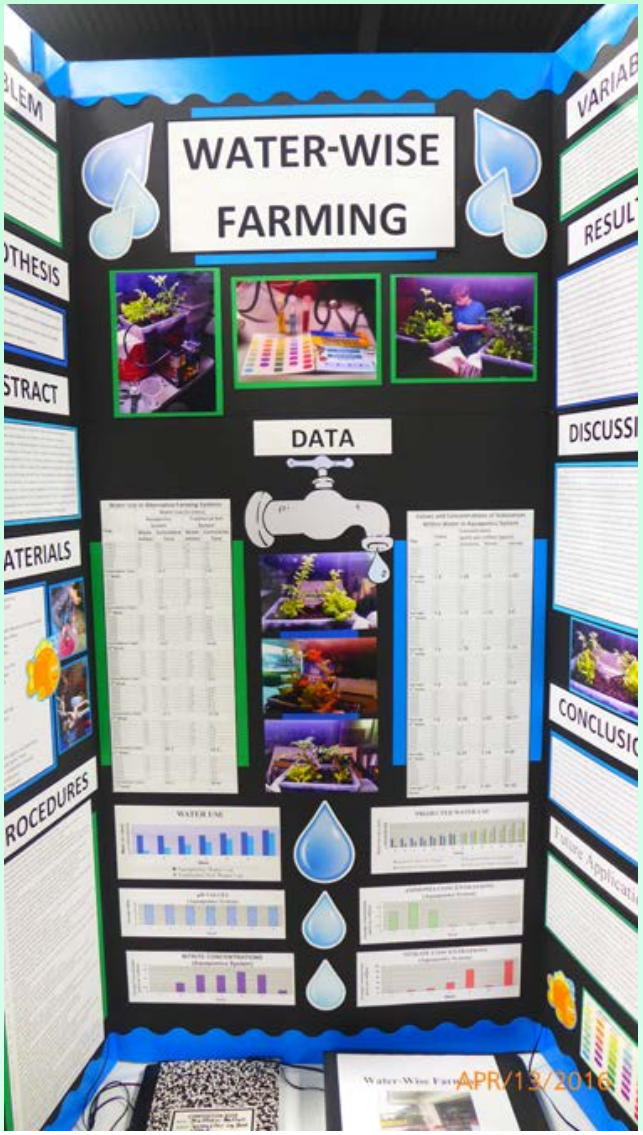
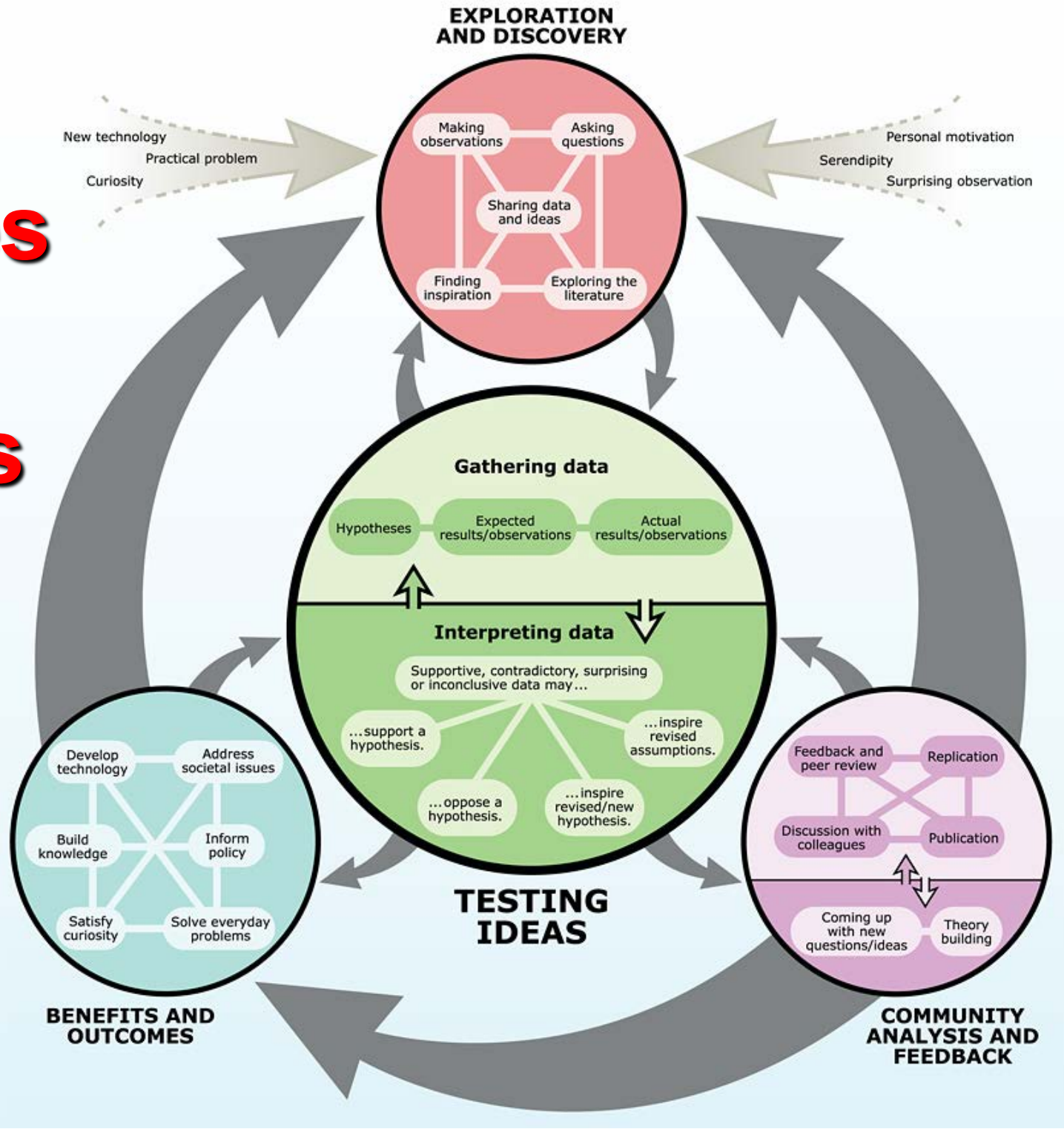
Designing a Research Project



