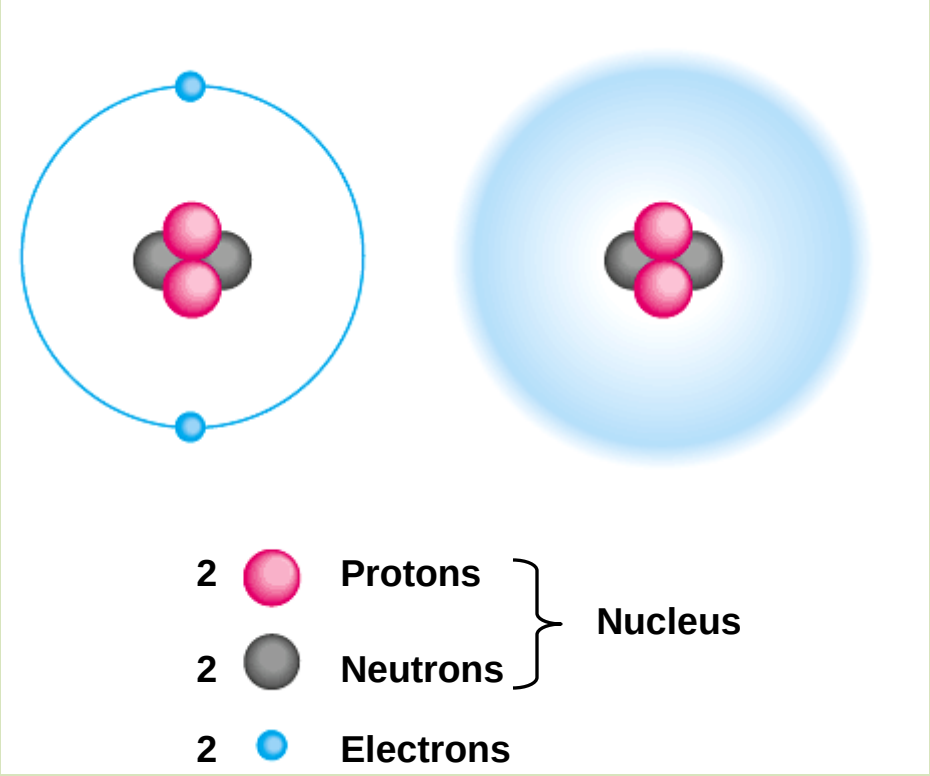
Pre AP Biology

BIOCHEMISTRY

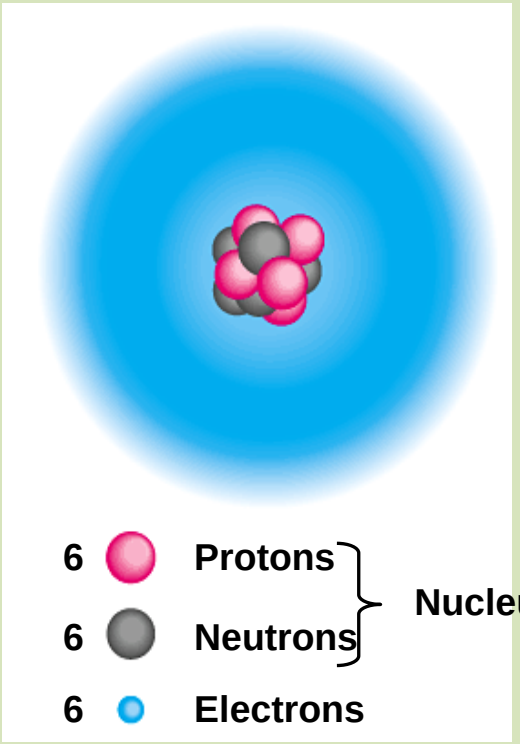
- An atom is made up of **Protons** and **Neutrons** located in a central nucleus
- The nucleus is surrounded by **Electrons**



A. Helium atom

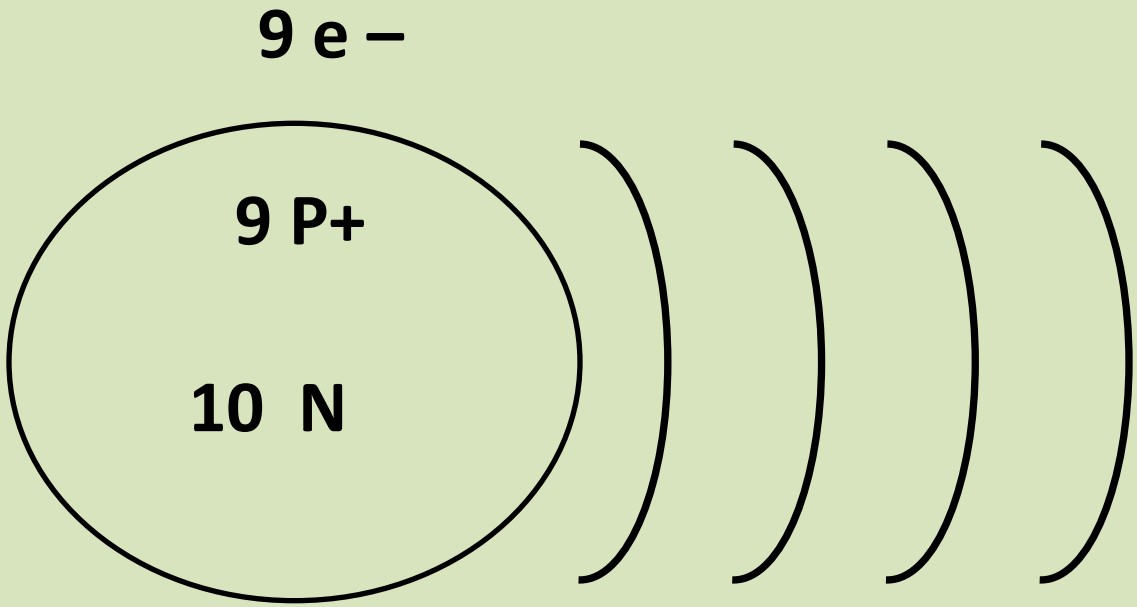
- Each atom is held together by attractions between the **positively** charged protons and **negatively** charged electrons

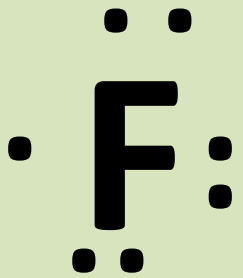
- Atoms are electrically **neutral** because they have the same number of positive protons and negative electrons



B. Carbon atom

- Let's draw a diagram of a **fluorine** atom

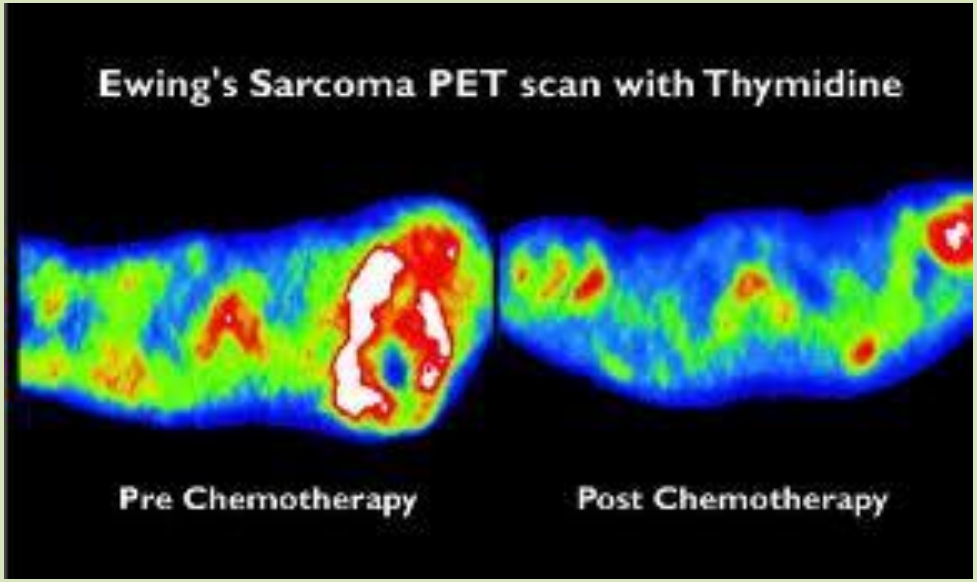


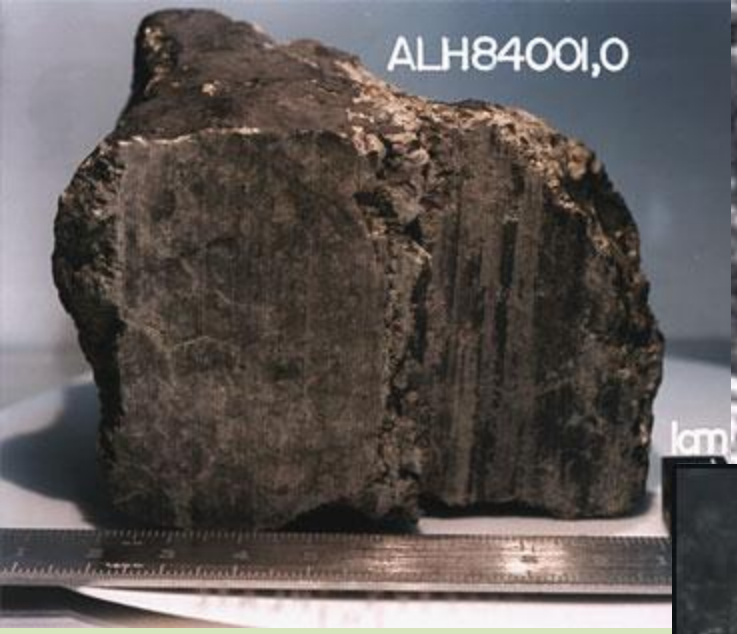


- Atoms of each element are distinguished by a specific number of protons = **Atomic number**
  - The number of **neutrons** may vary for atoms of the same element
  - Variant forms of an element are called **isotopes**
  - Some isotopes are **radioactive**

