Lab 1. Heart Rate, Physical Fitness, and the Scientific Method

Prelab Assignment

Before coming to lab read carefully the following pages on the scientific method and then answer the prelab questions at the end of this lab handout. Be prepared to discuss and/or hand in your responses to the prelab questions at the start of lab.

Introduction

Biology is a dynamic field of study whose aim is to unravel the mysteries of life itself. Throughout history, humans have been curious about the world around them. Through the millennia people have observed the natural world and have asked, "why?" Those that have advanced our biological knowledge the most, whether the great scientists of the centuries before us, such as Robert Hooke (Discovered cells in 1665) and Charles Darwin (Co-developer of the theory of evolution by natural selection in 1859), or modern molecular biologists such as James Watson and Francis Crick (Discovered the structure of DNA in 1953), have certain traits in common: They have inquiring minds, great powers of observation, and they use a systematic approach to answer their questions that intrigue them, the scientific method.

In this course you will have ample opportunity to develop your scientific skills. The weekly laboratory exercises are designed not only to stimulate your curiosity and heighten your powers of observation, but also to introduce you to and allow you to practice the scientific method. This laboratory activity will allow you to learn about and practice the scientific method as you study the impact of physical exercise on cardiovascular fitness.

In this experiment, cardiovascular fitness will be determined by using an arbitrary rating system to "score" fitness during a variety of situations. The heart rate will be measured while standing, in a reclined position, as well as during and after physical exercise.

Goals of this Lab:

- Use a computer and exercise heart rate monitor to measure the human heart rate.
- Determine the effect of body position on heart rate.
- Identify, describe, and practice the steps of the scientific method
- Define and identify *scientific* questions.
- Define hypothesis and identify the qualities of a good scientific hypothesis.
- Design an experiment to test a hypothesis.
- Correlate the fitness level of individuals with factors such as smoking, the amount of daily exercise, or other factors identified by students.
- Collect data and summarize it in tables and graphs.
- Interpret experimental data and discuss the validity of these interpretations and conclusions

Scientific Method

The scientific method is neither complicated nor intimidating, nor is it unique to science. It is a powerful tool of logic that can be employed any time a problem or question about the world around us arises. In fact, we all use the principles of the scientific method daily to solve problems that pop up, but we do it so quickly and automatically that we are not conscious of the methodology. In brief, the scientific method consists of

- Observing natural phenomena
- Asking a question (or questions) based on one's observations
- Constructing a hypothesis to answer the question
- Testing the hypothesis with experiments
- Drawing conclusions about the hypothesis based on the data resulting from the experiments
- Publishing results in a scientific journal

Making Observations

The scientific method begins with *careful* observation. An investigator may make observations from nature or from the written work of other investigators, which are published in books or research articles in scientific journals, available in the storehouse of human knowledge, libraries.

The following example will be used as we progress through the steps of the scientific method. Over the last couple of years you have been observing the beautiful fall colors of the leaves on the vine maples that grow in your yard, on campus, and in the forests in the Cascade Mountains. You note that their leaves turn from green to yellow to orange to red as the whether turns progressively colder and the days of fall get shorter and shorter. However, the leaves do not always go through their color changes on exactly the same days each year.

Asking Questions

It is essential that the question asked is a ***scientific question***. I.e. the question must be ***testable, definable, measurable, and controllable***. For example, one would have a tough time trying to test the following question, "Did a supernatural force such as God create all life on earth?" Moreover, it would be difficult to define what God is because of the multitude of cultures around the world and their many definitions of God. It is interesting to note that the since this question is *not* a scientific question, and hence not testable, the courts of the United States have ruled that "creation science" should not be taught in science classes as has been demanded by various groups in this country. However, that's not to say that God did not create life, it's just not testable, but rather, a matter of faith.

Now, back to the vine maple example...Being a curious and inquisitive person you ask, "What is responsible for the vine maple's leaves changing color each fall?"

Developing Hypotheses

After questions are asked, scientists try to answer them by proposing one or more hypotheses. A ***hypothesis*** is a *tentative* answer to a question has been asked. A hypothesis is an educated guess that is based on your observations. It is a trial solution to a question that will be tested through experimentation. A useful hypothesis must be ***testable*** and ***falsifiable*** (able to be shown false or untrue). It is important to note that a hypothesis can be supported by experiments and/or observations, but can *never* be proved true.

Back to the vine maples.... You have noted that vine maples change color in the fall on *approximately* the same dates each year, but this varies by a week or two each year. You reason that since air temperature is not constant each year in the fall, the progressively cooler days and nights in fall are responsible for stimulating the color changes. Therefore, you hypothesize that the cooler days of fall are responsible for the color changes.

