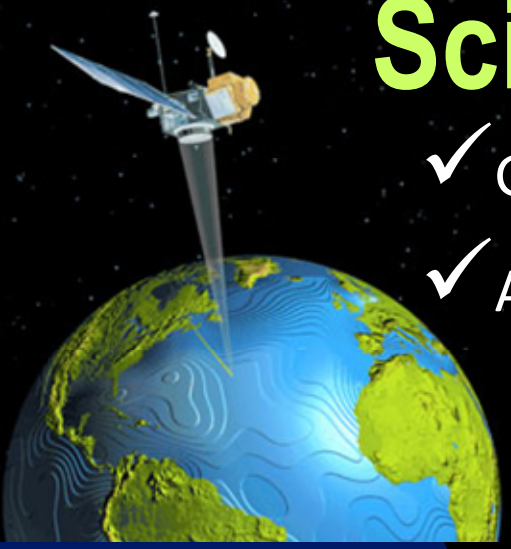
Science of Geology



- ✓ Geology is the scientific study of the Earth
- ✓ An interdisciplinary science

Hydrologic Studies

Volcanic Studies

Seismic Studies

Marine Studies

GEOLOGY -- an Interdisciplinary Science

Geology integrates many different types of geosciences

- **Mineralogy and Petrology** - the study of minerals and rocks
- **Marine geology** - the study of Earth's ocean bottom
- **Geochemistry**- study of chemical nature of rocks, minerals and fluids
- **Hydrology** - study of rivers, groundwater, flooding, dams
- **Volcanology** – study of the nature and distribution of volcanoes
- **Engineering geology-** design and construction of structures
- **Structural geology -** form and development of geologic structures
- **Geophysics –** study of forces and mechanisms of geologic phenomena
- **Environmental geology** – study of geological resources and pollution
- **Petroleum geology** – Locate. assess, and extract oil and natural gas

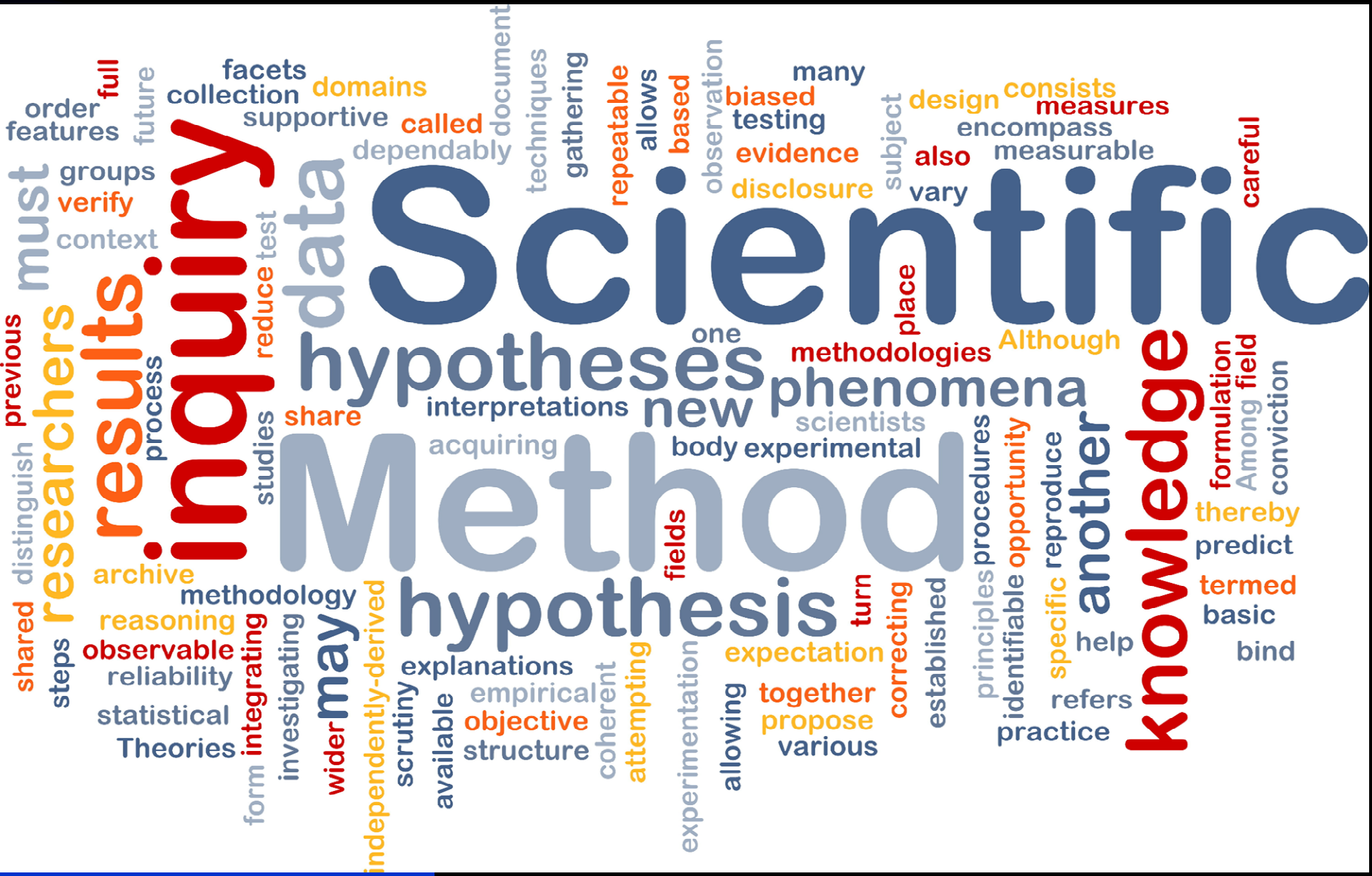
What Do Geologists Do?