ISOTOPES OF CARBON

	Carbon-12	Carbon-13	Carbon-14
Protons	6	6	6
Neutrons	6	7	8
Electrons	6	6	6


Ewing's Sarcoma PET scan with Thymidine
Pre Chemotherapy
Post Chemotherapy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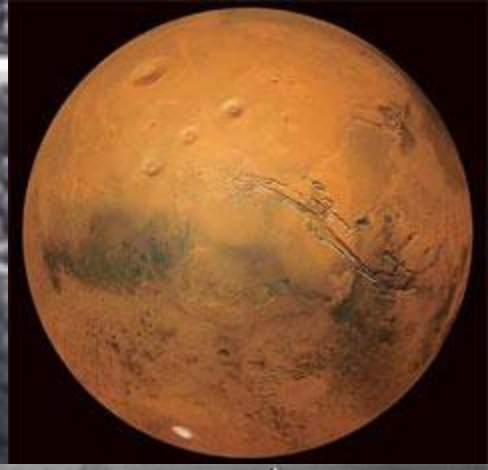
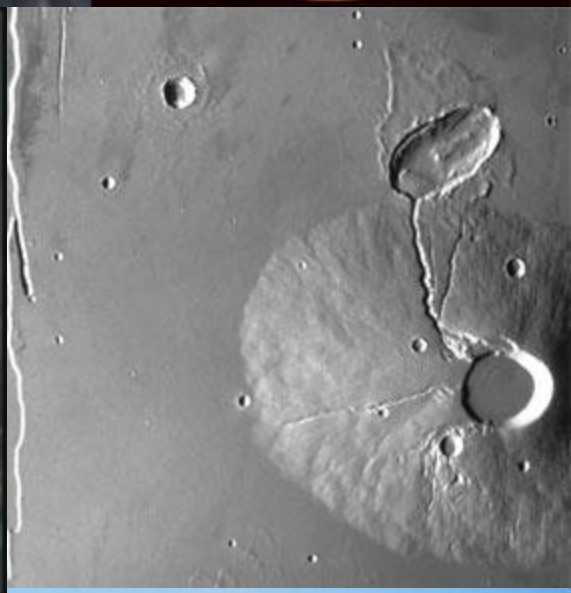
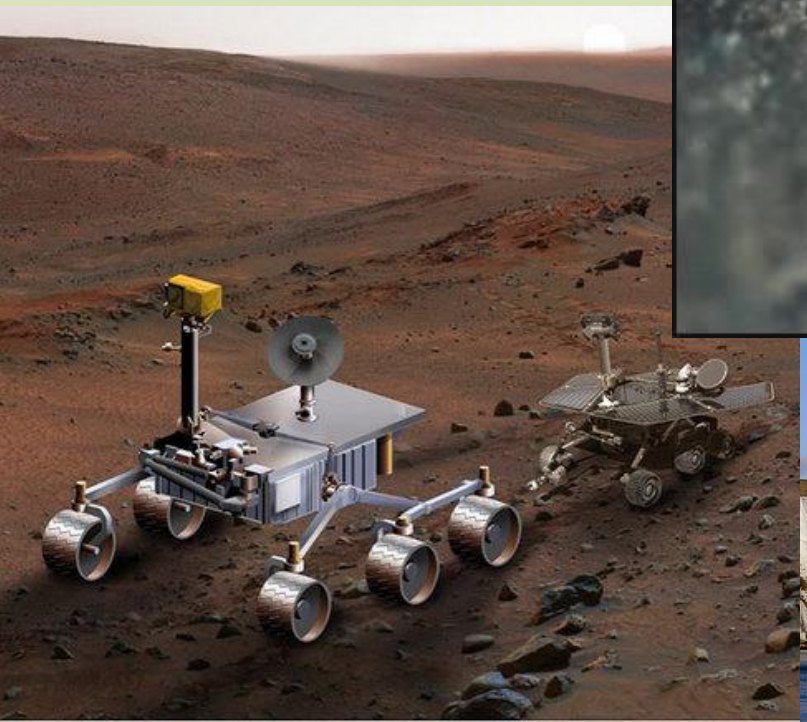
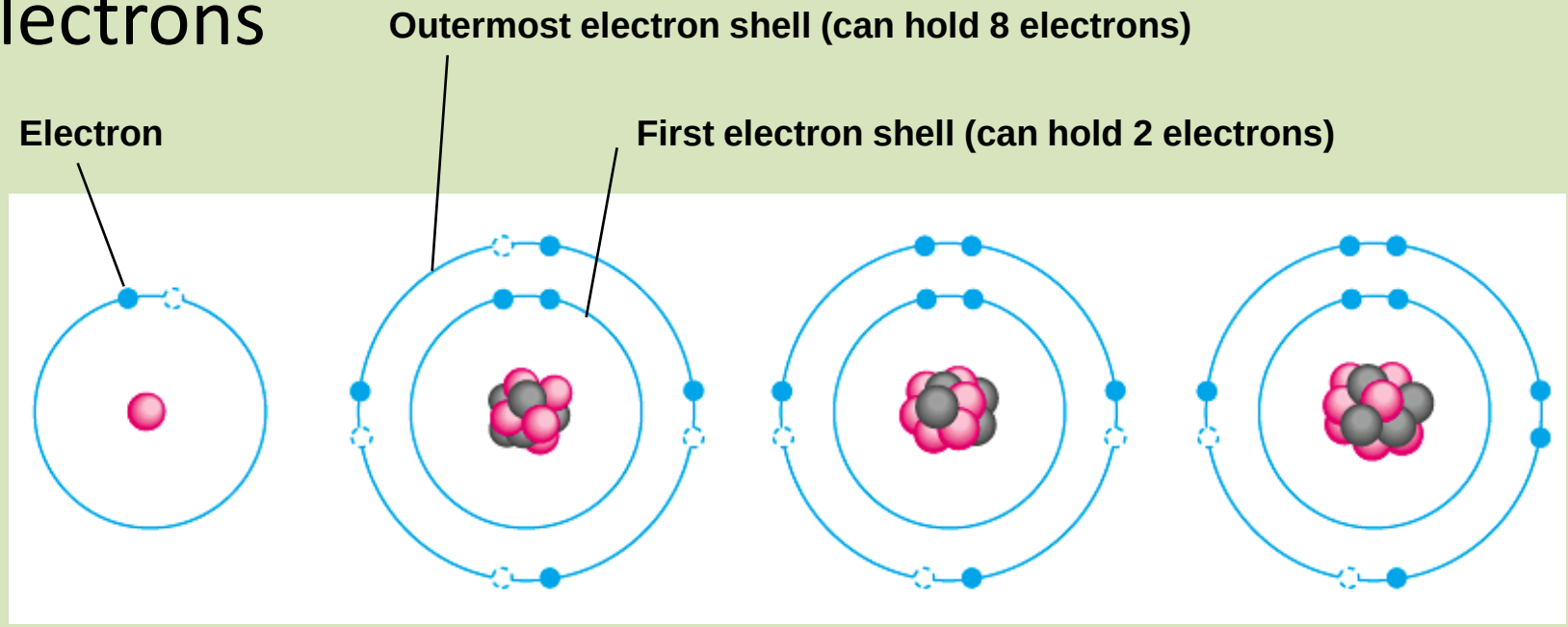






- Electrons are arranged in shells
  - The **outside** shell determines the chemical properties of an atom
  - In most atoms, a full outer shell holds **8** electrons
- Atoms whose shells are **NOT FULL** tend to react with other atoms and gain, lose, or share electrons



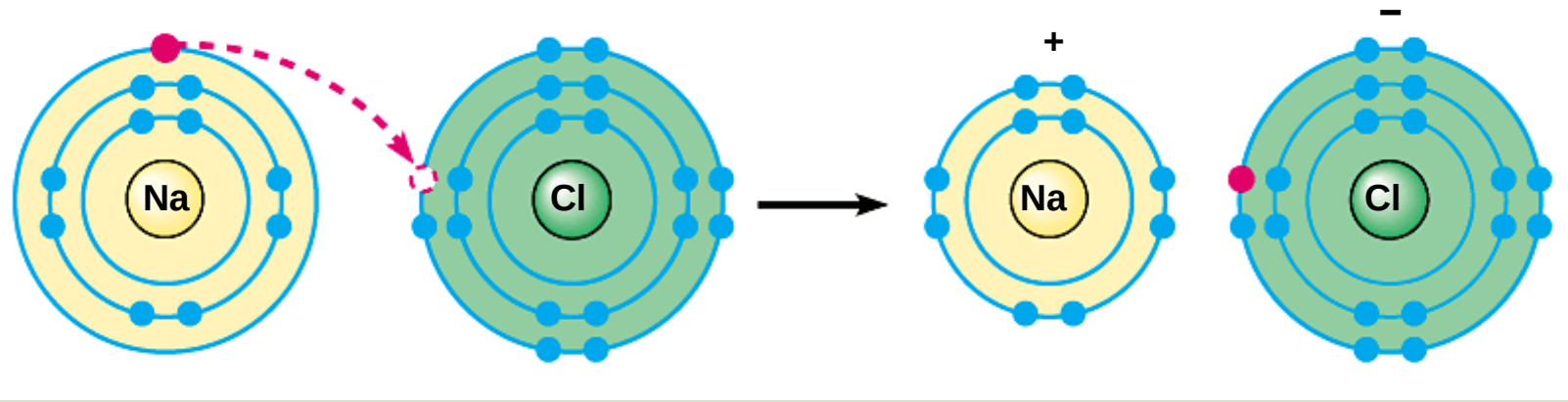
- **3 types of chemical bonds**: atoms can improve their **stability** by bonding with other elements.

ionic

covalent

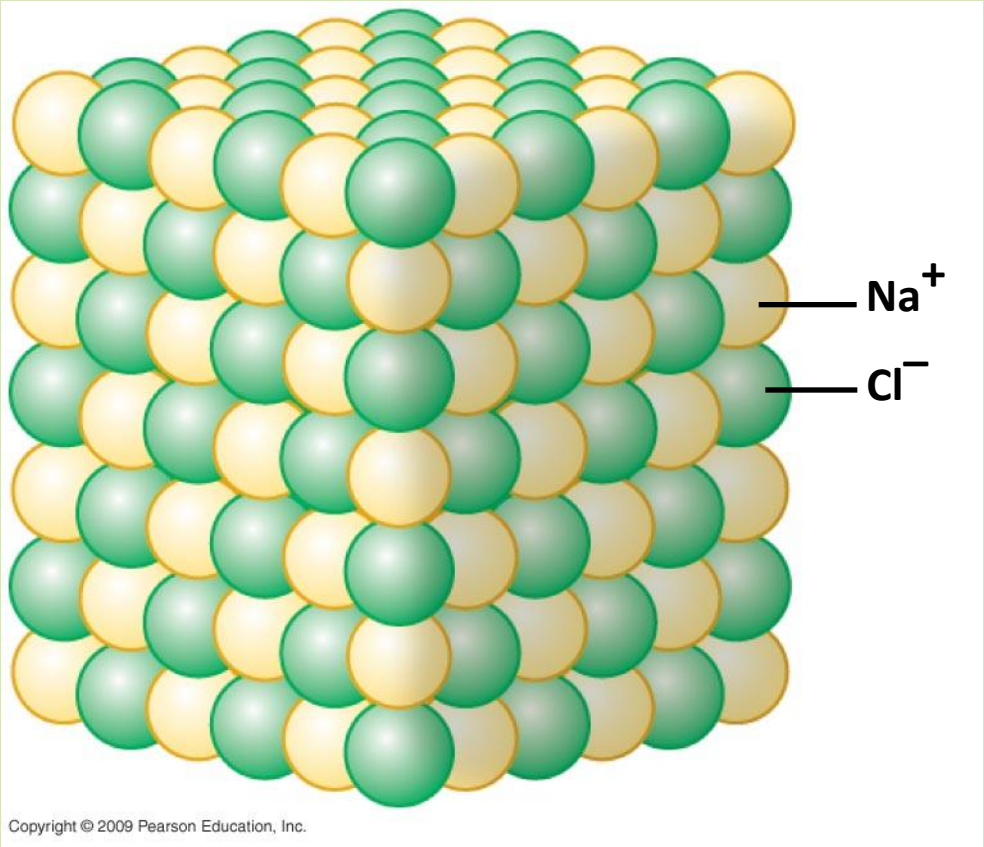
hydrogen

1. IONIC BOND: forms when electrons are _gained_ or _released_ from unstable atoms which create stable charged atoms called _IONS_. These stable ions are held together because of the attraction between _opposite_ charges.



Animation

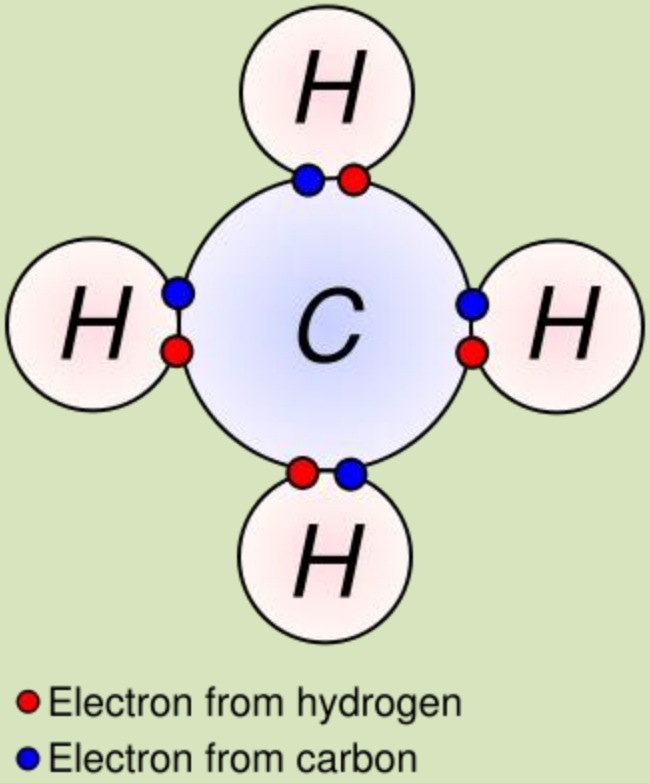
A closer look at one salt crystal



2. Covalent Bond: forms when electrons are _____ between unstable atoms. When atoms are bonded by covalent bonds they form a _____.