A good hypothesis will always lead to predictions that are testable. A scientist never conducts an experiment without a prediction of its outcome. A hypothesis and its prediction(s) are often stated together as an "If... then...." statement. " If the hypothesis is true, then the results of the experiment will be...." So you develop your hypothesis into a "If... then...." statement: "If progressively cooler temperatures are responsible for stimulating the color changes in the leaves of vine maples, then vine maples placed in a growth house and exposed to constant light (e.g. 12 hours light and 12 hours of darkness per day), and exposed to slightly cooler temperatures each day should go through the same color changes as would the vine maples in nature."

The investigator will then evaluate the results of the experiment by seeing if the results agree with or contradict the prediction. For example, if you conduct the experiment and discover that the vine maple's leaves remain green, then the hypothesis has been falsified and another hypothesis must be developed. But if the leaves *do* change color, the hypothesis is supported, ***but not proved*** since other explanations and factors must be excluded through further experimentation. It is always possible that future evidence from other experiments might falsify the hypothesis. Thus hypotheses are *never* proven true, only supported by experiments and observations. It takes only one experiment to falsify a hypothesis, but it takes an infinite number of experiments to prove a hypothesis correct.

Testing Hypotheses via Experiments or by Pertinent Observations

The most creative and challenging aspect of science is designing a means to test a hypothesis, be it through observation or by experimentation. Although many hypotheses may be tested by making observations (e.g. All of the following were discovered through careful observation: Watson and Crick's determination of DNA's double helix structure, Robert Hooke's Cell Theory, and Darwin's theory of evolution by natural selection), we will test most of our hypotheses in lab by conducting experiments. An experiment involves ***defining variables, designing a procedure,*** and ***determining controls*** to be used as the experiment proceeds. In any experiment there are three kinds of variables.

- **Independent variable:** The independent variable is the *single* condition (variable) that is manipulated to see what impact it has on the dependent variable. The independent variable is the factor that causes the dependent variable to change. E.g. the temperatures the trees are exposed to is the independent variable in the vine maple example. The independent variable is the factor (i.e. experimental condition) you manipulate and test in an experiment. The value of the independent variable is known as the ***level of treatment***—e.g. the specific temperature(s) the trees are exposed to and for how long. A great challenge when designing an experiment is to be certain that only one independent variable is responsible for the outcome of an experiment. As we shall see, there are often many factors (known as ***controlled variables***) that influence the outcome of an investigation. We attempt, but not always successfully, to keep all of the controlled variables constant and change only one factor, the independent variable, when conducting an experiment.
- **Dependent Variable:** The thing measured, counted, or observed in an experiment. E.g. the color of leaves is the dependent variable in the vine maple example.
- **Controlled Variables:** These are the variables that are kept constant during an experiment. It is assumed that the selected independent variable is the only factor affecting the dependent variable. This can only be true if all other variables are controlled (i.e. Held constant) e.g. In the vine maple example: Species of vine maple, age and health of the trees used, length of day, environmental conditions such as humidity, watering regime, fertilizer, etc. It is quite common for different researchers, or for that matter, the same researcher, to get different and conflicting results while conducting what they *think* is the very same experiment. Why? They were unable to keep all conditions identical, that is, they were unable to control all controlled variables.

In an experiment of *classica*l design, the individuals under study are divided into two groups: an ***experimental group*** that is exposed to the independent variable (e.g. the group of trees that are exposed to the decreasing temperatures), and a ***control group*** that is not. The control group would be exposed to the *identical* conditions as the experimental group, but the control group would not be exposed to the independent variable (e.g. The control group of vine maples would be kept at a constant temperature, everything else would remain identical.)

Sometimes the best test of a hypothesis is not an actual experiment, but pertinent observations. One of the most important principles of biology, Darwin's theory of natural selection, was developed and supported by his extensive observations of the natural world. Since Darwin's publication of his theory, a multitude of experiments and repeated observation of the natural world continue to support Darwin's theory.

An *important* hypothesis may become a theory after it stands up consistently to repeat testing. A ***scientific theory*** is a hypothesis that has yet to be falsified and has stood the test of time. Hypotheses and theories can only be supported, but *cannot* be proved true by experimentation and careful observation. <u>It is impossible to prove a hypothesis or theory to be true</u> since it takes an infinite number of experiments to do this, but it only takes *one* experiment to disprove a hypothesis or a theory. Scientific knowledge is dynamic, forever changing and evolving as more and more is learned.

