Experimental Design in Life Sciences

Jenifer Gifford, Ph.D.

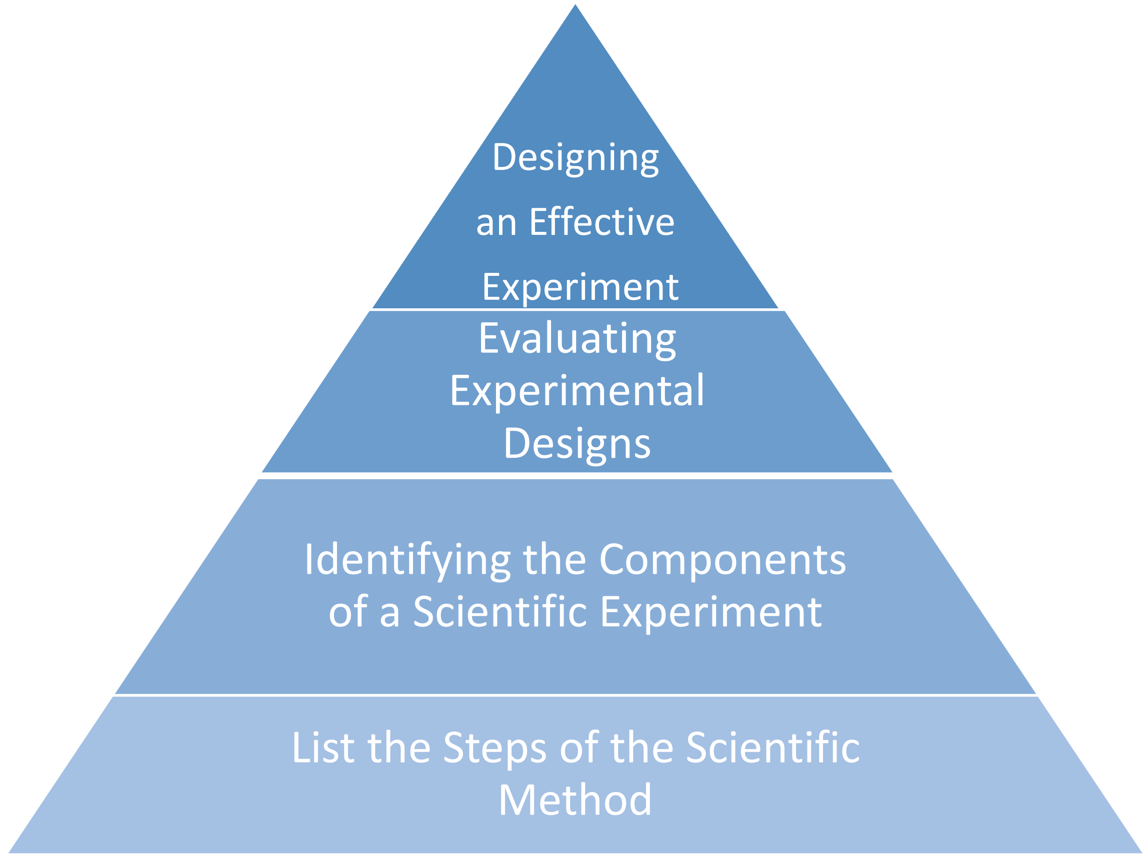
Instructional Assistant Professor

Department of Biology and Biochemistry

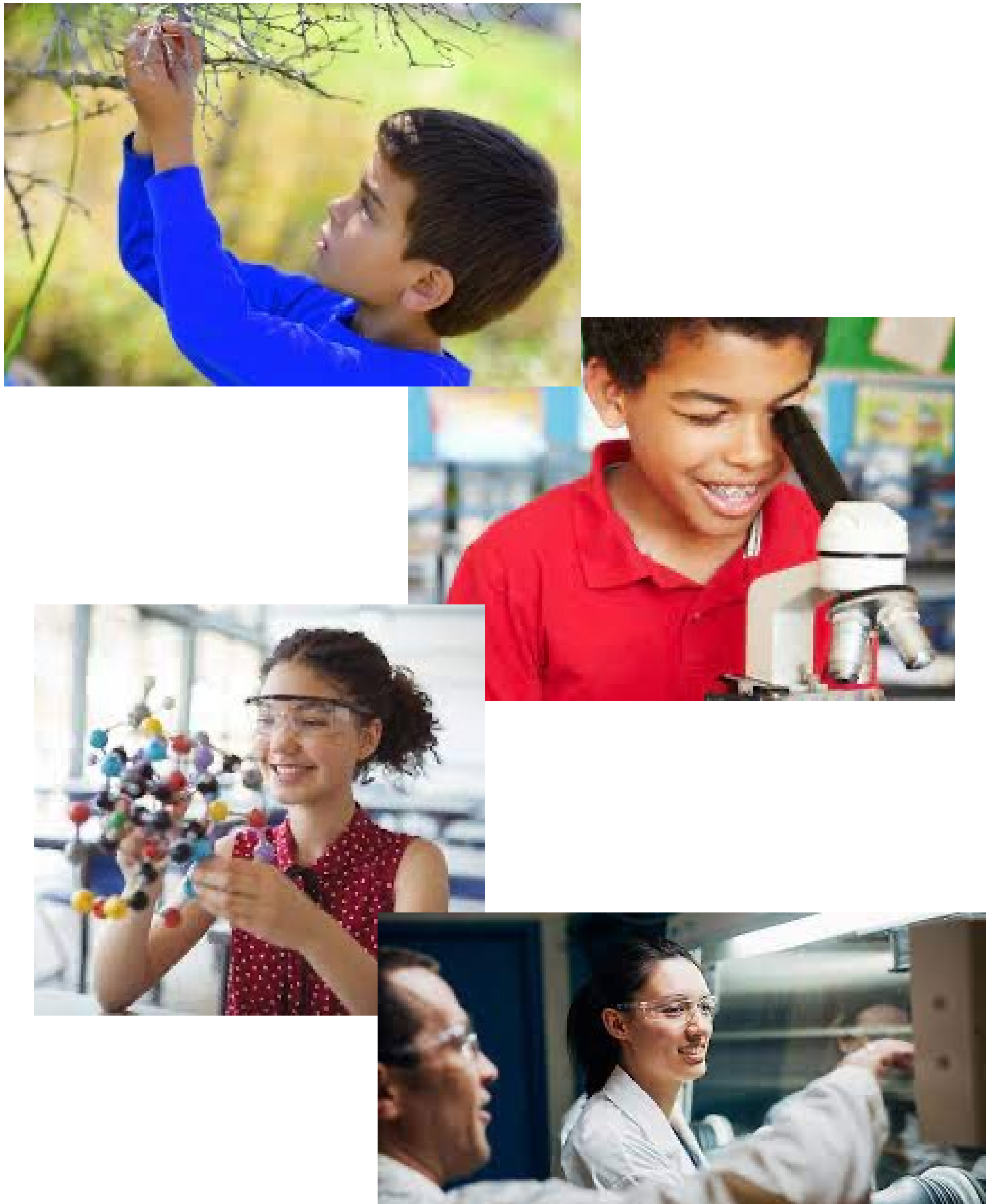
University of Houston

Seminar Objectives

1. Engaging students in the scientific method
   - Choosing a question/topic
   - Understanding the purpose of the scientific method
2. Designing an experiment:
   - Setting up a control
   - Establishing constants
   - Types of Variables
   - Recognizing design flaws
3. Collecting and Presenting Data/Conclusions



Generating a Project Idea



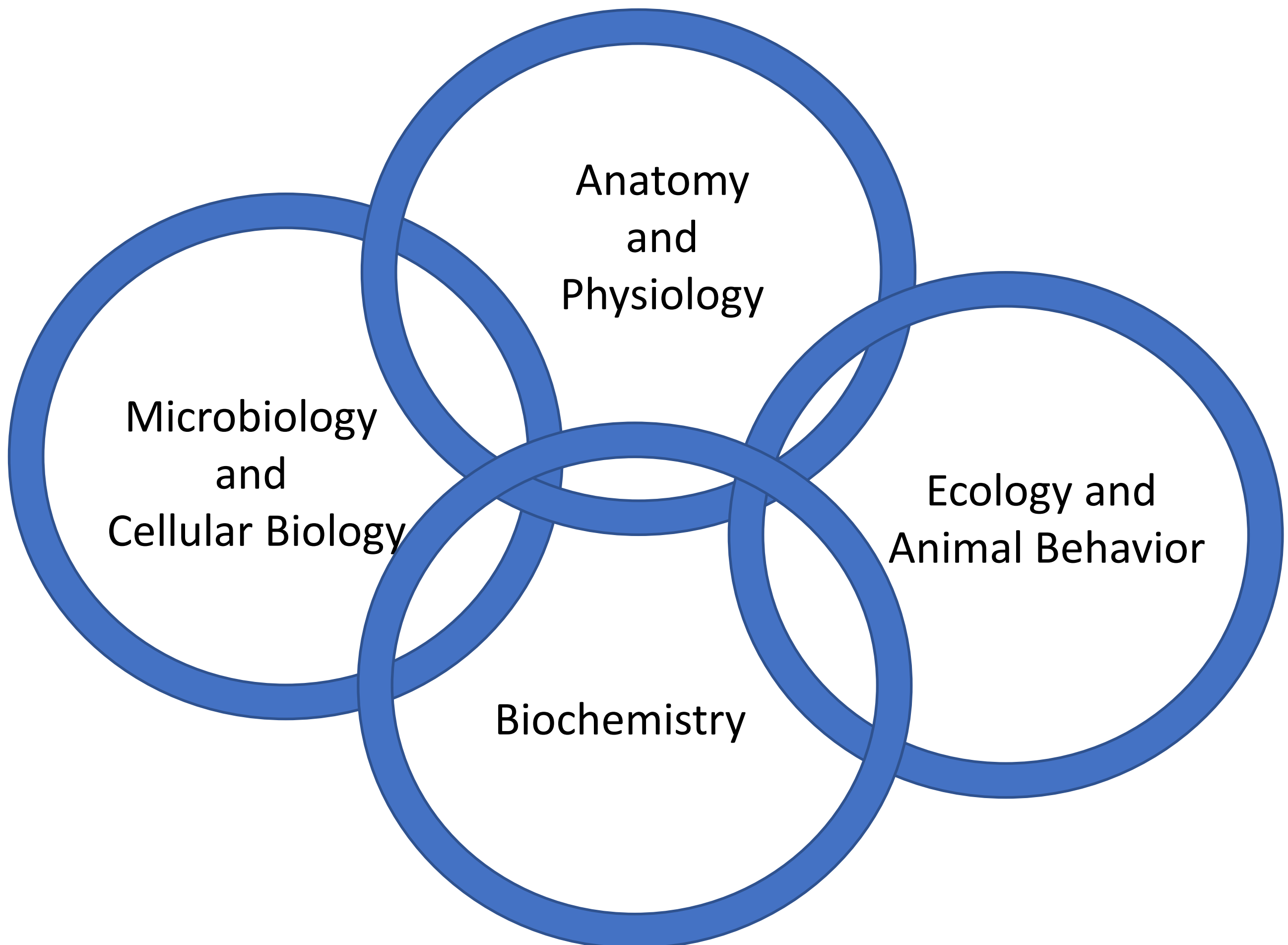
- Encourage Curiosity!
- Allow your student to investigate something they find interesting, rather than staying with a safe experiment done many times before.
- Remember that the goal is not to discover something completely new
- Letting their interest drive the project will give them more ownership and that will show in their presentation.

Generating a Scientific Question




- The world around us is teeming with organisms that are easy to find and simple to grow and study.

- Encourage your student to observe the life around them and ask how organisms function or why they behave the way they do.



The Process of Science

Students are usually familiar with the scientific method and can recite the steps as a list, but they do not necessarily view it as a thought process they they use every day to solve problems.

Training Students to Identify the Scientific Method as a Thought Process

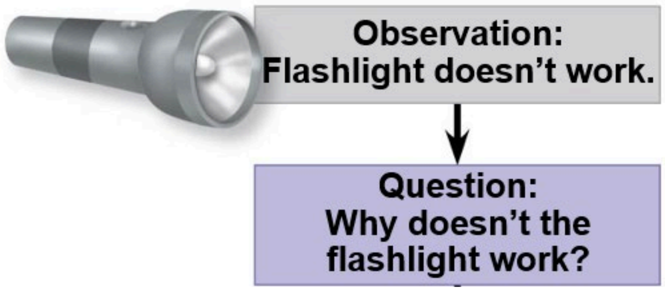
We solve everyday problems by forming hypotheses and following the scientific method to troubleshoot.

