SCIENTIFIC METHOD

A logical and systematic problem solving process

WHAT IS SCIENCE?

A process and way of learning

Verb, not a noun. Action, not a thing.

Science allows us to test, challenge and question ideas.

SCIENTIFIC METHOD

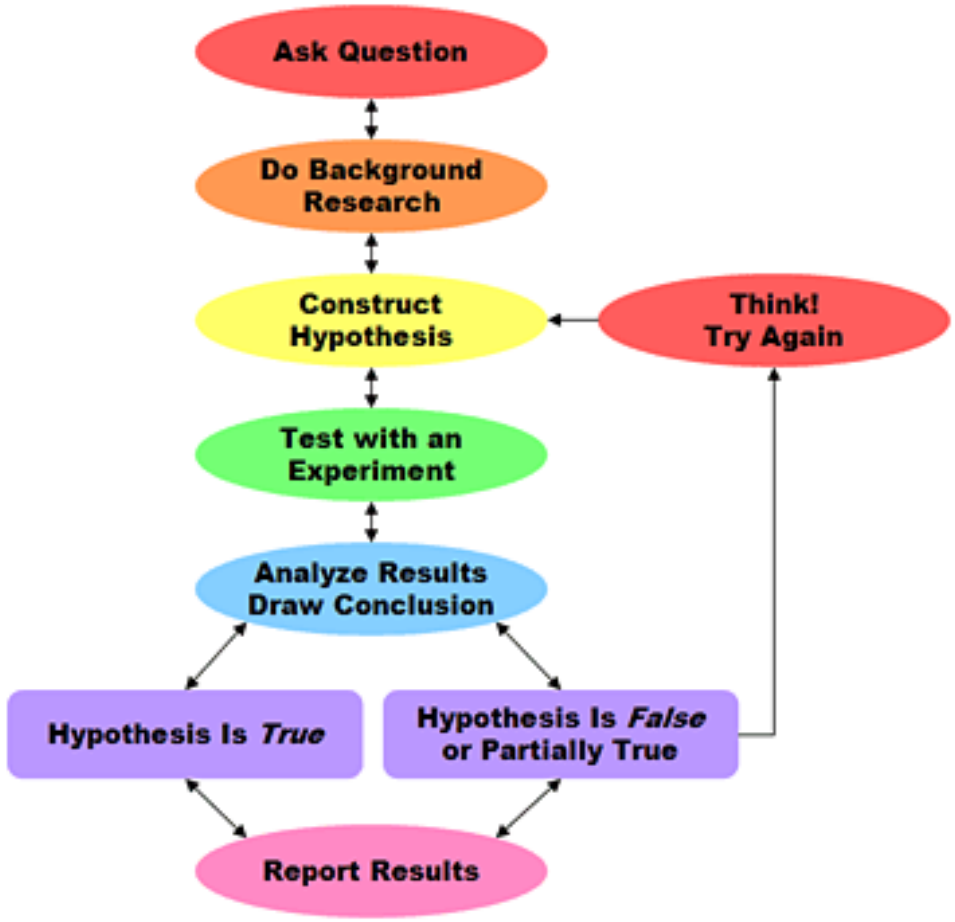
The scientific method is….

- A logical and organized series of steps to gather information *in order to answer questions about the natural world.*

SCIENTIFIC METHOD

The steps……

- Ask Question & Collect Information
- Form a Hypothesis
- Test the Hypothesis / Perform Experiment
- Collect, Record & Analyze Data
- Draw Conclusions and Share Findings



If needed, do more investigation!