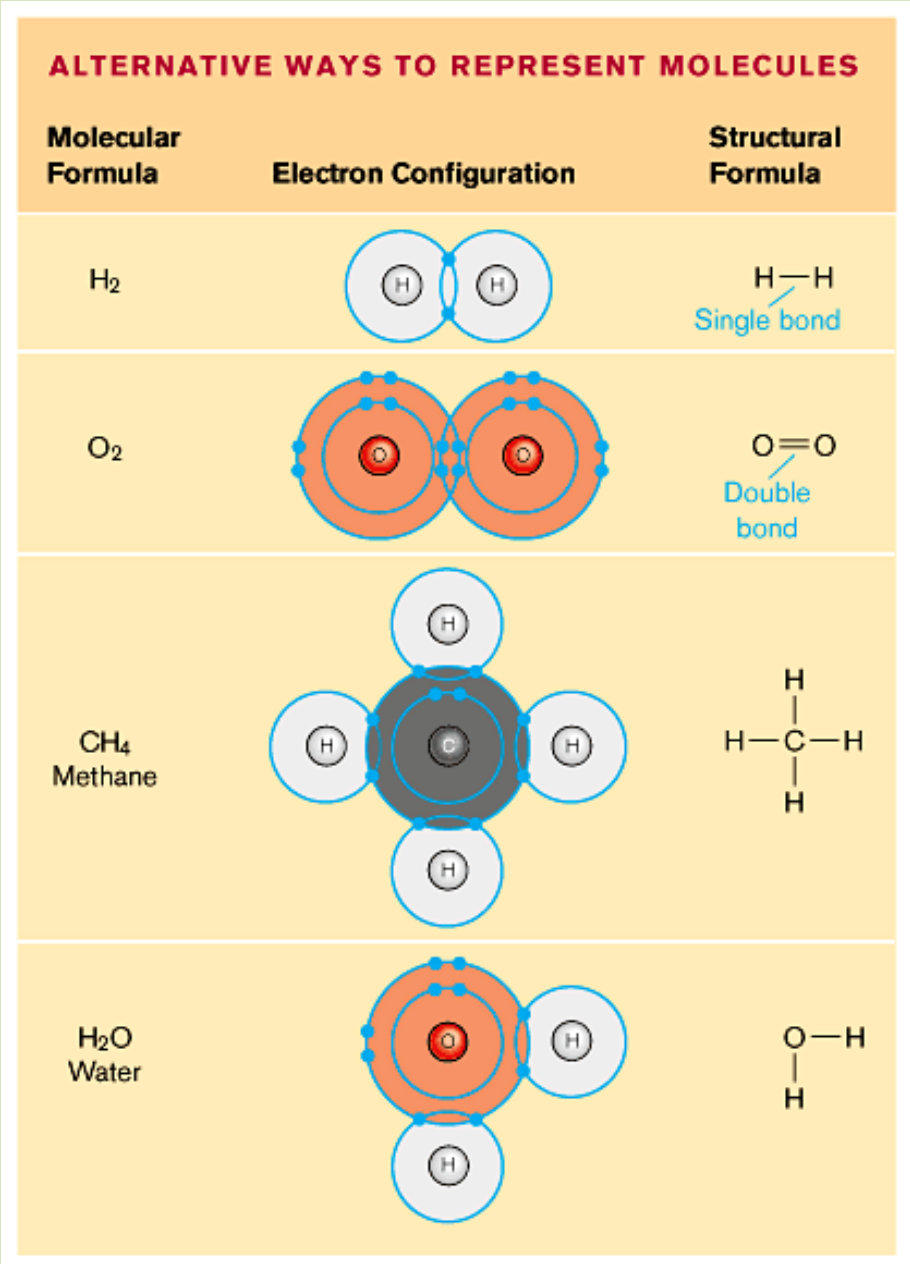
shared

molecule



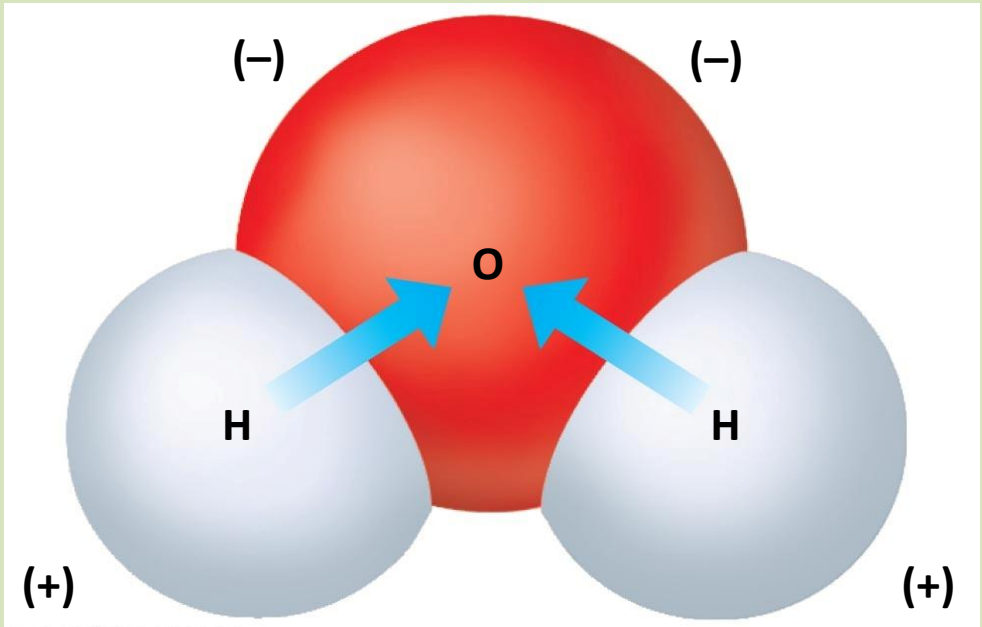
More examples of covalently bonded molecules

Animation

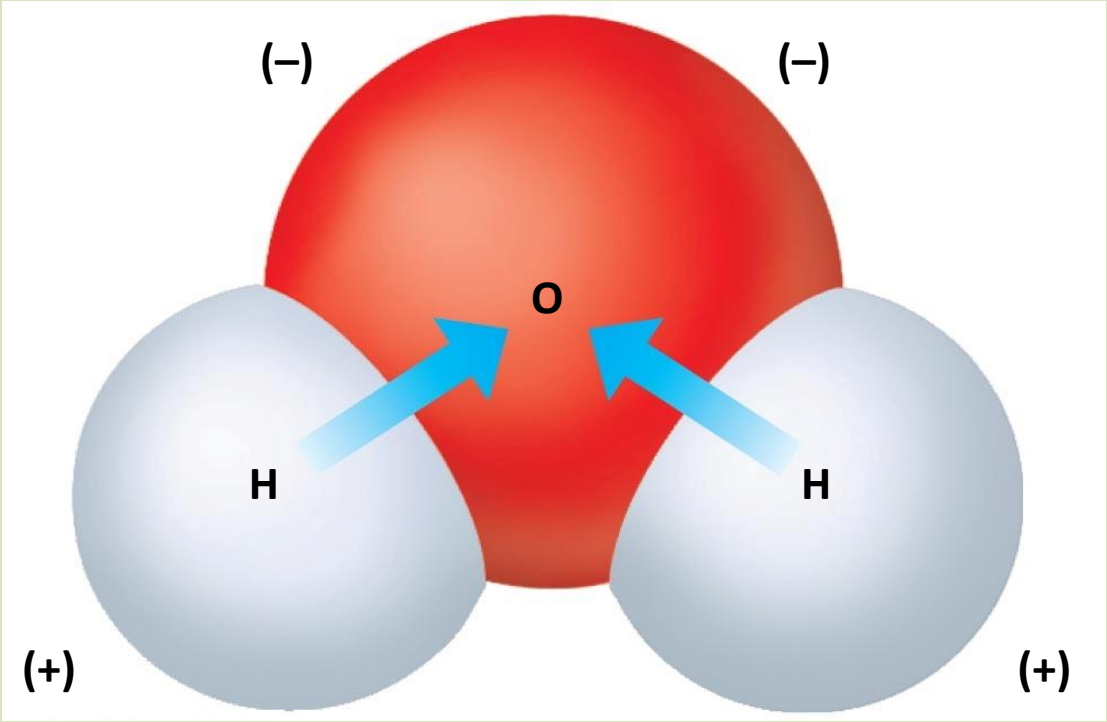


Unequal electron sharing creates polar molecules

- Water has atoms with different electronegativities
  - Oxygen attracts the shared electrons more strongly than hydrogen
  - So, the shared electrons spend more time near oxygen
  - The result is a **polar** **covalent bond**



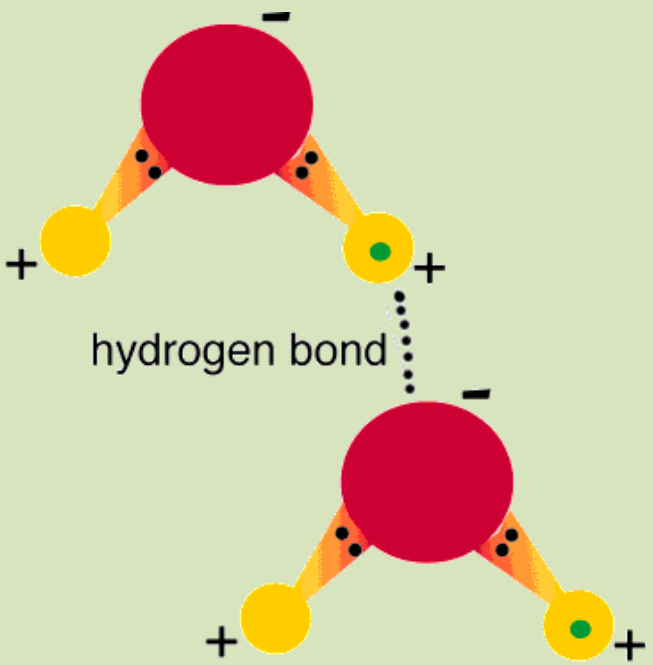
Animation

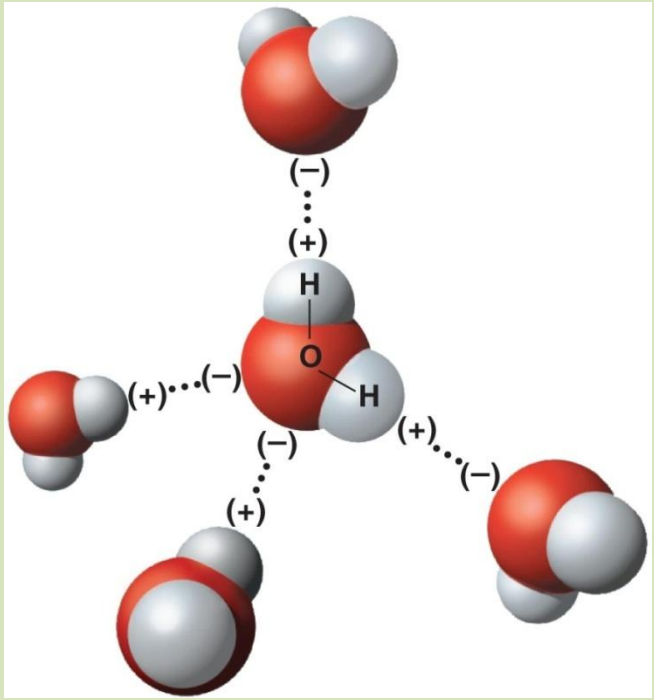


- In H_2O the oxygen atom has a slight _negative_ charge and the hydrogens have a slight _positive_ charge
  - Molecules with this unequal distribution of charges are called _polar_ **molecules**

Animation

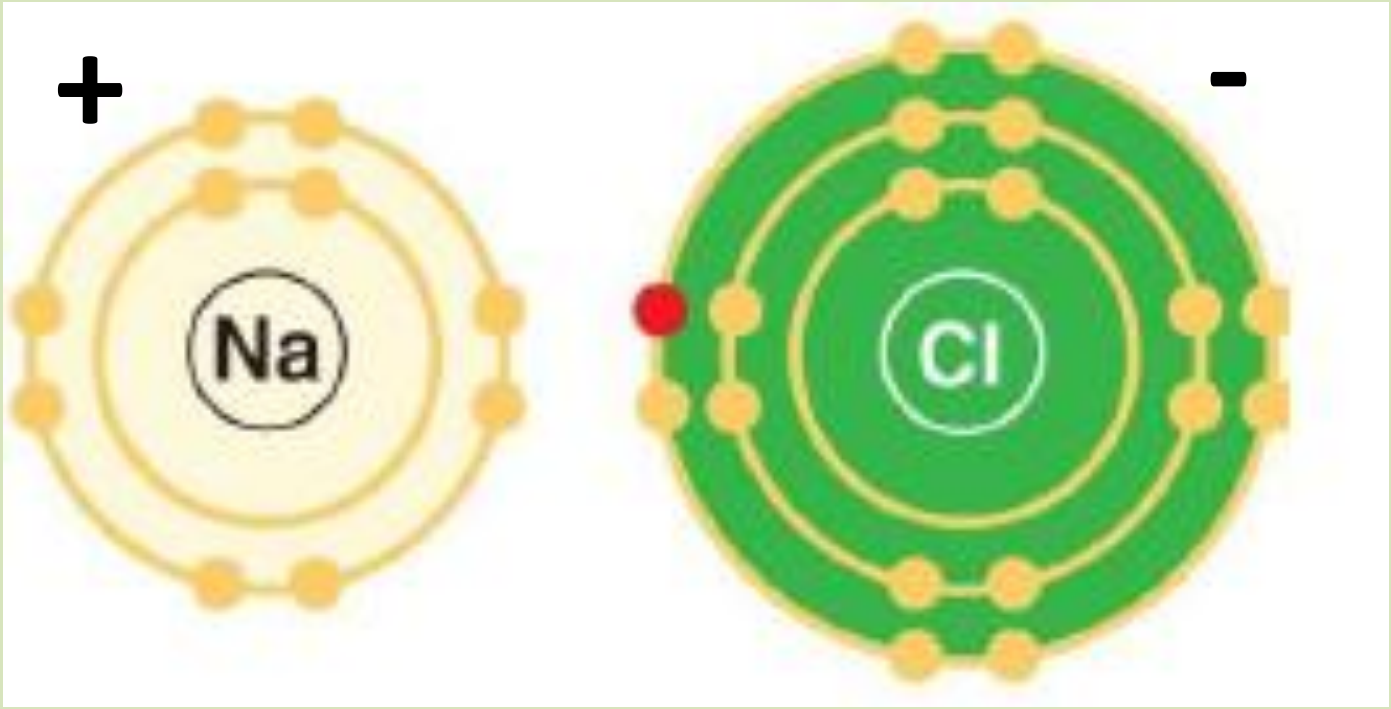
3. Hydrogen Bond: form between neighboring polar molecules. A polar molecule has a partial (+) charge at one end of the molecule and a partial (-) charge at the other. Water molecules are attracted to oppositely charged regions on neighboring molecules



