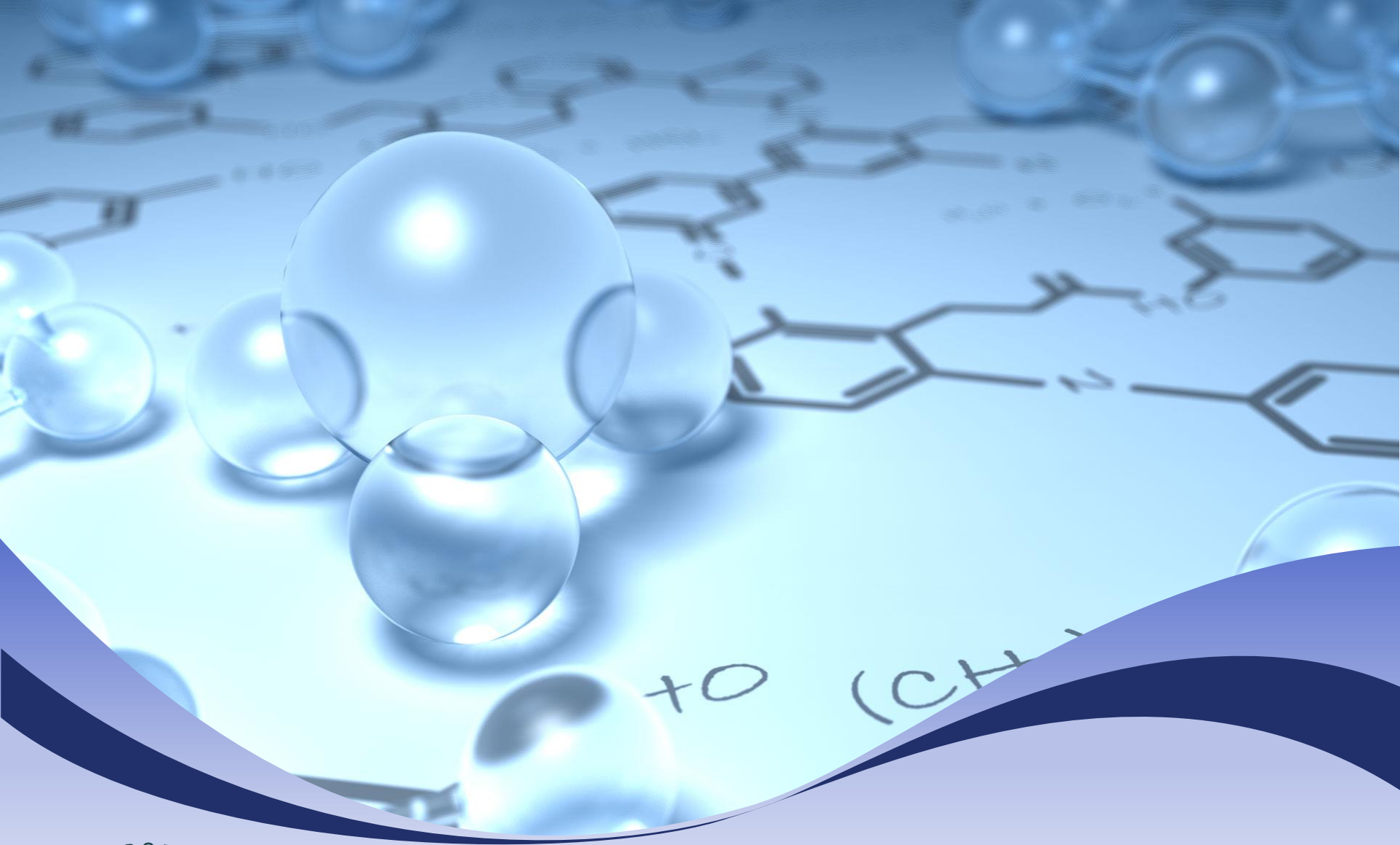


Basic Water Chemistry

Rain Drops to Well Water

Today's Topics

1. The Water Molecule
2. The Water Cycle
3. Drinking Water Contaminants
4. Aggressive Water

Building Blocks of EVERYTHING!

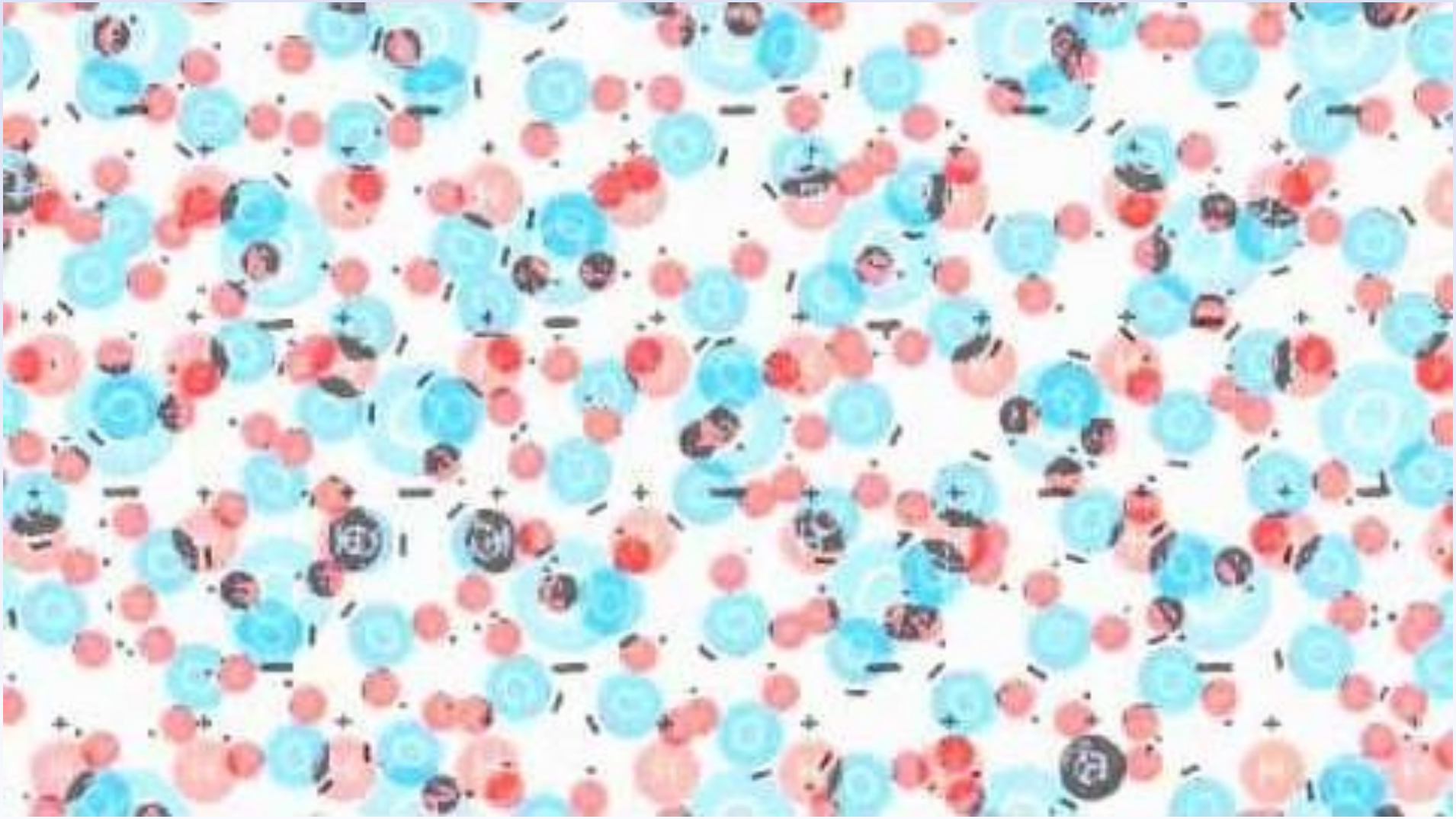
Atoms –Smallest Unique Particle of Matter

Elements –All of the atoms are the same

Molecule –two or more atoms chemically joined(the same or different)

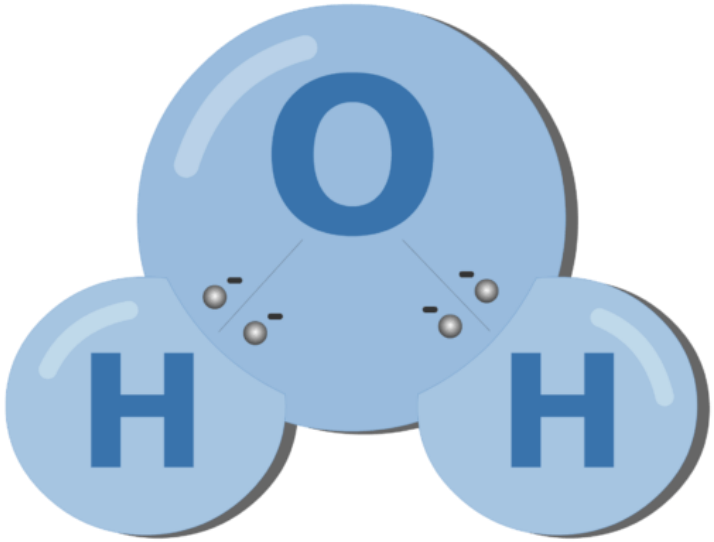
Compound –two or more atoms of different elements chemically joined

Mixture –two or more elements or compounds not chemically joined.

