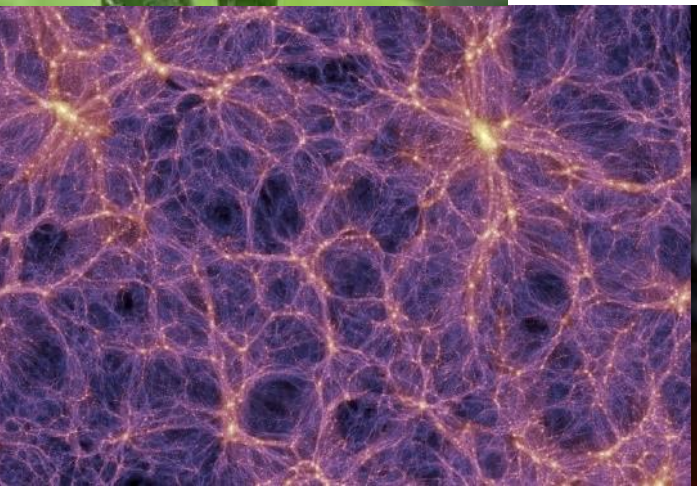



OH DEAR, WHAT CAN THE

MATTER

BE?





What is Matter?

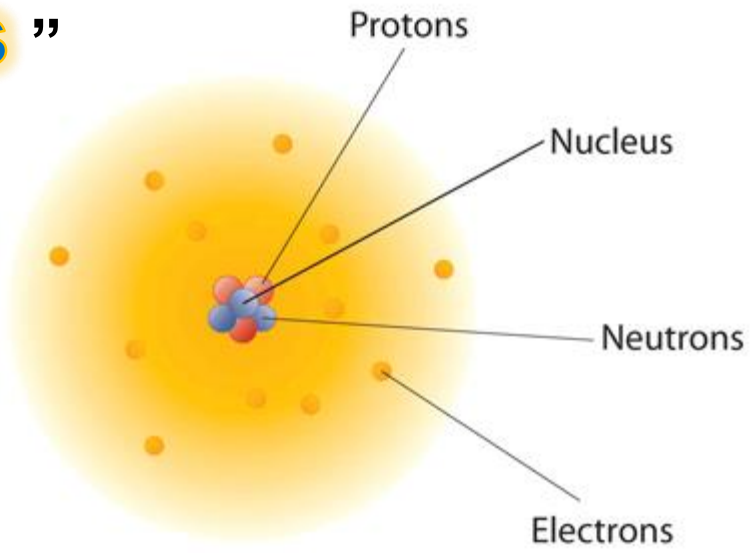
1. **Common "classical" definition (known as *mechanical, abstract mathematical*), René Descartes, Isaac Newton - 17th century:**

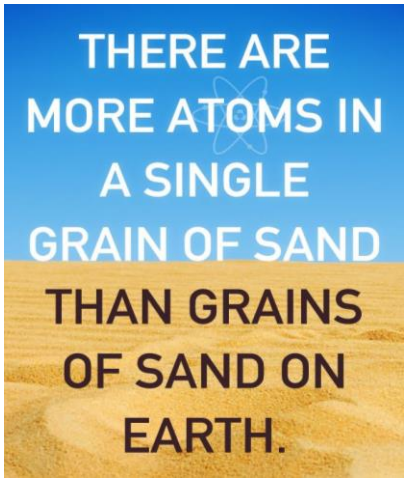
"Matter is anything that has mass and takes up space"

2. **Late 19th century definition (based on physical and chemical structure):**

"Matter is made up of atoms"

This *atomic*, or *ordinary*, matter is in turn made up of interacting *subatomic particles* — usually a nucleus of *protons* and *neutrons*, and a cloud of orbiting *electrons*.



