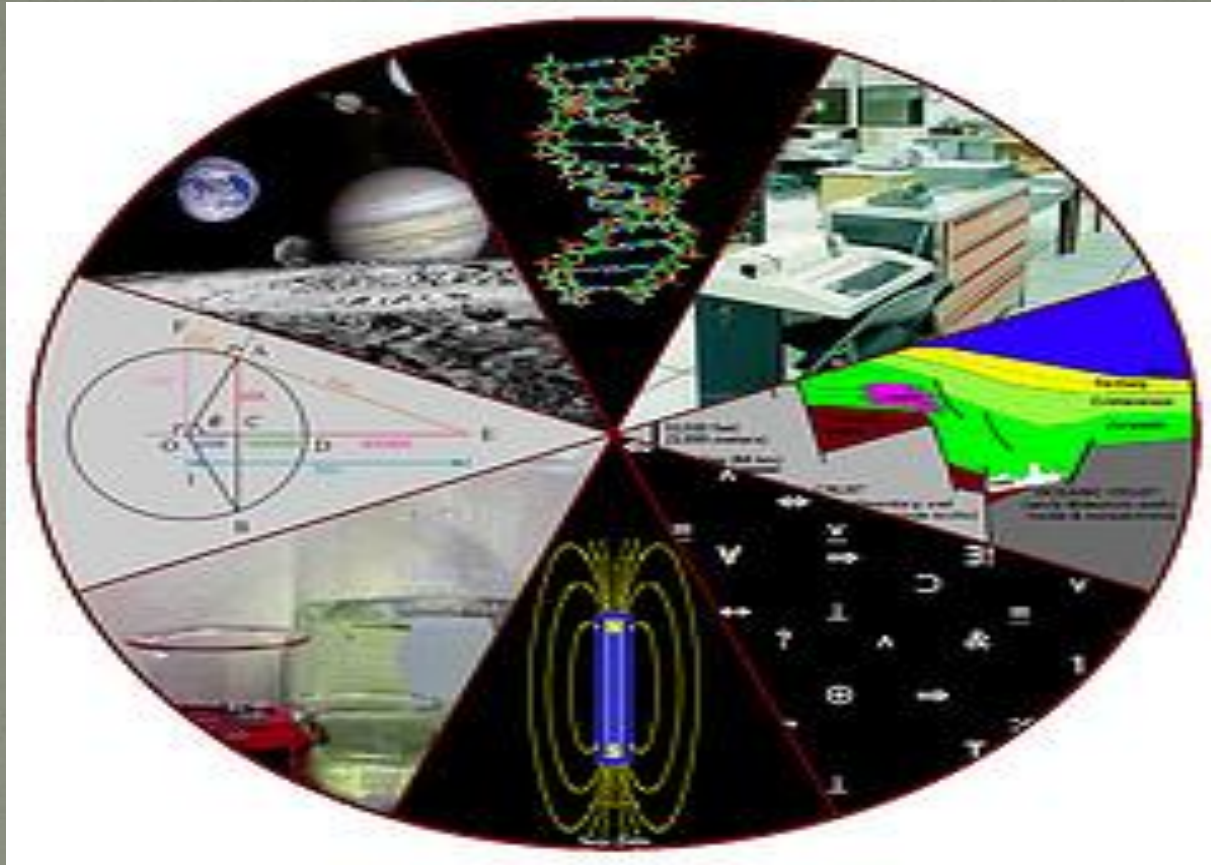


The Nature of Science



“Everything is a part of every other thing, now and forever”
The Lieutenant by Kate Grenville

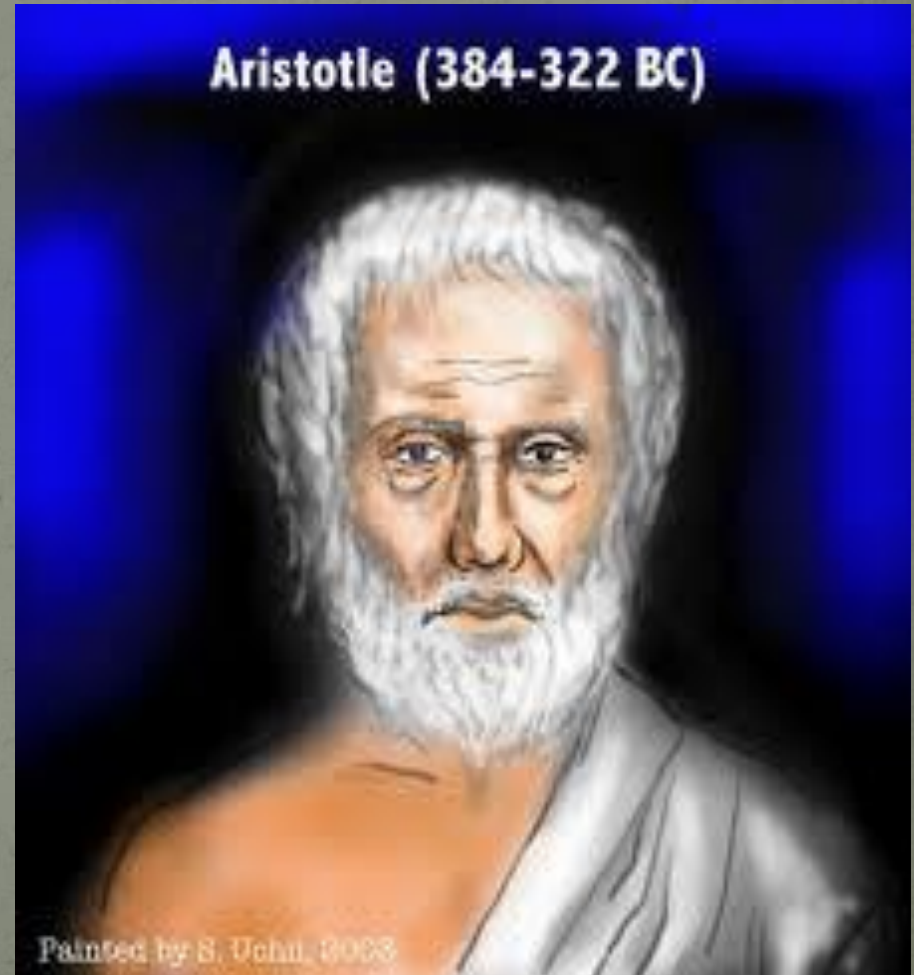
Why Science?