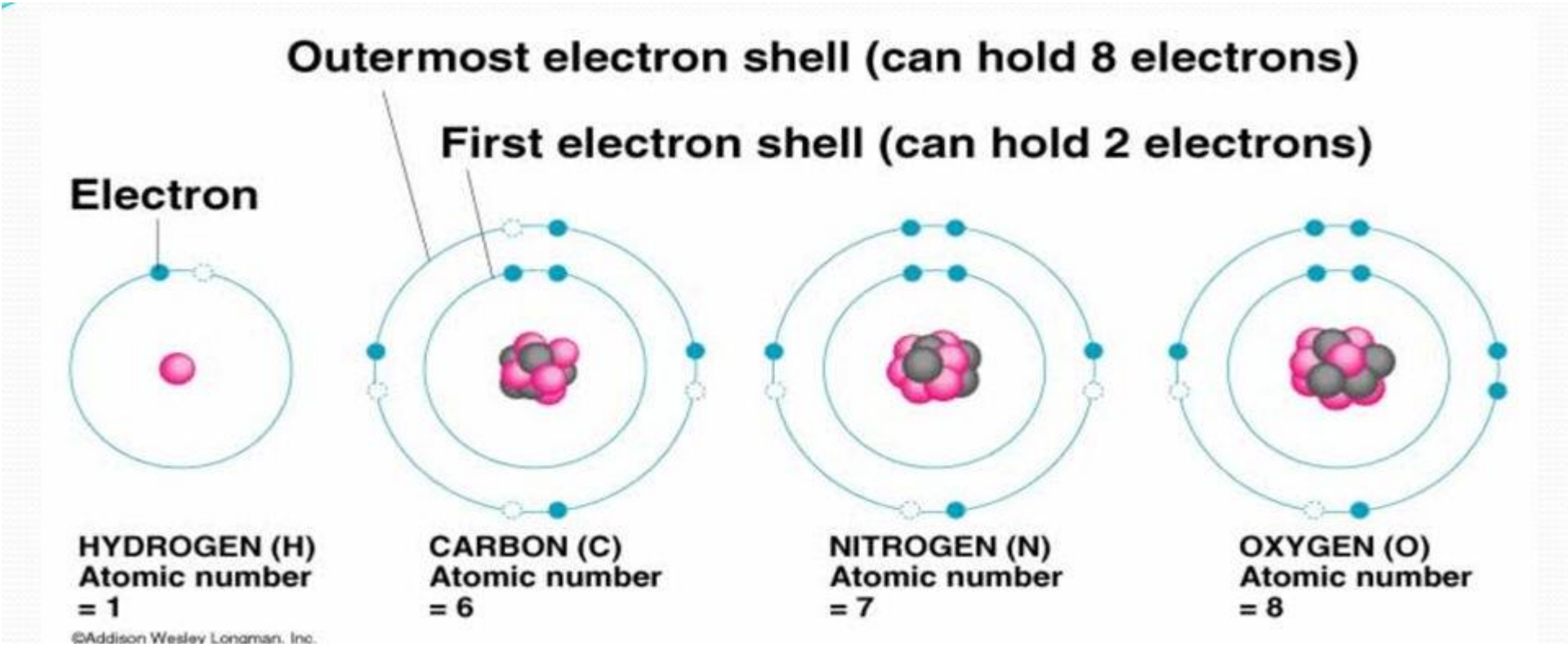


Water **Structure**

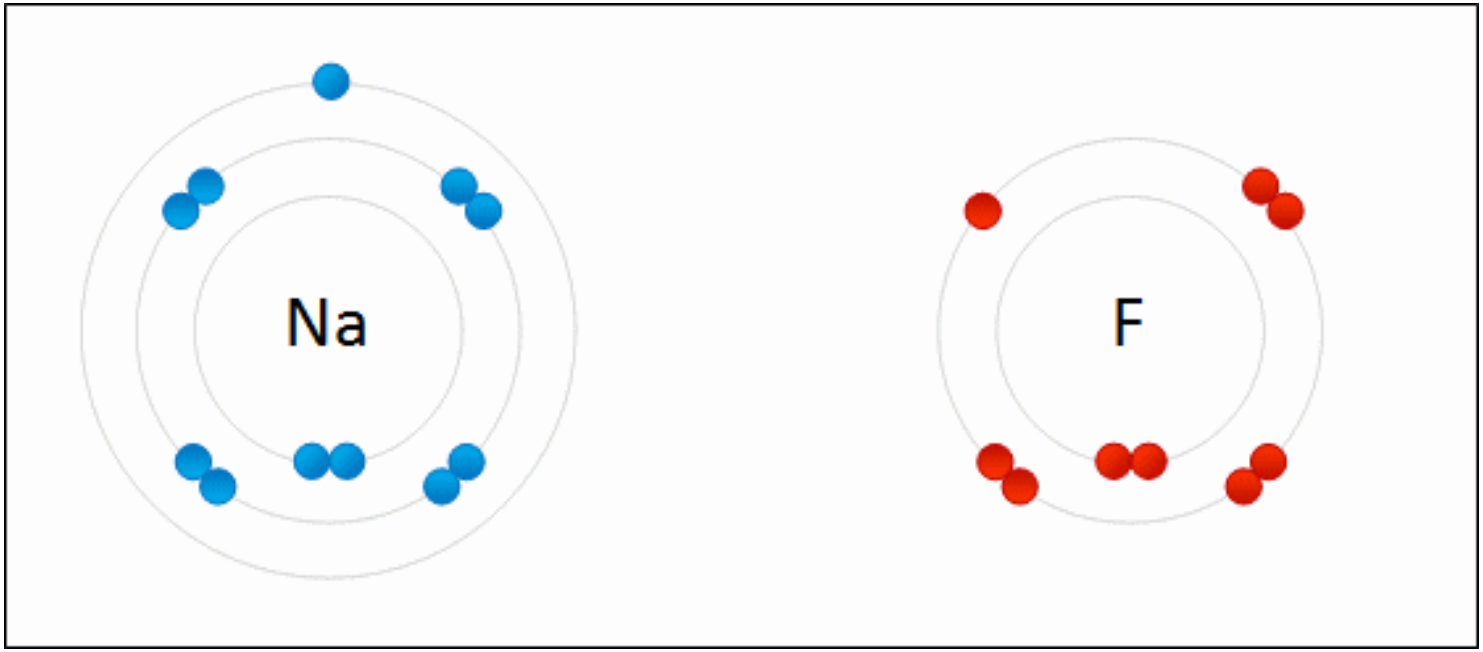
Water can either be called a molecule or a compound. It is known as H20 because it has two hydrogen atoms bonded to an oxygen atom



Electron **Shells**

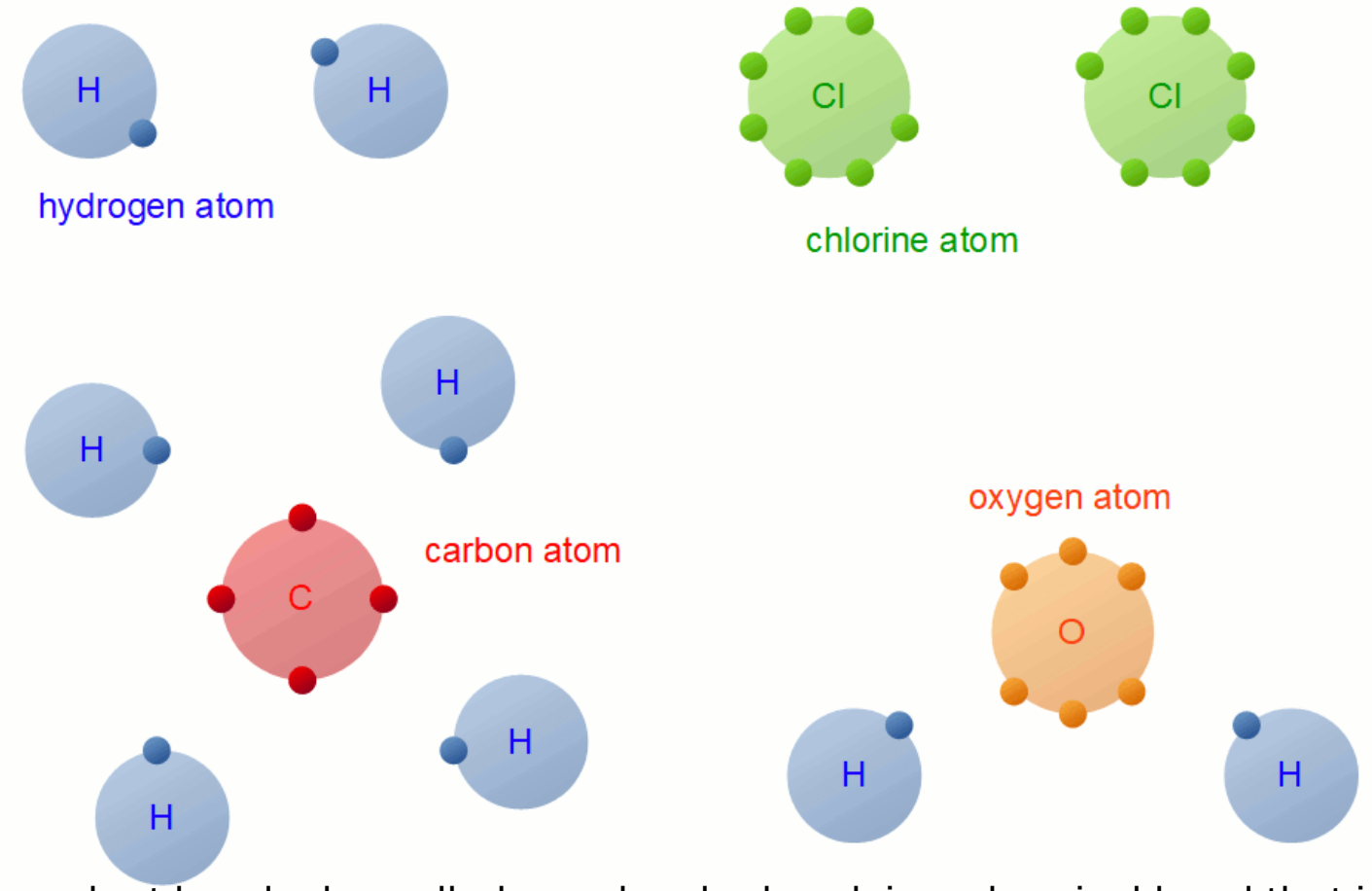


Types of **Bonds - IONIC**



Ionic bonds are formed between a cation, which is usually a metal, and an anion, which is usually a nonmetal. The attraction of oppositely charged atoms and the transfer of electrons leads to the formation of an ionic compound. In this case, Sodium Fluoride.