Conclusion

Making conclusions is the next step in the scientific method. You use the results and/or pertinent observations to test your hypothesis. However, you can never completely accept or reject a hypothesis. All that one can do is state the *probability* that one is correct or incorrect. Scientists use the branch of mathematics called statistics to quantify this probability. Later in the quarter you will use a statistical test called the Chi-square test to determine the probability that your hypothesis in a fly breeding experiment is correct.

Publication in a Scientific Journal

Finally, if the fruits of your scientific labor were thought to be of interest and of value to your peers in the scientific community, then your work would be submitted as an article for publication in a scientific journal. The goal of the scientific community is to be both cooperative as well as competitive. Research articles both share knowledge and provide enough information so that the results of experiments or pertinent observations described by those articles may be repeated and tested by others. It is just as important to expose the mistakes of others, as it is to praise their knowledge.

Presenting and Analyzing Experimental Results

Constructing Tables and Graphs

Once data is collected, it must be organized and summarized and interpreted to see if it supports or falsifies the hypothesis being tested. In this exercise, you will design tables and graphs to make *your* data easier to analyze and interpret. The primary functions of tables and graphs are to (i) help you analyze and interpret your results, and (ii) enhance the clarity with which you present the work to a reader or viewer.

Tables

In formal lab reports and scientific papers tables are numbered consecutively and appear on the same page where they are referred to or discussed. The title, which is located at the top of the of the table, should give enough information to allow the table to be understandable apart from the text. Consider the following questions when constructing a table. How could the data best be organized to make it easy to interpret? Would it be useful to average the data when presenting it? Should all of the data collected be presented, or only a summary table?

Below is an example of a table that could be used to summarize part of the data obtained in an experiment involving *fictitious* data involving basketball and baseball players.

Table 1. Average pulse rates, recovery times, and fitness points for GRCC basketball and baseball players taken before and after exercise (All data is fictitious!!)

	GRCC Basketball Players	**GRCC Baseball Players**
Average standing pulse rate before step test (beats/min)	62	88
Average pulse rate after step test (beats/min)	68	125
Average Fitness Points for heart rate increase after exercise	12	4
Average recovery time (sec)	11	114
Fitness Points for recovery rate	14	8
Sample Size	9	11

Graphing Data

Often the first step in analyzing the results of an experiment is the presentation of the data in the form of a graph. A graph is a visual representation of the data, which assists in bringing out and finding the possible relationship(s) between the independent and dependent variables. Examination of a graph makes it much easier to see the effect the independent variable has on the independent variable(s).

Accurate and clearly constructed graphs will assist in the interpretation and communication of your data, and when presenting a well-documented argument supporting or falsifying your hypothesis in the final steps of a scientific investigation. All graphs should be easy to interpret and labeled fully. The following guidelines will help you construct a proper graph.

How to become a graphing wizard

- Use *Excel or* ***graph paper*** of a high quality and a straight edge (i.e. ruler) to plot data neatly and accurately.
- *Always* graph the ***independent variable on the x-axis*** (horizontal axis), and **the *dependent variable on the y-axis*** (vertical axis).
- The scales of the axes should be adjusted so that ***the graph fills the page as much as possible***. The axes often, but not always, start at zero. Choose your intervals and a scales to maximize the use of the graph paper. Intervals should be logically spaced and easy to interpret when analyzing the graph (e.g. intervals of 1's, 5's, or 10's are easily interpreted, but non-integer intervals (e.g. 3.25's, 2.33's, etc.) are not. To avoid producing a graph with a lot of wasted space a ***discontinuous scale*** is recommended for one or both scales if the first data point is a large number. Simply add two tic marks between the zero and your lowest number on one or both axes to show that the scale has changed.
- Label the both axes to indicate the variable and the units of measure. Write the specific name of the variable. Do *not* label the axes as the dependent variable and independent variable. Include a legend is different colors are used to indicate different aspects of the experiment.
- Graphs (along with drawings, and diagrams) are called figures and are numbered consecutively throughout a lab report or scientific paper. Each figure is given a title that describes contents, giving enough information for the figure to be understandable apart from the text (e.g. Figure **1.** Relationship between the change in vine maple leaf color changes and temperature). Generally, the title is placed *above* the figure or graph.
- Choose the type of graph that best presents your data. Line and bar graphs are the most common. The choice of graph type depends on the nature of the variable being graphed.

Line vs. Bar Graphs

Line Graphs are used to graph data that only involves ***continuous variables***. A continuous variable is capable of having values over a continuous range (i.e. anywhere between those that were measured in the experiment). For example, pulse rate, temperature, time, concentration, pH, etc. are all examples of continuous variables.

