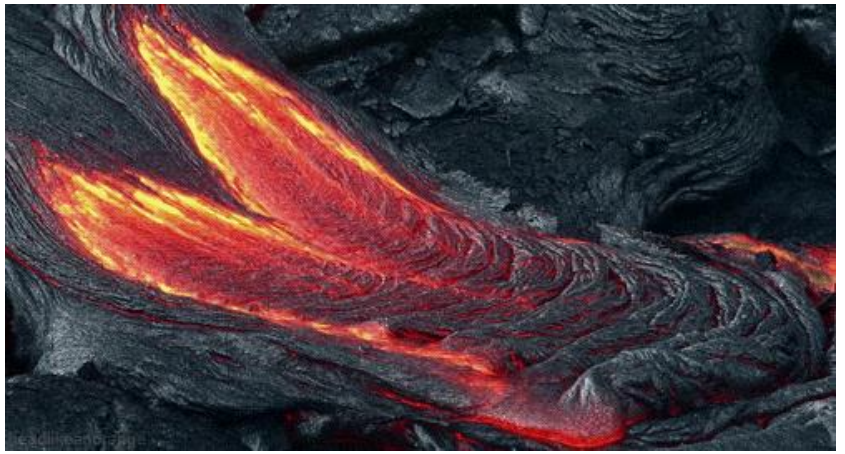
Fluids and Density

Lesson 26

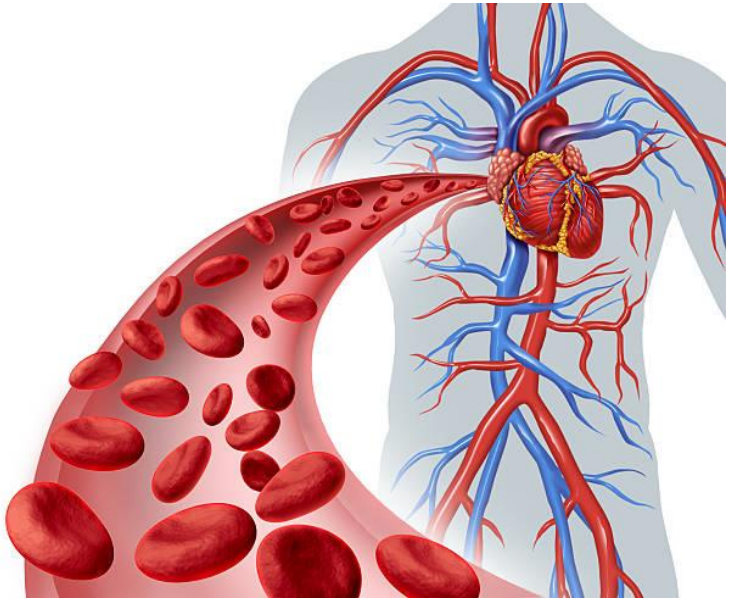
Fluids and Density

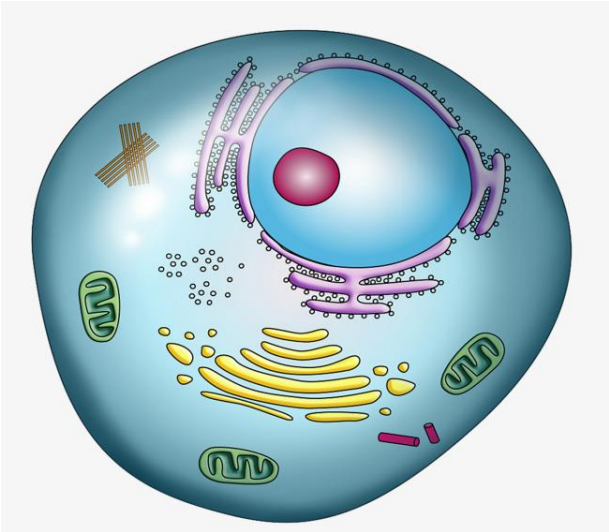
- What do pancake syrup, water in a mountain stream, and lava flowing from a volcano have in common?
  - They are all fluids!
- A **fluid** is any form of matter that can flow
  - Liquids and gases are able to flow because they do not have a fixed shape
  - Therefore, solids are not fluids

