Experimental Design
Observations, Inferences and the Scientific Method
New Haven Science Grades 5 - 8

Team Leader: Suzanne Botta Sullivan
Grades 7 & 8 Science Teacher
Team Members: Jere Melvin, Sharee Vereen
Grade 5 – Classroom Teachers
King/Robinson Interdistrict Magnet School

Introduction:
Enclosed is a series of lessons focused on teaching students the process of “Experimental Design” in science. The lessons begin with teaching students to differentiate between observations and inferences then culminates with students designing and conducting their own experiment.

These lessons modify the way the curriculum is taught to ensure English Language Learners (ELLs) receive input in a comprehensible manner and are able to communicate their learning with their peers and teachers at an appropriate LAS links level.

This unit addresses CT State Standards and New Haven pacing requirements in science. The specific science standards are inquiry skill based (and will likely still be required if/when the Next Generation Science Standards are adopted).

*Please note the inquiry standards enumerated below appear repetitive. They appear repetitive because the standards overlap from elementary to middle school inquiry standards. (B INQs represent the elementary requirements and C INQs are the middle school requirements).*

B INQ.1 Make observations and ask questions about objects, organisms and the environment.
C INQ.1 Identify questions that can be answered through scientific investigation.
B INQ.3 Design and conduct simple investigations.
C INQ.3 Design and conduct appropriate types of scientific investigations to answer different questions.
B INQ.4 Employ simple equipment and measuring tools to gather data and extend the senses.
C INQ.4 Identify independent and dependent variables, and those variables that are kept constant, when designing an experiment.
C INQ.5 Use appropriate tools and techniques to make observations and gather data.

The benefit of working in a vertical team is to ensure the same academic language regarding the scientific method is used beginning in 5th grade and continuing through 8th grade. Moreover, we are looking to ensure our students learn to conduct valid experiments and improve their scientific literacy through collaboration amongst teachers. Further, we have noticed this area is a uniquely challenging topic for our students. We believe by incorporating ELL modifications we will greatly improve our students’ ability to comprehend and incorporate the information into their skills repertoire.
Significant time was spent creating resources that can be used after these lessons are completed and throughout the remainder of the students' experience at our school. These resources such as graphic organizers and the systematic use of icons are scaffolds that can be augmented or removed as the students' skill set changes.

A key strategy throughout this unit is the use of scaffolded student talk. We believe this is a critical component to the students acquiring the intended skills and knowledge over the long-term. If teachers using this unit have different time constraints we suggest splitting lessons as opposed to reducing student talk.

*1 Please note that this should not be the students' first lab experience. It is assumed that lab procedures have already been taught and reinforced.
*TAT Curriculum Writing Institute
King/Robinson Inter-district Magnet School
Science 5_8

Connecticut Science standards
B INQ.1 Make observations and ask questions about objects, organisms and the environment.
C INQ.1 Identify questions that can be answered through scientific investigation.
B INQ.3 Design and conduct simple investigations.
C INQ.3 Design and conduct appropriate types of scientific investigations to answer different questions.
B INQ.4 Employ simple equipment and measuring tools to gather data and extend the senses.
C INQ.4 Identify independent and dependent variables, and those variables that are kept constant, when designing an experiment.
C INQ.5 Use appropriate tools and techniques to make observations and gather data.

Abbreviations
SWK: Students Will Know
SWBAT: Students Will Be Able To
SWE: Students Will Explain
TW: Teacher Will
Day 1
Qualitative and Quantitative Data and Observations vs. Inferences
Objectives
SWK: what an observation is
SWBAT: differentiate between quantitative and qualitative data
SWBAT: differentiate between an observation and an inference
SWBAT: make a series of observations
SWE: the difference between quantitative and qualitative data
SWE: the difference between an observation and an inference

Warm Up: Anticipatory guide {1}
Teacher gives out anticipatory guide. Students have five minutes to complete the guide.

TW direct students to move to six work stations. Each station will have an object and a ruler. Student will be directed to talk and write down as many observations as they can about their object {2}. Each group chooses their top two (favorite) observations to write on a post it note and bring to the board.

Teacher asks students, “are all observations the same? What does it mean to observe?” Long deliberate pause, students to turn and talk (no more than 30 sec). Teacher elicits responses from class. Teacher leads students to definition of observation. Teacher writes on the board and student copy into vocabulary graphic organizer {3} “observation” definition. Observation: Using one or more of your five senses to notice details about an object, e.g. sight, sound, taste, touch, smell. Students will complete the other three columns for the word observation. Teacher and students will collaborate in create variations of the word observation, e.g. observe, observable, observing, observed.

TW post the words quantitative and qualitative on the board. TW ask, “Does anyone see or hear a root that makes you think of another word?” TW slowly repeat both words written on the board. Focusing on announciating “quantı” and “qualıtı”. TW underline the root words “quant” and “qual”. TW give students time to turn and talk to neighbor and refer to sentence starters posted on board.

“I think that _______ reminds me of _______”
Teacher will take responses from students until someone describes quantity and/or quality correctly.