Science Processes & Practices

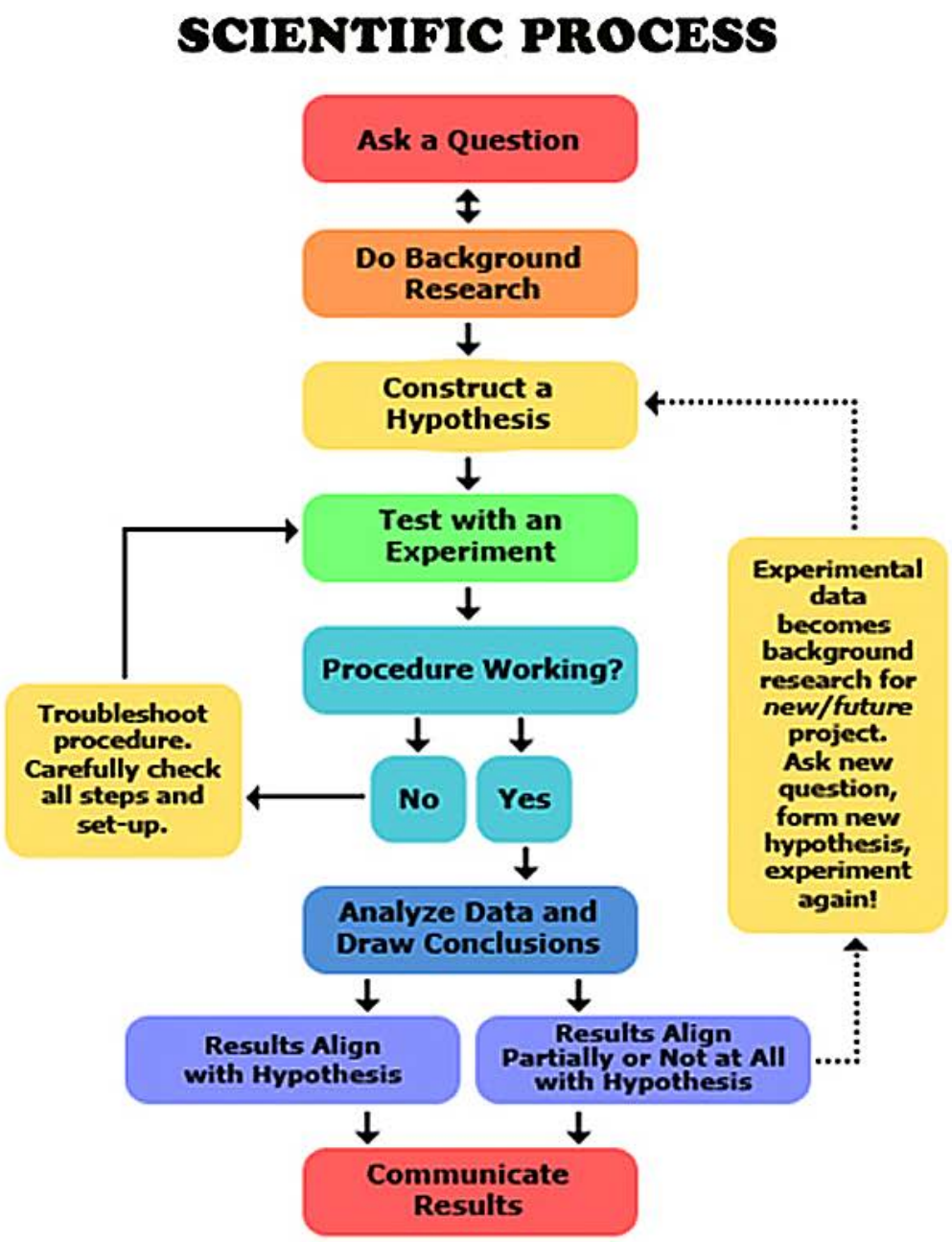
A flexible framework that guides the study of nature.