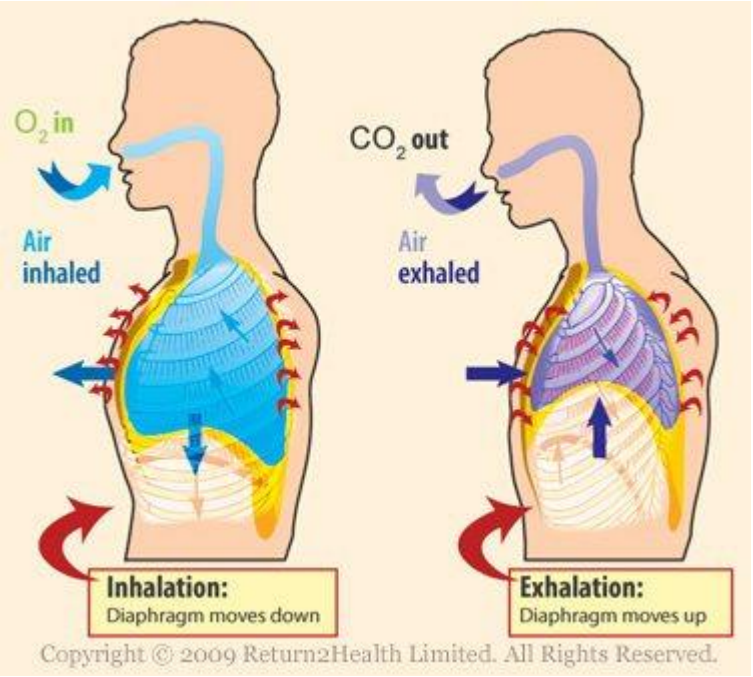


Fluids and Density

- Our body contains many fluids
  - Blood and the watery cytoplasm inside cells
  - Air flows into and out of our lungs each time we inhale and exhale







Solid, Liquid, and Gas Density

- **Density** = The mass of a given volume. Describes how *closely packed* together the particles are in a material.
  - One property that is useful in understanding both fluids and solids

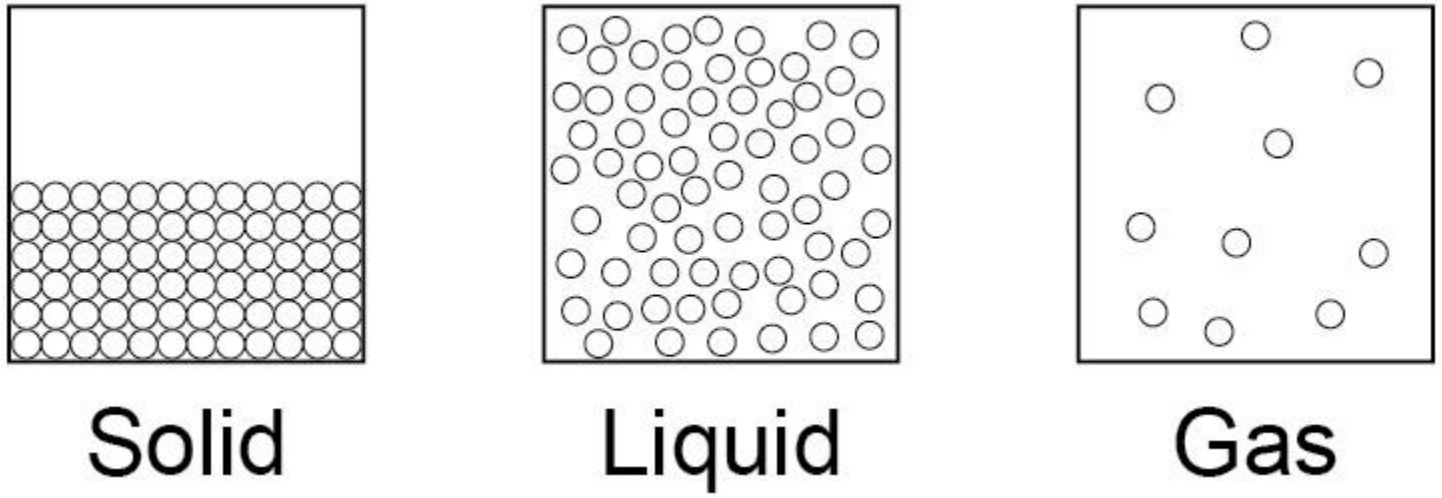
<u>Analogy Example: Vehicles on a highway</u>

