Part I: Scientific Methods

Introduction: Often as teachers we tell students what they need to know without helping them understand why they should know it. The following unit was designed to give students an understanding of how the acceptance of the scientific method led to better medical practices in the 1900's. Students will learn that well-accepted theories are ones that are supported by different kinds of scientific investigations. This unit addresses the NYS Living Environment Standard #1 "The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing and creative process."

I. Overview: Concepts addressed

- ☒ How infectious diseases have affected history
- ☒ Koch's Postulates (what they are and how are they are still relevant today)
- ☒ Designing a controlled experiment (developing a hypothesis, defining independent and dependent variables, importance of using control groups for comparison, testing only 1 variable at a time)
- ☒ Organizing data in tables and graphs

II. Student Prior Knowledge and Skills Required

- ☒ No prior knowledge is required. Can be done in high school or middle school
- ☒ This would be a great unit to begin with early in the year to introduce scientific inquiry skills
- ☒ The experimental design matrix is a graphic organizer created by Dr. Nancy Elwyss of SUNY Plattsburgh. It can be used in any science course in which students are designing experiments.

III. Time Requirement

- ☒ 2-3 – 40 min. class periods depending on the pace of the instructor and reading level of the students
- ☒ 1-2 – 40 min lab periods depending on the level of the students

IV. Advance Preparation

- ☒ This first series of lessons requires a copy of Victoria E. Rinehart's book Portrait of Healing **ISBN # 0-925168-83-1**
- ☒ Graphing paper
- ☒ Student activity sheets and experimental design matrix (attached)

V. What is expected from students

- ☒ Student activity #1: Students read an exert from the book and answer focused questions
- ☒ Student activity #2: Students use the experimental design matrix to critically analyze an experiment
- ☒ Lab #1: Students design a controlled experiment.
- ☒ Lab #2: Students make a table for data entry and practice graphing data from a table.

VI. Assessment

- ☒ Prior to these lessons have students design an experiment to test a hypothesis (any simple hypothesis). This will act as a preassessment of their understanding of experimental design.
- ☒ After completing these lessons give them back their pre-assment and using the experimental design matrix have students critique their own work and redo the assigment.
- ☒ The final revision of their experiment can be used as an indication of mastery.

Lesson #1: Medical Research Now and in the past

Objectives:

- ☒ Students will understand the importance of testing theories by learning about misconceptions → poor medical practices.
- ☒ Students will learn about 3 major diseases that have caused and continue to cause human suffering and death : tuberculosis, influenza, and pneumonia

Introduction and Input:

1. In order to gain a historical perspective students will pretend to be living in the 1800's
   a) give students numbers between 1 and 10
   b) have the 10's stand up → they represent the people that would have died of tuberculosis before the age of 40
   c) 1's stand up → represent people dying of influenza before 40
   d) 3's stand up → represent people dying of pneumonia before 40

2. A brief description of each disease should follow
   a) During the 19th century, TB claimed more lives in the United States than any other disease. But, with improvements in nutrition, housing, sanitation, and medical care during the first half of the 20th century, the number of cases and deaths dropped dramatically. In the 1940s and 1950s, with the introduction of antibiotic therapies for TB, the decline continued. By 1985, the number of cases had fallen to the lowest figure recorded in modern US history.
   However, TB re-emerged as a serious public health problem in the US, with more than 25,000 active TB cases reported in 1993, an increase of 14 percent since 1985. Between 1992 and 1998, the number of reported TB cases declined 31 percent. However, in addition to those with active TB, an estimated 15 million people in the US have latent TB infections that may develop into active TB at some time in their lives.
   The following are the most common symptoms for TB. However, each individual may experience symptoms differently.
   - ☒ cough that will not go away
   - ☒ fatigue
   - ☒ loss of appetite
   - ☒ loss of weight
   - ☒ fever
   - ☒ coughing blood
   - ☒ night perspiring

   UNIVERSITY OF MARYLAND MEDICINE
   (http://www.umm.edu/travel/tuberc.htm)

b) Influenza epidemics had been known to occur in large epidemics in the mid 1700's and the late 1800's. One of the worst plagues in modern times claimed 20 million people from 1918-1919. Although the symptoms of influenza were understood, and some basic concepts in epidemiology and disease prevention were emerging, the aggressive nature of this epidemic caught everyone by surprise. More people died (estimated 20-40 million worldwide) from the epidemic of 1918-1919 than died in World War 1 (1914-1918).
Many patients reported being ill in the morning, demonstrated a bluish-purple complexion by noon-time, and were dead by evening. By December, hundreds of thousands had died in the U.S. These deaths have been attributed to a strain of influenza A.
http://www.hsc.wvu.edu/resource/mbim/Flynn/StructureAntigenicity/Orthomyxoviruses.htm

c) A child with pneumonia in the 1800's had a good chance of succumbing to the bacteria. Today, with the help of two "miracle" drugs, people are more likely to survive and live without pain. The discoveries of aspirin and penicillin drastically changed the face of modern medicine.
http://inst.augie.edu/~jjrobins/aspirin.html

