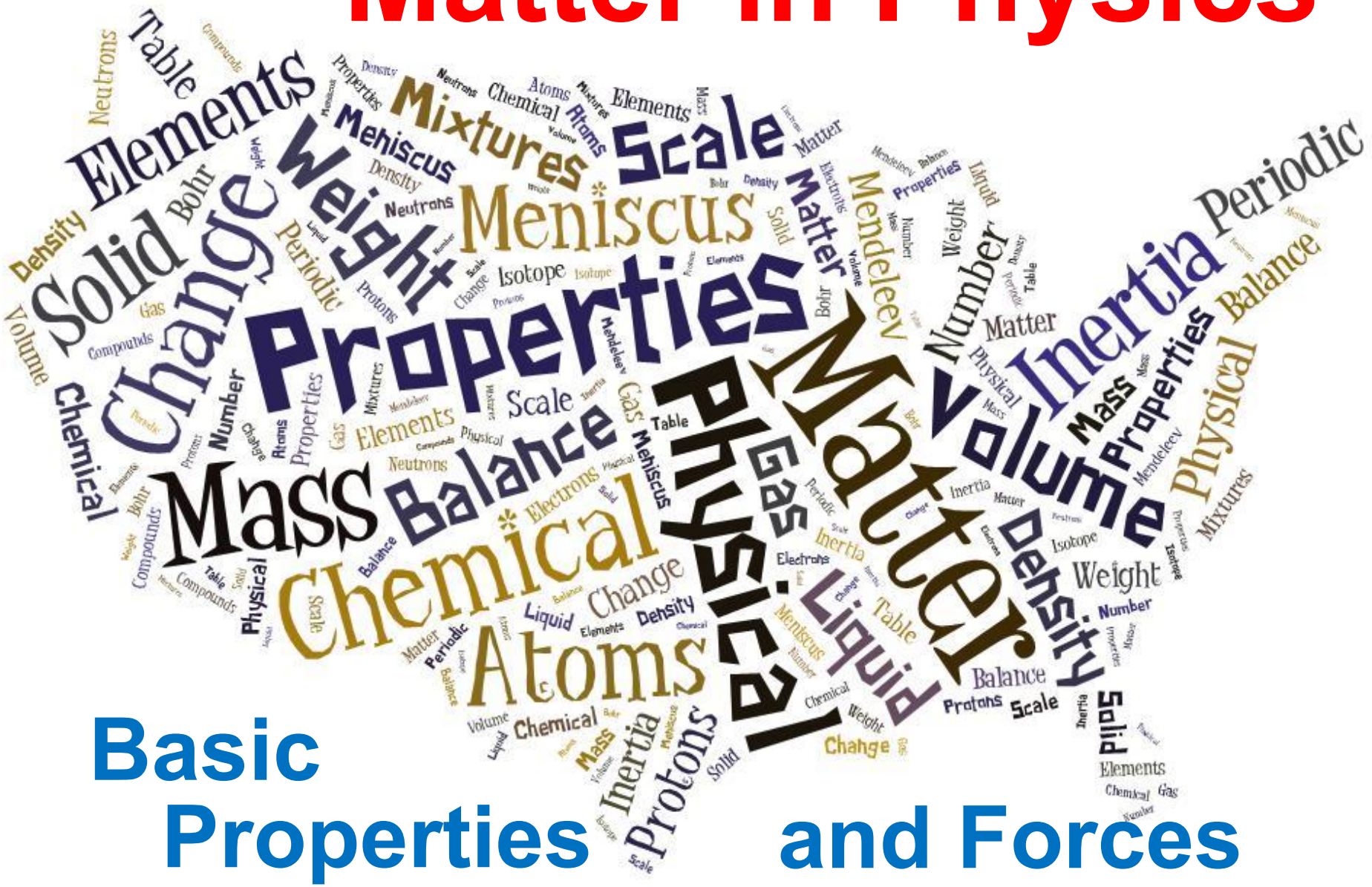
Matter in Physics



Basic Properties and Forces

What is Matter?