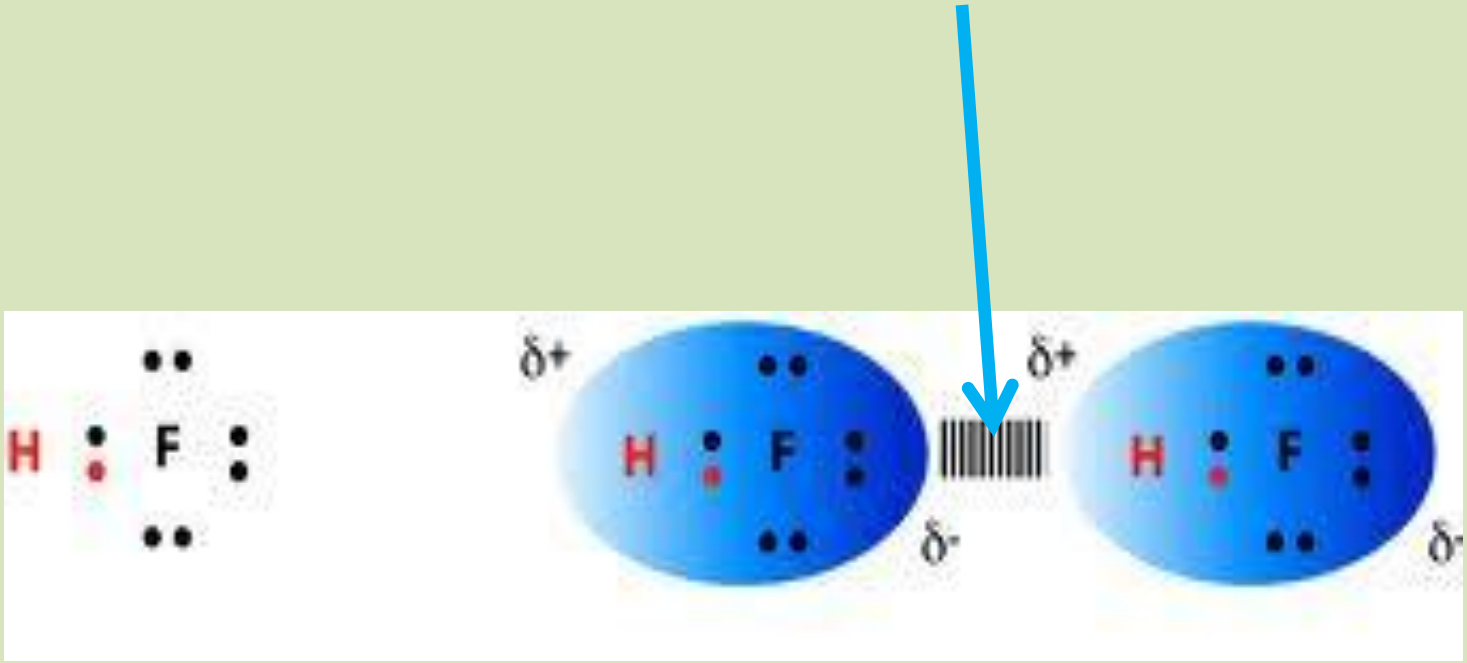


Let’s Review Types of Bonds

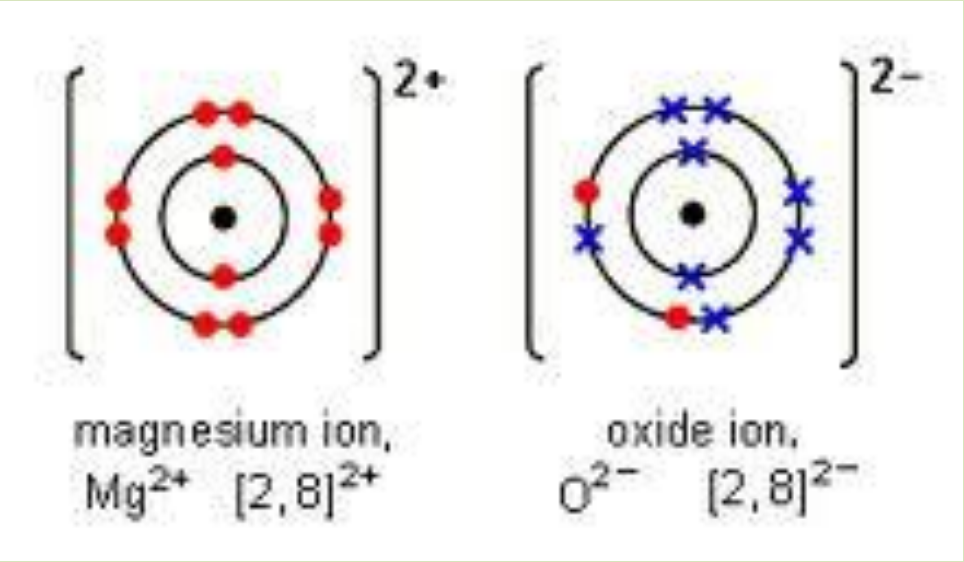
Ionic, Covalent or Hydrogen Bond?



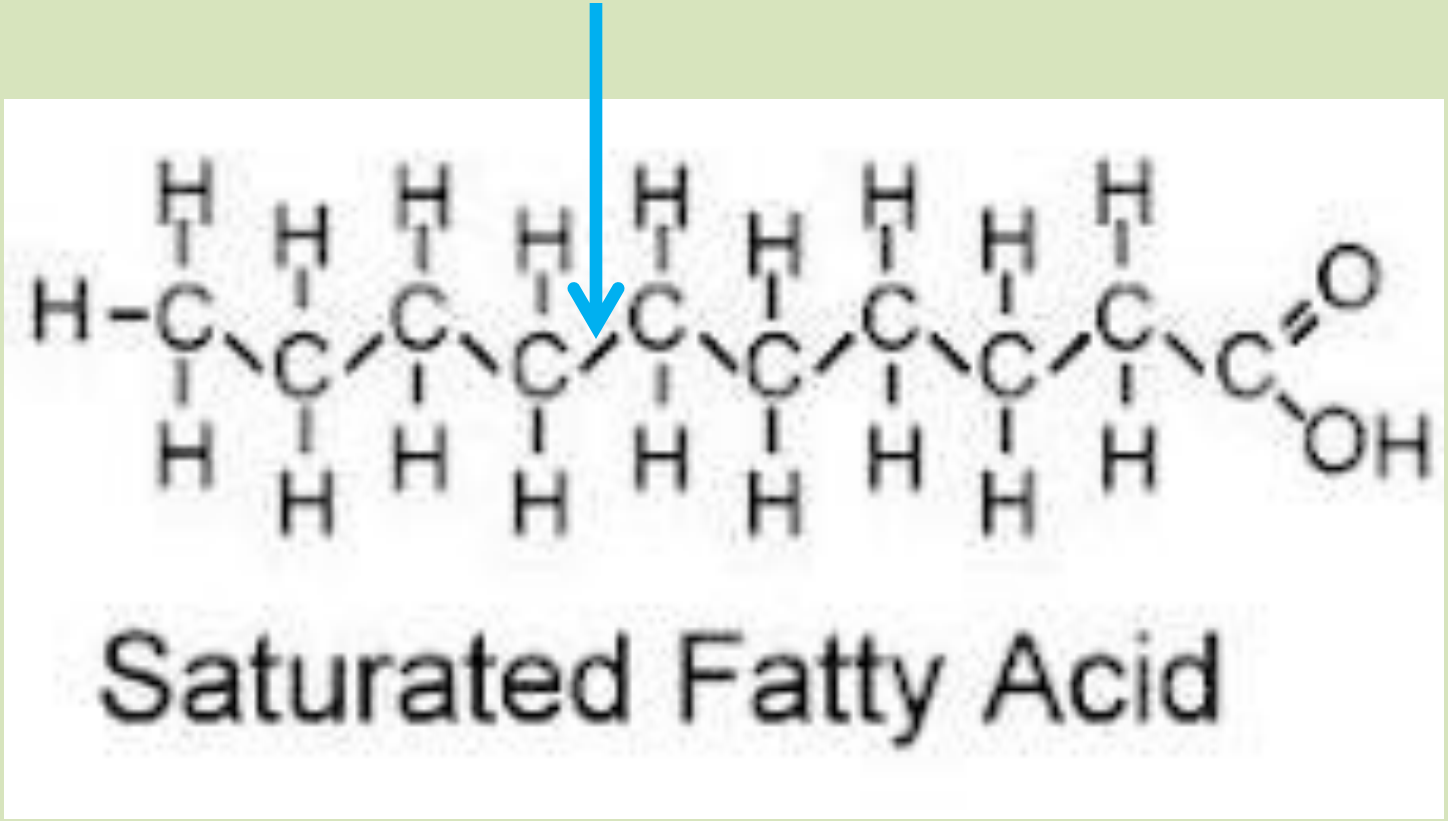
Ionic, Covalent or Hydrogen Bond?



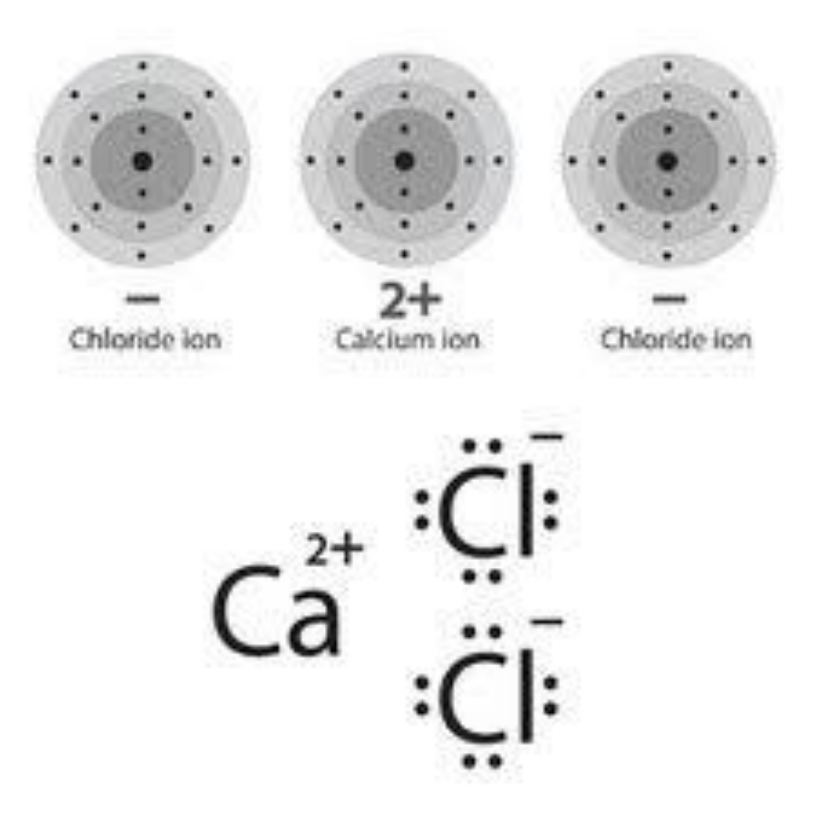
Ionic, Covalent or Hydrogen Bond?