Answer: …they *do* earth science.

Science defined: The investigation and acquisition of useful, reliable knowledge of earth's crust that is based on empirical observations (physical evidence).

- ✓ Earth scientists use a powerful way of thinking, that is rational, logical, and organized, called ***scientific thinking***.
- ✓ Intelligence, imagination, creativity, inspiration, and luck are other important attributes of scientific study.
- ✓ Earth scientists use a powerful approach to inquiry called the ***scientific method***.
- ✓ Central to science is community and peer review.

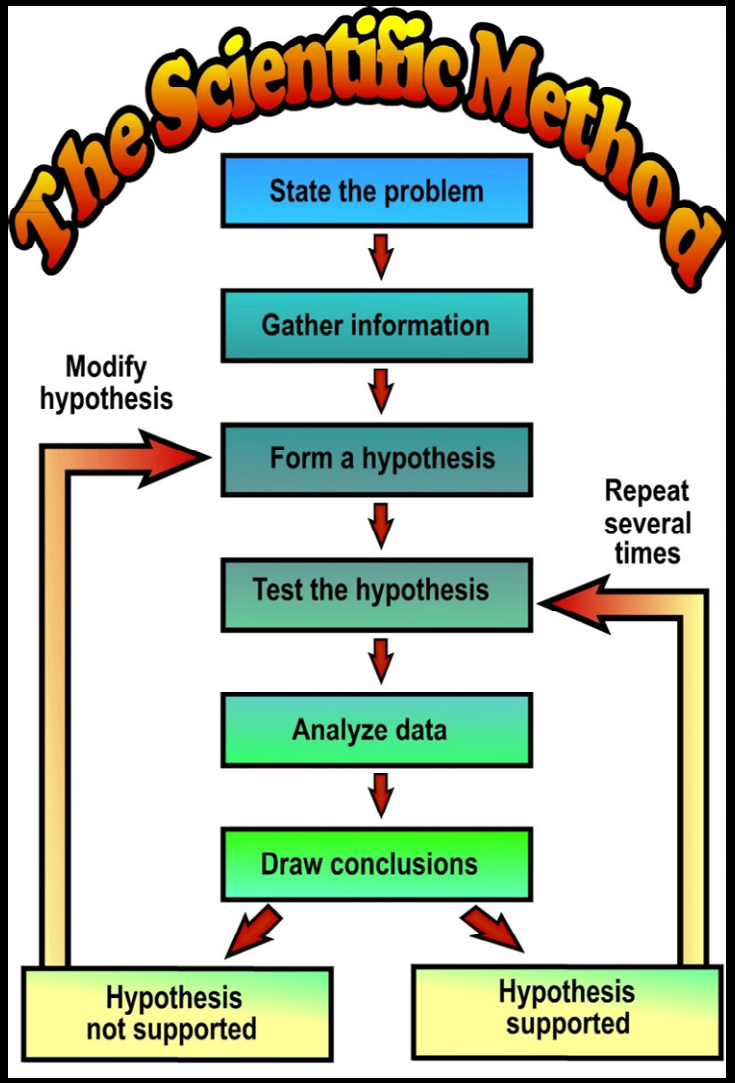
The Scientific Method – Heart of Science



THE SCIENTIFIC METHOD

The Basic Components

- ✓ *Empirical Observations*
- ✓ *Questions / Problems*
- ✓ *Hypotheses / Models*
- ✓ *Predictions*
- ✓ *Tests / Experiments*
- ✓ *Analysis of Results*
- ✓ *Draw Conclusions*
- ✓ *Reevaluate Hypothesis*



Note: The scientific method is NOT a *recipe* – it's a *process*

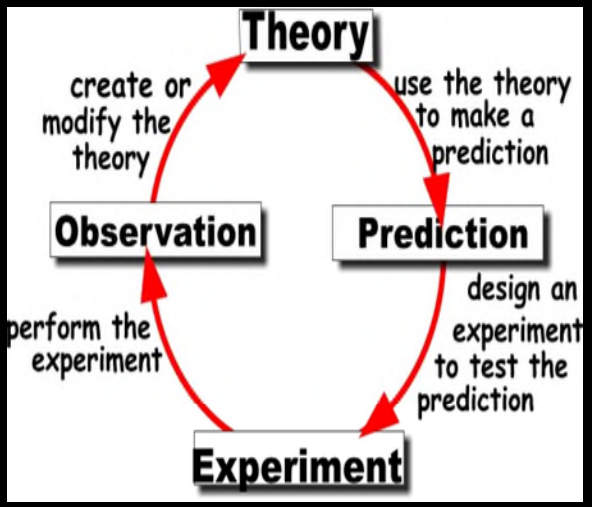
Today's Ocean Lab: *Investigation and Application of the Scientific Method*

Rationalism
(Logic & Reasoning)

Empiricism
(Experience & Observation)

