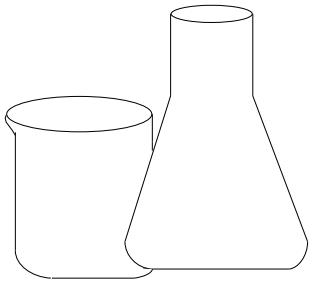


THE SCIENTIFIC METHOD

Introductory Activities

- Small Group Activity: Mary's T-Shirt Solution
- Individual Activity: Analyzing Elements of the Scientific Method

Identifying the Question

- Small Group Activity: Types of Questions

Research

- Small Group Activity: Researching

Hypothesis

- Overhead: Hypothesizing - Invite students to identify a hypothesis for each of the questions on the overhead.
- Handout: Semmelweis and Puerperal Fever - invite students to read the handout and answer the two questions. Review the story and discuss student answers.

Testing the Hypothesis (Experimental Design)

- Overhead: Designing an Experiment
- Small Group Activity: Evaluating Experimental Designs
- Demonstration: Show that procedures must be very specific. Invite students to write on a small index card the procedures for making a peanut butter and jelly sandwich. Take up these cards and review them during #2. Choose some fun ones and end the class by making sandwiches following these directions exactly!

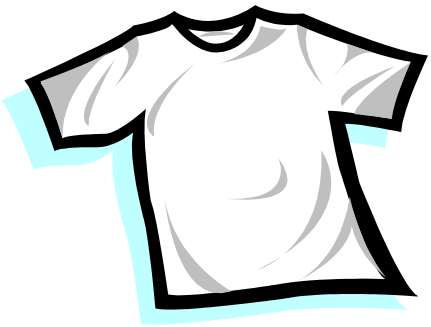
Collecting and Analyzing Data

- Individual Activity: Observation Skills
- Have students choose a three dimensional object from their belongings or in the room that they can sit upon their desk. Have them divide a sheet of paper into four sections. Have them draw enlarged versions of four different views of their objects. Provide them with magnifying glasses and rulers.
- Group Activity: Observations of a Candle

Review and Evaluation

- Small Group Activity: Mice Testing
- Individual Activity: Write an essay on how you have used the scientific method in your personal life.

Mary's Shirt Solution



Mary is in charge of dying T-shirts for the cheerleaders to wear at the next pep rally. She has 10 white, 100% cotton T-shirts and wants to dye them to match the orange border on the cheerleader shirts. Mary buys a box of orange Ritz dye.

Mary is not sure how to dye the shirts the exact color of the skirts. She reads the dye label and discovers that the length of time that cloth is soaked in the dye will determine the shade of the color that the cloth will become.

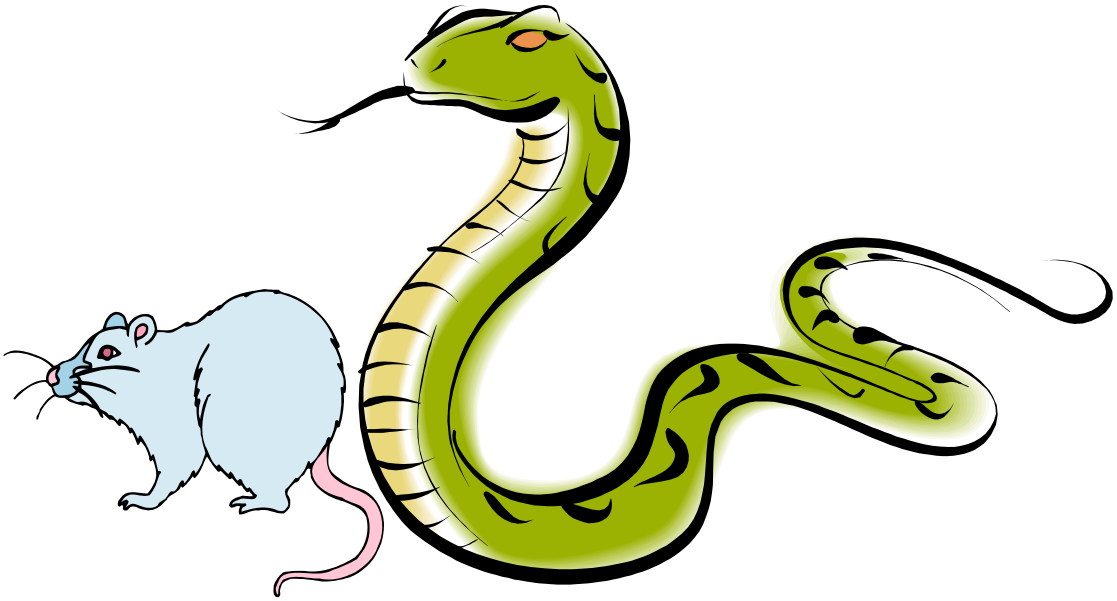
She guesses that soaking the shirts for about fifteen minutes should be long enough to dye them the proper shade of orange. But she is still uncertain. She decides to use one extra shirt to test her prediction.