- The word is derived from the Latin term *scientia*, meaning “**knowledge**”.
- It’s a **process** of arriving at an **understanding of a question or a problem** .
- Science began **before** recorded history, when people first saw patterns in nature.



The History of Science

- The **Ancient Greeks** were **natural philosophers** (like **Aristotle**) and they used “thinking only” to explain the world.
- “Philosophy” means the **love of wisdom**.
- Natural philosophers didn’t test their ideas, they relied on their thinking skills.



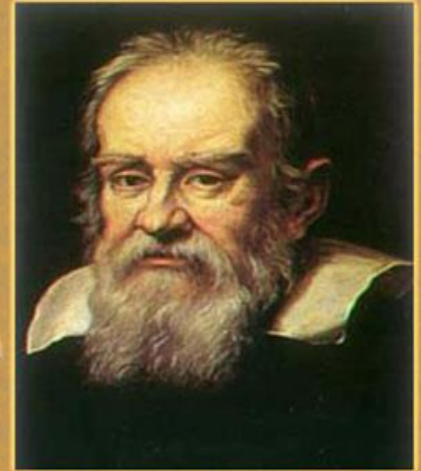
First “Modern” Scientists

- Began in the 1600’s with Galileo.
- He conducted **experiments** and **collected evidence**.
- He was the first “modern scientist” to base his work on **testable facts**.
- **Galileo** and **Frances Bacon** are considered to be the founders of what is now called “**The Scientific Method**”.

Galileo Galilei



www.ChikyMiky.com



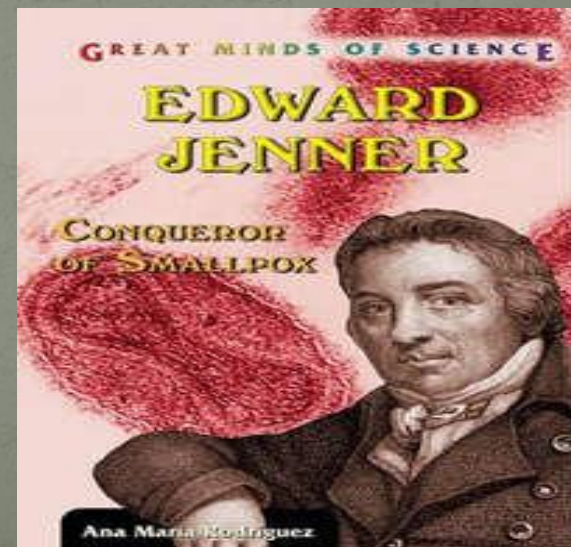
Smallpox

- Up through the 20th century, one of the most serious diseases of mankind was smallpox.
 - One of out every 10 children born in France and Sweden died of smallpox.
- The only known “cure” was to contract the disease and recover.
- Some inoculated themselves with fluid and pus from the sick, hoping to contract a mild case and survive.



The First Vaccination

- A British physician named Edward Jenner observed that dairymaids living in his hometown often contracted cowpox, a nonlethal disease with similar symptoms to smallpox.
- He decided to intentionally infect a young boy with cowpox, then expose him to smallpox. (1796)
 - Immunity was successfully conferred to the boy.



Eradication

- A different virus was eventually discovered for use in smallpox vaccinations.
 - Produced much milder symptoms.
- Smallpox was declared eradicated by the World Health Organization in 1980.
- The same basic technique has been used to develop vaccines for other illnesses, such as measles, tetanus, chickenpox, whooping cough, and others.



A monument dedicated to smallpox eradication at the WHO headquarters in Geneva. Source: Wikimedia.

Basic Rules of Science

- Science assumes that everything in the universe can be explained, given enough data and experimentation.
- All ideas in science are constantly being tested, evaluated, and re-considered.
 - **Hypothesis:** Testable prediction based on prior knowledge and observation.
(Can be supported or rejected based on an experiment)
- Discoveries must be **reproducible** -- designed and recorded such that the results can be repeated by other researchers.

Scientific Method

- The first step is making an **observation**.
 - Information gathered by noticing specific details of a phenomenon.
- Dr. Edward Jenner observed that dairymaids who contracted cowpox seemed to be protected from the more deadly smallpox.