A common example would be troubleshooting why a flashlight isn't working

Form Two Hypotheses-- Potential explanations as to why, specifically, the flashlight doesn't work.

A)

B)



The Scientific Method

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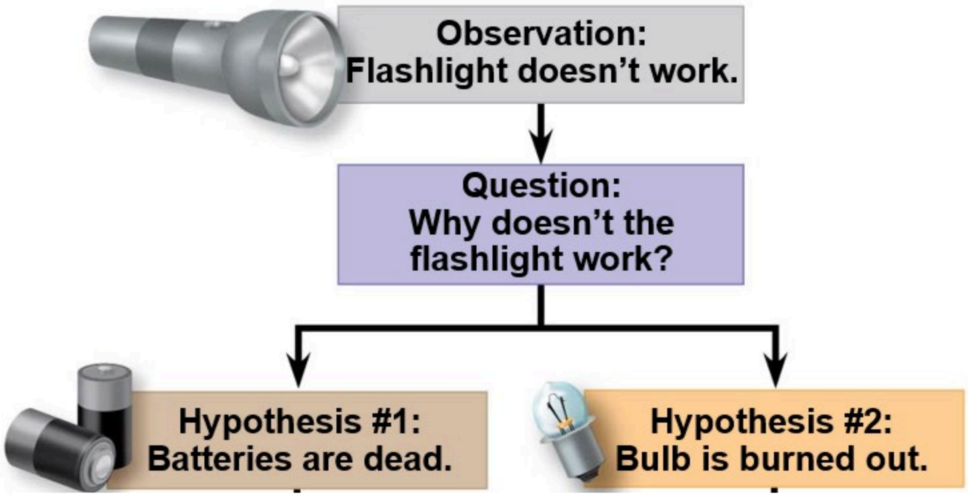
What do you do to figure out which hypothesis is correct? (Design an Experiment to test each hypothesis independently). For each experiment, make a prediction regarding the result of each experiment: "If X is true, then we would expect to see Y when we (perform experiment)"



> **Experiment A)**
>> **Prediction A:**
>
> **Experiment B)**
>> **Prediction B:**

The Scientific Method

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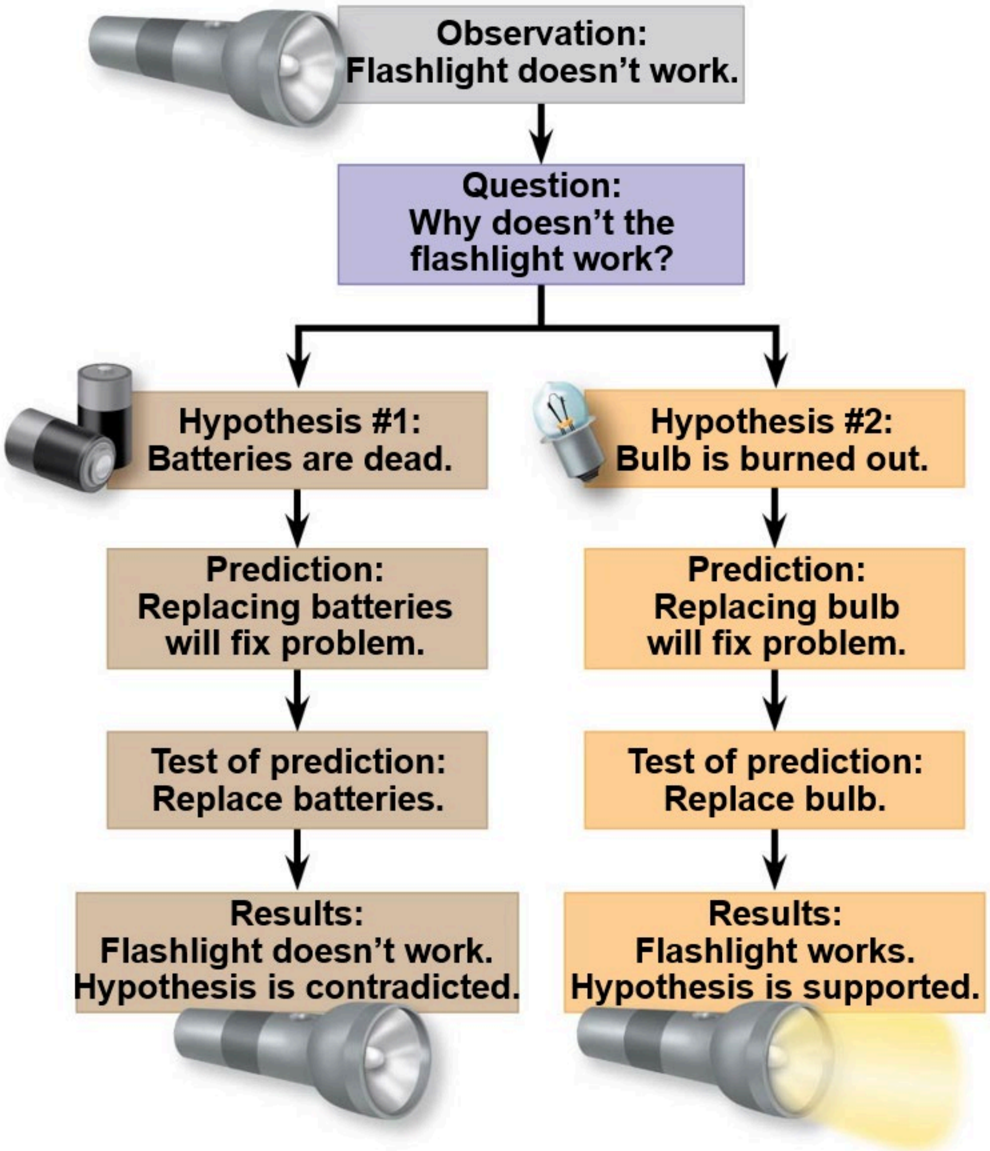
Experiment A)

Prediction A:

Experiment B)

Prediction B:



The Scientific Method

Ask students: If we had changed the batteries AND the lightbulb at the same time, the flashlight will (probably) work, but do we know what the problem/solution was?

This demonstrates that scientific experiments have to be carried out in a very specific way in order to understand the results

Let's Breakdown the Method in More Detail

Understanding a Hypothesis: Why do Giraffes have Long Necks?