- A traffic jam is a model of high density
- Free flowing loosely packed traffic is a a model of low density

Solid, Liquid, and Gas Density

Based on what you know about particles and the state of matter, which is likely to be the densest?

A. A solid
B. A liquid
C. A gas



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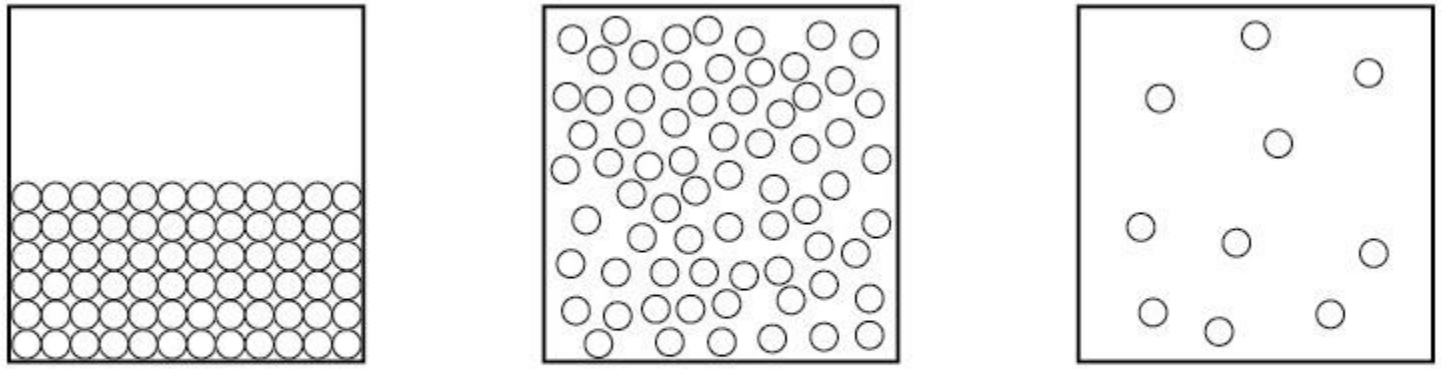


Solid, Liquid, and Gas Density

- Aluminum (a solid), is denser than water (a liquid), and water is denser than air (a mixture of gases) – but why?
- The key to density is the spacing of the particles…
  - The particles of a piece of solid aluminum are tightly packed
  - Liquid water particles have enough room between them to change position
  - The particles of air have a large amount of space between them – free to move independently

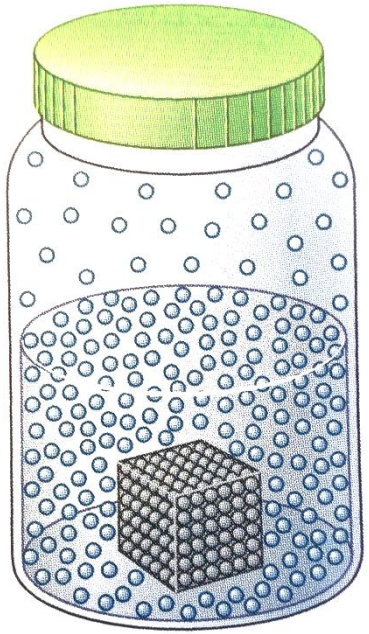
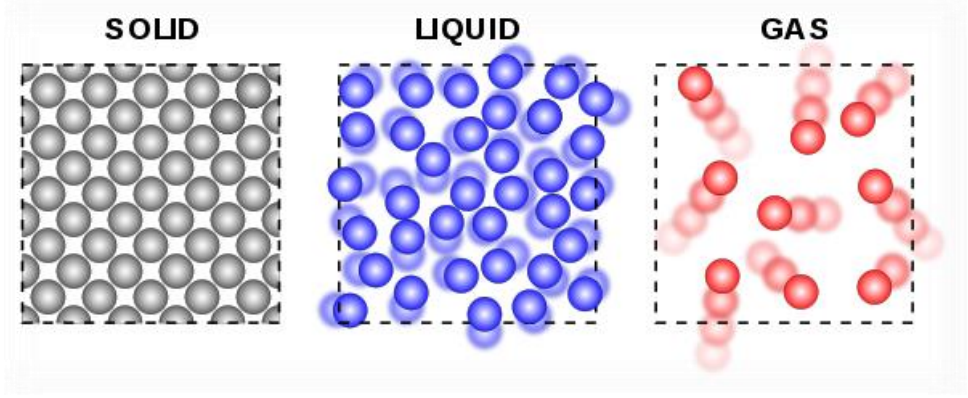


