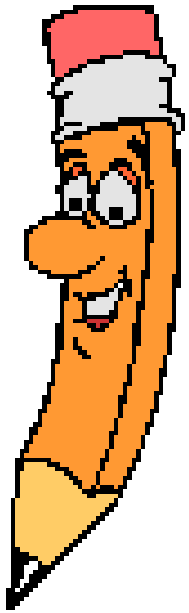
S-1

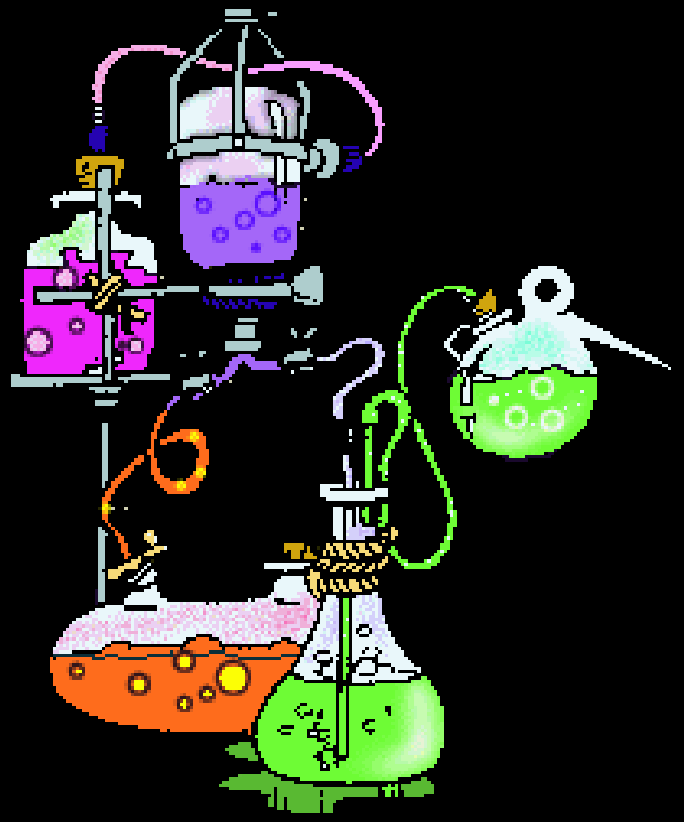
- Please fill out the information sheet that is on your desk.



Chapter 1
Science Skills

SPS2 Students will explore the nature of matter, its classifications, and its system for naming types of matter

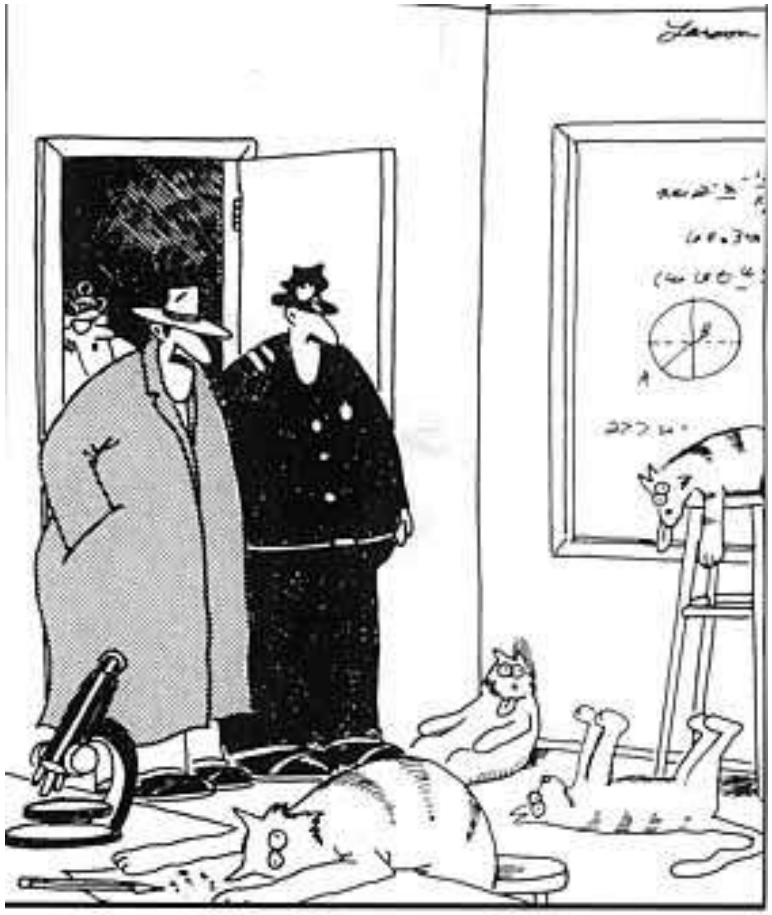
1.1 What is Science?



How does the process of science start and end?
What is the relationship between science and technology

1.1 What is Science

- Curiosity – leads to discovery
- Science – system of knowledge and methods to find knowledge



"Notice all the computations, theoretical scribblings, and lab equipment, Norm. ... Yes, curiosity killed these cats."

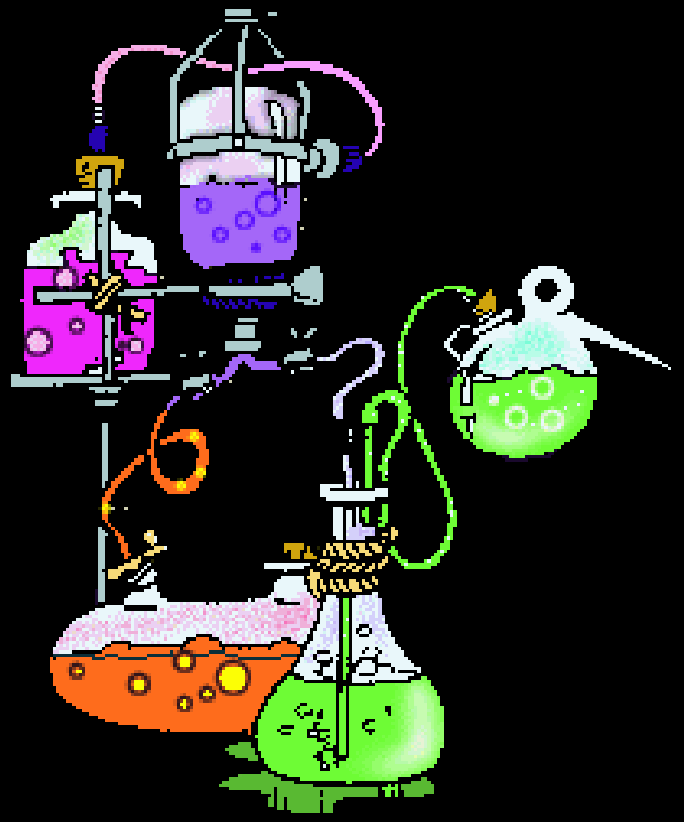
1.1

- Te
  pr
- Ac
  te
- Ex
- Computers – 1979 Atari 400 (16Kb Ram, 5.25 Floppy 760 Kb)
- I-Pad (16-64 Gb, wireless, flash)