Mary cuts the shirt into 10 six inch squares. She places 2 grams of orange Ritz dye into 500 milliliters of water. She measures the temperature of the water and finds that it is 28º C. She places the squares of cloth into the bowl, making sure that each one is covered by the dye solution. She sets a timer and removes one square of cloth every 5 minutes. She labels each square and allows them to dry for three hours.

Mary observes the squares to discover which one best matches the skirts. She finds that the square that was soaked for 35 minutes is the best match.

QUESTIONS

1. What question did Mary have about dying the T-shirts?
2. Where did she find information about the Ritz dye?
3. How much time did she predict the shirts should be soaked?
4. Describe the experiment that she designed to test her prediction.
5. What was one thing that she did differently to each piece of cloth in her experiment?
6. List the ways that each piece of cloth was treated exactly the same in her experiment.
7. What did Mary observe?
8. Was her prediction correct?
9. How long do you think she decided to soak the 10 remaining T-shirts?
10. Why would it be important that Mary record how much dye she used, the amount of water she used, and the temperature of the water?



Analyzing Elements of the Scientific Method

1. You are walking through a forest with a friend on May 19, 1994, at 4:00 PM.
2. You see a mouse run into a clearing from the east.
3. You see a rattlesnake spring from behind a bush and bit the mouse.
4. The mouse then runs away toward the west while the rattlesnake stays put.
5. After 3 minutes, the rattlesnake moves out of the clearing towards the west.
6. You follow and discover that the rattlesnake has found the mouse, which is dead.
7. This leads you to ask yourself, "Why did the rattlesnake follow the mouse's outgoing trail to the west rather than its incoming trail from the east?"
8. You think for a moment and come up with a possible explanation: "Seemingly, the only difference between the mouse when it arrived from the east and left toward the west was that when it left it had rattlesnake venom in it. So perhaps the snake followed the scent of its own venom."
9. You suggest to your friend: "I believe a rattlesnake always follows the outgoing trail of an animal it has bitten."
10. You tell your friend that to test your explanation, you will capture a rattlesnake and some mice and set up a situation where you can carefully observe the behavior of the rattlesnake again and again.

Answer the following Questions:

1. In which statement is a **prediction** made?
2. Which statement defines a **problem**?
3. In which statement is part of an **experiment** described?
4. Which statement contains a **hypothesis**?
5. Which statements contain **data**?
6. Which statements describe **observations**?
7. **Draw a picture** of what happened.

TYPES OF QUESTIONS

1. LITERATURE RESEARCH QUESTIONS: These questions can be answered by locating answers to questions in books and articles, or on maps and graphs, etc.
2. OBSERVATION ONLY QUESTIONS: These questions can be answered by observing things around you.
3. DEMONSTRATION QUESTIONS: These questions can be answered by making a model or performing a demonstration.
4. INVESTIGATION QUESTIONS: These questions can be answered by testing a hypothesis, making observations, analyzing your observations, and drawing conclusions.

	LITERATURE RESEARCH	OBSERVATION ONLY	DEMONSTRATION	INVESTIGATION
WHAT INSECTS CAN YOU FIND IN A ONE SQUARE FOOT AREA OF THE SCHOOL YARD?				
HOW WOULD YOU DETERMINE THE pH OF VINEGAR USING CABBAGE JUICE AS AN INDICATOR?				
DO VIOLETS MAKE MORE FLOWERS EXPOSED TO MANY OR FEW HOURS OF LIGHT?				
HOW DOES A NUCLEAR POWER PLANT PRODUCT ENERGY?				
WHAT ARE 5 TYPES OF BIRDS MOST COMMONLY FOUND IN CALIFORNIA?				
WHY DO SOME TREES CHANGE COLOR IN THE FALL?				
DO GERMINATING SEEDS PRODUCE HEAT?				
WILL MOLD GROW MORE QUICKLY ON TOASTED BREAD OR ON UNTOASTED BREAD?				
CAN YOU IDENTIFY DIFFERENT ELEMENTS USING A FLAME TEST?				
DOES KENTUCKY BLUEGRASS OR BERMUDA GRASS BEST HELP PREVENT SOIL EROSION?				
DO SEEDS GERMINATE FASTER IN AN ACID, BASIC, OR NEUTRAL ENVIRONMENT?				
HOW WOULD YOU ILLUSTRATE THE ACTION OF A VOLCANO?				
WHAT ARE FIVE DISEASES CAUSED BY VIRUSES?				
CAN YOU BLOW UP A BALLOON WITH YEAST CELLS AND A BOTTLE?				
WHAT PRODUCTS IN YOUR KITCHEN ARE ACIDS?				
WHAT TYPES OF BIRDS INHABIT YOUR BACK YARD?				
WHAT PRODUCTS IN THE SNACK BAR ARE SOLD BY METRIC MEASUREMENTS?				
WHAT TYPE OF PLANTS ARE INSECTIVOROUS?				
CAN YOU SEPARATE PLANT PIGMENTS USING CHROMATOGRAPHY?				
WILL WASHING YOUR HANDS WITH SOAP REMOVE MORE BACTERIA THAN WASHING THEM WITHOUT SOAP?				

