MEASUREMENT TOPICS 1, 2, & 3

What is Science? The Science Process. Theories, Laws & Models
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<td>C) Constants</td>
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<td></td>
<td>D) Independent Variable aka TEST VARIABLE =</td>
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Performing an experiment

involves

Scientific Thinking

That starts with looking and making what is called an...

Then follows developing a testable explanation for the observation/problem, which is called a...

After the hypothesis, then you must design a way to test your hypothesis, which is called a...

Controlled Experiment...

That can only test one thing at a time; this ‘one thing’ is called a...

Experiments will have a...

CAUSE

Which also called the...

EFFECT

Which also called the...

Once all the DATA is gathered, it is

and then put in a table or a...

Graph

The Independent Variable is found on the...

The Dependent Variable is found on the...

When the controlled experiment is completed, the results are written in a...

To ensure accuracy and I then have my fellow scientists review my work in what is called...

To make sure there is no favoritism or & that it follows the norms of society aka
Developing a Good Hypothesis
This is a Non-Negotiable Assignment!

The following steps make up a method which may be used to logically solve problems in many areas of life. The steps are only a guide – it forces the researcher to think scientifically - it helps the researcher proceed in an organized fashion.

1) OBSERVATION - ask a question
2) **HYPOTHESIS** - statement that may answer your question—has the CAUSE & EFFECT
3) EXPERIMENT - test to see if your statement is correct or not
4) COLLECT DATA - quantitative—what happens during the experiment
5) CONCLUSION - interpret results of experiment
6) REPEAT the experiment- to ensure accurate results

- *Before an experiment begins, you must develop a HYPOTHESIS… an idea what of you think will happen.
- A hypothesis should include a CAUSE and an EFFECT and is written in the If... then... format:
  - **IF** I make a study sheet that explains scientific thinking (that’s the **CAUSE**). **THEN** my students will pass the test with at least an 80% (that’s the **EFFECT**)!!

Procedure: After reading the information above, for each observation below, write a workable hypothesis that could be used in a laboratory experiment to test some aspect of the observation. Use the **If…, then… Format**

1. Caitlin knows that if she **practices texting without looking** (CAUSE), then she will be able to use her phone (EFFECT) at school,
   - If__________________________________________________________
   - Then________________________________________________________

2. Justin wants to earn a ‘B’ in Biology. He finally realizes that if he **participates** (CAUSE) in class and reads over his notes each night, then he will earn the **grade** (EFFECT) he wants.
   - If__________________________________________________________
   - Then________________________________________________________

3. While on a hike, Jill noticed during the **hot summer** (CAUSE) that a canal in Tallahassee is **green and murky** (EFFECT)
   - If__________________________________________________________
   - Then________________________________________________________

4. While visiting his new house under construction, Jim notices that shiny nails rust when left exposed on the construction site, but **galvanized** (with a coating that prevents rust) (CAUSE) nails do not rust (EFFECT) in the same conditions.
   - If__________________________________________________________
   - Then________________________________________________________

5. Kim, an avid lizard lover, likes the **colder months** because she has a **better time catching** her favorite reptiles.
   - If__________________________________________________________
   - Then________________________________________________________

6. Bees spend hours **flying** around Alicia when she wears her **neon yellow** maternity top to work in her garden, but not when she wears pastel (light colored) colors.
   - If__________________________________________________________
   - Then________________________________________________________

7. While camping, Billy refuses to bathe because “real mountain men” hardly ever bathed. Kyle takes a bath at least every other day. After two weeks, Kyle has a lot of mosquito **bites**. Billy is unapproachable, but virtually bite-free.
   - If__________________________________________________________
   - Then________________________________________________________

8. Isaac finds an abandoned puppy. He gives it cow’s milk to drink. Later he sees a “mommy dog” with puppies that are identical to his but far more **alert and active** than his puppy.
   - If__________________________________________________________
   - Then________________________________________________________

9. Kelly noticed that the inexpensive Sunshine bread does not mold after a week in an open bag. Pepperidge Farm Bread that is made with very few **preservatives**, however produces a layer of **black mold** in the same length of time.
   - If__________________________________________________________
   - Then________________________________________________________

4
Identifying Parts of an Experiment
This is a Non-Negotiable Assignment!

Procedure: For each of the scenarios below identify:
A) Independent Variable (Test Variable)—CAUSE; you, the scientist control this; it’s something you change
B) Dependent Variable (Outcome Variable)—EFFECT; result of the change/independent variable
C) Constants—things that are the same or identical in the experimental set-up
D) Control Group (if any) - group that you do nothing to; it is used to compare the experimental groups to
E) State the hypothesis for the experiment—statement as to what you think may happen
F) Come up with a way to improve the experimental design—what could be done better next time?