1.1 What is Science?

- Telephones
- 1979 – Black Rotary Phone – called people
- 2010 – Motorola Droid – phone, internet access, gps, camera
- Science (and Technolgy are always changing

1.2 Using a Scientific Approach



What is the scientific method?
How does a scientific law differ from a scientific theory?
Why are scientific models useful?

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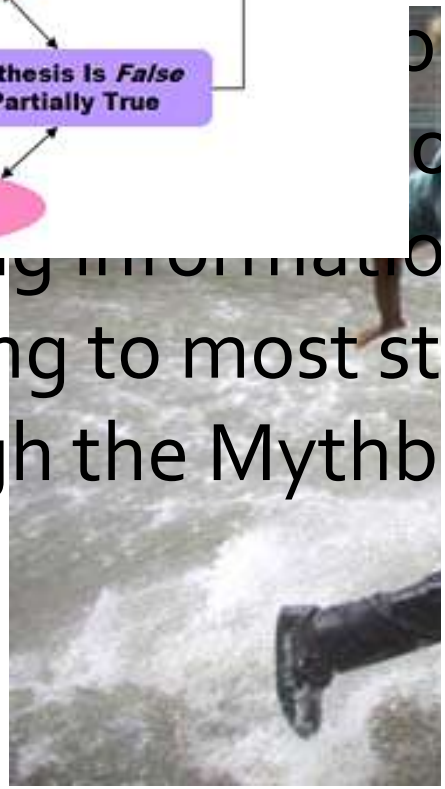
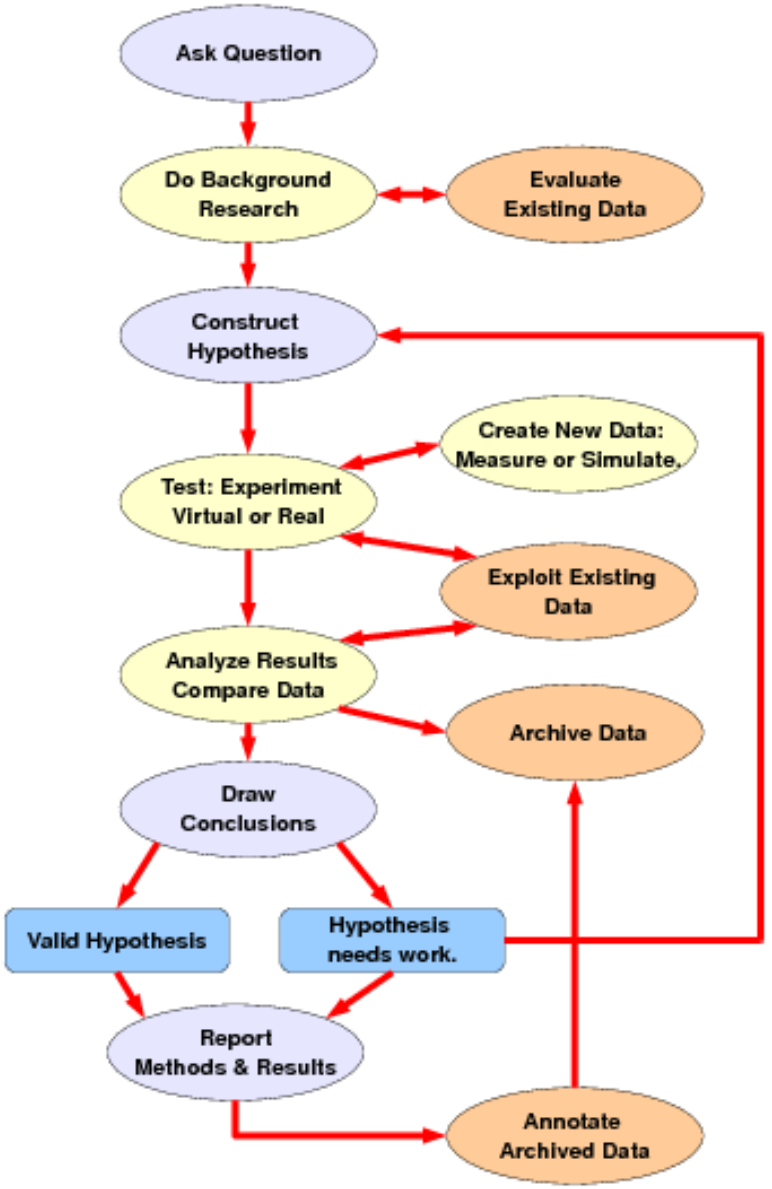




