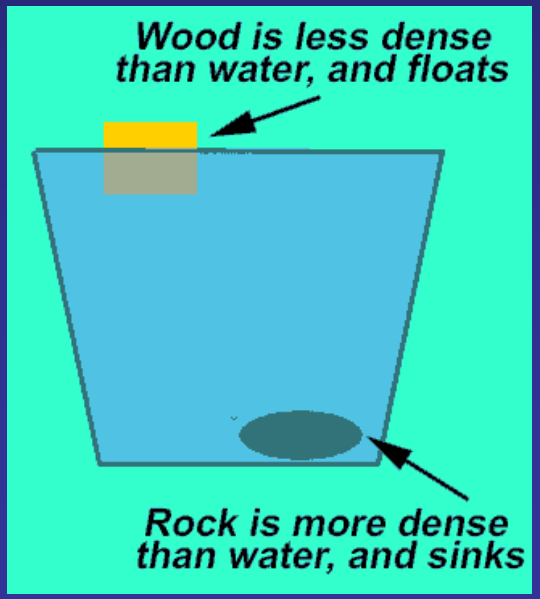
Density of Matter

I. What is Density?

A. A substance's density is a **physical property**.

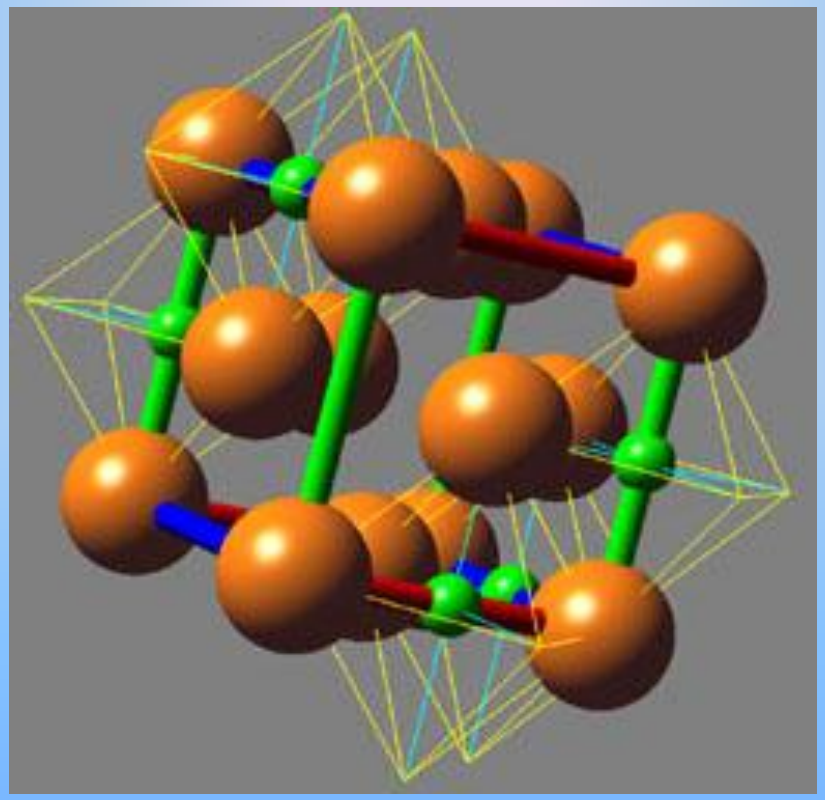
B. Density is defined as the **quantity** of a matter in a certain amount or **space**.

1. The quantity of the material (matter) is its **mass**.
2. The amount of space occupied by the material is its **volume**.



C. Phases of Matter

1. Solid



a. Retains a fixed volume and **shape**.

b. **Rigid** - particles locked into place

c. Most materials are **densest** in their solid phase

2. Fluids

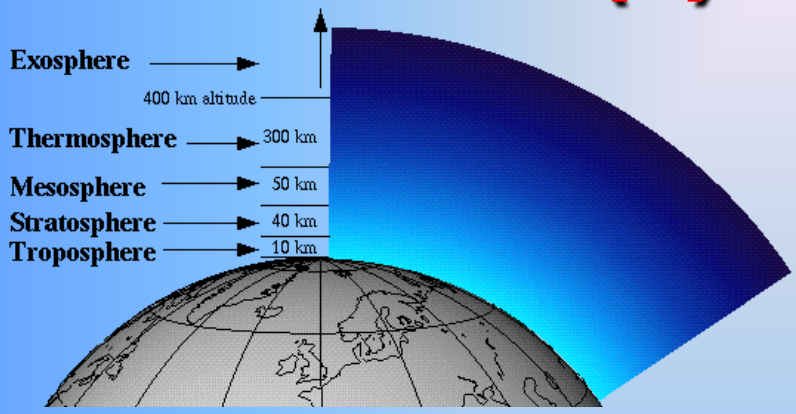
a. Takes the shape of its container
b. Compressible and capable of flowing
c. Liquids and gasses are fluids.

(1) Liquids

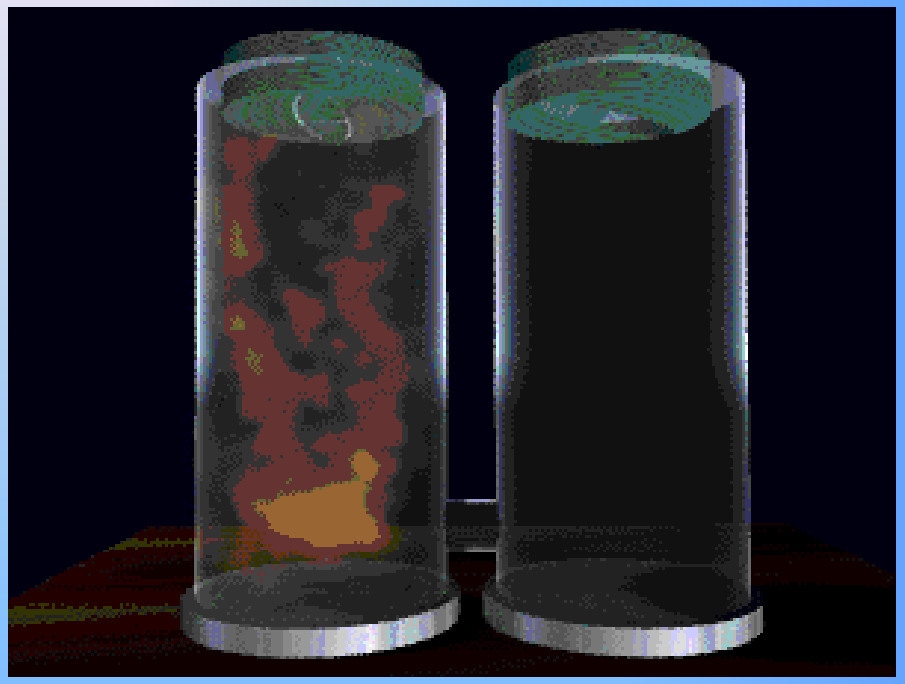
(a) Assumes the shape of the part of the container which it occupies

(b) Particles can move/slide past one another

(2) Gases



Earth's Atmosphere is a mixture of gases

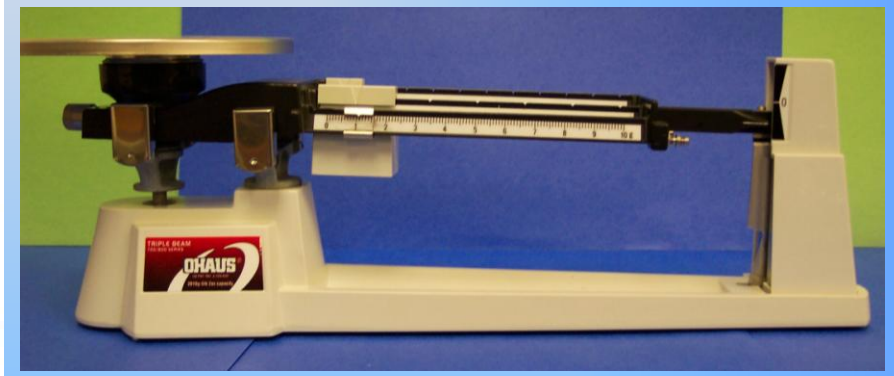


(a) Assume the shape and volume of the container which they occupy.
(b) Particles can move past one another
(c) Easily compressible
(d) Will expand to the volume of the container it occupies

II. Finding Density

A. Density is the ratio of a substance's **mass** to its **volume** .

1. Measure the Mass



a. Use a **scale**.

b. The standard unit of mass in the Metric or SI (Standard Internationale) System is the **kilogram (kg)** but in density measurements the smaller unit, the **gram (g)**, is commonly used.

2. Measure the Volume

a. Liquids

(1) Use a volumetric container that is appropriate to the fluid (e.g., graduated cylinder or beaker)

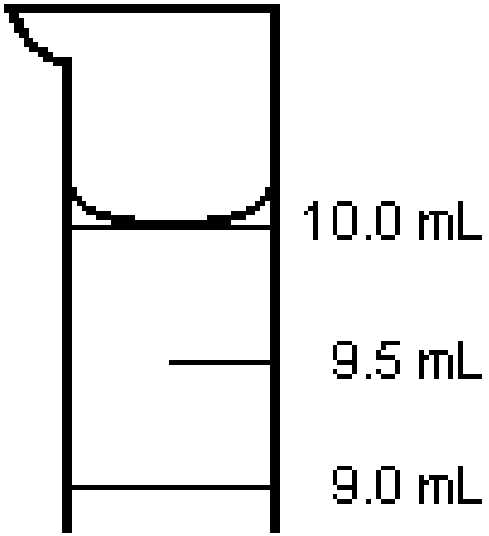
(2) Volume units

(a) The SI unit for volume is the **liter** .