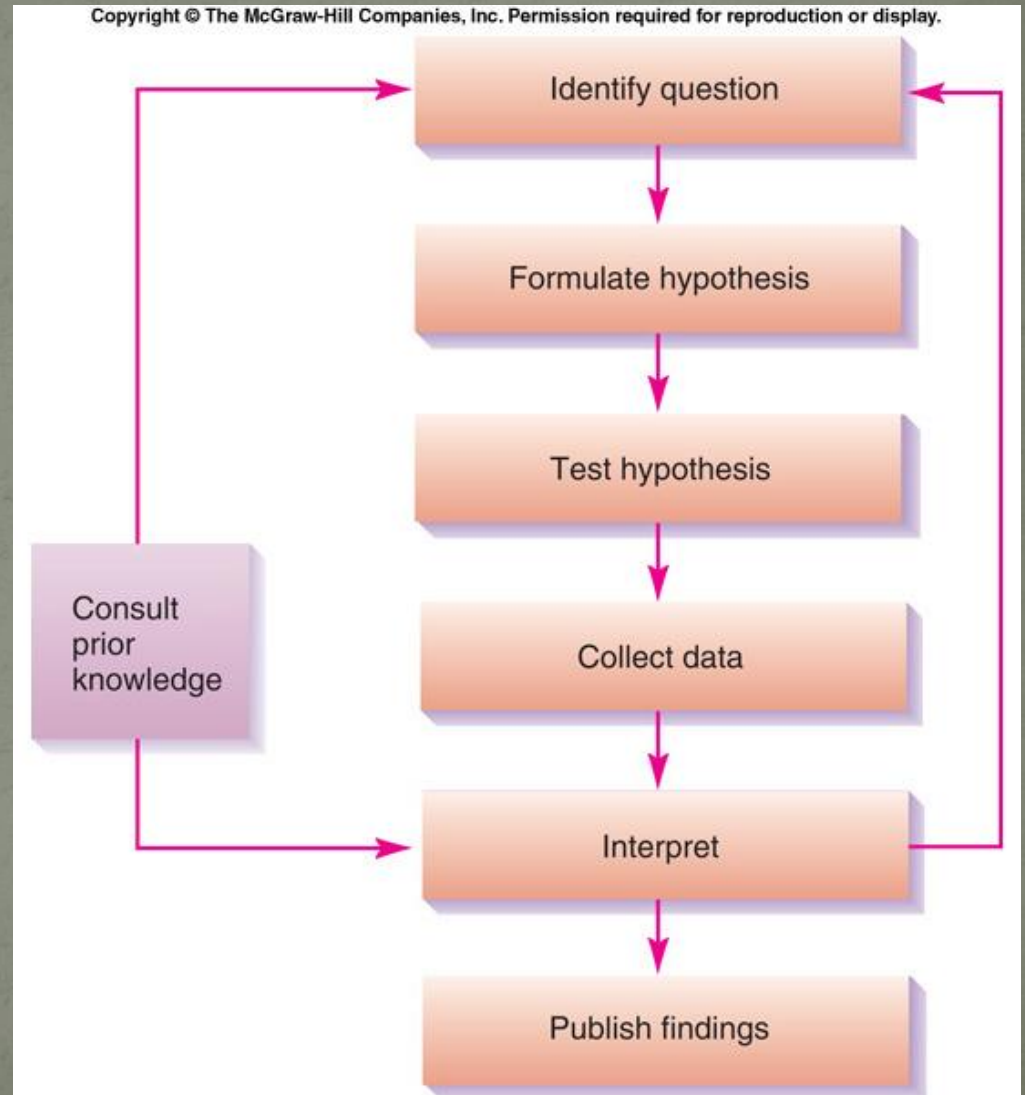
The Dairy Maid,
1650s, by Aelbert
Cuyp.

Scientific Method

- The goal is to be able to explain the observation.
- A **hypothesis**, or testable explanation, will be made based on the scientist's prior experience and research.
 - Hypotheses are preliminary explanations – they can and are often proven false.
- Dr. Jenner's hypothesis was that exposure to cowpox would grant immunity to smallpox.
- The hypothesis must be tested.

Scientific Method

- All scientific studies, regardless of complexity, follow the same series of steps, called the **scientific method**.



Testing the Hypothesis

- The **experiment** tests the hypothesis under controlled conditions.
 - A controlled experiment attempts to test a **single variable**, while keeping all others constant.
 - The **experimental group** receives the variable, while the **control group** does not.
- Dr. Jenner's experiment was to inoculate the 8 year-old son of his gardener with fluid from a cowpox pustule, allow the infection to pass, then repeat with a smallpox pustule.
 - The boy (experimental group) survived 20 inoculations without succumbing to smallpox!
- The **conclusion** states whether or not the hypothesis is supported by the results of the experiment.

The Experiment

Experiment – testing a hypothesis.

“Controlled Experiment” - comparing two situations with all factors alike except one

- **Control group** - fixed set for comparison
- **Experimental group** - differs from control group by one factor, known as the *variable*.

By controlling the variables, only one thing is tested in an experiment....

More on the Scientific Method

- The final step is **communication**, where the results are published and reviewed by others to check for errors, bias, or other issues.
- Dr. Jenner submitted his study to the Royal Society for Medicine, but was told he needed more proof.



“The Cow-Pock—or—the Wonderful Effects of the New Inoculation!—vide. the Publications of ye Anti-Vaccine Society.”
- Satirical cartoon, 1802.

Other Factors Affecting Experiments

- Accounting for every single variable in a scientific study is nearly impossible. There are many factors that can cause error.
- There is where **probability** comes in. This is the likeliness that a result occurred simply due to random chance.
 - This can be countered by increasing **sample size**, or the number of observations used in an experiment or study.
- Dr. Jenner was able to locate several other parents who were willing to volunteer their children. He even included his own 11 month-old son in the study.
- The results were finally published. Jenner called his technique vaccination after the Latin word for cow “vacca”.