Scenarios:
1. Taylor wanted to investigate which air soft pellets are the most accurate. He bought four different brands of pellets to compare them to his standard Brand X pellets. Using the same type of rifle, he shot each of the five brands 20 times at a target that was placed 100 feet away.
   A. Independent Variable: ________________________________________________________________
   B. Dependent Variable: ________________________________________________________________
   C. Constants: _______________________________________________________________________
   D. Control Group (if one): ___________________________________________________________________
   E. Hypothesis: _________________________________________________________________________
   F. Improvement Needed?: ___________________________________________________________________

2. Brandy decided to experiment with different types of fertilizers to determine which was the best for her tomato seeds. She planted seeds from the same source in each of four pots. The seeds were planted with the same kind of potting soil. Equal amounts of three different types of fertilizers were used, one in each of three pots. The fourth pot did not receive a fertilizer. All pots were placed in the same location and given the same amount of water. The height of the tomato plants was measured at the end of the experiment.
   A. Independent Variable: ________________________________________________________________
   B. Dependent Variable: ________________________________________________________________
   C. Constants: _______________________________________________________________________
   D. Control Group (if one): ___________________________________________________________________
   E. Hypothesis: _________________________________________________________________________
   F. Improvement Needed?: ___________________________________________________________________

3. Jeannie set out to see if people would resist eating a familiar food in a different color. A popular cafeteria style restaurant allowed her to place rice of three different and unusual colors as choices in the serving line. The colors were purple, green and blue. The same amount of rice was placed in identical bowls in all cases. All other regular colored rice was removed from the serving line. She kept track of how many people chose each type of rice for one day.
   A. Independent Variable: ________________________________________________________________
   B. Dependent Variable: ________________________________________________________________
   C. Constants: _______________________________________________________________________
   D. Control Group (if one): ___________________________________________________________________
   E. Hypothesis: _________________________________________________________________________
   F. Improvement Needed?: ___________________________________________________________________

4. Cait wanted to find out if she studied more, would her Biology grade increase by at least 10%. She studied sporadically during the week; sometimes on Mondays, sometimes on Tuesdays and Thursdays, and sometimes every night. She used different methods each week… sometimes she re-wrote her notes, other times she just read over them, and sometimes she had her brother quiz her.
   A. Independent Variable: ________________________________________________________________
   B. Dependent Variable: ________________________________________________________________
   C. Constants: _______________________________________________________________________
   D. Control Group (if one): ___________________________________________________________________
   E. Hypothesis: _________________________________________________________________________
   F. Improvement Needed?: ___________________________________________________________________

5. Two groups of 50 people were randomly selected and assigned a group. Group 1 was given 5 mL of Drug A; Group 2 was given 5 mL of Drug B. Ten minutes later, each person was given a memory test. Group 1 scored 83% on the memory test and Group 2 scored 82% on the test.
   A. Independent Variable: ________________________________________________________________
   B. Dependent Variable: ________________________________________________________________
   C. Constants: _______________________________________________________________________
   D. Control Group (if one): ___________________________________________________________________
   E. Hypothesis: _________________________________________________________________________
   F. Improvement Needed?: ___________________________________________________________________
MORE PRACTICE!

Non-Negotiable

Identifying Parts of an Experiment

**Experiment 1.** A student wants to know if her hosta plants (normally grown in shaded areas) will be able to grow under full sunlight. She plants 10 hostas in a shaded area of her yard. She plants 10 more in an area of her yard that receives full sun exposure. She waters them three times a week for 6 weeks. After six weeks, she measures the heights of the hostas.