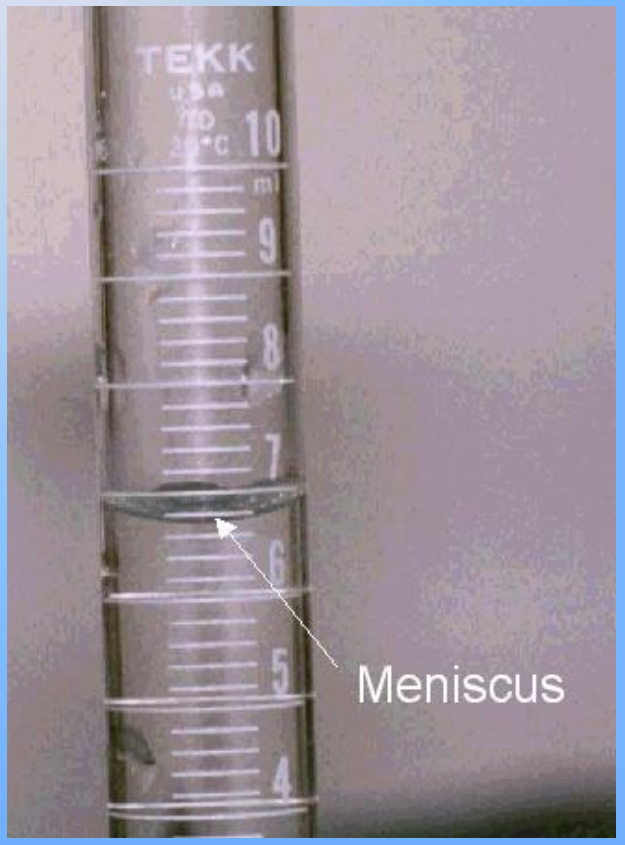
(b) This is usually used for **fluids**.

(c) The **milliliter** is commonly used for density measurements.

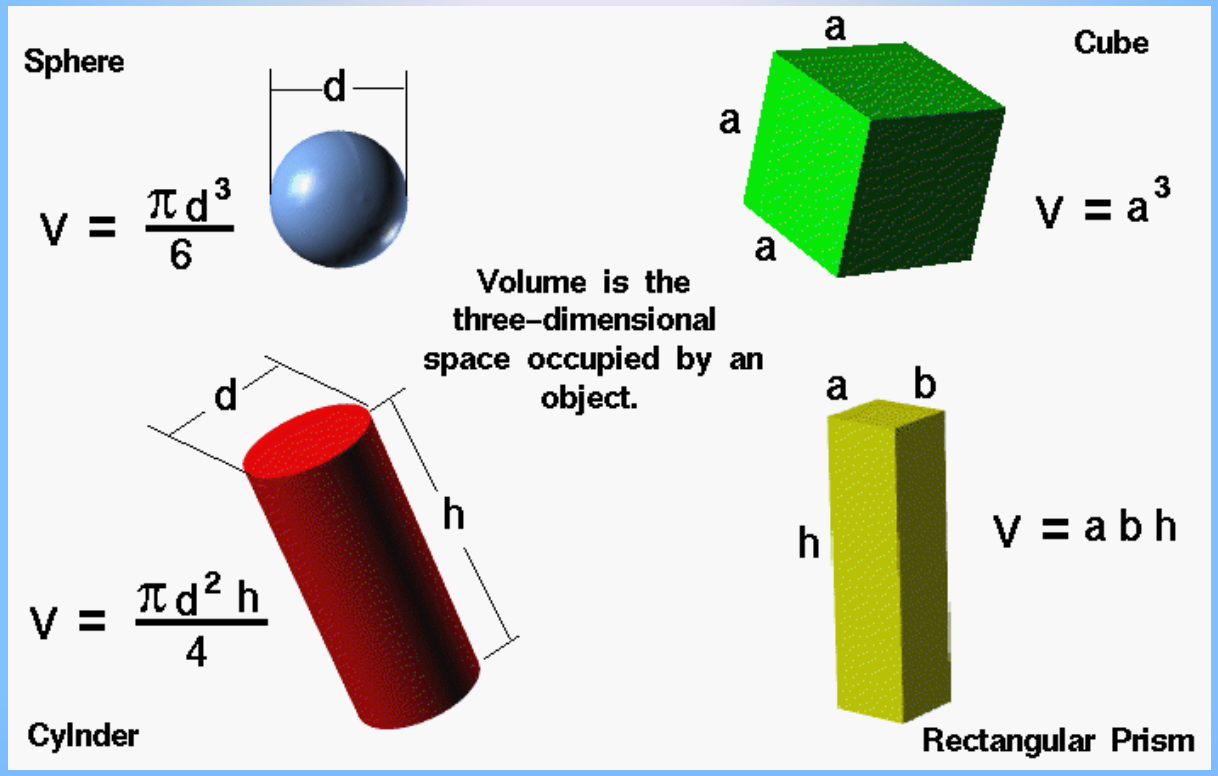
Remember to Consider the Meniscus When Reading the Volume



Portion of graduated cylinder showing meniscus

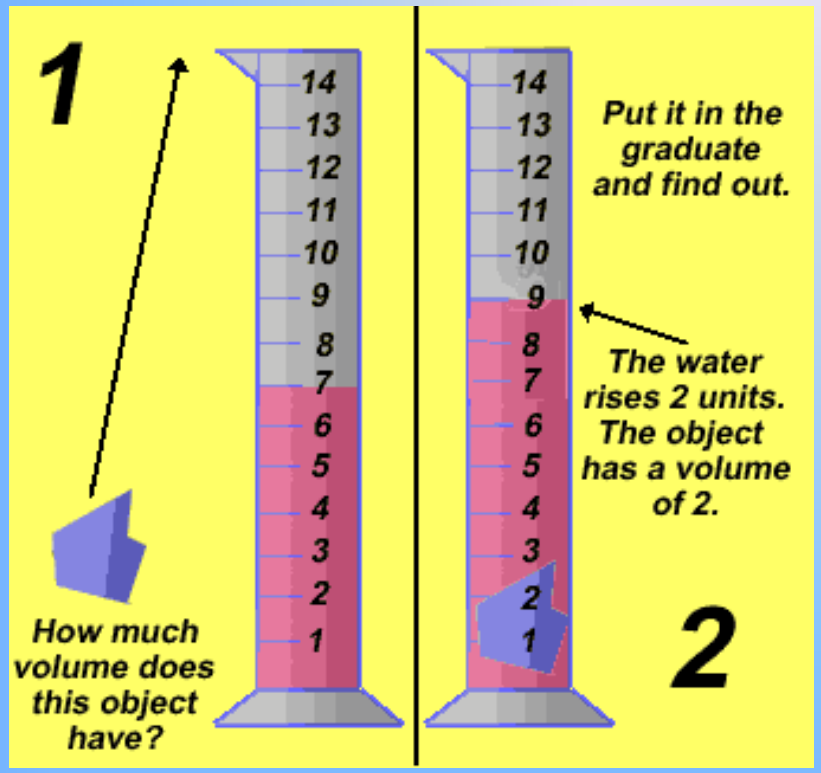


b. Solids



(1) Objects with **regular** geometric shapes can be measured and then the values can be substituted into the appropriate equation for volume.