TW write the definitions on the board for the students to see and record in their vocabulary graphic organizer {3}. Then students will complete the remaining three columns for the words quantitative and qualitative. Teacher and students will collaborate in create variations of the words quantitative and qualitative, e.g. quantity, quantify, quality, qualify.

Quantitative- an observation that uses numbers: e.g. 3 ft, 4 apples, 2 eyes
Qualitative- an observation using non-numerical description: e.g size, color, shape, smell, texture
TW pass out worksheet, Quantitative vs Qualitative and Observation vs. Inference {4} TW post this worksheet on the whiteboard and interactive board. TW work with the students to complete the first two examples. Students will then only complete the top box only.

TW create a T-chart on the white board. One heading will be qualitative observations and the other will be quantitative observations. TW read the observations written on the post it notes. TW elicit responses from the class about where to categorize each observation. {5} ELLs will use quantitative/qualitative flashcard.
TW ask, if the students have any questions. TW say, “I am going to give you a minute to think. Please decide if you have a question and ask.” TW give a long deliberate pause.

Example: The Sahara desert covers 3.5 miles vs. The Sahara is a big place

TW say, “Next, we are going to talk about observations verses something called an inference.” TW review the definition of an observation. Then TW say and write on the board, Inference definition “Conclusions based on observations. The process of drawing a conclusion from given evidence.” Let me show you what I mean.” Teacher will pull up the PowerPoint titled, Mystery Footprints {5} and pass out Mystery Footprints guided worksheet {6} page 2. TW also display and refer to the worksheet on the interactive board and white board. TW walk students through the practice observation and inference activity, slides 4, 5 and 6. After each slide, students will write on their guided worksheet {6} (page 2) and share their thoughts with their neighbor. TW post sentence starters for students to use in order to share their thinking:

I observed _________.
One observation is _________.

I infer that _________.
My inference is _________.

Closing:
Students will complete a Venn diagram for qualitative and quantitative observations {7}. Review the objectives by having students say the answers to the objectives to a neighbor.
<table>
<thead>
<tr>
<th>Term</th>
<th>Never Heard of it</th>
<th>Heard of it but can't really define it</th>
<th>I think it's something like (fill in the blank)</th>
<th>I have heard this word and I can explain what it means</th>
</tr>
</thead>
<tbody>
<tr>
<td>independent variable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>dependent variable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>constant</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>function</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>experiment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>observation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>qualitative</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>quantitative</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>inference</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>conclusion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>data</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tool</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>series</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hypothesis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>procedure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>scientific method</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>problem</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>classification</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>evidence</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## 2 Object Observation – Guided Worksheet

<table>
<thead>
<tr>
<th>Name (object)</th>
<th>Observation</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## 2b Object Observation – Guided Worksheet *

<table>
<thead>
<tr>
<th>Name (object)</th>
<th>Observation</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Experimental Design, 2013
Melvin, Vereen, and Sullivan*
Yes ✓ Quantitative

No ✗ Qualitative
Venn Diagram – Qualitative and Quantitative

<table>
<thead>
<tr>
<th>Qualitative</th>
<th>Both</th>
<th>Quantitative</th>
</tr>
</thead>
</table>

Word Bank
- numbers
- color
- soft
- observation
- evidence
- weight
- conclusion
- measurements
- sweet

Bonus: Give three examples on your own.
Day 2 **Develop shared experience of experimental design**

SWK: there are independent, dependent and constants in an experiment
SWBAT: make observations
SWBAT: use appropriate tools to record data
SWBAT: identify independent (cause), dependent (effect) variables and constants
SWE: restate the function of the different variables in an experiment

**Warm Up: Fill in the Missing Words {6} page 1**
Teacher will pass out and post the worksheet on the white and interactive board. Students will read the passage and fill in the correct vocabulary words. Then the teacher will elicit student answers to review the worksheet. Student volunteers can write on the interactive board.

Teacher should review the classroom procedure and expectations on running labs *1.

TW pass out lab written directions and review purpose paragraph with the students.

TW say, “Today we will do an experiment and use our observation skills to discover how different water temperatures affect how long it takes for the sponge creature to emerge from this chrysalis (chrysalis should be taped to board and labeled). Let’s work on creating a hypothesis. Who has heard of a hypothesis? If you think you know what that word is hold it in your mind for a minute. Turn and talk with your neighbor about what you think a hypothesis is.”
TW call on students to share aloud their definition of the word hypothesis. TW post and read aloud the definition for a hypothesis on the board. Students will record the definition on vocabulary graphic organizer, The Scientific Method {8}.

Guiding Question: Which do you think will cause the sponge creature to emerge the fastest: warmer water, cooler water, or it won’t matter?