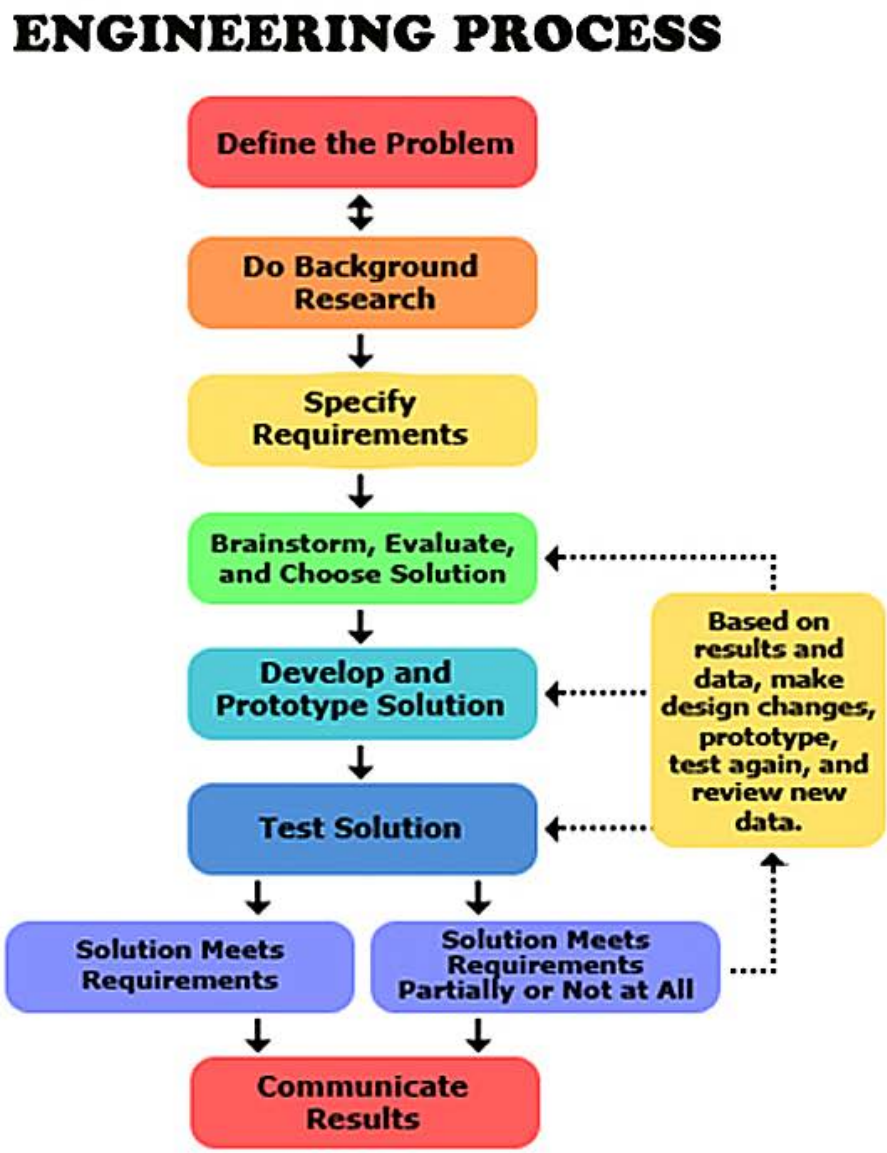


Engineering Design Processes

- **Define the Problem.** **What** is the problem/need and **Why** is it important to solve?
- **Do Background Research:** two major areas: users/customers and existing solutions
- **Specify Requirements**: analyze a similar, existing product
- **Brainstorm Solutions:** generate many possible solutions
- **Choose the Best Solution:** which best meets your design requirements?
- **Develop the Solution:** refine and improvement of a solution
- **Build a Prototype**: Allows the designers to test how the solution will work.
- **Test and Redesign**: test new solutions before settling on a final design.
- **Communicate Results**: in final report, display board.

Comparing Design Processes





Engineering: Specify Requirements

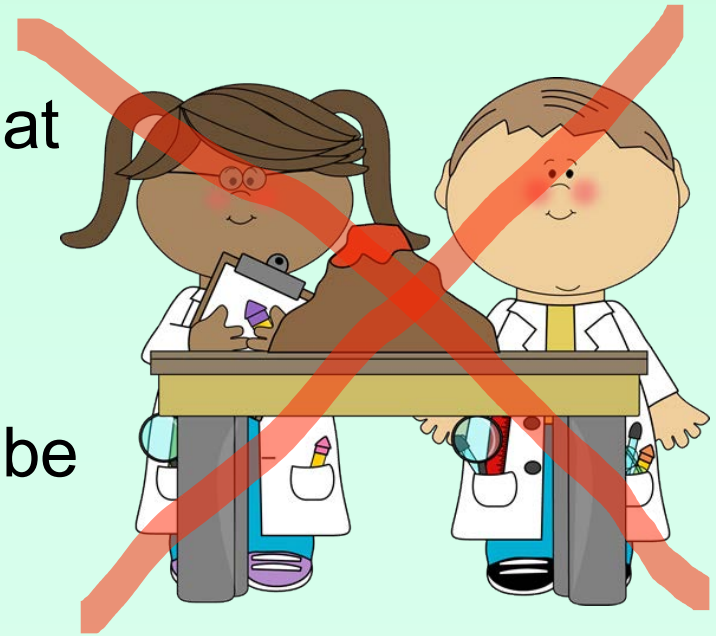
- What **important characteristics** that your solution must meet to succeed?
  - Compare **YOUR idea** with existing similar designs
  - What are their **key features**?
  - Will the cost **justify** the invention or re-design?
  - Do you need to work in a team for **safety**?

