Exercise 1 LABORATORY

Measurement in Science

Introduction

Science is the study of physical phenomena. The human body and its structure and function fall within the realm of scientific investigation. The science of **human anatomy** involves the understanding of the structure of the human body, while **human physiology** is the study of the function of the body. There are many different ways that people can achieve an understanding of anatomy and physiology. Some of these have been described in a process known as the **scientific method.**

The beginning of the scientific understanding frequently begins with a question. An example of a question might be how the body digests food. The next part in this understanding frequently involves the development of a **hypothesis,** a testable proposal that seeks to explain a scientific question. The test done to prove or disprove the hypothesis is usually done in the form of an **experiment.** A more lengthy discussion of the scientific method is provided in your lecture text in chapter 1 "Major Themes of Anatomy and Physiology."

Much of science involves measurement and collecting **data.** Experimental data are the pieces of information or "facts" obtained and later examined to support or reject the proposed hypothesis. In this exercise you collect data and examine how to graph data so that the information becomes more comprehensible. You will also look at what type of measurement is done in science.

Objectives

At the end of this exercise you should be able to

1. describe the advantages of the metric system over the U.S. customary system;
2. define independent variable and dependent variable;
3. list four base units of the metric system;
4. convert fractions into decimal equivalents;
5. collect and graph data taken in class;
6. determine some factors involved in experimental error.

Materials

Meter stick
Small metric ruler (30 cm)

Procedure

Measurements in Science

Members of the scientific community and people of many nations of the world use the **metric system** to record quantities such as length, volume, mass (weight), and time. This is because the metric system is based on units of 10, and conversion to higher or lower values is relatively easy when compared to using the U.S. customary system. For example, assume you are working on a bicycle and are using a ½-inch wrench. If you need a larger wrench you move to a 9/16-inch, then a ⅝-inch, then an 11/16-inch, or perhaps as large as a ¾-inch wrench. This requires a bit of computation as you move from one size to the next. On the other hand, if you are using the metric system and a 12-millimeter (mm) wrench is too small, you progressively move to a 13 mm, 14 mm, or 15 mm wrench.

The same idea can be applied to volume, temperature, or weight. In the case of volume, there are 8 ounces per cup, and 128 ounces per gallon. The calculation for the number of ounces in 7 gallons is a little cumbersome (7 gallons × 128 ounces). In the metric system, there are 1,000 milliliters in 1 liter so there are 7,000 milliliters in 7 liters. The conversions are much easier. Medical dosages are given frequently in milliliters or cubic centimeters (cc). One milliliter occupies one cubic centimeter and so these values are interchangeable.

You can use the metric system to measure four quantities—length, volume, mass, or time. Examine table 1.1 and compare the quantity, base unit, and U.S. equivalent.

If the quantity measured is much larger or smaller than the base unit, then the base unit can be expressed in multiples of 10. For example, if you had one thousand grams (1,000 grams),

Table 1.1 Metric System and Equivalents

Quantity	Base Unit	U.S. Equivalent
Length	Meter (m)	1.09 yards (39.4 inches)
Volume	Liter (l)	1.06 quarts
Mass	Gram (g)	.036 ounces (1/454 of a pound)
Time	Second (s)	Second

Table 1.2 Decimals of the Metric System

Name	Description	Multiple/Fraction		Scientific Notation
Kilo	One thousand times greater		1,000	1.0×10^3
Deca	Ten times greater		10	1.0×10^2
Base Unit				
Deci	One-tenth as much	1/10	0.1	1.0×10^{-1}
Centi	One-hundredth as much	1/100	.01	1.0×10^{-2}
Milli	One-thousandth as much	1/1,000	.001	1.0×10^{-3}
Micro	One-millionth as much	1/1,000,000	.000001	1.0×10^{-6}
Nano	One-billionth as much	1/1,000,000,000	.000000001	1.0×10^{-9}

then you would have a **kilo**gram. If you had one thousandth of a gram (1/1,000 gram), you would have a **milli**gram. Examine table 1.2 as you answer the following questions:

What is 1/100 gram? ________________

What is 1,000 seconds? ________________

What is 10 meters? ________________

What is 1/1,000,000,000 liter? ________________

As you can see from table 1.2, some measurements in science are very small. For example, the amounts of hormones circulating in the blood are very minute. To provide a shortened notation of very large or small numbers we use scientific notation. A number such as 60,000 is written as 6×10^4. You move the decimal point four places to the left and thus the superscript above the ten is a four. Write 6,000 in scientific notation __________. For very small numbers, the superscript is written as a negative number. The number 0.00006 is written as 6×10^{-5}, as you move the decimal point five places to the right. Convert the following numbers into scientific notation:

4,300,000 __________

0.000034 __________

2,200 __________

0.0019 __________

Working in the science lab requires you to focus on the procedures and materials at hand. You may work as part of a group in some labs, and it is important that you read your lab material before coming into the lab. Some of the materials you work with may be dangerous, and a thorough, prior knowledge of the lab exercise will ensure a safer lab.

Pay attention to the experiment and what is to be done and when. Casual observation and carelessness may lead to incorrect results. Establish a procedure for conducting experiments. If you are working with one or more lab partners, divide responsibilities before the experiment begins. If you are responsible for a particular portion of the experiment, make sure your lab partners see the results. Make a careful record of the results of your experiment.

Be honest. Fudging data is not tolerated in the scientific community. Record your data as you measure it. If your results do not seem to be what they should, then discuss this with your instructor. Never record data that you think you *should* get but rather *record the observed data.*

Correlation Between Leg Length and Height

In this part of the exercise, you will look for a correlation between the length of the leg and the overall height of the individual.

Make a hypothesis about any relationship between leg length and height.

Record your hypothesis in the following space.

By graphing data you can more easily see trends present in a sample size. One problem in sampling is that you need to have a large enough number to have a valid sample. Let's suppose that one-half of the basketball team is enrolled in your lab section. This might have a rather unusual effect on your graph (see figure 1.1). On the other hand, if you are able to sample your entire school, the effects of the basketball players' sizes would be minimized (see figure 1.2).

Your lab partner should measure the length of your leg from the back of the knee to the bottom of your heel. To do