Sentence Starters:
*My hypothesis is that the warmer water will make it emerge _______.*
*My hypothesis is that the colder water will make it emerge _______.*
*My hypothesis is that the water temperature_________________.*

Level 1/2
*My hypothesis is that the warmer water will make it emerge **faster**/slower. (Circle one)*
*My hypothesis is that the colder water will make it emerge **faster**/slower. (Circle one)*
*My hypothesis is that the water temperature will have an effect/will have no effect. (Circle one)*

TW direct students to work in their lab groups to complete the experiment following the written directions. {9} {9b with images}
(Allow 20 minutes for lab, data collection, and questions 1 – 3, questions 4 – 6 are for homework).
Following completion of the lab, allow 5 minutes for clean up and return to classroom seats.

TW tell students to turn and talk to neighbor, describe what you did in the experiment. TW post sentence starters

*Experimental Design, 2013*
*Melvin, Vereen, and Sullivan*
During the experiment we started by
Then we
I noticed that
I was surprised when

TW say, next we are going to breakdown the parts of an experiment that you as a scientist are responsible for, they are called “variables”. Please notice the root “vari”, like her mood varies from day to day, one day happy, one day mad. What do you think vary means?” Take responses until someone says, “change”. Write vari = change.

TW pass out and on post on the white and interactive board a double-sided copy of Effect of Temperature on the Emergence of Sponge Creatures {11}. TW gesture to the teacher copy of the guided worksheet and work at a deliberate pace. On the first side, students will pair with their neighbor to think, discuss and record what they think are the independent, dependent variables and constants. TW encourage partnerships to identify at least three constants.

TW post sentence starters on the board to help guide student conversation:
I think the independent variable is _______, because _______.
I think the dependent variable is _______, because _______.
I think some constants are ________, because ___________.

Through class discussion students will confirm or correct their answers and record them on the back. TW say, “Does anyone have any questions? I will give you a minute to think and then please ask any questions you may have.” TW give a long pause.

TW will pass out Scientific Method graphic organizer {8}. Students will copy the definitions for the independent and dependent variables and constants.

Independent Variable: What the experimenter changes on purpose, the cause (I.V.)
Dependent Variable: What the experimenter measures or observes because of the I.V., the effect (DV)
Constant(s): Steps, materials, etc. that are kept the same so the experiment is fair

TW give students more opportunities to identify the independent, dependent variables and constants {12}

Closure:
In small groups, students will create a thought splash {13}. Students will write and/or draw any thoughts, words, or illustrations that come to mind about the word “experiment”. Students will share out their splashes.
Effect of Temperature on the Emergence of Sponge Creatures \{9\}

Problem / Question
In this activity you will run an experiment to determine if different water temperatures affect the rate at which “sponge creatures” emerge from their gelatin chrysalis.

Hypothesis
Write a prediction based on your background knowledge, what you think will happen?

<table>
<thead>
<tr>
<th>Materials – What you need (Per Group)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 Cups, insulated</td>
</tr>
<tr>
<td>2 Stirrers, plastic</td>
</tr>
<tr>
<td>1 Thermometer</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Procedure:
Step 1
Using a marker, label three cups 30° C. Go back and also write trial 1 on the first cup, trial 2 on the next cup and trial 3 on the last of those cups.

Then label three cups 45° C. Go back and also write trial 1 on the first cup, trial 2 on the next cup and trial 3 on the last of those cups.

Step 2
Observe the chrysalis of the sponge creatures and list 3 qualitative observations.

Step 3
Use graduated cylinder to measure 100 mL of 30° C water and pour into each cup labeled 30° C. Record the water temperature in table 1.

Step 4
One member of your team will be the timer. His/her job is to tell the other three team members when to drop the sponge creatures into the water sample. Using a stopwatch/timer you will measure how long it takes for the sponge creatures to emerge from its chrysalis. When the student who has the timer says “go”, drop the sponge creatures into the water samples. Using the

*Experimental Design, 2013*
*Melvin, Vereen, and Sullivan*
plastic stirrer gently stir the water sample continuously. Stop the timer as soon as the creature emerges.

Record the emergence time in the data table.

**Step 5**
Repeat steps 3 and 4 for the cups labeled 45° C using hot tap water maintained at no more than 45° C.

**Caution:** Do not use water with a temperature greater than 45° C.

**Step 6**
Provide your results to your teacher to record on the board.

**Step 7**
Complete the conclusion section on the response page. Make sure that you include whether the results of your experiment verified your hypothesis.

---

**Recording Quantitative Observations**

<table>
<thead>
<tr>
<th>Water Sample</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Mean (Average)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>30° C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>45° C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Questions:**

1. Which sample took the longest to emerge?  

(Analyze)

2. Do you observe a pattern or relationship between water temperature and time for the creature to emerge? **Circle one:** yes / no

Describe your thinking:
A pattern I notice is ____________________________

(Conclude)

3. In the space below draw a conclusion from this activity. Does water temperature affect how long it takes for a sponge creature to emerge?

---

Experimental Design, 2013  
Melvin, Vereen, and Sullivan
Make sure you **explain** if your results agreed or disagreed with your hypothesis.