Irregularly Shaped Objects

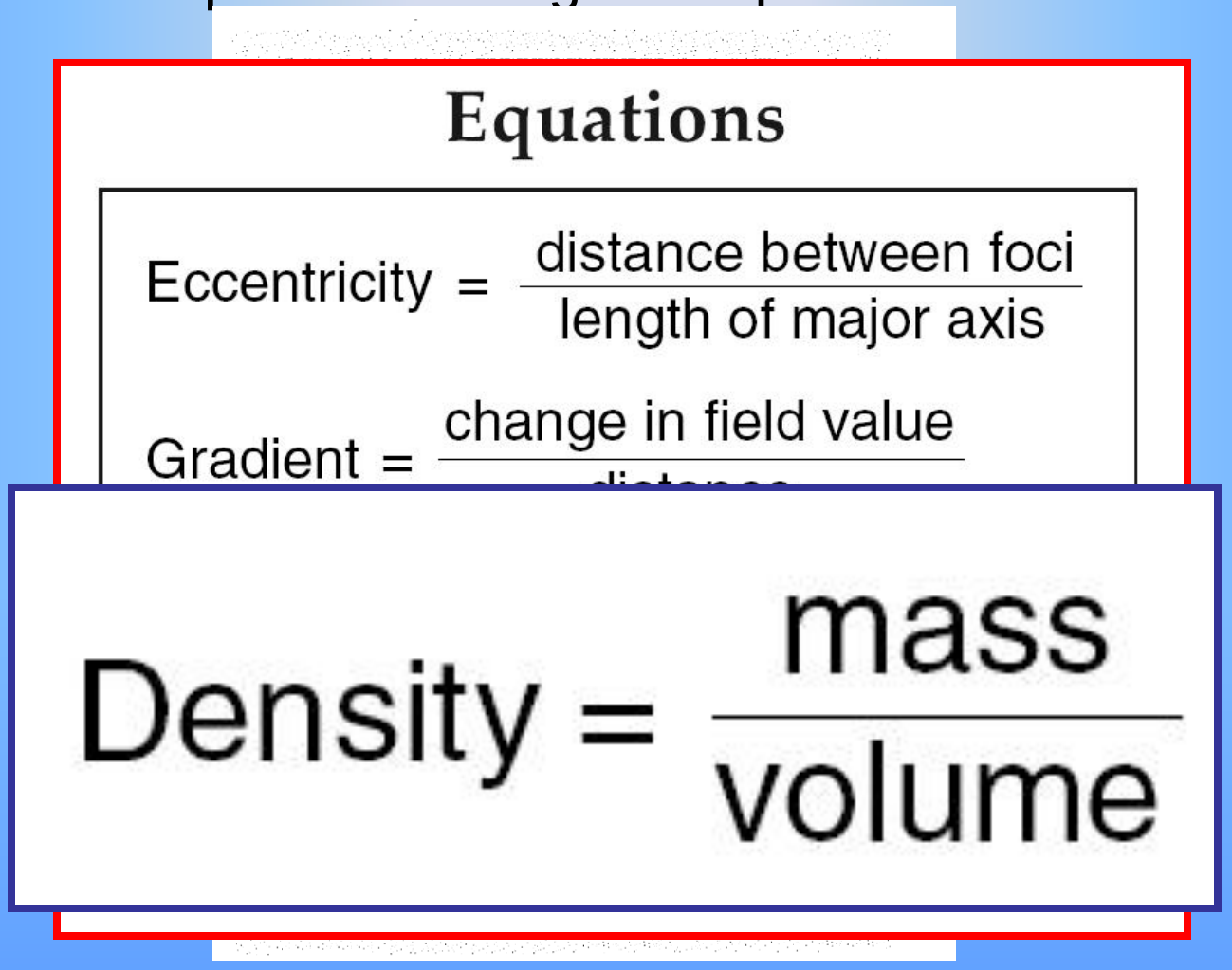


(2) **Water Displacement** can be used for irregularly shaped objects.

(3) Units: Usually expressed as **cubic centimeters (cm^3)** instead of liters or milliliters

B. Substitute Values into the Density Equation

1. It can be expressed using the equation



2. Density Units

a. Density is labeled using a **compound** unit.

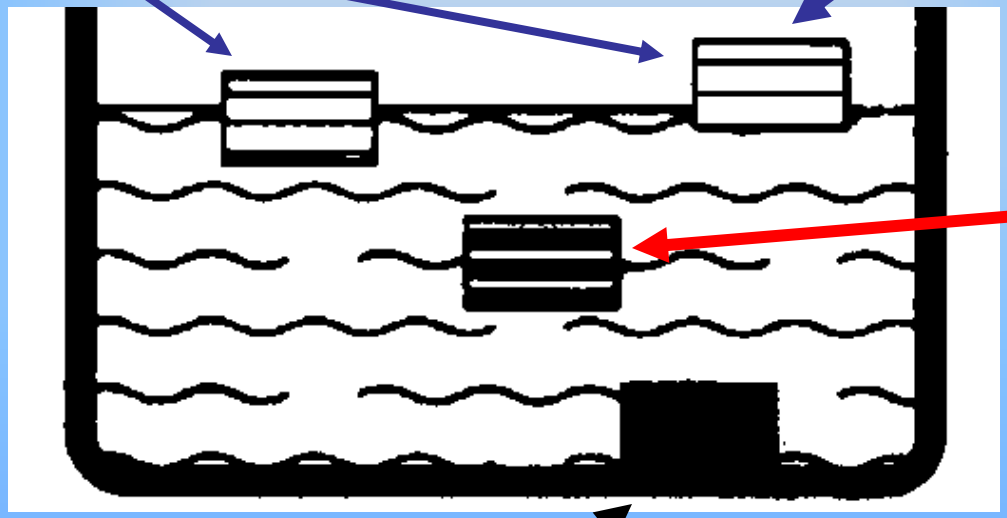
b. For **solids** use g/cm^3.

c. For **liquids** use g/mL.

C. Comparing Densities by Flotation in Water

Substances that are less dense than water float

The less dense the object is, the higher it floats.

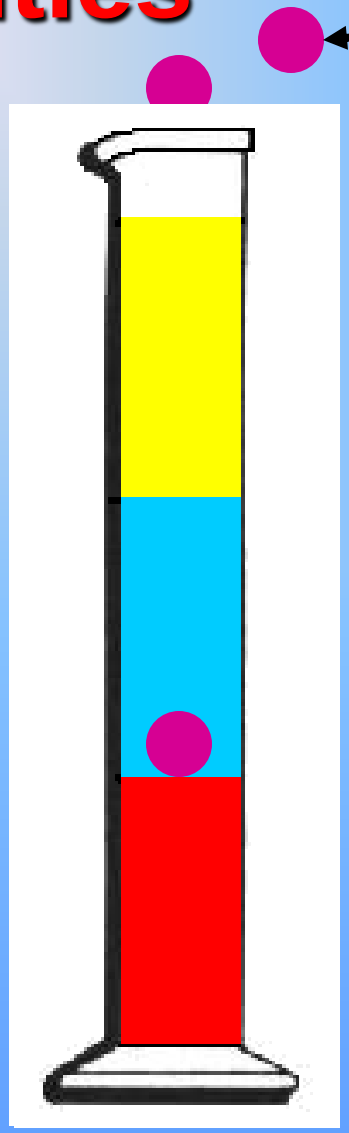


Substances that are Equal to water in density can remain suspended within the water

Substances that are more dense than water sink.

Fluids will Separate According to Their Densities

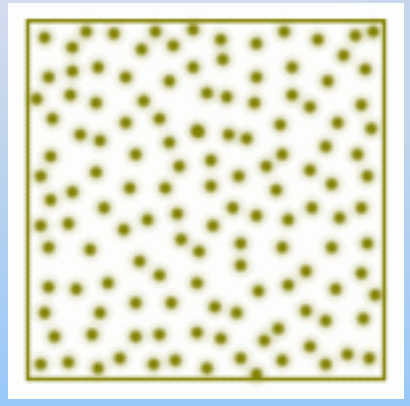
Red Fluid: 2.4 g/mL
Yellow Fluid: 1.0 g/mL
Blue Fluid: 1.3 g/mL



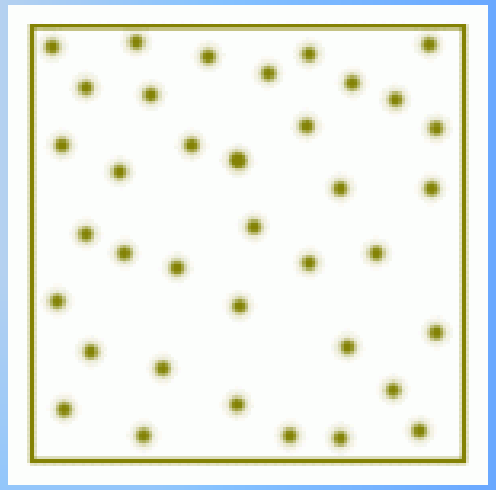
How far will the ball sink?

III. Factors Affecting Density

A. Temperature



Colder

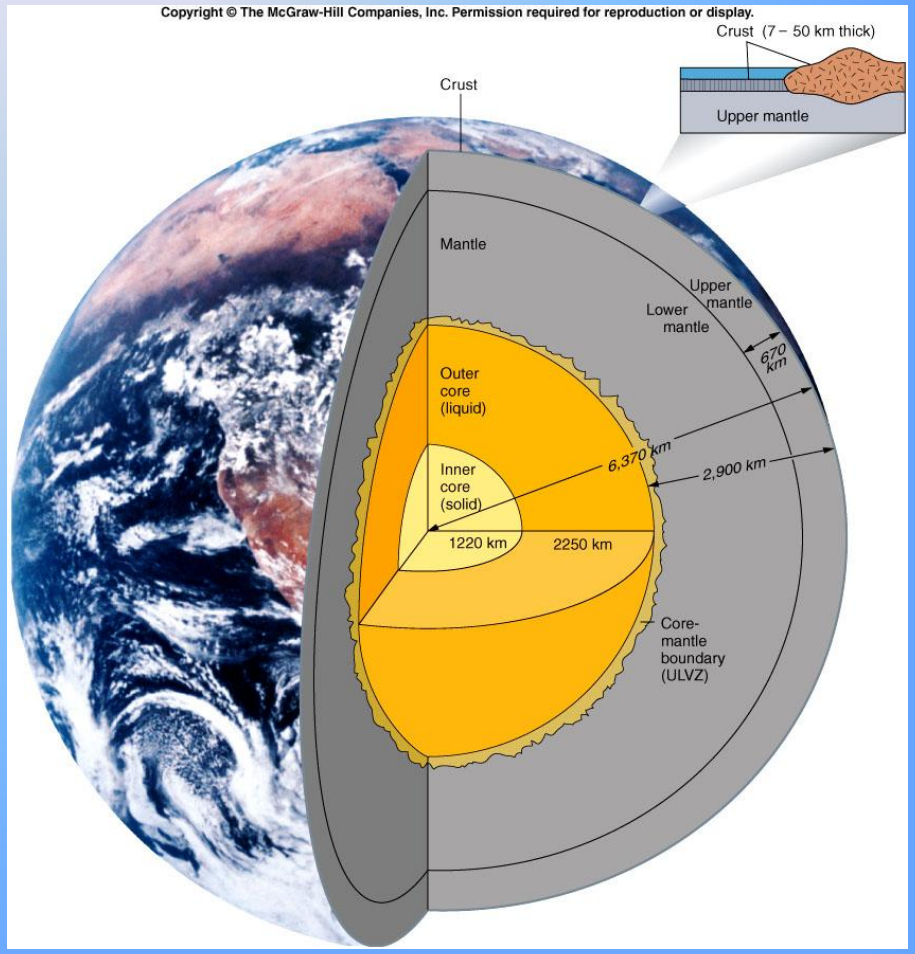


Warmer

1. As the temperature of most substances increases
   a. Atoms move **faster** and spread apart.
   b. Expansion **increases** the volume which **decreases** the density because the mass **remains the same**.
2. This is an **inverse** relationship.