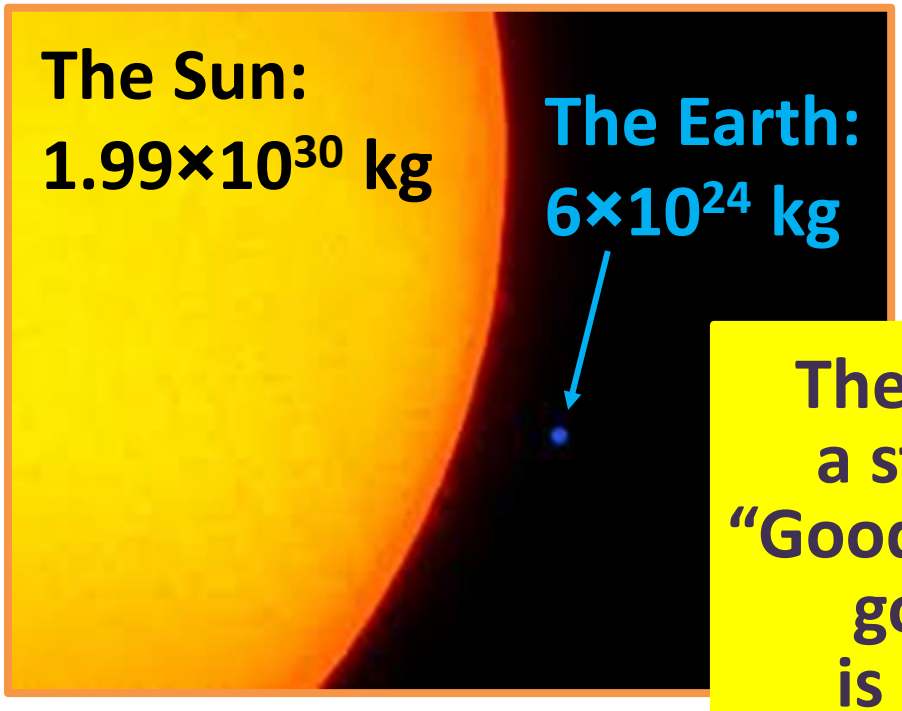
REVIEW

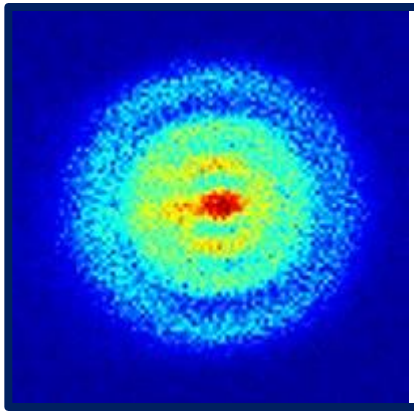
"Matter is anything that has mass and takes up space"

"Matter is made up of atoms"

Mass is the **amount of material** in an object

- **SI unit of mass is kg**



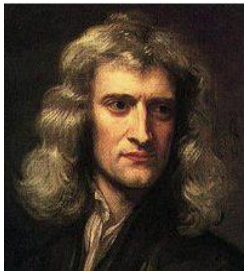


The mass of a smallest atom, Hydrogen, is 1.67×10^{-27} kg

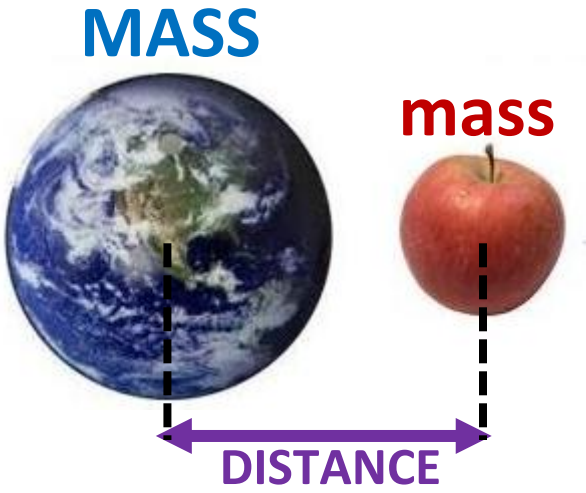
The mass of a standard "Good Delivery" gold bar is 12.4 kg

- Since **all atoms making up any object are composed of protons, neutrons and electrons**, mass is essentially defined by the **total amount of those particles in an object**.