- Controlled experiments aren't always possible or ideal.
- **Natural experiments** are conducted in the field under normal circumstances.
 - The advantage is that these experiments take place in a more accurate, realistic environment.
 - The disadvantage is that natural phenomena are often very difficult to find.



Example Experiment

Twenty-five bean plants were placed in a chamber and exposed to the same 30-minute passage of recorded violin music three times a day: 7am, 1pm, and 6pm. Twenty-five other bean plants were placed in another chamber but were not exposed to any music.

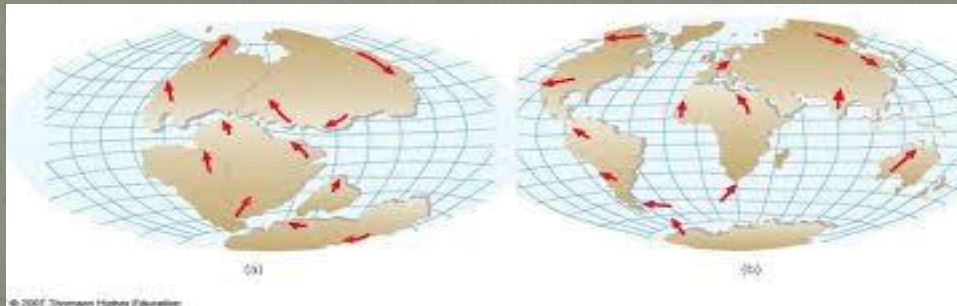
Each chamber was kept at the same temperature and humidity. The daily cycle of light and dark were the same.

After 21 days, the height and weight of all the bean plants was measured and the results were compared....

1. What is the question or problem?
1. Which plants are in the control group?
1. What is the experimental variable?
1. What is a possible hypothesis for this experiment?
1. How did this experiment allow for probability?

Theories & Laws

- Theory: Broad explanation based on many experiments and large amounts of data.
 - Examples: Evolution, Plate Tectonics, Cell Theory



- Law: An important relationship observed to occur time after time.
 - Examples: Law of Gravity



Combating Bias

- Another significant problem in science is **bias**; the **preference for an experiment to turn out in a certain way**.
- Bias is not always intentional, but must be controlled by the experimental design.
- A **blind experiment** is conducted so the experimental subjects do not know which is the control and which is the experimental group.
 - Eliminates the “placebo effect”
- A **double-blind experiment** also prevents the actual scientists from knowing which is the control or experimental group.

Research Studies





Do you want to participate in research?

Healthy Volunteers Needed for Brain Imaging Studies at Stanford!

The Etkin Lab at Stanford University is recruiting for fMRI and TMS studies.

Are you:

- Between 18-60 years old?
- Right handed?
- Healthy, without neurological disorders?
- Able to travel to Stanford?
- Interested in contributing to brain research?

Study procedures include:

- In-person assessment at Stanford
- Functional magnetic resonance imaging (fMRI)
- Transcranial magnetic stimulation (TMS)

Then get in touch with us for a phone screening to determine eligibility!

If interested, please contact the Etkin Lab at stanfordpsychiatry@gmail.com.

You may also call and leave a voicemail at (650) 549-6604.

Volunteers are compensated a minimum of \$125 for study participation.

HIV + Individuals Needed for Paid Research Study

The Department of Genetic Medicine, at Weill Cornell Medical College, is looking for volunteers (smokers and nonsmokers), for a research study on the development of lung disease.

Eligible subjects will complete:

Screening visit: medical history, physical exam, electrocardiogram (EKG), blood and urine tests, breathing test and a chest X-ray

Study visit: bronchoscopy procedure

Compensation for completing study visits:

Screening visit: \$50

Baseline bronchoscopy: \$200

To see if you are eligible, call our Patient Coordinators:

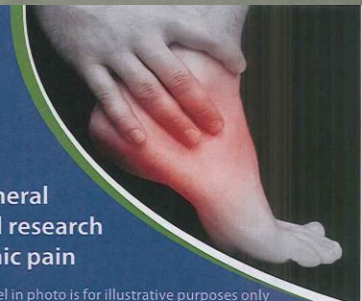
IRB # 1204012331

646-962-2672

Do you have Diabetes?

Do you suffer from persistent burning, throbbing, or tingling pain in your feet? Are you currently taking medication for this pain?

If so, you could have a condition called Diabetic Peripheral Neuropathy (DPN). You may be interested in a medical research study of Lyrica®, a drug that is approved for neuropathic pain associated with DPN.



Model in photo is for illustrative purposes only

Individuals who qualify must be:

- Men or women who are 18 years of age or older;
- Currently diagnosed with Type 1 or 2 diabetes; and
- Currently taking a non-steroid anti-inflammatory drug (NSAID) primarily for a non-DPN pain.

1268: A study of Pregabalin in the treatment of subjects with painful DPN with background treatment of NSAID for other pain conditions.