+

Science



Investigation and Application of the Scientific Method

Scientific Method

- O — OBSERVATION

- H — HYPOTHESIS

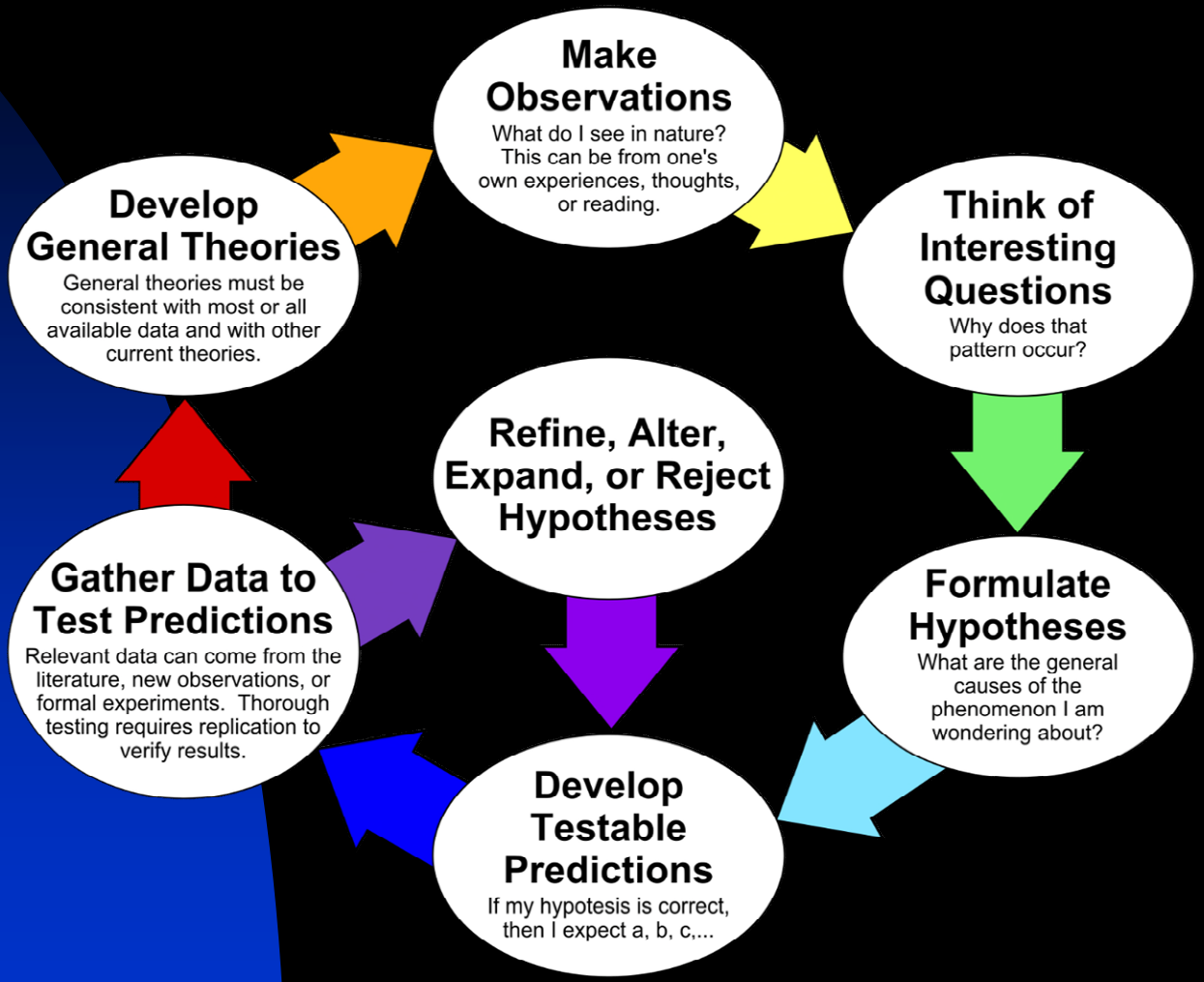
- T — TEST

Star	Color	Elements in Spectrum	Class	Other Observations
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

- A — ANALYZE DATA

- C — CONCLUSION

Scientific Method is an Ongoing Process



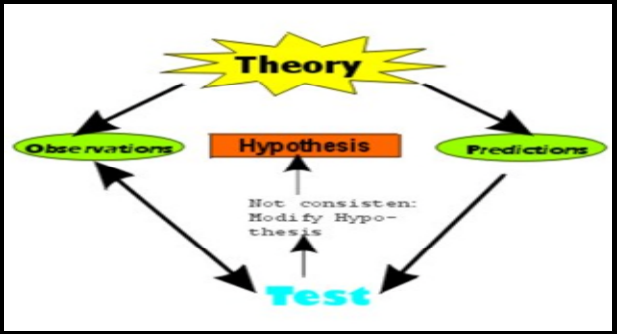
Scientific *Observations*

Making Observations

- There are two different types of observations – **quaLitative** observations and **quaNtitative** observations.

