Lab #3: Experimentation Lab

INTRODUCTION:

In this lab we are going to gain experience and practice using the scientific method. The first part of the lab will be focused on becoming familiar with the scientific method and the various parts of the process. The final activity will be to conduct a controlled experiment to compare groups to test a hypothesis related to general health.

Part I: Understanding the Scientific Method

Please reread the textbook from the beginning of section 1.2: The Process of Science up through and including the subsections "The Nature of Science" and "Hypothesis Testing" including the "art connection" figure from chapter 1 of your textbook. How the scientific method is written can vary from textbook to textbook and professor to professor, however, the basic elements are usually always the same. Here is the Welday version which is slightly different from the textbook:

Scientific Method (some parts differ from textbook):

1. Make an observation
2. Ask questions
3. Formulate a hypothesis (a specific answer to a question)
4. Make predictions (based on hypothesis)
5. Test hypothesis based on predictions (conduct experiment)
   a. Design experiment with proper controls
   b. Conduct experiment
   c. Record data (this often occurs while conducting experiment)
6. Analyze data and determine results (often occurs after experiment completion)
7. Draw a conclusion
   a. Determine if hypothesis is supported or not supported (based on Analysis of results)

Careful **observation** is usually where the scientific process starts. Observing similarities and differences between phenomena that occur in the natural world often leads to the formation of **questions**, i.e. why does "Y" occur? We use the scientific method as a way to test particular answers to those questions, which we call **hypotheses**, a kind of "educated guess." A hypothesis is an explanation of a *cause* and *effect* relationship, i.e. effect "Y" occurs because of cause "X". A proper scientific hypothesis is always testable which means it leads to **predictions** that can, *at least theoretically*, be observed under particular conditions. Predictions are usually in the form of an if "this" then "that" kind of statement, i.e. if I could change "X" in "this" way then I would expect "Y" to change in "that" way. An **experiment** is a procedure designed to test the prediction from a hypothesis. Controlled experiments are experiments comparing at least two groups where, ideally, the two groups are exactly the same except for the change in "X." The **results** of the experiment are determined by what happens to "Y" as a result of changing "X" between groups. The results are *objective* facts determined purely from the data collected and analysis performed. In other words this is not what you think happened or an explanation of why something happened, it is what was actually observed that happened and anyone observing the same experiment would report the same results even if they think something different was the cause.

Finally, if "Y" changed in the way we originally predicted we make the **conclusion** that that our hypothesis is supported and still valid. If "Y" does not change or changes in some other way, we make the **conclusion** that our hypothesis is not supported and the hypothesis should be rejected.

The "X" and "Y" above are variables, where "X" is the **independent variable** (or the potential cause) since it is the variable that the scientist can manipulate and "Y" is the dependent variable (or the potential effect) that the scientist measures. The **dependent variable** is so named because it depends on "X." The **controlled variables** are all the other variables that are kept the same between the groups. Here is an example to help illustrate what this means:

One can make the observation that many different people are similar in many ways but have different heights. This could lead to the question "why are some people taller than others?" One hypothesis could be: "people that drink milk as children grow taller" This leads to the prediction that if one child drinks milk daily and another very similar child never drinks milk, then the child that drinks milk daily show grow taller. An experiment would be to study two groups of children that are the same age and live in the same region but one group (group A) is given milk daily and the other group (group B) is never given milk but otherwise given the same total amount of calories. If at the end of the experiment the results were that the average height of group A was larger than the average height of group B, then the conclusion would be that the experiment provided support for the hypothesis and is still valid. If the results instead were that average heights were the same or group A was shorter than group B, then the conclusion would be that the experiment did not provide support for the hypothesis and the hypothesis should be rejected. Here the dependent variable was height and the independent variable was milk consumption (daily or none). Some of the controlled variables were daily calorie intake, age, and geographic region. The data that was collected was the measurement of each person's height and the analysis of that data was a calculated average. Note that these results do not depend on what a person thinks about the cause of differences in heights. Anyone could take the same measurements and calculate the same averages to produce the same results. Someone could come to a different conclusion based on the same results. For example someone else could say that there were genetic differences in the group that were not well controlled for and milk intake had nothing to do with the height differences.

I know that some of these concepts may be difficult at first, so for the quiz don't worry about knowing all the definitions of the bolded and underlined terms such as independent vs dependent variables, what exactly a hypothesis is or the exact order of the scientific method. Just read through the entire protocol and be generally familiar with the example I used above and a general understanding of the experiment you will be doing in this week's lab (experiment involving running up stairs) so that I know you have read this protocol.

UNDERSTANDING HYPOTHESES: in the following activity, you will be given two different scenarios to read. Afterward discuss it with your group completely BEFORE you answer the following questions:

Scenario 1: Disease of the Dutch East Indies

a. State the important initial observation that led to the initial experiment:

b. What was the question that led to the initial experiment?

c. What was the hypothesis that led to the initial experiment?

d. How was the hypothesis tested (explain the experiment)?

e. Should the hypothesis be supported or rejected based on the initial experiment?

f. What would be an alternative hypothesis and how would you test it?