1.2 Using a Scientific Approach

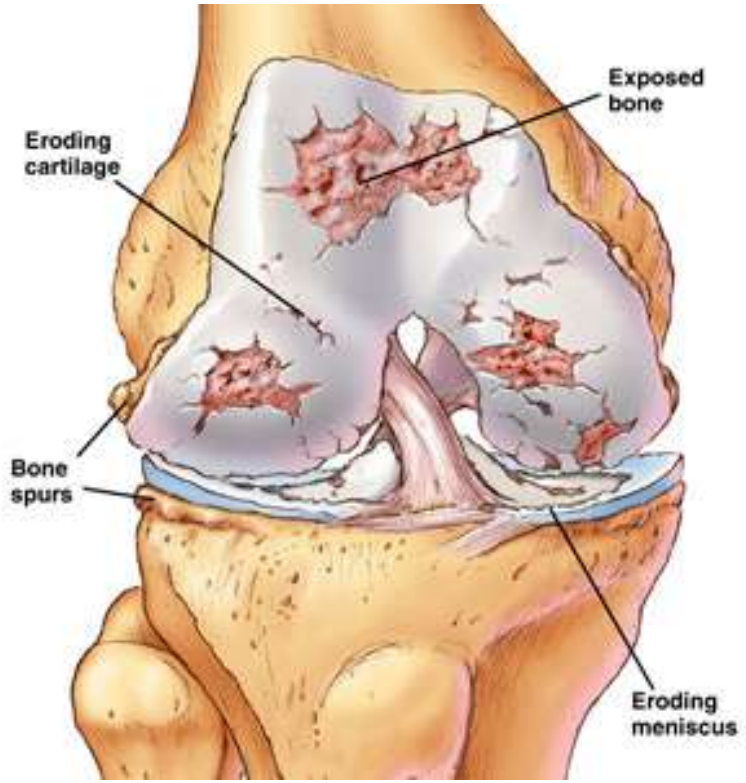
- Testing a Hypothesis (doing the experiment)
  - Sometimes formal, sometimes informal
  - Manipulated variable – variable that causes a change in another
  - Responding variable – changes in response to manipulated variable
  - Controlled experiment – only one variable is changed

1.2 Using a Scientific Approach

- Testing a Hypothe
  - Hypothesis – socc
    football players
  - Manipulated varia
  - Responding variab
  - Controlled experir
    socio-economic ba
    educational backg

1.2 Using a Scientific Approach

- Drawing Co
  - The hypoth
  - The hypoth
  - The hypoth ...tior
  - Examples
  - Eating Ome ...s brain function an
  - Glucosamine supplements heal knee joints



1.2 Using a S

- Developing a T
  explanation for
- Theory of Evolu
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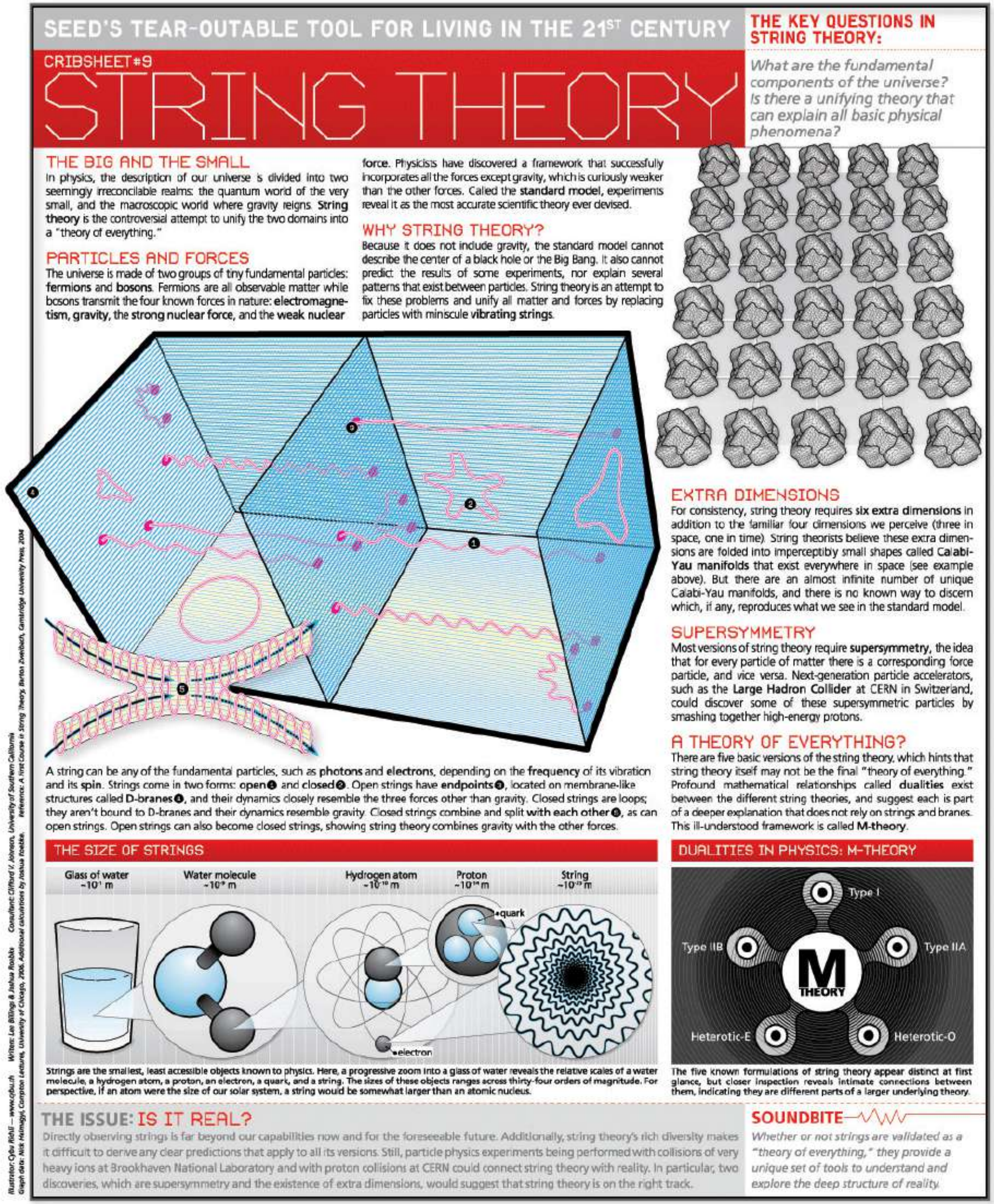
- Strir



SEED'S TEAR-OUTABLE TOOL FOR LIVING IN THE 21ST CENTURY

CRIBSHEET #9

STRING THEORY

THE KEY QUESTIONS IN STRING THEORY:

What are the fundamental components of the universe? Is there a unifying theory that can explain all basic physical phenomena?

THE BIG AND THE SMALL

In physics, the description of our universe is divided into two seemingly irreconcilable realms: the quantum world of the very small, and the macroscopic world where gravity reigns. **String theory** is the controversial attempt to unify the two domains into a "theory of everything."