Hypothesis (If...then): ______________________________________________________

Experimental Group: _____________________________________________________

Control Group: __________________________________________________________

Independent (test) Variable: ______________________________________________

Dependent (outcome) Variable: ____________________________________________

**Experiment 2.** A student wants to know what effect temperature will have on the germination rate of radish seeds. To test this, she obtains 3 petri dishes and 60 radish seeds. She places 20 seeds in the first petri dish and stores it at room temperature. She places another 20 seeds in the second dish and places it in the freezer. She places 20 seeds in the third petri dish and places the dish in an incubator. Over the next two weeks, she waters the dishes daily and records the number of seeds germinated. At the end of the experiment she calculates the germination rate for the seeds at each temperature.

Hypothesis: ______________________________________________________________

Experimental Group: _____________________________________________________

Control Group: __________________________________________________________

Independent (test) Variable: ______________________________________________

Dependent (outcome) Variable: ____________________________________________

**Experiment 3.** A student investigated whether ants dig more tunnels in the light or in the dark. She thought that ants used the filtered light that penetrated the upper layers of earth and would dig more tunnels during the daytime. Ten ant colonies were set up in commercial ant farms with the same number and type of ants per ant farm. The same amount of food was given to each colony, and the colonies were in the same temperature. Five of the colonies were exposed to normal room light and five were covered with black construction paper so they did not receive light. Every other day for three weeks the length of the tunnels was measured in millimeter using a string and a ruler. Averages for the light and dark groups for each measured were then computed.

Hypothesis (If...then): ____________________________________________________

Experimental Group: _____________________________________________________

Control Group: __________________________________________________________

Independent (test) Variable: ______________________________________________

Dependent (outcome) Variable: ____________________________________________
Designing an Experiment

A botanist thinks that mustard plants will grow faster in red light compared to sunlight. The following table shows his experimental design.

<table>
<thead>
<tr>
<th></th>
<th>Experimental Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Light</td>
<td>Red</td>
<td>Sunlight</td>
</tr>
<tr>
<td>Type of plant</td>
<td>Mustard</td>
<td>Garden Pea</td>
</tr>
<tr>
<td>Temperature</td>
<td>20°C</td>
<td>30°C</td>
</tr>
<tr>
<td>Amount of Water</td>
<td>5 ml /day</td>
<td>10 ml/day</td>
</tr>
</tbody>
</table>

The botanist measures the height of each plant daily and uses this information to calculate a growth rate after a two-week period. He concludes that his hypothesis is incorrect because the plant in sunlight showed a faster growth rate than the plant in red light.

1. Was this a controlled experiment?

2. How many Independent (test) variables were there in this experiment? List them.

3. Help the botanist fix his experiment by completing the table below.

<table>
<thead>
<tr>
<th></th>
<th>Experimental Group</th>
<th>Control Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Light</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of Plant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of Water</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. What is the Independent (test) Variable now?
**Background:** A thumb war or thumb wrestling is a game played by two players in a tournament called a thumb-a-war (or thumb war) using the thumbs to simulate fighting. The object of the game is to pin the opponent’s thumb, often to a count of three.

**Purpose:** Complete a task using the scientific process
1. Observation/State the Problem
2. Hypothesis
3. Experiment
4. Collect Data
5. Draw Conclusions
6. Repeat to ensure accuracy

**Problem:** Which member of your group will win a Thumb War Competition?

**Hypothesis:** Do you think the member of your group with the longest thumb OR the shortest thumb will win? Why?

Develop a hypothesis, BEFORE you start the war, you must write a hypothesis. A hypothesis may be written in an “If... (CAUSE = the TEST VARIABLE), then... (EFFECT = the OUTCOME VARIABLE)” format

If (cause)________________________________________

then (effect)________________________________________

**Experiment:**

**Step 1:** Use a ruler to measure the length of group members thumbs in centimeters. Record your measurements in the table below:

<table>
<thead>
<tr>
<th>TEAM MEMBER NAME</th>
<th>THUMB LENGTH (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