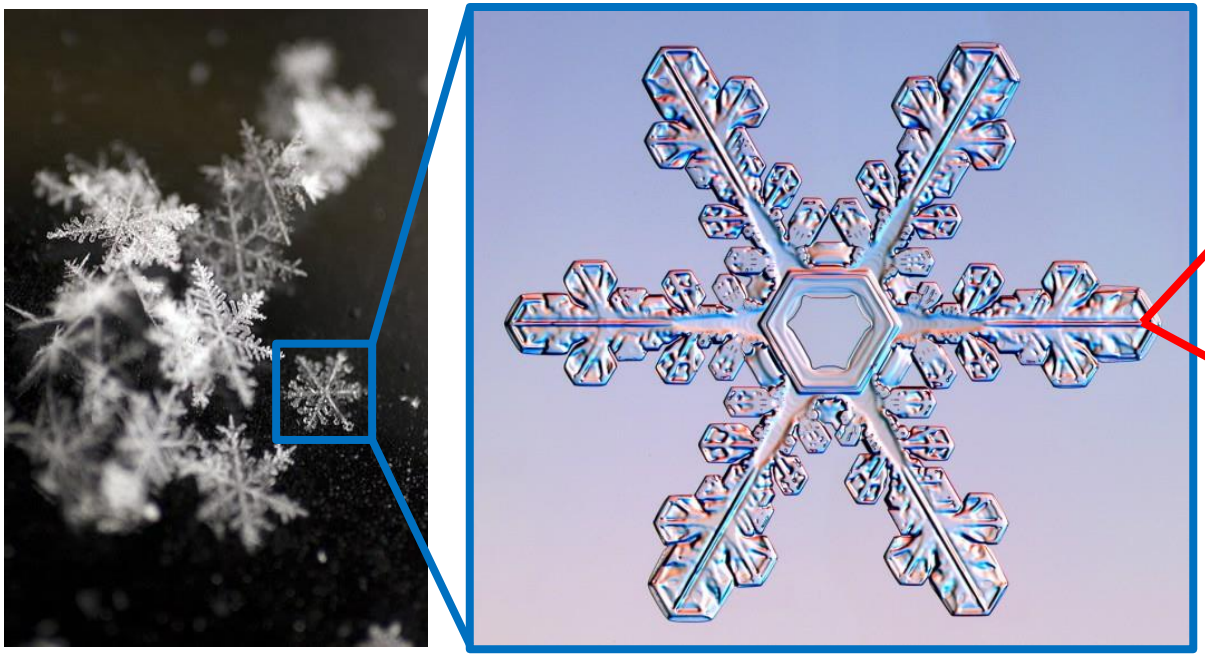


Atoms are very small!

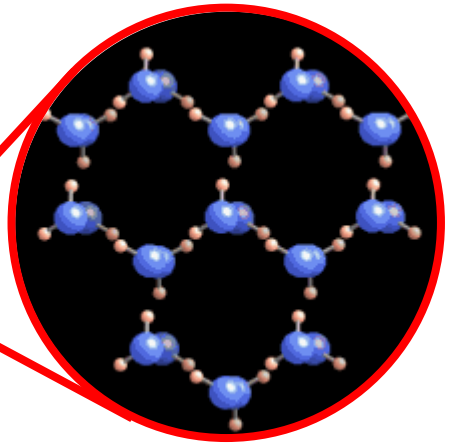
Voyage into the World of Atoms:

https://www.youtube.com/watch?v=7WhRJV_bAiE

Snowflake ~1-3 mm



Ice crystal unit cell 5 nm



Single atom ~1Å=10^{-10} m

A typical snowflake is made of about 10^{18}-10^{19} atoms.

Study of Matter

- **Physics** – ***physical science*** **that studies forms of matter, its change and motion through space-time, and related concepts such as energy and force.**
- **Chemistry** – ***physical science*** **that studies material substances, their composition and change of composition (chemical reactions), as well as matter behavior related to chemical reactions.**

Physical science – branch of natural science that studies non-living systems.

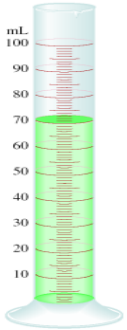
Natural science – major branch of science, that tries to explain and predict nature's phenomena, based on empirical evidence.

Science – systematic effort of acquiring knowledge—through observation and experimentation coupled with logic and reasoning.

Physical Properties of Matter

We can describe <u>physical properties</u> of matter in terms of physical quantities and laws.