PARTICLES AND FORCES

The universe is made of two groups of tiny fundamental particles: **fermions** and **bosons**. Fermions are all observable matter while bosons transmit the four known forces in nature: **electromagnetism, gravity,** the **strong nuclear force,** and the **weak nuclear force**. Physicists have discovered a framework that successfully incorporates all the forces except gravity, which is curiously weaker than the other forces. Called the **standard model**, experiments reveal it as the most accurate scientific theory ever devised.

WHY STRING THEORY?

Because it does not include gravity, the standard model cannot describe the center of a black hole or the Big Bang. It also cannot predict the results of some experiments, nor explain several patterns that exist between particles. String theory is an attempt to fix these problems and unify all matter and forces by replacing particles with miniscule **vibrating strings**.

A string can be any of the fundamental particles, such as **photons** and **electrons**, depending on the **frequency** of its vibration and its **spin**. Strings come in two forms: **open**❶ and **closed**❷. Open strings have **endpoints**❸, located on membrane-like structures called **D-branes**❹, and their dynamics closely resemble the three forces other than gravity. Closed strings are loops; they aren't bound to D-branes and their dynamics resemble gravity. Closed strings combine and split **with each other**❺, as can open strings. Open strings can also become closed strings, showing string theory combines gravity with the other forces.

EXTRA DIMENSIONS

For consistency, string theory requires **six extra dimensions** in addition to the familiar four dimensions we perceive (three in space, one in time). String theorists believe these extra dimensions are folded into imperceptibly small shapes called **Calabi-Yau manifolds** that exist everywhere in space (see example above). But there are an almost infinite number of unique Calabi-Yau manifolds, and there is no known way to discern which, if any, reproduces what we see in the standard model.

SUPERSYMMETRY

Most versions of string theory require **supersymmetry**, the idea that for every particle of matter there is a corresponding force particle, and vice versa. Next-generation particle accelerators, such as the **Large Hadron Collider** at CERN in Switzerland, could discover some of these supersymmetric particles by smashing together high-energy protons.

A THEORY OF EVERYTHING?

There are five basic versions of the string theory, which hints that string theory itself may not be the final "theory of everything." Profound mathematical relationships called **dualities** exist between the different string theories, and suggest each is part of a deeper explanation that does not rely on strings and branes. This ill-understood framework is called **M-theory**.

THE SIZE OF STRINGS

Strings are the smallest, least accessible objects known to physics. Here, a progressive zoom into a glass of water reveals the relative scales of a water molecule, a hydrogen atom, a proton, an electron, a quark, and a string. The sizes of these objects ranges across thirty-four orders of magnitude. For perspective, if an atom were the size of our solar system, a string would be somewhat larger than an atomic nucleus.

DUALITIES IN PHYSICS: M-THEORY

The five known formulations of string theory appear distinct at first glance, but closer inspection reveals intimate connections between them, indicating they are different parts of a larger underlying theory.

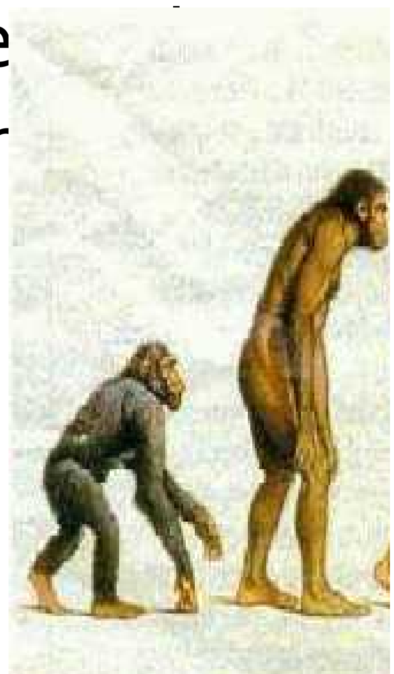
THE ISSUE: IS IT REAL?

Directly observing strings is far beyond our capabilities now and for the foreseeable future. Additionally, string theory's rich diversity makes it difficult to derive any clear predictions that apply to all its versions. Still, particle physics experiments being performed with collisions of very heavy ions at Brookhaven National Laboratory and with proton collisions at CERN could connect string theory with reality. In particular, two discoveries, which are supersymmetry and the existence of extra dimensions, would suggest that string theory is on the right track.

SOUNDBITE

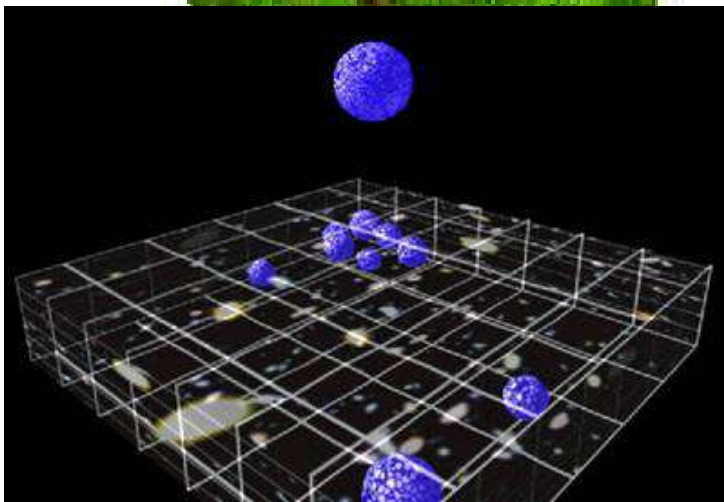
Whether or not strings are validated as a "theory of everything," they provide a unique set of tools to understand and explore the deep structure of reality.