4. Why do you think we used two different but specific water temperatures (30º C and 45º C?)

5. Infer a new hypothesis: How long do you think it would take for the creature to emerge in:
   - Boiling water: ________________________________
   - Ice Water: ________________________________

   **(Develop new questions)**

6. If you could create your own experiment using sponge creatures, what would you test?
Effect of Temperature on the Emergence of Sponge Creatures {9b}

Problem / Question

In this activity you will run an experiment to determine if different water temperatures affect the rate at which “sponge creatures” emerge from their gelatin chrysalis.

Hypothesis

Write a prediction based on your background knowledge, what you think will happen?

Materials – What you need (Per Group)

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 Cups, insulated</td>
<td>1 Marker</td>
</tr>
<tr>
<td>100 mL Tap Water, 30°C</td>
<td>100 mL Tap Water, 45°C</td>
</tr>
<tr>
<td>2 Stirrers, plastic</td>
<td>100 mL graduated cylinder</td>
</tr>
<tr>
<td>1 Thermometer</td>
<td>Timer</td>
</tr>
</tbody>
</table>

Procedure:

Step 1

Using a marker, label three cups 30°C. Go back and also write trial 1 on the first cup, trial 2 on the next cup and trial 3 on the last of those cups.

Then label three cups 45°C. Go back and also write trial 1 on the first cup, trial 2 on the next cup and trial 3 on the last of those cups.

Step 2

Observe the chrysalis of the sponge creatures and list 3 qualitative observations.

1. ________________________________ 2. ________________________________
3. ________________________________

Experimental Design, 2013
Melvin, Vereen, and Sullivan
Step 3
Use graduated cylinder to measure 100 mL of 30°C water and pour into each cup labeled 30°C. Record the water temperature in table 1.

Step 4
One member of your team will be the timer. His/her job is to tell the other three team members when to drop the sponge creatures into the water sample. Using a stopwatch/timer you will measure how long it takes for the sponge creatures to emerge from its chrysalis. When the student who has the timer says “go”, drop the sponge creatures into the water sample. Using the plastic stirrer gently stir the water sample continuously. Stop the timer as soon as the creature emerges.

Record the emergence time in the data table.

Step 5
Repeat steps 3 and 4 for the cups labeled 45°C using hot tap water maintained at no more than 45°C.

Caution: Do not use water with a temperature greater than 45°C.

Step 6
Provide your results to your teacher to record on the board.

Step 7
Complete the conclusion section on the response page. Make sure that you include whether the results of your experiment verified your hypothesis.

Recording Quantitative Observations

<table>
<thead>
<tr>
<th>Water Sample</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Mean (Average)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>30°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>45°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Questions:
(Analyze)
1. Which sample took the longest to emerge?

2. Do you observe a pattern or relationship between water temperature and time? Circle one: yes / no

Describe your thinking:

*Experimental Design, 2013
Melvin, Vereen, and Sullivan*
A pattern I notice is

**Conclude**
3. In the space below draw a conclusion from this activity. Does water temperature affect how long it takes for a sponge creature to emerge?

__________________________________________

__________________________________________

__________________________________________

__________________________________________

Make sure you explain if your results agreed or disagreed with your hypothesis.

__________________________________________

__________________________________________

__________________________________________

4. Why do you think we used two different but specific water temperatures (30° C and 45° C)?

__________________________________________

__________________________________________

5. **Infer a new hypothesis**: How long do you think it would take for the creature to emerge in:
   - Boiling water: ____________________________
   - Ice Water: ____________________________

6. **Develop new questions**
   6. If you could create your own experiment using sponge creatures, what would you test?
### Step by Step Chart

<table>
<thead>
<tr>
<th>Step</th>
<th>Detail — What it Looks Like</th>
<th>Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Teacher note, copy Scientific Method pictures 2 and 3 onto back). See below.
<table>
<thead>
<tr>
<th>Step</th>
<th>Detail — What it Looks Like</th>
<th>Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <strong>Create or Identify the problem or question</strong></td>
<td>![Question Mark]</td>
<td></td>
</tr>
<tr>
<td>2. <strong>Create a hypothesis</strong></td>
<td>![Thought Bubble]</td>
<td></td>
</tr>
<tr>
<td>3. <strong>Plan your experiment / make a procedure</strong></td>
<td>![Notebook]</td>
<td></td>
</tr>
<tr>
<td>4. <strong>Conduct experiment</strong></td>
<td>![Scientist and Equipment]</td>
<td></td>
</tr>
<tr>
<td>5. <strong>Gather data/make observations</strong></td>
<td>![Magnifying Glass]</td>
<td></td>
</tr>
<tr>
<td>6. <strong>Analyze data</strong></td>
<td>![Graphs and Chart]</td>
<td></td>
</tr>
<tr>
<td>7. <strong>Draw Conclusions</strong></td>
<td>![Brainstorming]</td>
<td></td>
</tr>
<tr>
<td>8. <strong>Pose new questions for further experimentation OR Communicate Findings</strong></td>
<td>![Interactive Figures]</td>
<td></td>
</tr>
</tbody>
</table>