- **An *<u>extensive</u>* property depends upon how much matter is being considered:**
  - **mass**
  - **volume**
  - **electrical charge**

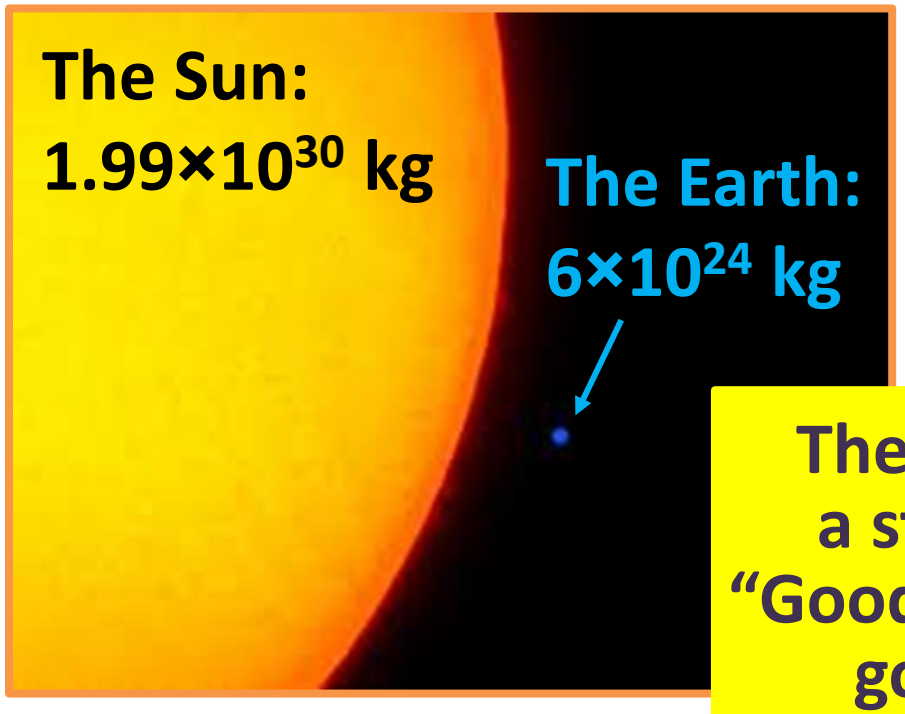


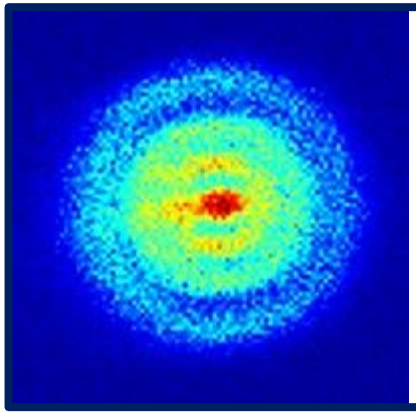
- **An *<u>intensive</u>* property does *<u>not</u>* depend upon how much matter is being considered:**
  - **density**
  - **temperature**
  - **color**

  - **elasticity**
  - **metallicity**
  - **solubility etc…**

Mass

- **Mass** is the **amount of material** in an object (doesn't change).
- Don't confuse with **weight**, a measure of how strongly gravity is pulling on an object (decreases as elevation increases).



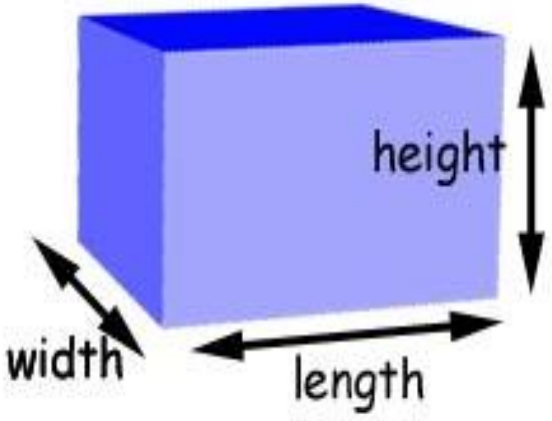


The mass of a smallest atom, Hydrogen, is 1.67×10^{-27} kg

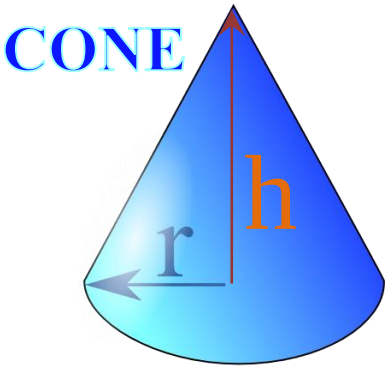
The mass of a standard "Good Delivery" gold bar is 12.4 kg