Hypotheses and Scientific *Testing*

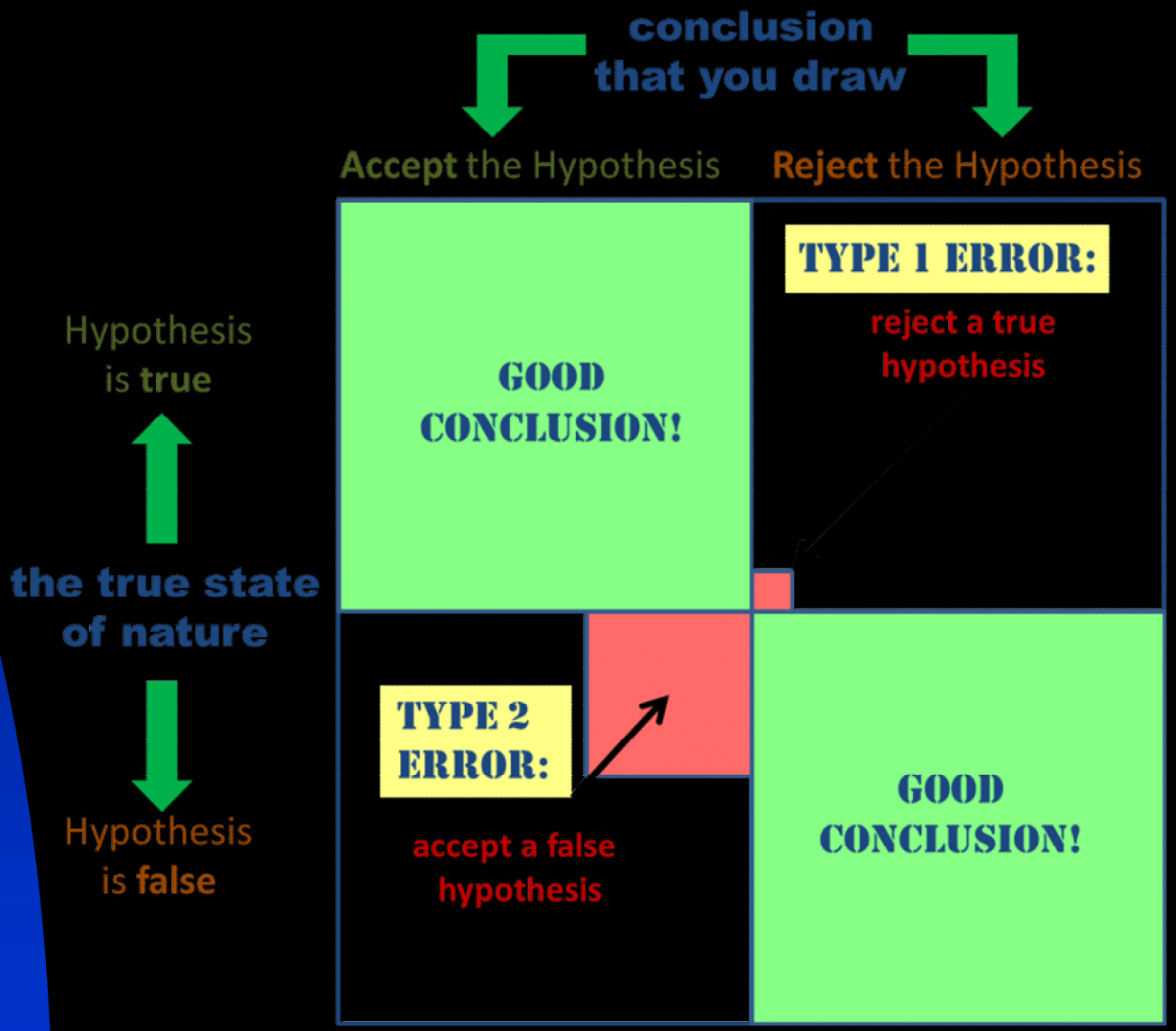
Observations and Predictions



Testing Hypotheses and Theories

1) A hypothesis is a simple explanation, model, or prediction of nature that requires testing (attempt to falsify or confirm).
2) Hypotheses are based on empirical physical evidence (data).
3) Hypotheses must be falsifiable (testable/predictable).
4) Hypotheses can never be proven as an absolute fact.
5) Hypotheses are always open to elimination or modification.
6) A theory is a broad, elegant, unifying explanation of a set of otherwise unconnected natural phenomena.
7) A theory is established by the interconnection (framework) of well-tested and confirmed hypotheses that are, in turn, supported by an enormous amount of physical evidence.