Observation: Giraffes have long necks

Question: Why do they have long necks?

Hypothesis:
A <u>specific</u> and <u>testable</u> statement that serves as an explanation to a particular question

Long necks evolved because those with long necks can reach food unavailable to other mammals.

Prediction:

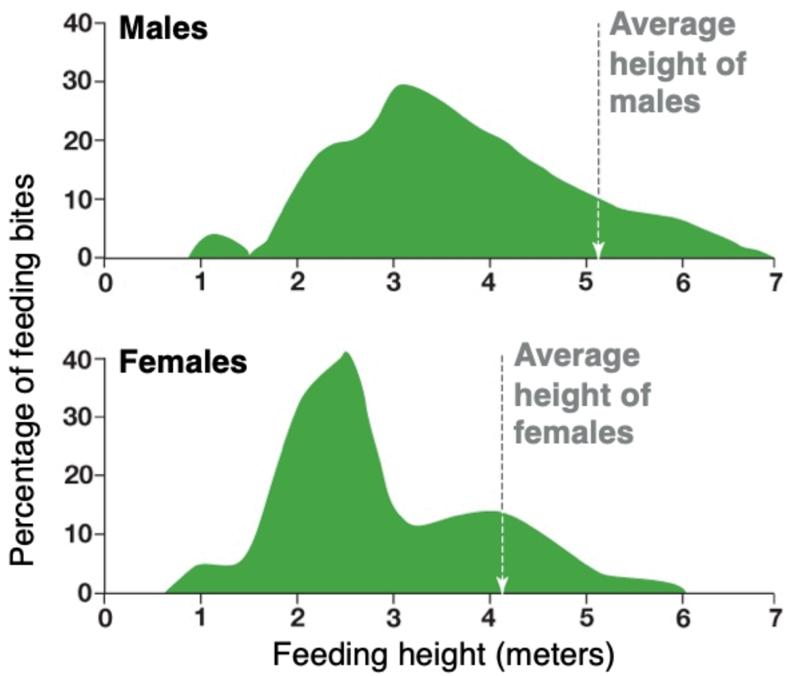
If this is hypothesis is supported, we should see giraffes feeding at or near their maximum height.

The Process of Science:

Observational Experiment: Observe giraffes feeding in the wild and measure the height at which they do the majority of their feeding.

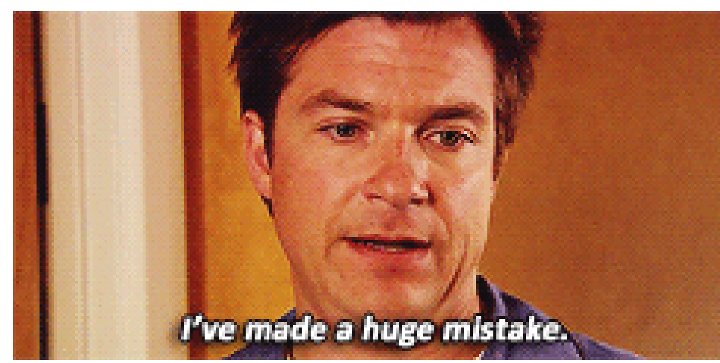
Collection and Analysis of Data:

(a) **Most feeding is done at about shoulder height.**



(b) **Typical feeding posture in giraffes**

What does that mean about the hypothesis?



It's okay to be "wrong"! Generate another hypothesis and let the data lead you to a better understanding of the world around us.

Alternative hypothesis—giraffes evolved long necks because:

- Longer-necked males win more fights than shorter-necked males
- Longer-necked males can then father more offspring

- Data <u>supports</u> this hypothesis/refutes food competition hypothesis

Let's Breakdown the Method in More Detail

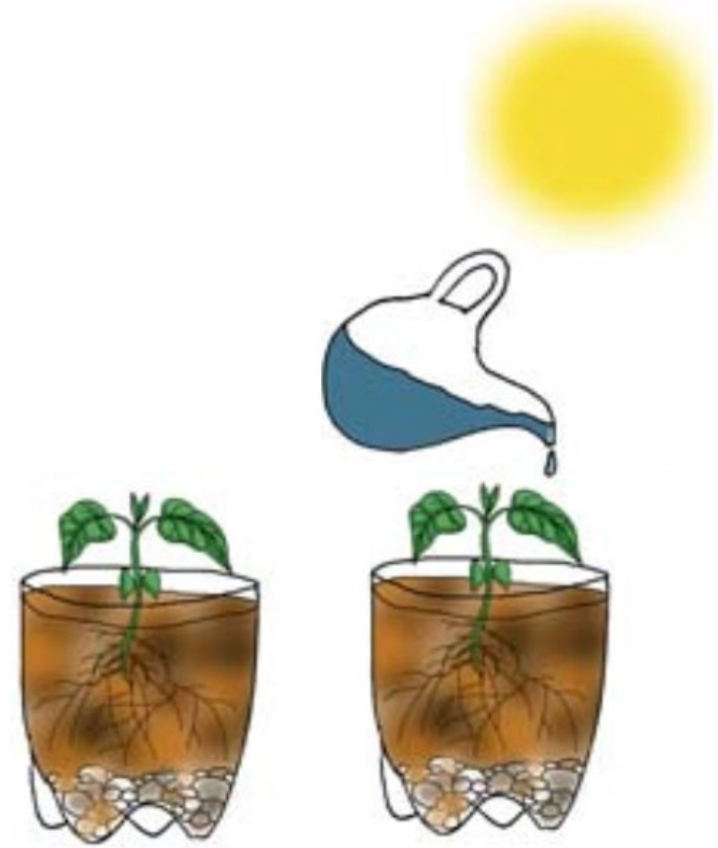
Experimental Design: Establishing the Groups

A proper scientific experiment contains the following elements:

- **Experimental Group**: This is the condition where you manipulate a single condition to test your hypothesis.
- **Control Group:** This is the condition where you **do not** manipulate a condition to establish the baseline behavior.
- **Replications** of these groups (at least three)

Hypothesis:
Water increases plant growth.