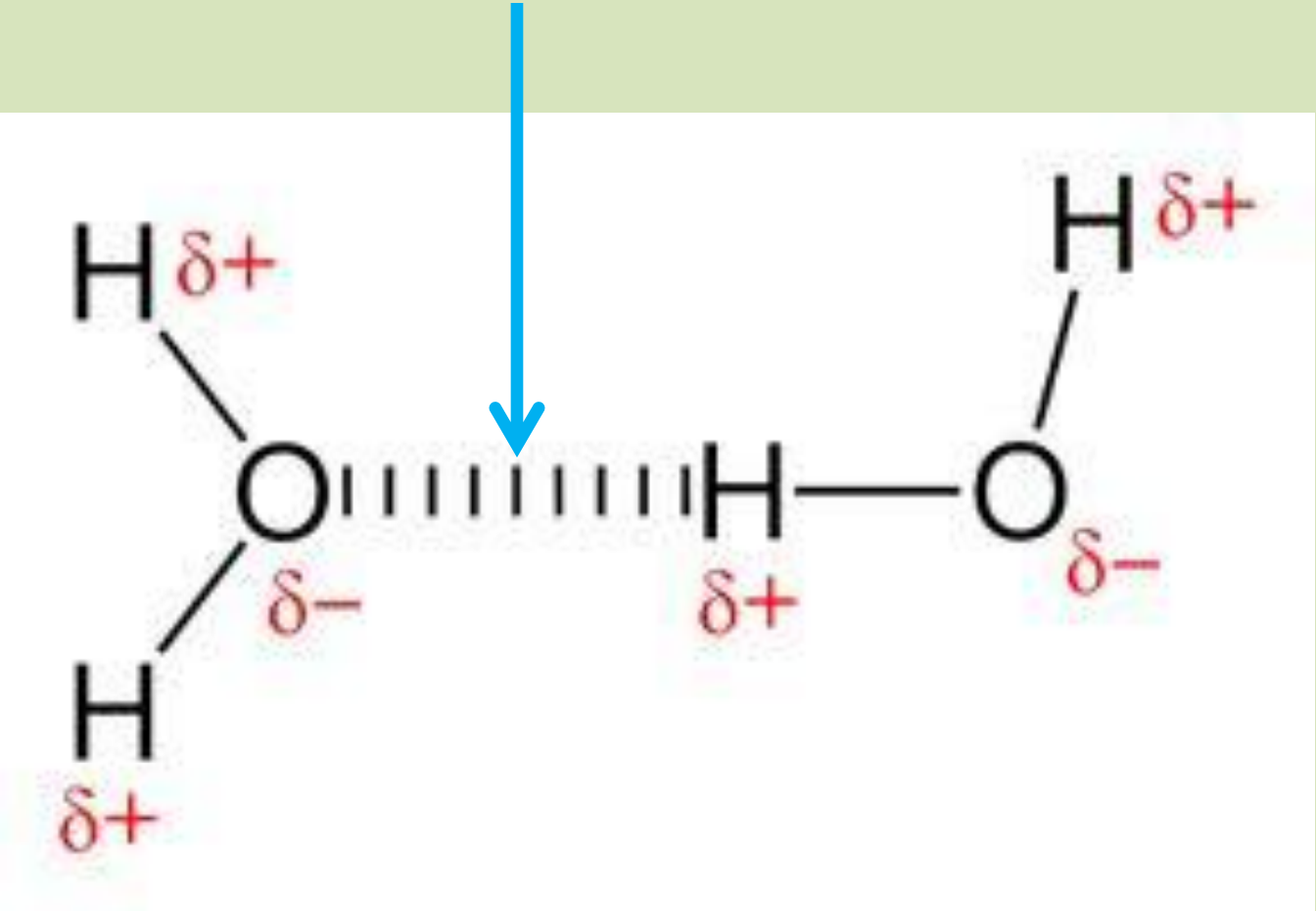
Ionic, Covalent or Hydrogen Bond?



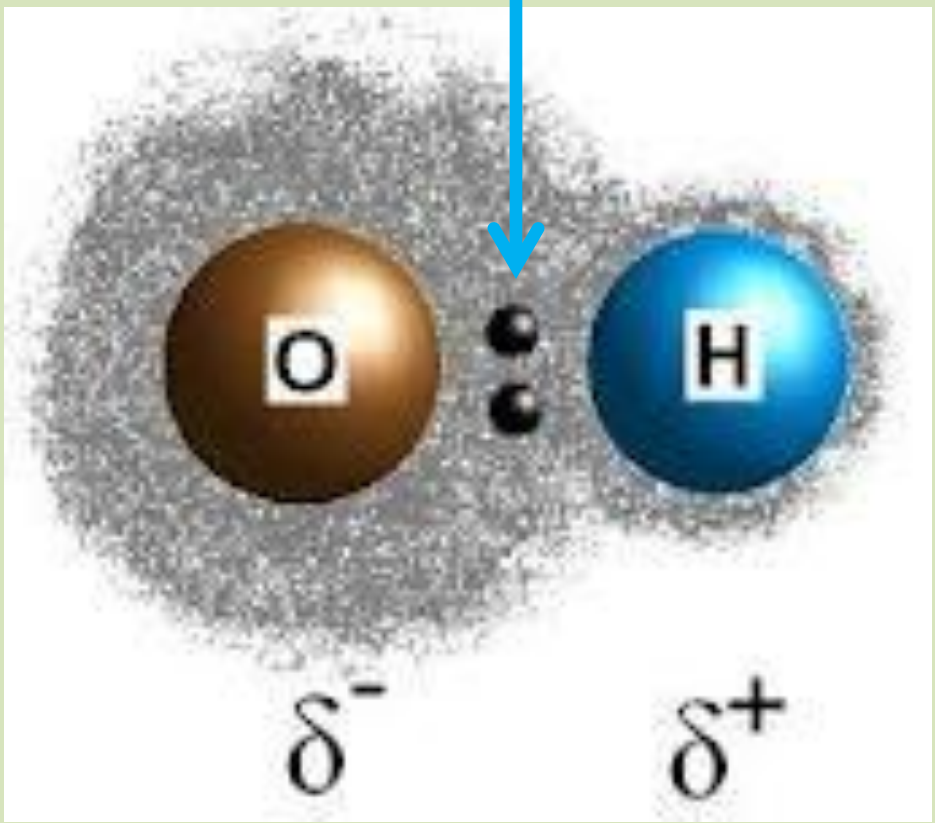
Ionic, Covalent or Hydrogen Bond?



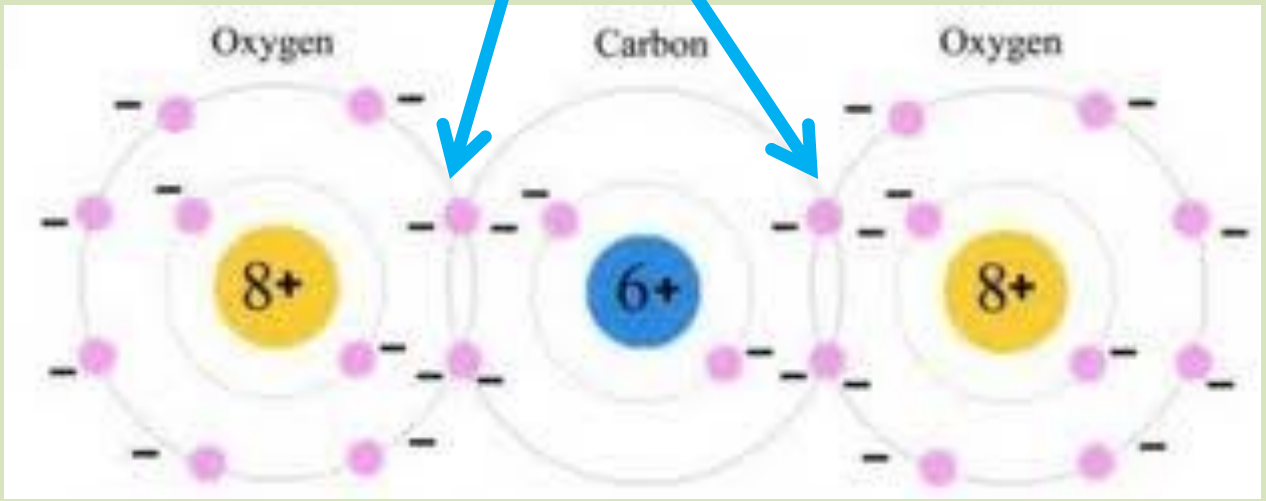
Ionic, Covalent or Hydrogen Bond?



Polar or Nonpolar Covalent Bond?



Polar or Nonpolar Covalent Bond?



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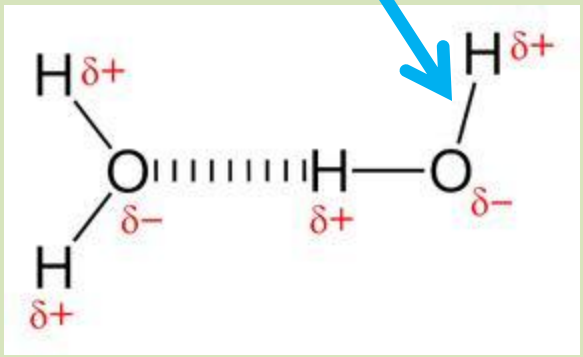
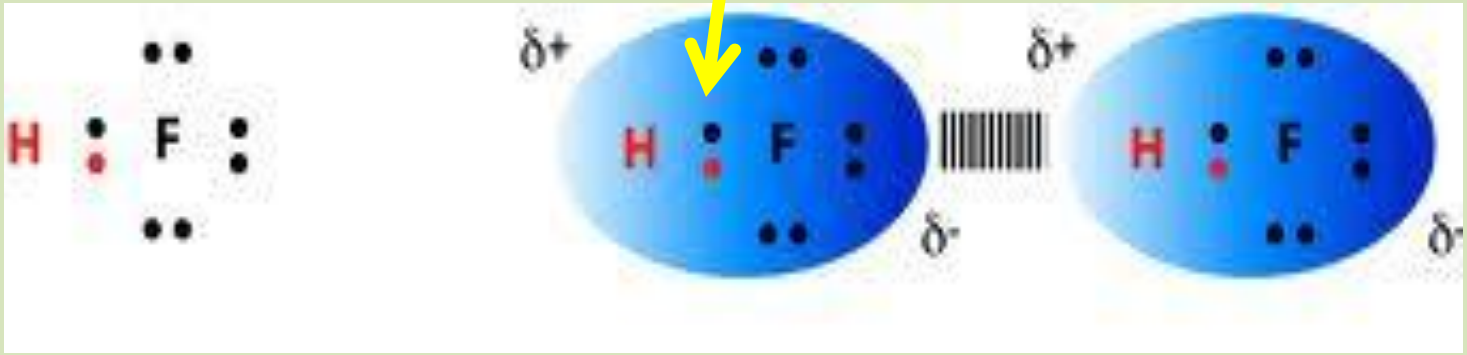
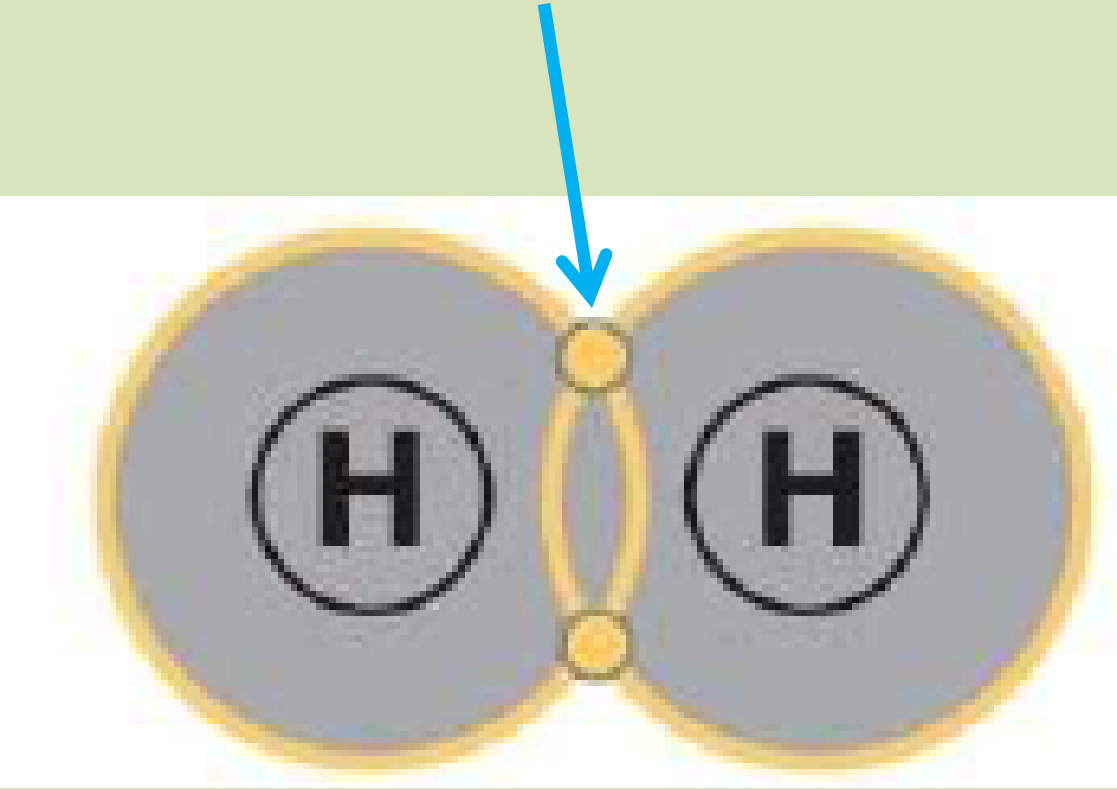


Polar or Nonpolar Covalent Bond?