For more information please contact:

Call CCRStudies at (860) 443-4567
342 Montauk Ave

Study Conducted by:
Dr. Radin with Neurological Group
Dr. Edward McDermott

A0081268_22JUL2011_US_ENG_ad_5x3_V1_11OCT2011

Scientific Fraud

- There are many examples of published studies or reports that have been later found biased, flawed, or outright fraudulent.
- These are always detected, eventually, due to the scientific method and peer review.
 - The net effect is loss of time, resources, and public mistrust.
- In 1998, Dr. Andrew Wakefield published a study in the British journal *The Lancet* documenting a link between the MMR vaccine and autism in children.
 - In the following year, over a thousand articles were written about the possible link, very few by actual experts in the field.
 - Vaccine rates dropped from 92% to 85% in the U.K., with similar results in other countries.

Autism / MMR Retraction

- Wakefield's conclusions were found out to be **fraudulent** and that he had **manipulated the data**.
- Several outbreaks of measles and mumps occurred across the world from 2002-2008.
- The United States has seen a similar effect, with vaccination rates below CDC recommendations in several schools.



According to a Time Magazine survey, 24% of adults place “some trust” in celebrities’ opinions on vaccines.

Scientific Work Today

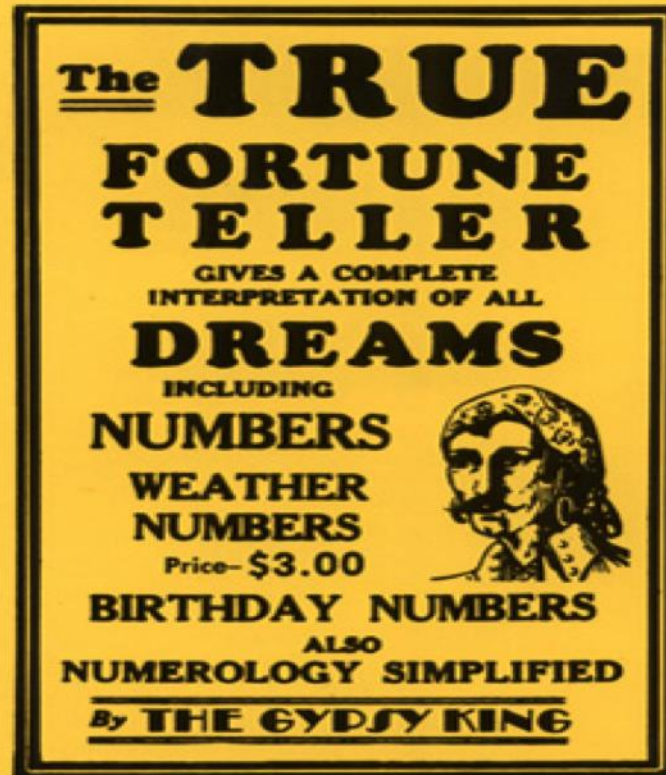
- Much research is conducted by **corporate sponsored** science researchers or in the pursuit of continuing **grants**.
- This means the **pressure to publish** and to publish real and positive results is higher than at any time in history.
- Fortunately science has a **strong desire** to produce **accurate work** that can be **defended**.



Pseudoscience

- A far different idea is **pseudoscience**, which appears or claims to be science, but does not follow scientific principles.
- Misleading and often absurd claims of results.
- How to recognize it:
 1. Scientific **background** of the author.
 2. History of review by **scientific peers**.
 3. Participation in scientific organizations.
 4. Published in **scientific journals** and validated by other scientists.
 5. Does the claimant have **something to gain**?

Real or Fake Science?



For Medical Advise?



Examples of Pseudoscience

<https://www.youtube.com/watch?v=e3SLiQFdKnA>

https://www.youtube.com/watch?v=ix_DEto6nH4

How Real Scientists Work

- Begins with an **observation** (using senses: smell, sight, hearing, taste, touch).
- Builds explanations **using** “steps” or “methods” to determine a valid conclusion.....
- But descriptive language can be vague....
- **Precise** measurement avoids these problems.

Measurement Systems

1) English system:

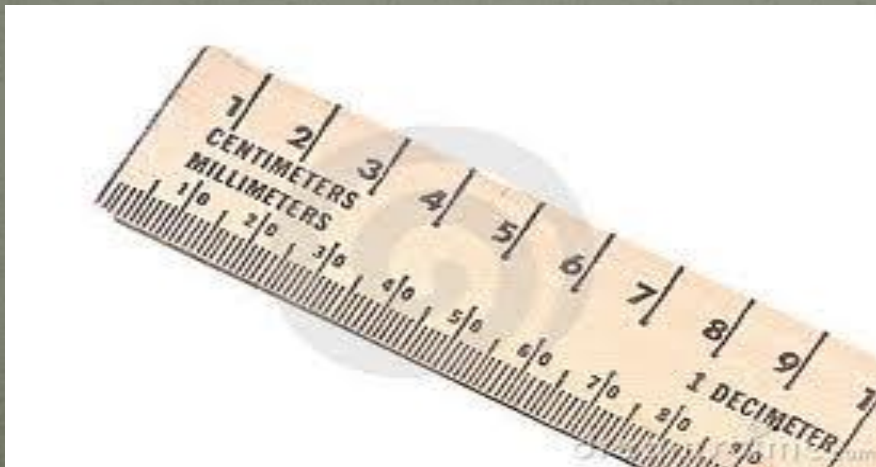
- Many units based upon parts of the human body.
 - They are always with you!
- Units are randomly related to each other.
 - 12 in = 1ft
 - 3 ft = 1 yd

2) Metric (SI) system:

- Established in 1791
- Units:
 - **Meter (m) - length**
 - **Gram (g) - mass**
 - **Liter (l) - volume**
- Based on units of 10
- Easy to convert