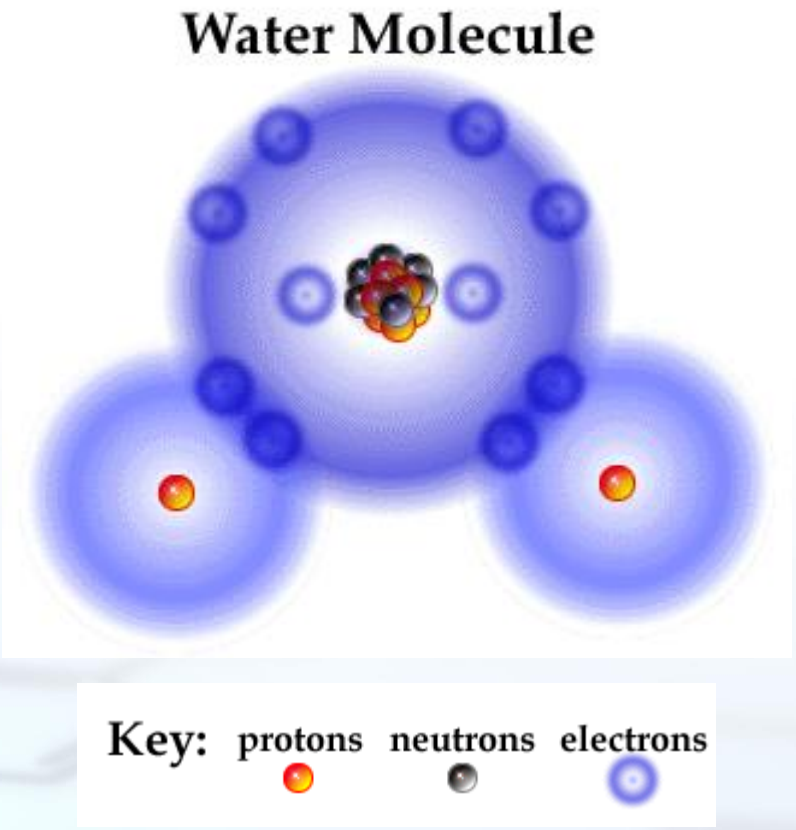
Types of **Bonds - Covalent**



A covalent bond, also called a molecular bond, is a chemical bond that involves the sharing of electron pairs between atoms

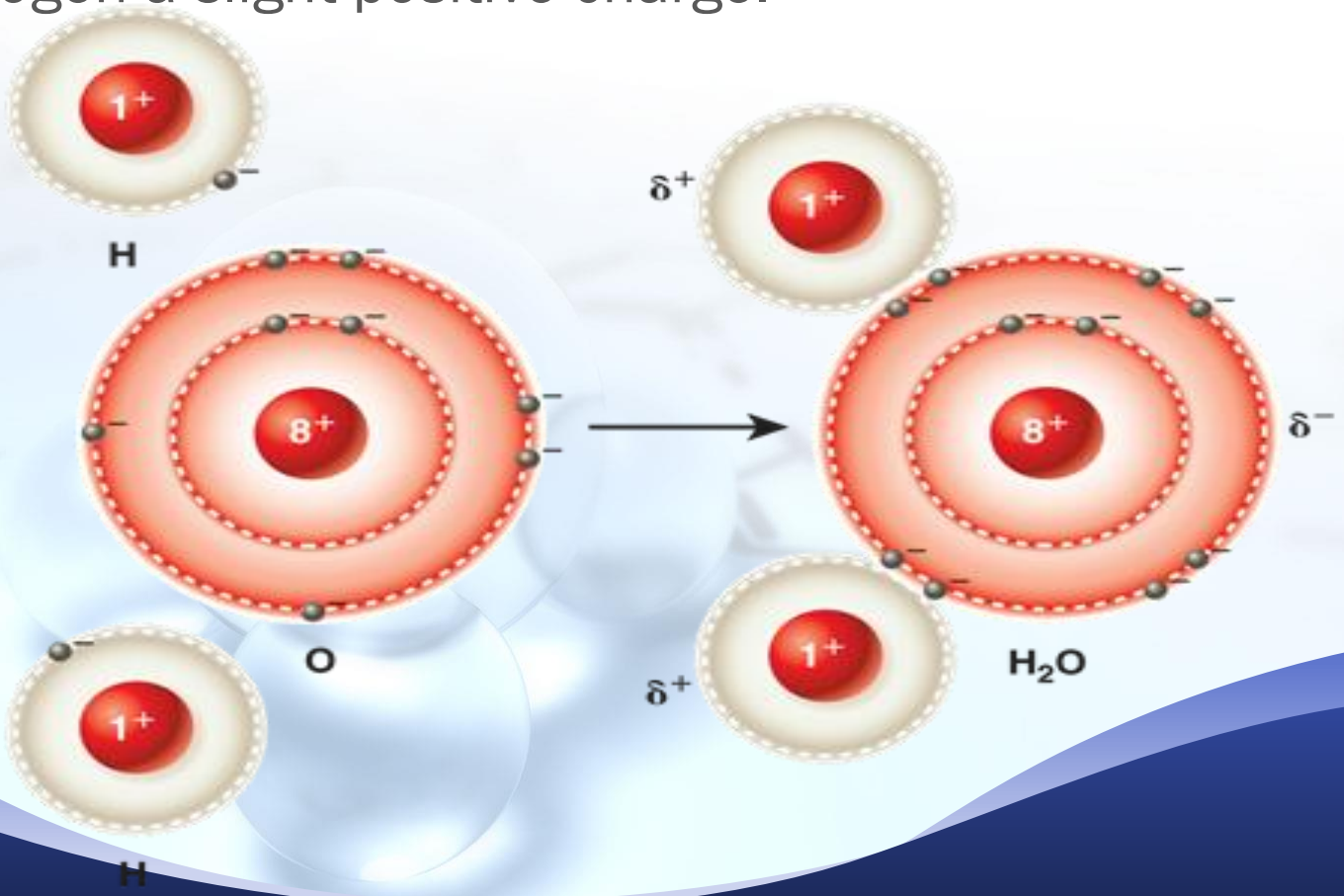
Hydrogen and oxygen atoms “share” electrons.

- Hydrogen has only one electron
- Oxygen has eight electrons
  - 2 in the inner shell
  - 6 in the outer shell
- “Sharing” forms new bonds



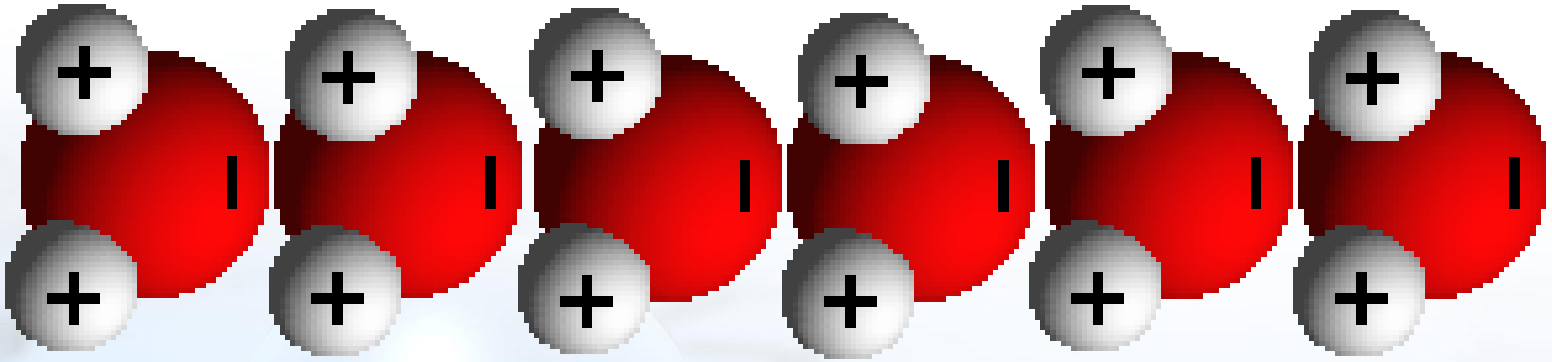
Water Molecules are polar

The shard electrons spend more time near the oxygen atom. This gives oxygen a slight negative charge and each hydrogen a slight positive charge.



Water Molecules are polar

Polar molecules tend to line up with each other.

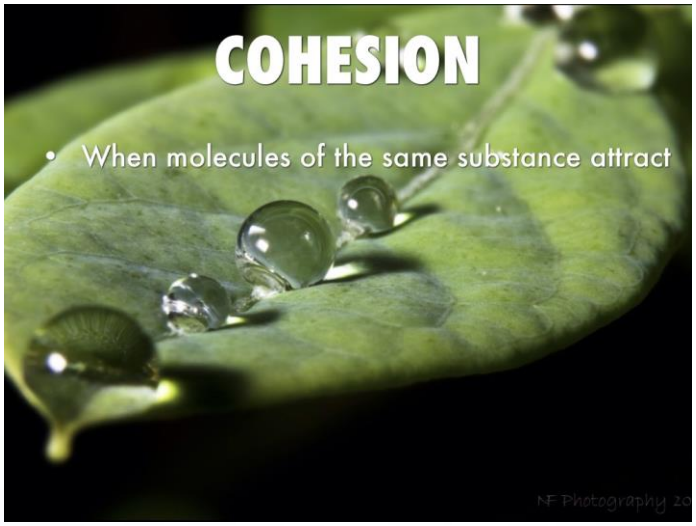


The hydrogen (positive) end of one water molecule will bond with the oxygen (negative) end of another water molecule and that positive end to the negative end of yet another. (as do magnets)

Water is essential to life because of four important properties.