- **SI unit of mass is kg**

Volume

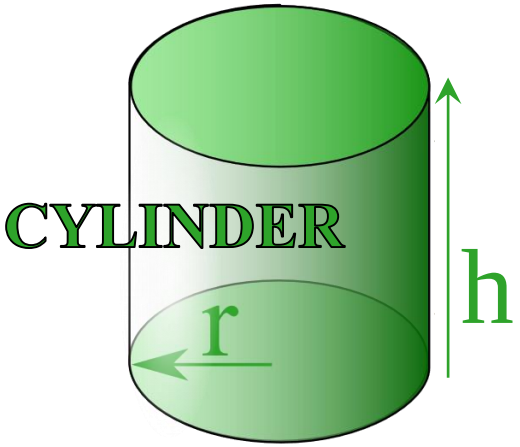


- **Volume** is the <u>amount of three-dimensional space that a substance or shape occupies or contains</u>.
- SI unit of volume is m^3 *(cubic meters)*
- $V_{\text{rectangular prism}}$ = length × width × height



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

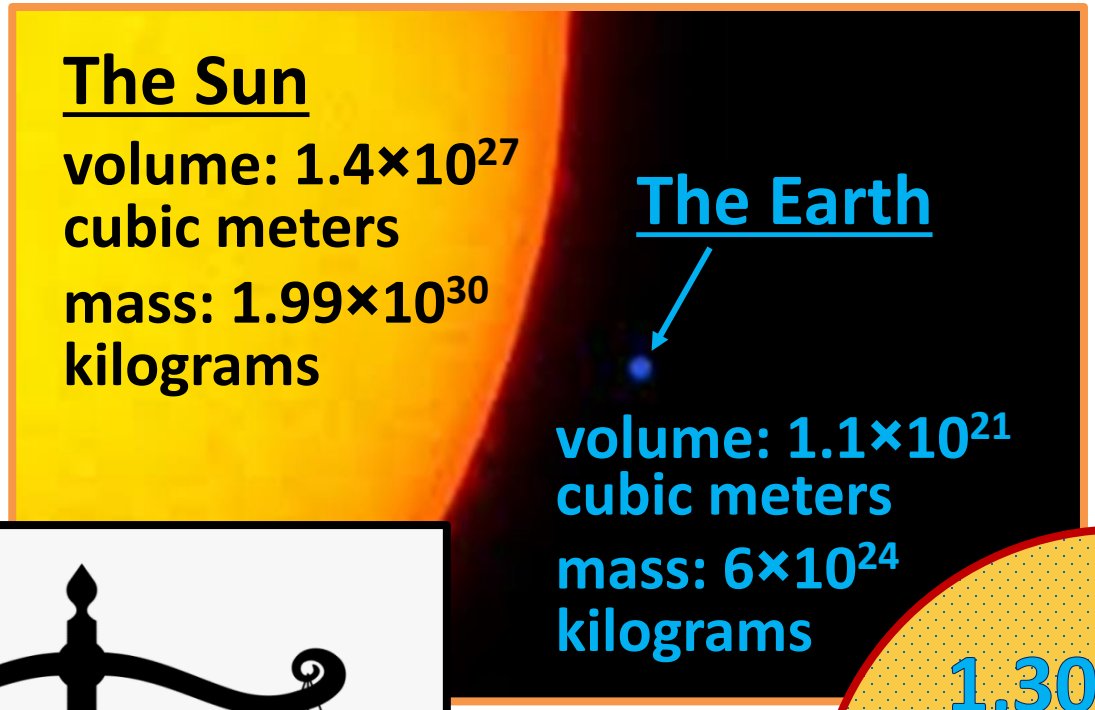
$\left(\frac{4}{3}\right)\pi r^3$