Experiment: We are testing the effect of water on plant growth

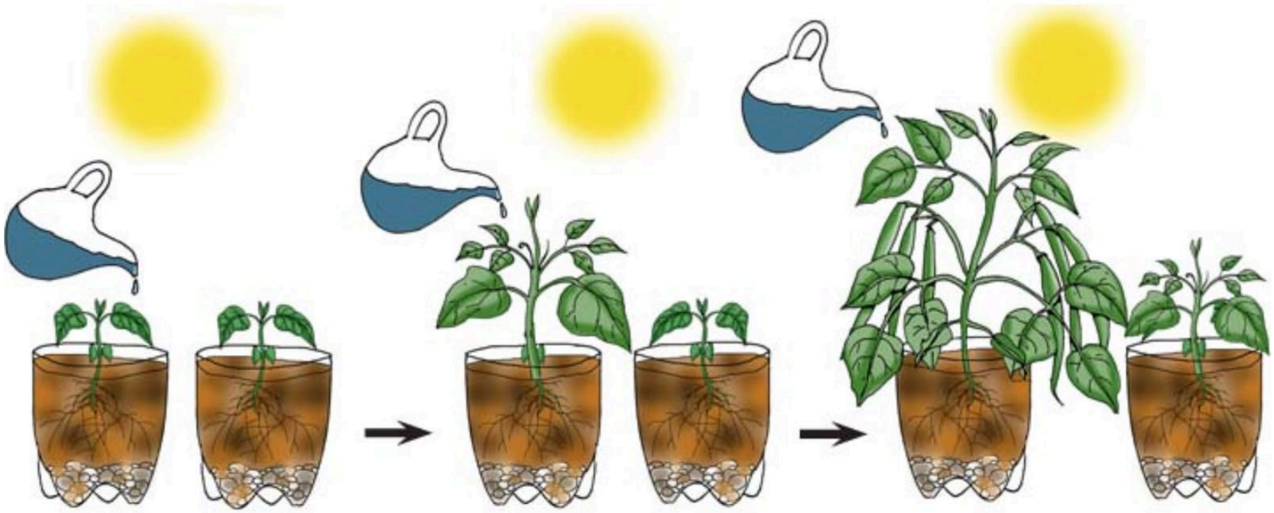


The Process of Science: Establishing Variables and Constants

A good scientific experiment contains the following elements:

- **Dependent Variable**: What you are **measuring**? This is what you will observe changing.
- **Independent Variable**: What you are **changing**? There should only be ONE thing you change at a time in an experiment.
- **Experimental Constants**: All other possible variables, aside from your independent variable, that could affect the results. All other potential variables must be constant in both the control and experimental group.

Exercise 1



1. Identify the dependent variable
2. Identify the independent variable
3. List examples of experimental constants

Exercise 2: Identifying Flaws of an Experimental Design

Foundational knowledge

- Stomach and intestinal ulcers are caused by a bacterium called H. Pylori.
- The standard of care is antibiotic A
- A new antibiotic (antibiotic B) has been developed by scientists and it's efficacy has not been tested

Major Question:

- Which antibiotic is more effective?

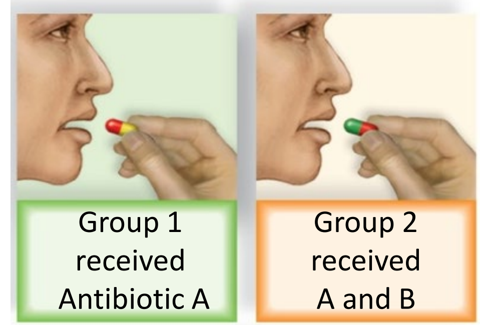
Hypothesis: New Antibiotic B is a more effective than antibiotic A

Conclusion: Antibiotic B cures patients of ulcers.

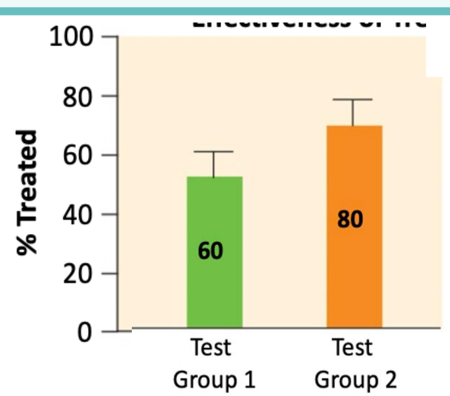
1. Does the hypothesis address the question?
2. Does the experiment have a proper control?
3. Does the experiment have a clear experimental group?
4. Is there a single independent variable?
5. Is the conclusion appropriate? Is it over or understated?

State Hypothesis:
Antibiotic B is a more effective treatment for ulcers than antibiotic A.

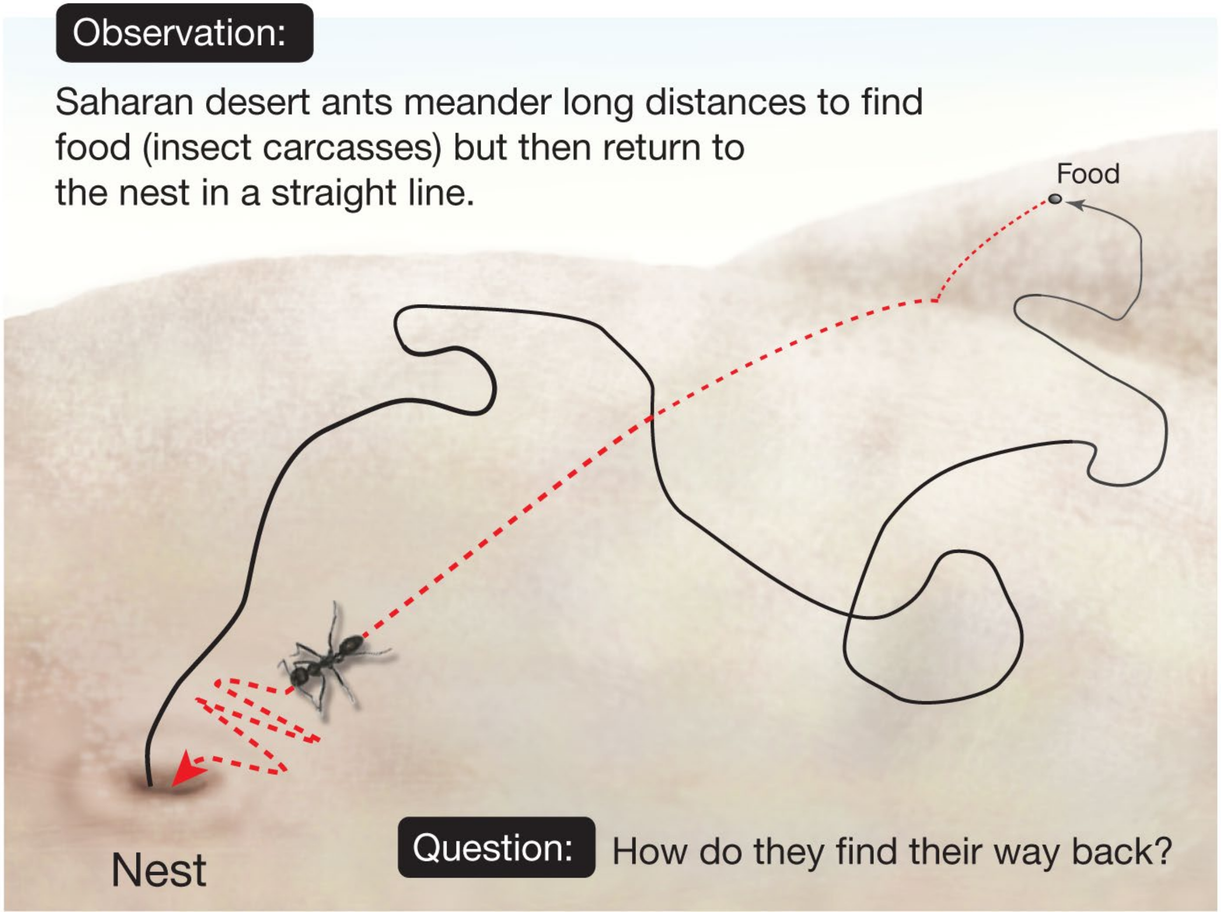
Perform Experiment:
Patients were treated with antibiotics



