The Scientific Method

The scientific method is the method that virtually every scientist uses in his/her research. It is a type of logic that allows one to start at the current level of knowledge and with appropriate observations, extend that body of knowledge. By application of this method, Francisco Redi in the 1600's was able to conclude that living things came only from existing living things (instead of by spontaneous generation). In the 1800's, Louis Pasteur was able to prove that certain microbes caused a specific disease such as anthrax.

When applied, this method can vary somewhat and is flexible. The general parts are:

1. Hypothesis: This is a statement of association (or independence) that is either rejected or failed to be rejected. This can be tested by further investigation.
2. Method: This is the design of the experiment so that appropriate observations can be made.
3. Materials: Those things that are needed in order to conduct an experiment.
4. Experiment and observations: This is the actual experiment and the place where observations are made. Usually this involves accurate measurements and the collection of information or data.
5. Analysis: This is the examination of the observations. Frequently this analysis of observations is done with the help of a statistical analysis.
6. Conclusion: This is the step where the question posed in the hypothesis is answered. That is, you have either rejected or failed to reject the hypothesis.

Notes on the scientific method:

Measurement

You will note that very good measurements are required in the "experiment and observations" portion of the scientific method. The ability to analyze data mathematically is required in the "Analysis" portion of the scientific method. For this reason, several types of calculations and units of measurement will be discussed. It is also important students learn the basic math skills necessary to fully participate in the laboratory activities.

Exercise 2. Units of Measure

When describing anything using numbers, there is something called the unit of measurement. This follows after the number. The unit tells what the number means. It answers the question, "How much of what?" To put it differently, the number is an adjective that tells you how much; and the unit is the noun that the number modifies. The unit tells you what you are dealing with. Table 1.1 relates types of measurements with units that are commonly used.

Table 1.1: Types and Units of Measurement

Types of Measurement	Common Units
Mass	ounce, pound, ton, gram, kilogram
Length	foot, mile, meter
Volume	gallon, liter, cubic meter
Time	second, hour, day, year, century
Energy	British thermal unit, joule, kilojoule, calorie, kilocalorie
Velocity	miles/hour, meters/second
Pressure	pounds/square inch, pascal
Temperature	degrees Celsius, degrees Fahrenheit

You will note that when you are describing the number of kilocalories or calories in a food, you are really talking about the amount of energy in a food.

Note: Generally, the world uses the metric system of measurement. The United States is the only industrialized country to still use the English system of measurement (for example, pounds, tons, miles, gallons, British Thermal Units or BTUs, et cetera). However, the United States is very slowly switching to the metric system (for example, gram, meter, liter, calorie, et cetera). On a worldwide basis, the trend is to adopt the "Systems International" (SI). This is a refinement of the metric system units of measurement. This involves using only selected prefixes and units from the metric system.

A very good habit to develop is to **always** write the unit of measurement after **every** number in formulas and calculations. This also gives a meaning to the number. Anothr reason is you can also calculate the unit answer in addition to the number answer. This is done by the process of dimensional analysis. The important things to remember are, common units are added subtracted, multiplied, and divided just like numbers. Some examples below:

If you ate a lunch of soup and bread where the soup contains 246 Kcal and the bread has 123 Kcal, how many Kcal did you eat in that meal?

246 Kcal + 123 Kcal = 492 Kcal

Since both items are expressed in Kcal, you may add these to get the total energy content or Kcal of the meal.

To convert your weight from pounds to kilograms: There are 2.2 lbs. per Kg and if you weigh 125 lbs. how many Kg do you weigh?