Illustrator: Cybu Richli — www.cybu.ch Writers: Lee Billings & Joshua Roebke Consultant: Clifford V. Johnson, University of Southern California
Graph data: Nick Halmagyi, Compton Lectures, University of Chicago, 2006. Additional calculations by Joshua Roebke. Reference: A First Course in String Theory, Barton Zwiebach, Cambridge University Press, 2004



1.2 Using a Scientific Approach

- Scientific Laws – describes an observed pattern in nature without attempting to explain it.
- Law of Gravity – masses are attracted toward each other
- The explanation is provided by a theory
- Theory of Gravitons



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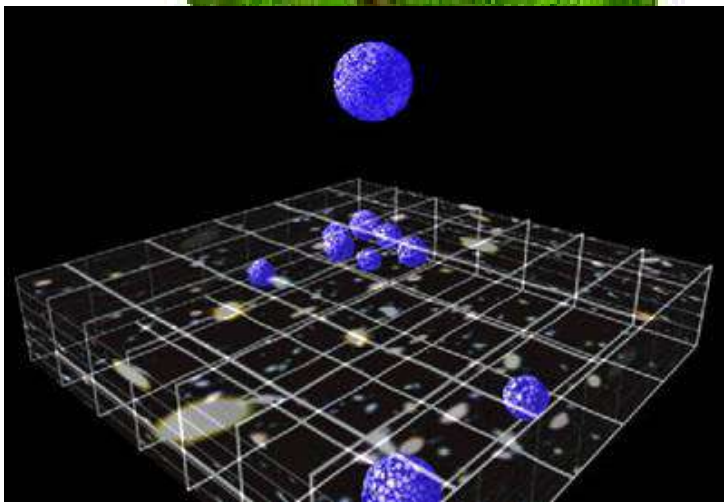
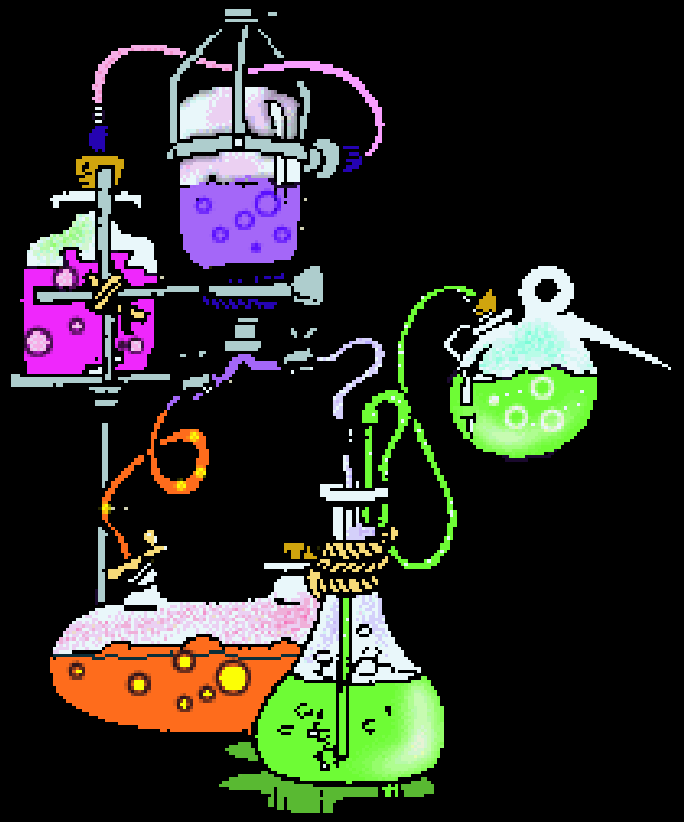


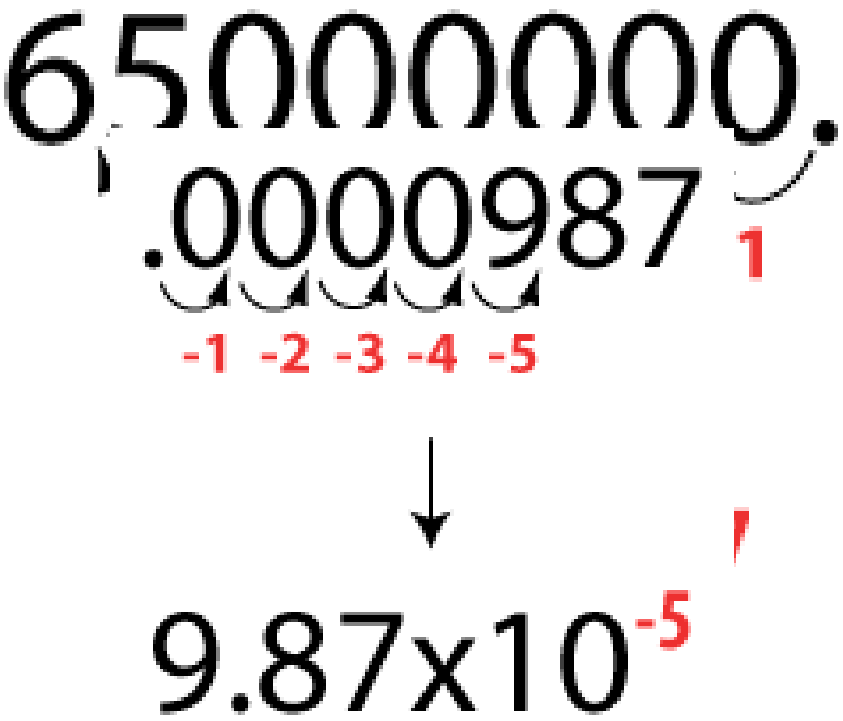
1.3 Measurement



Why is scientific notation useful?
What units do scientists use for their measurements?

1.3 Measurement

- Scientific Notation – represents very large or very small numbers as powers of 10
- Large nur ...nent
- Small nur ...onent