Cohesion

- Cohesion causes water molecules to be drawn together, which is why drops of water form beads on a smooth surface.



- Cohesion also produces surface tension, explaining why some insects and spiders can walk on a pond's surface.

Adhesion

- **Adhesion** is an attraction between molecules of different substances.

Density of Water

Most dense at 4°C

Contracts until 4°C

Expands from 4°C to 0°C

The density of water:

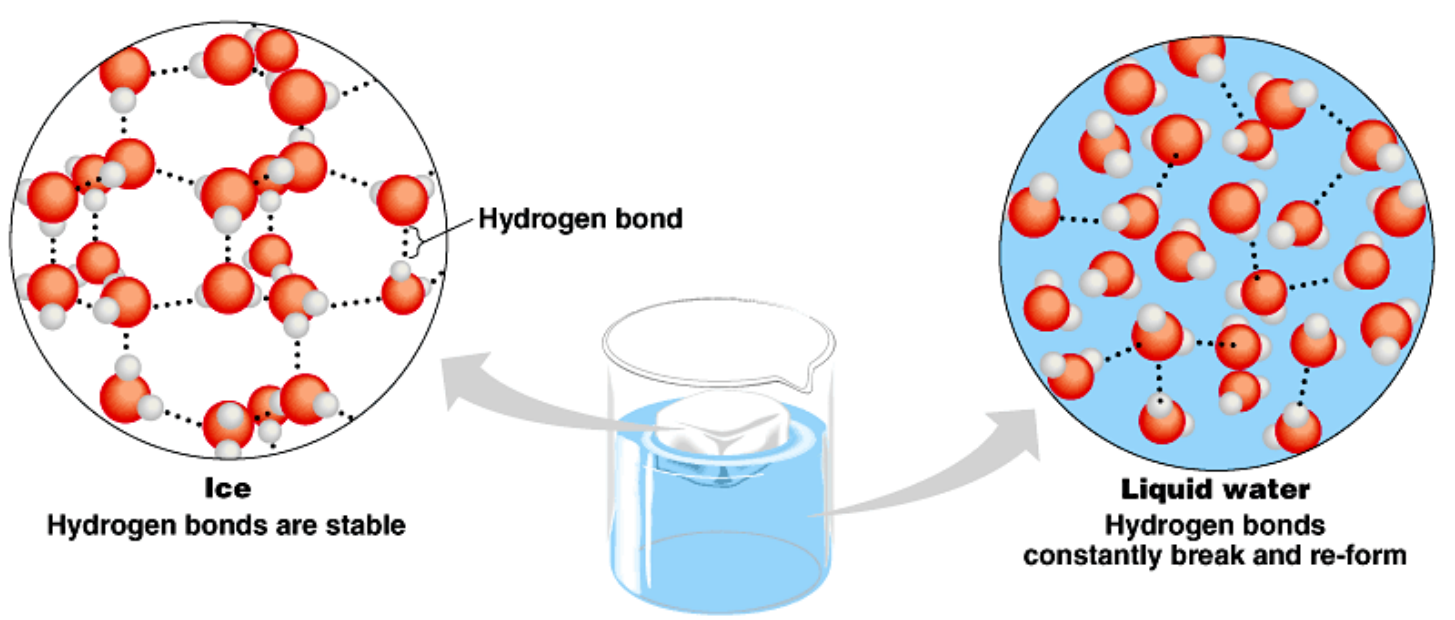
1. **Prevents water from freezing from the bottom up.**
2. **Ice forms on the surface first—the freezing of the water releases heat to the water below creating insulation.**
3. **Makes transition between season less abrupt.**

Density of Water

When water reaches 0°C, water becomes locked into a crystalline lattice with each molecule bonded to to the maximum of four partners.

As ice starts to melt, some of the hydrogen bonds break and some water molecules can slip closer together than they can while in the ice state.

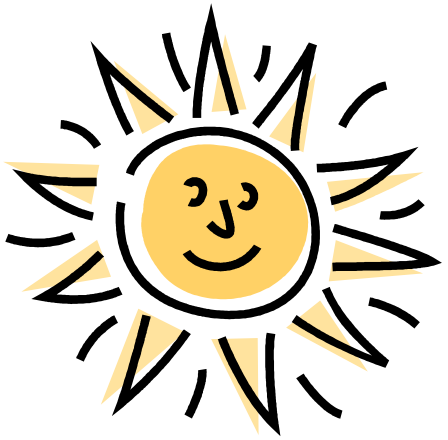
Ice is about 10% less dense than water at 4°C.

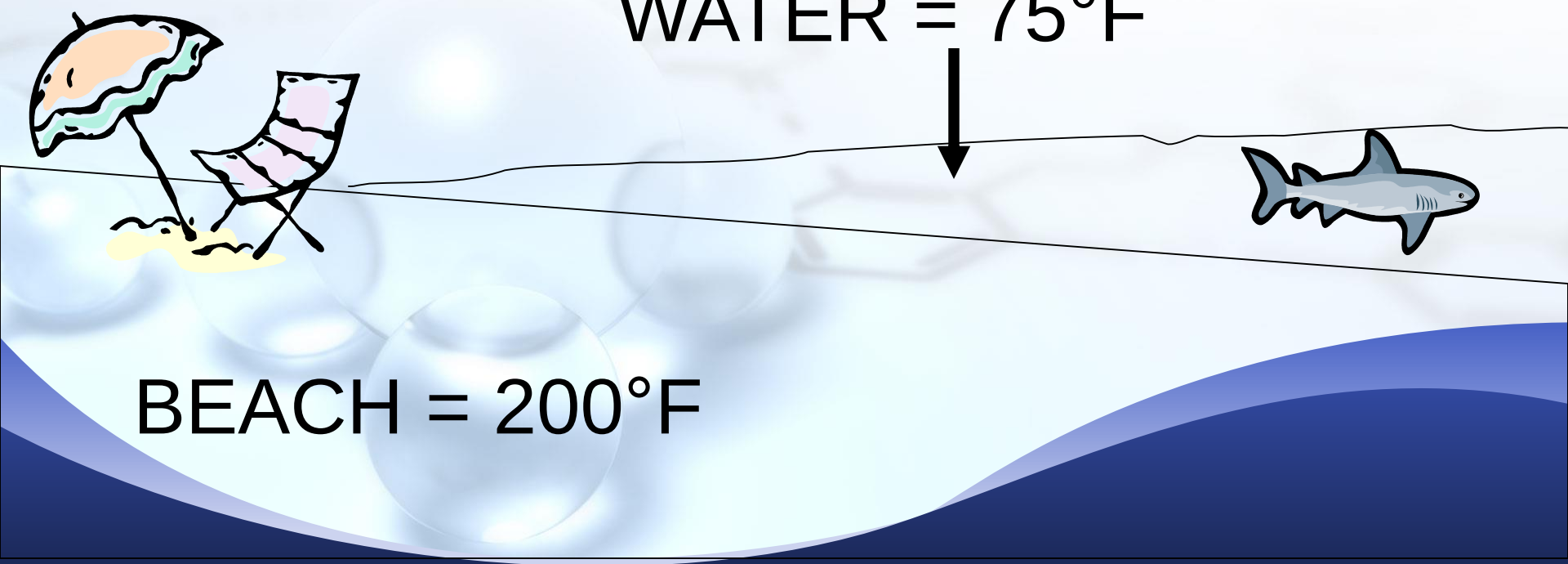


SPECIFIC HEAT

- Specific Heat = the amount of energy needed to increase the temperature of something 1 degree C.
- Water has a really HIGH specific heat
- That means it takes a lot of energy for water to increase its temperature.
- This is because of the STRONG ATTRACTION between water molecules.