(Teacher note, copy Scientific Method pictures 1 and 3 onto back). See below.
Step by Step Chart

1. Problem/Question

2. Using your background knowledge, create a hypothesis

3. Planning an experiment

4. Conducting an experiment

Experimental Design, 2013
Melvin, Vereen, and Sullivan
5. Gathering Data/Making Observations

6. Analyzing Data

7. Drawing Conclusions

8. Pose new questions for further experimentation or communicate findings

Experimental Design, 2013
Melvin, Vereen, and Sullivan
**Teacher Background**: Steps of the Scientific Method (for this set of lessons)

1. Problem / Question
2. Hypothesis
3. Planning
4. Conducting Experiment
5. Gathering Data / Making Observations
6. Analyzing Data
7. Drawing Conclusions
8. Pose new questions for further experimentation OR Communicate Findings

---

**Scientific Method Picture 1**

Simplified version

Levels 1, 2, 3

---

*Experimental Design, 2013
Melvin, Vereen, and Sullivan*
Scientific Method Picture 2

Text rich

Levels: 3, 4, 5
General Population

Scientific Method Picture 3

Simplified
And fun (helpful to levels 1 – 3) but given to all for fun and clear understanding

*Every baby knows the scientific method!*

1. Make an observation.
2. Form a hypothesis.
3. Perform the experiment.
4. Analyze the data.
5. Report your findings.
6. Invite others to reproduce the results.

Experimental Design, 2013
Melvin, Vereen, and Sullivan
Effect of Temperature on the Emergence of Sponge Creatures {11} Guided Discussion

Problem / Question:
In this activity you will run an experiment to determine if different water temperatures affect the rate at which “sponge creatures” emerge from their gelatin chrysalis.

Variables (Independent, Dependent, and Constants)

Think, Discuss, Decide: In this experiment what was the cause and what was the effect? Write your answers in the shapes below.

Cause: Independent Variable

Effect: Dependent Variable

Think, Discuss, Decide: In this experiment, what were some things that everyone did the same way and list some materials that everyone used. Write your ideas in the oval below.

Things that are kept the same in an experiment are called:

Constants

Experimental Design, 2013
Melvin, Vereen, and Sullivan
Variable Practice {12}

Name: ___________________________ Home Room: _______ Date: _______

Directions: Identify the variables and constants for the following experiments.

**Example:**
How does the size of a bowl affect how long it takes for hot porridge to cool?

a) Identify the Independent Variable: size of the bowl (3 different sizes)

b) Identify the Dependent Variable: how long it takes the porridge to cool

c) Identify Constants: starting porridge temp, same amt ingredients, environmental temp, bowl material

2. How does the weight of a truck affect how long it takes the truck to stop from traveling at 60 mph?

a) Identify the Independent Variable: ___________________________

b) Identify the Dependent Variable: ___________________________

c) Identify Constants: ___________________________

4. How does the temperature of milk affect how quickly it goes bad?

a) Identify the Independent Variable: ___________________________

b) Identify the Dependent Variable: ___________________________

c) Identify Constants: ___________________________

5. How does a student’s time "on task" affect his end of unit exam grade?

a) Identify the Independent Variable: ___________________________

b) Identify the Dependent Variable: ___________________________

c) Identify Constants: ___________________________

6. How amount of sun light affect how tall a plant grows?

a) Identify the Independent Variable: ___________________________

*Experimental Design, 2013
Melvin, Vereen, and Sullivan*
b) Identify the Dependent Variable


c) Identify Constants
Experiment Splash {13}

Name: _____________________________ Date: __________________

Directions: Write and/or draw any thoughts, words, or illustrations that come to your mind about the word “experiment”.

Experimental Design, 2013
Melvin, Vereen, and Sullivan
Day 3 Student designed experiments

SWK: how to set up their own experiment
SWBAT: create their own experiment based on their own questions
SWBAT: use tools to conduct and record data
SWBAT: identify independent, dependent variable and constants
SWE: the purpose of the scientific method

Warm Up
Students will copy text for the Scientific Method into the Step by Step Chart. ELLs level 1 & 2 will highlight bolded and underlined words (per the directions).

TW: remind the students that today they will be the scientist using the scientific method and will make decisions about their own experiment.

TW tell students to take out their guided worksheets {9} from yesterday, specifically we will use question 6 to brainstorm experiment ideas. TW pass out Experiment Variables graphic organizer {14} and pull up a copy on the interactive board (post copy on white board for reference). TW elicit ideas from the students and make a list on the board of possible alternate IVs and DVs. Class will choose 3 best ideas from the brainstorm / identify IVs and DVs and write them in appropriate symbols – students copy from board. TW emphasize that each IV has 3 variations, e.g. Temperature: 30 °, 45 °, 10 °C and that is part of their choice as scientists doing the experiment.

TW: Review safety/ lab expectations. *1

Students move into lab groups and are given 1 minute to choose their experiment’s IV. Students will use Student Designed Experiment – Guided Worksheet {15} to work through lab. TW monitor groups during lab and offer assistance where needed. It is recommended that the teacher should circulate the room taking anecdotal notes that highlight the use of academic language.