Student Activity #1: In the late 1800's a man named Edward Livingston Trudeau entered medical school read pages 6 and 7 ((Portrait of Healing), Rhinehart) to gain a perspective on what it was like to go to medical school in the US at that time in history. Then answer the following questions:

1) What were the 4 things that Trudeau had to do in order to become a physician?

Pay a $5 entry fee to the college
Attend 2 or more lecture courses at the college
Pass a brief oral examination which each professor gave members of the graduating class
Spend 3 years as a student working under a reputable physician (paying the physican $100 each year of service)

2) How much time did he have to spend in the lab?

None

3) What was he taught about tuberculosis?

It was non-contagious, incurable, and inherited

Day 2 Lesson: Experimental Design

Objectives:

- ☒ Students will learn about the importance of using the scientific method by learning about misconceptions about diseases that were passed on without ever being tested.
- ☒ Students will learn how to identify the independent variable and the dependent variable in an experiment. They will also learn the importance of testing only one variable at a time.
- ☒ Students will learn about controlled factors in an experiment and understand the importance of having control groups.
- ☒ Students will also be exposed to Koch's Postulates.

Introduction and Input:

In 1884 German scientist Robert Koch developed a scientifically sound way of determining whether a disease was caused by an organism (such as a bacteria, virus, or other)
What was later called Koch's postulates is still used by scientists today when looking for causes of new diseases (such as AIDS)

Koch's postulates

1. **The microorganism must be found in all cases of the disease.**
2. **It must be isolated from the host and grown in culture.**
3. **When injected into another host it must cause the same disease.**
4. **You should be able to isolate the same microorganism again from the newly infected host.**

Using these steps Koch was able to identify a rod shaped bacteria associated with anthrax and a different rod shaped bacteria from tuberculosis patients.

Remember what the physicians of this time were being taught about TB.
"it was non-contagious, incurable, and inherited"

Now for the first time scientific methods were being used to prove that it might be caused by a 'germ' and that it is contagious!

Student Activity #2

1) Now read Dr. Trudeau's reaction to these exciting new discoveries (page 23 and 24 **- Portrait of Healing**)

2) Using the attached experimental design lab fill in the blanks for Dr. Trudeau's experiment.

3) While Dr. Trudeau's experiment provided some very useful results; there are some things that he could have done to make them more informative and more reliable. What are some things he could have done differently:

He tested too many variables at a time (food, air quality, space, and light)
He only tested on rabbits
He didn't have an objective measurement of health, just his opinion on how they looked

4) Choose just 1 variable to test and design a controlled experiment to determine its affect on this disease in rabbits. Use the design matrix to describe your experiment.

Lab #1 Experimental Design

Scientific inquiry involves the testing of proposed explanations involving the use of conventional techniques and procedures. In this lab you will devise ways of making observations to test proposed explanations.

Below are the major steps involved in testing a proposed explanation (hypothesis). [Note: It is important to remember that to avoid bias in an experiment it is important to **repeat experiments**, use **a large sample size**, and data collection needs to be **objective**.]

1) **Title of experiment** = What are we trying to figure out?
    a. Ex: "The effect of the independent variable on the dependent variable on the organism being tested"

2) **Hypothesis** = What you predict will happen during the experiment (hypotheses are predictions based upon both research and observations
    a. Ex: "If you do this, then this will happen."

3) **Independent variable** = What you are testing or changing in your experiment
    a. [Note: you can only test one independent variable at a time]
    b. The independent variable goes on the X axis and it is usually the first column in a data table
    c. Remember to include units on graphs and tables.
    d. Ex: Time, temperature, and pH are common independent variables

4) **Dependent variable** = What you are measuring
    a. Dependent variable always goes on the y axis and is usually on the right hand side of a data table
    b. Remember to include units on graphs and tables.

5) **Procedures** = How will you measure your independent variable? Describe as completely as possible how and when you will make your measurements.

6) **Controlled factors** = things that it is important to keep the same during the experiment (**everything** except the variable being tested must be **treated equally**)

7) **Control group** = the group that is used as a standard for comparison in the experiment. Usually the group that does not get exposed to the independent variable

When designing an experiment use the attached design matrix as a guide to make sure you've included and you understand the major parts of a controlled experiment.