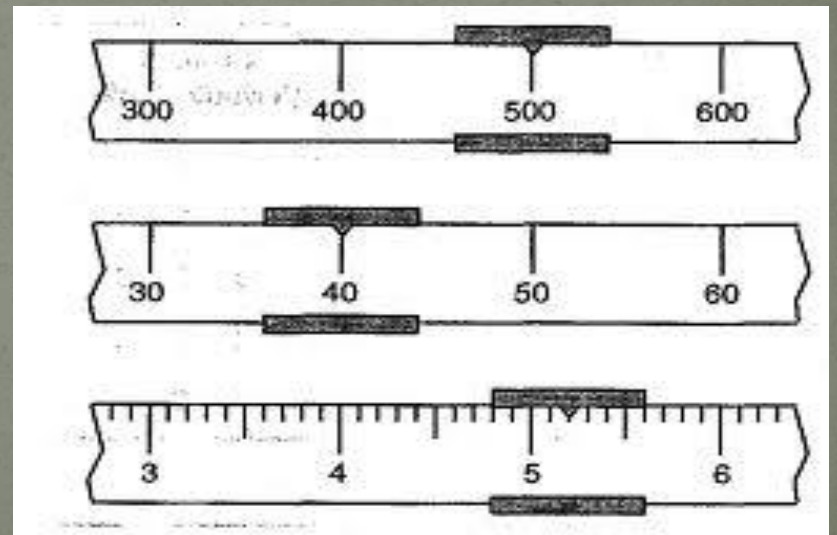
Length

- Base unit is the METER (m)
- Conversion Factors:
 - 1 meter = 39.4 in
 - 1 centimeter = 0.394 in
 - 1 kilometer = 0.621 mile



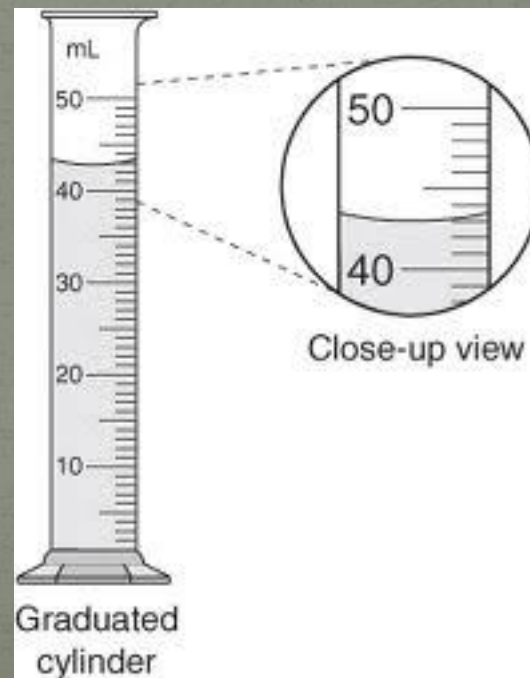
Mass

- Base unit is the GRAM (g)
- Conversion Factors:
 - 1 pound = 453.6 grams
 - 1 kilogram = 2.2 pounds



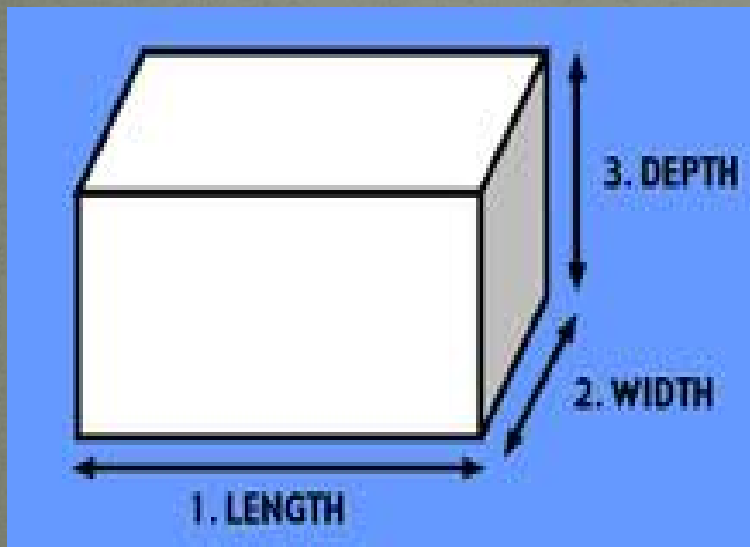
Volume

- Base unit is the LITER (L)
- Conversion Factors
 - 1 liter = 1.057 quart
 - 1 gallon = 3.786 liters