1.3 Measurement

- Multiplying Exponents

$$(4.0x10^{11}) \times (2.0x10^{2}) =$$

- 1. First multiply the numbers

$$(4.0) \times (2.0) = 8.0$$

- 2. Add the exponents

$$((4.0x10^{11})) \times ((2.0x10^{2})) = 8.0x10^{11+2}$$

1.3 Measurement

- Dividing Exponents

$$(4.0x10^{11}) \div (2.0x10^{2}) =$$

- 1. First divide the numbers

$$(4.0) \times (2.0) = 2.0$$

- 2. Subtract the exponents

$$(4.0x10^{11}) \div (2.0x10^{2}) = 2.0x10^{11-2}$$

1.3 Measurement

- Practice

$$(8.0 \times 10^{5}) \times (2.0 \times 10^{7}) = 16 \times 10^{12}$$

$$(8.0 \times 10^{5}) \times (2.0 \times 10^{7}) = 16 \times 10^{12}$$

$$(8.0 \times 10^{5}) \times (2.0 \times 10^{7}) = 16 \times 10^{12}$$

$$(8.0 \times 10^{-5}) \times (2.0 \times 10^{7}) = 4.0 \times 10^{-2}$$

$$(8.0 \times 10^{-5}) \times (2.0 \times 10^{7}) = 4.0 \times 10^{-2}$$

$$(8.0 \times 10^{-5}) \times (2.0 \times 10^{7}) = 4.0 \times 10^{-2}$$

$$(10.0 \times 10^{-3}) \times (4.0 \times 10^{-4}) = 2.5 \times 10^{-7}$$

$$(10.0 \times 10^{-3}) \times (4.0 \times 10^{-4}) = 2.5 \times 10^{-7}$$

$$(10.0 \times 10^{-3}) \times (4.0 \times 10^{-4}) = 2.5 \times 10^{-7}$$

1.3 Measurement

- International System of Units (SI or metric system)
- Base Units
- Length – meter (m)
- Mass – kilogram (kg)
- Temperature – kelvin (K)
- Time – second (s)

1.3 Measurement

- International System of Units (SI or metric system)
- Derived Units – combinations of base units
- Volume – length x width x height
  - meter x meter x meter
  - m^3
- Density – mass divided
  - Grams divided by meter x
  - g/cm^3 (in chemistry)

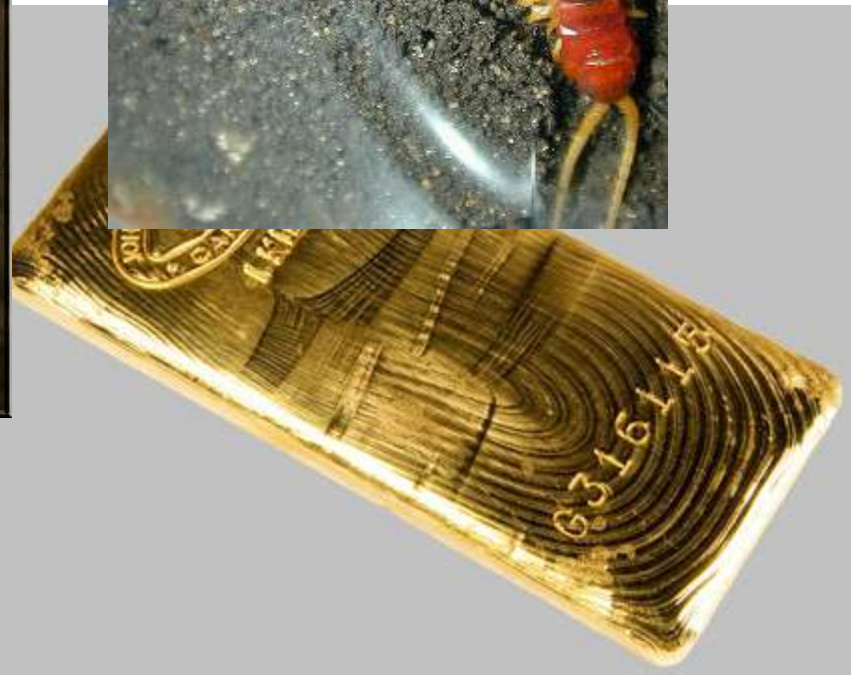
1.3 Measurement

- You will be asked to calculate density

$$D = \frac{m}{V} = \frac{22.5\ g}{63\ mL} = 0.36\ \frac{g}{mL}$$

- Mass (in grams) divided by volume (in cm^3 or mL)
- What is the density of a 63 mL block with a mass of 22.5 g?

1.3 Measurement



- milli (m) – 1/1000 – mu
- Millipede – they don't

1.3 Measurement

- Converting units (learn this well, you do similar stuff all year!)
- Convert by multiply by a conversion factor – () with a fraction inside $\left(\frac{1km}{1000m}\right)$
- What goes inside the fraction
  - The unit that you want goes on top
  - The unit you are getting rid of goes on the bottom

1.3 Measurement

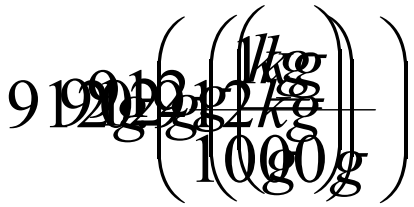
- So if I wanted to convert 18 g to mg

  - Unit I want is mg
  - Unit I want to get rid of is g
  - Now I have to remember that 0.001 g = 1 mg (or 1g = 1000 mg)
  - Put the numbers in your calculator and get the answer