125 lbs. divided by 2.2 lbs./Kg = 56.8 Kg (lbs. will cancel out, leaving you with Kg)

if you weigh 80 Kg, your weight in lbs. will be

80 Kg X 2.2 lbs./Kg = 176 lb. (Kgs cancel out leaving you with lbs.)

EXAMPLE: Energy from ethyl alcohol

Among heavy drinkers, the amount of ethyl alcohol consumed each day is 140 grams per day (about 5 drinks or cans of beer). The amount of energy from each gram of ethyl alcohol is 7 kilocalories/gram. The daily amount of energy from ethyl alcohol is:

$$\frac{140 \text{ grams}}{\text{day}} \times \frac{7 \text{ kilocalories}}{\text{gram}} = \frac{140 \cancel{\text{grams}}}{\text{day}} \times \frac{7 \text{ kilocalories}}{\cancel{\text{gram}}} = 980 \text{ kilocalories/day}$$

Grams are in both the numerator and denominator and they divide out (cancel). This leaves kilocalories per day as the unit of measure that you want as the answer to the question.

EXAMPLE: Determining number of heartbeats in a day

When the number of heartbeats is 70 beats per minute (bpm), determine the number of times a heart beats in a 24-hour period:

$$\frac{70 \text{ beats}}{\cancel{\text{minute}}} \times \frac{60 \cancel{\text{minutes}}}{\cancel{\text{hour}}} \times \frac{24 \cancel{\text{hours}}}{\text{day}} = 100{,}800 \text{ beats per day}$$

Minutes and hours are in both the numerator and denominator and they divide out (cancel). This leaves beats per day as the unit of measure that you want as the answer to the question.

Exercise 2. Units of Measure Data Sheet

1. Calculate the unit of measurement for distance traveled by train per day from the following:

$$\frac{65.0 \text{ miles}}{\text{hour}} \times \frac{24 \text{ hours}}{\text{day}} = \underline{\qquad\qquad}$$

(don't forget the unit of measurement)

2. Calculate the unit of measurement for volume of air inhaled or exhaled in a day from the following.

$$\frac{4.2 \text{ liters}}{\text{breath}} \times \frac{8 \text{ breaths}}{\text{minutes}} \times \frac{60 \text{ minutes}}{\text{hour}} \times \frac{24 \text{ hours}}{\text{day}} = \underline{\qquad\qquad}$$

(don't forget the unit of measurement

3. Mark weighs 85 Kg, how much does in weigh in pounds?

85 Kg X 2.2 lbs./Kg = ____________

(don't forget the unit of measurement)

NOTE: You must include the proper unit(s) of measurement with each numerical answer in every laboratory assignment.

Application of the Scientific Method: An Epidemiological Study

Introduction

Epidemiologists are public health professionals who attempt to relate a disease outbreak with the cause(s) of the disease. Epidemiology is really a method of thinking about disease and disease causation. One important part of this method is that epidemiology deals with groups of people instead of individuals.

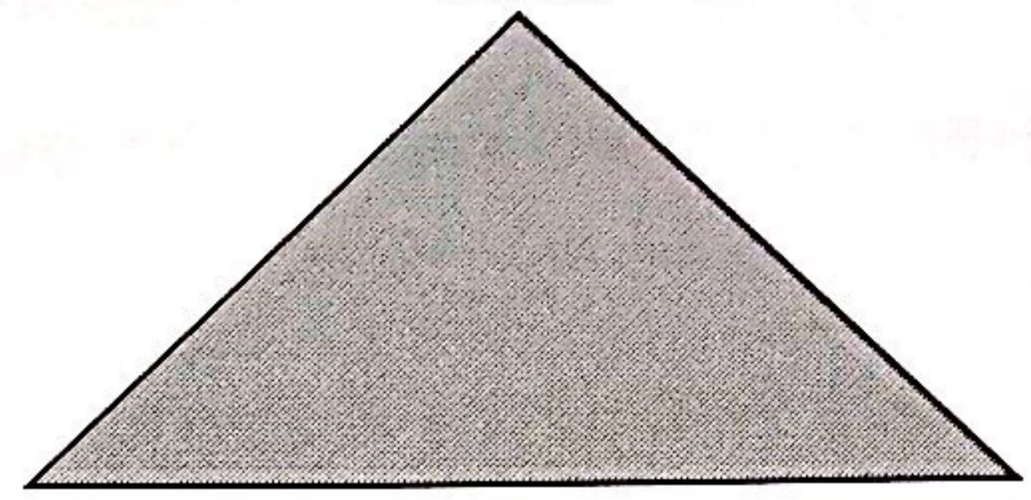
Epidemiology is defined as "the study of the distribution of disease or physical conditions in human populations and of factors that influence this distribution."