Collect Data: Patients were screened for ulcers



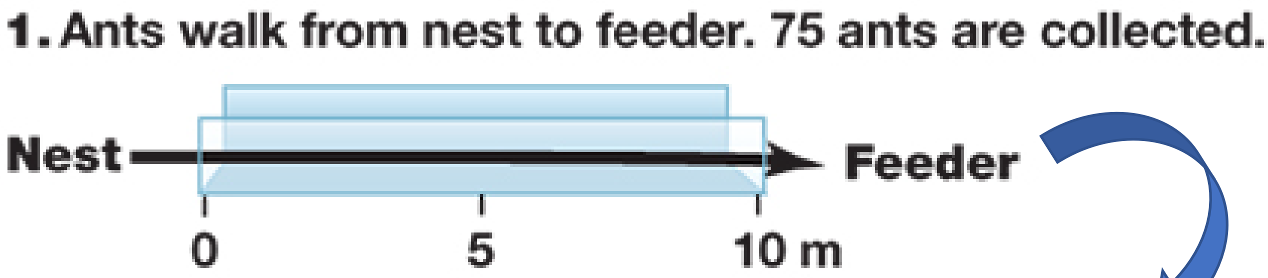
The Process of Science: Exercise 3
How do ants find their way home?



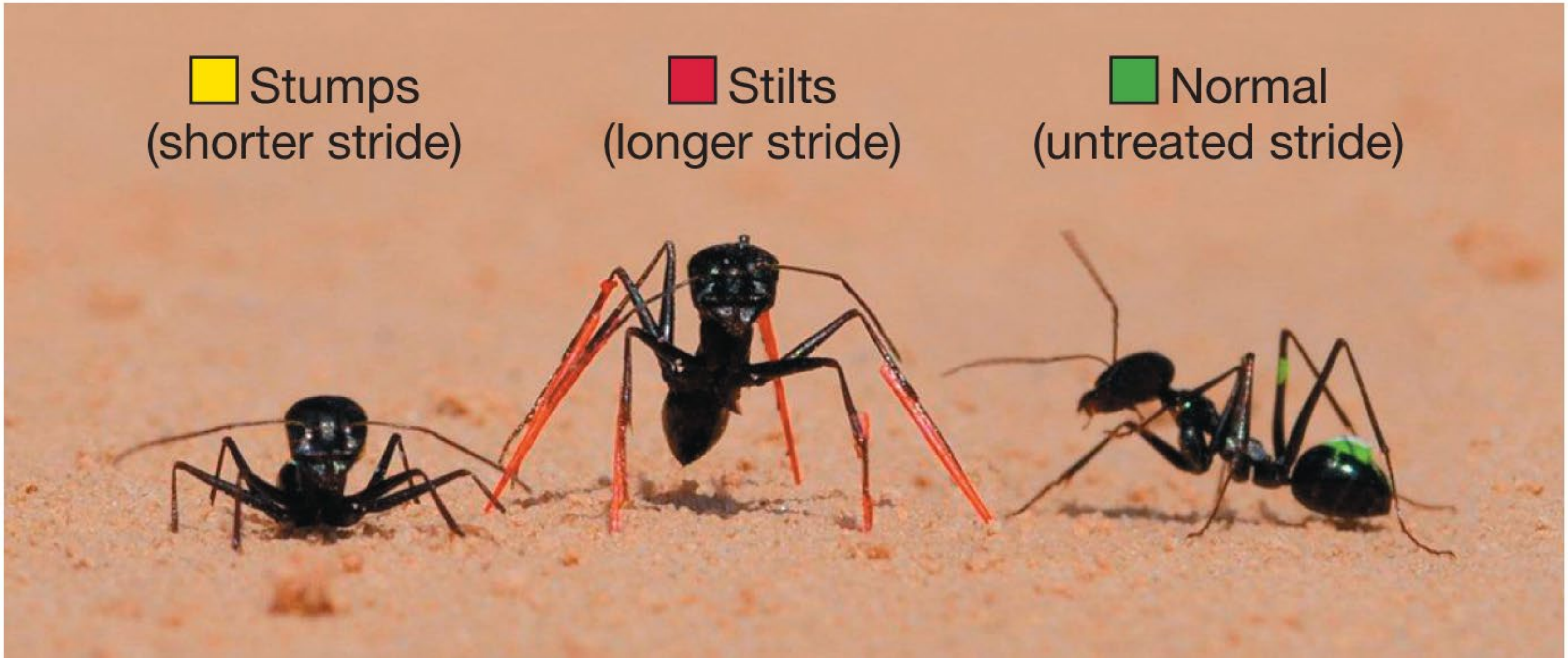
Pedometer hypothesis:

- Ants always know how far they are from the nest because they are aware of their stride length and the number of steps taken.