TW post sentence re: “lab talk”
  • That is interesting but off topic, let’s focus!
  • What do you think about this idea?
  • Can everyone explain how we got this answer?
  • Let’s come back to this later
  • We need to move on to the next step

Following lab and clean up – students return to their own seats and TW have the students look at their guided lab worksheets {15} and compare it to the scientific method worksheet – TW tell students to check off the steps they have used. Have they followed the scientific method... yes – then students are not acting as students or children but rather as scientists ☺

Closure:
Students will complete 3-2-1 Exit Ticket {16} in order to communicate their learning from the scientific method. Teacher can decide to have students share out or turn in for teacher evaluation.

Experimental Design, 2013
Melvin, Vereen, and Sullivan
Experiment Variables {14}

Water Temperature
30° C
45° C

Time it takes for the sponge animal to emerge

Independent Variable
(Cause)

Dependent Variable
(Effect)

Independent Variable
(Cause)

Dependent Variable
(Effect)

Independent Variable
(Cause)

Dependent Variable
(Effect)

Independent Variable
(Cause)

Dependent Variable
(Effect)

Experimental Design, 2013
Melvin, Vereen, and Sullivan

Dependent Variable
(Effect)
Experiment # 1

Before you begin your investigation, complete the following:
1. What is the problem (question) that you are investigating? Be sure to identify you independent and dependent variables.

   How does

   affect

2. Identify your independent and dependent variables.

   Independent Variable:

   Variation 1:

   Variation 2:

   Variation 3:

   Dependent Variable:

3. State your hypothesis
(Predict, what do you think your results will be and why do you think so).

   I think
4. List the materials that you will be using in your investigation.


5. Identify at least three constants that you will keep the same during the experiment.


Experimental Design, 2013
Melvin, Vereen, and Sullivan
6. **Gather Data - Make Observations**

Data Table (Record time AND 3 qualitative observations in each box)

<table>
<thead>
<tr>
<th>I.V.</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variation 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variation 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variation 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. **Conclusions**

A pattern I notice is ____________________________

In the space below draw a conclusion from this activity. Does ____________________________ (fill in the blank with your IV) affect how long it takes for a sponge creature to emerge?

__________________________________________________________________________

__________________________________________________________________________

Make sure you state if your results agreed or disagreed with your hypothesis.

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

Experimental Design, 2013
Melvin, Vereen, and Sullivan
Experiment # 1

Before you begin your investigation, complete the following:

1. What is the problem (question) that you are investigating? Be sure to identify you independent and dependent variables.

   How does

   affect

   

2. Identify your independent and dependent variables.

   Independent Variable:

   Variation 1:

   Variation 2:

   Variation 3:

   Dependent Variable:

3. State your hypothesis

   (Predict, what do you think your results will be and why do you think so).

   I think

   

Experimental Design, 2013
Melvin, Vereen, and Sullivan
Planning

4. List the materials that you will be using in your investigation.

---

---

---

5. Identify at least three (3) constants that you will keep the same during the experiment.

a. 

b. 

c. 

---

Experimental Design, 2013
Melvin, Vereen, and Sullivan
6. **Gather Data - Make Observations**

**Data Table**

(Record time AND 3 qualitative observations in each box)

<table>
<thead>
<tr>
<th>I.V.</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variation 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variation 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variation 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. **Conclusions**

A pattern I notice is ____________________________

In the space below draw a conclusion from this activity. Does __________________ (fill in the blank with your IV) affect how long it takes for a sponge creature to emerge?

____________________________________________________________________________________

____________________________________________________________________________________

Make sure you state if your results (observations / data) agreed or disagreed with your hypothesis.

if your ________ and ________ or ________ with your ________

____________________________________________________________________________________

____________________________________________________________________________________

*Experimental Design, 2013*

*Melvin, Vereen, and Sullivan*
### Exit ticket 3 – 2 – 1 {16}

**Scientific Method**

<table>
<thead>
<tr>
<th>3 Things I Learned</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2 Things I Liked</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1 Question I have</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