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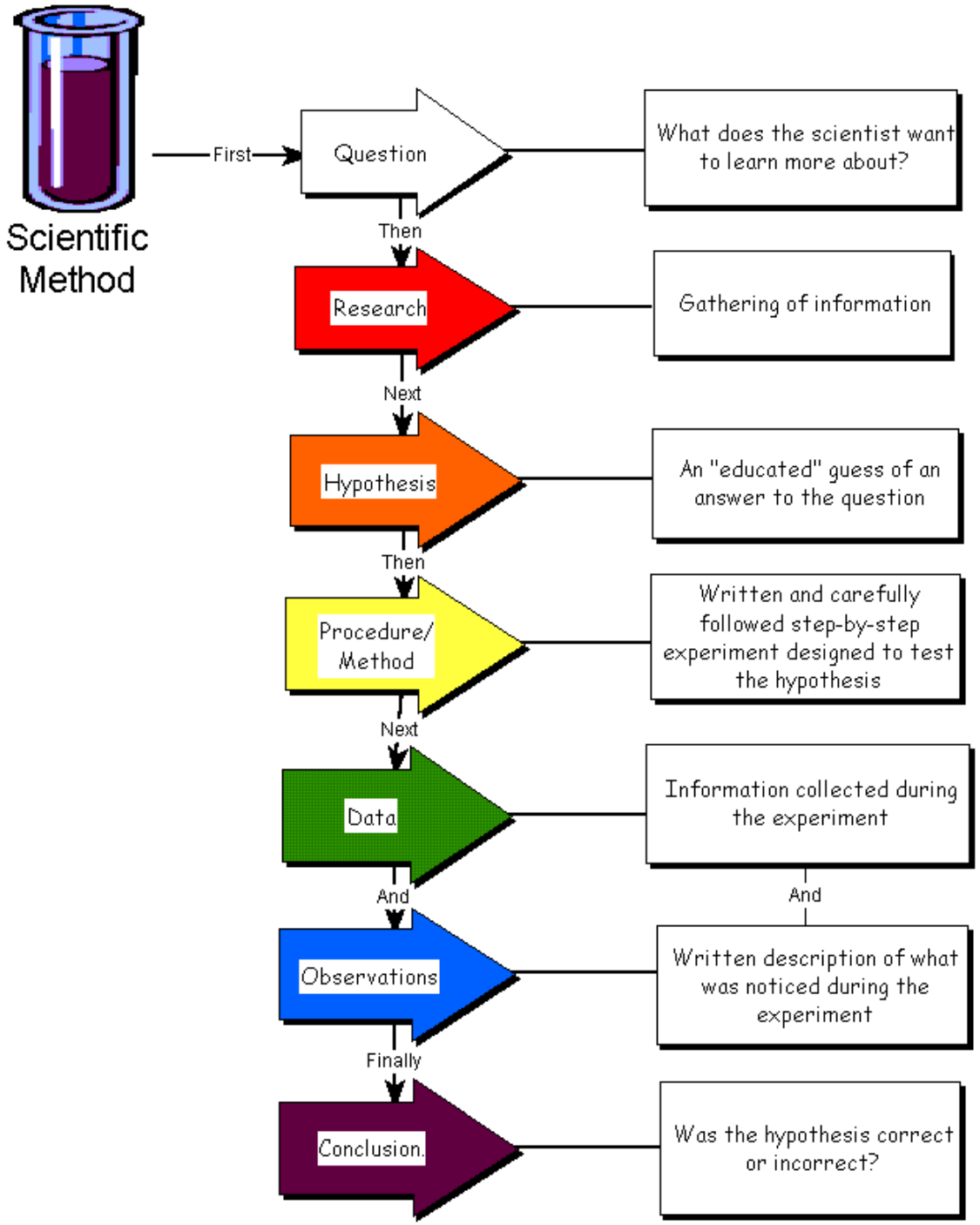
What the scientific method looks like on paper…..