Making a Line Graph

1. Plot data as separate points. Make each point as fine as possible and then surround each data point with a small circle. If more than one set of data is plotted on the same graph, distinguish each set by using circles, boxes, triangles, etc.
2. Generally, do not connect the data points dot to dot. Draw smooth curves, or if there appears to be a linear relationship between the two variables, draw a *line of best fit*.
3. If more than one set of data is plotted on a graph, provide a key of legend to indicate identify each set. Label the graph as a figure and give it an informative title as described earlier.

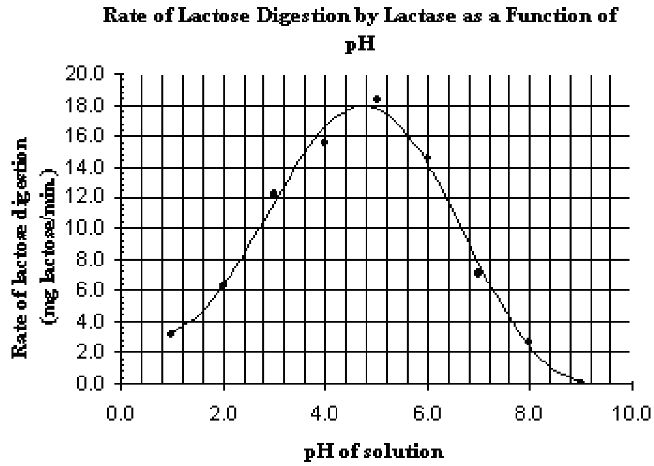


Figure 1. The effect of pH on the digestion of lactose by the intestinal enzyme lactase. Note that a line graph was used to graph the data because both variables, pH and the rate of digestion, are *continuous* variables. pH is a *continuous variable* since pH values between those used in this particular experiment are possible (e.g. pH 3.45, pH 5.07, etc.)

Bar Graphs are used if the data involves a discrete variable. A discrete variable, unlike a continuous variable, cannot have intermediate values between those measured. For example, a bar graph would be used to plot the data in an experiment involving the determination of herbicide concentration (continuous variable) found in tree species *X, Y*, and *Z* (discrete variable). Bar graphs are constructed using the same principles as for line graphs, except that vertical bars are drawn in a series down the horizontal axis.

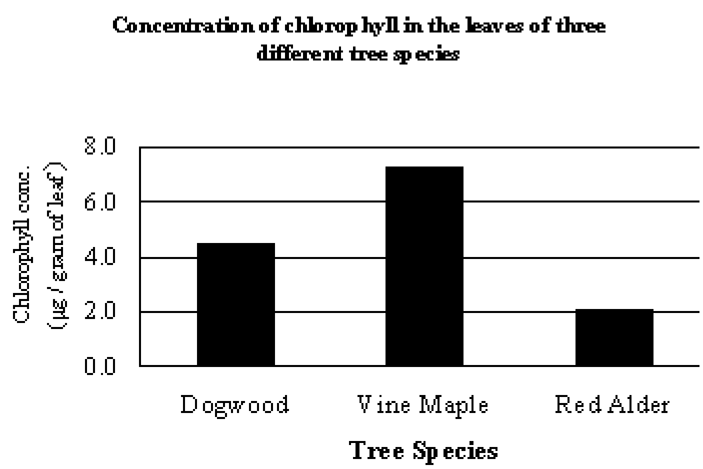


Figure 2. The concentration of chlorophyll in the leaves of three different tree species: dogwood, vine maple and red alder. Note that a bar graph was used since tree species is a discrete (or non-continuous variable) because it is impossible to have a species between those examined.

Discussing and Communication Results

The last component of a scientific investigation is to interpret the results and their implications. The tables and graphs are studied to see if the data supports or refutes the hypothesis. If the hypothesis has been falsified, alternate hypotheses should be suggested and tested. If the hypothesis is supported, the investigator suggests additional experiments to test and/or strengthen the hypothesis.

After a hypothesis has been thoroughly tested and the investigator is satisfied of the validity of the results obtained, he/she will communicate the results to other scientists. Preliminary results may be presented within a laboratory research group and at scientific meetings where the findings can be discussed. Ultimately, the completed project is presented in the form a of a scientific paper that is reviewed by scientists within the field, and then published in a scientific journal. Other scientists around the world will scrutinize the ideas, procedures, results, analysis, and conclusions. Because of this, **science is *self-correcting***, meaning that errors that may occur are usually discovered within the scientific community.