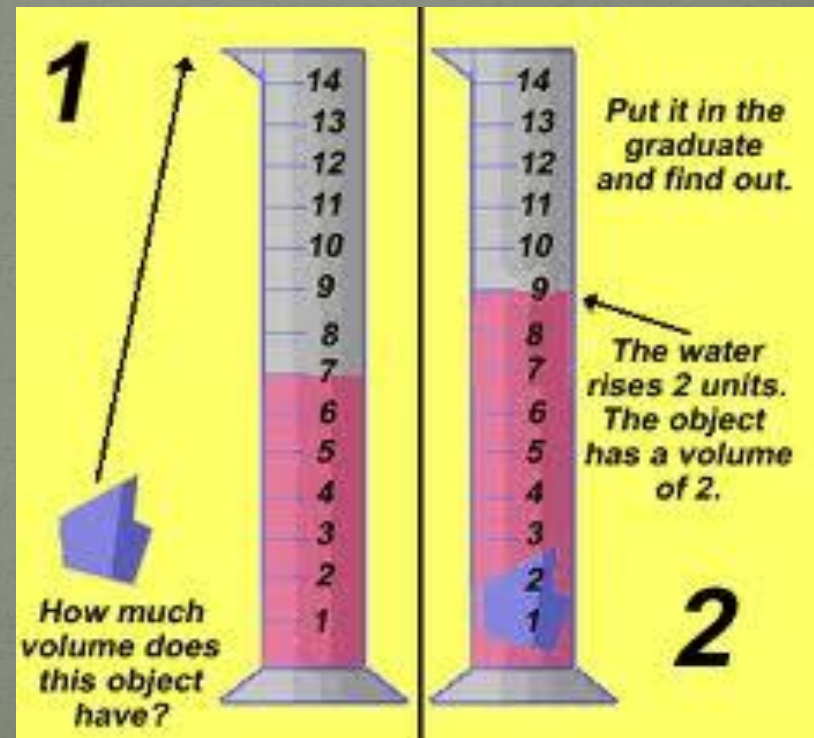


Finding Volume

- Regular shapes:
- Use formulas!
- EX: $l \times w \times h$

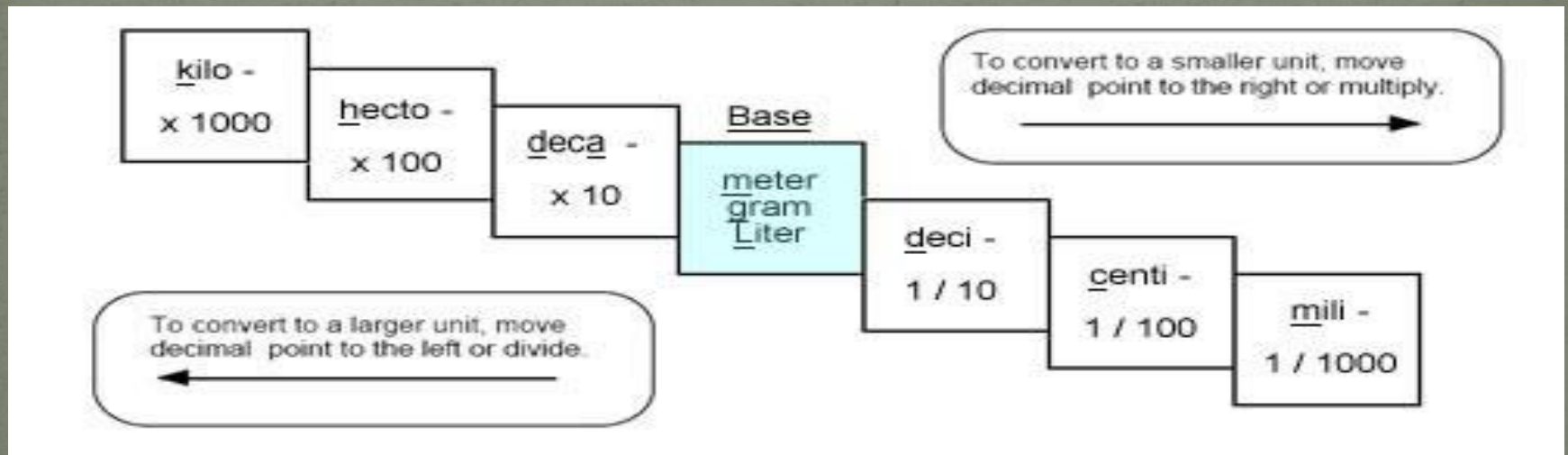


- Irregular shapes:
- Use water displacement!



Metric Prefixes

- Simplify the conversion process
- Help avoid writing large or small numbers

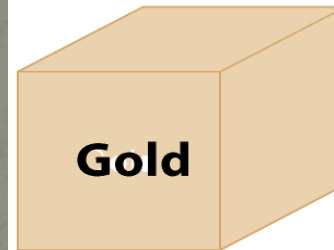


Density

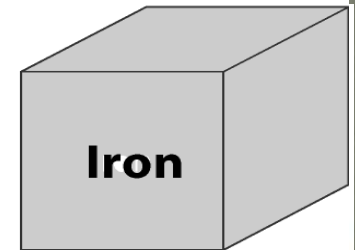
- A ratio of mass and volume.
- An intrinsic property of a material.
- **Density = mass/volume**
- Units are **grams/cm³**
- Conversion Factor:
1 ml = 1 cm³



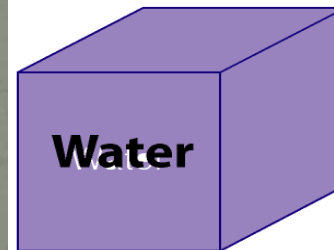
**All edges = 1 cm
Equal volumes = 1 cm³**