SPECIFIC HEAT





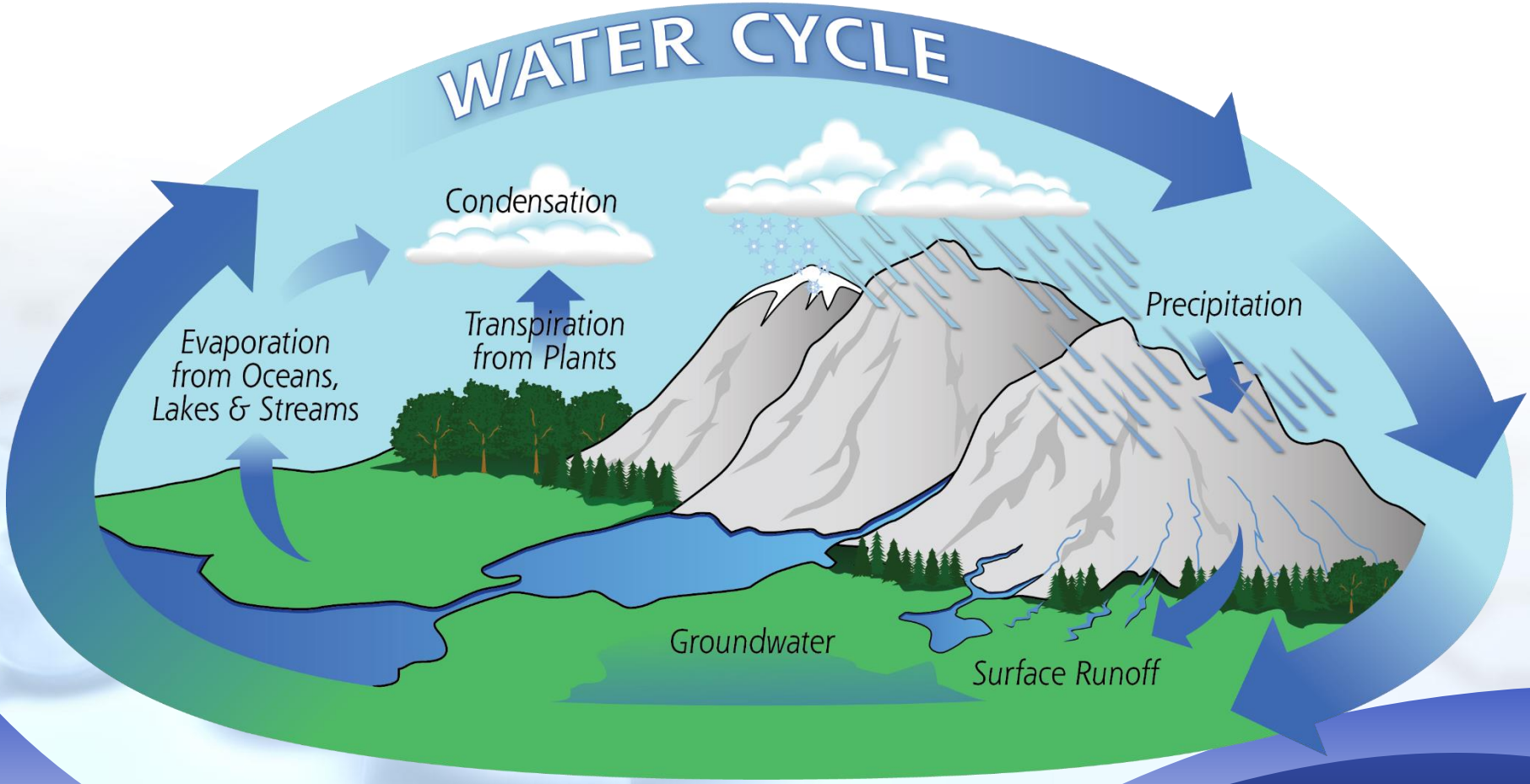
Universal **Solvent**

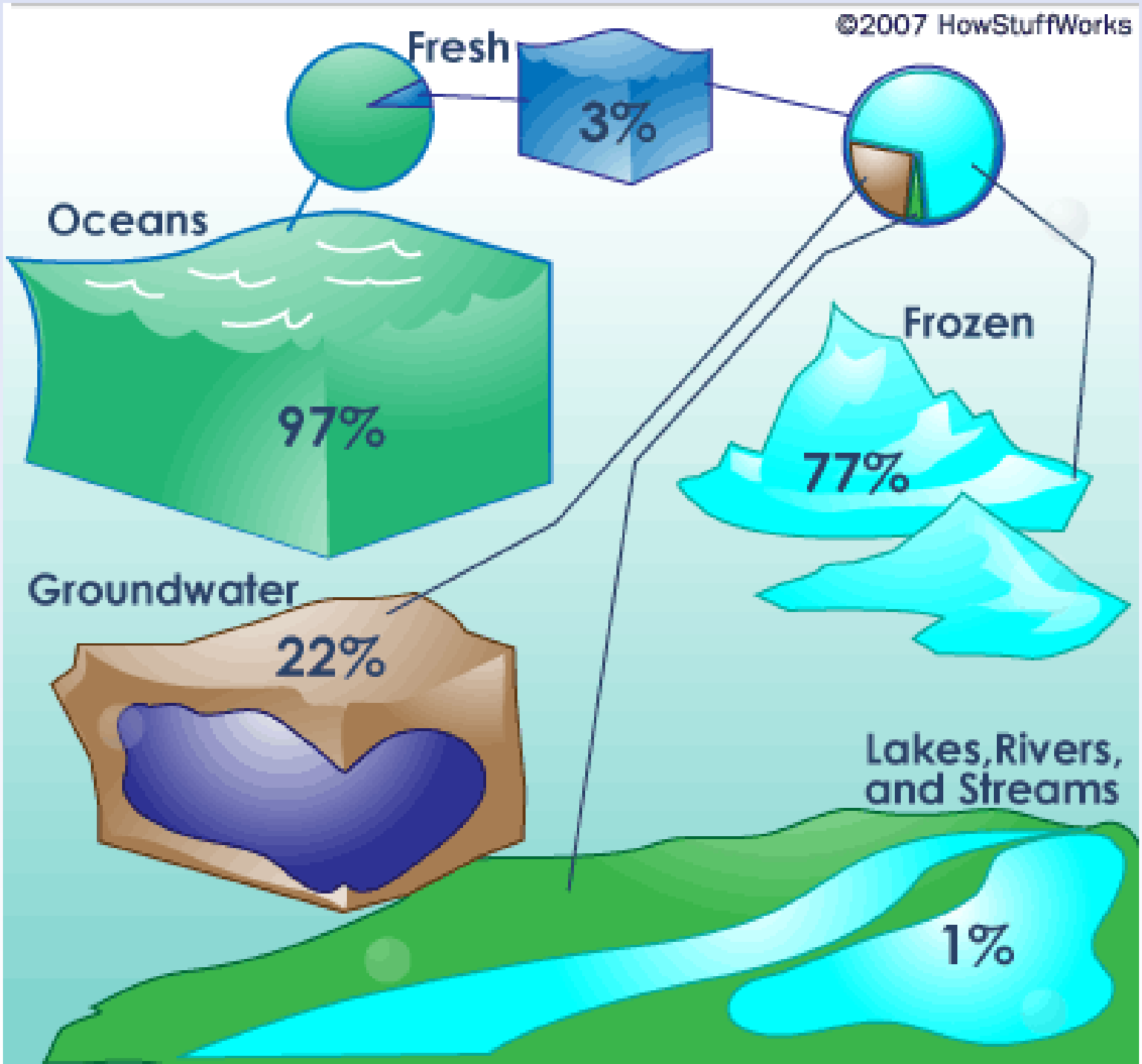
- We need to take the statement "Water is the universal solvent" with a grain of salt (pun intended).
- Of course it cannot dissolve everything, but it does dissolve more substances than any other liquid.
- It means that wherever water goes, either through the air, the ground, or through our bodies, it takes along valuable chemicals, minerals, and nutrients.

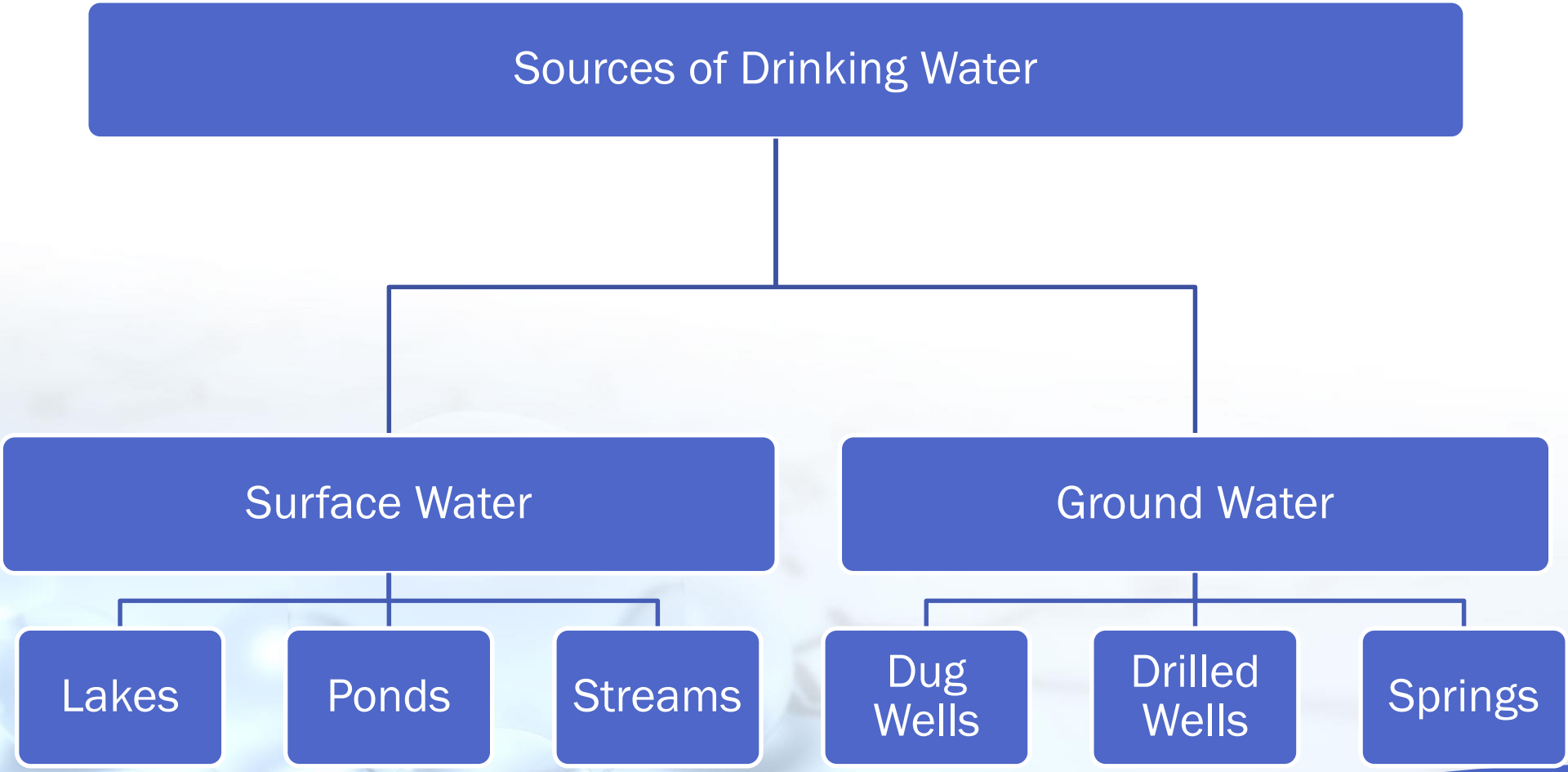
Questions?