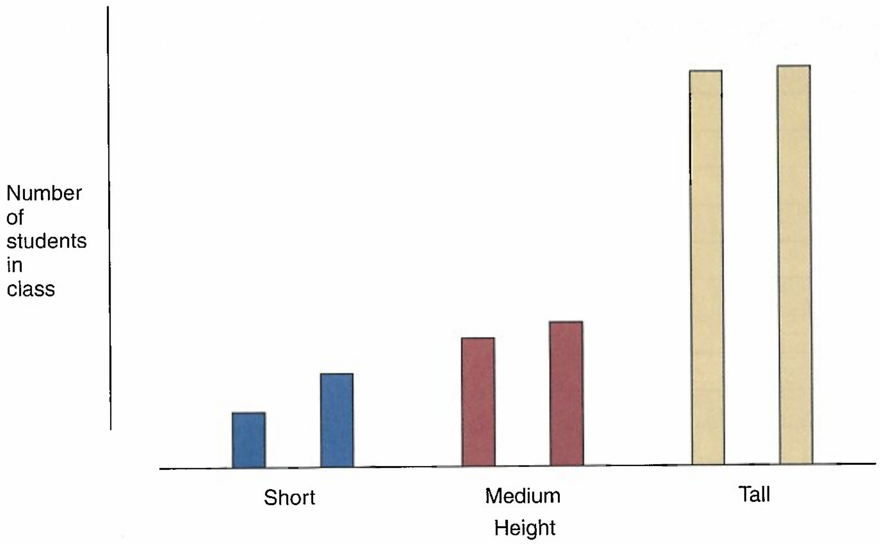


Figure 1.1
Distribution of Students in a Class

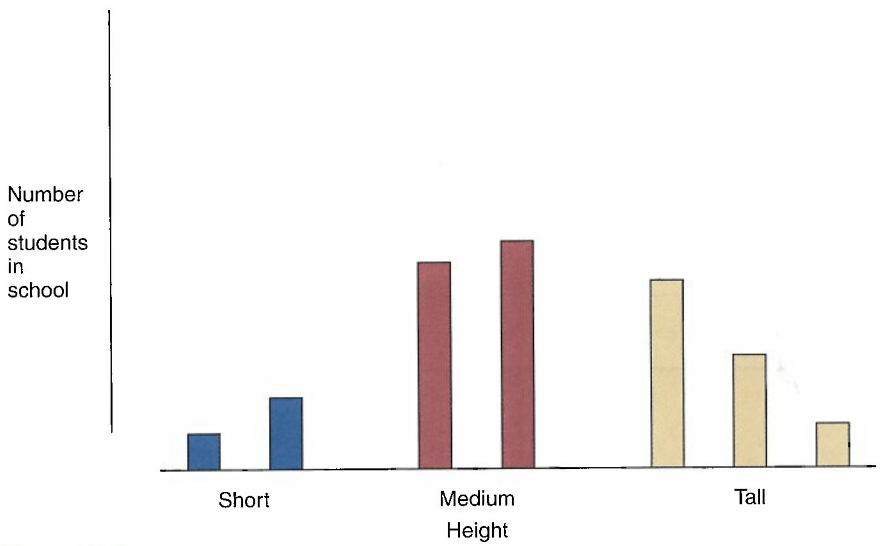


Figure 1.2
Distribution of Students in Entire School

Figure 1.3
Measurement of Leg Length

this, kneel on a chair with the thigh vertical and the back of the calf at a 90 degree angle to the thigh (figure 1.3). Place a meter stick along the outside (lateral) edge of the back of your calf. You should feel a tendon, which is the tendon of the biceps femoris muscle. Make sure that the meter stick is just at the edge of the tendon, and record the distance, in centimeters, from this tendon to the bottom of your heel.

Length (cm) between tendon and heel: ____________

Now record your overall height in centimeters. Determine this value directly. Have your lab partner measure your height against a wall in the lab, after removing your shoes.

Overall height in centimeters: ____________

Determine the distribution of the entire class in terms of leg length. Give your data to other members of the class to record in chart 1. Plot the length of the leg on the x-axis (the independent variable is plotted on the horizontal x-axis) and the overall height of the individual on the y-axis (the dependent variable) to see if leg length determines overall height. Is there a correlation?

Plot the distribution of leg length and overall height on chart 2 on page 6.

For every 5-centimeter change in leg length, what is the approximate change in height?

Range and Mean in Measurements

The extremes of measurement, which represent the longest and shortest measurements, represent the **range** of the measurements. Using the values obtained by members of your lab class, record the range of the leg length in centimeters for the entire class.

Chart 1 Leg Length and Height Data

Student Number	Leg Length (cm)	Height (cm)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		

Longest value: ______________

Shortest value: ______________

The **mean** leg length of the class is the average length for the group. Using the data obtained for the leg lengths, add all of the values together (the sum of the leg lengths) and divide that number by the number of individuals in the class. This is the mean leg length. Record the number in centimeters.

