# Scientific Investigation
## (Formal Outline Notes)

I. Scientific investigation | **scientific method:** a systematic (organized) approach to answering the unknown, solving a problem, or improving something; *flexible*

II. Components of an Investigation
- **A. Problem** | Purpose | Question | Objective | Goal | Inquiry
- **B. Research** | Background
- **C. Hypothesis** | Prediction
- **D. Procedure** | Experiment | Method | Protocol
- **E. Results** | Data | Observations
- **F. Analysis**
- **G. Conclusion** | Inference
- **H. Communication**
- **I. Future Work(s)**
- **J. Application**

III. **Problem**: a statement identifying what you want to learn or discover

IV. **Research**: information **selectively** gathered about a topic from books, professional **STEM** journals, professional **STEM** magazines, the Internet, encyclopedias, agencies, interviews w/ an **expert** on the subject, documentaries, etc.; **DO NOT USE WIKIPEDIA**

V. **Hypothesis**:

A. Characteristics
1. An educated guess
2. A possible solution (answer) to an inquiry (question)
3. A prediction based on the research
4. Based on the best possible information researched at that time
5. Must tell how the independent variable affects the dependent variable
6. Must be testable
7. May or may not be supported by the results of an experimentation
8. Format:
   a. Can be stated as an "If…, then…" statement
   b. Can be stated as a simple declarative statement
   c. Can be stated as a question
   d. Do **NOT** begin a hypothesis statement with "I believe…" nor "I think…"

VI. **Procedure**: activity(s) used to test a hypothesis

A. Components of an Experiment
1. Control setup | control group *(if animals are being used in the experiment)*
   a. Reproduces (shows) the normal condition
   b. Serves as a **standard for comparison** | **norm**
   c. Focuses **mainly** on the dependent variable
2. Experimental setup | experimental group *(if animals are being used in the experiment)*
   a. Where experimentation actually takes place
   b. The **test part** of the experiment
   c. Focuses on **both** independent and dependent variables

B. Key terms

"Cause"

1. Independent variable | manipulated variable | variable | test variable: the factor that is being **tested**; it actually affects the experiment by its **influence** on the dependent variable; technically found only in the experimental setup in some experiments

"Effect"

2. Dependent variable | responding variable: the factor that is being **measured**; **affected** by the independent variable
3. Control variables | constants | controls: all factors outside of the actual experimental steps that could affect the results; **things** that should be **the same** for the control setup and experimental setup and all of the sub-setups within the experimental setup
4. Repeated trials | trials: the experiment should be conducted at least three times to determine consistency in the run of the experiment; the results should be similar between all trials for each sub-setup
5. Placebo: "fake medicine"
6. Placebo effect: a situation in which false medicine is given in an experiment to **eliminate biasness**
7. Single blind experiment: an experiment in which **only** the **experimenter knows** which group receives which medicine
8. Double blind experiment: an experiment in which **neither the experimenter nor the test subjects know** which group receives which medicine
9. **NOTE: IT IS IMPORTANT TO HAVE A CONTROL SETUP WHEN APPLICABLE. IT IS VERY IMPORTANT THAT YOU TEST ONLY ONE INDEPENDENT VARIALBE AT A TIME. WHY?**

   *Answer:*
   - A control setup is needed to compare your results to in the analysis.
   - You need to make sure that the outcomes of your results are due to the one thing you are testing.

   *Explanation given for scenario from class*:
   - The plant receiving just water is the control setup.
   - Other plants receiving water with a fertilizer mixed in it is the experimental setup.
   - The *same* kind of plants, potted in the *same* kind of soil at the *same* depth, having the *same* light exposure, having the *same* kind of light exposure, being exposed to the *same* temperature, and receiving the *same* amount of fertilizer mixed in the *same* amount of water are the controls.
   - The growth of the plants would be the dependent variable.
   - The different kinds of fertilizer used for each plant in the experimental setup would be the independent variable.