Gravity aka gravitation



is the universal **force of attraction** that acts **between any two or more objects that have mass**



$$\text{GRAVITY} = G \cdot \frac{\text{MASS} \cdot \text{mass}}{(\text{DISTANCE})^2}$$

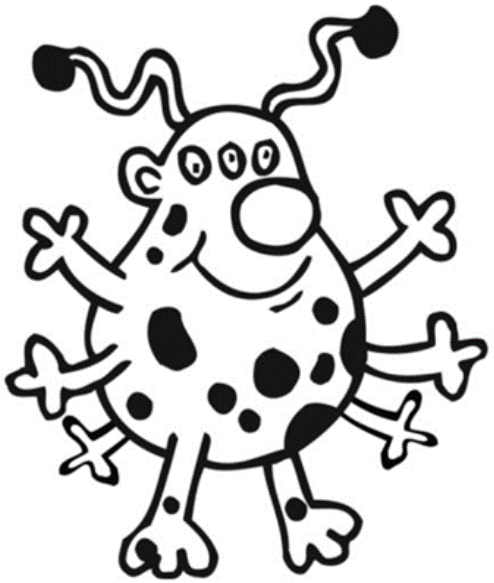
$$6.67 \times 10^{-11}\ \text{Nm}^2/\text{Kg}^2$$

"gravitation constant"

- **Gravity is generally a "weak" force…but massive objects create strong gravitational pull!**
- **Gravity has infinite range…but very distant objects experience very little attraction!**

Mass vs Weight

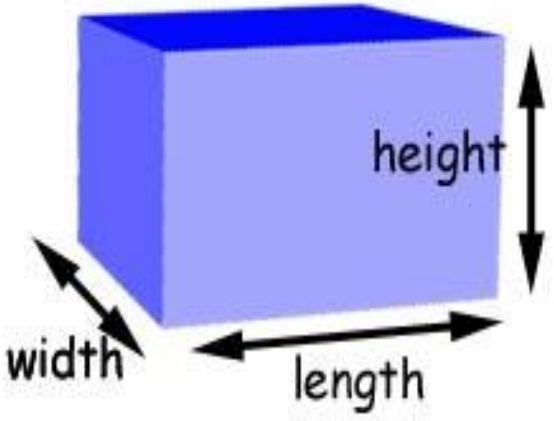
- **Mass** is the amount of material in an object (doesn't change).
- **Weight** is a measure of **how strongly *gravity* is pulling** on an object (decreases as elevation/distance increases).
- Note: on the Earth's surface, terms "weight" and "mass" are used interchangeably since we use a **weighing scale** to determine mass…



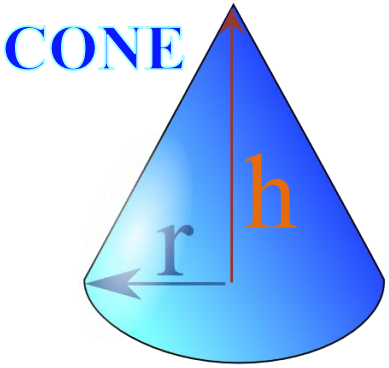
- Question: **What is the weight of a Martian on Mars and Moon if it weighs 50 kg on Earth?**
  - Gravity on Moon is 0.16 of Earth gravity; gravity on Mars is 0.38 of Earth gravity.
  - **Answer:** this Martian weighs 8.3 kg on Moon and 18.8 kg on Mars (the numbers shown by the scale), but **their mass is still 50 kg!!!**

Volume

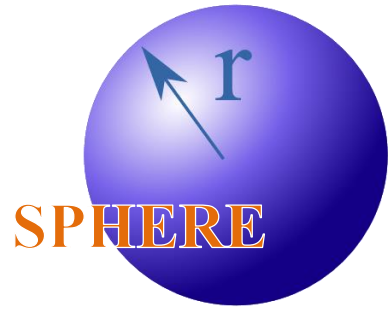
- **Volume** is the <u>amount of three-dimensional space that a substance or shape occupies or contains</u>.