Scenario 2: Sir Fleming the Serendipitous

a. State the initial observation that led to the experiment:

b. What was the question that led to the experiment?

c. What was the hypothesis that led to the experiment?

d. How was the hypothesis tested (explain the experiment)?

e. Should the hypothesis be supported or rejected based on the experiment?

ANALYZING DATA: observe the data projected and interpret the results

The number of mice in litters: An experiment studies the effects of an experimental drug on the number of offspring a mother mouse has. Ten female mice are given the drug and then impregnated. The number of mice in their litters is compared to the litters of mice that did not take the drug.

a. Based on the data, what would you conclude about Drug X?

Cow Growth Rates: A type of feed claims to boost the growth rates of cows. The feed is tested on two twin newborn cows. Bessie receives the experimental feed, and Bertha receives regular corn feed. See the handout in lab for the table:

Graph the data. Use a dotted line for Bessie and a straight line for Bertha. Make sure you label the graph with a descriptive figure caption, the x-axis, and the y-axis.

Figure 3.1. ____

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a. Both cows ended at the same weight, but did the experiment feed change the way they gained weight at all? Describe your conclusions about the experimental feed and explain why it is important that the experiment used twin cows.

Part II: The Heart at Rest

Doctors constantly encourage patients to remain physically active and avoid a sedentary lifestyle as much as possible. This is because many studies have shown that active individuals are healthier and less susceptible to a wide range of health risks compared to sedentary (less active) individuals. In fact, inactivity is a major risk factor for heart disease. A person who exercises often with high intensity has the lowest risk for heart disease, but any amount of exercise has been shown to be beneficial.

Your blood carries essential nutrients such as oxygen and glucose to all of your body's cells while also carrying away waste products. When most cells increase activity they require more nutrients. Your body reacts to this increase need by increasing the blood flow to these areas which delivers nutrients at a faster rate. Sometimes blood flow is just increased in one small region of the body, while other times, such as during exercise, overall blood flow through your body is increased. There are two ways to increase overall blood flow through your body: 1) increasing how fast your heart beats which we refer to as **heart rate** and/or 2) increasing the amount of blood that is pumped for every heart beat which we refer to as **stroke volume.**

As a result of exercise, the heart becomes stronger and efficient in pumping more blood through the body with every beat, or contraction. In other words, exercise can cause long lasting increases in stroke volume. A higher stroke volume, therefore, represents a higher volume of blood that is pumped throughout the whole body per beat. As a result of the increased pumping efficiency, one's resting heart rate will slow because the heart needs to pump fewer times to deliver the same amount of blood to the body's tissues during rest. This is why athletes generally have slower resting heart rates compared to non-athletes. In addition, exercise allows your heart to continue working at its maximum, if needed, with less strain. Thus, an athlete can push the heart to pump at its maximum for longer periods of time.

In this experiment, you will apply the scientific method to compare two individuals in your group that have different levels of average daily exercise to see how their circulatory system recovers after exercise. If possible, pick one individual that is an athlete, has a regular exercise routine and/or tends to be fairly active and another individual that is generally less active. Prior to performing the experiment, you will generate a hypothesis and try to predict which individual will recover his or her resting heart rate faster after moderate exercise. You will then determine the **independent variable** (variable that is manipulated and thought to be the cause) and the **dependent variable** (variable that is observed and measured and thought to be the effect) for this experiment.

Procedures:

1. Choose two volunteers (one more active and one less active) per group and follow the directions listed below for each volunteer.
2. As your heart pumps blood through your body, you can feel a pulsing in some of the blood vessels close to the skin's surface. Find the pulse for each of your volunteers along the inside of their wrists.
3. Once you have found the pulse, count the number of pulses felt in 30 seconds. Multiply the number of pulses by 2 to get a heart rate in beats/min
4. Repeat this three times and calculate an average to get an average heart rate at rest (again in beats per minute not beats per 30 sec).
    a. To calculate an average, add up all measurements and divide by the number of measurements. In this case there are 3 heart rates, so add all three and then divide by 3.

   b. Record this in Table 1 below. This is your average resting heart rate in beats per minute (bpm).
   c. You will need the resting heart rate to compare the heart rate after exercise. Why?
5. Have the volunteers **run** up the three flights of stairs in the Sci-Tech building and carefully **walk** down the three flights of stairs back to the lab. (Warning: be very careful not to trip on the stairs!)
6. As soon as the volunteers come back, IMMEDIATELY get a heart rate by counting beats in 30s (again multiplying by 2) and start the timer.
   a. Record this in the table provided below under "T_0". This represents the heart rate immediately after exercising.
7. 5 minutes after starting the timer, count the number of pulses felt in 30 seconds. Multiply the count by 2 and record this in the table provided below under "T_5". This represents the heart rate 5 minutes after exercising.
8. After another 5 minutes (10 minutes after starting the timer), count the number of pulses felt in 30 seconds. Multiply the count by 2 and record this in the table provided below under "T_{10}". This represents the heart rate 10 minutes after exercising.
9. Repeat for T_{15}, T_{20}, T_{25}, and T_{30}.