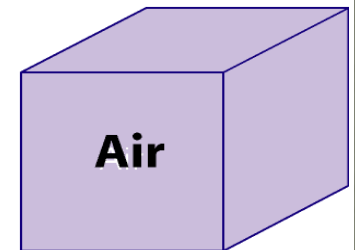
19.3 g/cm³



7.9 g/cm³



1.0 g/cm³



0.0013 g/cm³

Greater density = more massive

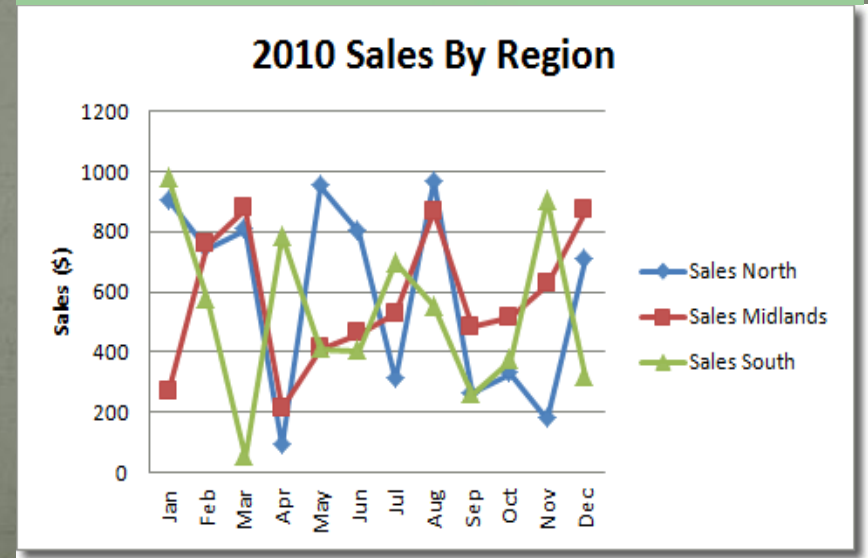
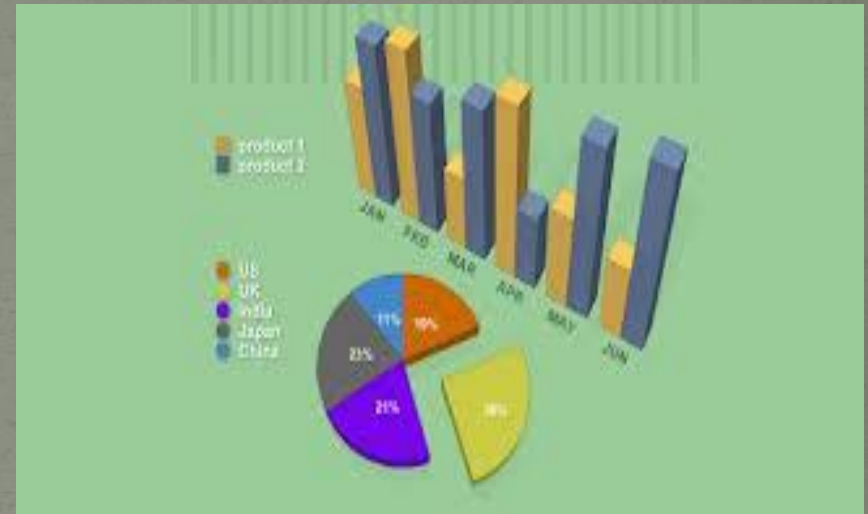
Data

Data- *measurement of information*

Used to **describe** something....
(objects, events, conditions)

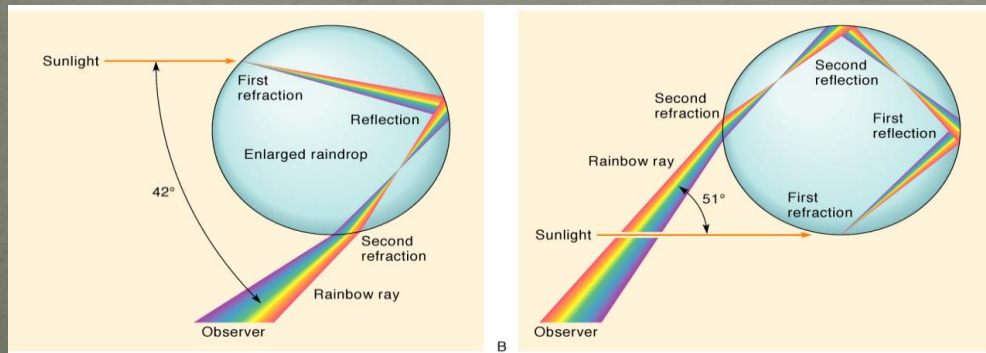
Data is compiled as a result of an experiment and then analyzed.

May be organized into a **chart or graph**.



Models

- Depict an idea or theory.
- Useful for things too small or vast to see.



GEOLOGIC TIME SCALE

ERA	PERIOD	EPOCH	SUCCESION OF LIFE
CENOZOIC recent life	QUATERNARY 0-1 Million Years Rise of Man	Recent Pleistocene	
	TERTIARY 62 Million Years Rise of Mammals	Pliocene Miocene Oligocene Eocene	
MESOZOIC middle life	CRETACEOUS 72 Million Years Modern seed bearing plants, Dinosaurs		
	JURASSIC 46 Million Years First birds		
	TRIASSIC 49 Million Years Cycads, first dinosaurs		
PALEOZOIC ancient life	PERMIAN 50 Million Years First reptiles		
	PENNSYLVANIAN 30 Million Years First insects		
	MISSISSIPPIAN 35 Million Years Many crinoids		
	DEVONIAN 60 Million Years First seed plants, cartilage fish		
	SILURIAN 20 Million Years Earliest land animals		
	ORDOVICIAN 75 Million Years Early bony fish		
	CAMBRIAN 100 Million Years Invertebrate animals, Brachiopods, Trilobites		
	PRECAMBRIAN Very few fossils present (bacteria-algae-pollen?)		

