Scientific Method and Metrics Unit Outline

Part One: What is Science?

- **Science** is a method of investigating the world that discovers **Reliable Knowledge** about it.
    - **Reliable Knowledge:** Knowledge that has a high probability of being true because its validity has been supported by a reliable method.
        - Scientists use the **Scientific Method:** A method used to get repeatable, factual, and consistent information about something
- **Science begins with observations:** Observations are a very important part of the scientific process.
    - **There are two types of observations- Objective and Subjective**
    - **<u>Scientific Observations MUST be Objective.</u>**
        - **Objective vs. Subjective Observations:**
            - **Objective Observation:** Based on fact. Must be repeatable, consistent, and/ or agreed upon by many people.
                - **Quantitative:** Based on measurements and numbers (graphs, charts, data table)
                - **Qualitative:** Based on description- using your five senses (what did you hear, see, taste, touch, or smell)
            - **Subjective Observation:** Based on opinion, bias, or personal feeling. **Non-scientific observations.**
    - What is the difference between an observation and an inference?
        - **Inference:** When you explain or interpret an observation. An inference can be a correct or incorrect way of explaining an observation. An investigation needs to be done to determine if the inference is correct or not.

Observation > Hypothesis > Experiment > Evidence > Theory > Fact > Law

Hypothesis: A hypothesis is an educated guess, based on observation. Usually, a hypothesis can be supported or refuted through experimentation or more observation. A hypothesis can be disproven, but not proven to be true.

Example: If you see no difference in the cleaning ability of various laundry detergents, you might hypothesize that cleaning effectiveness is not affected by which detergent you use. You can see this hypothesis can be disproven if a stain is removed by one detergent and not another.

Theory: A scientific theory summarizes a hypothesis or group of hypotheses that have been supported with repeated testing. A theory is valid as long as there is no evidence to dispute it. Therefore, theories can be disproven. Basically, if evidence accumulates to support a hypothesis, then the hypothesis can become accepted as a good explanation of a phenomenon. One definition of a theory is to say it's an accepted hypothesis.

Example: It is known that on June 30, 1908 in Tunguska, Siberia, there was an explosion equivalent to the detonation of about 15 million tons of TNT. Many hypotheses have been proposed for what caused the explosion. It is theorized that the explosion was caused by a natural extraterrestrial phenomenon, and was not caused by man. Is this theory a fact? No. The event is a recorded fact. Is this theory generally accepted to be true, based on evidence to-date? Yes. Can this theory be shown to be false and be discarded? Yes.

Law: A law generalizes a body of observations. At the time it is made, no exceptions have been found to a law. Scientific laws explain things, but they do not describe them. One way to tell a law and a theory apart is to ask if the description gives you a means to explain 'why'.

Example: Consider Newton's Law of Gravity. Newton could use this law to predict the behavior of a dropped object, but he couldn't explain why it happened.

Part Two: ***The Scientific Investigation***

1. **Posing Questions: What is a scientific question?**

- Experiments begin by asking a **scientific question**: a question that can be answered by gathering evidence.
    - What are some differences between a scientific and a non-scientific question?
    - What are some examples of good scientific questions?
        - *"Which freezes faster- fresh water or salt water?"* This is a good scientific question because it can be tested.
        - *A good scientific question includes the Independent and Dependent variables in the question statement.*

2. **Developing a Hypothesis**

- The next step is developing a hypothesis: a prediction about the outcome of an experiment.
    - A hypothesis is based on your observations and previous knowledge
    - It must be testable
    - It must be written in the correct format- ***"If… then… because"***
        - *If I <u>add salt to fresh water</u>, then the salt water will <u>take longer to freeze</u> because mixtures take longer to freeze than pure substances.*

3. **Designing an Experiment**

- The next step is planning a way to test your hypothesis.
    - Determining Variables: **Independent Variable** (the variable you change on purpose), **Dependent Variable** (What changes due to the independent variable- this is what you measure).
    - In an experiment- only one variable can change on purpose. All other variable must be kept the same and held constant.