Scientific communication, whether written or verbal, is essential to the advancement of scientific knowledge. During this laboratory course and in lecture, you will be asked to present and interpret your results before your group and/or the entire class. Moreover, you will write components of a scientific paper for a few of the laboratory investigations. *A complete scientific paper or an oral presentation of an in-depth scientific investigation will be required of you later in the quarter*.

Materials (per group of four students)

Computer	Heart Rate Monitor program
Serial Box Interface	Stepping platform, 9 inches high
Vernier Heart Rate Monitor	Metronome

Caution !!

- Do not attempt this exercise if physical exertion will aggravate a health problem.
- Inform your instructor of any possible health problems that might be affected if you participate in this exercise.

Procedure

Developing a Question, Hypothesis, and Experimental Procedure

1. In teams of 4, take about 10 minutes to discuss several specific questions about an independent variable related to cardiovascular fitness. For example, you might ask: "Is there a difference in cardiovascular fitness between smokers and non-smokers? Select your group's best question and propose a testable hypothesis.
   - *Note:* Cardiovascular fitness will be assessed by determining and comparing the heart rate while standing, reclined, going from a reclined to a standing position, and before and after physical activity as outlined in steps 5 - 25, below.
2. Write your group's best question and hypothesis on the ***Lab Report Sheet*** at the end of this lab handout and contribute your group's question and hypothesis to the ***Class List*** on the front board or overhead projector.

3. **As a class.......**
    - Determine which question the *entire* class will attempt to answer. Record the question on the ***Lab Report Sheet***.
    - Develop a *testable* hypothesis of the "If....., then....." variety. Record on ***Lab Report Sheet***..
    - Design an experiment that will test this hypothesis. ***All teams will perform the same experiment.*** List in numerical order each step of the experimental design beginning with the recruitment of one test subject for each treatment category. Remember to designate group members to make the various measurements and to record the data obtained. List the steps of the experimental design the on ***Lab Report Sheet***..
4. Each group should recruit one subject for treatment 1 and another subject for treatment 2. Test subjects will take turns being tested. The other students in the group will serve as investigators. When being tested, one of your partners should record your data on *your* lab report sheet.

Setting up the Heart Rate Sensors

5. Prepare the computer for data collection by opening the ***Biology with Computers*** software as follows: Plug the hand held heart rate sensors into the Go-Link connector. Go to my computer → click on classes on madrona → Science → Classes → *Logger Pro* → Experiments → Biology with Computers → open "Exp. 27" Heart Rate & Fitness.
6. Have your first test subject stand calmly and grasp the sensors with the arrow on the sensor and the arrow on the receiver both pointing *upwards*. Click the **COLLECT** button and continue collecting until the test subjects' heart rate is steady and within the normal range for the individual—usually between *55 and 85 beats per minute*. It may take a minute or two for readings to stabilize with certain individuals. In such cases, allow the readings to stabilize before starting data collection.
7. Click on the **STOP** button to stop data collection when you have determined that all equipment is functioning properly.
8. To obtain the ***average heart rate***, ***maximum heart rate***, etc.: Select "***Analyze***" on the menu bar at the top of the screen and click on ***Statistics*** this will place a table onto the graph.
9. Erase the data from this run and begin the experiment with your first subject.

Measurement of the Resting Heart Rate while Standing

Please Note!	Half of the groups in the class should carry out steps 10-25 with a subject for treatment category 1, the other half with a subject for treatment category 2. After step 25, each group should repeat steps 10-25 with a subject representing the treatment category they have yet to test.

10. Instruct the test subject to calmly stand upright, and then begin taking data with the Heart Rate Monitor program. Wait until the heart rate becomes stabile, and then ***record the subject's heart rate in Table 6 on the Lab Report Sheet.***
11. Compare the subject's standing heart rate to the values in Table 1. Assign fitness points based on Table 1 and ***record the points in Table 6.***

Table 1. Fitness Points for Standing Heart Rate

Beats/min	Fitness Points	Beats/min	Fitness Points
<60–70	12	**101–110**	8
71–80	11	**111–120**	7
81–90	10	**121–130**	6
91–100	9	**131–140**	4

Measurement of the Resting Heart Rate while Reclined

12. Instruct the subject to recline on a *clean* table with their feet on the table and knees bent. Wait until the heart rate becomes stabile, and then ***record the subject's heart rate in Table 6 on the Lab Report Sheet.*** The subject should remain reclined until step 14.
13. Compare the *subject's average reclining heart rate* to the values in Table 2. Assign fitness points based on Table 2 and ***record the points in Table 6.***