VII. **Results**: data collected during the run of the experiment

A. Results Process
   1. Take **picture(s)** when applicable
   2. Collect data in **table(s)** when applicable
   3. Plot data in **graph(s)** when applicable
   4. Explain any patterns and trends in the data in a **discussion**

B. Key terms

1. Qualitative observation: data collected that has **ONLY** descriptions; descriptions are based on one of the five senses; (Examples: red, foul, gaseous)
2. Quantitative observation: data collected that has numerical values (measurements); (Examples: 4 mL, 20 cm)

C. Table(s) should include the following:
1. A title relevant to the data at the top of the table
2. A heading at the top of each column
3. Sometimes a heading is needed at the beginning of each row
4. Independent variable's data is typically listed first
5. All repeated trials should be included
6. An average column should be provided when applicable
7. Figure 1. *Format of a Table*

**Relevant and Condensed Title Representing Data**

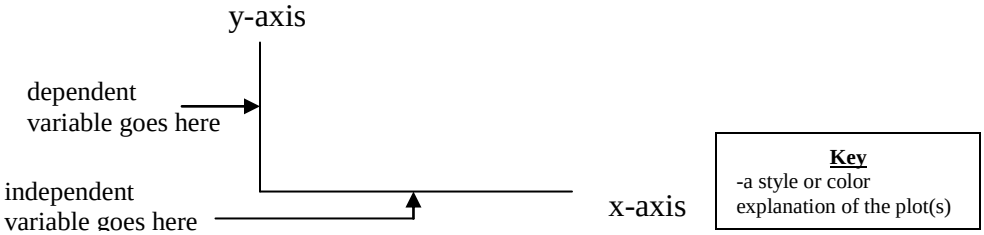
| Heading [Unit(s)] | Heading [Unit(s)] | | | Average [Unit(s)] |
|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 | |
| Name | | | | |
| Name | | | | |
| Name | | | | |
| Name | | | | |
| Name | | | | |

independent variable goes in first column

dependent variable goes in these columns

D. Graph(s) should include the following:
1. A title relevant to the data at the top of the graph
2. Independent variable is plotted on the x-axis of bar and line graphs
3. Dependent variable is plotted on the y-axis of bar and line graphs
4. A key (legend) footed for some graphs when applicable
5. Proper labels (identification) on both axes
6. Proper measuring units on both axes when necessary
7. Scales **include the data** (**NOT** is the data) ranging from the smallest number & the largest number
8. Scales are properly numbered in **multiples** on both axes. The multiples used for the **x-axis and y-axis can be different** from each other.
9. Spacing between numbers on both scales are in **uniform increments** throughout the scale. The spacing on the **x-axis and y-axis can be different** from each other.
10. Figure 2. *Format of a Bar or Line Graph*

**Relevant and Condensed Title Representing Data**



E. Discussion: explain patterns and trends in the data

VIII. **Analysis**: an explanation of the what's, how's and why's of your experiment and results

A. Should include the following:

1. Identify what was included in both setups (control & experimental).
2. Identify and discuss the independent and dependent variables in the experiment.
3. Compare and contrast the two setups.
4. Discuss all possible control variables that you should have acknowledged in your actions.
5. Determine the **significant difference** between the two setups.
6. Discuss **experimental limitations**.
7. Discuss **experimental errors** (quality of experimental techniques).
8. Identify and discuss the quality (**precision** & **accuracy**) of the data found in the table(s).
9. Identify and discuss patterns, trends, and relationships in the data of the graph(s).
10. **Interpolate** when possible and/or necessary.
11. **Extrapolate** when possible and/or necessary.
12. Have there been enough tests to develop a **theory**? What could that theory be?

B. Key Terms

1. Significant difference: a noticeable amount of difference between the results of both (control & experimental) setups
2. Interpolate: determine what missing or unknown data could be between two points
3. Extrapolate: estimate or infer what future data could be based on existing trend
4. Theory: an explanation of an observation; a hypothesis that has been tested many times; there may be a modification in the hypothesis based upon the data collected from the experiment
5. Law: a theory that has been tested many times and has been accepted as true; describes how nature works

IX. **Conclusion**: relates your results to the hypothesis

A. Characteristics

1. Tell if hypothesis is accepted or rejected by the results of the experiment. Do **NOT** use definite terms such as saying a hypothesis was right or wrong | correct or incorrect.
2. Explains how the results do or do not support the hypothesis.
3. An attempt to explain the solution to the problem based upon the results
4. Explain the importance of your findings.
5. Explain what your findings might lead to.

B. Examples of acceptance statements

1. The data seems to indicate that… may be effective…
2. The data seems to support…
3. The data seems to favor…

C. Examples of rejection statements
    1. The data seems to indicate that…may not be effective…
    2. The data seems to not support…
    3. The data seems to not favor…

X. **Communication**: report findings in print and possibly orally; others should be able to read, criticize, respond (give input), and test your hypothesis themselves by following your experiment

XI. **Future work(s)**: what you would do differently, improve, or enhance if you were to conduct your investigation again

XII. **Application**: explain how can your findings be used in real life; explain practical applications of your findings to real world matter(s); explain how could your findings benefit society