Figure 7.9 A sealed container holds air, water, and an aluminum block.

Solid, Liquid, and Gas Density

The key to density is the spacing of the particles…

- Less densely packed particles will “float” on more densely packed particles
- As temperature increases, a substance will change from solid → liquid → gas
- According to the KMT, the particles of a substance spread out as they gain energy when heated
  - The particles will take up more space, which means that the density of the substance decreases



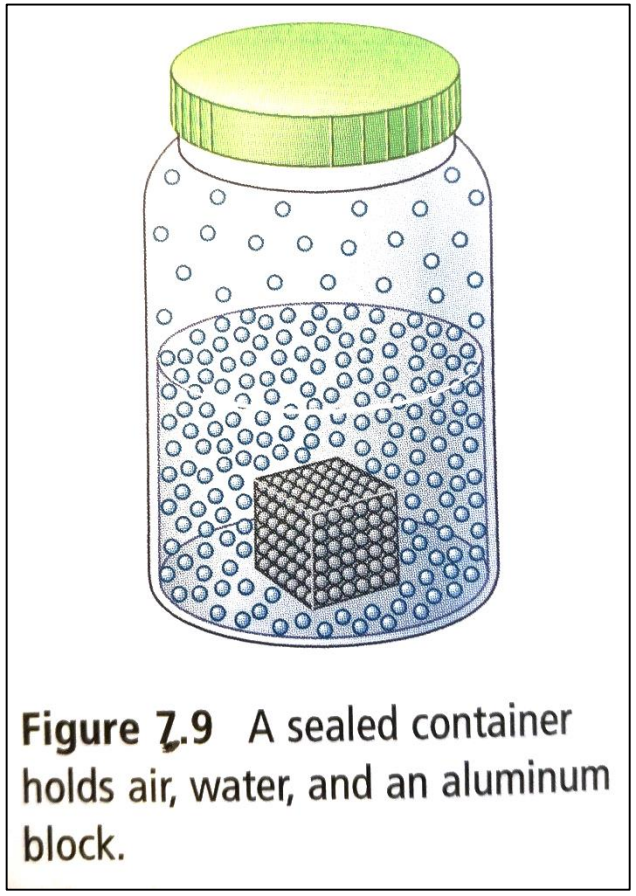
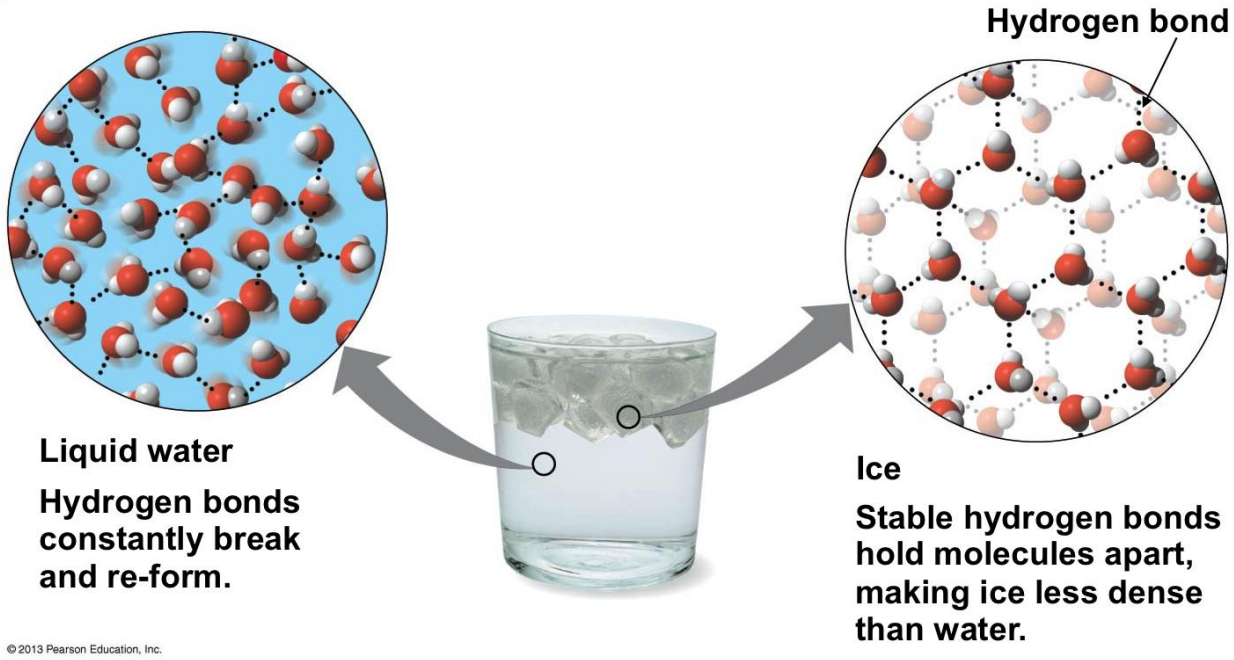