Table 2. Fitness Points for Reclining Heart Rate

Beats/min	Fitness Points	Beats/min	Fitness Points
50–60	12	**81–90**	8
61–70	11	**91–100**	6
71–80	10	**101–110**	4

Measurement of the Heart Rate Change from Reclining to Standing

14. Instruct the test subject to quickly stand up next to the lab table and remain still. ***Measure the subject's peak heart rate upon standing and then record it in Table 6.***

15. Find how much the heart rate increased after standing by subtracting the reclining rate value in Step 12 from the peak standing value in step 14. Locate the row corresponding to your reclining heart rate in Table 3 and use the heart rate increase value to obtain fitness points. ***In Table 6, record the fitness points.*** Stop data collection in the Heart Rate Monitor program.

Table 3. Fitness Points for Reclining to Standing

Ave. Reclining rate (beats/min)	Heart Rate Increase after Standing				
	0–10	**11–17**	**18–24**	**25–33**	**34+**
50–60	12	11	10	8	6
61–70	12	10	8	6	4
71–80	11	9	6	4	2
81–90	10	8	4	2	0
91–100	8	6	2	0	0
101–110	6	4	0	0	0

Step Test

16. Have the test subject stand, and then begin collecting heart rate data. Wait until the heart rate becomes stabile, and then ***record the subject's heart rate in Table 6 on the Lab Report Sheet.***

17. While holding the computer interface box and the sensor cord the test subject will step up and down on a low platform about 8 to 10 inches from the ground as follows:
    - Place the right foot on the top step of the stool.
    - Place the left foot completely on the top step of the stool next to the right foot.
    - Place the right foot back on the floor.
    - Place the left foot back on the floor.
    - Repeat the above stepping cycle for 3 minutes

18. Use the cassette tape of a metronome set at 96 beats per minute to ensure that all subjects maintain a constant step rate. The test subject should make one-foot movement for each beat of the metronome. The step exercise should be performed for 3 minutes at a rate of 24 stepping cycles per minute: (4 foot movements/stepping cycle) x (24 stepping cycles/min) = 96 bpm

19. ***Record in Table 6 the subject's average heart rate after 3 minutes of exercise.*** When the subject has completed the step exercise, quickly move to Step 20.

Recovery Time

20. With a stopwatch or clock, begin timing to determine the test subject's recovery time. During the recovery period, the test subject should remain standing and still. Monitor the heart rate and stop timing when the rate returns to the standing heart rate value before the start of the step test (recorded in Step 16). ***Record the recovery time in Table 6.***

21. Assign fitness points based on the information below and Table 4. ***Record the fitness point value in Table 6.***

Table 4 Fitness Points for Recovery Time

Recovery Time (seconds)	Fitness Points
0–30	14
31–60	12
61–90	10
91–120	8
121-150	6
> 150	4
Heart rate stabilized at a higher rate than the average standing value before starting the step test	6
Heart rate did not fall to within 6 to 10 beats/min. of the initial rate within 150 seconds after the cessation exercise	4

Table 5 Fitness Points for Endurance

Standing rate (beats/min)	Heart rate increase after exercise				
	0–10	**11–20**	**21–30**	**31–40**	**41+**
60–70	12	12	10	8	6
71–80	12	10	8	6	4
81–90	12	10	7	4	2
91–100	10	8	6	2	0
101–110	8	6	4	1	0
111–120	8	4	2	1	0
121–130	6	2	1	0	0
131+	5	1	0	0	0

Step Test for Endurance

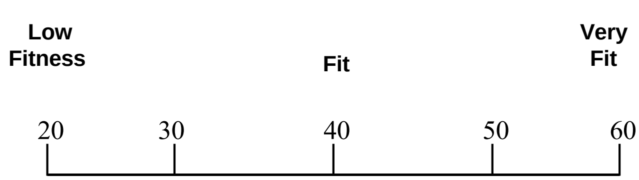
22. Subtract standing heart rate before exercise (from Step 16) from the average heart rate during exercise (step 19). Record this ***heart rate increase in the endurance row of Table 6.***

23. Assign ***fitness points based on Table 5 (on next page) and record the value in Table 6***. Locate the row corresponding to the test subject's standing heart rate in Table 5, and use the heart rate increase value to obtain fitness points.

24. Repeat steps 5 - 25 with a test subject of the treatment category that your group has yet to test. One or more of your group members may do step 25 (on the next page) while you are evaluating your group's second subject.