---

### Exit ticket 3 – 2 – 1 {16}

**Scientific Method**

| 3 Things I Learned | 🧠
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

| 2 Things I Liked | 🙌
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

| 1 Question I have | 🤔
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

---

*Experimental Design, 2013*

*Melvin, Vereen, and Sullivan*
<table>
<thead>
<tr>
<th>Icon</th>
<th>Word / Name</th>
<th>Lesson(s)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Head" /></td>
<td>Learned Learn</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td><img src="image2.png" alt="Thumb up" /></td>
<td>Like Liked</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td><img src="image3.png" alt="Question Mark" /></td>
<td>* Question * Problem * Wonder</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td><img src="image4.png" alt="Cup" /></td>
<td>Cup</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td><img src="image5.png" alt="Record" /></td>
<td>* Write * Record</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td><img src="image6.png" alt="Graduated Cylinder" /></td>
<td>Graduated Cylinder</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td><img src="image7.png" alt="Capsule" /></td>
<td>Capsule in cup of water</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td><img src="image8.png" alt="Stopwatch" /></td>
<td>* Stopwatch * Timer</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td><img src="image9.png" alt="Timer" /></td>
<td>Time</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td><img src="image10.png" alt="Sponge" /></td>
<td>Sponge Creatures Gelatin Chrysalis</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td><img src="image11.png" alt="Scientific Method" /></td>
<td>Scientific Method</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td><img src="image12.png" alt="Cloud" /></td>
<td>Hypothesis</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td><img src="image13.png" alt="Gather" /></td>
<td>Gather Materials</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td><img src="image14.png" alt="Procedure" /></td>
<td>Procedure Plan</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td><img src="image15.png" alt="Conduct" /></td>
<td>Conduct experiment</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td><img src="image16.png" alt="Make Observations" /></td>
<td>Make Observations</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><img src="image17.png" alt="Data" /></td>
<td>Analyze Data Data</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Icon</td>
<td>Word / Name</td>
<td>Lesson(s)</td>
<td>Notes</td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
<td>-----------</td>
<td>-------</td>
</tr>
<tr>
<td><img src="image.png" alt="Icons" /></td>
<td>Communicate Findings/Share Out</td>
<td>1 2 3</td>
<td></td>
</tr>
<tr>
<td><img src="image.png" alt="Icons" /></td>
<td>Conclusion Conclude Draw Conclusions</td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image.png" alt="Icons" /></td>
<td>Yes Agree</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><img src="image.png" alt="Icons" /></td>
<td>No Disagree</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><img src="image.png" alt="Icons" /></td>
<td>Stirrers</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td><img src="image.png" alt="Icons" /></td>
<td>Thermometer Temperature</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Next Steps

Extension – Socratic Seminar
SWE: the purpose of the scientific method

**Warm Up:** *Anticipation Guide* \{1\} (Post Assessment)
Students will complete the backside of their vocabulary anticipation guide.

Critical Thinking:
Scientific method puzzle \{link attached – see appendix A\}
In small groups, students will assemble their scientific method puzzles.

Class Discussion: If a step was missing, would it still be the scientific method? Would it still work?

TW post on board.
The scientific method is a process and it is the same around the world. It is the same here as it is at Yale. It is the same in China, Australia, Zimbabwe, and Russia. It is the same if you are a 12 year old student or a 55 year old professional scientist. It is a human ingenuity, a human creation.

Sentence Starters on Board

How does the scientific method help us learn, create, or solve problems?
*I think the scientific method helps us ____ by
*I think the scientific method helps us ____ because
*I think the scientific method helps us ____ when

Why have a scientific method, why not just do stuff?

*I think having a scientific method is important because______
*I think we use a scientific method to ______
* I think
* We can't just do stuff because ______
* Just doing stuff doesn't work because ______
Extended Talk – Listening Guide {18}

➢ How does the scientific method help us learn, create, or solve problems?
➢ Why have a scientific method, why not just do stuff?

1. _______________ said _________________________________

I agree / disagree with that because _________________________________

2. _______________ said _________________________________

I agree / disagree with that because _________________________________

3. _______________ said _________________________________

I agree / disagree with that because _________________________________

4. I think ____________________________________________
   ____________________________________________________
   ____________________________________________________
   ____________________________________________________
   ____________________________________________________
The scientific method is the same and used around the world.

It is the same if you are young or old.

It is a human invention.

Questions

How does the scientific method help us learn, create, or solve problems? (Circle One)

*I think the scientific method helps us ______ because ____________________________

Why have a scientific method, why not just do stuff?

* We can’t just do stuff because ____________________________
<table>
<thead>
<tr>
<th>Name</th>
<th>#</th>
<th>Page Number</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anticipation Guide</td>
<td>{1}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observation Guide</td>
<td>{2}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vocabulary Graphic Organizer</td>
<td>{3}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level 1 Vocabulary Graphic Organizer</td>
<td>{3b}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantitative vs Qualitative and Observation vs. Inference</td>
<td>{4}</td>
<td></td>
<td>Attached pdf</td>
</tr>
<tr>
<td>Mystery Footprints PowerPoint</td>
<td>{5}</td>
<td></td>
<td>Attached</td>
</tr>
<tr>
<td>Mystery Footprints Worksheet</td>
<td>{6}</td>
<td></td>
<td>Attached</td>
</tr>
<tr>
<td>Venn Diagram – Qualitative and Quantitative</td>
<td>{7}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 2</td>
<td>{8}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>vocabulary graphic organizer, The Scientific Method</td>
<td>{8}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effect of Temperature on the emergence of sponge creatures – Guided lab sheet</td>
<td>{9}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effect of Temperature on the emergence of sponge creatures – Guided lab sheet</td>
<td>{9b}</td>
<td></td>
<td>Supplemented with pictures / images for ELLs level 1,2, 3</td>
</tr>
<tr>
<td>Step by Step graphic organizer</td>
<td>{10}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step by Step graphic organizer filled in</td>
<td>{10b}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity</td>
<td>Page</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effect of Temperature on the emergence of sponge creatures</td>
<td>{11}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guided Discussion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variable Practice Worksheet</td>
<td>{12}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thought Splash</td>
<td>{13}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experiment Variables</td>
<td>{14}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student Designed Experiment – Guided Worksheet</td>
<td>{15}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student Designed Experiment – Guided Worksheet</td>
<td>{15b}</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Supplemented with pictures / images for ELLs level 1, 2, 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exit ticket 3-2-1</td>
<td>{16}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Icons</td>
<td>{17}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scientific Method – Extended Talk, listening Guide</td>
<td>{18}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extended Talk – Handout for ELLs Level 1, 2, 3</td>
<td>{19}</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Supplemented with pictures / images for ELLs level 1, 2, 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Turn images into puzzles