Figure 7.9 A sealed container holds air, water, and an aluminum block.

Solid, Liquid, and Gas Density

- Most substances are denser in their solid form than their liquid form
  - BUT, water is an exception!
- When water freezes, the particles move slightly farther apart as they become fixed in position
  - This means that ice (solid) is actually less dense than liquid water, so it floats



Layers of Fluids

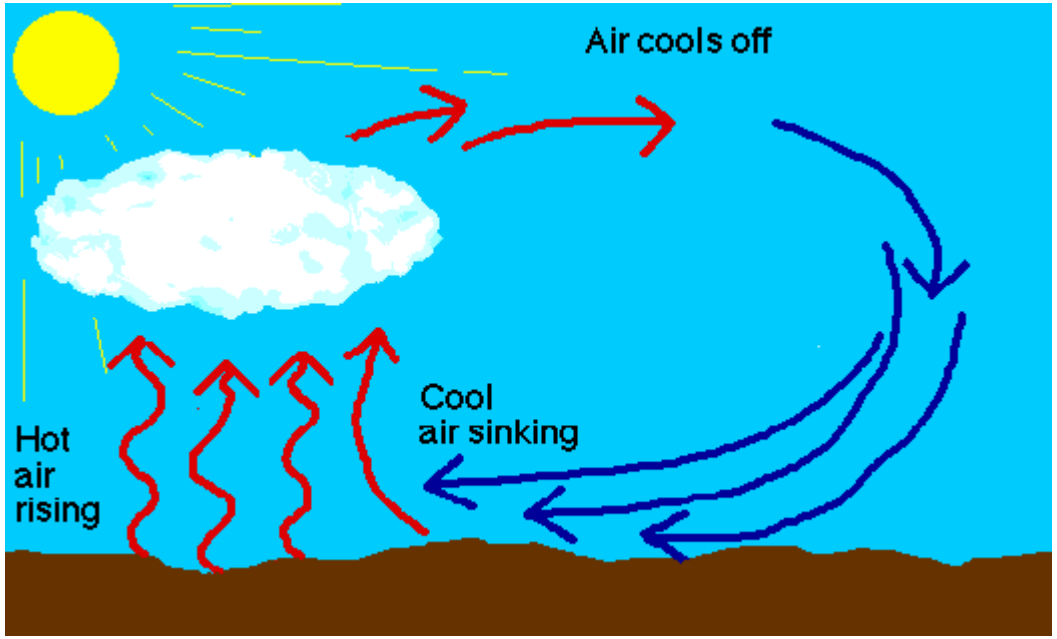
- Imagine two beakers, one filled with water, and one filled with corn syrup
  - Does the water or corn syrup have the greater mass?
  - Which has the greater density?
- Recall that density is the mass of a given volume
- When comparing the masses of equal volumes of different kinds of matter, we are comparing their densities