Experimental Design Matrix

Title of the experiment:

The effect of *the environment* on *disease symptoms*

in *TB infected rabbits*

Hypothesis: *It is believed that if given plenty of rest, fresh air, and food a TB infected organism will have fewer disease symptoms than a TB infected organism living in a poor environment.*

Independent Variable: The variable being tested

The environment is the variable being tested but note that there are more than one variables being tested here (amount of food, fresh air and amount of light)

Levels of independent variable being tested	*Best environment*	*Worst environment*	*Worst environment no TB*		
# of repeated trials	*5*	*5*	*5*		

Dependent Variable: The thing being measured

Overall health is being measured but note that his results are subjective not objective

Procedures: How and when you will measure

Note that it would be difficult to repeat his experiments exactly because they weren't described in detail students should be encouraged to include more detail than is recorded here.

Controlled Factors (List at least 5)

If students were to do this experiment things that they should include as controlled factors include: Same type, age and sex of all rabbits being tested and infecting rabbits with the same batch of TB using the same amount and same technique.

Control Group:

Very important to include the worst conditions no disease group! Without it you wouldn't know if the effects seen were from the conditions alone or the disease and the conditions together.

Lab #2: Organizing Data Using Tables and Graphs

Objective:

☒ Students will learn how to organize data into a table.

☒ Students will learn the basic components of designing a line or bar graph.

☒ How to label the axes, include a descriptive title, and provide appropriate scales for data.

Materials needed:

Pencil (not pen)

Graph paper

Introduction and input:

I. Designing a table

a.) Table should include a title that describes the independent variable and the dependent variable.

b.) The first row of any table should include headings describing what will be in each column. (ALWAYS REMEMBER TO INCLUDE UNITS IN THE HEADING)

c.) Columns on the right are used for putting data in (dependent variable or the thing being measured)

Title: The effect of temperature on seed germination in carrots		
Day of observation	**Total number of seeds that germinated**	
	10 (˚C)	**20 (˚C)**
7	0	5
10	20	35
15	40	70
20	45	80

Student activity

Design a data table below for the experiment that you designed. You don't have to fill in any data because you won't actually do the experiment.

II. Making a graph

a.) The independent variable (the one that you control) always goes on the X axis
Example: the days of observation

b.) The dependent variable (the one that you measure) always goes on the Y axis
Example: the number of seeds that germinated

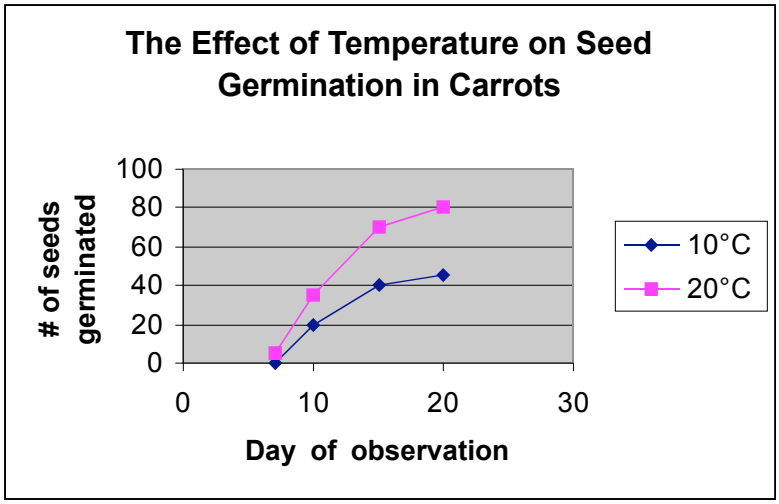
c.) REMEMBER to include UNITS on each axis

d.) Marking an appropriate scale (Use the 1,2,5 rule)

1) circle the highest # (ex: 80 is the highest number of seeds germinated)
2) circle the lowest # (ex: 0 is the lowest number of seeds germinated)
3) Both of those numbers have to fit on your graph!!!
4) Now count by 1's for each line
5) If the numbers won't go high enough Count by 2's
6) Then try counting by 5's
7) If the numbers still won't go high enough try 10's, 20's, 50's, 100's…

Student Activity

Using the data from the table below design a line graph comparing the number of seeds germinated at 10°C to the number at 20°C. Remember to include units.



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4) Choose just 1 variable to test and design a controlled experiment to determine its affect on this disease in rabbits. Use the design matrix to describe your experiment.

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Experimental Design Matrix

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The effect of _____ on _____

in _____

Hypothesis:

Independent Variable: The variable being tested

Levels of independent variable being tested					
# of repeated trials					

Dependent Variable: The thing being measured

Procedures: How and when you will measure

Controlled Factors (List at least 5)

Control Group:

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