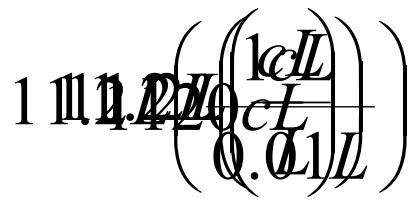
1.3 Measurement

Practice

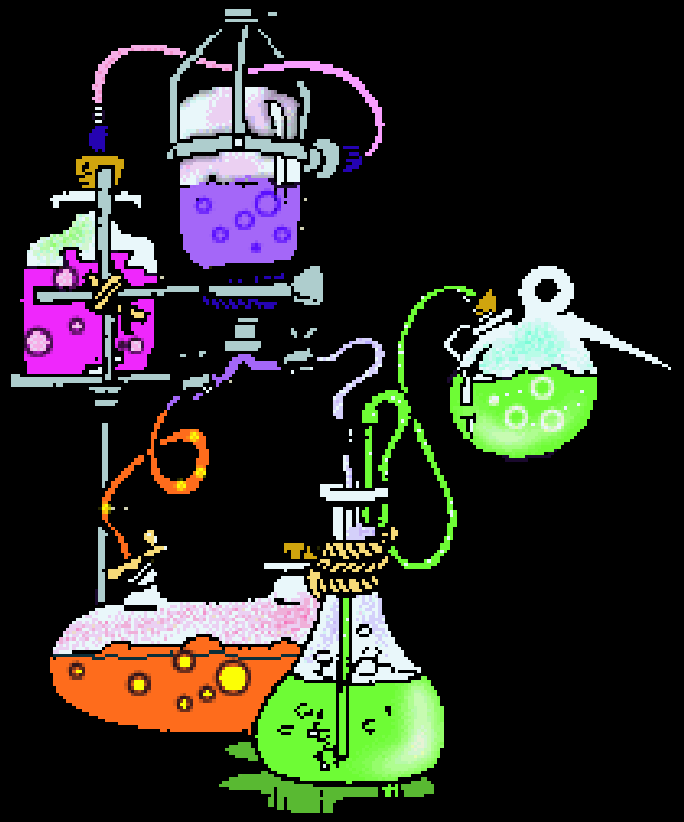
1. Convert 912 g to kg



2. Convert 11.2 L to cL



1.4 Presenting Scientific Data

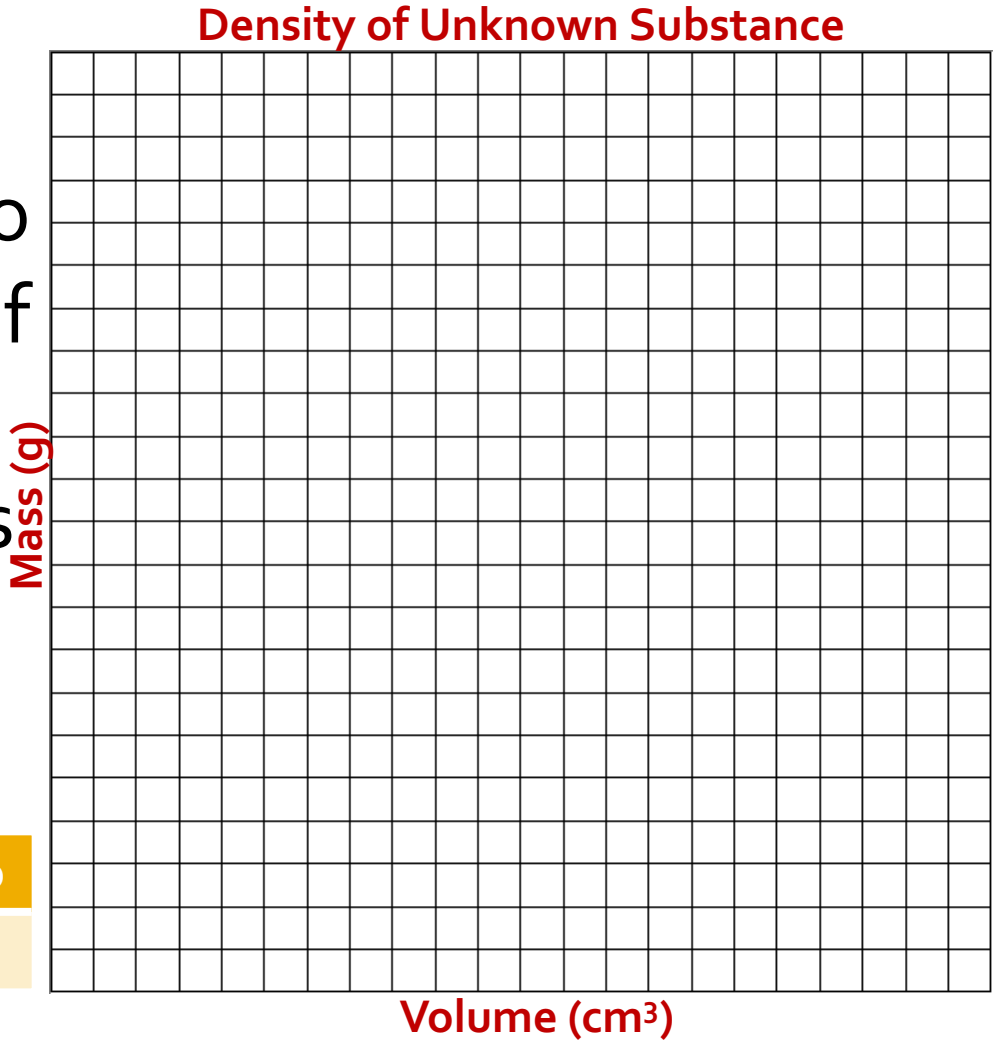


How do scientists organize data?
How can scientists communicate experimental data?

1.4 Presenting Scientific Data

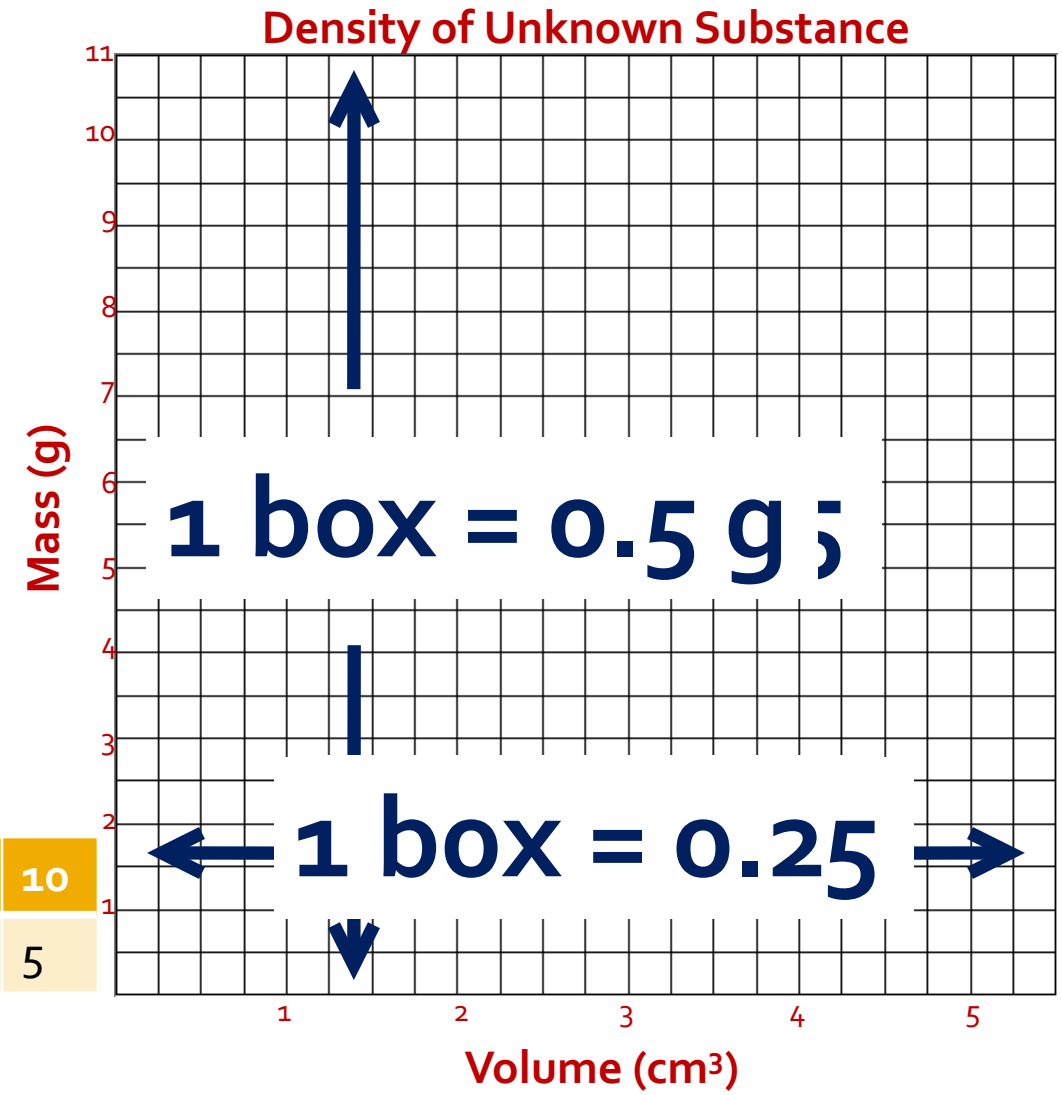
- Line graphs
- You must be able to draw a line graph of data
- First label each axis and give the graph a title