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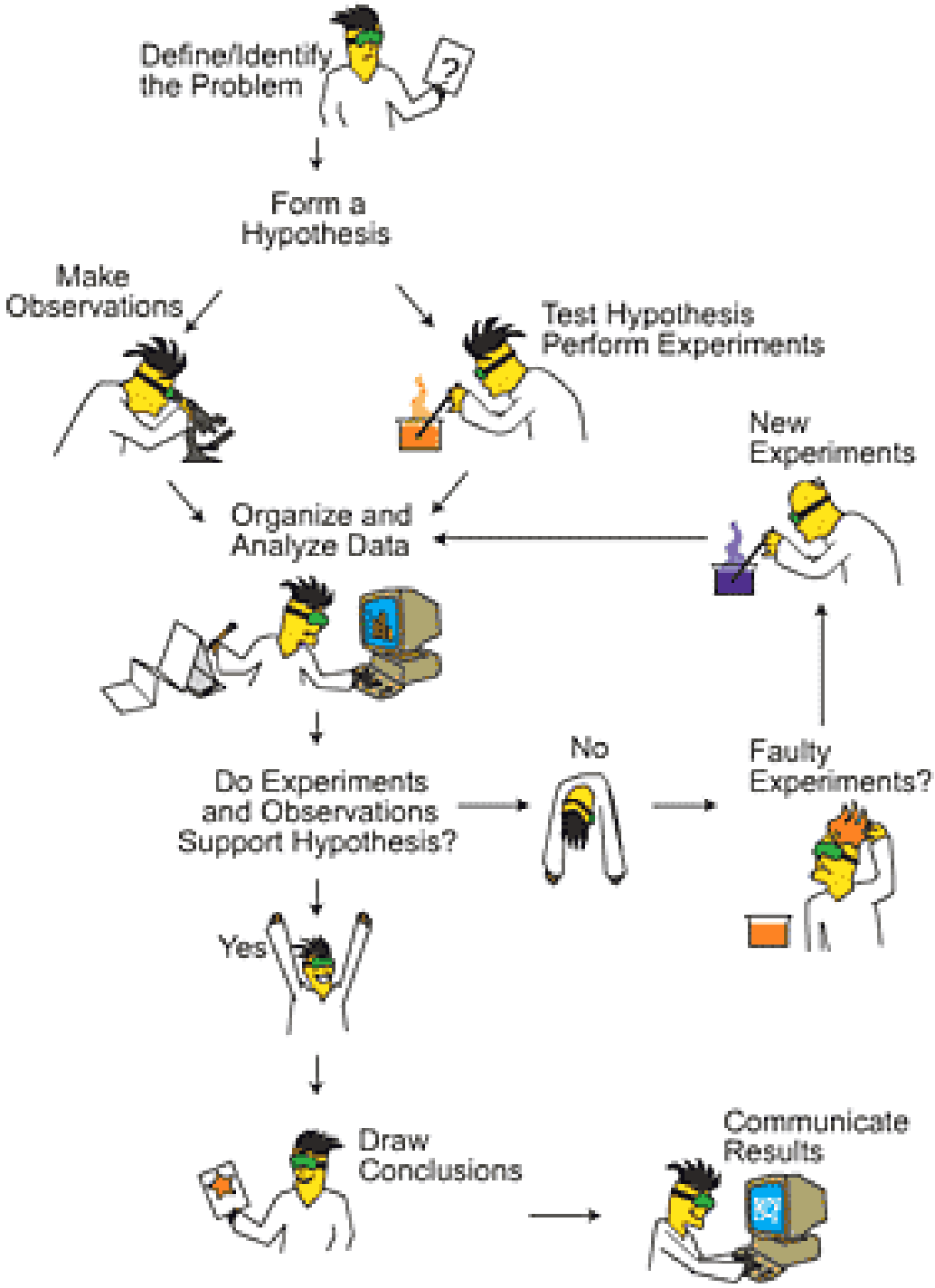
What the scientific method looks like in real life…….



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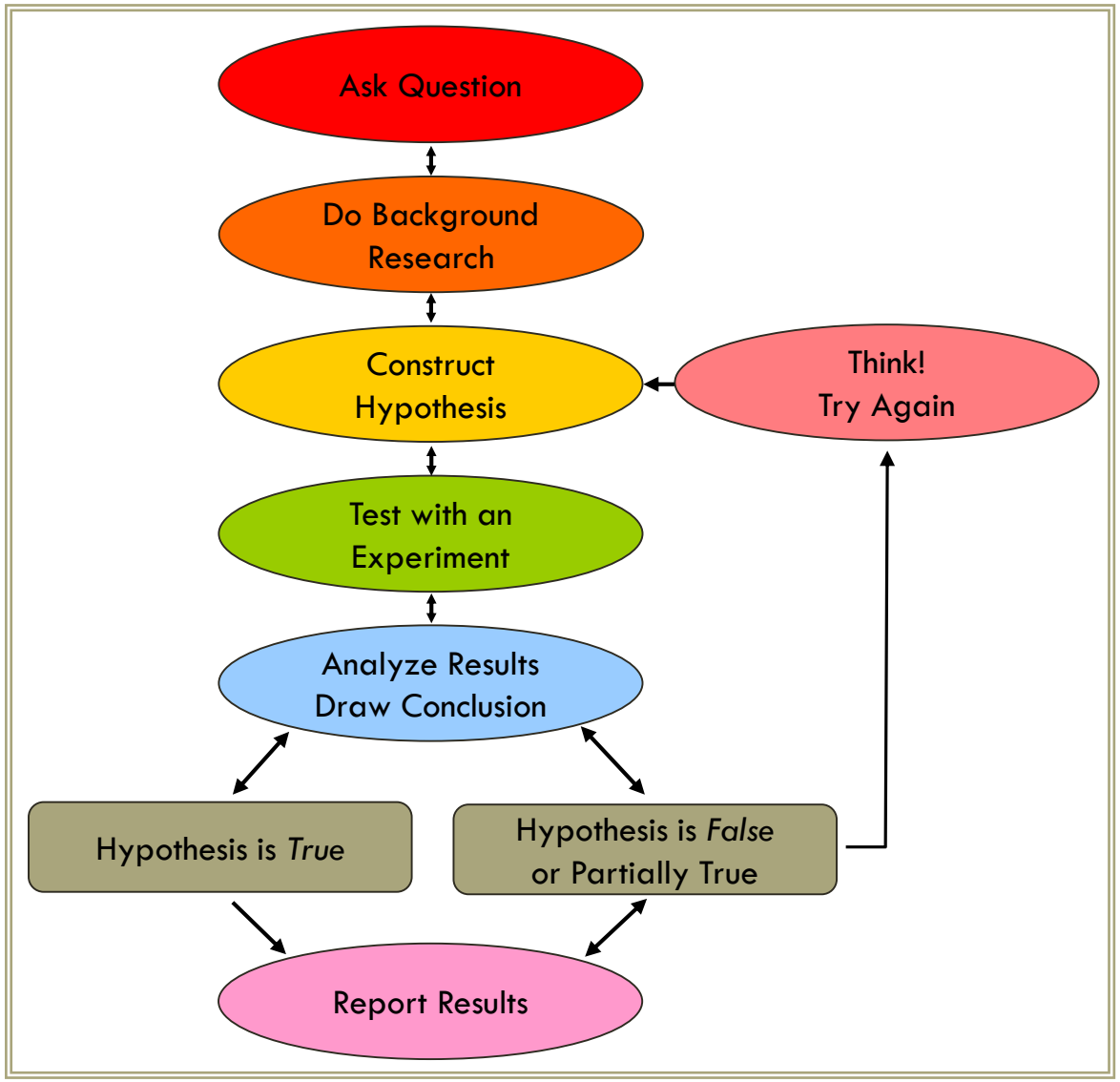
Let's break each of these steps down into their individual components:



SCIENTIFIC METHOD

An organized way of learning about the natural world

- 1. Ask a question and collect information
- 2. Form a Hypothesis
- 3. Test the Hypothesis / Experimental procedure
- 4. Collect, Record & Analyze Data
- 5. Draw conclusions & Communicate Findings

SCIENTIFIC METHOD

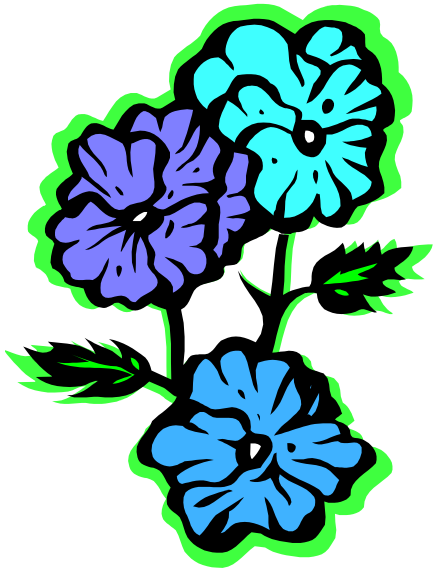
1.Ask a question and collect information

- Questions arise from scientific inquiry
  - Inquiry….thinking about something!
- Inquiry begins with observations
  - **Observation:** a direct method of gathering information
- The processing of information leads to inferences
  - **Inference:** logical conclusions drawn from previously collected information (observations)

SCIENTIFIC METHOD

1. Ask a question and collect information

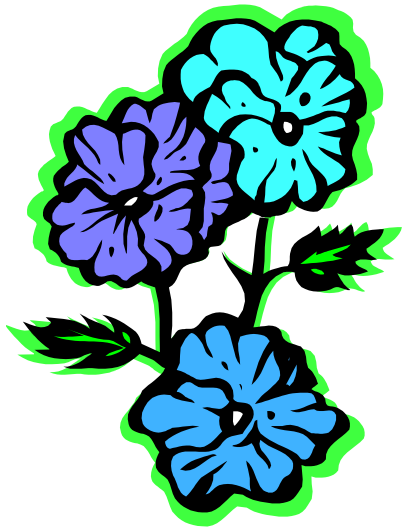
- So why ask questions? To learn something!
- What if you observe that your neighbors flowers grow much better than your flowers…
  - Observations: taller, fuller, more fragrant, more brightly colored
  - Inference: *your neighbor must take better care of their flowers.*



SCIENTIFIC METHOD

1.Ask a question and collect information

- These observations and inferences lead us to ***ask questions and collect information…***
  - What must I do in order for my flowers to grow better?
  - Then you begin collecting background information on gardening and your ready to form your hypothesis!



