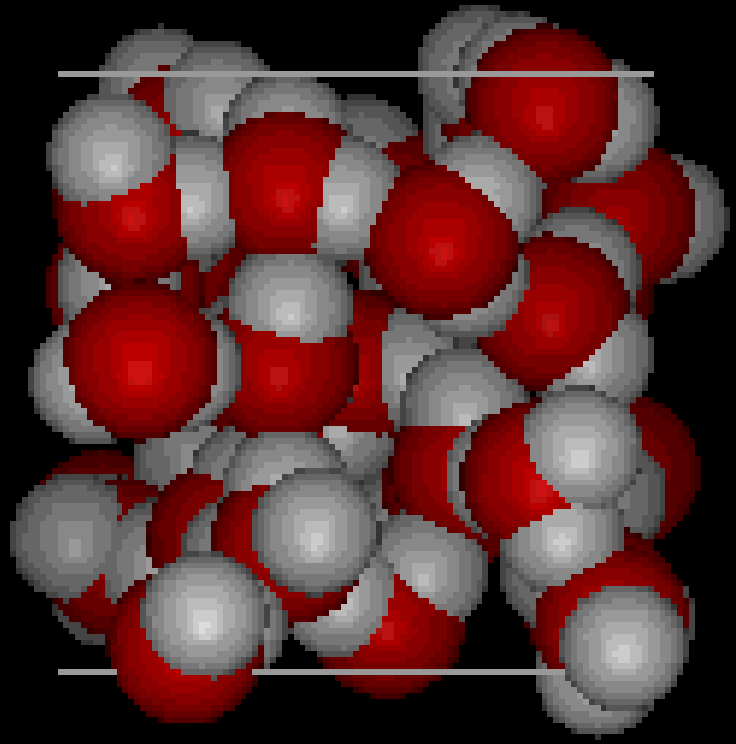
- Which is ice and which is water?



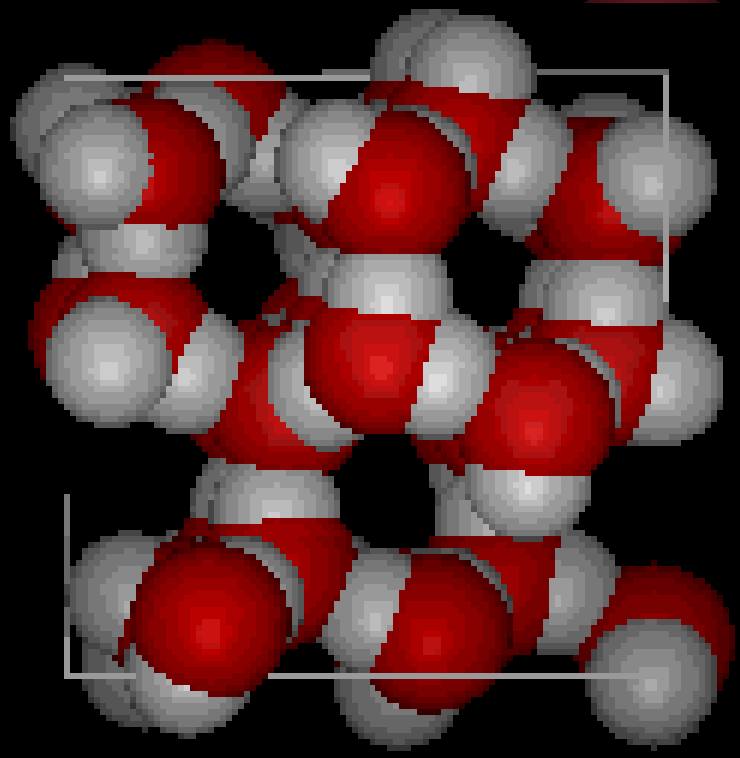


# Water is Less Dense as a Solid

Water



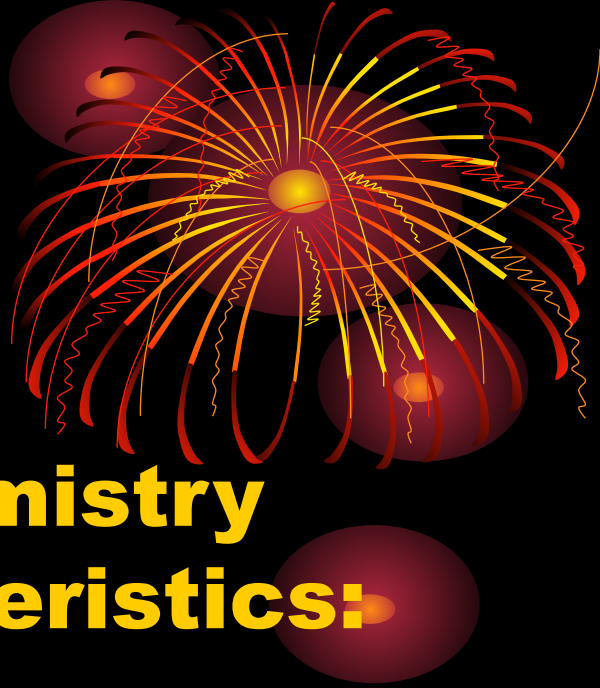
Ice



# Homeostasis

- Ability to maintain a steady state despite changing conditions
- Water is important to this process because:
  a. Makes a good insulator
  b. Resists temperature change
  c. Universal solvent
  d. Coolant
  e. Ice protects against temperature extremes insulates frozen lakes)

# Learning Target



- I can review basic chemistry properties and characteristics:
  - Atoms
  - Subatomic particles
  - Ions
  - Chemical bonding
  - Water
  - pH scale

# Learning Targets

⑩I can explain the fundamental principles of the pH scale and the consequences of having the different concentrations of hydrogen and hydroxide ions.

