Experimental Design

Scientific research requires a logical progression of steps that clearly define and focus the work being done. These steps are guided by a specific question or a problem. Research is rarely linear. Instead, scientists must be flexible, creative, and willing to change strategies. Persistence is essential, as there are many more failures than successes in research. These failures often result in new strategies and new questions that re-focus research.

There are guidelines to help you keep a logical progression of steps when you design an experimental procedure. Experiments have controls that allow for comparison and help prevent incorrect conclusions being made due to inconsistent conditions impacting the data.

The following experimental design process is a guideline for you to use when creating experiments in the PLTW Biomedical Science courses. It is not a strict "scientific method" protocol. It is a guide to help you create logical, thoughtful, and clearly defined procedures for investigative work. You are expected to follow these guidelines when you design experiments.

Steps of Experimental Design

Use your PLTW Laboratory Journal to record all experimental design work. When you record your work, write the number and title of each section as shown. After each design step is an explanation (in italics), of the format that you are to use in your lab journal for that specific step. The evaluation rubric is based on how well you follow the steps of design and use the correct format to record the information in your journal.

1. Identify the Problem or Question

- State the research problem or question in one sentence.
  The problem should be very specific and measurable.

Write one sentence in the form of a question or problem statement.

2. Predict a Solution to the Problem or an Answer to the Question

- Make a prediction. Your prediction will be in the form of a hypothesis.
  This hypothesis should be based on previously obtained knowledge or research and be supported by scientific evidence.
- Identify the independent and dependent variables.
  The independent variable is the variable that the researcher can vary or manipulate. The dependent variable is the measurable effect, outcome, or response in which you're interested. In other words, the independent variable is the presumed cause, and the

dependent variable is the presumed effect. In an experiment, the independent variable is the variable that the experimenter controls and manipulates; the experimenter does not manipulate the dependent variable, but instead observes or measures it for variations.

Write a one- or two-sentence statement that predicts the outcome of the experiment. In a separate statement, specify the independent and dependent variables.

3. Design the Experiment to Test Your Hypothesis

- Create a list of all required materials.
- Be specific.
- Take all safety concerns into account.
- Identify a control to be used for comparison if applicable.
- Control all outside variables that could affect the outcome of the experiment.
- Clearly define how the data will be collected and recorded, including measurement units.
- Design a data table to use to record information.
- Plan the strategy that you will use to summarize data. For example, you might use a graph to summarize the data.

Write a series of numbered steps and include a list of required materials. Your data table should include the units you'll collect the data in.

4. Carry Out the Experiment

- Collect data.
- Make observations.
- Complete multiple trials. (Do the procedure many times, collecting data each time.)

Complete the data table, including units and labels on each section.

5. Analyze the Data and Observations

- Make graphs or charts of the data.
- Check that the independent and dependent variables are properly placed on any graphs.
- Be logical and clear.
- Look beyond the obvious.

Make graphs and charts to visually and logically present the data. Write in paragraph form and include calculations showing all work. Clearly and concisely explain all analysis.

6. State the Conclusion

- Use a one-sentence statement.
- Be clear and concise.

Write a one-sentence statement directly related to the original hypothesis. It might start with "The hypothesis was correct…"

7. Write a Summary

- Write a brief paragraph.
- Explain the rationale for your conclusion.
- Clarify details.

Write one paragraph of text explaining the rationale for your conclusion.

After step 7

When you have completed the experimental design process, you may pursue other options, including but not limited to the following:

- Changing your hypothesis.
- Redesigning the procedure because of design flaws.
- Developing new questions based on the work in this experiment.
- Moving on to a new or related research topic.