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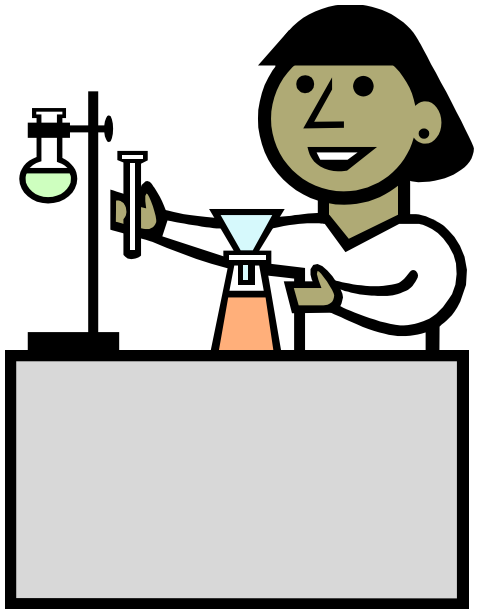
SCIENTIFIC METHOD

2.Formation of a hypothesis

- A scientific and ***testable*** explanation based on observations and collected information
- So basically, an inference!
- Typically written in "If……then……" format
  - If I do this, then this will happen.
  - If I put fertilizer on my plants, then they will grow bigger



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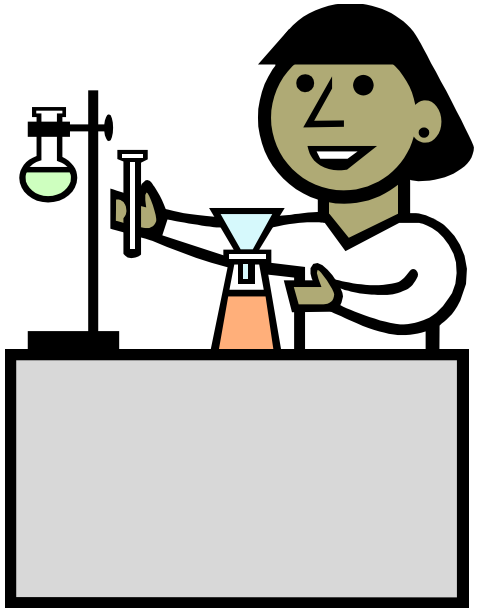
2.Formation of a hypothesis

- **Why form a hypothesis?**
- The support or rejection of a hypothesis determines the validity of an experiment
  - If the data *supports* the hypothesis: the investigation is accepted as valid
  - If the data *rejects* the hypothesis: the hypothesis is rejected and additional investigations are conducted



- So is a "wrong" hypothesis still a *good* hypothesis?

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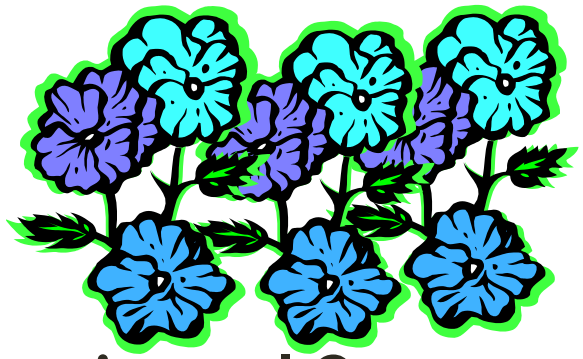
SCIENTIFIC METHOD

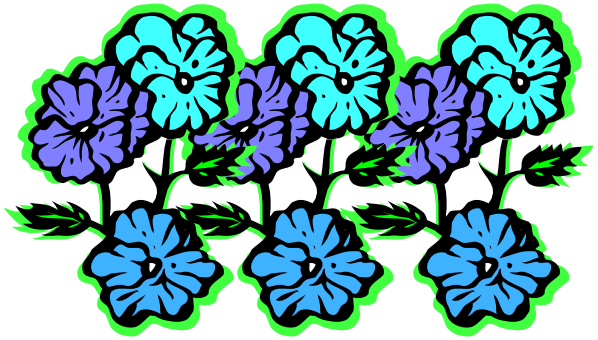
3.Experimental procedure- designed to *test the hypothesis*

Split subjects you are testing into groups:

- Experimental Group- Contains the changed variable.
- Control Group-NO changed variable. The "*comparison group*"
- Constants- other variables that remain the same in all groups.