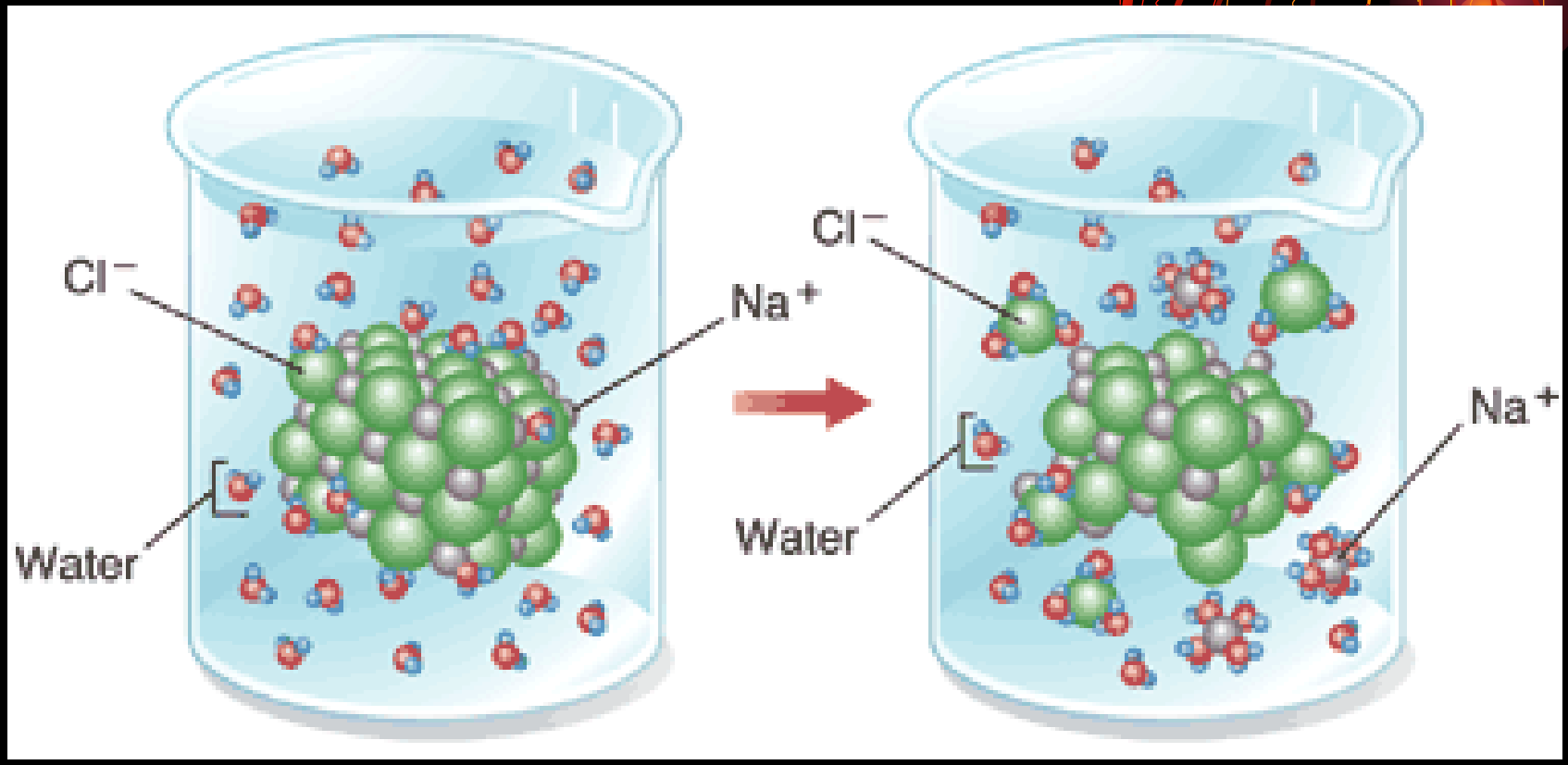
# Solutions & Suspensions

- Water is usually part of a **mixture.**
- There are two types of mixtures:
  - **Solutions**
  - **Suspensions**

# Solution

- Ionic compounds disperse as ions in water
- Evenly distributed
- SOLUTE
  - Substance that is being dissolved
- SOLVENT
  - Substance into which the solute dissolves

# Solution

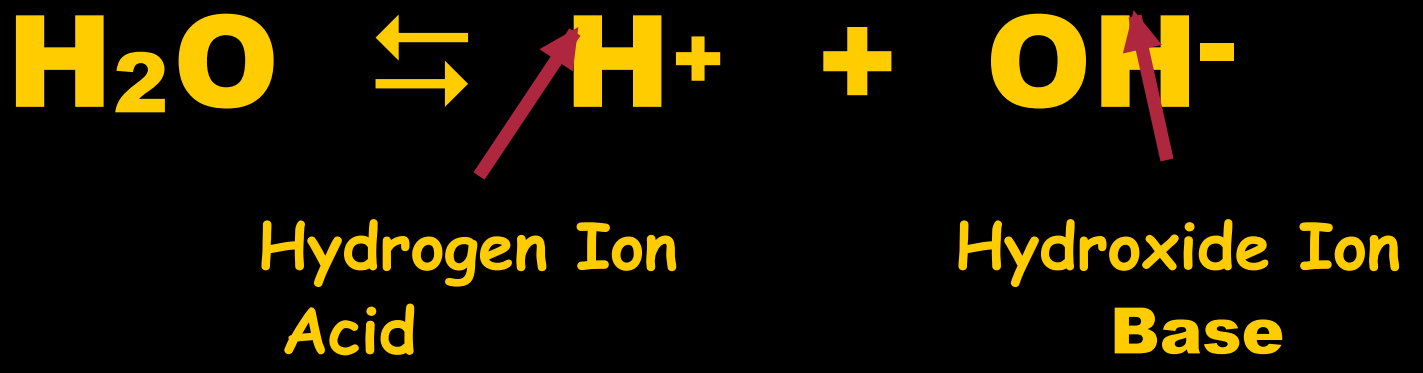


# Suspensions

- Substances that don't dissolve but separate into tiny pieces.
- Water keeps the pieces suspended so they don't settle out.

# Acids, Bases and pH

One water molecule in 550 million naturally dissociates into a Hydrogen Ion (H+) and a Hydroxide Ion (OH-)