25. Total all the fitness points recorded in Table 6. Determine the fitness level of the subject using the scale below.

Fitness Scale



Never take life too seriously…
Nobody gets out alive anyway! ☺

The other day I told my wife that a husband
is like a fine wine—he gets better with age.
The next day, she locked me in the cellar! ☹

Lab 1 Report Sheet
Heart Rate, Physical Fitness and the Scientific Method
Biol 211

Name ____
Group Number _______ **Date** _________________

Note: Neatly complete this lab report sheet as your group conducts the procedure in lab.

Question, Hypothesis, and Procedure

2. **Your group's best question:**

   Hypothesis:

3. **Question selected by the class to investigate:**

   Hypothesis proposed by the class:

   Summary of the experimental procedure designed by the class:

Components of the experiment designed by the class

- Dependent variable(s):
- Independent variable(s):
- Controlled variables:
- Control treatment (*Hint*: What will you compare the heart rate to after each test?):
- Level of Treatment for the step test:
- Replication (*Hint*: How many times will each subject be tested?):

Results

Table 6A.												
Treatment 1: **Name and number of subject your group tested:**												
Condition	**Heart Rate or Time for Subject No.**						**Fitness Points for Subject No.**					
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
Standing heart rate (beats/min)												
Reclining heart rate (beats/min)												
Peak heart rate upon standing (beats/min)												
Standing heart rate just before step test (beats/min)												
Ave. Heart Rate during step test (beats/min)												
Recovery time (seconds)												
Endurance (beats/min)												
	Total fitness points											
	Average total fitness points for treatment 1											

Misc. Notes and Observations:

Table 6B.												
Treatment 2: **Name and number of subject your group tested:**												
Condition	**Heart Rate or Time For Subject No.**						**Fitness Points For Subject No.**					
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
Standing heart rate (beats/min)												
Reclining heart rate (beats/min)												
Peak heart rate upon standing (beats/min)												
Standing heart rate just before step test (beats/min)												
Ave. Heart Rate during step test (beats/min)												
Recovery time (seconds)												
Endurance (beats/min)												
	Total fitness points											
	Average total fitness points for treatment 2											

Misc. Notes and Observations:

Exercice 1. Summary of Data in a Table and in narrative form (See page 10 for an example)

Using the data from this experiment, design a summary table to present the results for *one* of the *dependent variables*. See Table 1 on page 4 for a sample table. (Your table need not be the same size or design as the example on page 4!) Provide a title for your table, include the units for all variables, and indicate how many replications were used to calculate the averages.

a) **Table**

b) **Narrative summary.** Write a paragraph that summarizes the results displayed in your table, above.

Exercise 2. Summary of data with a graph and in narrative form

a.) Using the data from your experiment and the grid below, design a graph that shows the relationship between the dependent and independent variables in this experiment. Discuss with your teammates how to design this figure so that it includes each of the following on the *same graph*:

- Total fitness points for *each test subject* for treatment 1 and the average total fitness points for treatment 1
- Total fitness points for *each test subject* for treatment 2 and the average total fitness points for treatment 2

Don't forget to determine if your data should be plotted as a bar graph or line graph: Look at the variables involved—are they discrete or continuous variables? See pages 5-6 for tips on how to make a proper graph. Ensure that each axis is labeled fully (including units of measure), and compose an informative title for this figure.

Exercise 2 (cont.)

b.) **Narrative Summary.** Write a paragraph that summarizes the results displayed in your graph on the previous page.

Exercise 3. <u>Additional figure and narrative summary of the figure</u>

a.) Design an additional figure that will assist with interpreting the results from your investigation. You might use the data for recovery time, difference in pulse rate before and after exercise, difference in pulse rate before lying down, etc. Draw, label, and compose a title for the figure on the grid below.

Exercise 3. (cont.)

b.) **Narrative Summary.** Now write a paragraph that summarizes the results displayed in your graph on the previous page.

Discussing and Communication Results

Exercise 4. Weaknesses and improvements

Using your tables and figures, analyze your results and discuss your conclusions with your group. What weaknesses do you see in the experiment? Suggest ways the experiment could be improved to correct for each of the weaknesses. *Record your response on in the table below*

Weaknesses in Experiment	**Improvement**
1.	
2.	
3.	
4.	

Exercise 5. Summary statement

Write a summary statement for your experiment. Your summary statement should address whether the results support or falsify your hypothesis, and discuss any flaws and/or weaknesses that may exist. Be sure to discuss specifically how the results support or falsify your hypothesis. ***Quote your results specifically***. It is not enough to say that "our results" support or refute the hypothesis. Rather, quote ***specific numerical data*** for heart rates, recovery time, fitness points, etc.
Your summary should address, but not be limited to, the following….