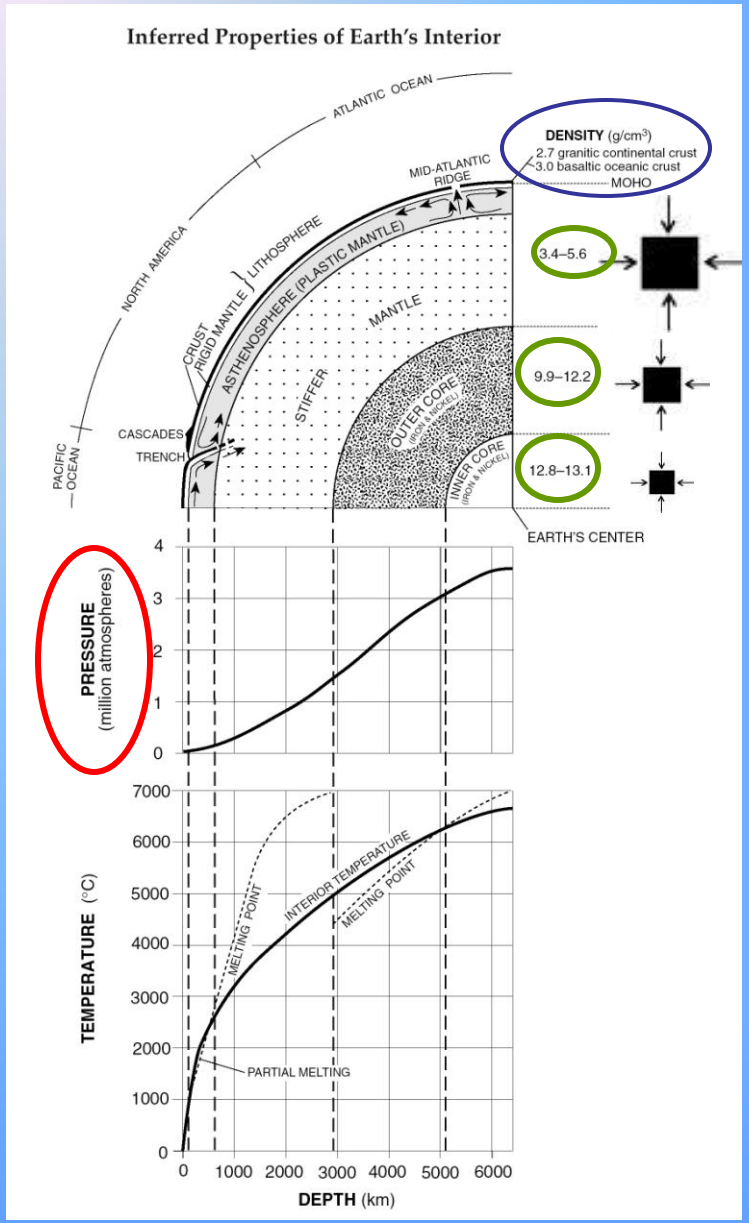
B. Pressure

1. Solids
   a. At great depths below Earth's surface there is extremely high pressure from the overlying rocks.
   b. Minerals are compressed
      (1) Volume _____.
      (2) Density _____.
   c. This is a _____ relationship.

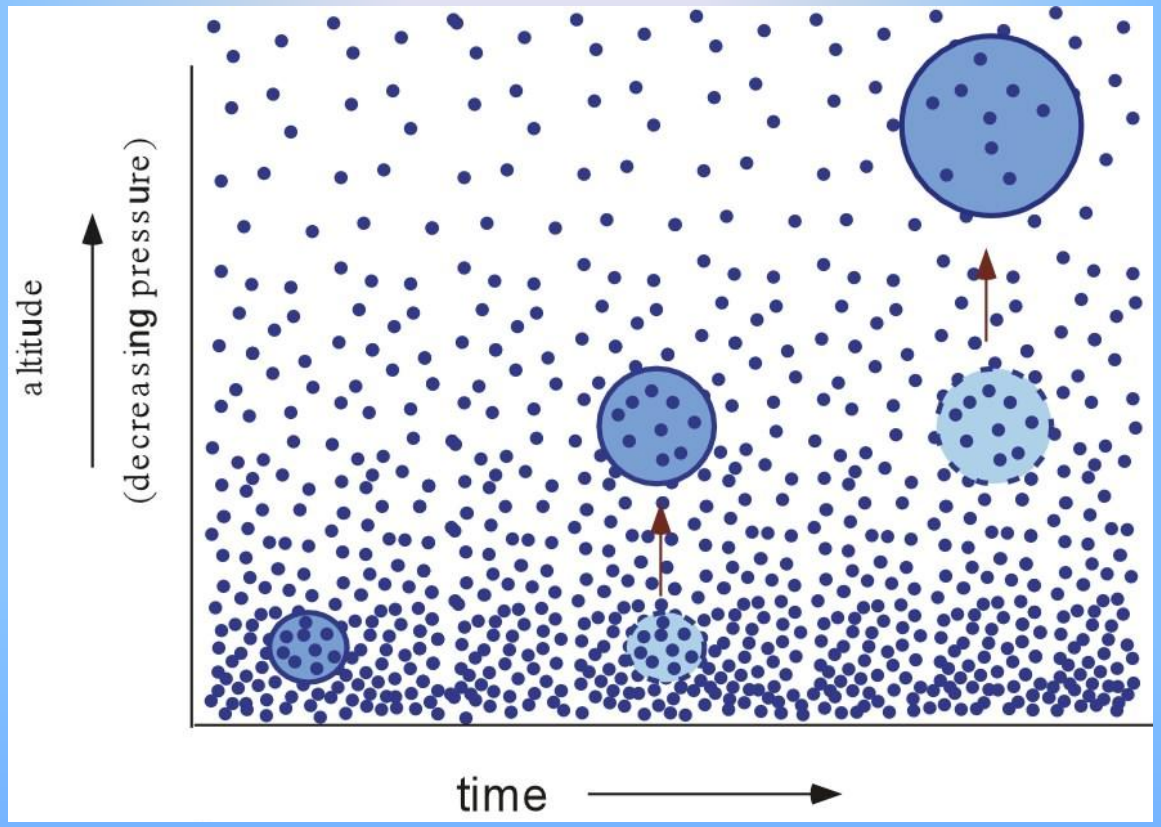


C. Pressure

1. Solids
   a. At great depths below Earth's surface there is extremely high pressure from the overlying rocks.
   b. Minerals are compressed
      (1) Volume __decreases__.
      (2) Density __increases__.
   c. This is a __direct__ relationship.

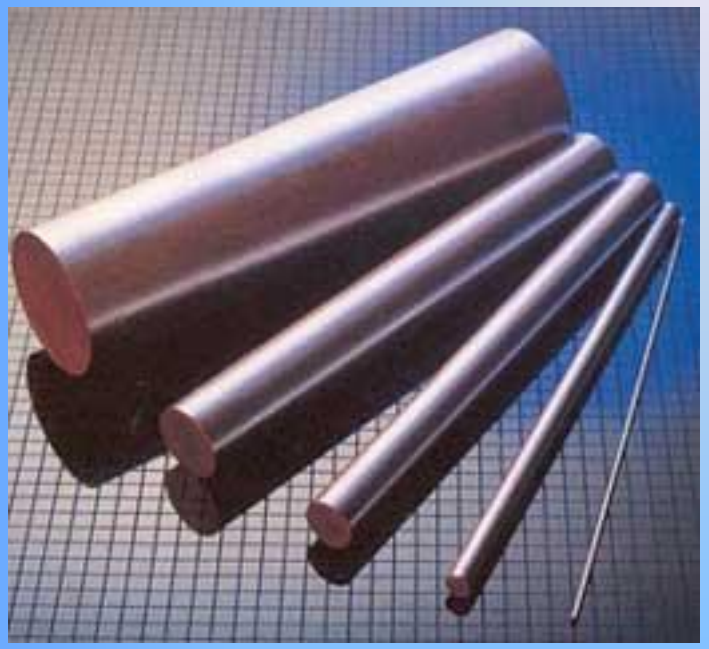


2. Fluids (Particularly gases such as the atmosphere)



a. As pressure _decreases_ gases expand.
b. This results in an _increase_ in volume.
c. Density _decreases_.
d. This is a _direct_ relationship.