Experimental Design

- ***You <u>cannot</u> BEGIN your research until you receive Science Review Committee (SRC) approval.***
- Projects that *do not demonstrate use of the Scientific and Engineering practices* are **not eligible** to compete in the OCSEF Fair.

No Simulations…

- The construction of a volcano that **simply simulates the process** of an eruption is **NOT** a science or engineering project involving experimentation.
  - If the student **predicted** that certain types of magma chambers caused specific types of eruptions and **constructed models to test this hypothesis**, *this* would be a valid research project.
  - If the student **designed sensors** that could predict when a volcano was likely to erupt and constructed a volcano model to **test how a prototype would work**, *this* would be a valid engineering design project.



Pill Bug Science Inquiry Project

1. Demonstrates **experimental design** principles and **Science & Engineering practices**

*** ***Remember, a valid science project is not just a summary of another person's research.***

Ask a Question (science) or Define a Problem (engineering)

- **A creative process**

Ex: *Where do pill bugs prefer to live?*

More Specific:

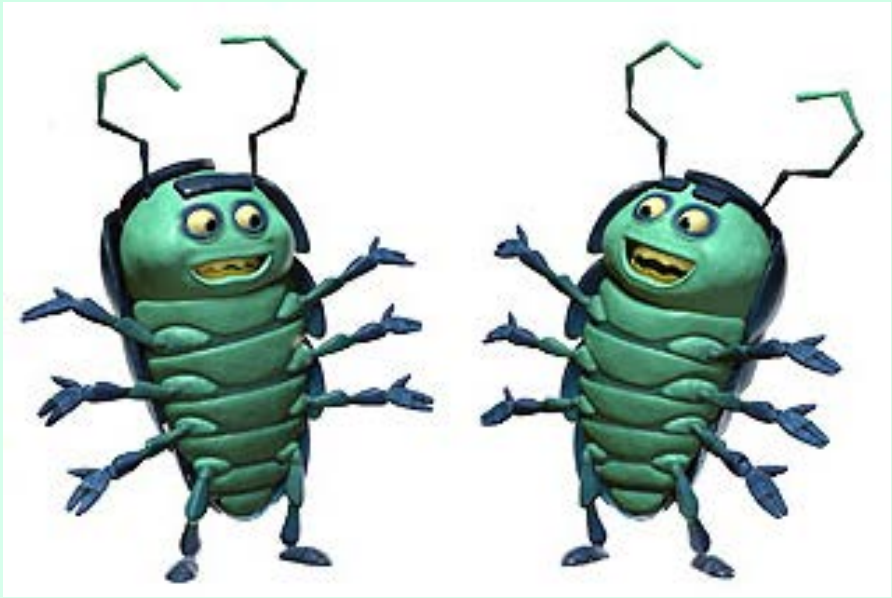
"What is the Effect of Different <u>Substrates</u> on Pillbug Habitat Selection?"

Science: Create a Hypothesis

- **Must be testable**
  - **Does it show Cause & Effect?**
  - ***If*** *Pillbugs prefer the natural humus chamber,* ***then*** *they will stay there at least 80% of the time after the first 10 minutes of experimentation.*
  - **It is objective?**
  - **Is it CLEAR?**