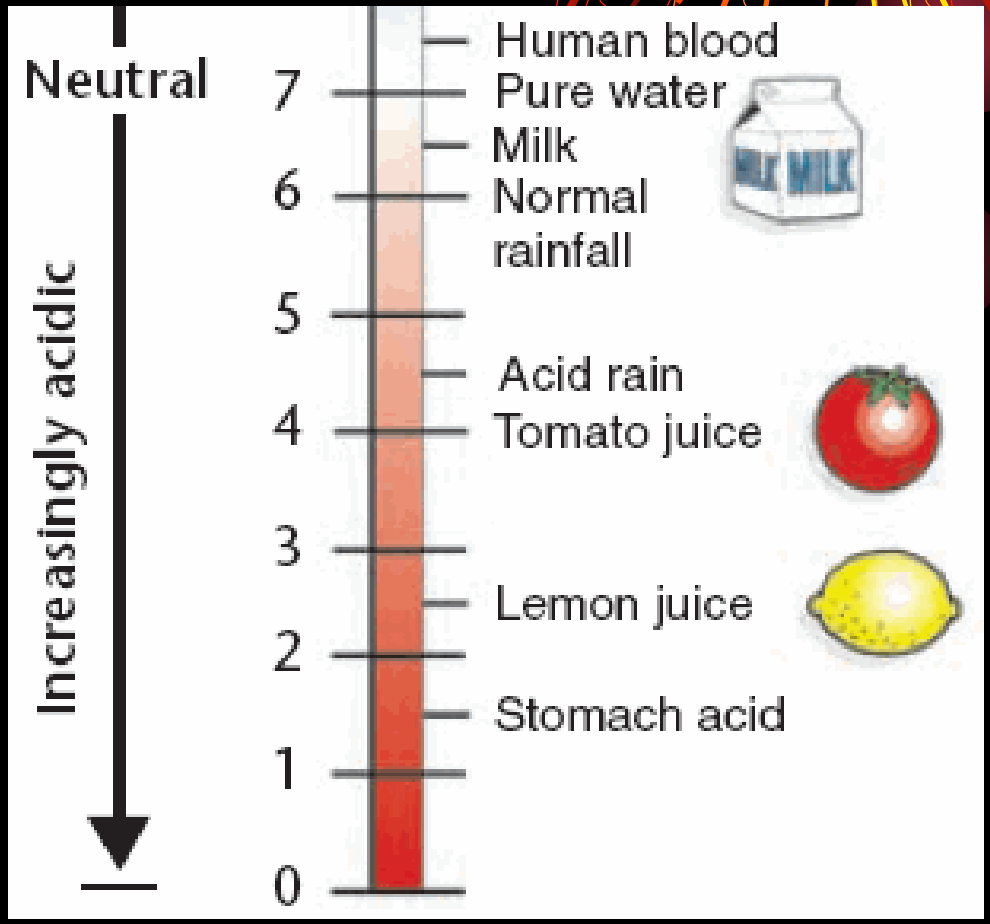


# The pH Scale

- Indicates the concentration of $H^+$ ions
- Ranges from 0 – 14
- pH of 7 is neutral
- pH 0 up to 7 is acid … $H^+$
- pH above 7 – 14 is basic… $OH^-$
- Each pH unit represents a factor of 10X change in concentration
- pH 3 is 10 x 10 x 10 (1000) stronger than a pH of 6

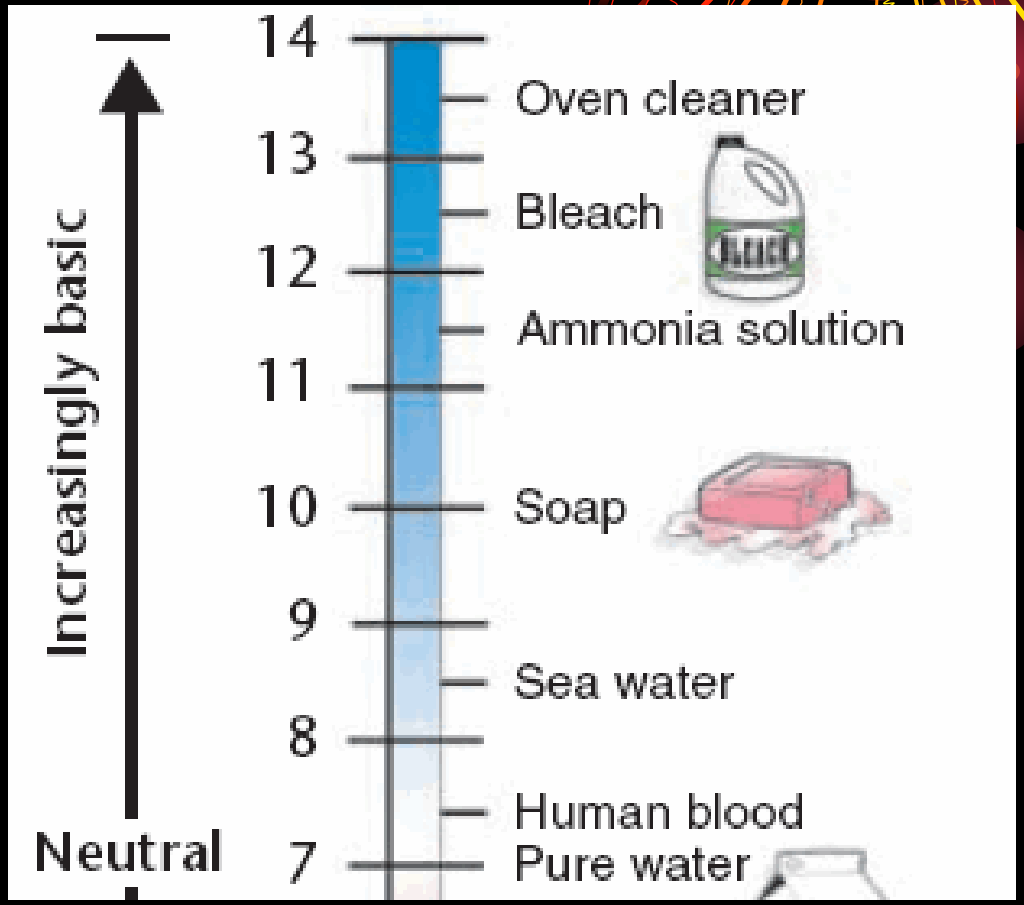
# Acids

- **Strong Acids** have a pH of **1-3**
- Produce **lots of $H^+$ ions**



# Bases

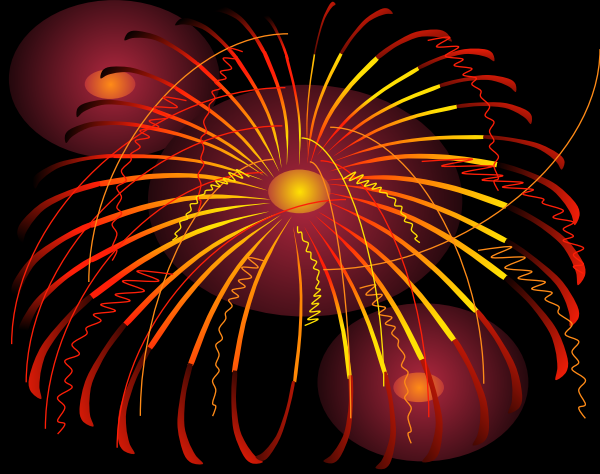
- **Strong Bases** have a pH of **11 to 14**
- Contain **lots of OH⁻ ions** and fewer H+ ions



# Buffers

- Weak acids or bases that react with strong acids or bases to prevent sharp, sudden changes in pH (neutralization).
- Produced naturally by the body to maintain homeostasis


# Learning Targets

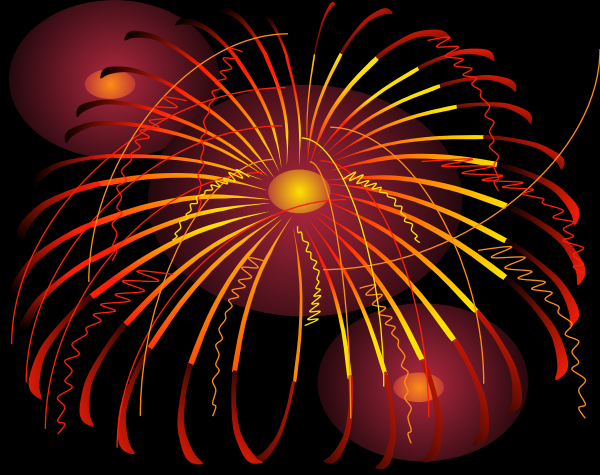


10. I can explain the fundamental principles of the pH scale and the consequences of having the different concentrations of hydrogen and hydroxide ions.