In recent years, as the focus of morbidity and mortality studies in humans has shifted from infectious diseases to chronic, degenerative diseases, there has evolved the concept of Behavioral Epidemiology. **Behavioral Epidemiology** can be defined as the study of the distribution and determinants of behaviors that influence diseases and injuries in human populations.

The integration of classical epidemiology and behavioral epidemiology is demonstrated when we look at sexually transmitted diseases. For each of the specific diseases, there is a causative agent that epidemiologists can isolate in infected persons and there are behaviors that increase/decrease an individual's risk of exposure to the infectious agent.

Throughout the course of this quarter, we will focus on factors that affect human health status, which can be traced and/or quantified by both classical and behavioral epidemiologists. Relationships between behaviors and diseases are often complex. Some behaviors may maintain health (for example, consuming adequate dietary fiber); others may threaten it (for example, consuming an excessive amount of dietary fat). Some behaviors may have a great influence on the incidence of a given disease (for example, cigarette smoking and lung cancer); other behaviors may have a comparatively small influence (for example, saccharin consumption and bladder cancer). Evidence associating some behaviors with certain diseases may be substantial (for example, excessive cholesterol consumption and atherosclerosis); whereas evidence associating other behaviors with certain diseases may be more tenuous (for example, sodium consumption and high blood pressure). Behaviors also vary with regard to their influence in human health and disease because of the severity of the disease, the prevalence of the behavior in the population, the incubation period of the disease in question and whether the behavior contributes to only one disease or acts synergistically with other behaviors or agents to influence several diseases.

Nearly all epidemiological studies however, involve three major factors in relationship to disease causation. The first is the **host**, who carries the disease. The second is the **agent**, the material that causes the disease. The third is the **environment**. Frequently something in the environment contributes to a disease outbreak when the host and the agent come together in some way. These relationships are illustrated as follows:



This means that for a given disease, there must be an interaction between the host or hosts, the agent, and the environmental factor(s). The following exercise will demonstrate these relationships.

Exercise 3. Special Study in Epidemiology

Coyote Manufacturing is a printing company that produces textbooks for nationwide distribution. Coyote Manufacturing is located in the city of San Bernardino, California and has between 40 and 60 employees at any given time.

Every summer, the management staff provides a picnic for all of its employees. The purpose of the picnic is to improve employee morale and allow the management staff to say, "thank you" for the previous 12 months of work. Employees are given the afternoon off, with pay, but are not required to attend the picnic. This year, the picnic was held on Friday, June 10 and 35 employees attended the gathering.

Management staff provided the paper goods, plastic utensils, napkins and beverages. The menu was developed by management staff but catered by Roadrunner Catering Services with the exception of the dessert. One of Coyote Manufacturing's employees offered to provide ice cream.

The picnic began about 12:00 pm in a nearby park. The menu included baked chicken, potato salad, shrimp salad, tossed green salad and ice cream. Drinks included soda and canned fruit juices. Employees began eating about 12:30 pm and when they had finished, they played softball, volleyball and badminton. The picnic ended at approximately 5:00 pm.

The following Monday (June 13), a number of employees who had attended the picnic complained of illness late Friday evening and early Saturday morning. Predominant symptoms included nausea and diarrhea. No one called in sick that morning. Management staff immediately contacted the San Bernardino County Department of Public Health and asked for guidance.

Epidemiologists developed a standardized questionnaire for all those in attendance (cases and non-cases) and Communicable Disease Investigators were dispatched to obtain medical and food histories. Attendees who reported being ill were asked to submit stool specimens.