Experimental Group
Fertilizer



Control Group
No Fertilizer

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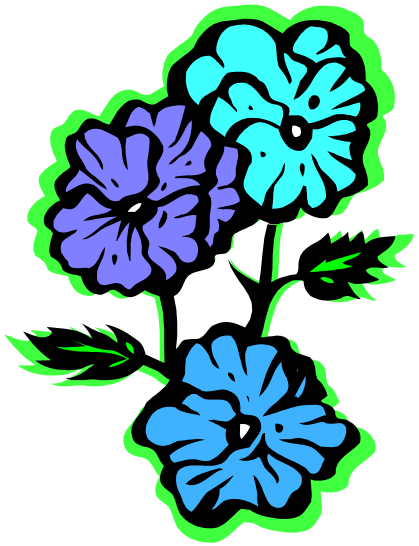
Variable-any factor in experiment that could be changed

- Fertilizer, sunlight, water, etc

- Independent variable- factor in experiment that is *changed* by the scientist
  - fertilizer
- Dependant variable - factor that is *measured* by the scientist
  - height and ?



Remember, only test ONE manipulated variable at a time, everything else should remain constant!

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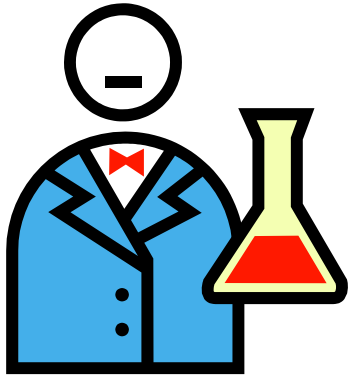
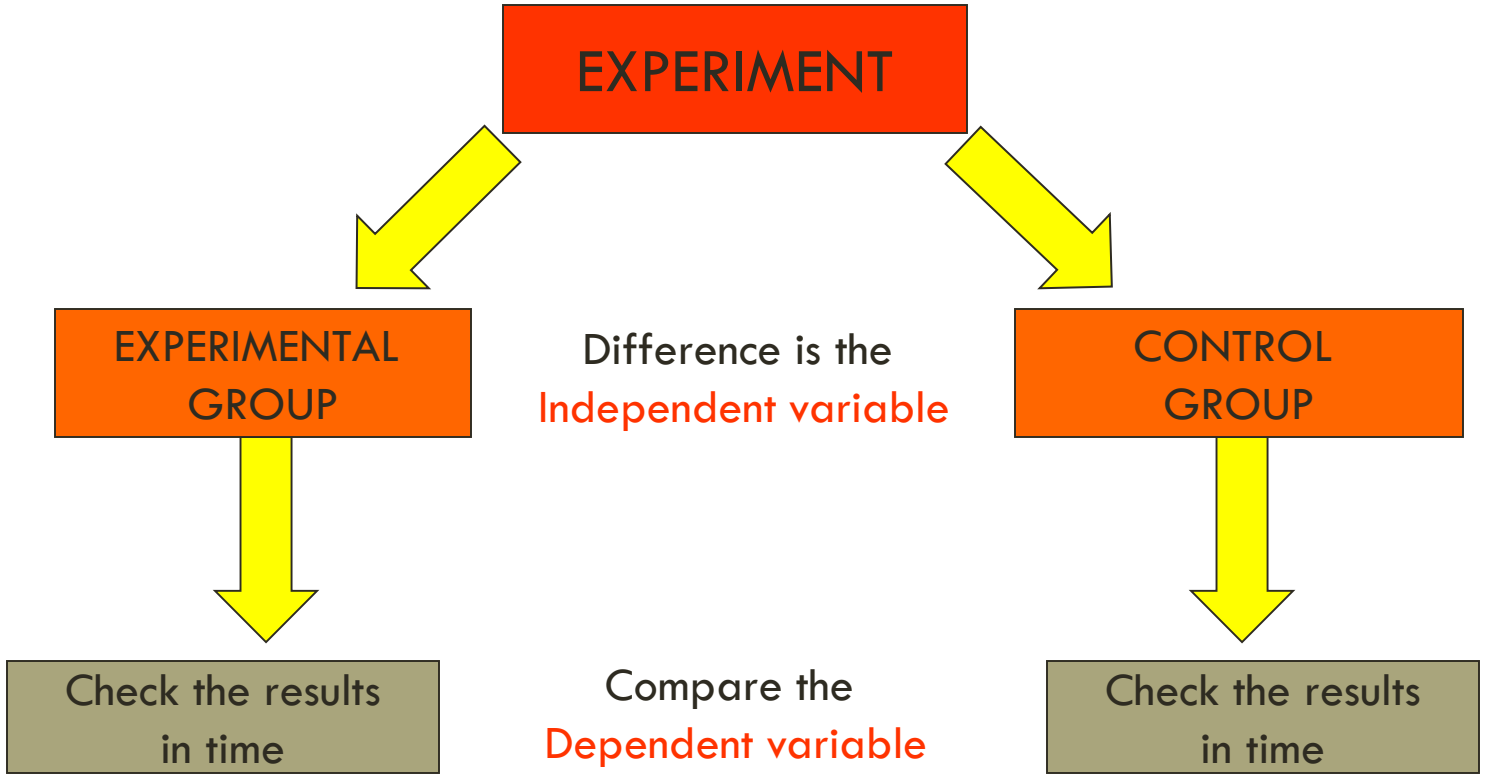