Background Research

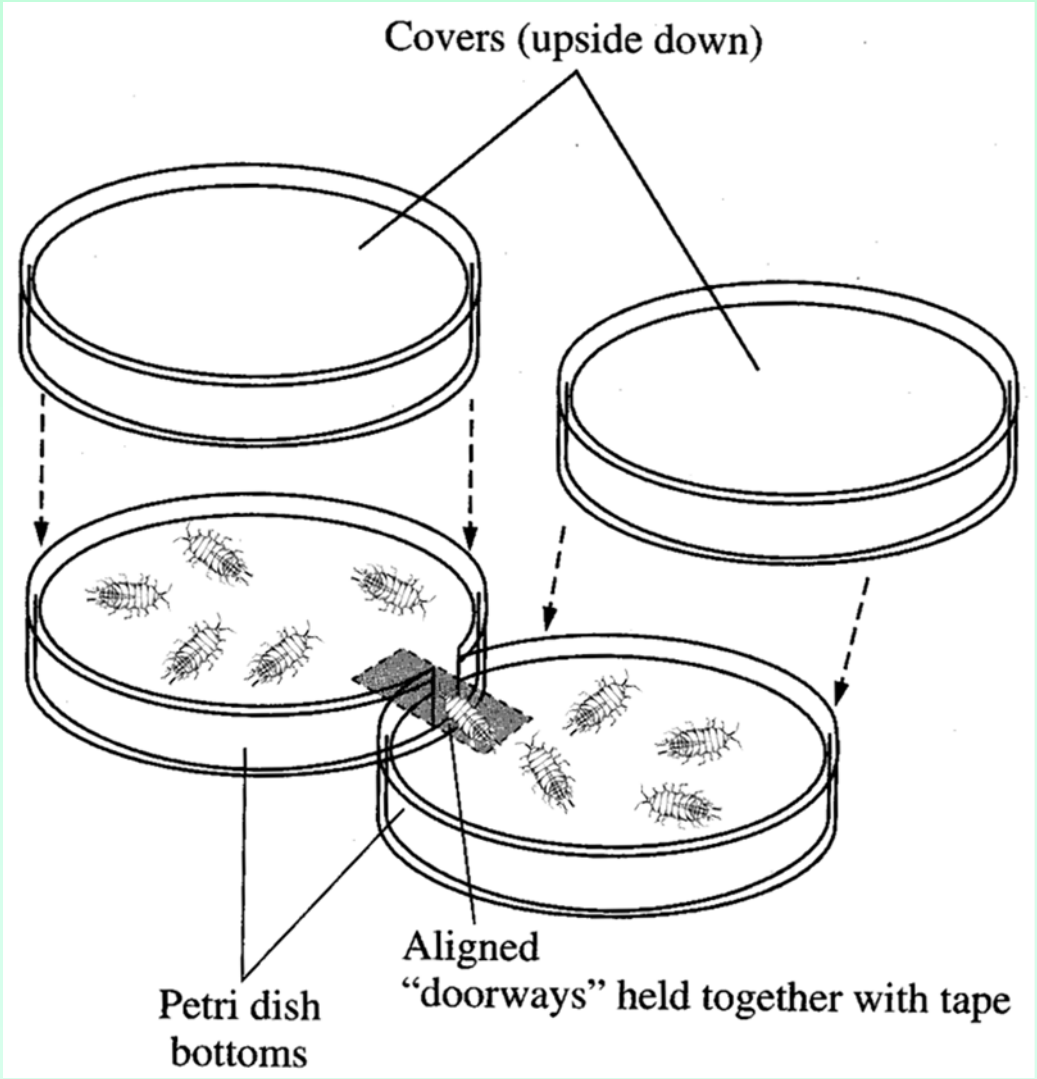
- Before generating a **hypothesis or proposed engineering solution:**
  - ***Conduct background research*** *to <u>understand</u> the scope of the study/design.*
  - *Helps to determine possible* ***dependent*** *and* ***independent variables***