The Process of Science: Exercise 3
How do ants find their way home?



2. Legs modified



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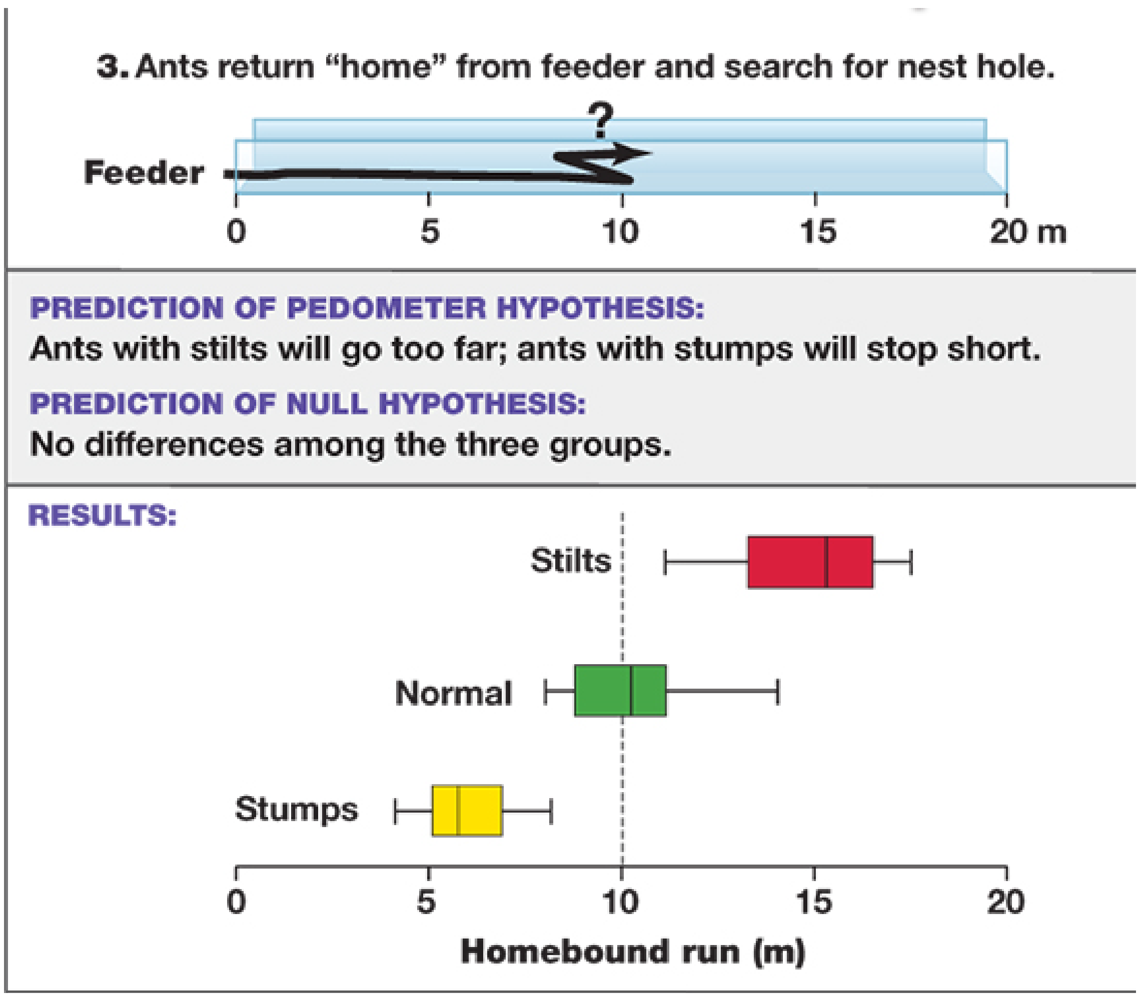
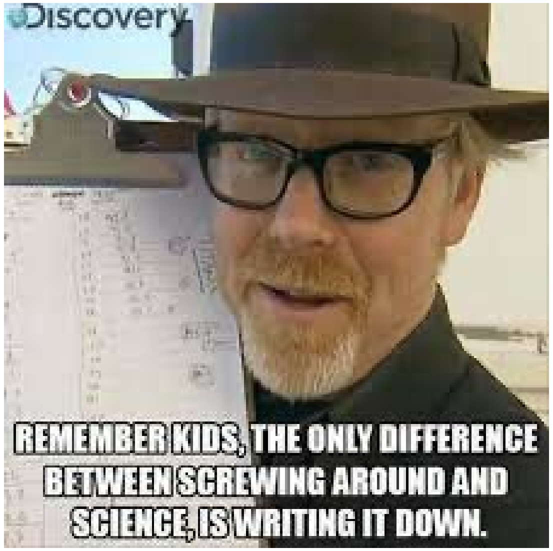


