Biology **Name:** _____

Experimental Design of a Controlled Experiment

Part I

STEP 1: DEFINING THE PROBLEM

Every scientific investigation begins with the question that the scientist wants to answer. The questions addressed by scientific inquiry are based on observations or on information gained through previous research, or on a combination of both. Just because a question can be answered doesn't mean that it can be answered scientifically.

STEP 2: IDENTIFYING THE DEPENDENT VARIABLE(S)

The dependent variable is what the investigator measures (or counts or records). It is what the investigator thinks will vary during the experiment. For example, he may want to study peanut growth. One possible dependent variable is the height of the peanut plants. There are different dependent variables possible in an experiment. The investigator can choose the one he thinks is most important, or he can choose to measure more than one dependent variable.

READING CHECK: Name some other aspects of peanut growth that can be measured.

READING CHECK: Define dependent variable.

STEP 3: IDENTIFYING THE INDEPENDENT VARIABLE

The independent variable is what the investigator deliberately varies during the experiment. It is chosen because the investigator thinks it will affect the dependent variable. The investigator can measure as many dependent variables as he thinks are important indicators of peanut growth. By contrast he must choose only one independent variable to investigate in an experiment. For example, if the scientist wants to investigate the effect that the amount of fertilizer has on peanut growth, he will use different amounts of fertilizer on different plants; the independent variable is amount of fertilizer.

READING CHECK: Name some factors that might affect the number of peanuts produced by peanut plants.

READING CHECK: Define independent variable.

CHECK FOR UNDERSTANDING

Identify the dependent and independent variables in the following examples.

a. Height of bean plants is recorded daily for 2 weeks growing in different fertilizers.

Dependent variable:_____

Independent variable:_____

b. Guinea pigs are kept at different temperatures for 6 weeks. Percent weight gain is recorded.

Dependent variable:_____

Independent variable:_____

c. The diversity of algal species is calculated for a coastal area before and after an oil spill.

Dependent variable:_____

Independent variable:_____

d. Light absorption by a pigment is measured for red, blue, green, and yellow light.

Dependent variable:_____

Independent variable:_____

e. Batches of seeds are soaked in salt solutions of different concentrations, and germination is counted for each batch.

Dependent variable:_____

Independent variable:_____

STOP HERE! CHECK YOUR ANSWERS WITH THE TEACHER

STEP 4: IDENTIFYING THE CONSTANT VARIABLES

A third type of variable is the constant variable. Constant variables are factors that are kept equal in all treatments, so that any changes in the dependent variable can be attributed to the changes the investigator made in the independent variable.

Since the investigator's purpose is to study the effect of one particular independent variable, he must try to eliminate the possibility that other variables are influencing the outcome. This is accomplished by keeping the other variables at constant levels. For example, if the scientist has chosen the amount of fertilizer as the independent variable, he wants to be sure that there are no differences in the type of fertilizer used. He would use the same formulation and same brand of fertilizer throughout the experiment.

READING CHECK: What other variables would have to be standardized in this experiment?

READING CHECK: Define constant variable(s).

STEP 5: WRITING THE HYPOTHESIS

A scientific question is usually phrased more formally as a hypothesis, which is simply a statement of the scientist's educated guess at the answer to the question.

As the investigator devises an experiment, he should also make predictions about the effect of the independent variable on the dependent variable in each situation. For example, a scientist has made the following hypothesis: Increasing the amount of fertilizer applied will increase the number of peanuts produced. He has designed an experiment in which different amounts of fertilizer are added to plots of land and the number of peanuts yielded per plot is measured. The predictions should state specifically how the dependent variable will change in relation to the independent variable and must be stated as an If … Then statement. The general format for an If … Then statement is "if the independent variable is changed in this way, then the dependent variable will change this way." For example, if the amount of fertilizer applied to a field is doubled, then the number of peanuts produced will double. Or, if the temperature of the reactants in a chemical reaction increases, then the rate of the reaction will increase.

READING CHECK: Define hypothesis.

READING CHECK: What is the general format for a hypothesis?