More Information?

The Water **Cycle**



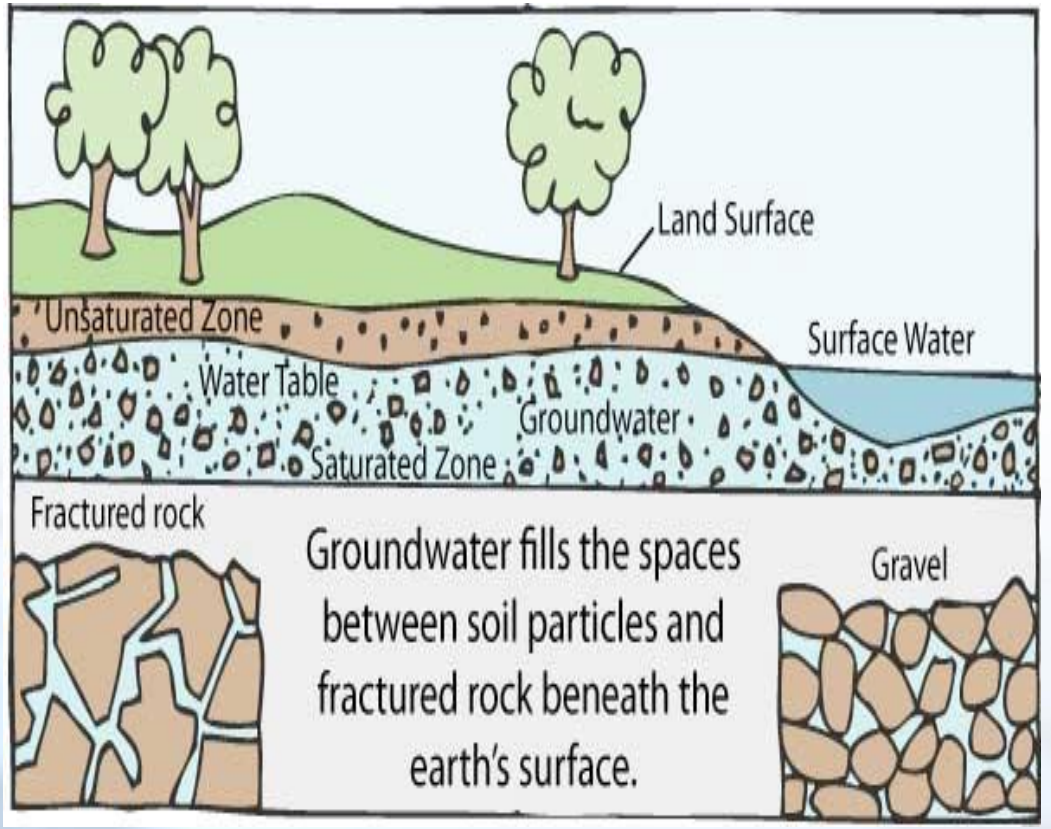

©2007 HowStuffWorks
Fresh
3%
Oceans
97%
Frozen
77%
Groundwater
22%
Lakes, Rivers, and Streams
1%


Sources of Drinking Water
Surface Water
Ground Water
Lakes
Ponds
Streams
Dug Wells
Drilled Wells
Springs

Groundwater

What is groundwater?

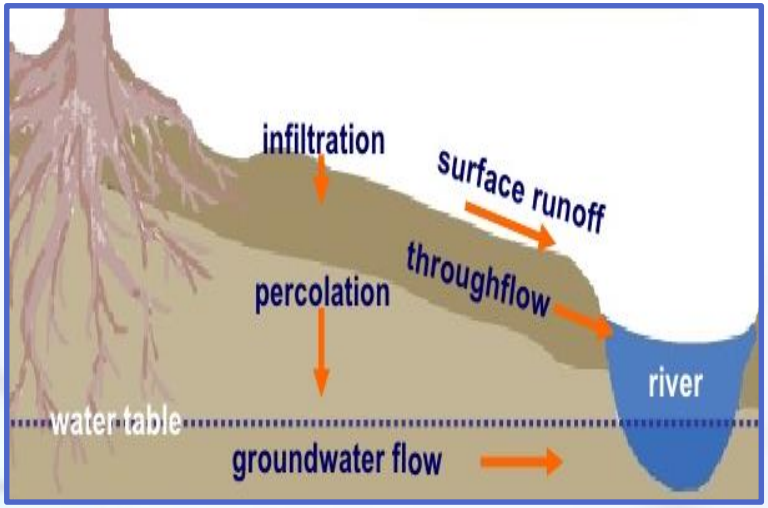
How is it transported below Earth's surface?



Groundwater Flow

Infiltration – when the water enters the soil surface after falling from the atmosphere.

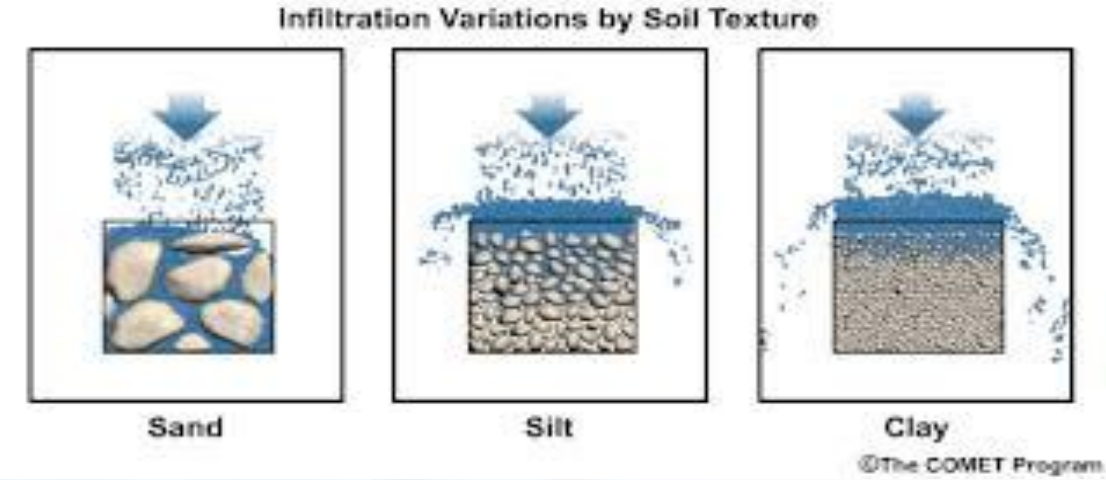
Percolation – the downward movement of water from the land surface into soil or porous rock.



Porosity and Permeability

How water infiltrates and percolates through the ground depends on what it is flowing through.

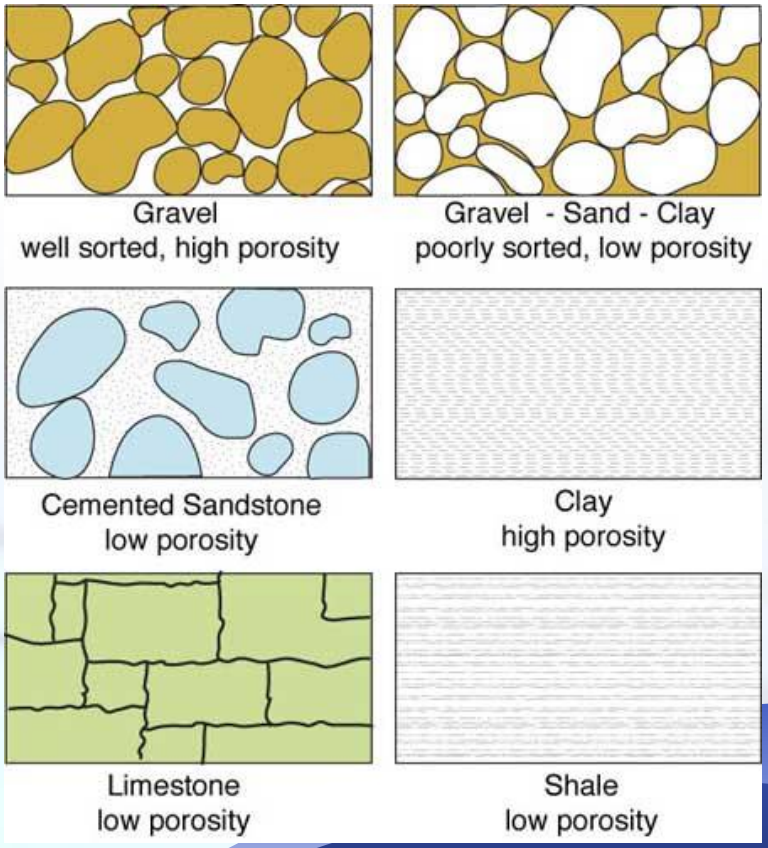
Porosity



The percent of rock or sediment that consists of open space is **porosity.** Groundwater moves through the **spaces** between soil particles. These spaces are called **pores**.

Pore Space

Porosity:
determines the **total amount** of water a material will hold.
depends on the **number** and **size of pores** in soil.
Sandy soils drain well but do not retain water.
Clay soils hold water but do not drain easily.