# Learning Targets

⑩ I can describe the general structure and function including common functional groups of monosaccharides, disaccharides, polysaccharides, carbohydrates, fatty acids, glycerol, lipids, amino acids, dipeptides, polypeptides, proteins and nucleic acids.

# Carbon Compounds



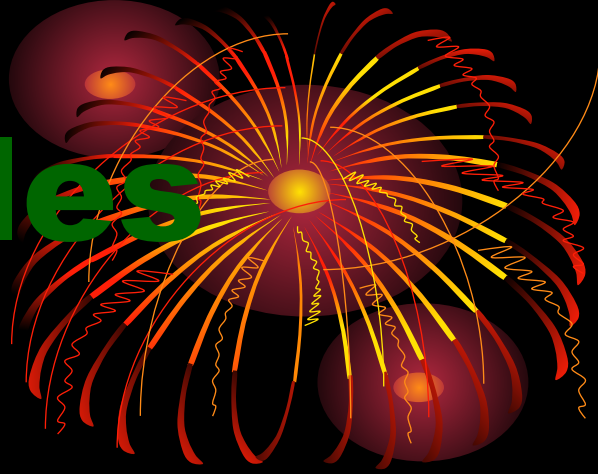
- Compounds that contain CARBON are called organic.

- Macromolecules are large organic molecules.

# Carbon (C)

- Carbon has 4 electrons in outer shell.
- Carbon can form covalent bonds with as many as 4 other atoms (elements).
- Usually with C, H, O or N.

# Macromolecules

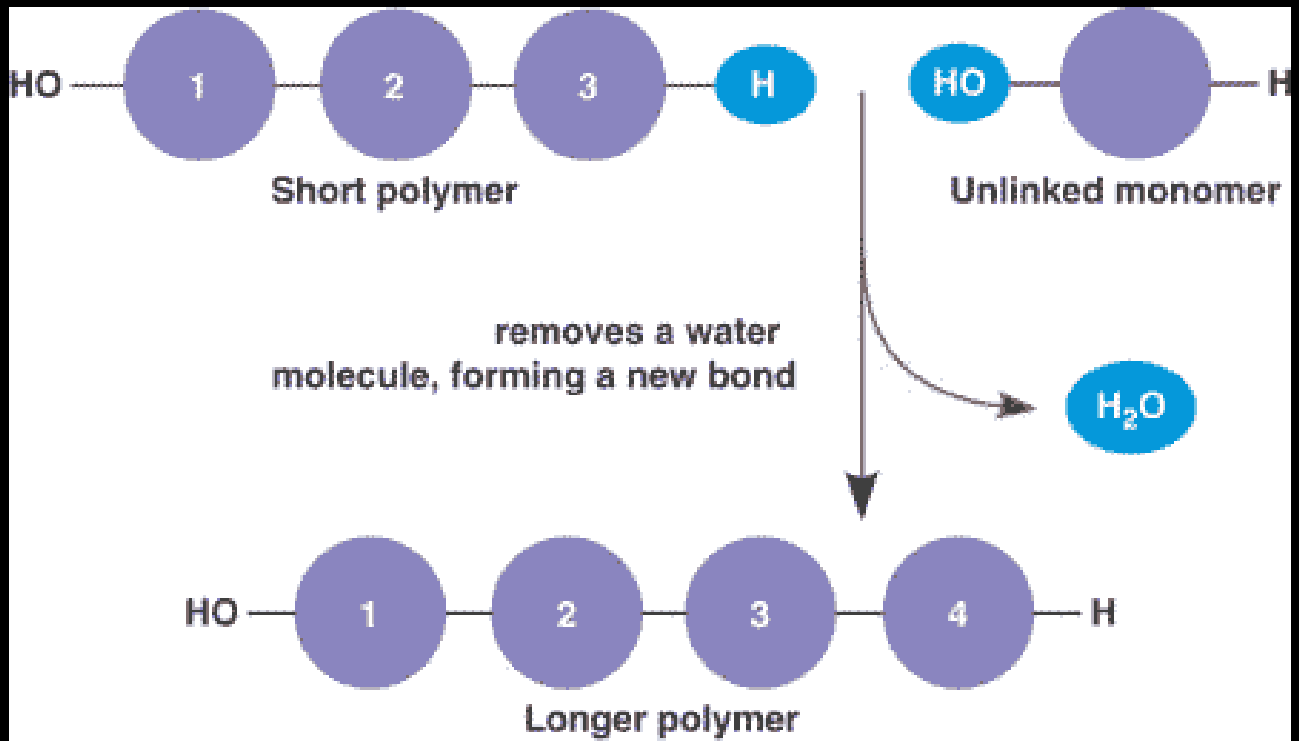


- Large organic molecules.
- Also called POLYMERS.
- Made up of smaller "building blocks" called MONOMERS.
- Examples:

1. Carbohydrates
2. Lipids
3. Proteins
4. Nucleic acids (DNA and RNA)

# How are macromolecules made?

- **Condensation (dehydration) reactions are reactions that remove a molecule of water from two monomers to make a larger polymer**



# Carbohydrates

# Carbohydrate Functions

- Provide energy for cells and organisms
- Provide structure to cells, especially plant cells

# Carbohydrates

- Small sugar molecules to large sugar molecules.

- Examples:

A. monosaccharide

B. disaccharide

C. polysaccharide

# Carbohydrates

**Monosaccharide: one sugar unit**

**Examples:** glucose ($C_6H_{12}O_6$)
fructose
galactosedeoxyribose
ribose

# Carbohydrates

Disaccharide: two sugar unit

Examples:

- Sucrose (glucose+fructose)
- Lactose (glucose+galactose)
- Maltose (glucose+glucose)