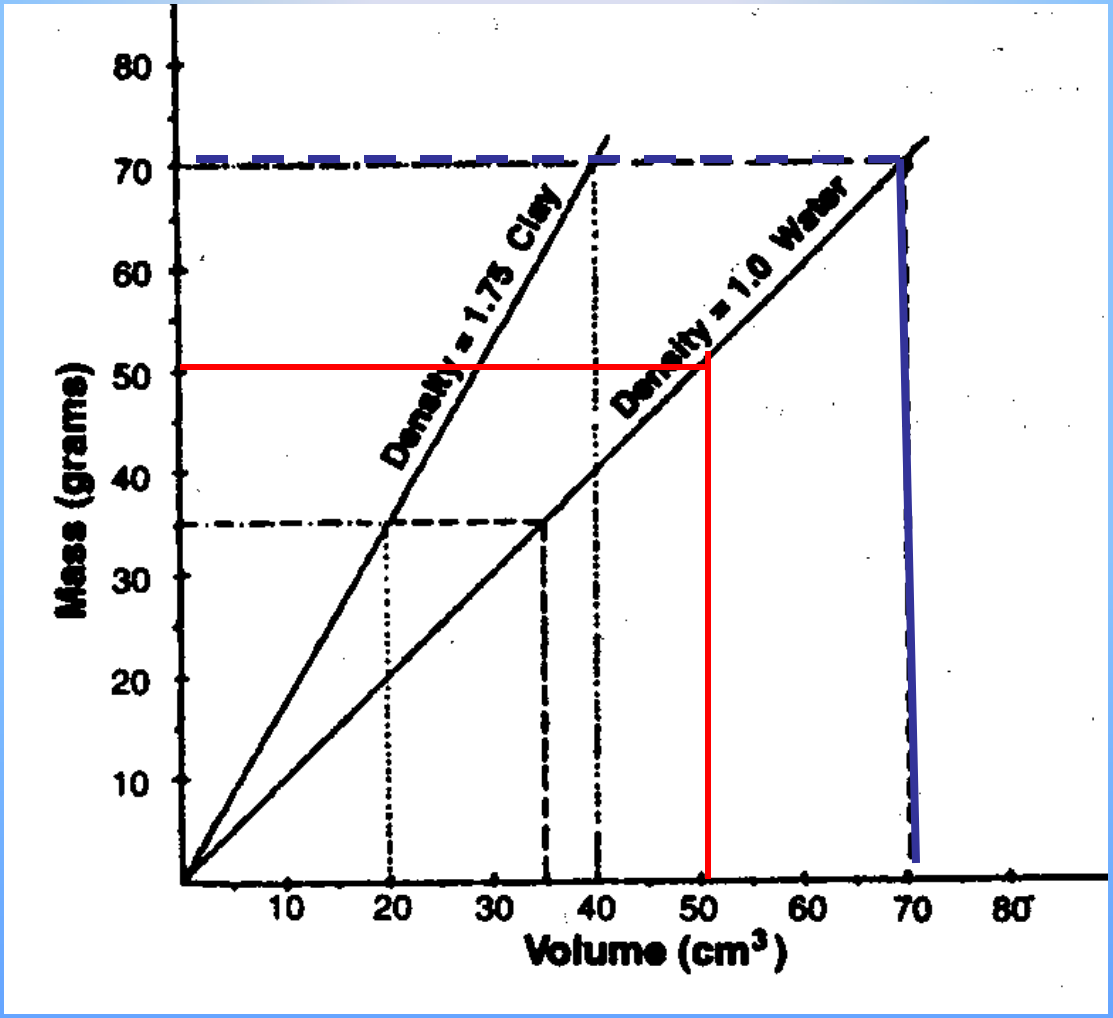
C. Shape and Size



Al of these Aluminum objects have the same density

1. If the temperature of a material remains *constant*, the size and shape will **not** affect it's density.
2. The mass and volume change **proportionately**.

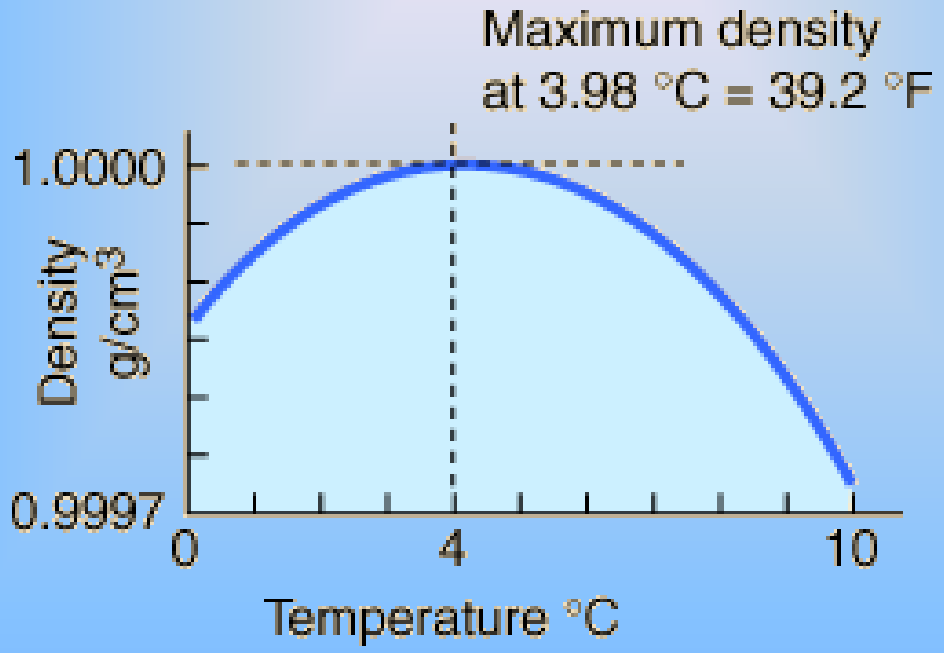
The Relationship between Mass and Volume is Linear



D. Phases of Matter

1. For most substances particles are most closely packed in the **solid** phase.
2. Most materials are **densest** in their solid phase.

3. Water unusual because it is densest as a _liquid_.



a. As liquid water cools, it contracts and becomes denser until it reaches a temperature of 4º Celsius (3.98º C).

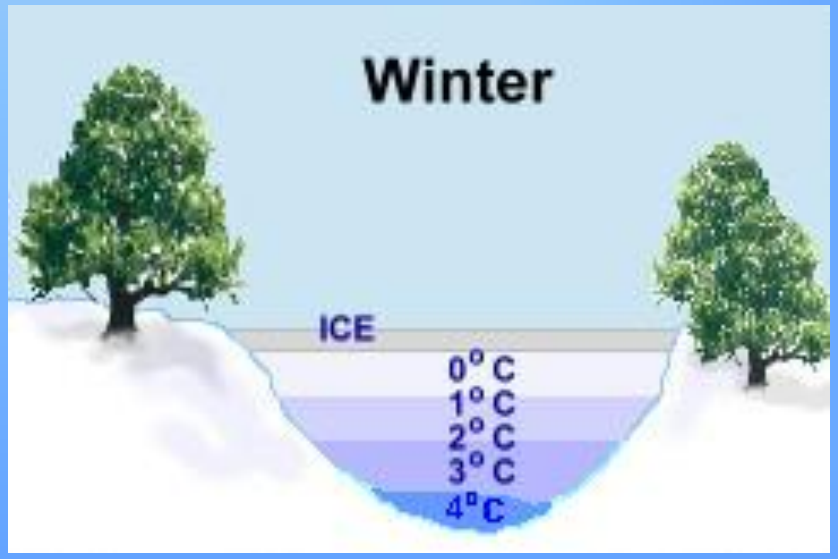
b. As water cools from 3.98º C to 0º C it _expands_, becoming _less_ dense.

c. This has profound implications

(1) Ice **floats** resulting in

(a) Icebergs floating in the ocean

(b) Lakes freezing from the top down.



(2) Expanding water in pipes and cracks in rocks will cause them to break apart

The reason for this unusual property is the nature of the water molecule.

(1) The molecule's shape is asymmetrical and polarized.

(a) One side is positively charged

(b) The other side has a slight excess of negative charges.

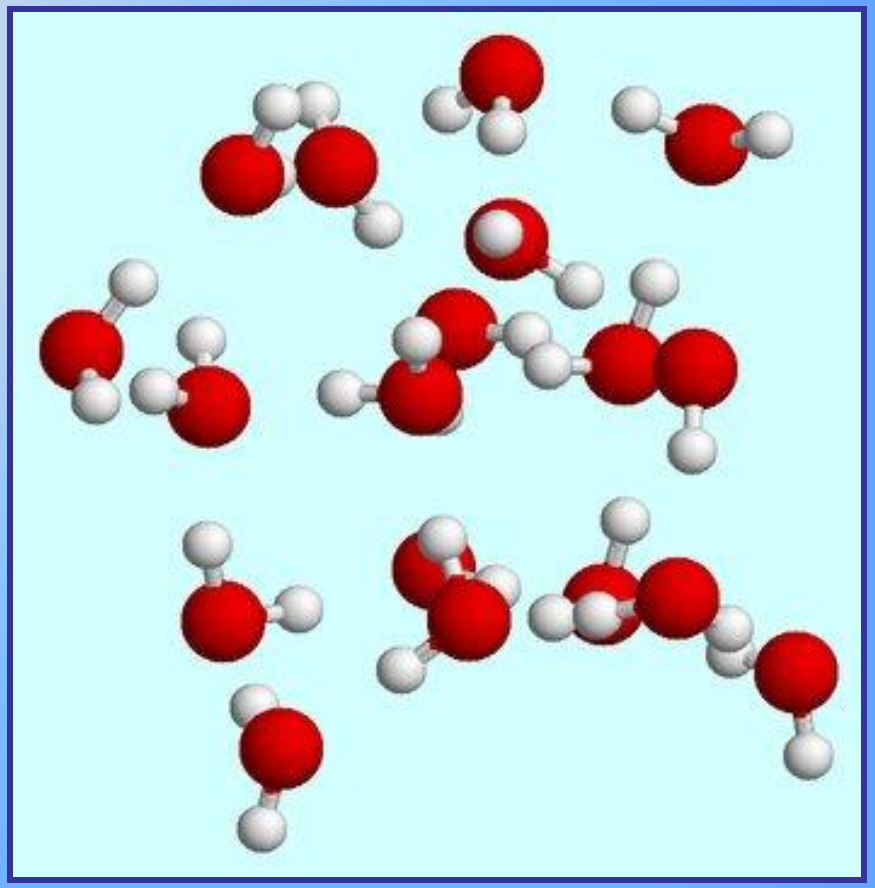
The molecule resembles a famous mouse!