Polar or Nonpolar Covalent Bond?



- Hydrogen bonding causes water molecules to stick together, a property called __cohesion__
  - Cohesion is much stronger for water than other liquids
  - This is useful in plants that depend upon cohesion to help “pull” water and nutrients up the plant in a process called __capillary action__

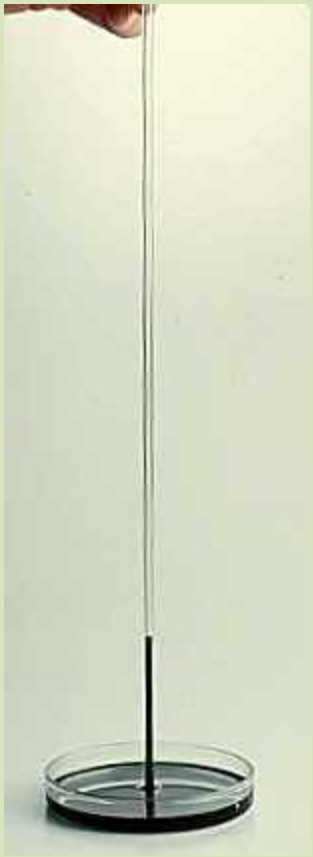
Animation

Cohesion

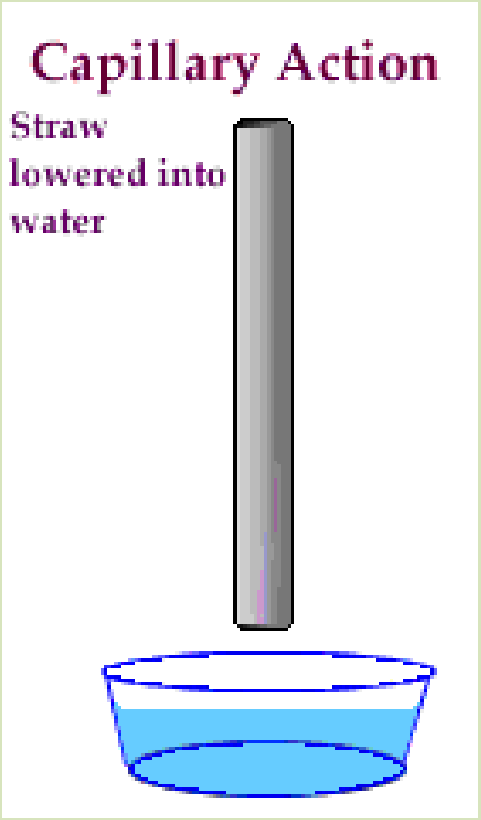
Capillary Action

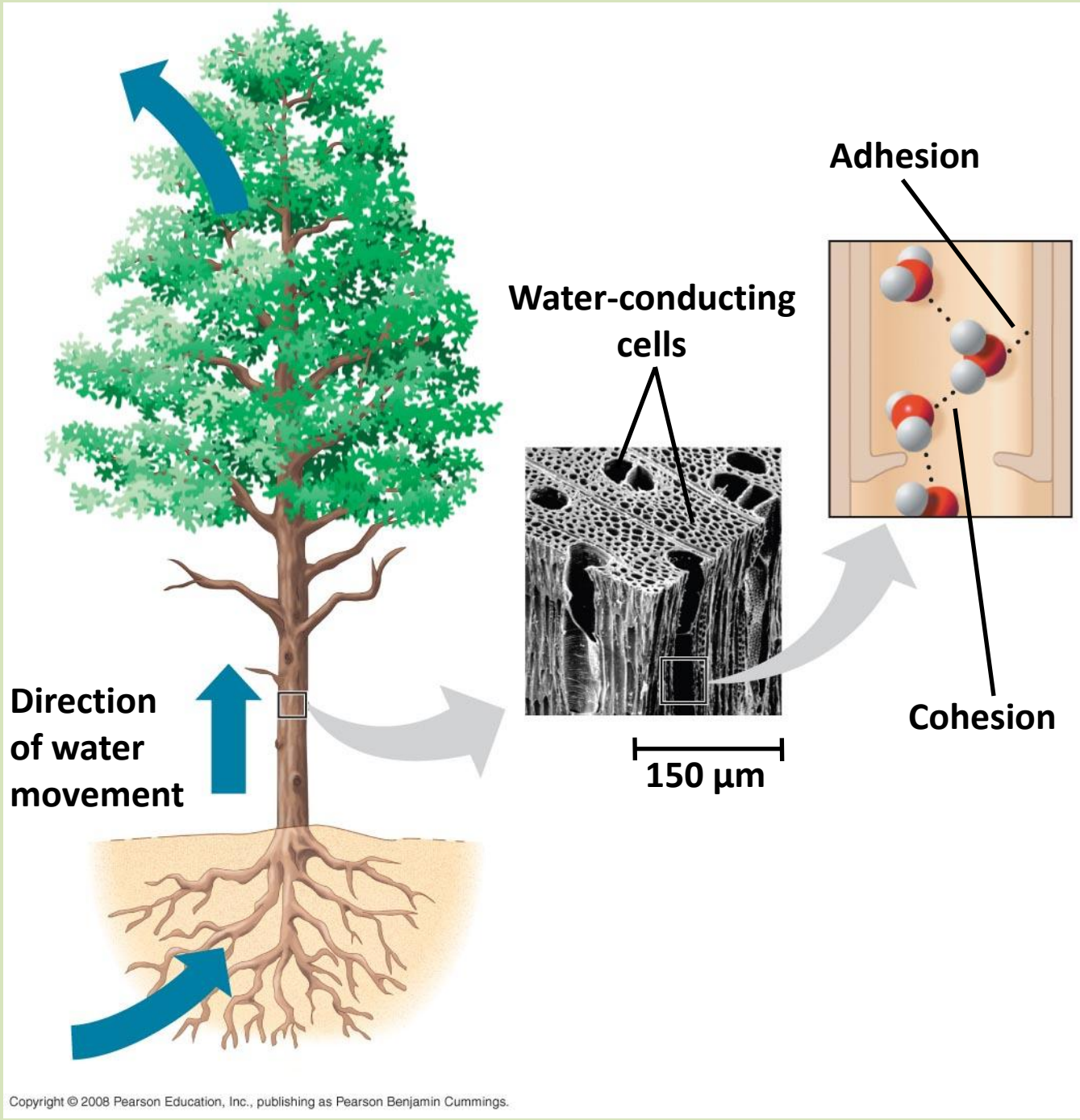
- Hydrogen bonding also causes water molecules to stick to other surfaces with charges , a property called **adhesion**

Capillary Action

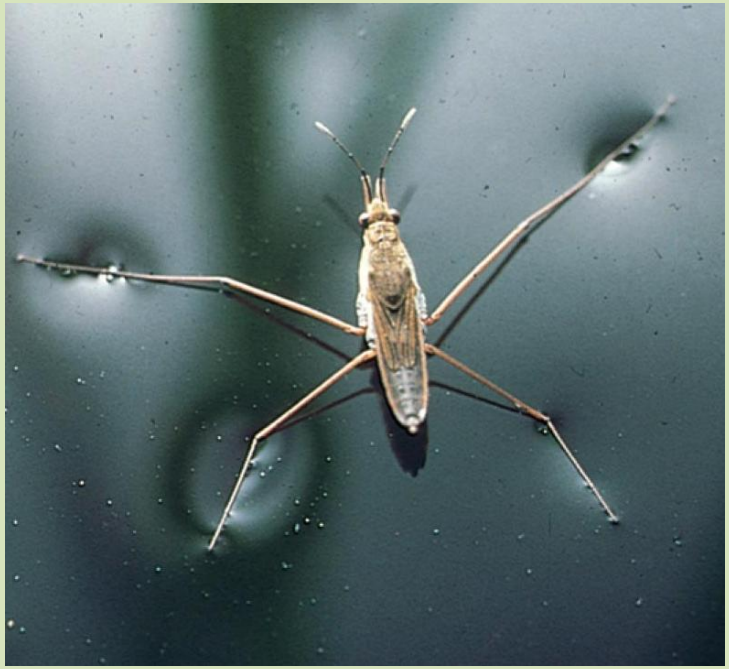


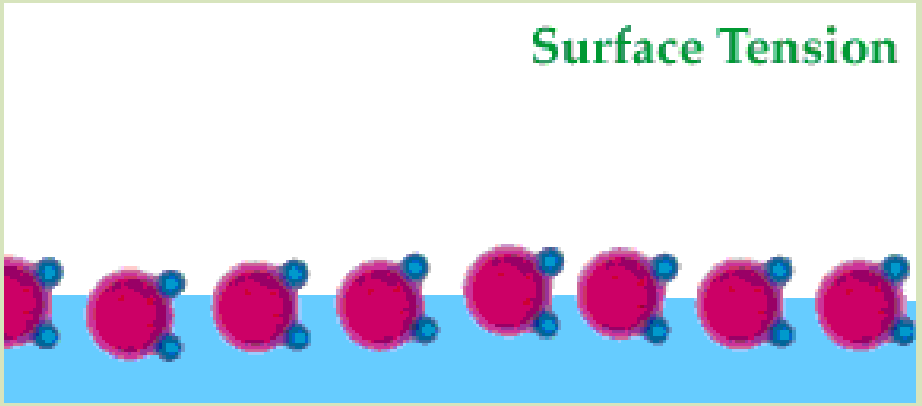
- Capillary action uses both the **adhesive** and **cohesive** properties of water.
  - You can see capillary action 'in action' by placing a straw into a glass of water. The water 'climbs' up the straw.



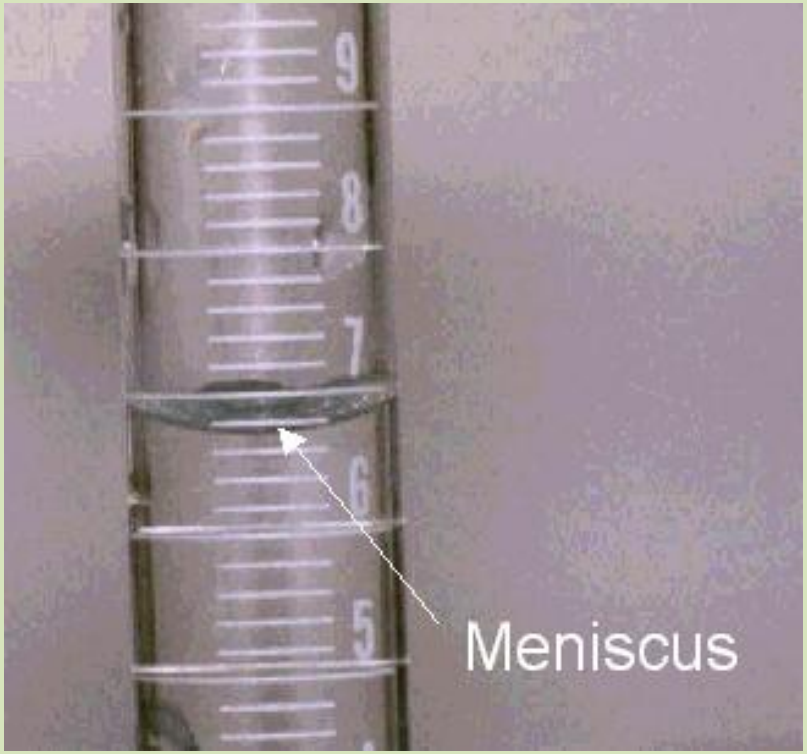


- Cohesion is related to **surface tension**—a measure of how difficult it is to break the surface of a liquid
  - Hydrogen bonds are responsible for surface tension