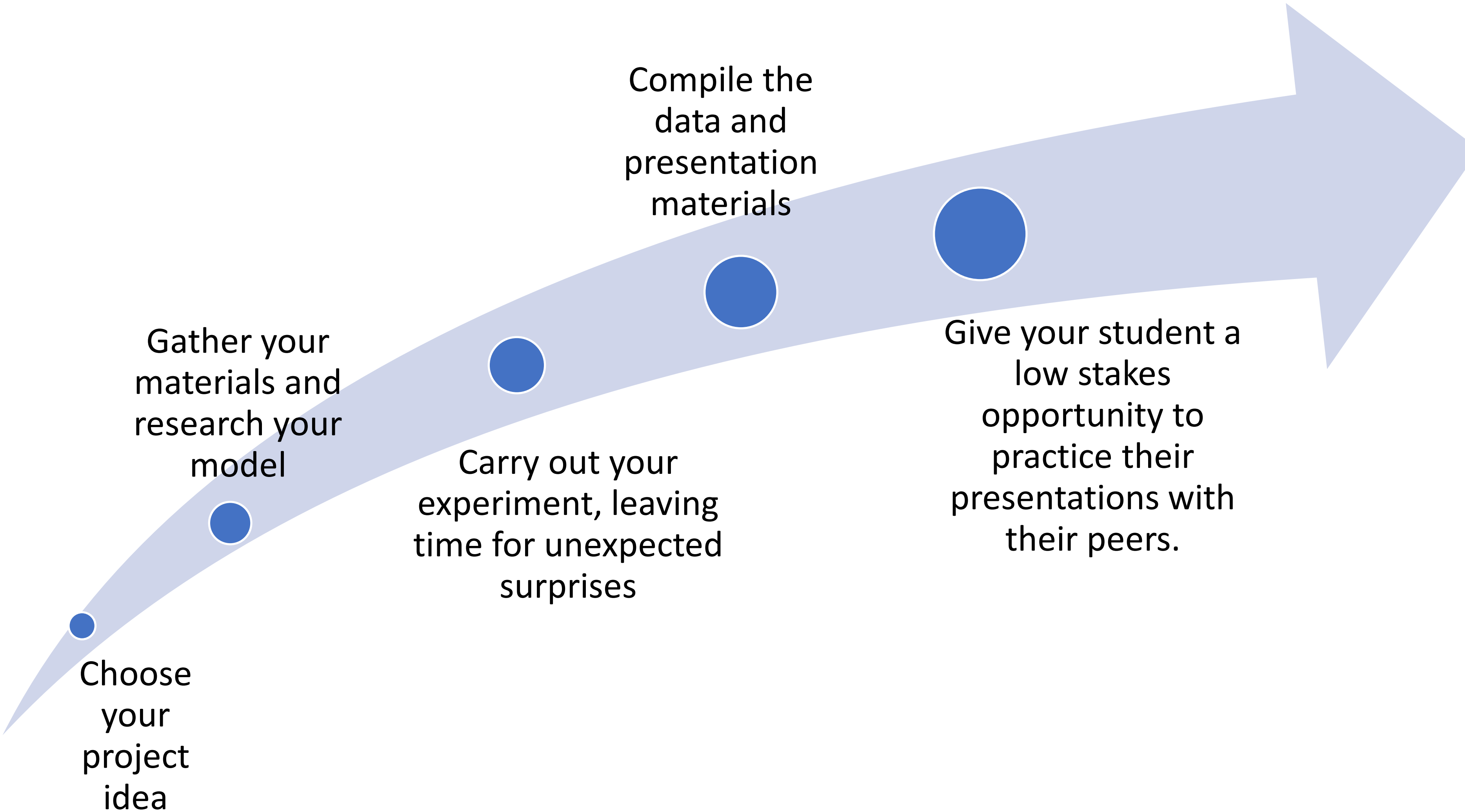
- What is the control?
- What is the dependent variable?
- What is the independent variable?
- What are experimental constants?
- What is the conclusion for this experiment?

One Last Note About Carrying Out The Scientific Method



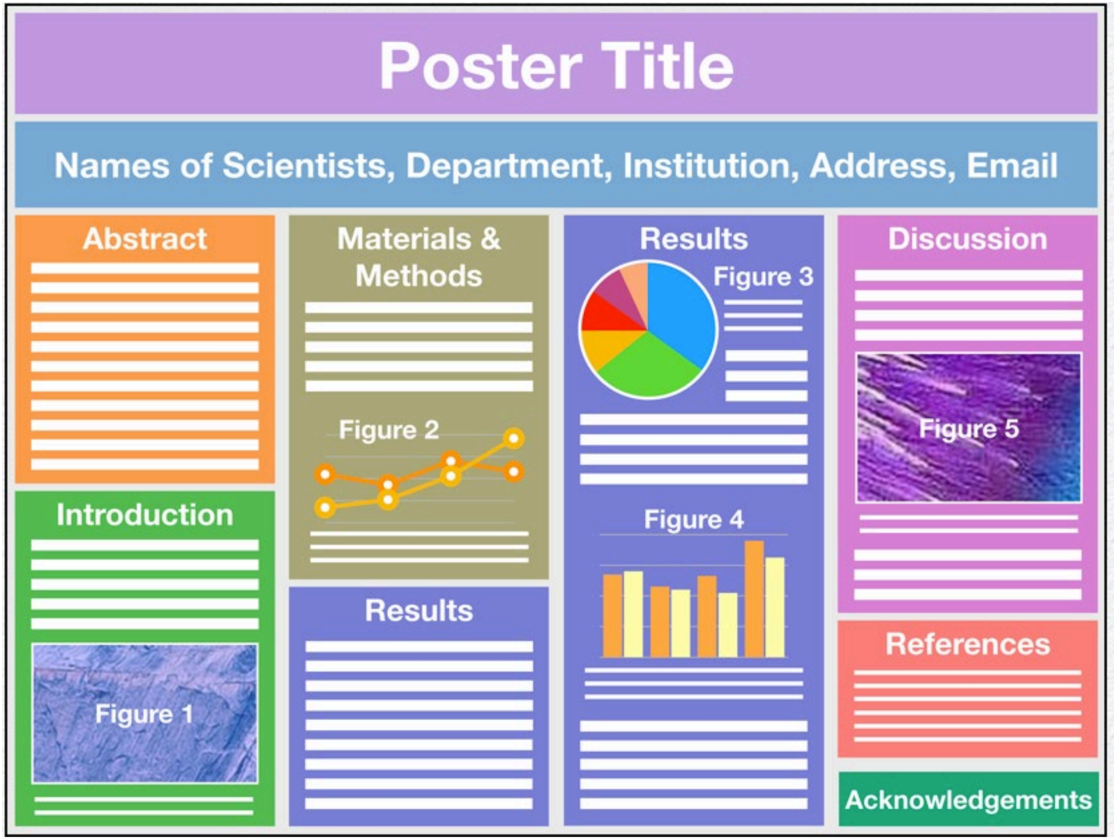
- Encourage students to document everything they do.
  - Write out each step of the scientific method
  - Diagram the plan for the experiment
  - Keep organized observations and data tables
- Allow laboratory notebooks to be an accurate record of the research conducted
  - Again, it's okay for there to be mistakes and failed attempts. That's real science!

Plan Early and Research Your Potential Limitations



Tips for a Successful Presentation

1. Organize the poster in the order of the scientific method
2. Clearly label the steps of the scientific method and the key components.
3. The more organized the poster is, the better flow of the presentation.
4. Enthusiasm!
5. Handling questions conversationally-- It's okay to not be 100% sure about every question.



Any Questions?

jgifford@uh.edu