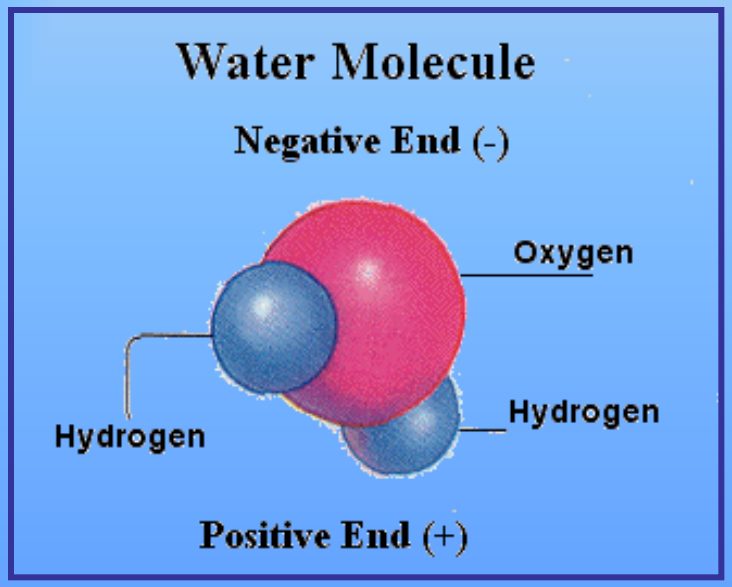
(2) When water is in the liquid state

(a) Molecules are moving around.

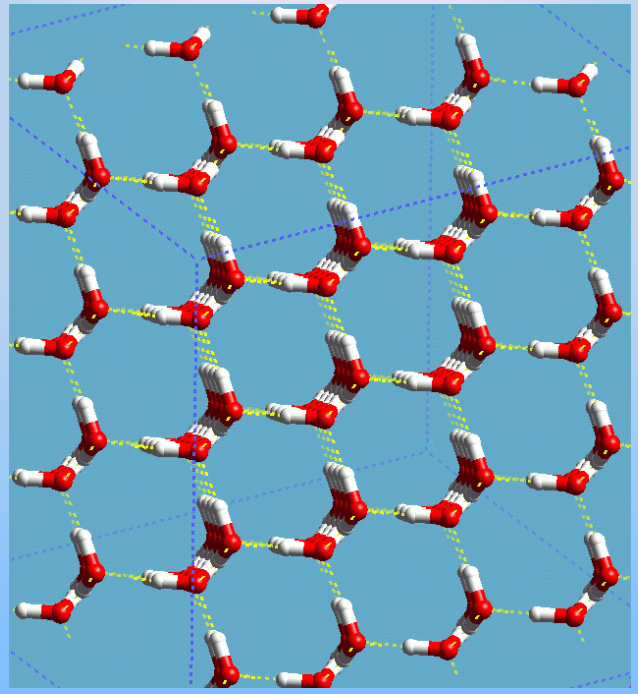
(b) Because of polarity some molecules are slightly attracted to one another

(c) The are closer together than in most liquids.





(4) When Water Freezes



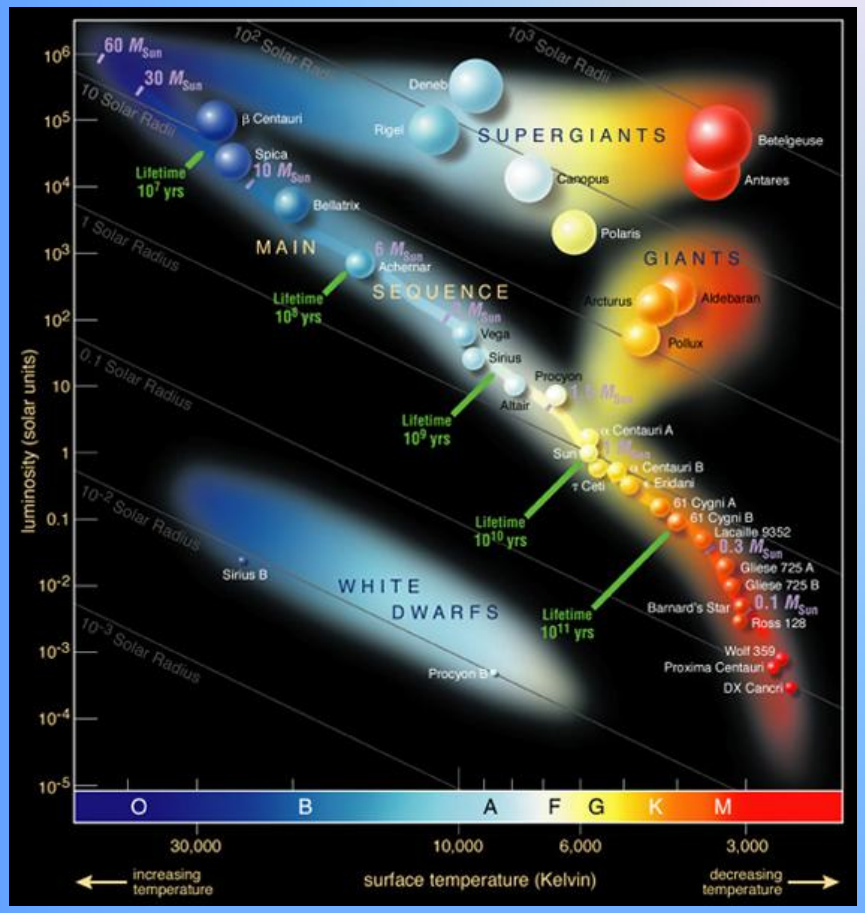
(a) Bonding hydrogen atoms are shared between adjacent water molecules.

(b) An orderly, hexagonal pattern results.

(c) The open honeycomb-like crystal structure contrasts with the more closely packed molecules in liquid water.