**Step 2:** Follow the procedure below to conduct your thumb war experiment to see if your hypothesis is correct.
1. A player hooks the four fingers of their right (or left) hand to the four fingers of the other player’s right (or left) hand and clasps firmly.
2. Your arms must stay touching the desk during the thumb war.
3. To start the game, both players say “One, two, three, four, I declare a thumb war.” Both students then try to trap, pin, or capture their opponents thumb for three (3) seconds to win.
4. No cheating! You may only use your thumb to capture your opponent’s thumb – you may not use other fingers or your other hand to win!
Step 3: Record your Results

<table>
<thead>
<tr>
<th>Team member # vs. Team member #</th>
<th>Result (Who is the winner?)</th>
<th>Repeat Experiment (only when you have finished Step 4!!)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 vs 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 vs 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 vs 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 vs 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 vs 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 vs 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 vs 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 vs 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 vs 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 vs 5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Step 4: Make a Conclusion

1) Who won the most rounds of thumb wars in your group? _________________________________________________

2) Does that person have the longest thumb in your group? _________________________________________________

3) Was your hypothesis correct? _________________________________________________

4) Why do you think you were correct or incorrect? (Why did the person with the longest thumb win OR why did someone who did NOT have the longest thumb win?) _________________________________________________

5) What was the INDEPENDENT (TEST) VARIABLE? _________________________________________________

6) What was the DEPENDENT (OUTCOME) VARIABLE? _________________________________________________

7) Was there a control group in the Thumb War Experiment? _________________________________________________

8) Suggest ways that you would improve this experiment. _________________________________________________

Step 5: Repeat the experiment.

If your group finishes early, then you have time to do the final step of the scientific method! Repeat your experiment again to make sure that the results you got the first time are correct. Record your results on the table above in the column that says “Repeat Experiment.”
Comparing Hypothesis, Theories, and Laws

One of the most difficult things for students and non-scientists to get ‘straight’ are the terms: Theory, Hypothesis, Law, Fact and Belief. This exercise consists of a series of statements, which you will mark as a statement of a Theory (T), Hypothesis (H), Fact (F), Law (L) or Belief (B).

**Fact:** A basic statement established by experiment or observation. All facts are true under specific conditions. Some facts may be false when re-tested with better instruments.

**Law:** A logical relationship between two or more things that is based on a variety of facts and proven hypothesis. It is often a mathematical statement of how two or more quantities relate to each other.

**Hypothesis:** A tentative statement such as ‘if A happens then B must happen’ that can be tested by direct experiment or observation. A proven hypothesis can be expressed as a law or a theory. A disproven hypothesis can sometimes be re-tested and found correct as measurements improve.

**Theory:** An explanation for why certain laws and facts exist that can be tested to determine its accuracy.

**Belief:** A statement that is not scientifically provable in the same way as facts, laws, hypotheses or theories. Scientifically disproven beliefs can still be held to be true.

1 – For every action, there is an equal and opposite reaction.
2 -  F = ma
3 – Water freezes at 32 F
4 – The Earth is a sphere.
5 – The universe is expanding.
6 – Humans were created separately from all other life on Earth.
7 – Humans and gorillas evolved from a common ancestor species.
8 – Light is an electromagnetic phenomenon described by Maxwell’s Laws
9 – Matter is comprised of atoms.
10 – The sun will die in 7.5 billion years.
11 – Earth’s magnetic field is generated by a conducting fluid in its core.
12 – Sunspots are colder than the surface of the Sun.
13 – There are such things as ghosts.
14 - The solar system formed from a primordial disk of gas and asteroidal material.
15 - Matter can be converted into energy.
16 - Energy can be converted into matter.
17 – The positions of the planets can cause humans to act in specific ways.
18 - Momentum is the product of a body’s mass and its velocity.
19 – The core of the Sun has a temperature of 14.5 million Centigrade.
20 – We will never know how life started on Earth.
21 – The Milky Way is a spiral-type galaxy.
22 – Black holes exist.
23 – The sun will rise tomorrow morning.
24 – The Earth is older than 10,000 years.
25 – Genetic mutations cause organisms to change over time.
26 – Primitive human-like creatures existed 2 million years ago.
27 – If I jump out a window I will die.
28 – The universe was created at the Big Bang.
29 – The first generations of stars appeared about 100 million years after the Big Bang.
30 – Space exists in 10-dimensions not just 3.
31 – Some numbers are more lucky than others.
32 – More babies are born, and crimes take place, during the full moon.
33 – The Coriolus Force makes water go down a drain counterclockwise.
34 – The first multi-cellular organisms appeared on Earth about 560 million years ago.
35 – The inverse-square law for gravity and Newton’s laws of motion explain why orbits are ellipses.
Notes and topics for discussion:

The distinction between a theory, a law, a fact, and an hypothesis is subtle. Theories, laws, and facts can start out as hypothesis when they are first proposed and before they are rigorously tested. Can facts be about events in the future?