Testing Your Hypothesis

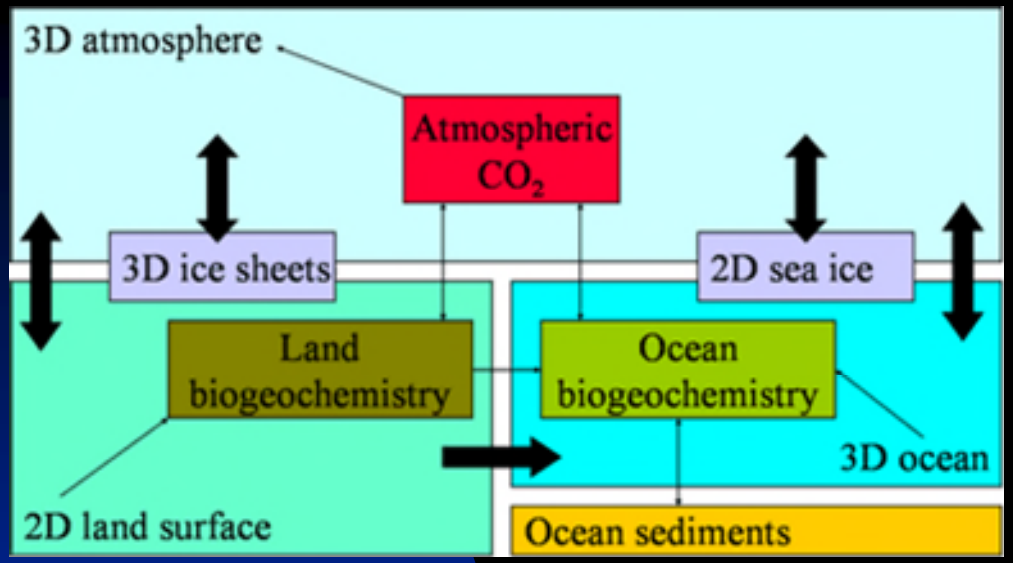


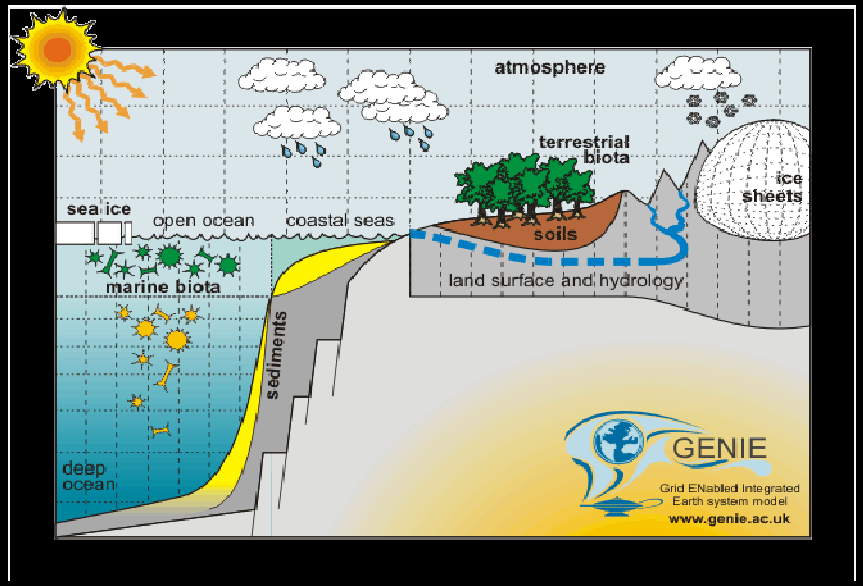
Scientific *Predictions*

Prediction

- A statement of what may happen in the future based on observations, data, experience or scientific reason

Scientific *Modeling* and *Predicting*





Purpose of Modeling: Understand and predict how parts of the Earth operate and interact with each other

--- Start simple and get more complicated over time

--- Add more and more parameters over time

--- Test computer models with real historic data

---- Develop and refine models to predict future scenarios

Application of the Scientific Method

Glitter Lamp Inquiry

Purpose:

Use the scientific method to gain a better understanding of how a glitter lamp works as a dynamic system

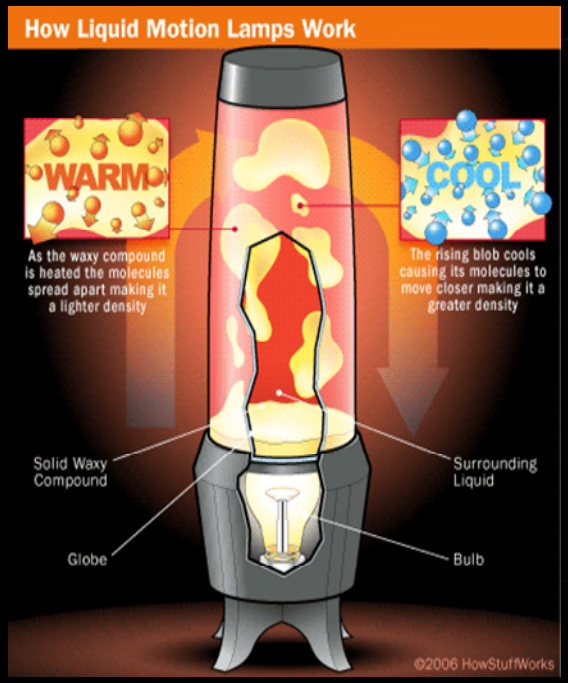
Procedure:

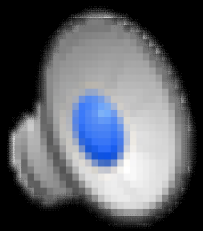
Get into groups of 2 to 4. Make good observations, explanations, predictions, and tests on the lamp. Focus on the dynamic properties of the lamp.

Lava Lamp as a Model for Convection

Convection Process

- ✓ Fluid material at top of lamp is cooler than material at the bottom.
- ✓ Hotter material is less dense than cooler material
- ✓ Less dense fluid rises while more dense fluid sinks
- ✓ Heat and gravity drive the system
- ✓ Earth's atmosphere, ocean, mantle and core undergo convection





Mantle-Core Convection

Application of the Scientific Method

Glitter Lamp Inquiry

Purpose:

Use the scientific method to gain a better understanding of how a glitter lamp works as a dynamic system

Procedure:

Get into groups of 2 to 4. Make good observations, explanations, predictions, and tests on the lamp. Focus on the dynamic properties of the lamp.