Beginning Experimental Design

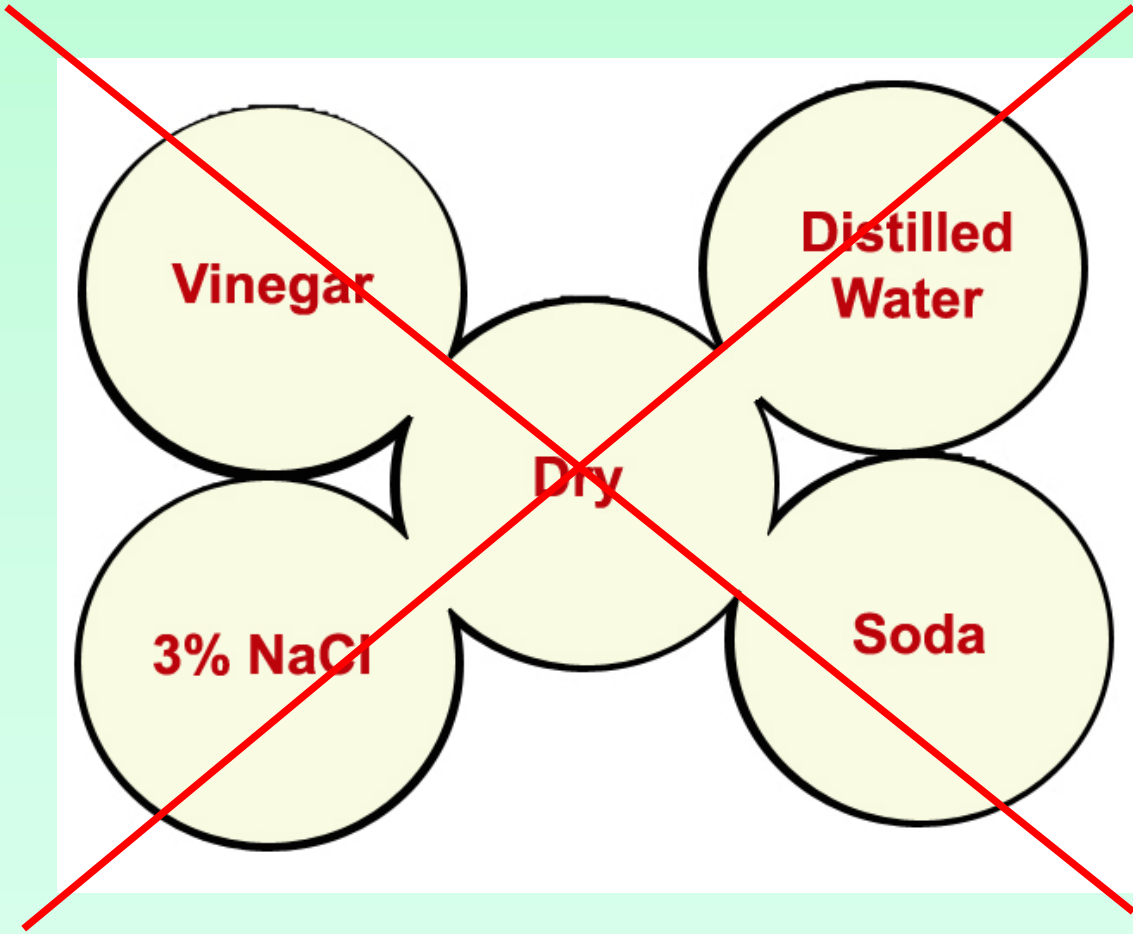
Ideas for **preferences to test:**

- *temperature*
- *moisture*
- *salinity*
- *pH*
- *food*
- *light sensitivity*
- *substrate*
- *light wavelength*



Dealing with Variables

- **Which variable** will you test?
- Test only **ONE variable** at a time



Too many variables!!!!
What are they???

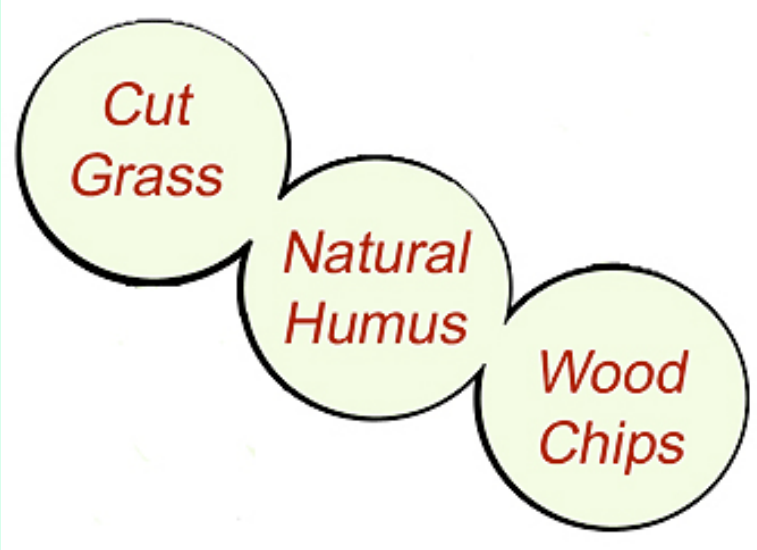
Define the Variables

- **Define the Independent Variable(s)**
  - *Time in habitat chamber*

- **Define the Dependent Variable(s)**
  - *Type of substrate*

Creating an ExD (science)

- **Define the Experimental Group(s)**
  - *Cut grass, wood chips*
- **Define the Control Group**
  - For comparative sets of data
  - *For behavioral studies, compare with known behavior in the wild*