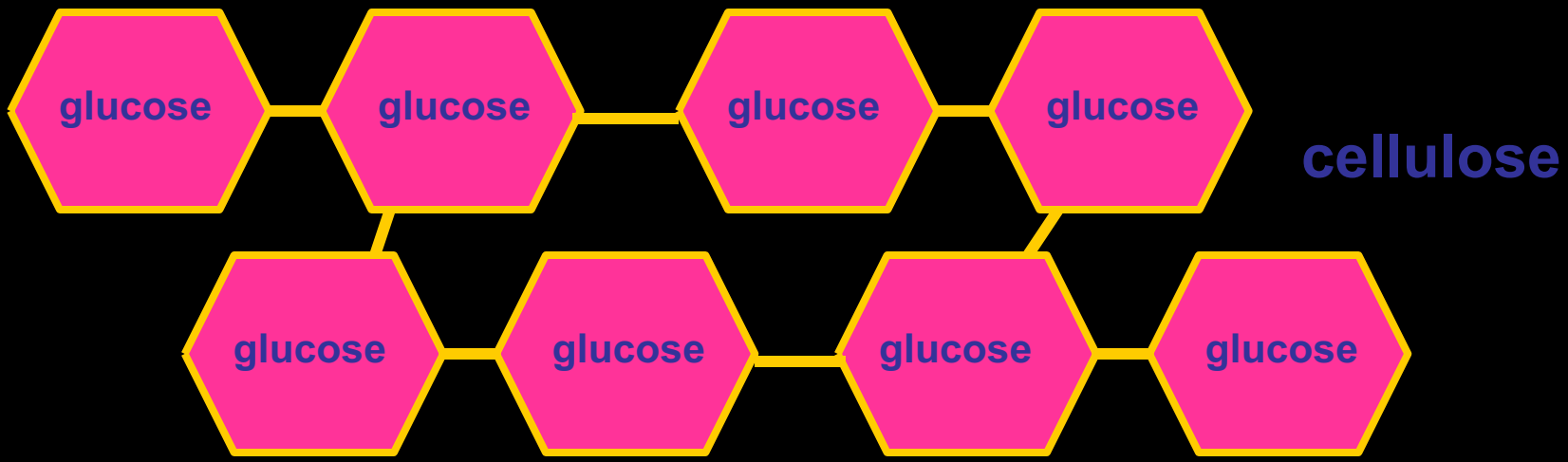
# Carbohydrates

Polysaccharide: many sugar units

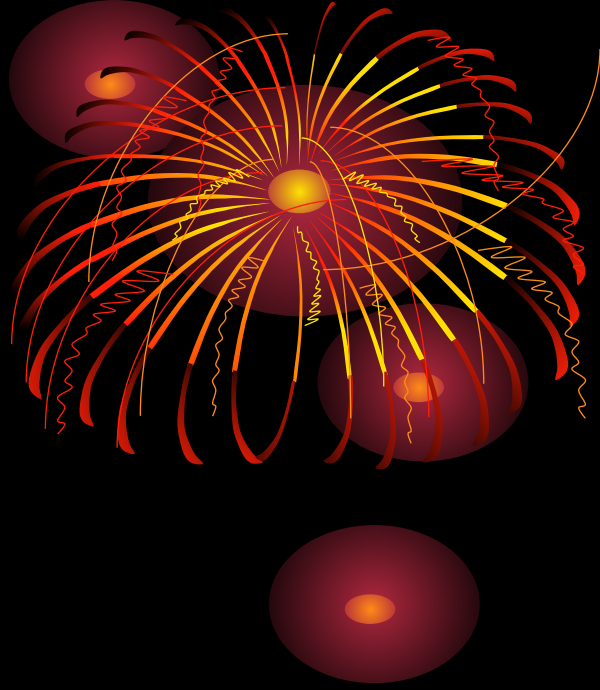
Examples: starch (bread, potatoes)

glycogen (beef muscle)

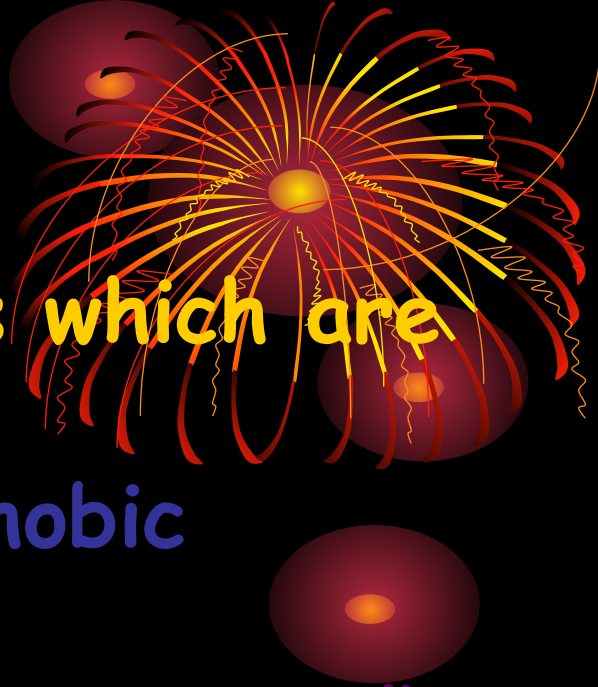
cellulose (lettuce, corn)



# Lipids



# Lipids



- General term for compounds which are not soluble in water.
- Lipids are soluble in hydrophobic solvents.
- Remember: "stores the most energy"
- Examples: 1. Fats
2. Phospholipids
3. Oils
4. Waxes
5. Steroid hormones
6. Triglycerides

# Lipids

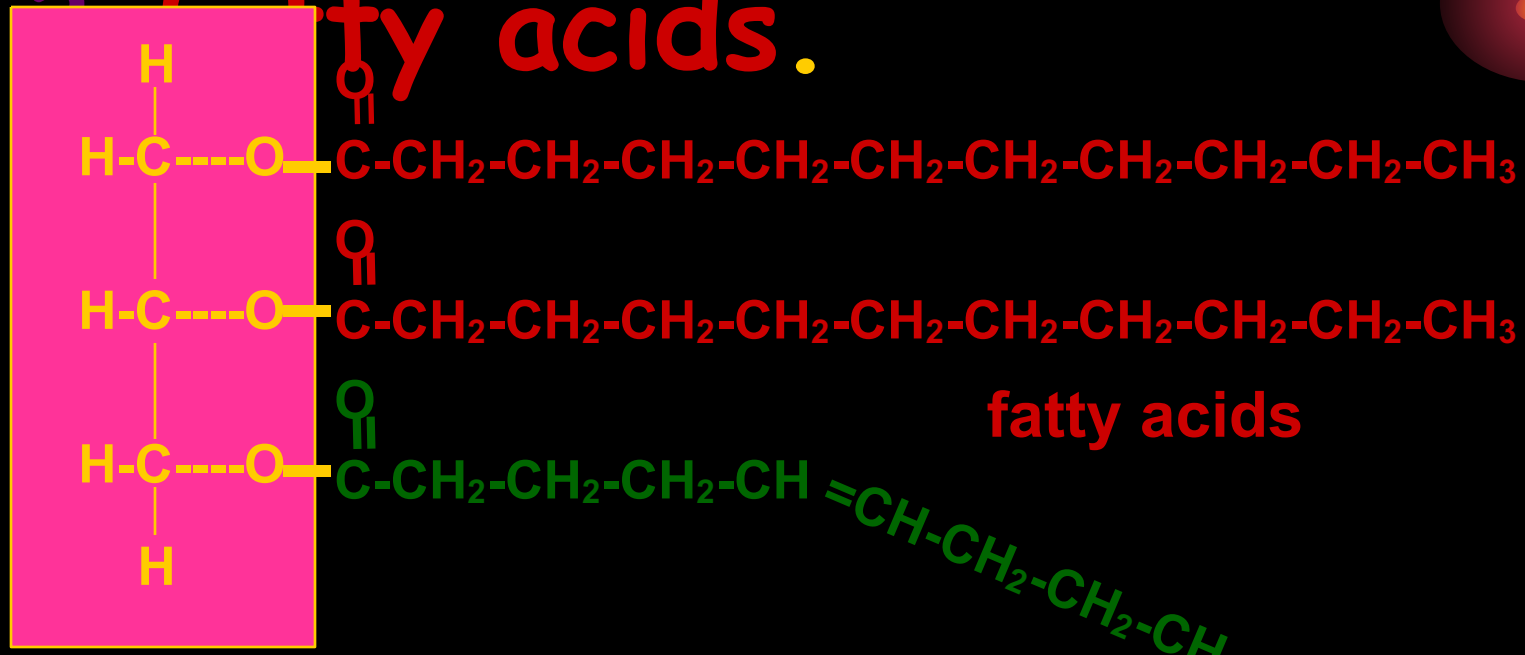
**Functions of lipids:**

1. Long term **energy storage**
2. Major component of cell membranes
3. Protection against heat loss, physical shock, water loss