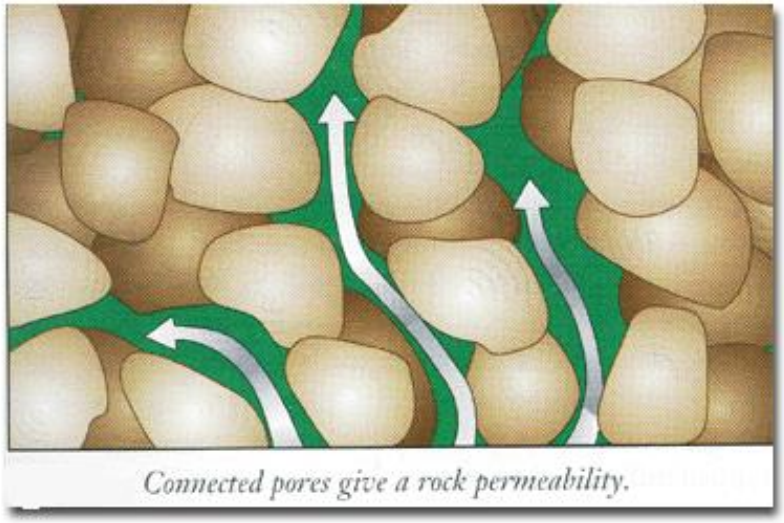


Permeability

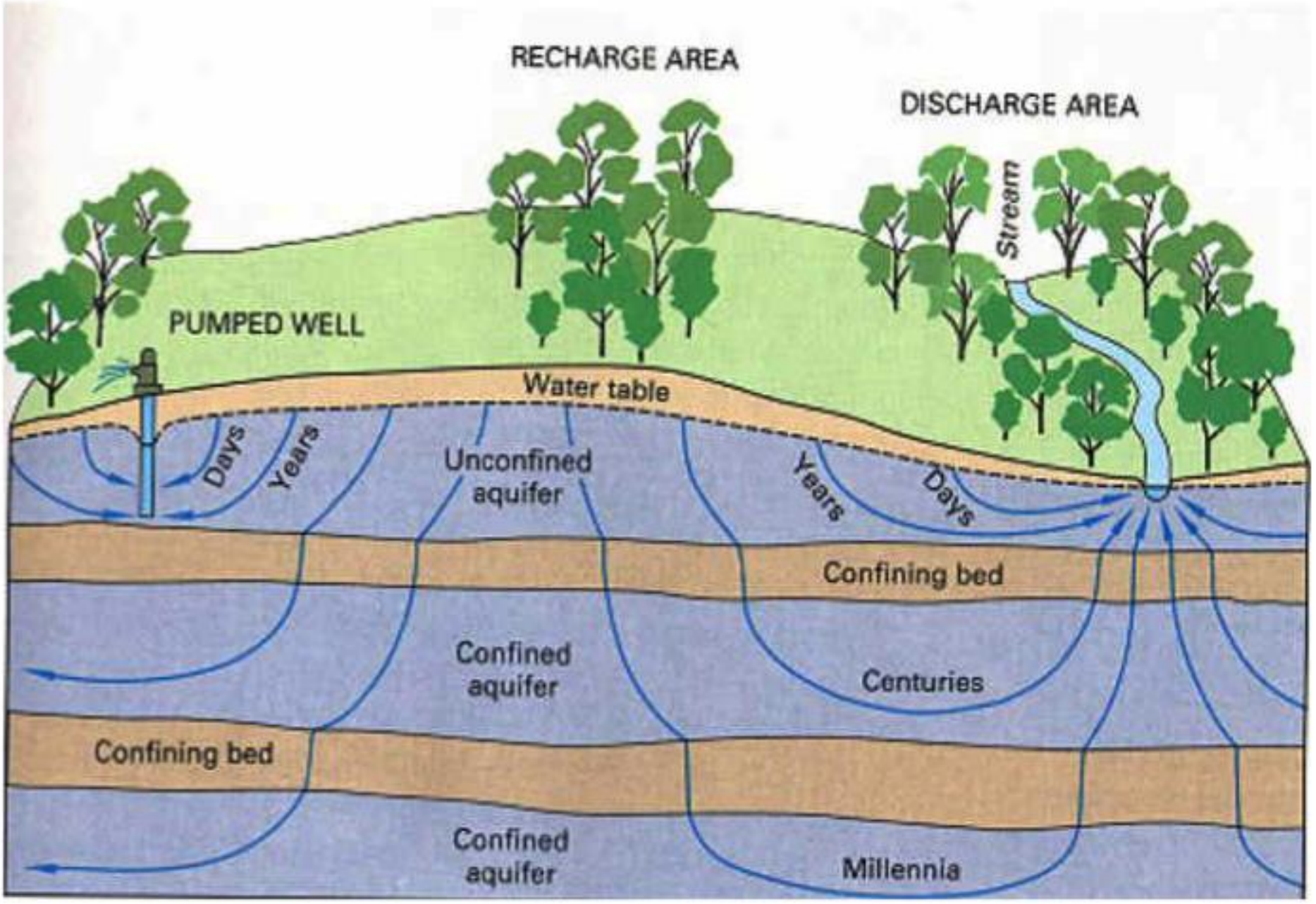
The ease with which water passes through a porous material is **permeability.**

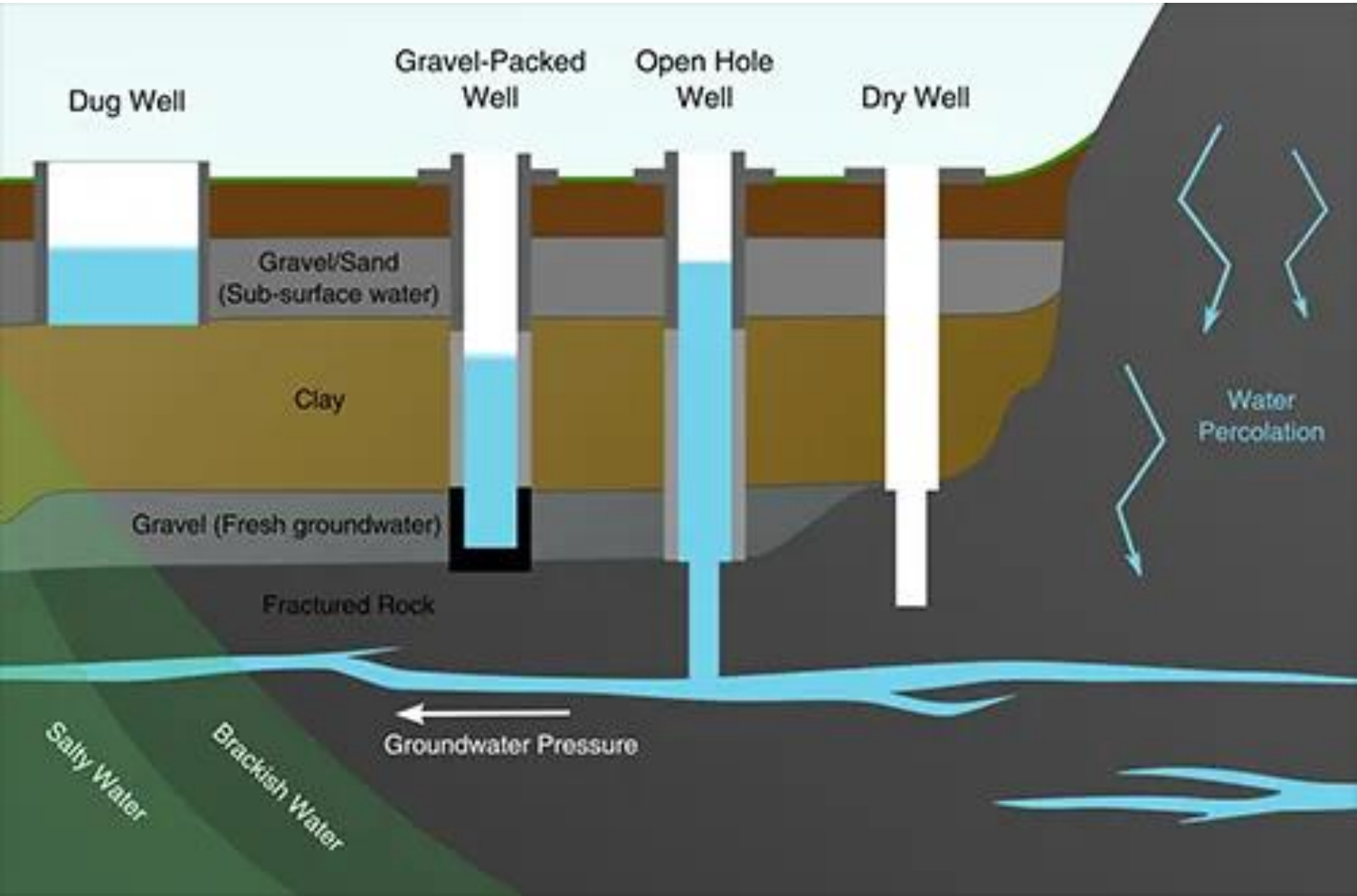
Factors affecting permeability include:

- How **large the pores** in the substance are.
- How well the particles **fit together.**
- The size and sorting of the particles.



Connected pores give a rock permeability.


RECHARGE AREA
DISCHARGE AREA
Stream
PUMPED WELL
Water table
Days
Years
Unconfined aquifer
Years
Days
Confining bed
Confined aquifer
Centuries
Confining bed
Confined aquifer
Millennia


Dug Well
Gravel-Packed Well
Open Hole Well
Dry Well
Gravel/Sand (Sub-surface water)
Clay
Gravel (Fresh groundwater)
Fractured Rock
Water Percolation
Groundwater Pressure
Salty Water
Brackish Water

Heavy Metals

Elements or compounds found in water supplies and may be natural in the geology or caused by activities of man through mining, industry or agriculture

It is common to have trace amounts of many inorganic Contaminants in water supplies these are found in our bedrock.

Nitrate & **Nitrite**

These are compounds that are present in chemical fertilizers, human sewage, and animal waste and fertilizers.