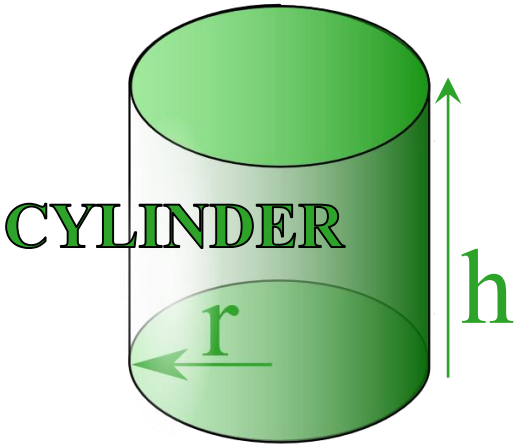
- SI unit of volume is m^3 *(cubic meters)*
- $V_{\text{rectangular prism}} = \text{length} \times \text{width} \times \text{height}$



$$\left(\frac{1}{3}\right)\pi r^2 h$$



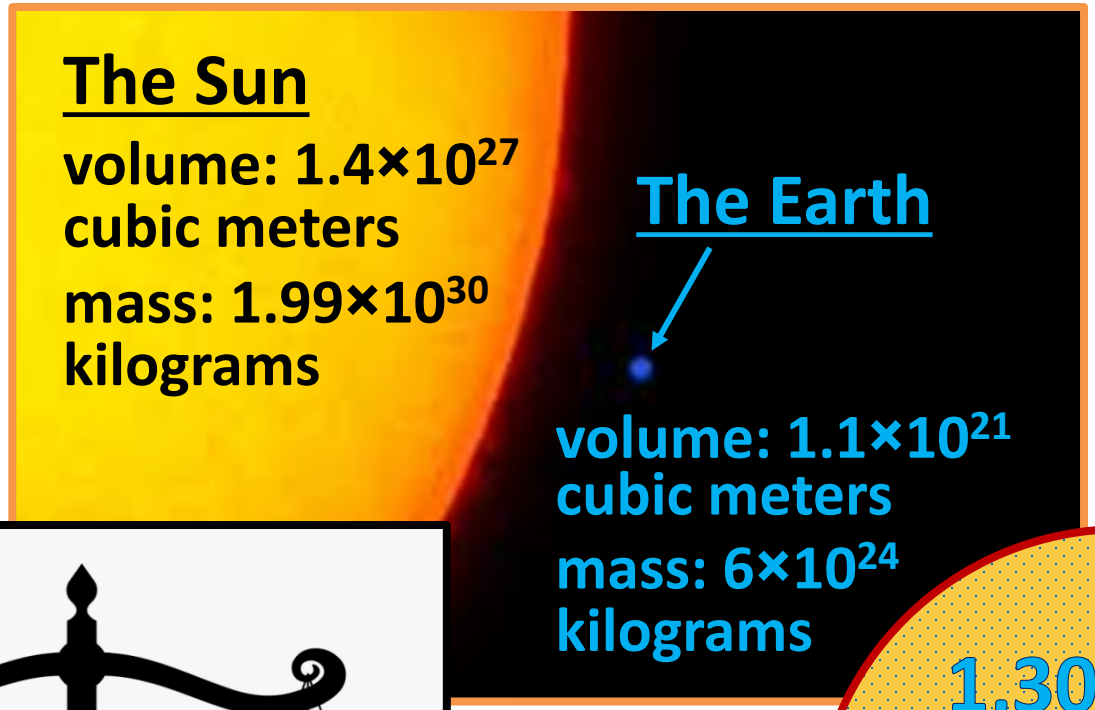
$$\left(\frac{4}{3}\right)\pi r^3$$

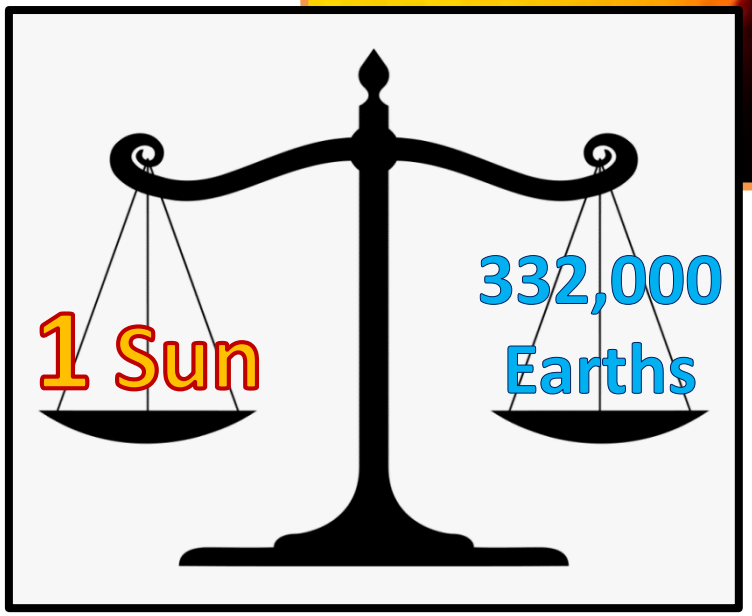


$$\pi r^2 h$$

Where r = radius, h = height, and $\pi = 3.14$