Registered Environmental Health Specialists from the Environmental Community Health Program visited Roadrunner Catering Services to determine where the raw food was purchased and how the individual foods were prepared, transported and stored prior to serving. They also determined whether or not any food samples remained from the picnic.

Preliminary Findings

The Department of Public Health staff were able to determine the following:

- Sixteen (46%) of the 35 who attended the picnic reported onset of nausea, diarrhea, fever or vomiting between 8:30 pm on Friday and 3:30 am on Saturday.
- One employee was transported to the hospital with an elevated fever (104°F) but was not admitted.
- The Department of Public Health staff suspected that the illness may be due to food-borne intoxication.
- Roadrunner Catering Services routinely retains one serving of each dish served at a catered event in case of any complaint of food-borne illness or poor quality of product. The Environmental Community Health Program staff secured samples of the baked chicken, potato salad, shrimp salad and tossed green salad for analysis by the San Bernardino County Department of Public Health Laboratory.
- Environmental Community Health Program staff obtained detailed information on how the foods were prepared, stored, transported and served. No deficiencies or irregularities were noted.
- Epidemiology Program staff interviewed all of those who attended the picnic to determine what each attendee had eaten.
- No one reported that any food tasted spoiled, however, two attendees said that the shrimp salad tasted, "nasty".
- The ice cream was home made. The cream that was used was pasteurized, but the eggs used were purchased at a road-side market.

Descriptive Epidemiology

In order to complete the investigation of a food-borne outbreak, one must complete a number of tasks. The first is to define a case by creating a case definition. In this outbreak, cases were narrowly defined by the Epidemiologists as any Coyote Manufacturing employee reporting nausea, diarrhea and having eaten at the picnic.

Then one must calculate the overall attack rate and characterize the outbreak by person, place and time.

$$\textbf{Attack Rate} = \frac{\textbf{Number of Cases}}{\textbf{Number Susceptible to Disease}}$$

6. The age range for all of those in attendance was (specify youngest to eldest) ___ to ___.

7. The outbreak occurred in (specify the city and state) ______________________.

8. The outbreak commenced on (specify date) ______________________.

Determination of Risk

In order to determine whether or not there is an association between exposure to a risk factor and the development of disease, one can calculate the relative risk.

The relative risk can be defined as the probability of developing a disease among those exposed to a risk factor divided by the probability of developing disease among those not exposed to a risk factor.

$$\textbf{Relative Risk} = \frac{\textbf{Attack Rate Among Those Exposed to a Risk Factor}}{\textbf{Attack Rate Among Those Not Exposed to a Risk Factor}}$$

If the relative risk is greater than 1.0, this is indicative of a positive association and the exposure may be causal.

If the relative risk is approximately equal to 1.0, then the attack rate among those exposed is essentially equal to that of those with no exposure. Therefore, there would not be any evidence to suggest increased risk for that risk factor.

If the relative risk is less than 1.0, then the attack rate among the exposed is less than that among the non-exposed. This is evidence of a negative association which may be protective in nature.

9. Calculate the relative risk for each of the foods served at the picnic:

	Exposed			Not Exposed			
Food	**Sick**	**Not Sick**	**Attack Rate**	**Sick**	**Not Sick**	**Attack Rate**	**Relative Risk**
Baked Chicken							
Potato Salad							
Shrimp Salad							
Green Salad							
Ice Cream							
Soda							
Fruit Juice							

10. Based on the calculation of the relative risk, this outbreak was associated with consumption of the ______________________.

Determination of Causative Agent

The Department of Public Health Laboratory will not accept multiple food items for microbial evaluation due to the cost to process each specimen. The Epidemiologists must consider possible agents and the symptoms they produce, the foods that were served and their susceptibility to contamination, the relative risk associated with each food and the incubation period of the suspected pathogen. After such consideration, the Epidemiologists will submit selected specimens and ask that they be tested for specific pathogens.