Mass (g)	2	4	5	7	10
Volume (cm^3)	1	2	2.5	3.5	5



1.4 Presenting Scientific Data

- Line graphs
- The hard part – determine the value of each space

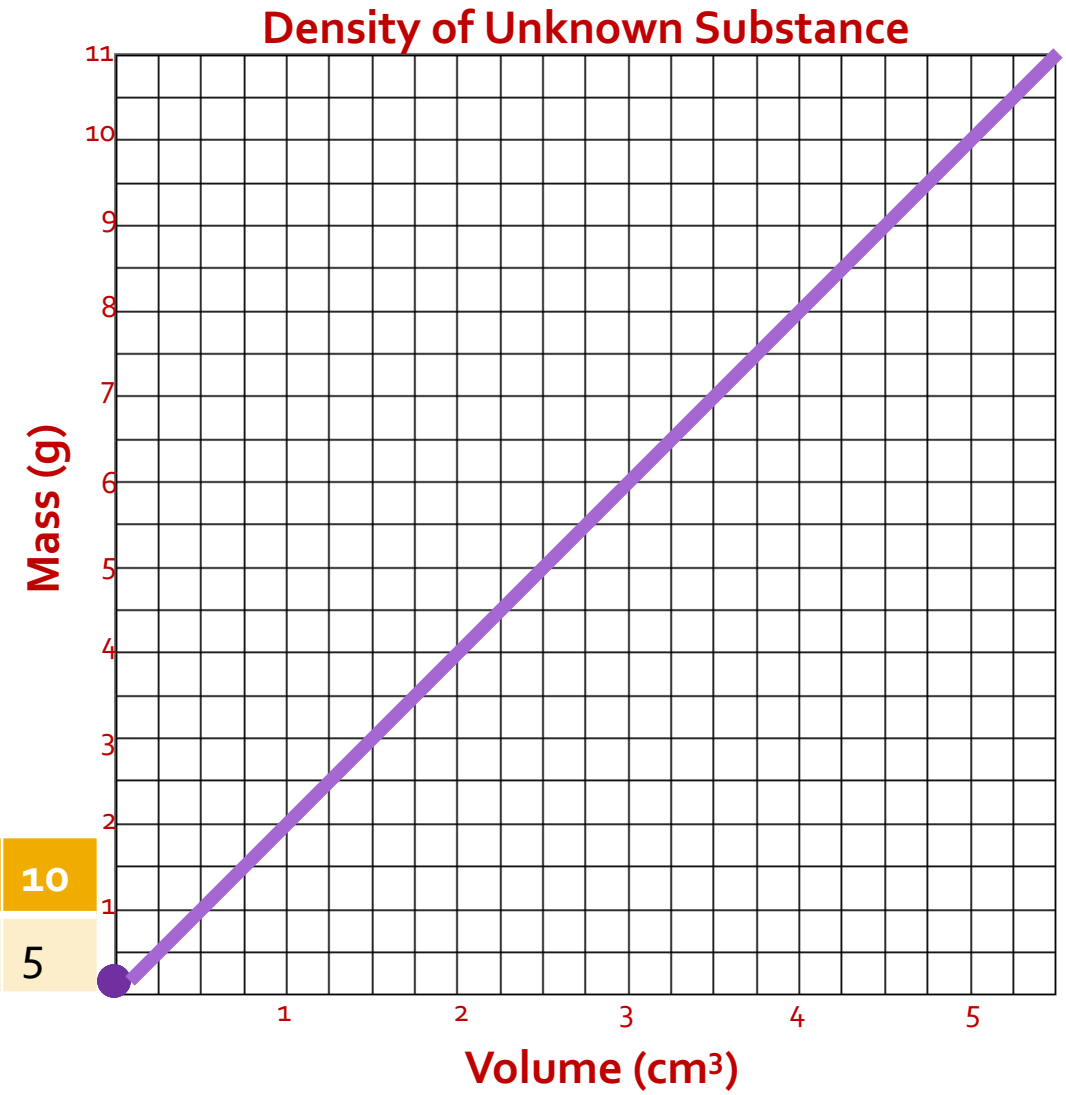


Mass (g)	2	4	5	7	10
Volume (cm^3)	1	2	2.5	3.5	5

1.4 Presenting Scientific Data

- Line graphs
- Now plot your points
- Finally draw the best straight line or curve

Mass (g)	2	4	5	7	10
Volume (cm^3)	1	2	2.5	3.5	5



1.4 Presenting Scientific Data

- Line graphs
- You should be able to get data from your graph
- What is the volume of a 8.5g sample?
- 4.25 cm^3