Mean leg length: ______________

Measurement and Experimental Error

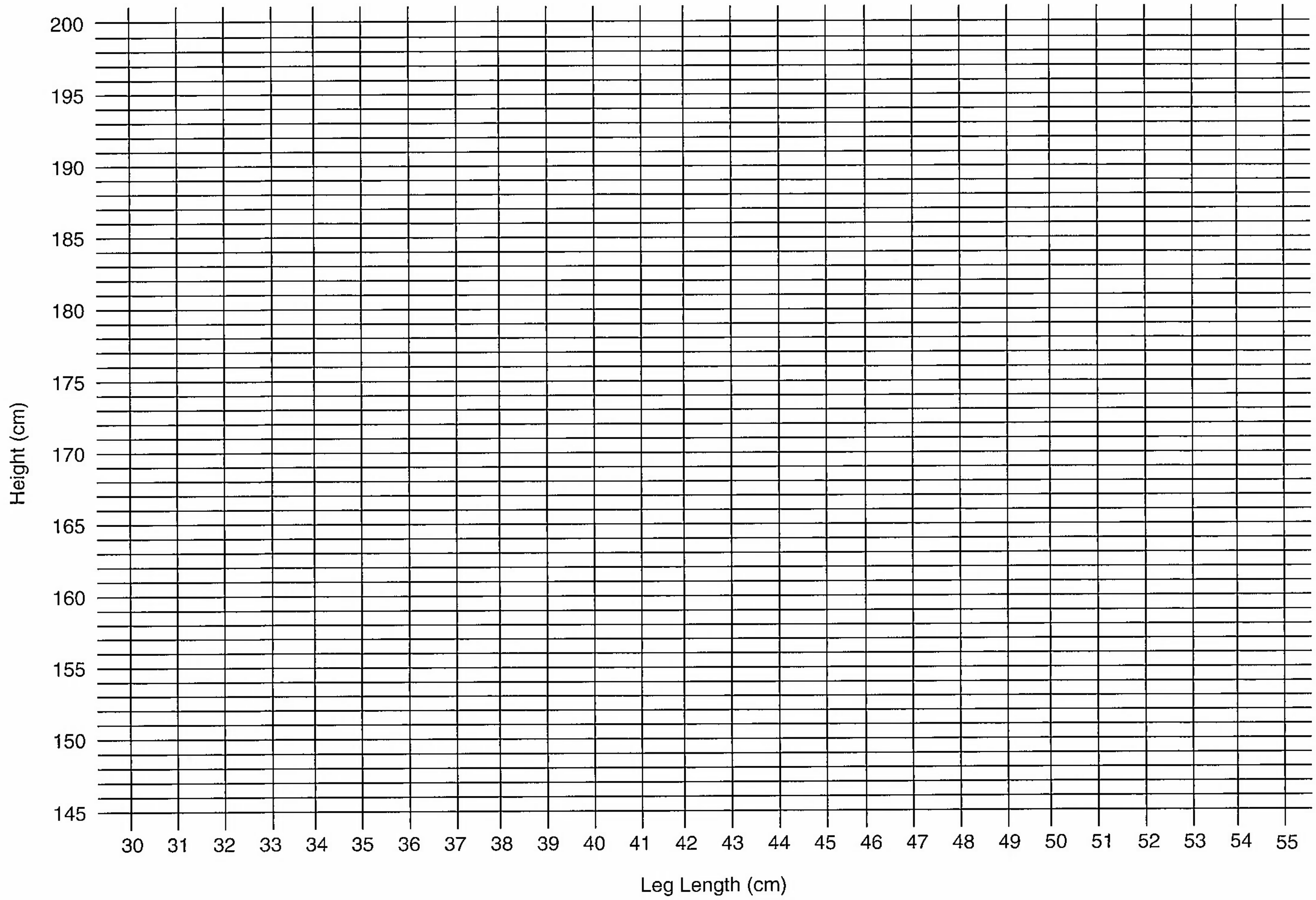
In this part of the lab, all members of the lab will take a measurement of a single individual's hand. You should perform the next exercise by following these directions.

1. Select *one* person in your lab class who will serve as the experimental subject for this section of the lab.
2. Everyone in the lab should take a metric ruler from the lab table and measure the length of the hand of the selected subject. To obtain individual results, the measurements should be conducted alone and the results recorded without any discussion with classmates.
3. With a ruler, measure the test subject's hand from the wrist to the tip of the middle finger and record this value in millimeters.

   Length of the hand in millimeters: ______________

4. After everyone has made a measurement and entered the data in his or her lab book, every individual in the class should write his or her results on the board.

Chart 2 Distribution of Leg Length and Height



In chart 3, record all of the data from the class.

Chart 3

Length of hand in millimeters:

If everyone measured the same person, all of the values should be the same. Was this the case in your lab?

If this was not the case, what are some reasons why the measurements were different?

If you were to do this experiment again, how would you change the procedure to try to get a more accurate recording of lengths among the people measuring the subject's hand?

Notes

Exercise 1

REVIEW

Measurement in Science

Name ______________________________ Date ____________

1. In terms of base units
   a. What is the base unit of length in the metric system?
   b. What is the base unit of volume in the metric system?
2. How many cubic centimeters are there in 200 milliliters?
3. Assume a pill has a dosage of 350 mg of medication. How much medication is this in grams?
4. How would you write 0.000345 liters in scientific notation?
5. How many milligrams are there in 4.5 kilograms?
6. How many meters is 250 millimeters?

7. If given a length of 1/10,000 of a meter
   a. convert this number into a decimal:

   b. convert it into scientific notation:

8. Use a word to describe
   a. one thousandth of a second:

   b. one thousand liters:

   c. one hundredth of a meter:

9. According to your graph, predict how tall a person would be if his or her leg length was 37 cm. How tall do you predict this person would be if the individual had a leg length of 48 cm?

10. If you were to do a new experiment, what do you estimate the relationship between the *length of the arm* and the *overall height* of an individual to be?

11. In the case of arm length and overall height, which is the independent variable and which is the dependent variable?

12. What was the range in values for the hand length measured in lab?