Must be a controlled, reproducible procedure

Testing effects of only ONE manipulated variable

Other scientists need to be able to reproduce it and find same results.

EXPERIMENTAL SET UP



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4. Collect and record data

- As scientists test their hypotheses, they gather data.
  - Data – information gained from observations.
- Data can be qualitative or quantitative
  - Qualitative data -physical traits (qualities) that can be described
  - Quantitative data -measurements (quantities) that can be taken

SCIENTIFIC METHOD

4. Collect and record data

- Quantitative Data
  - Examples: time, temperature, length, mass, area, volume, density, etc
  - NUMBERS
- Qualitative Data
  - Examples: descriptions of what our senses collect.
  - Interpreted differently by different people

- Which type of data would you consider "stronger?"

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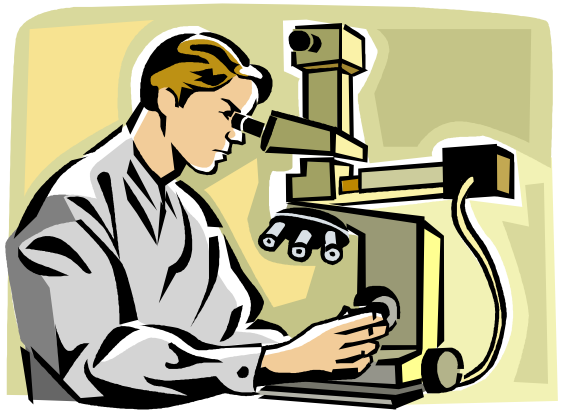
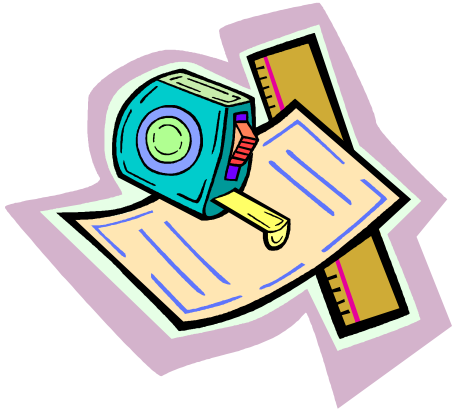
Common measurement system

- Metric system or (SI)- a measurement system used worldwide by scientists based on multiples of 10
  - Mass-grams (g)
  - Volume-liters (L)
  - Distance-meters (m)
  - Temperature- Kelvin (K) or Celsius (^{O}C)