Generally, a Fact is a very elementary statement based on some measurement such as ‘Humans are about 6 feet tall’ or ‘Water boils at 212 F’. A Law is based on a collection of individual facts, and is an attempt (usually with mathematics) to relate one set of measurable quantities to another (mass, speed, temperature, viscosity). Example, F = ma, V = d/t, PV = nkT. A Theory is an attempt to explain why certain laws exist, and why certain facts are true under specific conditions. Example 1: Planetary orbits are elliptical (A Law) because gravity is an inverse-square force (A Law) and matter operates under Newton’s Laws of Motion. Example 2: Matter is comprised of atoms, and this explains how gases behave (Laws), why we have specific chemical reactions (Laws), and why the Periodic Table exists (Facts).

Are some facts more certain than others? Water always boils at 212 F at sea level, but at higher altitudes it boils at lower temperatures. So every fact depends on the specific circumstances under which it was measured.
Below you will see an outline of the major points you should have learned in the Introduction to the Nature of Science. In subsequent unit essays, you will be asked to write a Reflection Essay describing what you learned. In your English class, you have or will learn how to write an 8 or 11 sentence paragraph. Please see below how I have done that for you in this introductory unit. Your job is to fill in the blanks to make the essay make sense.

I. The Scientific Process is
   A. Observation involves
   B. Hypothesis is a
      1. If… then… A hypothesis
   C. Experiment
      1. Control Group
      2. Experimental group
      A. Variables
         1) IV (test variable)
         2) DV (outcome variable)
   D. Collect & Graph Data
   E. Draw Conclusions
   F. Repeat the Experiment

II. Graphing
   A. X-axis vs. Y-axis
   B. IV vs. DV

1. **TOPIC SENTENCE:** The scientific process is an organized series of _________________________________.

2. **FACT #1:** Those steps do not necessarily have to be completed exactly in that ____________________________; many problems/discoveries have been solved/made by accident.

3. **DETAIL:** To solve a problem, a scientist usually starts by making an _________________________________.

4. **COMMENTARY:** For example, I may walk into my room & ___________________________ that my plants are not very tall.

5. **FACT #2:** Once I make my observation, I move on to form a workable explanation for my plant’s lack of growth called a

6. **DETAIL:** This statement contains the cause and the _____________________.

7. **COMMENTARY:** For example, my plant may not be very tall because of the type of water I am using.

8. **FACT #3:** I move on to test why my plant is so short by developing a _________________________________.

9. **DETAIL:** In my controlled experiment I must have a ___________________ group and an ___________________ group.

10. **DETAIL:** The control group is used for ________________________ purposes, while the experimental group is the one that I _____________________________.

11. **COMMENTARY:** I would like to see if using different types of water would make a difference in the growth rate of plants, so I keep watering my plant with tap water. I also buy four more of the same plant and water each one with a ___________________ type of water.

12. **FACT #4:** I observe my plants over the next four weeks and collect and record the ___________________________ every day.

13. **DETAIL:** After four weeks I make a graph that shows the _________________________________.

14. **DETAIL:** On the X-axis, I put the _________________________________, while on the Y-axis, I put the _________________________________.

15. **COMMENTARY:** My graph will give me an overall view of how the ___________________________ (CAUSE) affects the ___________________________ of the plants (EFFECT).

16. **CLOSING SENTENCE:** What I learned in my introduction to my science class was to how to write a hypothesis with a cause and an effect in it, how to run a ___________________ experiment, and how to set up the data with the ___________________ /Outcome Variable (the CAUSE) on the _______ axis and the ___________________ /Outcome Variable (the EFFECT) on the _______ axis.