- Does the data support or refute the hypothesis proposed by the class? Explain. ***Quote specific numerical data from the investigation to support/substantiate your response.***
- What additional conclusions can be made from the results of this experiment? ***Quote specific numerical data from the investigation to support/substantiate your response.***
- Did the experiment have one, or more than one independent variable? Discuss the significance of your response.

Exercise 6. Additional hypotheses and the next experiment

Suggest additional and/or modified hypotheses that might be tested and briefly describe what your next experiment might be.

Application and Review Questions

1. Samples of the freshwater algae *Elodea* were placed in 0.5%, 1.0%, 1.5%, and 2.0% salt solutions, then examined under the microscope to determine the effect the salt solutions have on the *Elodea* cells. What would be a suitable control treatment for this investigation?

2. Why is it important that an experiment has only one independent variable? Can an experiment have more than one dependent variable? Explain.

3. How did the heart rate change after moving from a standing position to a reclining position? By how much did heart rate change? Is this what you expected? Explain.

   How do you account for this change? (<u>Hint</u>: don't forget about gravity!)

4. Current research indicates that most heart attacks occur as people get out of bed after sleep. Account for this observation in light of your experimental findings in this experiment. ? (<u>Hint</u>: don't forget about gravity!)

5. Why is science said to be "self-correcting"?

Lab 1: Prelab Questions **Name** ______________________________
Physical Fitness and the Scientific Method **Group Number** ______ **Date** __________
Biol 211

Note: Do the prelab reading at the beginning of this lab handout on the scientific method *before* attempting to answer the questions that follow! Be prepared to hand in and/or discuss these questions at the start of the lab session.

Asking Questions: Circle the number of each of the following questions that can be answered *scientifically*. Explain *briefly* how you came to your decision in each case.

1. Does excessive exposure to electromagnetic radiation produced by high voltage power lines cause an increased risk of cancer in humans?

2. Did the 75-year-old man get skin cancer because of his high exposure to ultraviolet light while sailing to and from Hawaii every summer vacation?

3. Does good nutrition (as defined by the FDA guidelines) lead to higher intelligence?

Developing Hypotheses: Restate each of the following hypotheses as "If... then..." statements

4. Hypothesis: Students that attend class regularly usually get better grades than those with poor attendance.

5. Hypothesis: The application of fertilizer to apple trees each spring may result in better apple production.

Write a testable hypothesis for each of the following questions. Use the "If... then..." format for each of your hypotheses.

6. Why is the rate of skin cancer higher today than it was 100 years ago?

7. Why are there more women biologists today than 35 years ago?

Circle the number of each of the following hypotheses that can be tested *scientifically*. Explain *briefly* how you came to your decision in each case.

8. The first dinosaurs appeared about 230 million years ago and then became extinct about 65 million years ago.

9. A global climatic cooling is responsible for the extinction of Dinosaurs.

Major Components of an Experiment: Complete the following statements.

10. Variables that are held constant during an experiment so that they don't impact the results of are known as ____ .
11. The appropriate values used for the independent variable is the ______________________________ .
12. The variable that the investigator measures, counts, or observes is the ______________________ .
13. The treatment that removes the independent variable or sets at its standard value is known as the ____ .
14. A tentative answer to a question is called a ____ .
15. The variable that the investigator varies in the experiment (e.g. humidity, temperature, concentration, etc.) is the ____ .

Independent vs. Dependent Variables

Identify the independent and dependent variables in the following experiments

16. Number of coddling moths visiting the yellow, blue, and green pheromone traps

    Dependent variable:

    Independent variable**:**

17. Pea plant height measured daily for 30 days

    Dependent variable:

    Independent variable:

18. Number of leaves found on pea plants 5 days after having been treated with gibberellic acid

    Dependent variable:

    Independent variable:

Control Treatment: Suggest a control treatment for each of the following experiments.

19. Pea plants are sprayed with an aqueous solution of gibberellic acid and their height determined daily after the spraying.

    Control treatment:

20. Pulse rate is determined after 3 minutes of aerobic exercise.

    Control treatment:

Line vs. Bar Graphs: Indicate if the data obtained in the following experiments should be plotted as a line graph or a bar graph. *Briefly* explain your reasoning.

21. Number of coddling moths visiting the yellow, blue, and green pheromone traps.
    Line graph or **Bar Graph**? (circle one) **Why?**

22. Pea plant height measured daily for 30 days.
    Line graph or **Bar Graph**? (circle one) **Why?**