Density is considered in many Earth Science Topics

Astronomy



Classification of Stars

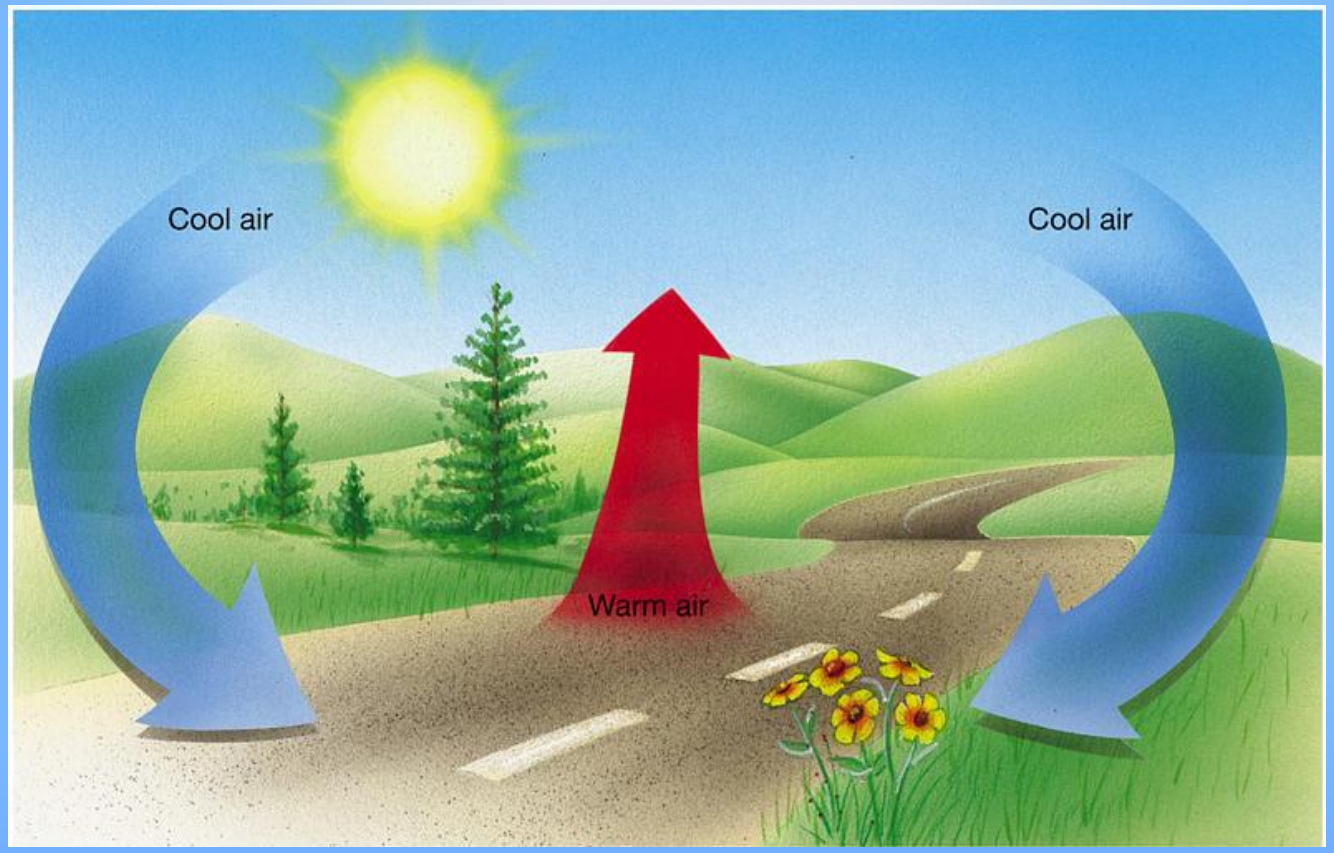
Solar System Data

Celestial Object	Mean Distance from Sun (million km)	Period of Revolution (d=days) (y=years)	Period of Rotation at Equator	Eccentricity of Orbit	Equatorial Diameter (km)	Mass (Earth = 1)	Density (g/cm^3)
SUN	—	—	27 d	—	1,392,000	333,000.00	1.4
MERCURY	57.9	88 d	59 d	0.206	4,879	0.06	5.4
VENUS	108.2	224.7 d	243 d	0.007	12,104	0.82	5.2
EARTH	149.6	365.26 d	23 h 56 min 4 s	0.017	12,756	1.00	5.5
MARS	227.9	687 d	24 h 37 min 23 s	0.093	6,794	0.11	3.9
JUPITER	778.4	11.9 y	9 h 50 min 30 s	0.048	142,984	317.83	1.3
SATURN	1,426.7	29.5 y	10 h 14 min	0.054	120,536	95.16	0.7
URANUS	2,871.0	84.0 y	17 h 14 min	0.047	51,118	14.54	1.3
NEPTUNE	4,498.3	164.8 y	16 h	0.009	49,528	17.15	1.8
EARTH'S MOON	149.6 (0.386 from Earth)	27.3 d	27.3 d	0.055	3,476	0.01	3.3

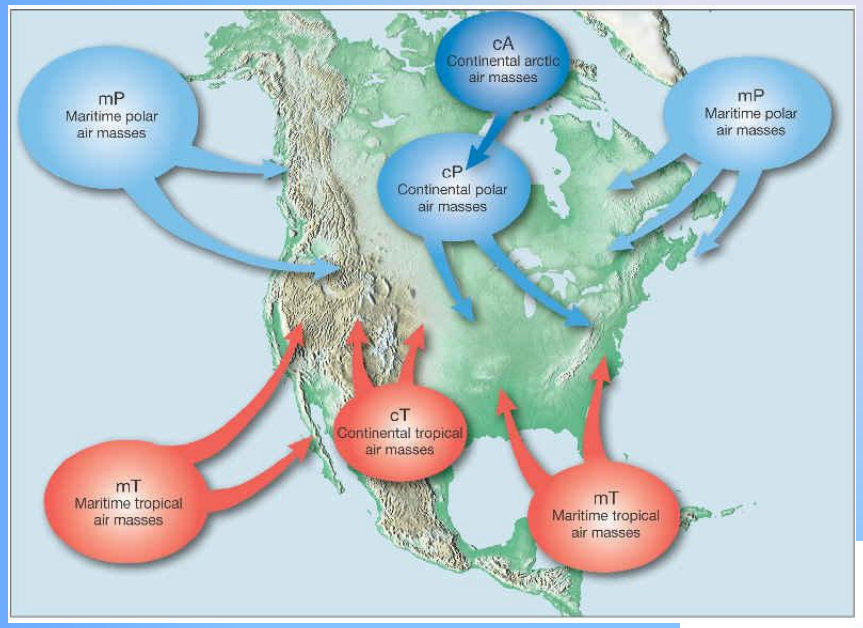
Planets

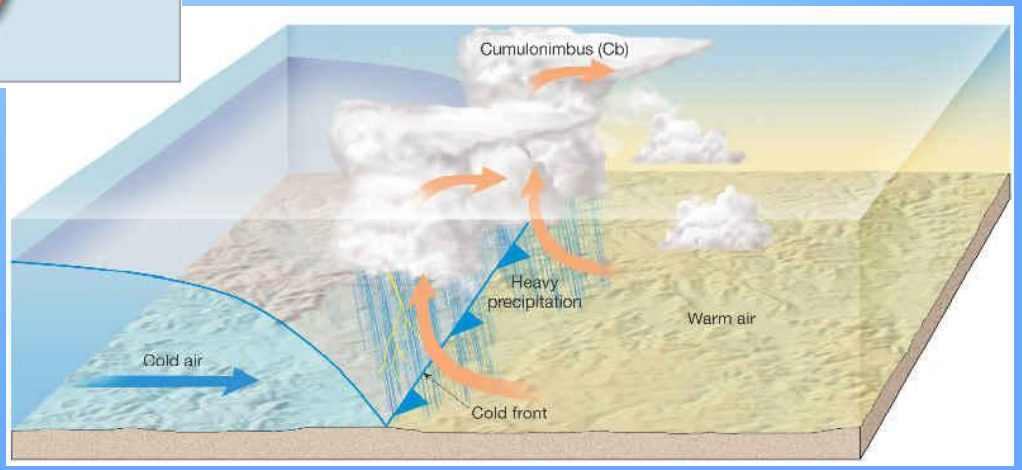
Meteorology

Convection



Air Masses and Fronts





Violent Weather

Planetary Winds, Ocean Currents and Related Weather Conditions

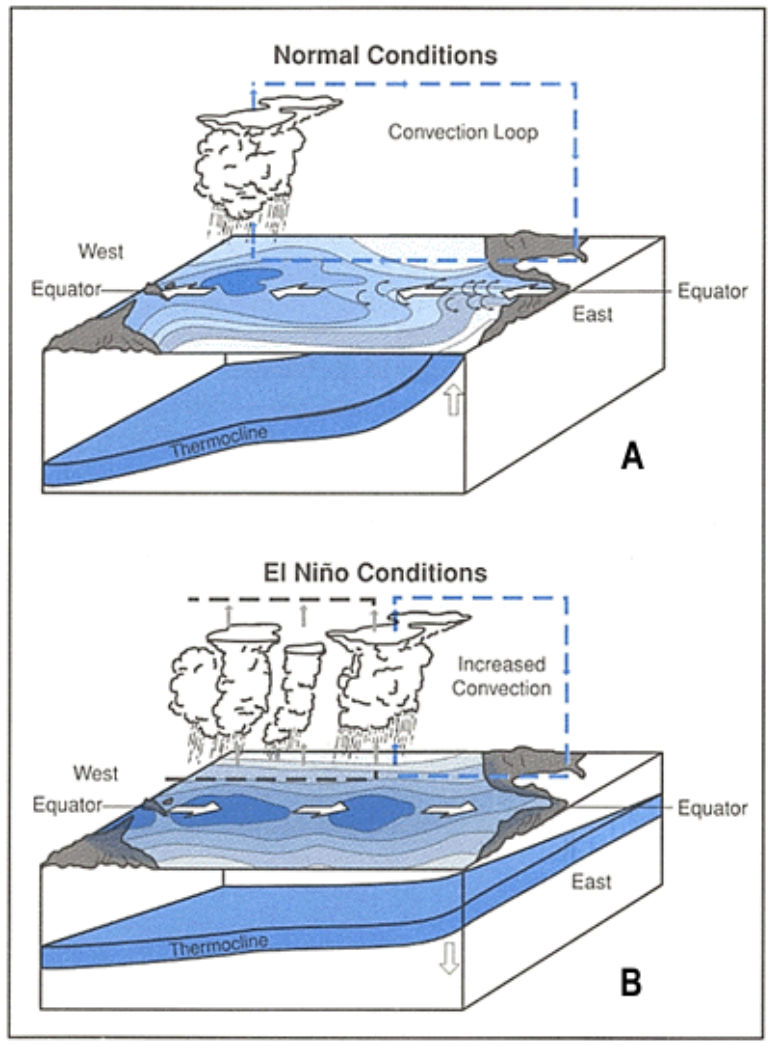
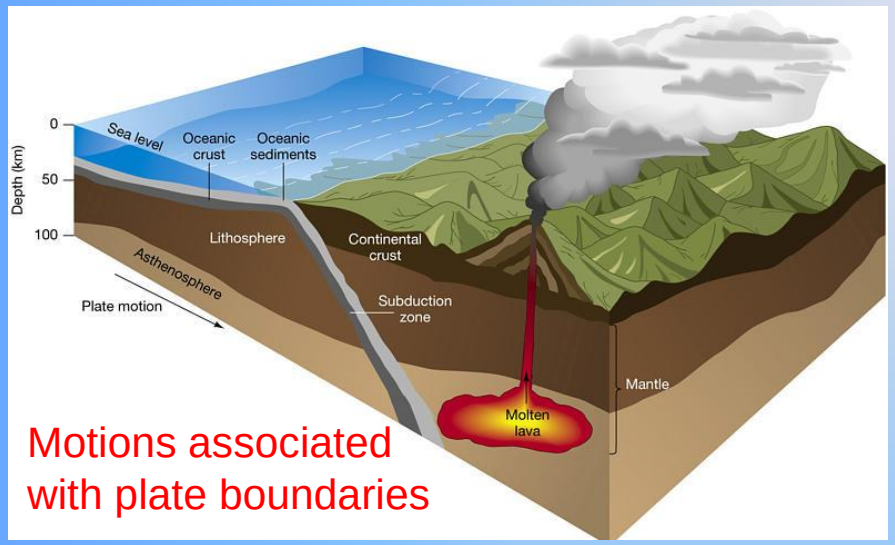
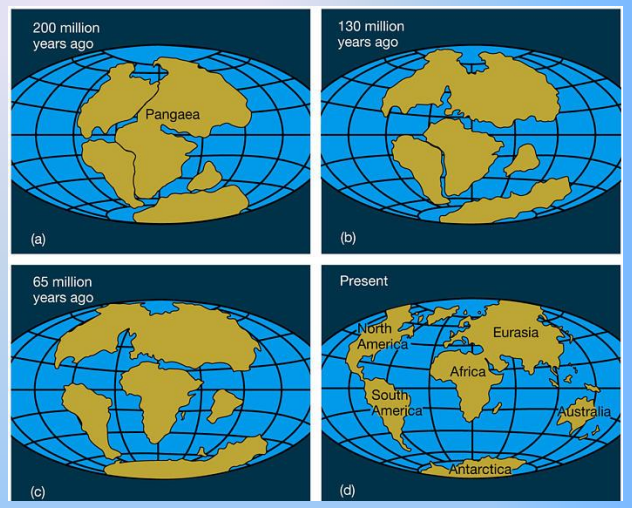