# Lipids

## Triglycerides:

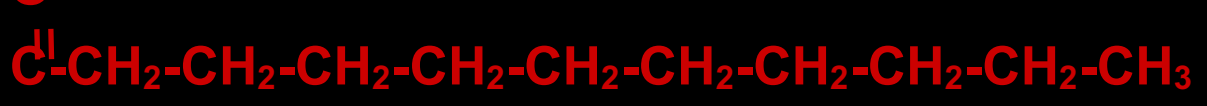
composed of 1 glycerol and 3 fatty acids.



# Fatty Acids

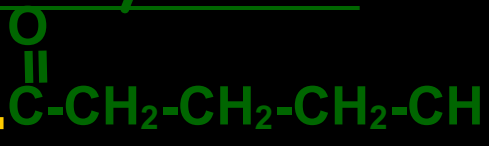
There are two kinds of fatty acids you may see these on food labels:

1. Saturated fatty acids: no double bonds (bad)




saturated

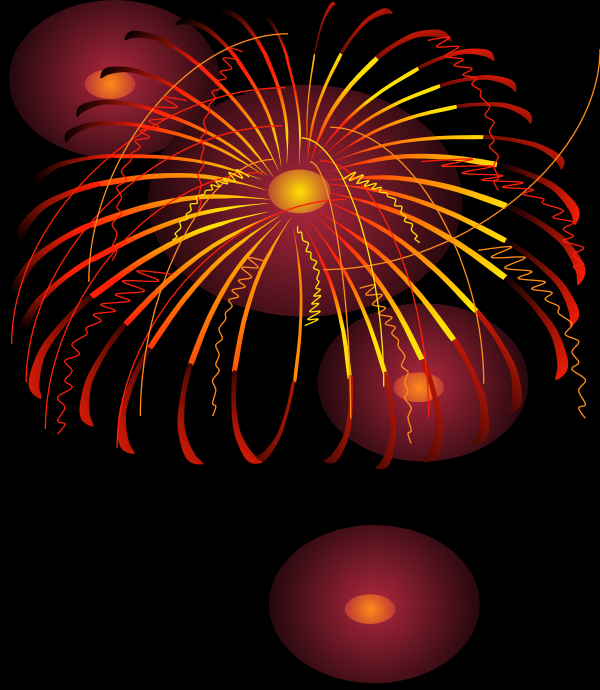
2. Unsaturated fatty acids: double bonds (good)



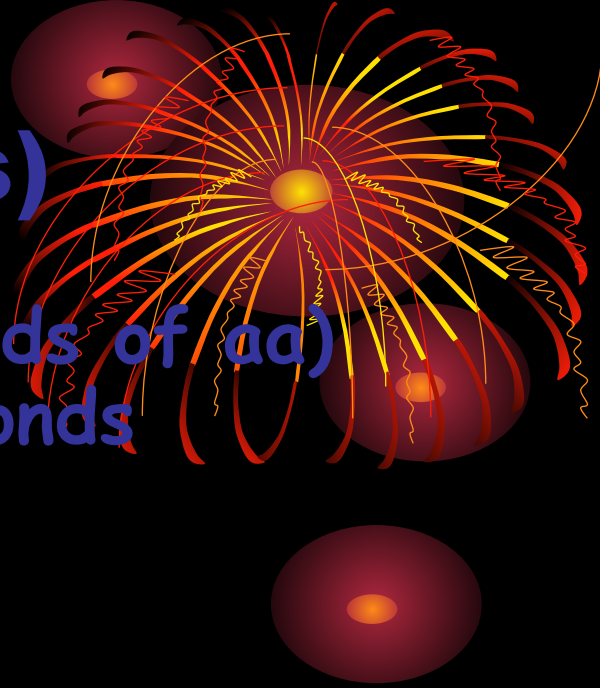

unsaturated

=CH-CH2-CH2-CH

# Proteins



# Proteins (Polypeptides)



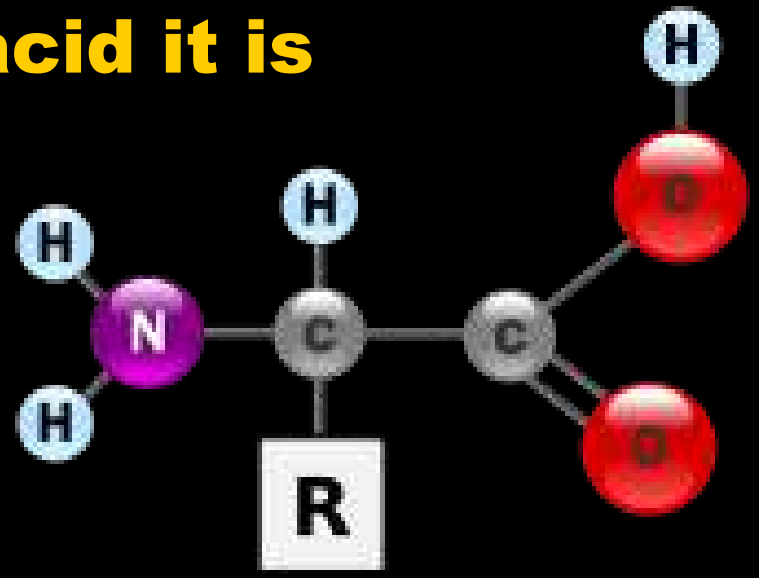
- Amino acids (20 different kinds of aa) bonded together by peptide bonds (polypeptides).

