Name: Class: Date:

SUMMARY: EXPERIMENTAL DESIGN

Have you ever timed two different routes to school to see which is faster? Have you ever compared two kinds of shampoo to see which one is better for your hair? If you have, you have performed a simple experiment. You probably did not plan your experiment on paper before you carried it out. Scientists, however, **design experiments** carefully before actually performing them.

The parts of the process of experimental design are as follows:

1. Problem

A problem is a statement that describes the main topic of the experiment. A good problem is detailed, identifies the relationship between the two variables, and should be answered by a yes or no answer. A good problem statement should be written generally as "What is the effect of the (independent variable) on the (dependent variable)?"

For example, suppose you've heard that adding a small amount of sugar to water in a vase of flowers keeps the flowers fresh longer. You want to perform an experiment to determine whether that statement is true. A good problem statement would be "Does adding sugar to water in a flower vase keep the flowers fresher over one week's time?"

2. Hypothesis

A hypothesis is a prediction about the outcome of an experiment. A properly worded hypothesis takes the form of an *If . . . then* . . . statement. A good hypothesis must be testable by an experiment and always include an explanation why.

In our example, a suitable hypothesis for the experiment would be "If I add sugar to the water in a vase, then the flowers will stay fresh longer. This is because the sugar provides nutrients to the plant cells in the flowers which allows them to stay alive longer than without nutrients."

3. Variables

Variables are factors in an experiment that can change. There are 3 types of variables:

Independent variable

- The factor you is purposely changed or manipulated in the experiment.

Dependent variable

- The factor will change according to changes in the independent variable. It is the variable that is typically measured in an experiment.

Constants

- Constants are all of the other factors that must be kept the same to ensure a fair test.

In our example, the independent variable is the amount of sugar in the water. The dependent variable is the length of time that the flowers remain fresh. Several control variables include the type of vases, the number of flowers in each vase, the temperature of the water and the amount of light the plants receive.

4. Experimental Control

An experimental control is a test in your experiment where the independent variable is not changed or manipulated at all. A control is used to check that from trial to trial, everything is kept the same and that the independent variable is *actually* causing the response in the dependent variable.

In our example, an experimental control would be a test where sugar is NOT added to the water in the vase – just water. All other factors are kept the same. That way, we can tell if the sugar is causing the change in the flowers at all.

5. Materials

Before you begin writing out the procedure, you must also identify the materials you will need, and be specific. Write a list of those materials and then continue writing your procedure. When your procedure is complete, double check your list of materials and make changes if necessary.

6. Procedure

The procedure is a "recipe" for conducting the experiment. It describes what you plan to do and identifies the type of data you plan to collect. A good procedure is always written in step-by-step form, always starts each step with a verb, does NOT personal pronouns, such as "I" or "we", and includes multiple trials.

7. Data

Observations are things noticed by senses or by measurement tools during the experiment. These observations are your data. There are two main types of data:

Quantitative Data
- Data that is represented by numbers.
- *e.g. The flowers grew 2.5 cm over 1 week*

Qualitative data
- Data that is represented by statements of opinion or observation.
- *e.g. The flowers appear healthy and are not drooping*

Scientists use data tables to organize the data as it is collected. Good data tables are organized neatly, include detailed headers that contain the unit of measurement and ensure that all of the raw data is recorded to the correct number of **significant figures**.

8. Graph

Graphs are used to summarize the data and are useful for interpreting data before making a conclusion. When graphing, remember that the independent variable goes on the horizontal, or X-axis, while the dependent variable goes on the vertical, or Y-axis. To scale (number) the axes so it fits the grid properly, use the following formula:

$$Correct\ size\ of\ spacing\ (graduation) = \frac{highest\ value - lowest\ value}{number\ of\ spaces\ in\ the\ axis}$$

Note: Use zero for the lowest value if you plan to start numbering at zero. Always round up. Begin numbering by the lowest value and go up by your calculated graduation.

9. Analysis

Analyzing the data means explaining that data. You may make simple comparisons or look for trends or patterns in the data that was collected. How do the results of your different trials compare to each other? What was learned from the experiment? Does your data support your hypothesis? Why or why not? How can you explain your results with scientific facts?

10. Conclusion

A conclusion is a written summary of the findings of the experiment. In a good conclusion, the results of the experiment are summarized, the hypothesis is restated, and a statement is made about whether the hypothesis was supported by the data or not. In addition, a good conclusion always tries to explain the results of the experiment using scientific knowledge.

11. Evaluation

It is very rare that a scientific experiment is done without any problems! In the evaluation, you must describe how the experiment went overall, identify weaknesses in your procedure and give reasonable suggestions to improve it or extend it in the future. A basic outline of questions that should be addressed in an evaluation section is:

1. Was the experiment a success overall? Why or why not?

2. Was the data gathered during the experiment accurate? If some of the data was not accurate, point out where this inaccurate data is in the results and suggest why it may have occurred.

3. What are some recommended improvements to the design or procedure for future testing? Recommend other parts of the problem that could be examined in the future if more time is given.