Layers of Fluids

- Some liquids float on top of others
- Liquids will layer in order of density
  - The less dense liquid floats on the denser liquid if the two liquids do not mix together
- How would corn syrup and water be layered if they were placed in the same beaker?
  - Corn syrup has more mass, therefore greater density than water
  - Water would float on top of the corn syrup

Layers of Fluids

- Layering according to density can even occur within the same substance
- Air is an example of this…
  - Differences in air density greatly contribute to weather
  - When air is heated near the ground on a hot summer day, the particles gain energy and move farther apart
  - The warm air has a lower density than the air around it, and as a result, it begins to rise
  - As the warm air rises, cooler air rushes in beneath it, and a breeze is created

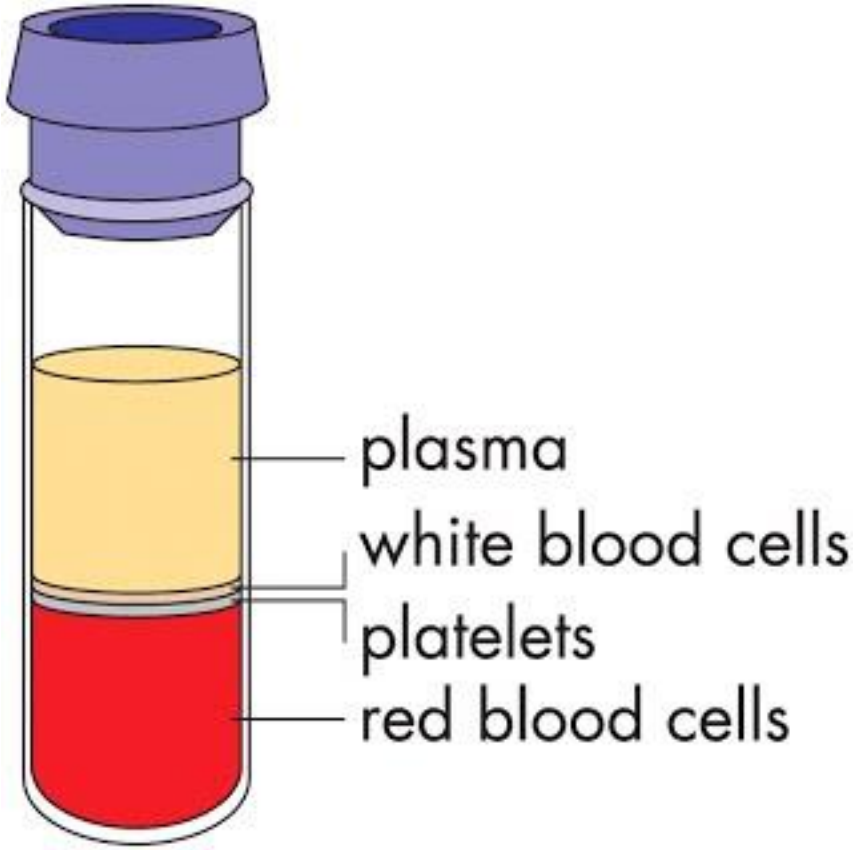


Measuring Density

- Layering is a useful technique for comparing densities
- When an object is placed in a less dense fluid, the object will sink down toward the bottom
- If the fluid is denser than the object, the object will float
- If the object has the same density as the fluid, the object will “hover” in place