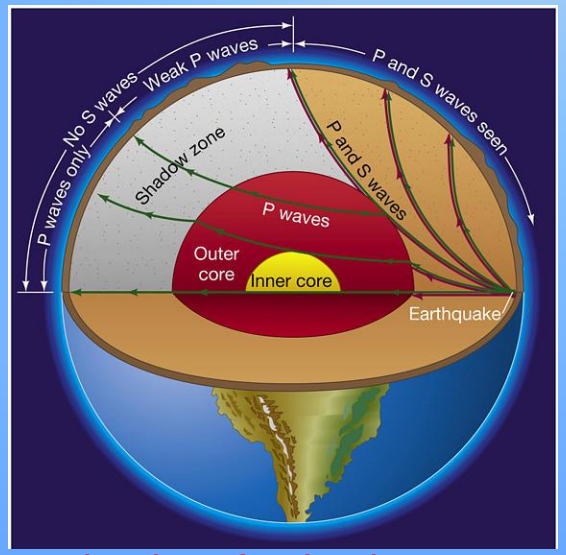
Plate Tectonics – Density is a factor for …



Motions associated with plate boundaries



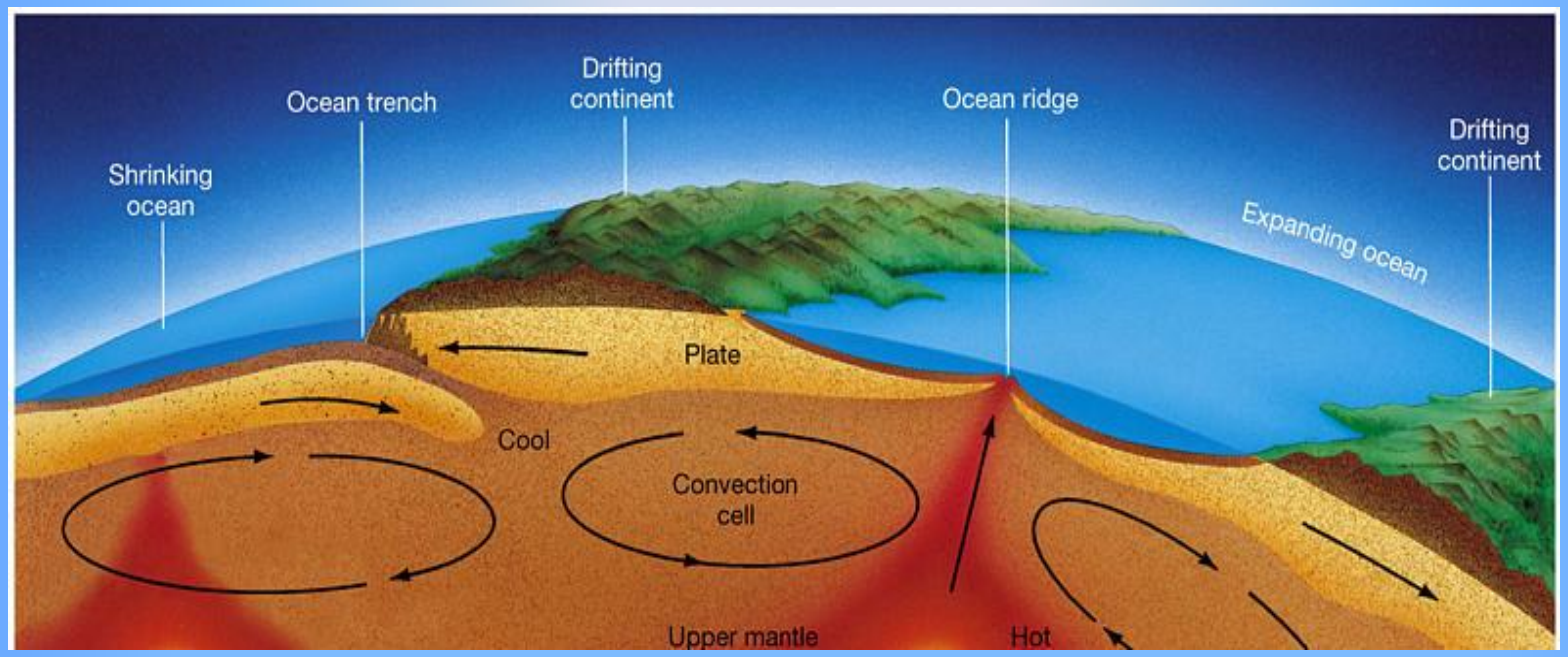
Continental Drift



Behavior of seismic waves traveling through Earth's interior

Volcanic and Earthquake Activity

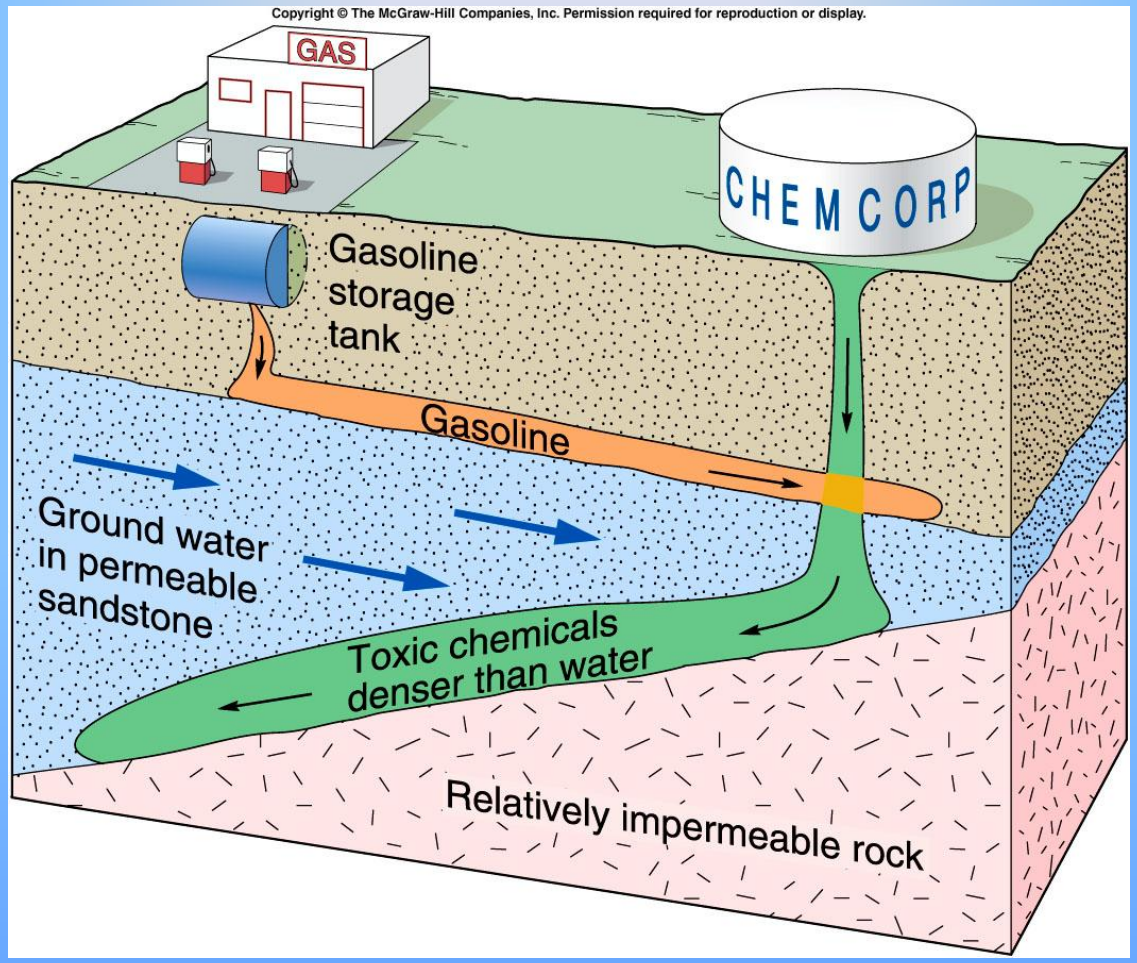
Mantle Convection



Behavior of Pollutants

Oil Spills

Density of Pollutants Affects Flow



Sediments Flowing into the Ocean