STEP 6: IDENTIFYING THE EXPERIMENTAL & CONTROL GROUP

In order to make sure that only one factor is being changed in an experiment, the independent variables are then divided into two groups. One group, called the control group, is exposed to all of
the circumstances of the experiment but does not get whatever is being tested or changed in the experiment. At the same time, the experimental group gets all of the circumstances of the experiment PLUS the one variable being tested by the experiment.

In the fertilizer example, the investigator must be sure that the peanuts don't grow just as well with no fertilizer at all. The control would be a treatment in which no fertilizer is applied. The experimental group is the peanuts that are given different amounts of fertilizer. An experiment on the effect of temperature on guinea pigs, however, cannot have a "no temperature" treatment. Instead, the scientist will use a standard temperature as the control and will compare weight gain at other temperatures to weight gain at the standard temperature.

READING CHECK: Define experimental group.

READING CHECK: Define control group.

CHECK FOR UNDERSTANDING
Tell what an appropriate control and experimental group would be for each of the following examples.

a. An investigator studies the amount of alcohol produced by yeast when it is incubated with different types of sugar.

Control Group:_____

Experimental Group:_____

b. The effect of light intensity on photosynthesis is measured by collecting oxygen produced by a plant.

Control Group:_____

Experimental Group:_____

STOP HERE! CHECK YOUR ANSWERS WITH THE TEACHER

STEP 7: DETERMINING REPLICATION

Another essential aspect of experimental design is replication. Replicating the experiment means that the scientist repeats the experiment numerous times using exactly the same conditions to see if the results are consistent. Being able to replicate a result increases our confidence in it. However, we shouldn't expect to get exactly the same answer each time, because a certain amount of variation is normal in biological systems. Replicating the experiment lets us see how much variation there is and obtain an average result from different trials.

Part II: For each of the statements identify the variables, control group, and experimental group. In the experimental group, make sure to identify the constants.

1. Eating breakfast increases performance in school.

    Independent Variable:

    Dependent Variable:

    Control Group:

    Experimental Group w/ Constants:

2. Salt in soil affects plant growth.

    Independent Variable:

    Dependent Variable:

    Control Group:

    Experimental Group w/ Constants:

STOP HERE! CHECK YOUR ANSWERS WITH THE TEACHER

Part III: Write a hypothesis for each of the following problem statements. Identify the dependent and independent variable for each.

Remember a hypothesis is an IF (cause or IV)…THEN (effect or DV) statement

1. To what extent does the amount of leaves on a tree affect how many birds will build nests in it?

   Independent Variable:

   Dependent Variable:

   Hypothesis:

2. To what extent does the acid level of a lake affect how many fish live there?

   Independent Variable:

   Dependent Variable:

   Hypothesis:

3. To what extent does the amount of milk you drink affect the strength of your bones?

   Independent Variable:

   Dependent Variable:

   Hypothesis:

4. What effect does the salt concentation in soil have on plant growth?

   Independent Variable:

   Dependent Variable:

   Hypothesis:

STOP HERE! CHECK YOUR ANSWERS WITH THE TEACHER

Part IV: Read the following situation and answer the following questions.

Adele wants to know the effect of different colors of light on the growth of plants. She believes that plants can survive best in white light. She buys 5 ferns of the same species, which are all approximately the same age and height. She places one in white light, one in blue light, one in green light, one in red light and one in the closet. All of the ferns are planted in Miracle-Grow and given 20 mL of water once a day for 2 weeks. After the two weeks, Adele observes the plants and makes measurements.

Hypothesis:

Independent Variable:

Dependent Variable:

Control Group:

Experimental Group:

Constants (controlled variables):

Part V: Designing an Experiment

Visit
http://www.biologycorner.com/worksheets/scientific_method_plant_exp.html#.UnbLpaPnbIV
and answer the following questions.

1. What are your independent and dependent variables?

2. Write your hypothesis for this experiment in the proper format.

3. Describe your control group.

4. Describe your experimental group.

5. Create a data table to show your results. This table should include an average for your experimental and control group.

6. Explain why you need a control group.

7. Explain why an average or multiple trials are needed to compare your results.

8. Was your hypothesis correct? What can you conclude based off of your results? Explain.