Sun and Earth comparison





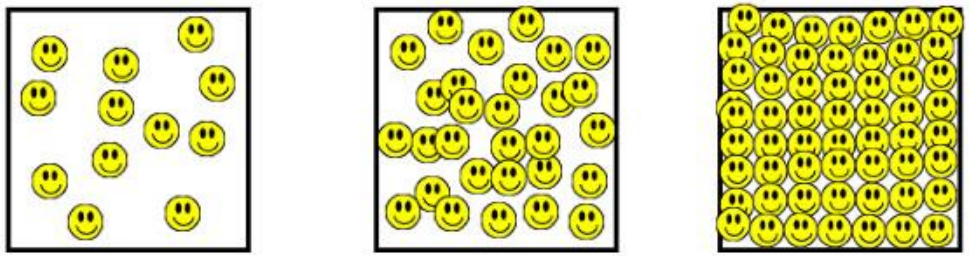
???

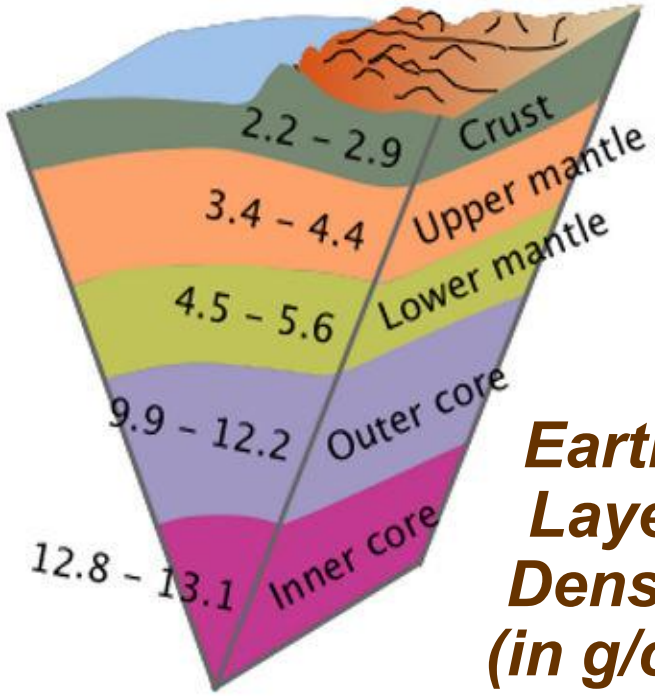
1,300,000 Earths can fit inside 1 Sun

Density

- **Density** is a measure of **how much matter (particles!) is contained in a unit of volume**:

  - **density** = $\frac{\text{mass}}{\text{volume}}$
  - **SI unit is kg/m^3**





Earth's Layers Density (in g/cm^3)