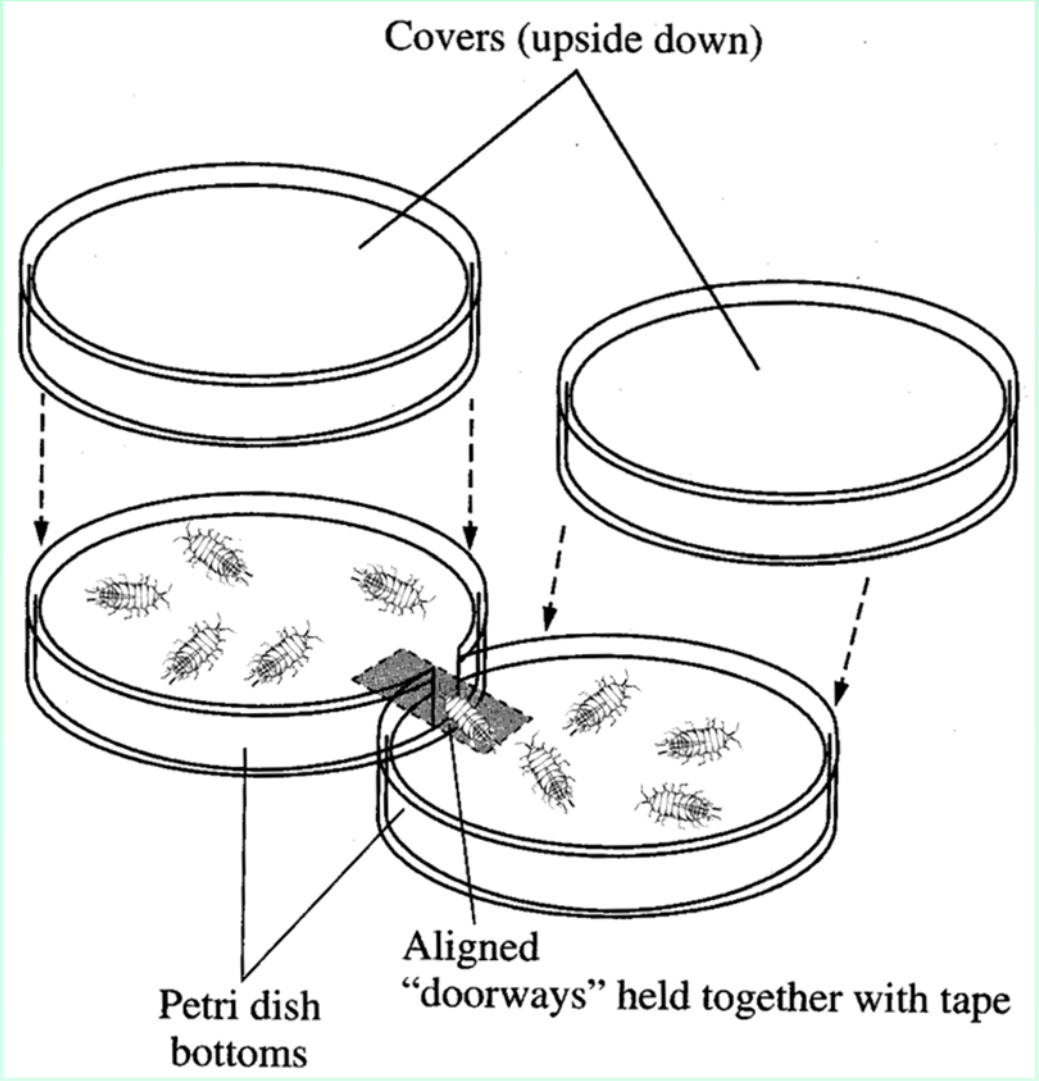
Creating an ExD

- Determine the **number of trials or groups** needed for validity
  - *10 pillbugs/chamber*
  - *10 trials*
- Determine **how** the results will be **quantified**
  - *# of pillbugs/ chamber/time increment*

Design the Study

- Provide ***AT LEAST 10*** replicates or organisms per experimental group

- Decide **how** to keep other variables that may affect your data **constant**



Write Up the Procedure

1) **Prepare a choice chamber**
2) **Cover the bottom** of each chamber with either wood chips, cut grass or natural humus
3) **Transfer ten pillbugs** from the stock culture into each choice chamber
4) **Cover** the chambers

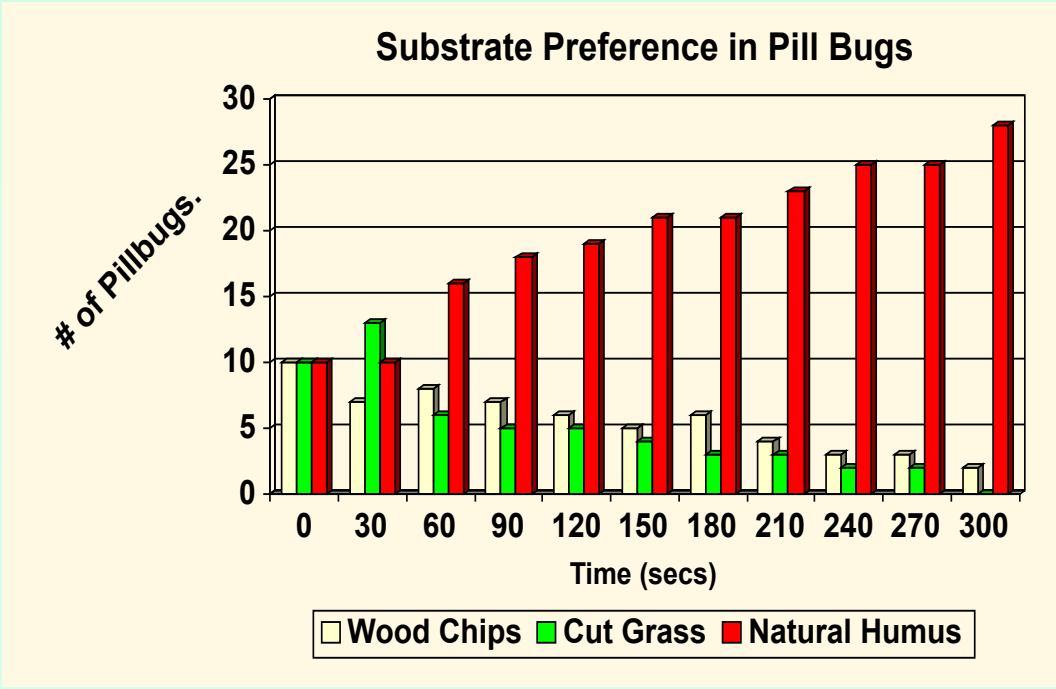
Write Up the Procedure

5) **Count and record** how many pillbugs are in each chamber every 30 (or 10, 20) seconds for I0 - 30 minutes