Quantitative Units of Measurement

US Standard System of Units

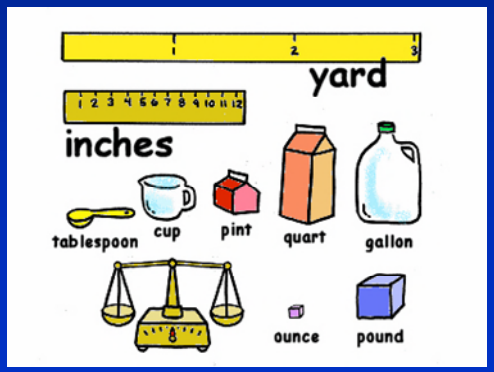
inch/foot
square foot
ounce/gallon
ounce/pound
second
Fahrenheit

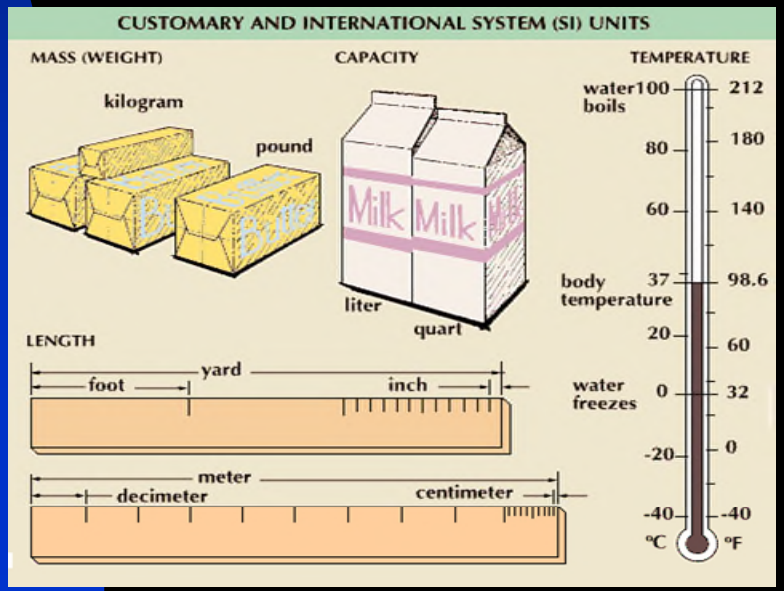
Measurable Physical Quantities

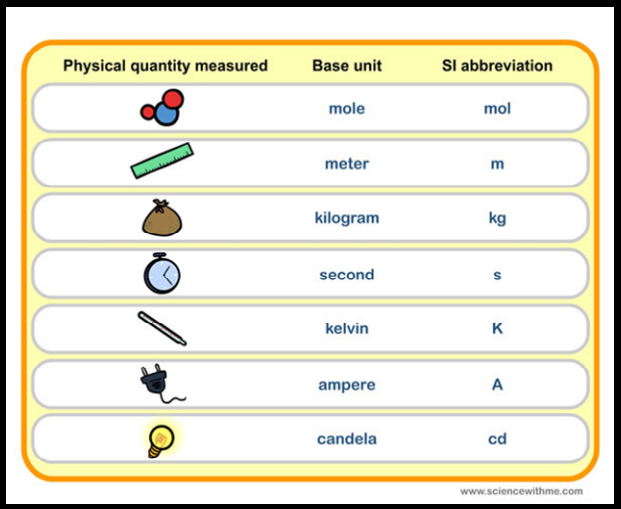
1) Distance -
2) Area -
3) Volume -
4) Mass -
5) Time -
6) Temperature -

International Metric System of Units

centimeter/meter
square meter
milliliter/liter
gram/kilogram
second
Kelvin/Celsius



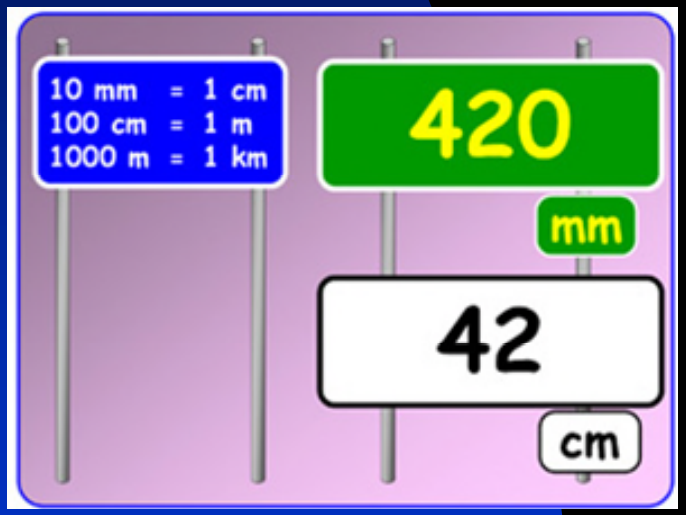




International Metric Units

Quantity measured	Unit	Symbol	Relationship
Length, width, distance, thickness, girth, etc.	millimeter	mm	10 mm = 1 cm
	centimeter	cm	100 cm = 1 m
	meter	m	
	kilometer	km	1 km = 1000 m
Mass (“weight”)*	milligram	mg	1000 mg = 1 g
	gram	g	
	kilogram	kg	1 kg = 1000 g
	metric ton	t	1 t = 1000 kg
Time	second	s	
Temperature	degree Celsius	° C	
Area	square meter	m^2	
	hectare	ha	1 ha = 10 000 m^2
	square kilometer	km^2	1 km^2 = 100 ha
Volume	milliliter	mL	1000 mL = 1 L
	cubic centimeter	cm^3	1 cm^3 = 1 mL
	liter	L	1000 L = 1 m^3
	cubic meter	m^3	
Speed, velocity	meter per second	m/s	
	kilometer per hour	km/h	1 km/h = 0.278 m/s