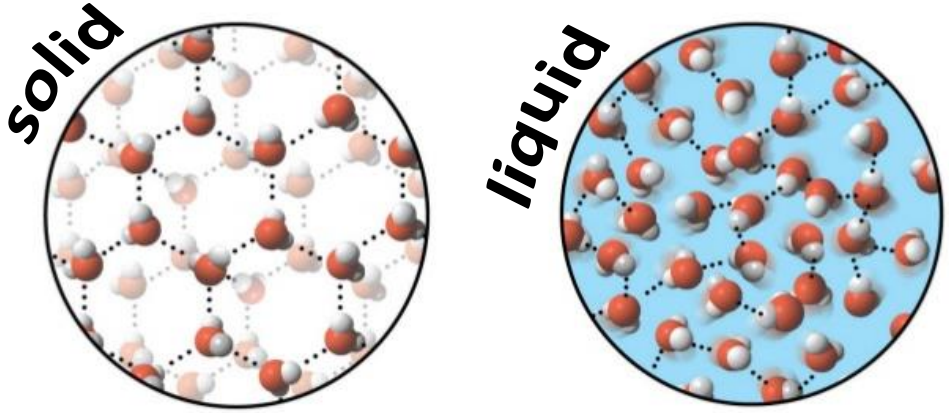
- **The density of a material varies with temperature and pressure** (this variation is typically small for solids and liquids but much greater for gases).
  - **In general, lowering the temperature results in density increase**
  - **Increasing the pressure also results in density increase**

Understanding Water Density

↓ temperature = ↑ density
therefore colder water sinks…

If colder water is more dense than warmer water, and the denser goes under the less dense, how come ice cubes float?

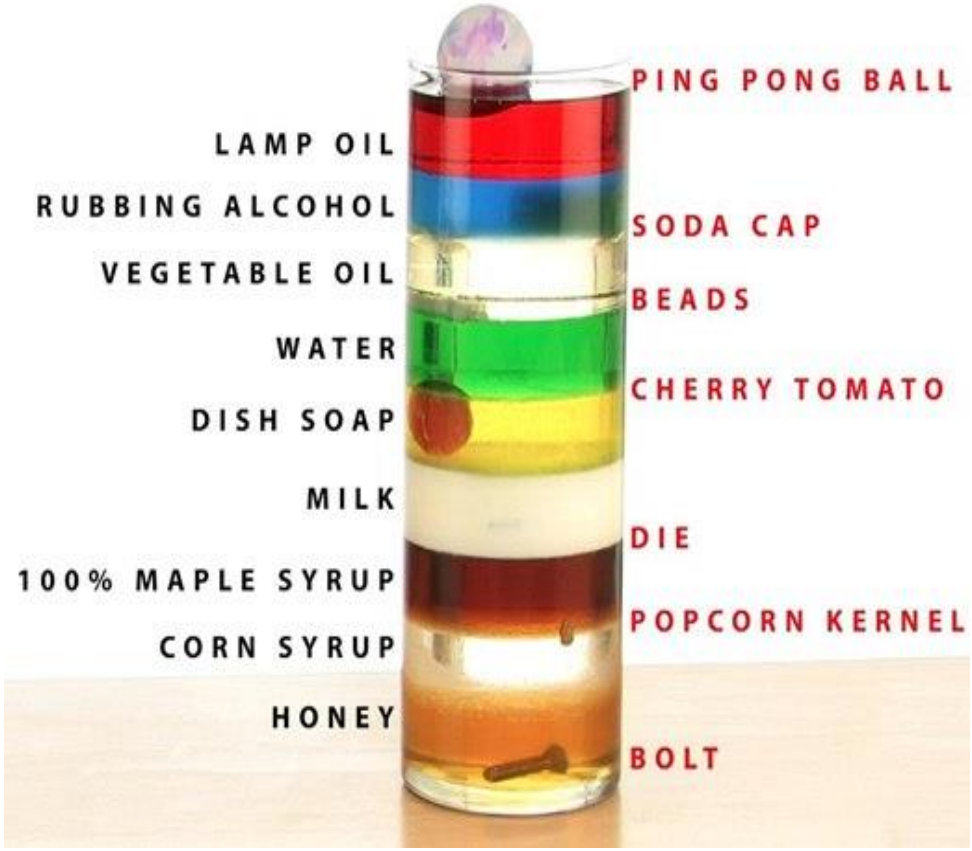
Aren't they colder water on top of warmer water?



ANSWER: Water is the only substance that gets denser as it cools down until it is close to 4°C… it then becomes less dense and only then freezes!

Fun with Liquids

Have you ever heard the phrase "oil and water don't mix"?



The term "<u>miscibility</u>" describes how well two substances mix. "Immiscible" liquids do not mix. When combined together, they form <u>layers</u>.

WHY?