They can contaminate a private well or surface water source through groundwater movement and surface water seepage and water run-off.

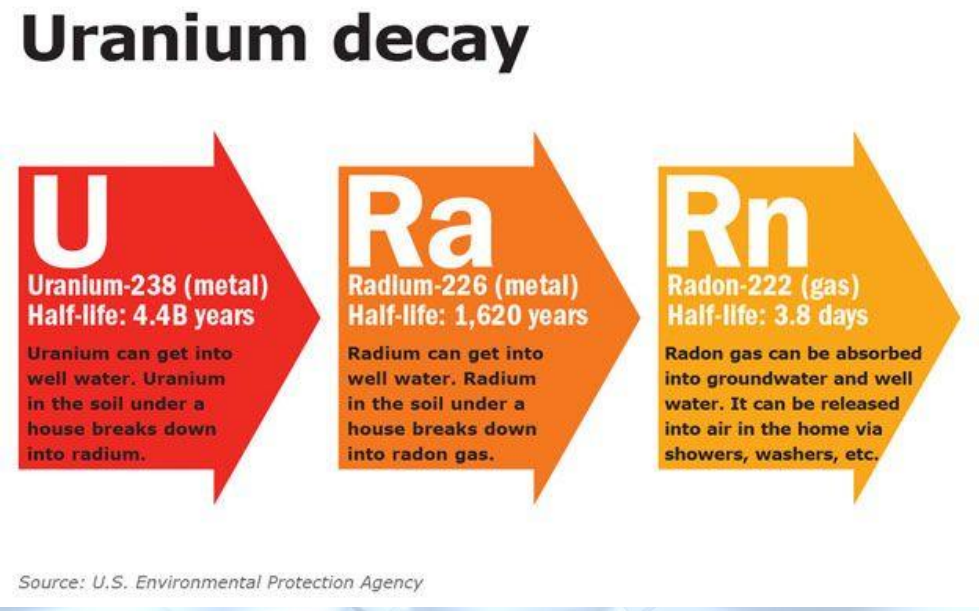
Organic Chemicals

Organic Chemicals are carbon-containing compounds that evaporate easily from water into air at normal air temperatures. Organic Contaminants are used as pesticides, defoliants, fuel additives and as ingredients for other organic compounds.

VOCs & SOCs are generally man-made products including fuel oils, gasoline, solvents, cleaners and degreasers, paints, inks, dyes, refrigerants and pesticides.

Radionuclides

Radionuclides are radioactive isotopes that can occur naturally or result from manmade sources. Natural radiation comes from cosmic rays, naturally-occurring radioactive elements in the earth's crust, and radioactive decay products.



Typical radionuclides found in drinking water sources are isotopes of radium, uranium, and radon that are naturally occurring on our bedrock.

Microorganisms

Various types of bacteria/viruses are categorized as pathogens, disease-causing organisms that can be found in pretreated and/or inadequately treated water.

Coliforms are bacteria naturally present in the environment and used as indicators that other possibly harmful bacteria may be present. E. coli and fecal coliform are bacteria whose presence can indicate water contaminated by human or animal wastes

What is **Corrosion?**

- Corrosion is a complex series of reactions between the water and metal surfaces and materials in which the water is stored or transported.

- It is an oxidation/reduction reaction that returns refined or processed metal to their more stable ore state.

Corrosion is accelerated by?

Low pH or high pH

High velocity

High temperature

Dissolved solids, salts, sulfates, etc.

Suspended solids, sand, sediment, etc.

Bacteria and electrochemical reactions

Langalier Saturation Index (LSI)

Corrosivity is MUCH more complex than just pH!

$$LSI = pH(actual) - pH(saturation)$$

$$pH(s) = \text{Temperature factor} + \text{TDS factor} - \text{Hardness factor} - \text{Alkalinity}$$


pH
Calcium Hardness
Alkalinity
TDS
Temperature

pH

One chemical property of water that affects its ability to dissolve minerals and influence chemical reactions is its pH.

What does pH stand for?

"p" stands for potenz (power) or potential

"H" stands for Hydrogen

The measure of the abundance of positively charged hydrogen ions (H+)

Logarithmic Scale

- The pH scale is a logarithmic scale that usually runs from 1 to 14.
- Each whole pH value below 7 is ten times more acidic than the higher value
- Each whole pH value above 7 is ten times less acidic than the one below it.
-

Representative pH values	
Substance	**pH**
Hydrochloric acid	0
Lead-acid battery	0.5
Gastric acid	1.5 – 2.0
Lemon juice	2.4
Cola	2.5
Vinegar	2.9
Orange or apple juice	3.5
Tomato Juice	4.0
Beer	4.5
Acid Rain	<5.0
Coffee	5.0
Tea or healthy skin	5.0
Urine	6.0
Milk	6.5
Pure Water	7.0
Healthy human saliva	6.5 – 7.4
Blood	7.34 – 7.45
Seawater	7.7 – 8.3
Hand soap	9.0 – 10.0
Household ammonia	11.5
Bleach	12.5
Household lye	13.5

Signs of **Low pH**

- Blue/green staining with copper plumbing
- Leaks in plumbing
- Red or rust-colored staining with galvanized steel or cast-iron plumbing
- Corrosion and leaching
- Metal toxicity
- Sour taste
- Feels slippery

Signs of **High pH**

- Scale build up on fixtures and shower doors
- Reduced water flow
- Scale accumulation at the bottom of tank water heaters
- Bitter taste

Water Hardness

Generally, hard water deposits minerals and soft water dissolves them.

Water hardness between 60 and 120 mg/L as calcium carbonate ($CaCO_3$) may be beneficial for protecting pipes.

Term	Grains Per Gallon	ppm ~ mg/L
Soft	<1.0	<17.0
Slightly Hard	1.0 - 3.5	17.1-60.0
Moderately Hard	3.5 – 7.0	60.0- 120
Hard	7.0 – 10.5	120 – 180
Very Hard	>10.5	>1.80

Soft Water

Corrosion occurs because of the lack of dissolved cations, such as calcium and magnesium.

Hard Water

Creates a coating of calcium or magnesium carbonate on the inside of the pipes protecting it from corrosion.

Total Alkalinity

Total alkalinity is the measure of the buffering capacity of the water.

Buffers are weak acids and bases that are designed to resist rapid changes to pH; they contribute H+ ions (or absorb OH- ions) when a base is added and absorb H+ ions when an acid is added.

Major contributors to total alkalinity can stand on their own to protect pH, while minor contributors cannot. (They will still contribute to the overall total alkalinity reading.)

Major Contributors
Carbonates
Bicarbonates
Hydroxides

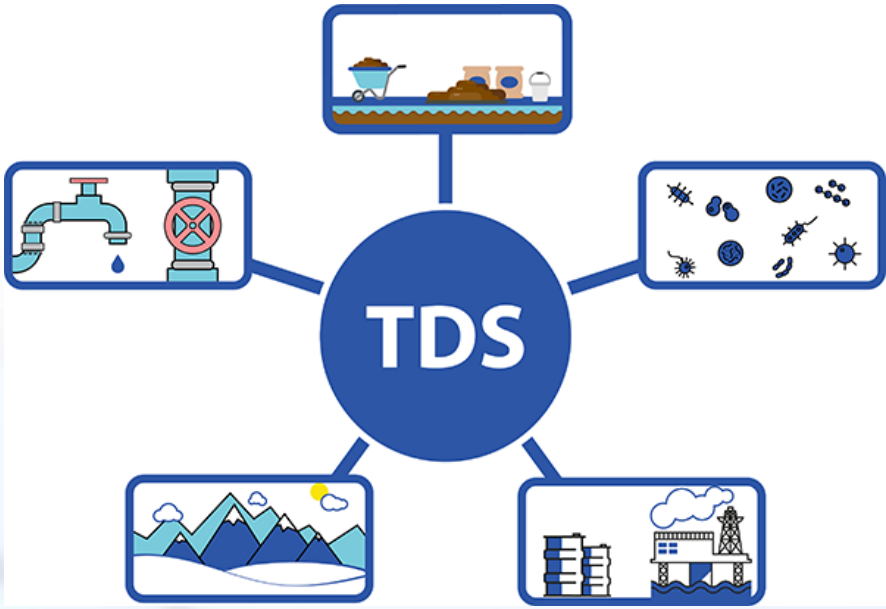
Minor Contributors
Cyanuric Acid
Borates
Silicates
Phosphates

Total Dissolved Solids

TDS is the total of all dissolved solid matter such as minerals, metals, salts and contaminants in the water.

The TDS in drinking water comes from natural water sources, sewage, urban run-off, industrial wastewater and chemicals used in the water treatment process, and the hardware or piping used to distribute water.

TDS levels are often determined with a conductivity meter, which measure the water's ability to conduct an electric current. The greater the concentration of charged particles (to include both positive and negative ions), the more freely electric current can flow through the water.



Temperature

Usually, a temperature increase directly leads to a higher corrosion rate because electrochemical or biological reactions generally occur faster at higher temperatures.

Temperature increases add energy to the reactions, which increases the corrosion rate. Most corrosion models are accurate only within prescribed temperature ranges

Langlier Saturation Index

Saturation Index	Description	Recommendation
-5	Severe Corrosion	Treatment Recommended
-4	Severe Corrosion	Treatment Recommended
-3	Moderate Corrosion	Treatment Recommended
-2	Moderate Corrosion	Treatment May be Needed
-1	Mild Corrosion	Treatment May be Needed
-0.5	None-Mild Corrosion	Likely No Treatment
0	Balanced	No Treatment
0.5	Some Faint Coating	Likely No Treatment
1	Mild Scale Coating	Treatment May be Needed
2	Mild to Moderate Coatings	Treatment May be Needed
3	Moderate Scale Forming	Treatment Advisable
4	Severe Scale Forming	Treatment Advisable

Questions?
More Information?

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