Prior to conducting the experiment, answer the following:

1. a. If both volunteers have the same blood volume of 5L and both circulate the same volume per min 5L/min, how can one have a higher heart rate than the other? (don't just guess, read through above)

   b. Do you think their hearts would be the same size? Which one would you expect to have the larger heart (more active or less active) if different?

2. Which variable is the independent variable?

3. Which is the dependent variable?

4. What are some important controls that should be used?

5. What is your hypothesis?

DATA

Table 1. Resting heart rate (bpm) and heart rates 30 minutes after exercise of both volunteers

	Resting HR average of 3x	T_0	T_5	T_{10}	T_{15}	T_{20}	T_{25}	T_{30}
More active								
Less active								

↑ Start Exercise

Graph your results: Include a proper and descriptive figure caption, x-axis and y-axis labels with appropriate units, and a legend to distinguish between the results of the more active and less active volunteers (dotted vs solid line, different colors, etc)

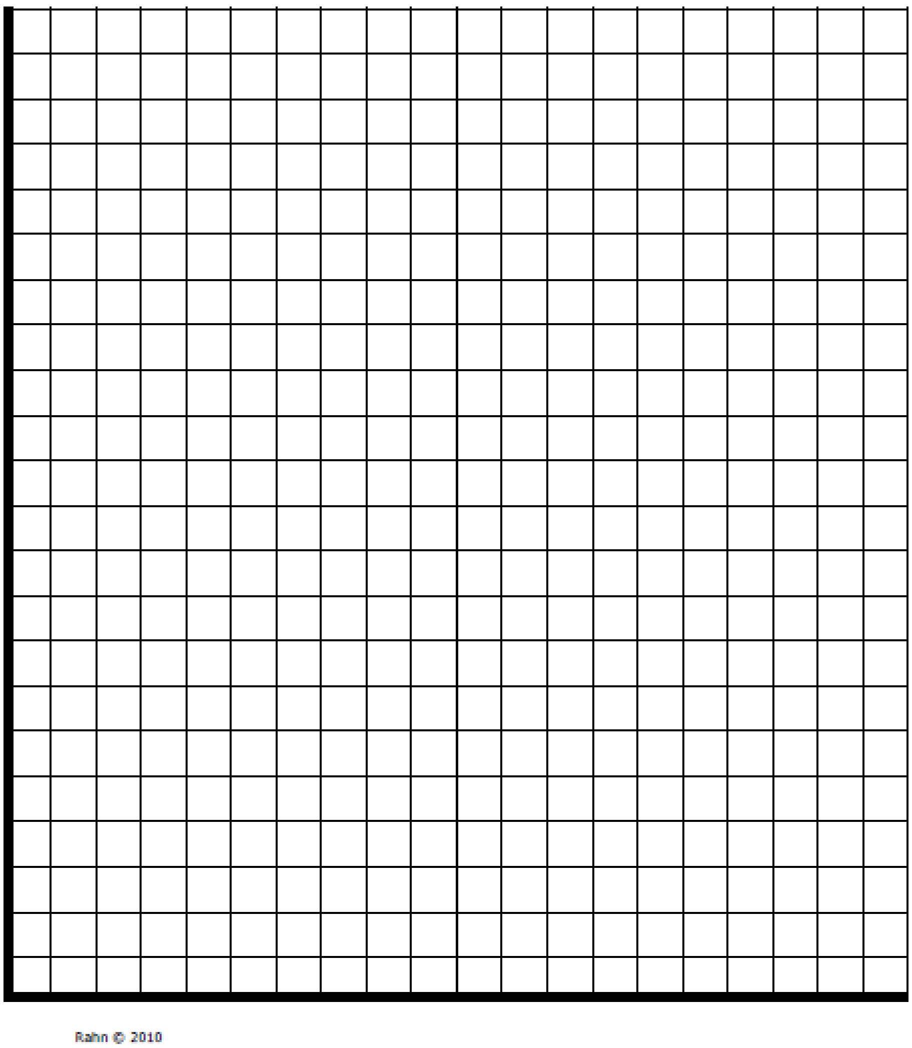

Figure 1. ____

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After conducting the experiment, answer the following:

1. Based on your results, which volunteer’s heart rate recovered faster after exercise?

2. What can you conclude about your hypothesis from this experiment?

3. What general conclusions can you make in terms of exercise and heart health?

4. Whose heart is more efficient at pumping blood to the rest of the body?

5. Since this is just a classroom exercise with limited resources, this isn’t a perfectly controlled experiment. What are some possible variables that are different between the two individuals that you might want to control for in a more rigorous scientific experiment?