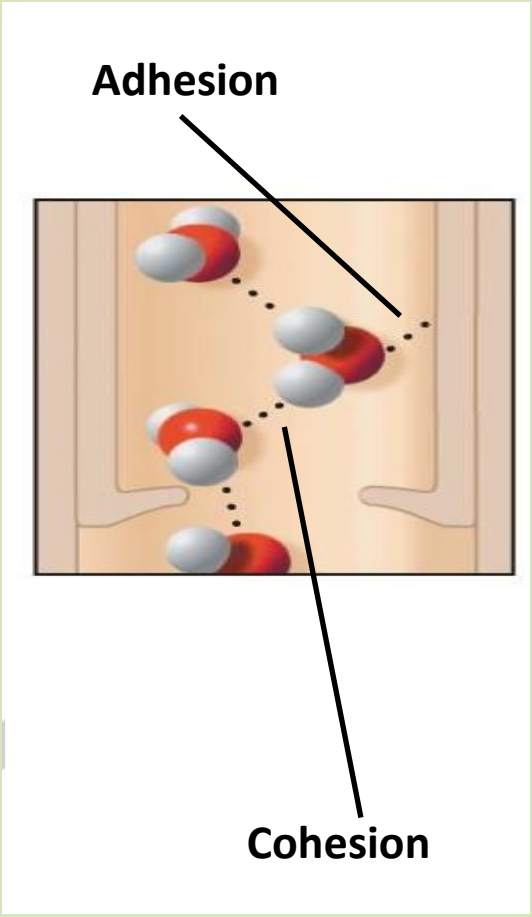




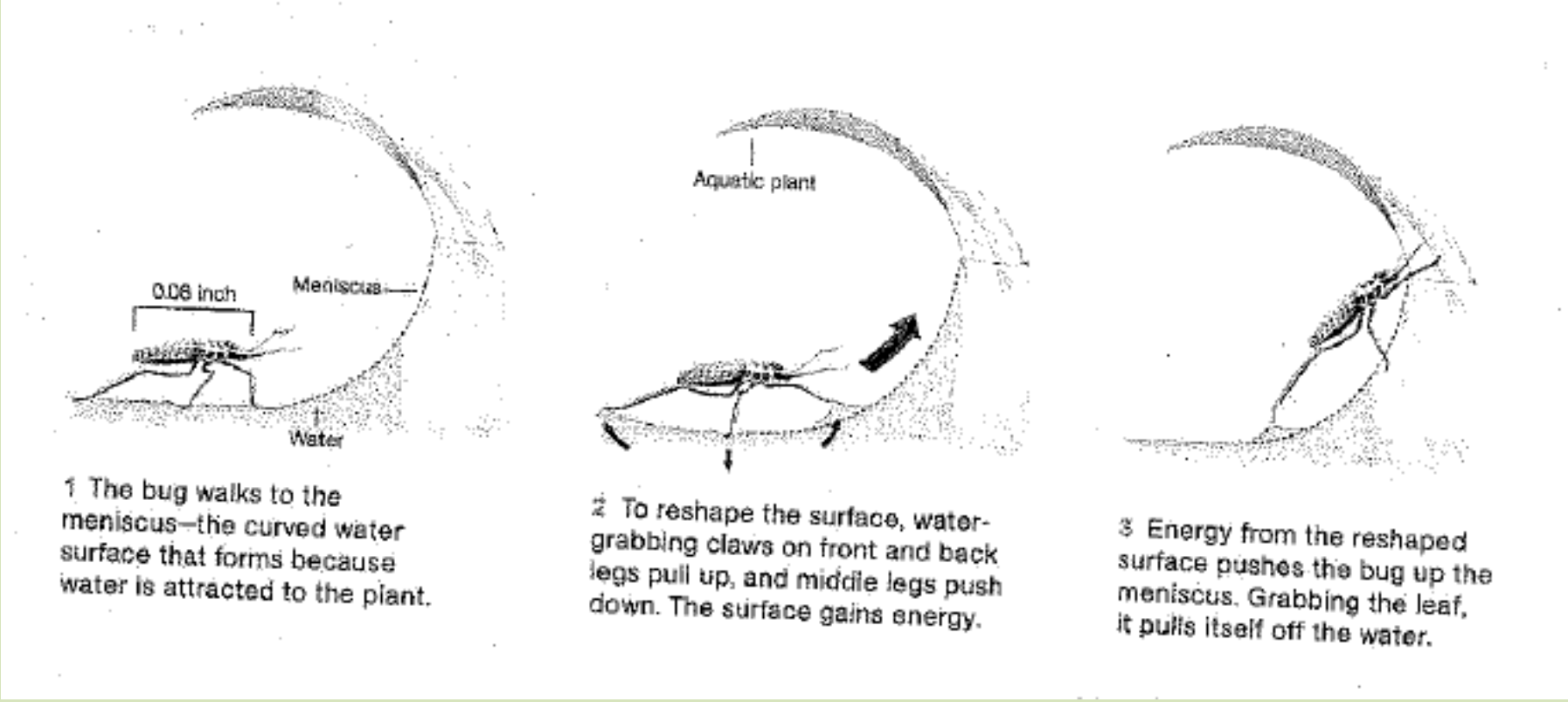
- Which property of water is the strongest in a <u>meniscus</u> … **Adhesion** or **Cohesion**?



Meniscus



How do they do that?

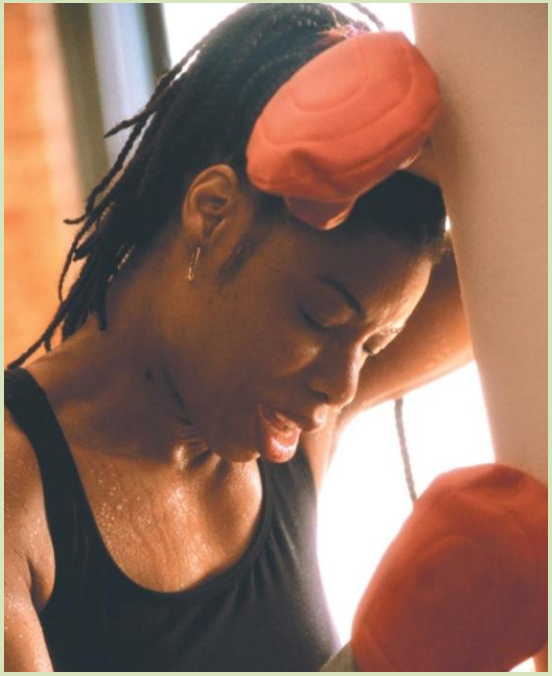


1 The bug walks to the meniscus—the curved water surface that forms because water is attracted to the plant.

2 To reshape the surface, water-grabbing claws on front and back legs pull up, and middle legs push down. The surface gains energy.

3 Energy from the reshaped surface pushes the bug up the meniscus. Grabbing the leaf, it pulls itself off the water.

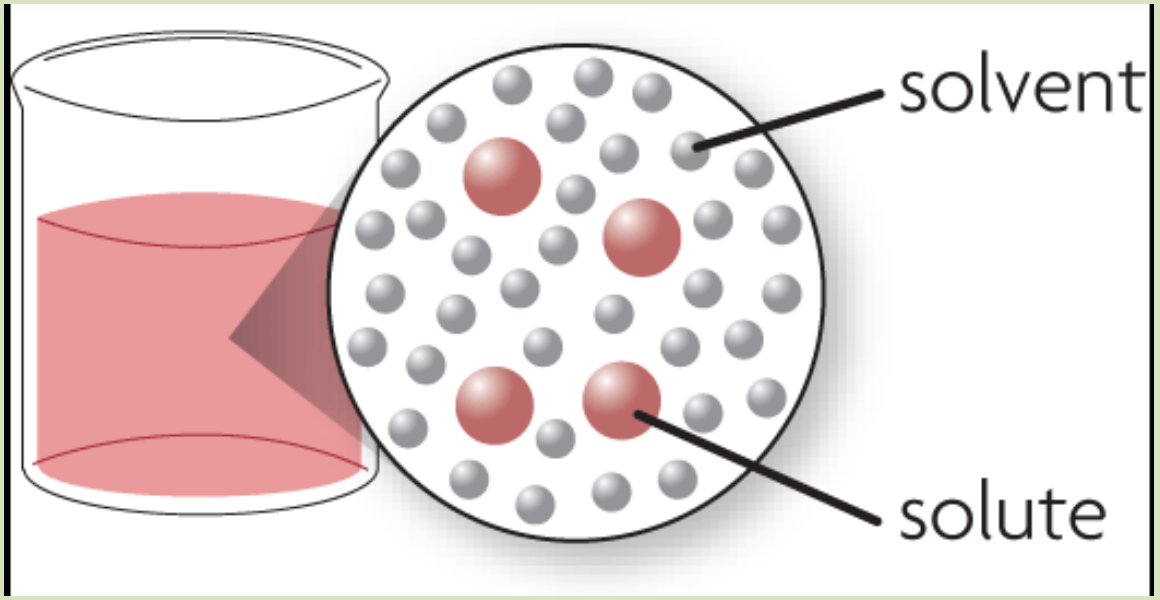
- Because of hydrogen bonding, water has a greater ability to _____resist temperature change_____than other liquids … this helps prevent overheating in living organisms
- Heat must be absorbed to break hydrogen bonds (e.g., like when body heat is absorbed to break hydrogen bonds that allow the water in sweat to _____evaporate_____)



- In summary, WATER is crucial for life to exist for many reasons

The chemistry of life happens in liquid **solutions**

- Most substances dissolve in the **water** in your body
- A **solution** is a liquid mixture of substances that is the **same** throughout
- The **solvent** **dissolves** another substance
- The **solute** is what is dissolved by the **solvent** and is evenly spread throughout the liquid

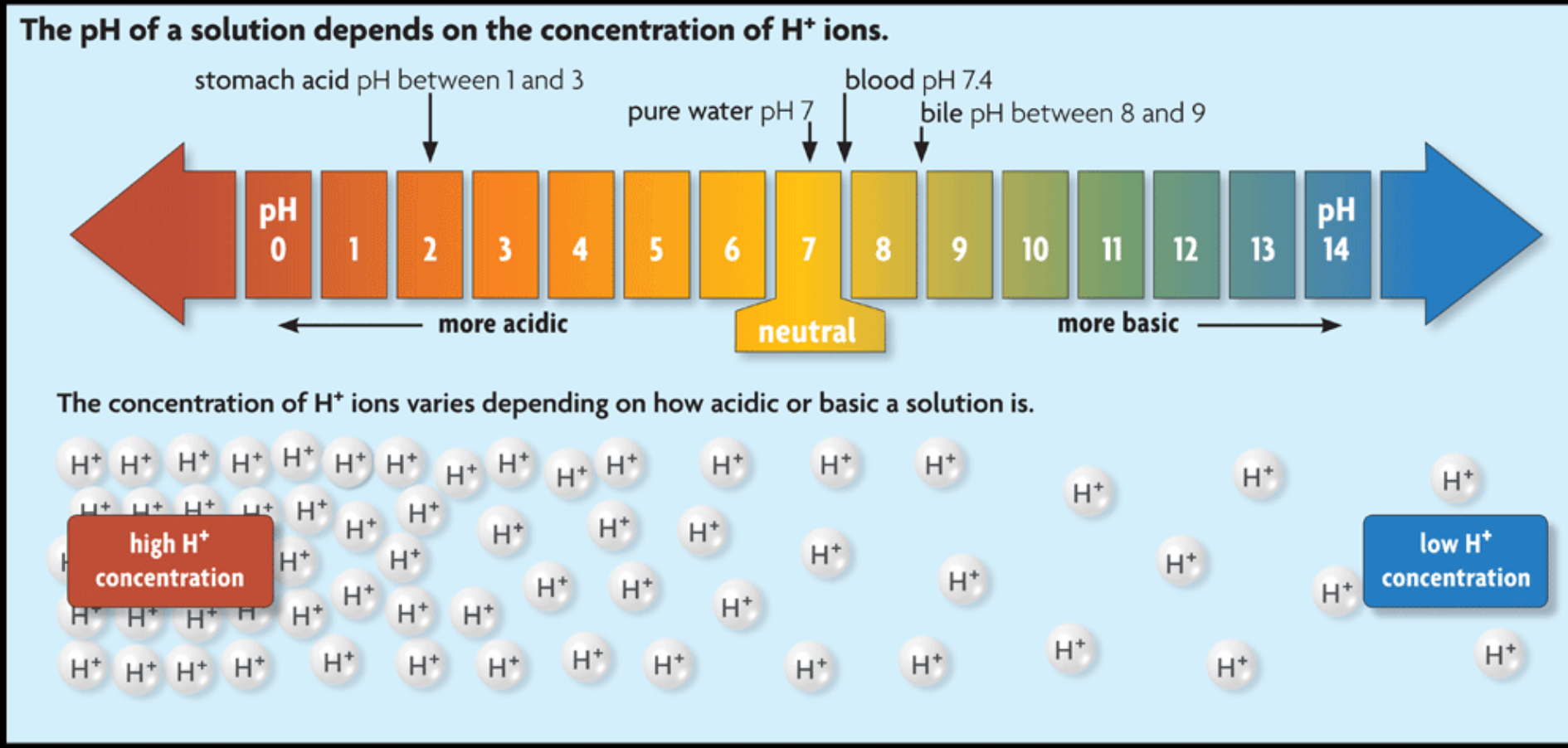


The chemistry of life follows the **general solubility rule**:

- ___LIKE___ dissolves ___LIKE___
- Polar water will dissolve other materials that are also ___polar___ or have strong ___charges___
- Examples?
- Nonpolar substances will only dissolve in other ___nonpolar___ solvents
- Examples?