The Epidemiologists referred to the food-borne intoxication section of The Control of Communicable Disease Manual, David L Heymann, MD, Editor, 18th edition 2004 and provided you with the following table:

Agent	Symptoms	Source	Incubation Period
Campylobacter jejuni	Diarrhea, abdominal pain, fever nausea and vomiting	Undercooked poultry and pork	1 to 10 days, usually 2 to 5 days
Clostridium perfringens	Nausea, diarrhea but vomiting and fever are usually absent	Inadequately heated or reheated meats, usually beef, turkey or chicken	6 to 24 hours, usually 10 to 12 hours
Staphylococcus aureus	Nausea, cramps, vomiting, often accompanied by diarrhea and subnormal temperature	Foods that have come into contact with food handler's hands or foods that have been inadequately heated or refrigerated	30 minutes to 8 hours, usually 2 to 4 hours
Vibrio parahaemolyticus	Watery diarrhea with cramps, sometimes with nausea, vomiting and fever	Raw or inadequately cooked seafood	4 to 30 hours, usually 12 to 24 hours

11. Based on the symptoms of those who became ill, the relative risk of the suspected food and the incubation period of the suspected pathogen, the probable cause of this outbreak was (select one):

Agent	Mark with an X
Campylobacter jejuni	
Clostridium perfringens	
Staphylococcus aureus	
Vibrio parahaemolyticus	

Prevention

Prevention is the cornerstone of Public Health. It is fundamental to understand that it is far less expensive to prevent disease than to treat disease...

12. What might you do to prevent further occurrences of this nature?

Body Systems

The following terms will be useful in understanding the processes of human health and disease that will be considered throughout the quarter. Take notes on the following.

- Cell: The smallest unit of living matter capable of existing independently in a suitable, non-living environment.
- Tissue: A collection of cells of the same kind.
- Organ: A structure composed of tissues of different kinds.
- Body System: A group of organs and tissues that work together to carry out important body functions.

Now that we have reviewed the cell and organization of the body, we will consider how these specialized cells function together in the healthy body. When we understand this, we can begin to appreciate how disease and disease processes change the normal functions of the body and produce the signs and symptoms to enable us to recognize disease.

The body systems are divided into three groups:

- Movement Group: Skeletal
  Muscular
- Energy Group: Circulatory
  Respiratory
  Digestive
  Excretory
- Control Group: Endocrine
  Nervous
  Reproductive

Following is a description of each body system.

- Skeletal—a supporting structure or framework of the body made up of 206 bones.
- Muscular—muscles are the outer framework of the skeletal system that allows for mobility (the muscles contract to move).
- Circulatory—the heart, blood vessels, and lymphatic system of the body. Pumps blood, including gasses and nutrients, throughout the body.
- Respiratory—the system of organs involved in the intake and exchange of oxygen and carbon dioxide between an organism and the environment.
- Digestive—the alimentary canal along with the glands, such as the liver, salivary glands, and pancreas, that produce substances needed in digestion.
- Excretory—linked to the digestive system. Consist of the kidneys, bladder, large intestine, and the small intestine in which byproducts of metabolism are excreted.
- Endocrine—(endocrine glands include hypothalamus, pituitary, thyroid, adrenals, pancreas, kidneys, ovaries, and testes) these glands are important for the regulation of metabolism in humans. The secretions of such glands are internal, as they are released into the blood.
- Nervous—the system of cells, tissues, and organs that regulates the body's responses to internal and external stimuli.
- Reproductive—sex organs concerned with producing sperm, the ovum and maintaining a pregnancy once it has started.

Disease

The term "disease" describes a state in which there is sufficient departure from the normal for signs or symptoms to be produced. A "symptom" is an abnormality noted by the victim. A "sign" is an abnormality observed by another person.