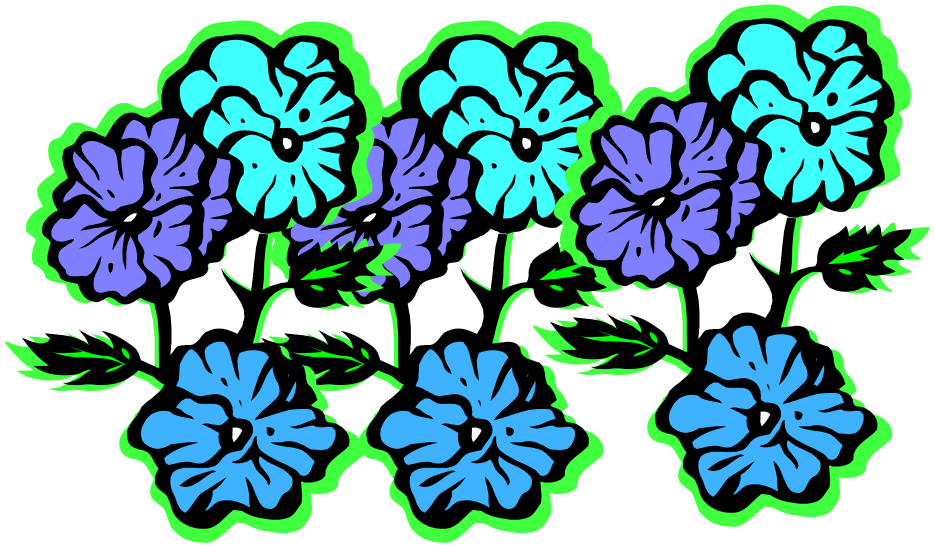


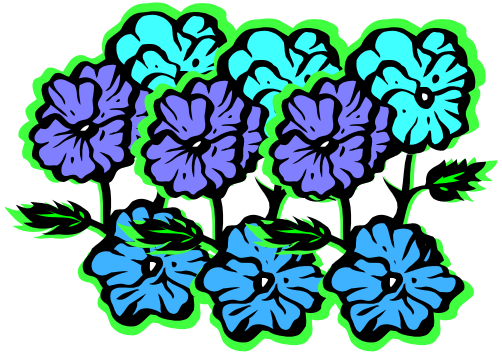
Scientific Method

Results

Qualitative?

Quantitative?





Experimental Group

fertilizer

Control Group

no fertilizer

SCIENTIFIC METHOD

4. Collect and record data

- Analyze the data and state the results
- Pictures, tables, graphs
  - Make patterns more easily visible
  - Trends noticed
- State the results
  - *Should be a summary, not a conclusion*

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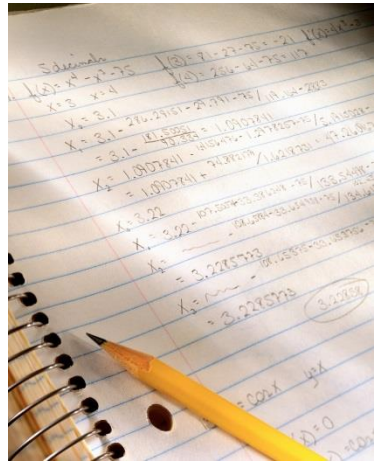
5.Conclusions

- A good conclusion…
  - Restates the results
  - Addresses the hypothesis
  - Forms a conclusion



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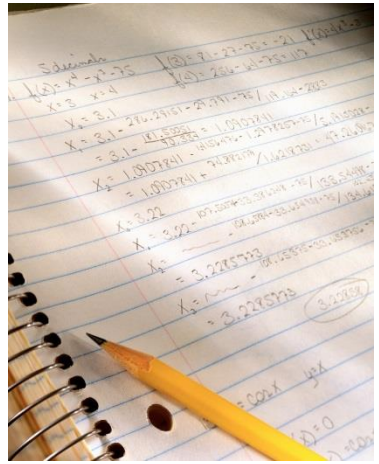
5.Conclusions

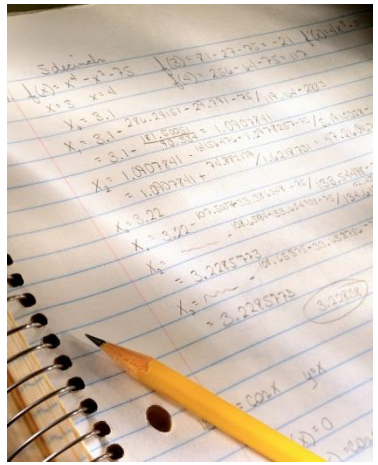
- Hypothesis is either supported or rejected. NEVER "PROVEN!"
- If supported
  - Draw conclusions, publish findings, further testing
- If rejected
  - Hypothesis is modified and tested again
- Can be partly supported
- Either way, findings are always useful!!!



SCIENTIFIC METHOD

5.Conclusions

- After you state the results, the conclusion is the "therefore…"
- Example:
  - According to the results, the flowers given fertilizer consistently grew taller and fuller; therefore, my hypothesis is supported. The use of fertilizer will lead to better growing flowers.



COMMUNICATE RESULTS

Results of experiments are communicated formally in written reports published in scientific journals.

Other scientists can analyze the design and conclusions or repeat the experiment themselves.

Repeatability is a good check on correctness of scientific conclusions.

NOW LET'S PRACTICE!