WHAT INFORMATION WOULD YOU WANT TO DISCOVER IF RESEARCHING THESE QUESTIONS?		
	What is the proper amount of water for growing peas?	
	Which brand of carpet is the most flame retardant?	
	Are certain types of flowering plants less susceptible to smog damage?	
	Does the type of stucco on a house effect the pH of the soil near the house?	
	Which type of insecticide has the least effect on the pH of the soil and the water running off of the soil?	

WRITING A HYPOTHESIS

Compose a hypothesis for each of the following questions.

	Will planting seeds too shallow or too deep inhibit their growth?	
	Does temperature effect seed germination?	
	Can earthworms effect the porosity of soil?	
	Can earthworms help in the decay process of compost material in soil?	
	Does fertilizer effect the pH of pond water?	
	Does fertilizer effect the number of organisms in pond water?	

Analyzing Experimental Design

Read each experiment below and answer the questions.

Tom wanted to test his hypothesis that plants grow better at room temperature than in cold temperatures. He placed an ivy plant in the refrigerator, which had no light source. He also placed a spider plant in the window in his room.

a. What were Tom's variables?

b. What were Tom's controls?

c. What was wrong with Tom's experimental design?

Latoya wanted to discover if beans or corn would grow best in the soil in her garden. She planted beans in a corner under a tree, and planted corn in full sunlight.

a. What were Latoya's variables?

b. What were Latoya's controls?

c. How could Latoya have improved her experimental design?

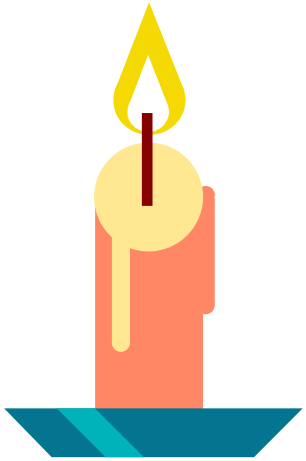
Raul wanted to see if Jiffy Pop or Von's brand popcorn left fewer unpopped kernels. He poured some of each type of popcorn into two different types of pans containing oil. He popped the corn for three minutes each. He then recorded the number of unpopped kernels in each pan.

a. What were Raul's variables?

b. What were Raul's controls?

c. List two parts to Raul's experimental design that were planned correctly.

d. How might Raul have improved his experimental design?



OBSERVATIONS OF A CANDLE

The observations that you could make about a candle - weight, length, diameter, time - are called variables because they can change, especially if the candle is burning. Design an experiment that allows you to make comparisons on three candles. Identify your controls and your variables. Compose a hypothesis involving your variable. Identify procedures, materials, and conduct the experiment. Record your observations and data. Draw conclusions.

1. Identify your variable and controls:

   Variable: _____

   Controls: _____

2. Compose a hypothesis to be tested based on your variables and controls.

3. List your materials and equipment.

4. Write out your procedures. Include specific measurements and units.

5 Record your observations and data on the back of this page – using a construct a graph, table, or diagram to organize your information.

6. State your conclusions. Accept or reject your hypothesis and support your decision with reasons.

REVIEWING EXPERIMENTAL DESIGN

A scientist observed that white mice that were fed seeds appeared to grow more than mice given leafy green and yellow vegetables. The scientist hypothesized that the protein in the seed was responsible for the growth. He designed an experiment to test his hypothesis. He divided 200 mice of the same age, size, health, and sex into two groups of 100 mice each. The mice were kept under identical conditions for fourteen days. One group was given a diet low in protein. The other group was given a normal protein diet. The mass of each mouse was recorded daily for fourteen days.

1. Which group of mice served as a control group? _____

_____

2. What was the variable? _____

3. What elements were controlled? _____

_____

4. What effect of a protein diet was tested? _____

_____

5. What other effects of a protein diet could have been tested? _____

_____

6. Why were large numbers of mice used in the experiment? _____

_____

7. If the results of the experiment do not show a marked change between the two groups, what should the scientist do next?

_____

_____

8. Given the scientist's hypothesis, what do you hypothesize should happen to the masses of the mice in the two groups?

   Mice w/Low Protein Diet _____

   Mice w/Normal Protein Diet _____