Substrate Type	*# of Pillbugs/Chamber*										
Wood Chips	10	7	8	7	6	5	6	4	3	3	2
Cut Grass	10	13	6	5	5	4	3	3	2	2	0
Natural Humus	10	10	16	18	19	21	21	23	25	25	28
	Time (in secs)										
	0	30	60	90	120	150	180	210	240	270	300

Run the Experiment

- **Quantitatively** summarize data
  - **Choose a Graph** to visualize the number of pillbugs in experimental and control chambers per 30 second interval.
  - **Analyze** the trend

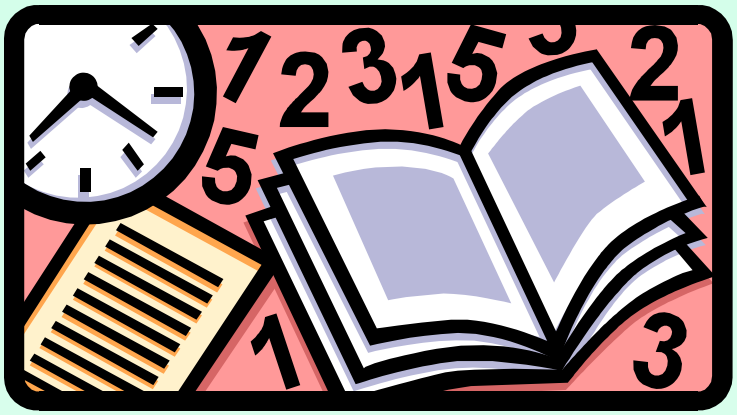


Analyze The Results

- **Interpret statistics** properly
  - ***DON'T*** make broad statements from small samples

Not: This experiment proves that pillbugs prefer pine needles as a substrate

Instead: *The results show that pillbugs seem to prefer pine needles as a substrate)*

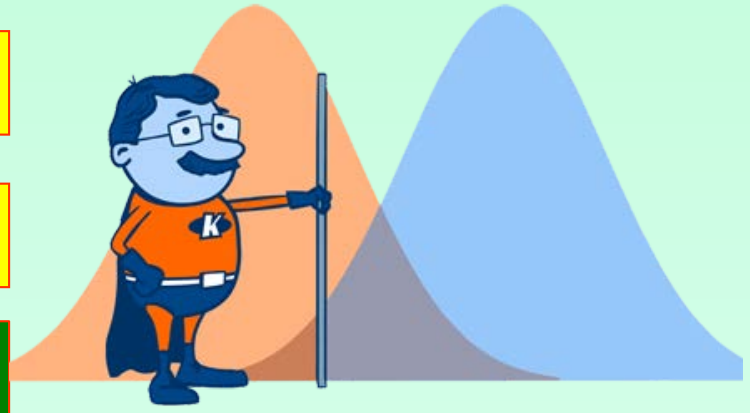


Analyze The Results

- **Compare data** with other groups
- Analyze the **trends**
- Address **errors**
- Look at all **alternative interpretations**

Objectively Analyze Data

- Common Statistics
  - Mean (Average) — Jr. Div.
  - % Error — Jr. Div.
  - Standard Deviation — Jr. Div.
  - Chi Square — Sr. Div.
  - T-tests — Sr. Div.
  - Diversity Indices — Sr. Div.
  - *<u>Any</u> statistical tests appropriate to your grade level*



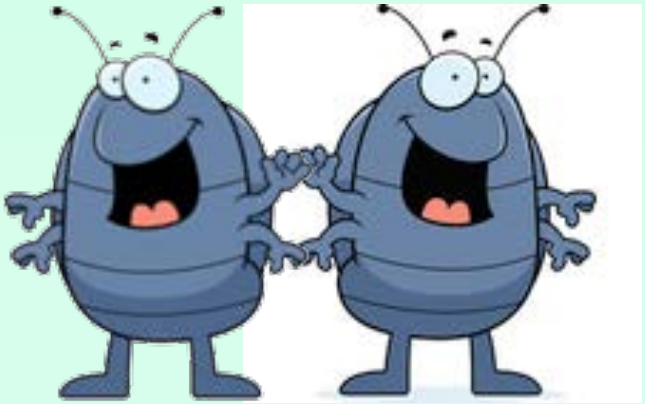
***See PPT on "Statistics" for details**

Come to a Conclusion

- **Validate** the hypothesis
  - Decide whether your data fits your hypothesis/problem or whether you need further testing and revision.
- Engineering: Solution consensus

Retest, Review, Refine

- ***Re-test***
- **Peer Review**
- **Refine** the experiment/engineering project
  - Example: *Choose the same size pillbugs*



Report the Findings

- Team members should work **closely**
- Make **deadlines**
- **Sharing your research** with others through peer review and/or science fair judging interviews

Developed by

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Science Consultant, UCLA Science Project

For the

OCSEF Orange County Science & Engineering Fair

http://www.ocsef.org/