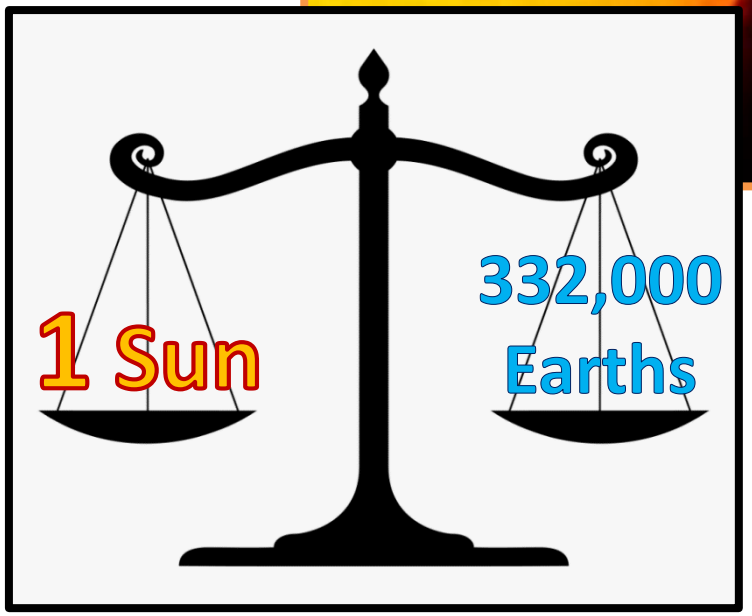


$\pi r^2 h$

Where r = radius, h = height, and π = 3.14

Sun and Earth comparison





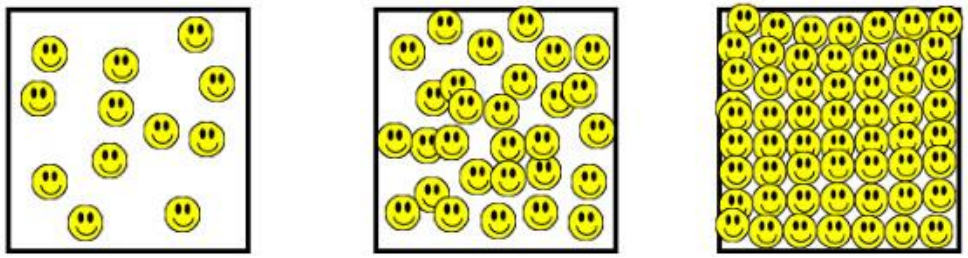
???

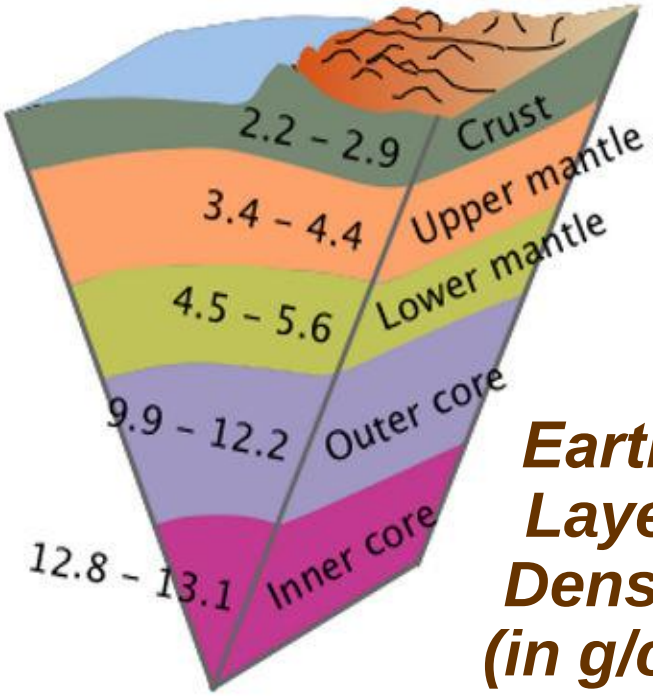
1,300,000 Earths can fit inside 1 Sun

Density

- **Density is a measure of <u>how much matter (atoms!) is contained in a unit of volume</u>:**

  - **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**