Metric Unit Prefixes



Prefix	Symbol	Factor	Numerically	Name
giga	G	10^{9}	1 000 000 000	billion**
mega	M	10^{6}	1 000 000	million
kilo	k	10^{3}	1 000	thousand
centi	c	10^{-2}	0.01	hundredth
milli	m	10^{-3}	0.001	thousandth
micro	μ	10^{-6}	0.000 001	millionth
nano	n	10^{-9}	0.000 000 001	billionth**

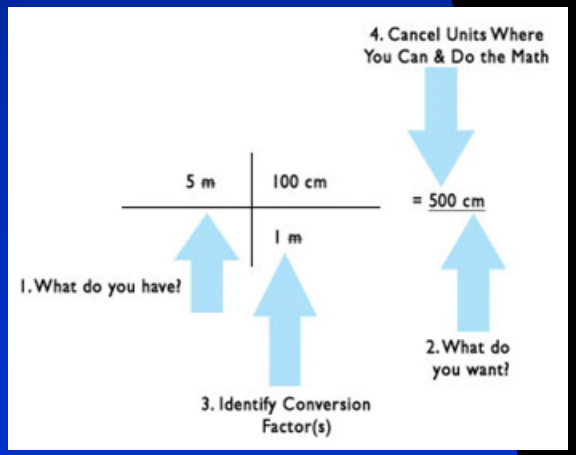
Converting Units of Measurement

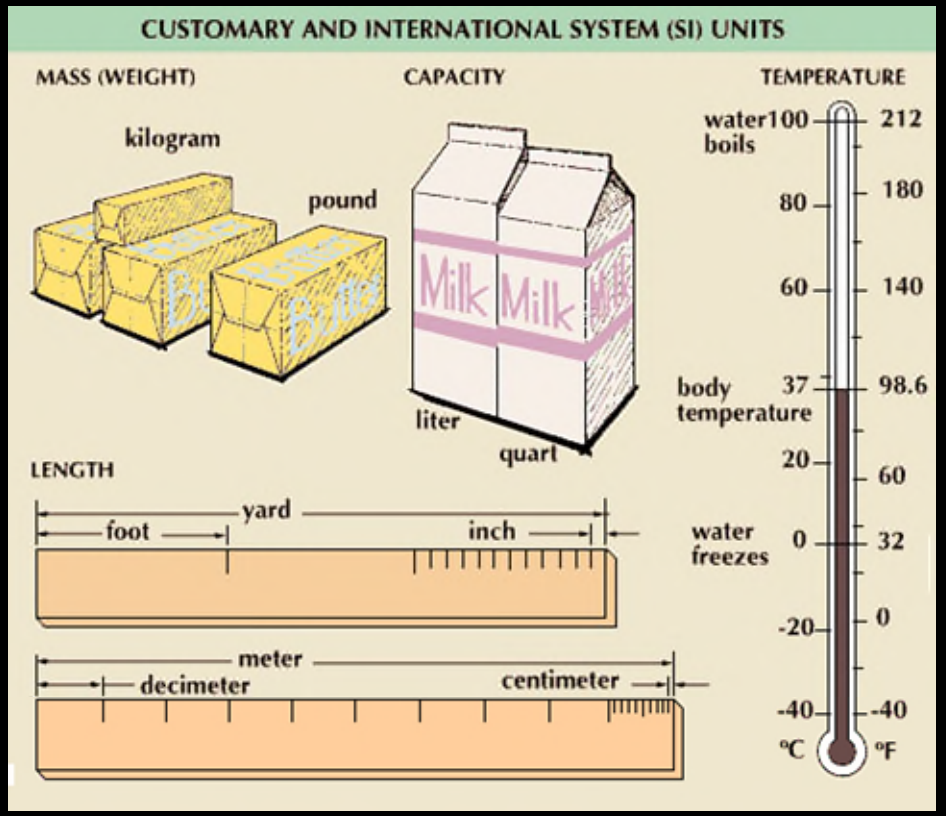
Setting Up the Problem:

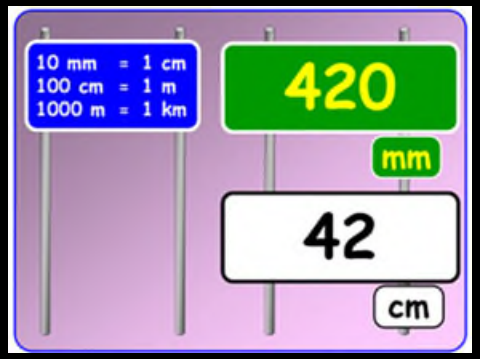
Starting Units	Desired Units	= Desired Units
	Starting Units	

Example:

Convert 15 m to ? cm







Converting Units

Make sure to:

1) Find the proper conversion factor for the two units
2) Set up the equation with all numeric values having a unit symbol
3) Do the conversion making sure that the old unit cancels

APPROXIMATE CONVERSIONS FROM ENGLISH UNITS TO SI UNITS				
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY (CF)**	**TO FIND**	**SYMBOL**
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: volumes greater than 1000 L shall be shown in m^3				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
^oF	Fahrenheit	5 (F-32) ÷ 9	Celsius	^{o}C