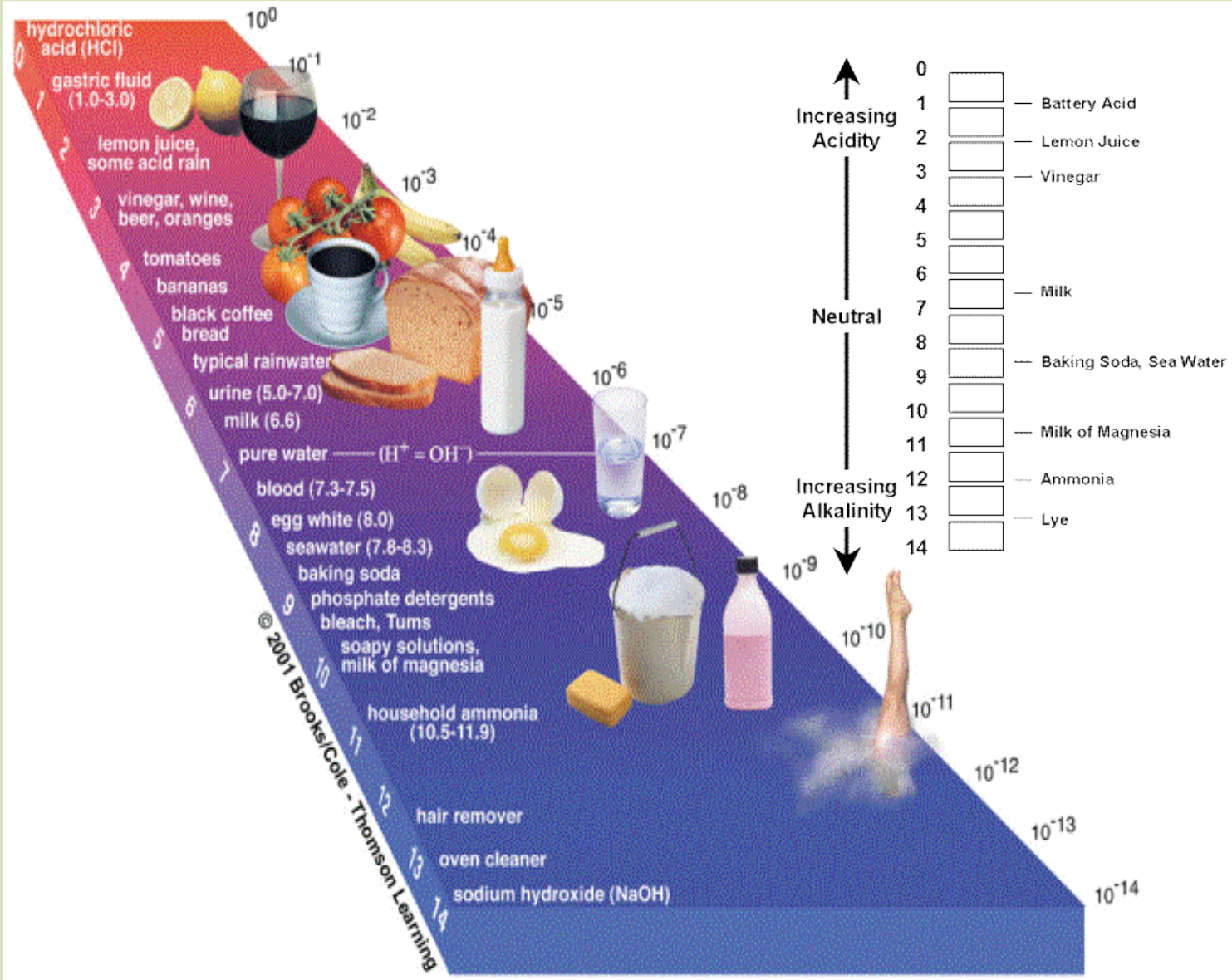
The chemistry of life is sensitive to the **pH** of the solution

- **Acids** and **Bases**:
- **Acids** :
  - taste sour
  - corrosive to metals
  - form hydrogen ions (**H+**) in water
  - become less acidic when mixed with **bases**.
  - **0 → 6** on the pH scale
  - Examples: **HCl** (hydrochloric acid found in the stomach)
- **Bases** :
  - feel slippery
  - Form hydroxide ions (**OH-**) in water
  - become less basic when mixed with **acids**
  - **8 → 14** on the pH scale
  - Examples: **NaOH** (sodium hydroxide)



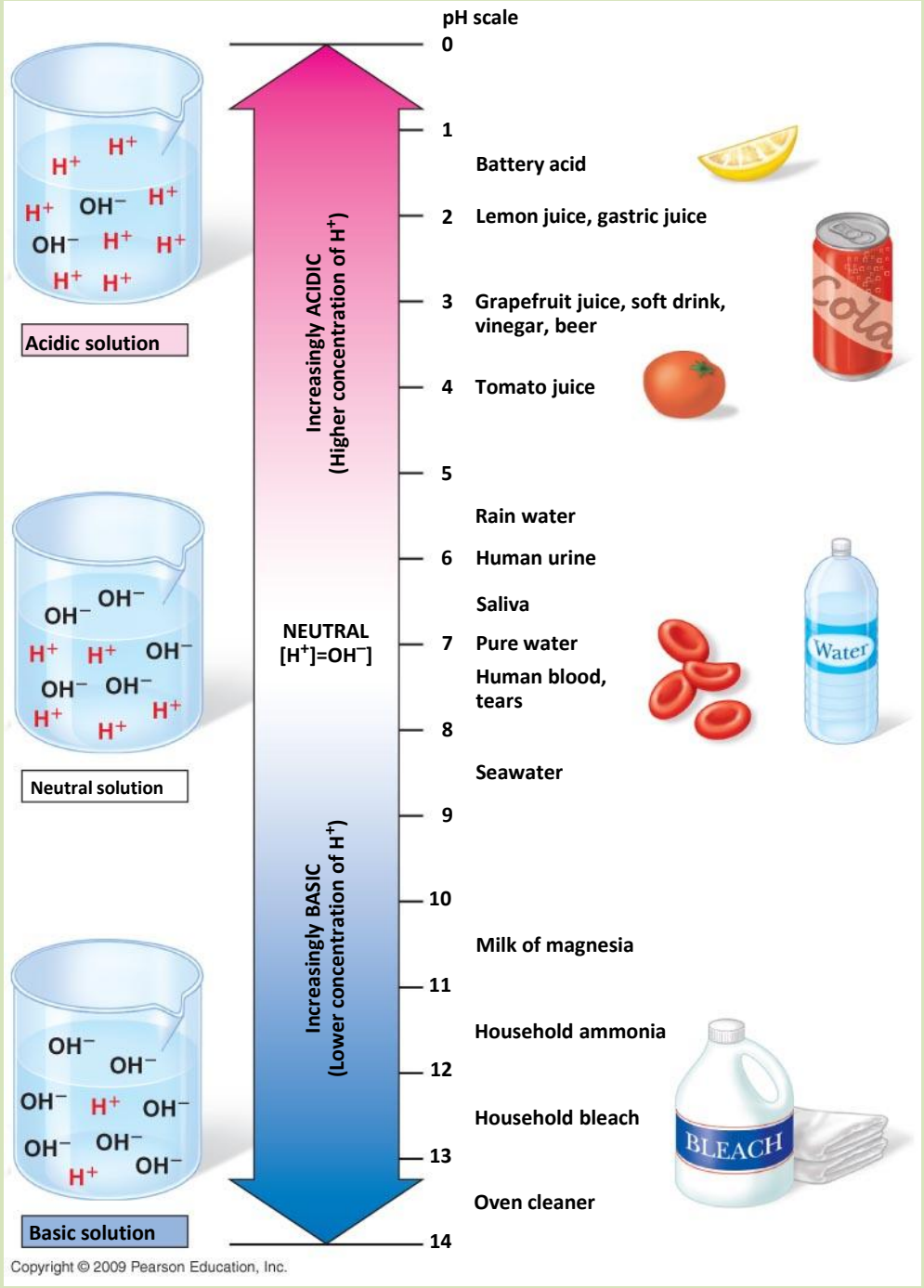
pH Scale

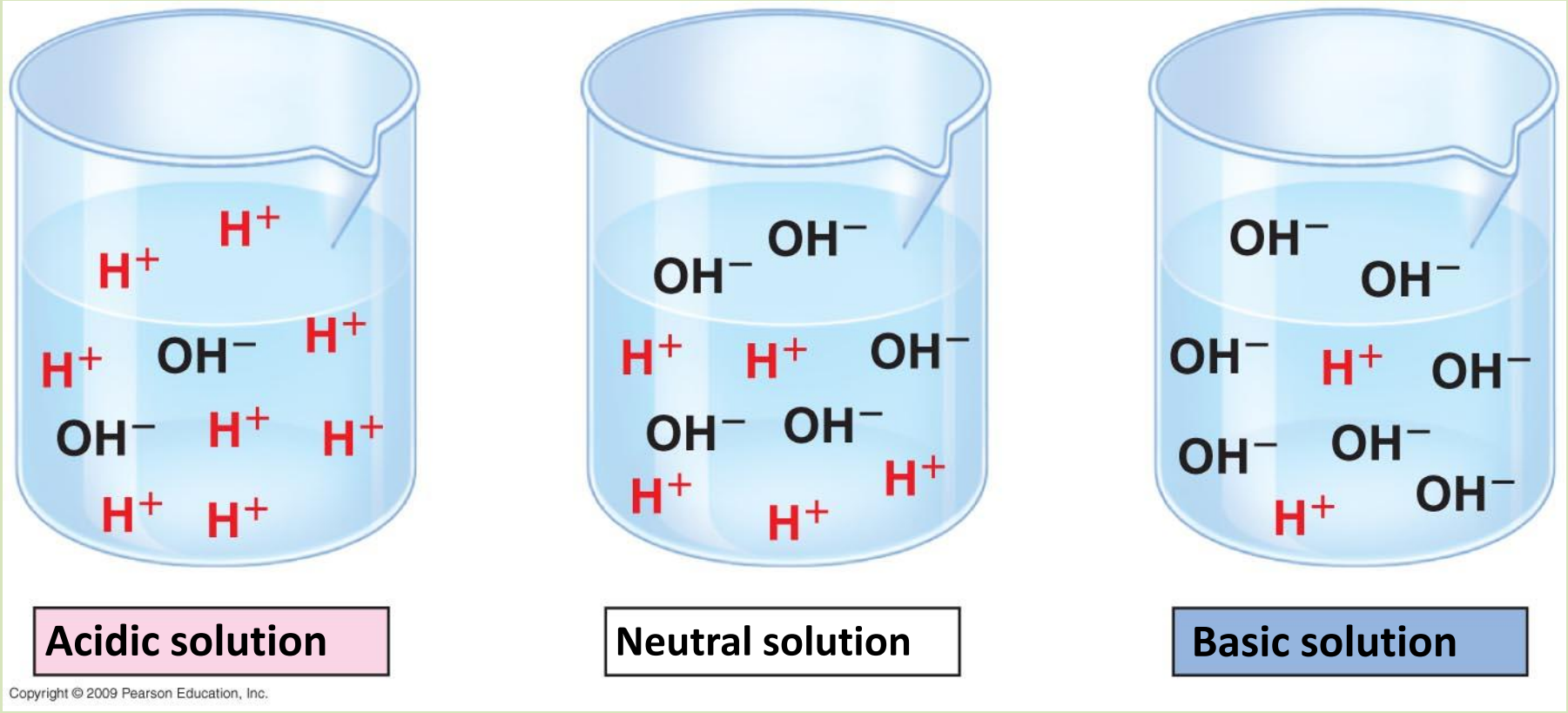
The pH of a solution depends on the concentration of H ions.


hydrochloric acid (HCl)
gastric fluid (1.0-3.0)
lemon juice, some acid rain
vinegar, wine, beer, oranges
tomatoes
bananas
black coffee
bread
typical rainwater
urine (5.0-7.0)
milk (6.6)
pure water
$(H^+ = OH^-)$
blood (7.3-7.5)
egg white (8.0)
seawater (7.8-8.3)
baking soda
phosphate detergents
bleach, Tums
soapy solutions, milk of magnesia
household ammonia (10.5-11.9)
hair remover
oven cleaner
sodium hydroxide (NaOH)
10^0 10^{-1} 10^{-2} 10^{-3} 10^{-4} 10^{-5} 10^{-6} 10^{-7} 10^{-8} 10^{-9} 10^{-10} 10^{-11} 10^{-12} 10^{-13} 10^{-14}
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Increasing Acidity
Neutral
Increasing Alkalinity
Battery Acid
Lemon Juice
Vinegar
Milk
Baking Soda, Sea Water
Milk of Magnesia
Ammonia
Lye
© 2001 Brooks/Cole - Thomson Learning

pH Scale

pH Scale





Lets Review Why Water is so IMPORTANT

- Because living organisms are ~ 70 % water, understanding the chemistry of water is important toward understanding how living things work.

Water is important to cells in the following ways:

- Keeps the body **temperature** from changing very quickly (i.e., water is slow to warm & slow to cool)
- Provides the right environment for **chemical reactions**
  - Holds dissolved **nutrients** needed by the cell
  - Can change **pH** to help different enzymes work correctly
- Often a **reactant** in many chemical reactions
- Provides hydration that keeps cells turgid and **full of water**
- Hydrogen bonding helps **proteins** fold in the correct shape

Ice floats in liquid water … **WHY?**