http://www.jigsawplanet.com/?rc=createpuzzle&ret=%2F%3Frc%3Dplay%26pid%3D3c36e79a24c9

http://bighugelabs.com/jigsaw.php
<table>
<thead>
<tr>
<th>Word</th>
<th>Definition</th>
<th>A Clue in your own words</th>
<th>Variations of word</th>
<th>What is it Not</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantitative</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qualitative</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inference</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conclusion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Vocabulary Graphic Organizer {8}
**The Scientific Method**

<table>
<thead>
<tr>
<th>Word</th>
<th>Definition</th>
<th>A Clue in your own words</th>
<th>Variations of word</th>
<th>What is it Not</th>
</tr>
</thead>
<tbody>
<tr>
<td>hypothesis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>procedure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>independent variable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>dependent variable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>constant</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>data</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Observations

• Any information collected with the senses.
  • Quantitative – measureable or countable
    » 3 meters long
    » 4 marbles
    » 50 kilograms
    » 35 degrees Celsius
  • Qualitative – describable, not measureable
    » red flowers
    » smells like fresh baked cookies
    » Tastes bitter

• The skill of describing scientific events
Inference

- Conclusions based on observations.
- The process of drawing a conclusion from given evidence.

Practice:
- **Observations:**
  - I hear people screaming
  - I smell cotton candy, popcorn, and hamburgers
  - I see a lot of people
- **Inference = ?**
Look at these two sets of animal tracks.

List 3 OBSERVATIONS

Make an INERENCE
Now what do you think?

Make 3 OBSERVATIONS

Make an INFERENCE
Now what do you think?

Make 3 OBSERVATIONS

Make an INFERENCE
Activity Page

www.middleschoolscience.com/footprints-isn.pdf

In your science notebook, write your conclusion.
Source of graphic:

http://bob.nap.edu/html/evolution98/evol6-e.html
FILL IN THE MISSING WORD

QUANTITATIVE  QUALITATIVE  OBSERVATIONS  INFERENCE

One of the most important skills in science is the use of our five senses, or making ____________. Most of the time we think of observing as something we do with our eyes; when we see something, we observe it. However, all five of our senses can be used to make observations: sight, hearing, taste, touch, and smell. A good scientist is observant and notices things in the world. He or she notices what’s going on in the world and becomes curious about what’s happening.

We can make two kinds of observations: either Qualitative or Quantitative. ______________ data is information that is hard to measure, count, or describe in numbers. It describes the qualities or characteristics of something. Examples are colors, tastes, and smells.

____________ data is information that can be expressed using numbers: something that can be counted or measured. Tools are often used to collect quantitative data. Examples include quantity, temperature, mass, and length.

After we make observations, our brain makes logical conclusions about our observations called ____________.
### Practice

#### Observations

1. I hear people screaming
2. I see many people
3. I smell cotton candy, popcorn, and hamburgers

#### Mystery Footprints

<table>
<thead>
<tr>
<th>Observations</th>
<th>Inference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame 1</td>
<td></td>
</tr>
<tr>
<td>Frame 2</td>
<td></td>
</tr>
<tr>
<td>Frame 3</td>
<td></td>
</tr>
</tbody>
</table>

#### Conclusion:
In your notebook, write 2-3 sentences about what you learned from Mystery Footprints.
Ask Question

Do Background Research

Construct Hypothesis

Test with an Experiment

Analyze Results Draw Conclusion

Hypothesis Is True

Hypothesis Is False or Partially True

Report Results
Define/Identify the Problem

Form a Hypothesis

Make Observations

Test Hypothesis Perform Experiments

Organize and Analyze Data

Do Experiments and Observations Support Hypothesis?

Yes

Draw Conclusions

No

Faulty Experiments?

New Experiments

Communicate Results
Every baby knows the **scientific method!**

1. **Make an observation.**
2. **Form a hypothesis.**
3. **Perform the experiment.**
4. **Analyze the data.**
5. **Report your findings.**
6. **Invite others to reproduce the results.**