- **Functions of proteins:**

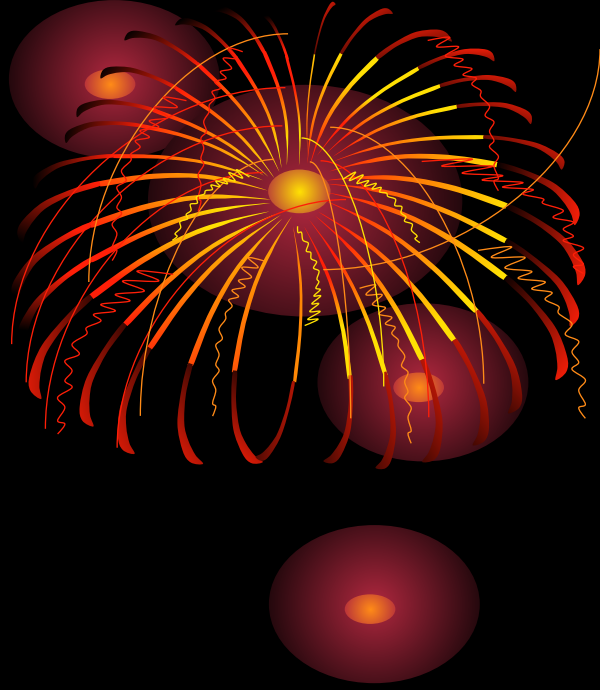
1. Control rates of chemical reactions
2. Regulate cell processes
3. Transport materials into and out of cells
4. Forms bones and muscles

# Proteins

- Contain N, C, H, O
- Each has an amino group and a carboxyl group on each end
- Has an R group that makes it the specific amino acid it is



# Nucleic Acids



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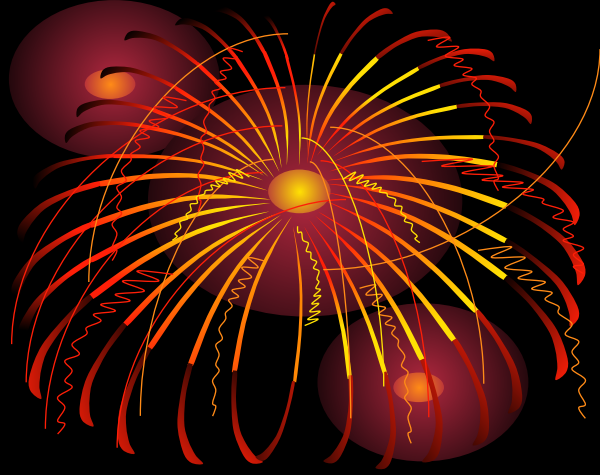


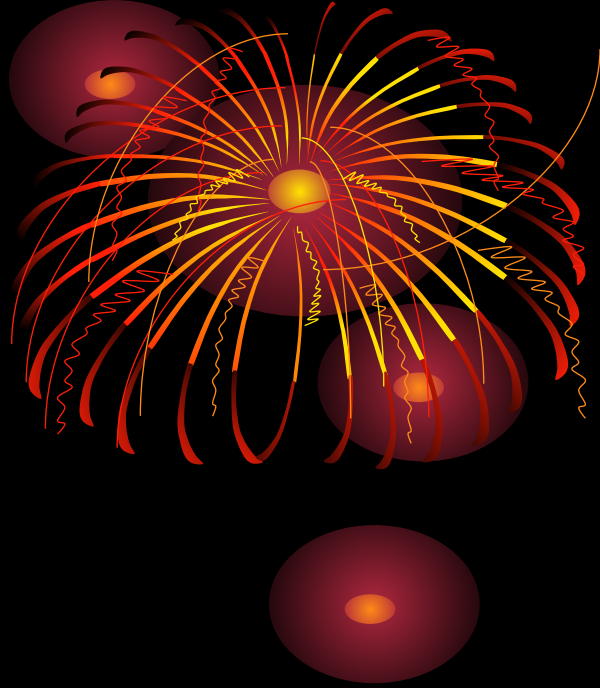
⑩Two types:

a. Deoxyribonucleic acid (DNA-double helix)

b. Ribonucleic acid (RNA-single strand)

Each is composed of a nucleotide

# Nucleic acids



⑩Nucleotides include:

phosphate group

pentose sugar (5-carbon)

nitrogenous bases:

adenine (A)

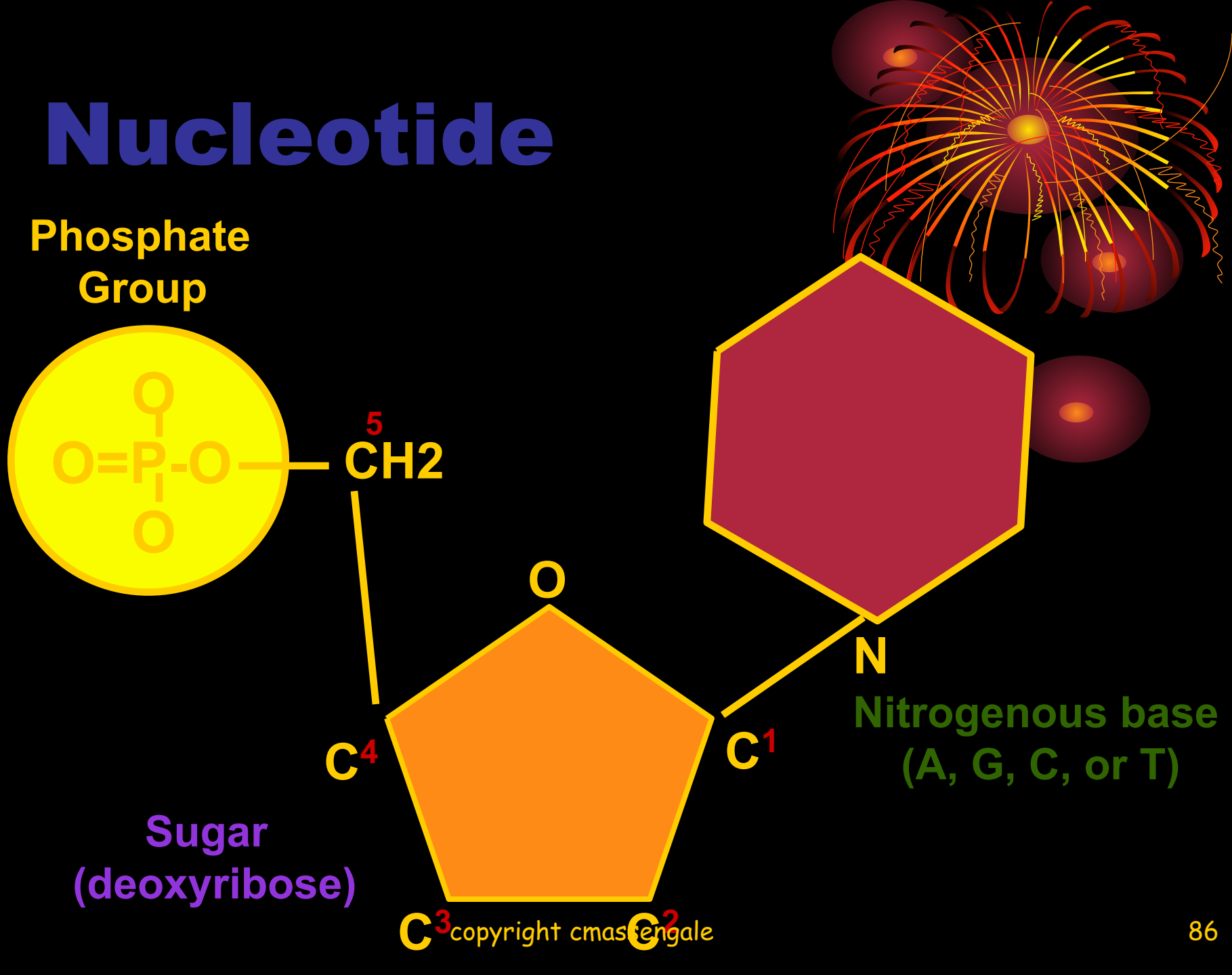
thymine (T) DNA only

uracil (U) RNA only

cytosine (C)

guanine (G)