In order to discuss and study diseases in humans, it is necessary to examine what causes humans to die. Humans have a **life span** or a **life expectancy**; it is the average age at the time of death for a group of people. In the U.S., the average life span has tended to increase; as a matter of fact it has surpassed 78 years for the first time in history. The preliminary estimate of life expectancy at birth in 2009 is 78.2 years. The increase is due mainly to falling mortality rates in almost all the leading causes of death, federal health officials said. Based on 2009 data, females generally outlive males by an average of 5 years. For females, the life expectancy is 81 years; for males the life expectancy is 76 years. The 2009 life expectancy increase is due mainly to falling mortality rates for nine of the 15 leading causes of death, including heart disease, cancer, accidents and diabetes. You should be aware that life expectancy is the average age at death and that there is considerable variation from person to person.

We will introduce the concept of disease by examining mortality tables. The leading causes of death in humans will be examined. You will note that some leading causes of death are clearly caused by disease. However, it is also true that humans die from causes that are not diseases. In order to examine the leading causes of death, we must understand death rates. The death rate formula follows:

$$\text{death rate} = \frac{\text{number of people at risk who die}}{\text{number of people at risk}} \times 100{,}000$$

You will note that life expectancy and death rates are indirectly related. That is, as life expectancy goes up,. death rates must go down. The **unit of measurement** is deaths per 100,000 people.

The next page contains a table based on data from the National Center for Health Statistics. Table 1.2 details death rates for the fifteen leading causes of death in 2009. When you review the table, keep in mind the following information:

1. Data were the latest available at the time of printing of this Exercise Book. They take several years for mortality data to be compiled and printed.
2. The total estimated number of people in the United States in 2009 was 307,006,550. Of these, the total number of people in the United States who died in 2009 was 2,436,652 people.
3. Even though the life expectancy for males is lower than that for females, males do not have a higher death rate for every cause of death.
4. The fifteen leading causes of death in 2009 accounted for 80.7% of all deaths in the United States.
5. People are not dying of "old age" as it is not in itself a cause of death. This is because medical practitioners can determine a much more exact cause of death. The term "old age" is non-specific.
6. The number of deaths and the death rate from human immunodeficiency virus (HIV) infection peaked in 1995 and HIV is no longer ranked as a leading cause of death for all age groups in the U.S. From 1987 until 1994 HIV disease mortality increased an average of 16% annually. Between 1996 and 1998 death from HIV infection decreased more than 70%. However, HIV remains the sixth leading cause of death for people ages 25-44, and is a leading cause of death among African-Americans in this age group. This infection is largely preventable.
7. Not all the leading causes of death are diseases.
8. The fifth leading cause of death is "unintentional injuries." Unintentional injuries are accidents and their adverse effects.
9. In 2009, 3,6284 people died in motor-vehicle accidents (a type of unintentional death). It is generally accepted that half of the motor vehicle deaths are alcohol and/or drug-related.

In laboratory periods that follow, selected types of diseases will be studied in more detail.

Table 1.2: Death Rates for the 15 Leading Causes of Death, All Ages, 2009

Cause of Death	**Death Rate** (deaths/100,000 people)	**Number of Deaths**
Heart disease	195.0	598,607
Malignant neoplasms (cancer—all types)	185.2	568,668
Chronic lower respiratory diseases	44.7	137,082
Cerebrovascular diseases (stroke)	41.9	128,603
Unintentional injuries (accidents)	38.2	117,176
Alzheimer's disease	25.7	78,889
Diabetes mellitus	22.3	68,504
Influenza and pneumonia	17.5	53,582
Nephritis, nephrotic syndrome, and nephrosis	15.9	48,714
Intentional self-harm (suicide)	11.9	36,547
Septicemia	11.6	35,587
Chronic liver disease and cirrhosis	9.9	30,444
Essential hypertension and hypertensive renal disease	8.4	25,651
Parkinson's Disease	6.7	20,552
Assault (Homicide)	5.4	16,591
Overall from all causes	**793.7**	**2,436,652**

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