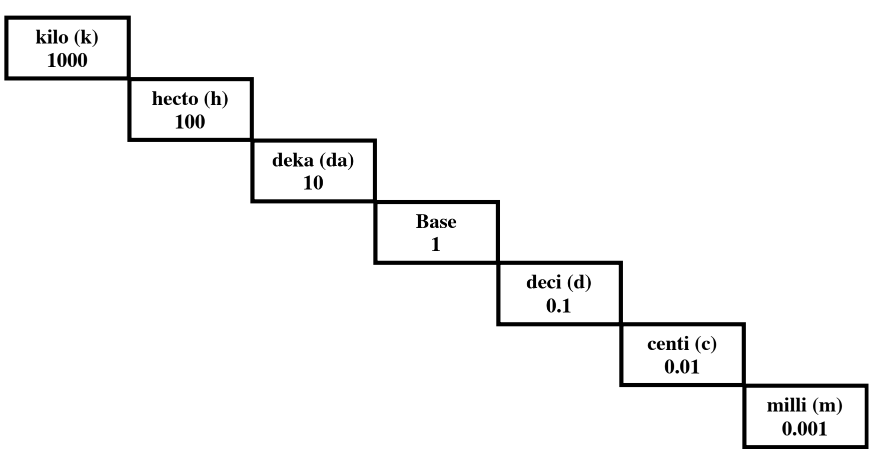
- **Control**- the group in the experiment that does not include the independent variable.
- **Constants-** things in an experiment that stay the same in every trial.
- **Fair Test**: *In order for an experiment to rule out possible error, you should always include three trials. You then take the average of the three trials to get the most accurate data.*

4. Interpreting Data

- The observations and measurements you make in an experiment are called **data**.
- Scientists use the **METRIC SYSTEM** of measurement to collect data. The metric system is a base-ten system of measurement that increases and decreases by multiples of ten. It is a consistent and easy system of measurement that is used worldwide.

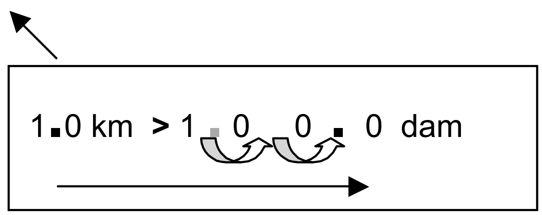
Length	Meter (m)
Mass	Gram (g)
Volume	Liter (L)
Temperature	°C

Kilo	Hecto	Deka	Base	●	Deci	Centi	Milli
1,000	**100**	**10**	**1**		**0.1**	**0.01**	**0.001**
kg	hg	dag	g		dg	cg	mg
kL	hL	daL	L		dL	cL	mL
km	hm	dam	m		dm	cm	mm



- Metric Conversions: Sometimes you may need to convert one unit of measurement into another. For example, “How many dekameters are in one kilometer?”

- To convert from a smaller unit to a larger unit, move the decimal point to the left however many times bigger that new unit is.
- To convert from a larger unit to a smaller unit, move the decimal point to the right however many times smaller the new unit is.
    - Bigger unit > Smaller unit
    - 1.0 km = 1,00.0 dam



Explanation:
This conversion is from a bigger unit to a smaller unit, so the decimal is going to move to the right. The unit dekameter is two steps to the right of the unit kilometer, so the decimal moves two spaces to the right, fill in the spaces with zeros and you get 100.0 dam

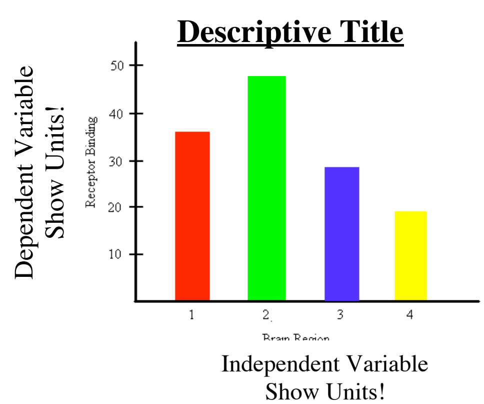
- **In order to run an experiment, scientists use lab equipment**

Graduated Cylinder	Thermometer
Triple Beam Balance	Mortar and Pestle
Ring Stand	Test Tube
Bunsen Burner	Beaker
Flask	Meter Stick

- Graphs:

Analyzing Data- Organizing Data for analysis

- **Line Graph-** Shows data over time
- **Bar Graph-** Compares data
- **Pie Chart-** Shows a percentage out of 100



5. **Drawing Conclusions**

- A conclusion is a statement that sums up what you have learned from the experiment. When you draw a conclusion, you need to decide whether the data you collected supported or refuted your hypothesis.
- Conclusions often lead you to ask new questions and plan new experiments to answer them
- You may need to repeat an experiment several times before you can make any definite conclusions.

Part Three: Design and Test your Own Experiment

- Evaluate and critique real life data/ experiments to determine validity of claims.
- Practice designing experiments
- Consumer Product Test