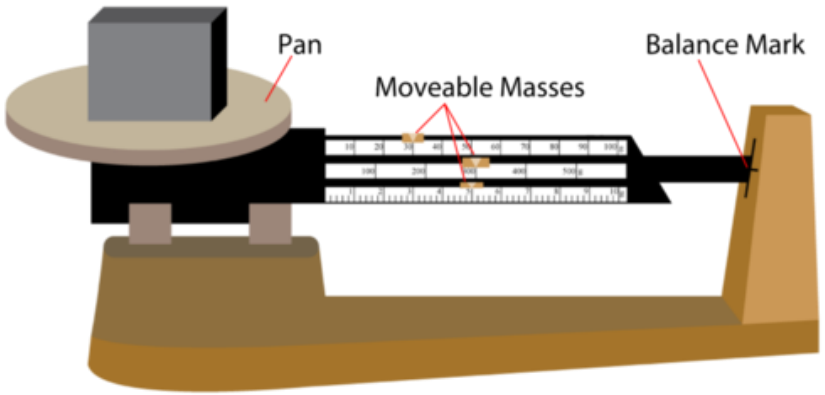
Measuring Density

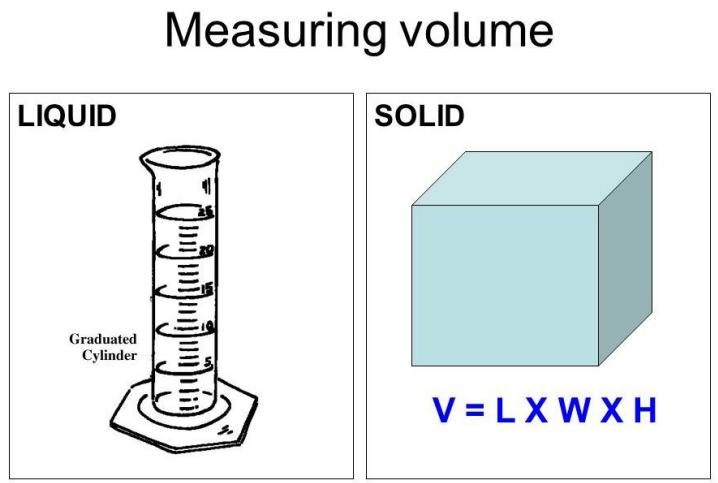
- Layering allows us to determine whether one substance is denser than another substance
- Shortcomings of layering
  - Does not provide a specific measurement of density
  - Cannot be used with solids
    - Solids do not flow, and their particles are so close together that other substances cannot move through them



How can we measure the density of a substance?

- To find the density of a substance we need to know its **mass** and its **volume**
- **Mass** can be determined using an electronic scale or balance
- **Volume** of a solid is often measured in **<u>cubic centimeters (cm^3)</u>**
  - A cubic centimeter is the volume of a cube that measures 1cm on each side
- The **volume** of an object equals the number of 1cm cubes it takes to fill that object





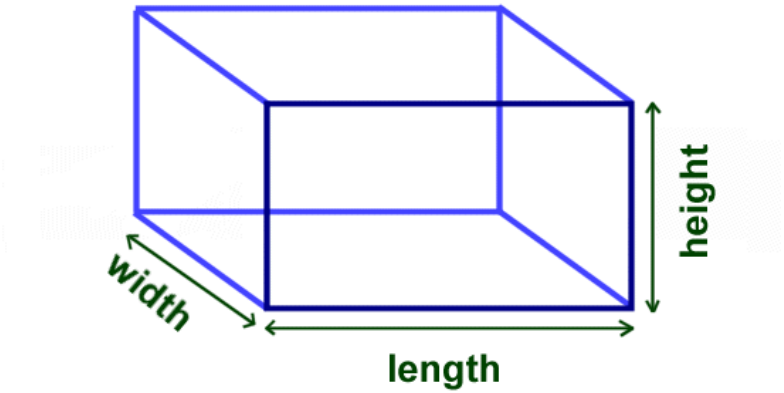
How can we measure the density of a substance?

- The volume of an object with a simple shape can be determined mathematically

For example:

- The volume of a block-shaped object can be calculated using the equation:

  volume = length × width × height
- What is the volume of a rectangular box that is 10cm long, 5 cm wide, and 2 cm high?