# Nucleotide



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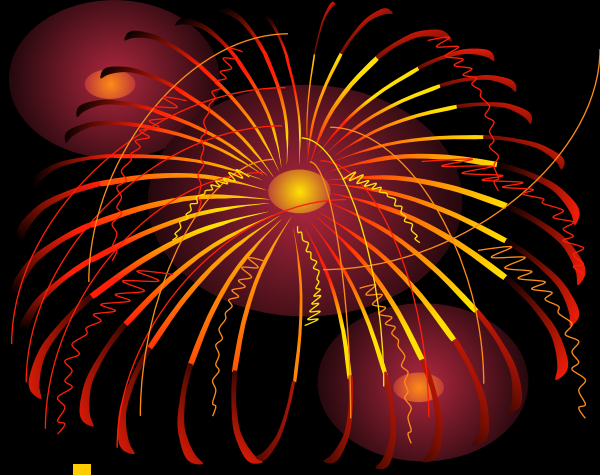
# Learning Targets



- I can show how chemical reactions can be represented by chemical formulas.
- I can describe the function of enzymes, including how enzyme-substrate specificity works, in biochemical reactions.

# Chemical Reactions

⑩A process that changes one group of chemicals into another.

$CO_2 + H_2O$ $H_2$ 

Reactants Product

# Chemical Reactions

- http://www.youtube.com/watch?v=66kuhJkQCVM

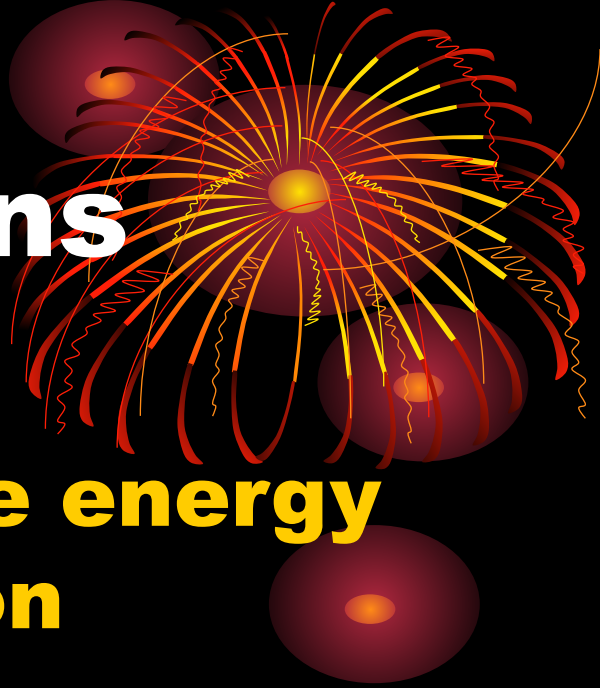
- http://www.youtube.com/watch?v=m8mbGH6b2cg

# Energy in Reactions

- Chemical reactions can release or absorb energy

- The ones that release energy can happen spontaneously
- The ones that absorb energy won't happen with a source of energy

# Energy in Reactions



- Activation energy is the energy needed to get a reaction started.
- The rate or how fast the reaction occurs depends on catalysts.

# Energy in Reactions

- A catalyst is something that speeds up the rate of the reaction.
- Often a catalyst is a special protein called an enzyme.

# Enzymes

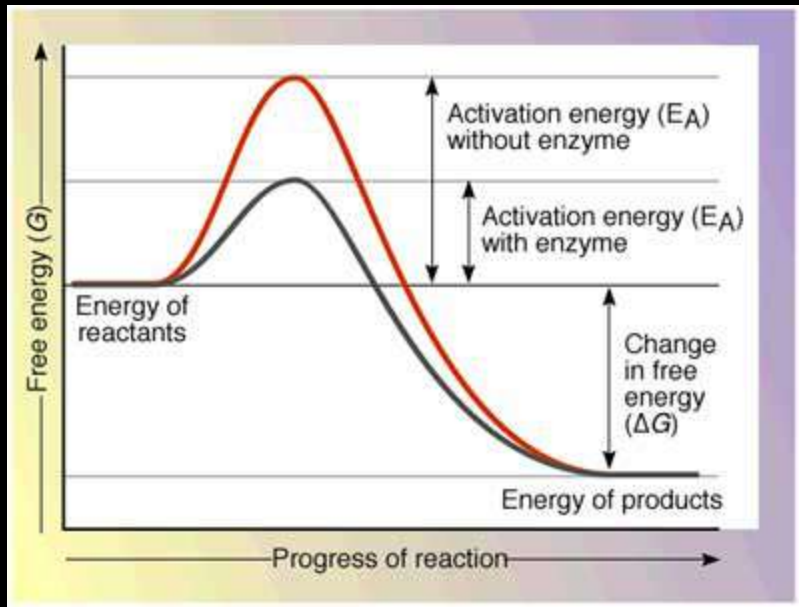
- Proteins that act as biological catalysts.
- Enzymes are very specific; catalyzing only one chemical reaction.
- Often end is “ase”

# Enzyme-Substrate Complex

- Enzymes provide a site where reactants can be brought together.
- Reactants are known as substrates.
- The substrate fits into the active site on the enzyme to start the reaction.

# Energy in Reactions

- Enzymes lower a reaction's activation energy
- http://www.youtube.com/watch?v=VbIaK6PLrRM



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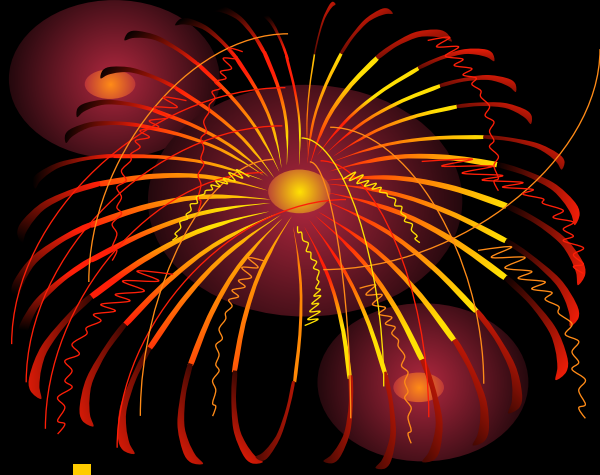

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