Metric Conversion Chart and Table

Length

1 centimeter (cm)	=	10 millimeters (mm)
1 inch	=	2.54 centimeters (cm)
1 foot	=	0.305 meters (m)
1 foot	=	12 inches
1 yard	=	3 feet
1 meter (m)	=	100 centimeters (cm)
1 meter (m)	≅	3.281 feet
1 furlong	=	660 feet
1 kilometer (km)	=	1000 meters (m)
1 kilometer (km)	≅	0.62137119 miles
1 mile	=	5280 ft
1 mile	=	1.61 kilometers (km)
1 nautical mile	=	1.85 kilometers (km)

Area

1 square foot	=	144 square inches
1 square foot	=	929.03 square centimeters
1 square yard	=	9 square feet
1 square meter	≅	10.76104 square feet
1 acre	=	43,560 square feet
1 hectare	=	10,000 square meters
1 hectare	≅	2.47 acres
1 square kilometer	=	100 hectares
1 square mile	≅	2.59 square kilometers
1 square mile	=	640 acres

Speed

1 mile per hour (mph)	≅	1.467 feet per second (fps)
1 mile per hour (mph)	=	1.61 kilometers per hour
1 knot	≅	1.15 miles per hour
1 foot per second	≅	0.68 miles per hour (mph)
1 kilometer per hour	≅	0.62 miles per hour (mph)

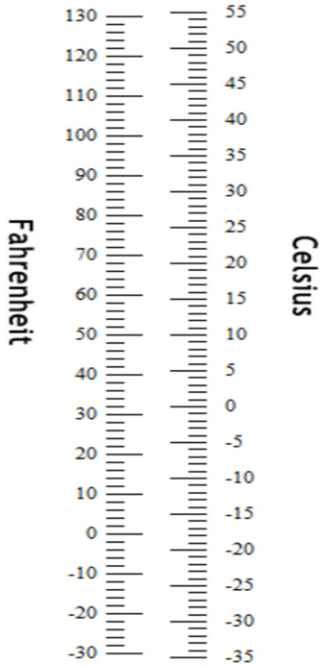
Volume

1 US tablespoon	=	3 US teaspoons
1 US fluid ounce	≅	29.57 milliliters (ml)
1 US cup	=	16 US tablespoons
1 US cup	=	8 US fluid ounces
1 US pint	=	2 US cups
1 US pint	=	16 US fluid ounces
1 liter (l)	≅	33.81 US fluid ounces
1 liter (l)	=	1000 milliliters (ml)
1 US quart	=	2 US pints
1 US gallon	=	4 US quarts
1 US gallon	=	3.785 liters

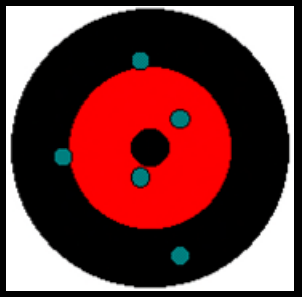
Weight

1 milligram (mg)	=	0.001 grams (g)
1 gram (g)	=	0.001 kilograms (kg)
1 gram (g)	≅	0.035 ounces
1 ounce	=	28.3 grams (g)
1 ounce	=	0.0625 pounds
1 pound (lb)	=	16 ounces
1 pound (lb)	=	0.45 kilograms (kg)
1 kilogram (kg)	=	1000 grams
1 kilogram (kg)	≅	35.27 ounces
1 kilogram (kg)	≅	2.2 pounds (lb)
1 stone	=	14 pounds
1 short ton	=	2000 pounds
1 metric ton	=	1000 kilograms (kg)

Temperature

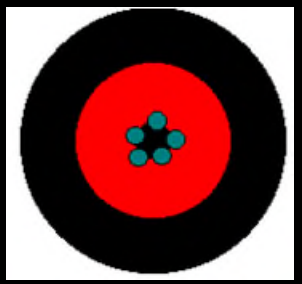


Accuracy, Precision and Uncertainty in Measurement



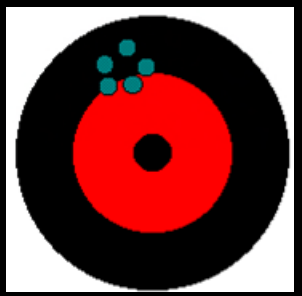
1) ***Accuracy*** of the measurement refers to how close the measured value is to the true or accepted value.

2) ***Precision*** refers to how close together a group of measurements actually are to each other.



3) Accuracy can be determined by only one measurement, while precision can only be determined with multiple measurements.

4) Precision has nothing to do with the true or accepted value of a measurement, so it is quite possible to be very precise and totally inaccurate.



5) When precision is high and accuracy is low, the fault can lie with the instrument.

Significant Digits or Figures

Rules For Significant Digits

1. Digits from 1-9 are always significant.

2. Zeros between two other significant digits are always significant

3. One or more additional zeros to the right of both the decimal place and another significant digit are significant.

4. Zeros used solely for spacing the decimal point (placeholders) are not significant.

EXAMPLES	# OF SIG. DIG.	COMMENT
453 g	3	All non-zero digits are always significant.
5057 L	4	Zeros between 2 sig. dig. are significant.
5.00 ml	3	Additional zeros to the right of decimal and a sig. dig. are significant.
0.007 km	1	Placeholders are not sig.

Next Weeks Lab Topic

Minerals

- Define
- Formation of Minerals
- Mineral Classification
- Physical Properties
- Identification

Pre-lab Exercises

- Read Mineral Chapter in Lab Textbook
- Complete the Pre-labs