10 cm x 5 cm x 2 cm = **100 cm^3**

Displacement

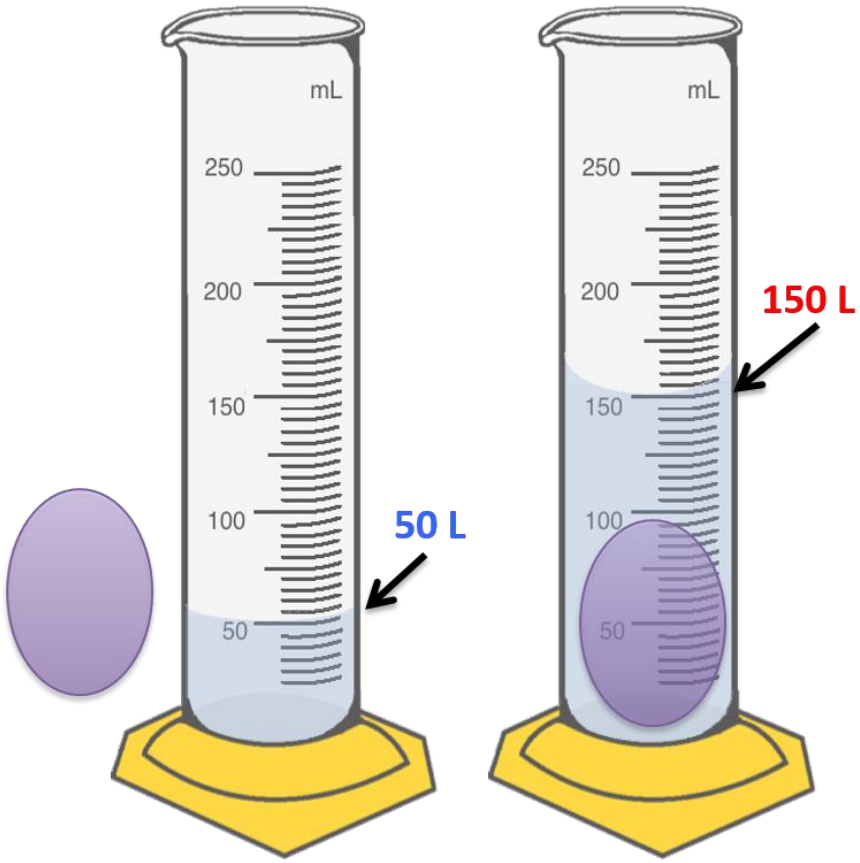
How would you measure the volume of an irregular shaped object?

- **Displacement** = the amount of space that an object takes up when placed in a fluid

- Have you ever noticed how the water level rises in a bathtub when you get into it?
  - The amount of water you are displacing is the volume of your body that is in the water
- By measuring the displacement of an object, we can measure the volume of an object

Finding Volume:

150 L – 50 L = 100 L



Calculating Density

- Once we know the **mass** and **volume** of a substance, we can calculate density
- The density of both fluids and solids can be calculated
- The units for density depend on how you measure the mass and volume of your objects
  - The density of **fluids** is usually measured in **g/mL**
  - The density of **solids** is usually measured in **g/cm^3**
  - 1 mL has the same volume as 1 cm^3

Equation for density →

$$\text{Density (D)} = \frac{\text{mass (m)}}{\text{volume (V)}}$$

Calculating Density Question Example

1 mL of glycerol has a mass of 1.26g. What is the density of glycerol?

Use the formula: $D = \frac{m}{V}$

$= \frac{1.26g}{1\ mL}$

Answer: The density of glycerol is 1.26g/mL

Practice calculating density

Density is measured in:
g/mL
g/cm^3

1. What is the density of a 2 cm^3 sugar cube that has a mass of 3.18g?

   3.18 g/2 cm^3 = 1.59 g/cm^3

2. A 3 mL sample of oil has a mass of 2.64g. What is the density of the oil?

   2.64 g/3 mL = 0.88 g/mL

3. The mass of 1 cm^3 of lead is 11.34g. The mass of 1 cm3 of iron is 7.87g. Which solid has the greater density?

   Lead

Summary

- Fluid are forms of matter that can flow
- Density is a measure of the mass contained in a given volume
  - D = m/V
- Substances with a lower density will float on substances with a higher density