SCIENTIFIC METHOD

Notes & Observations

Biology 9A

Name: _____ Hr: _____

Important Vocabulary:

Scientific Method	Observation	Inference	Qualitative
Quantitative	Problem	Hypothesis	Control Group
Experimental Group	Independent	Dependent	Variable
Controlled Experiment	Conclusion	Law	Theory

Learning Goals:

After this unit, you should be able to

- ✓ Follow the steps of the scientific method
- ✓ Differentiate between quantitative and qualitative data
- ✓ Differentiate observations and inferences
- ✓ Set up a controlled experiment, complete with control/experimental groups and independent and dependent variables
- ✓ Identify the variables and factors in experimental scenarios
- ✓ Organize data in a variety of ways
- ✓ Read and analyze data in various forms
- ✓ Form conclusions based on data
- ✓ Explain what happens if a hypothesis is proven or disproven
- ✓ Describe how a theory is different from a law

THINKING LIKE A SCIENTIST Name: Hour:

Activity 1: Watch the video clip, then try to answer the questions that follow. Record your answers below

OBSERVATION	VS.	INFERENCE

Activity 2: Using observations and inferences to describe an unknown situation. Fill in the chart as you view the 3 different slides

Slide	Observations	Inferences
1		
2		
3		

After hearing other student's answers, have you changed your idea of what you think happened? Why/Why not

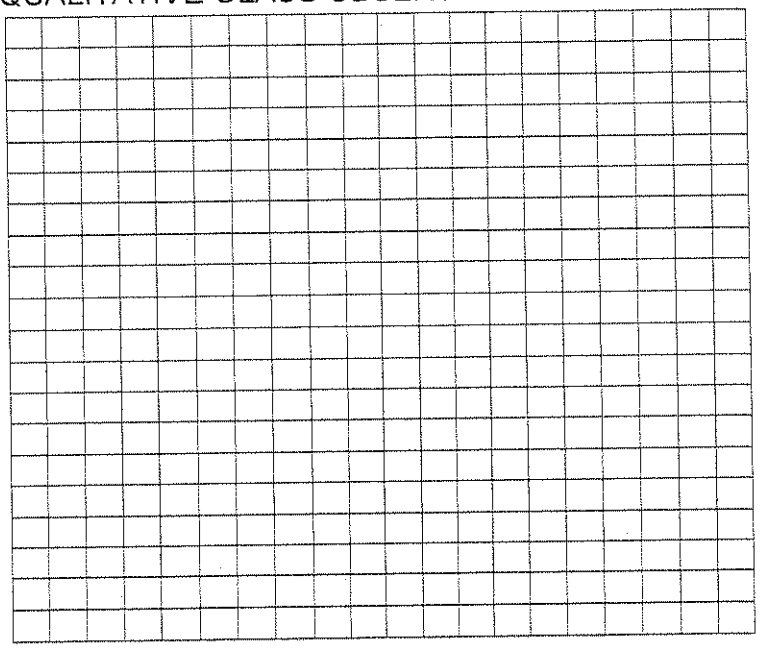
Will we ever know what happened? Explain.

How can this be related to thinking like a scientist?

QUALITATIVE OBSERVATIONS	VS.	QUANTITATIVE OBSERVATIONS

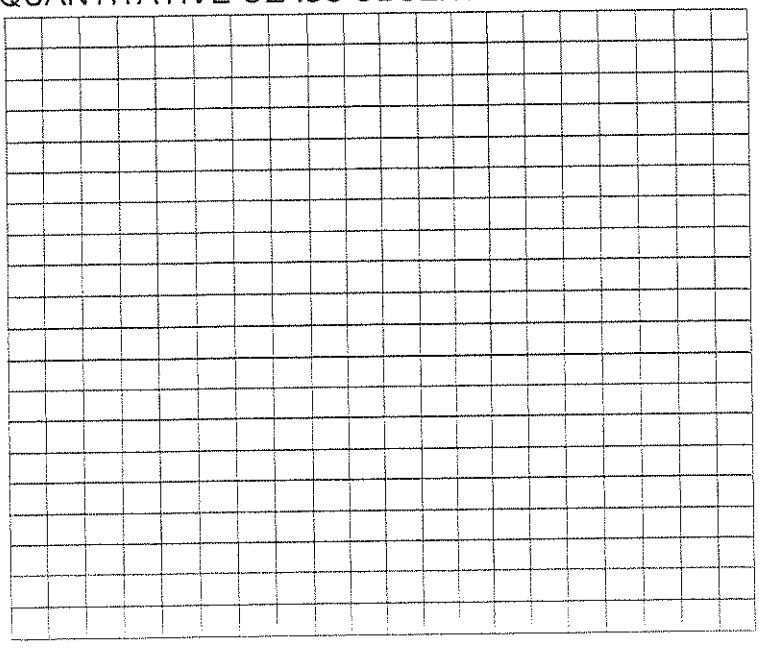
Activity 3: Recording qualitative and quantitative data. Come up with something qualitative you can find out about class members. Record your data. Then come up with something quantitative to record about class members, and record your data. Use the graph areas below to display your data.

QUALITATIVE CLASS OBSERVATION



-What inferences can you make about class members based on your observations?

QUANTITATIVE CLASS OBSERVATION



-What would you need to do in order to make a conclusion about this data?

SCIENTIFIC METHOD & EXPERIMENTAL DESIGN Name: Hour:

F Map of the **Scientific Method**/Process:

Experimental Design:

- Uses Scientific Method
- Tests a _____ to solve a problem
- Requires 2 groups:
    - **Control Group**:
    - **Experimental Group**:
- Includes variables or factors
    - **Controlled variables:**
    - **Independent variable:**
    - **Dependent variable:**

Drawing Conclusions:

- **Theory**
- **Law**

Controlled Experiment Handout

The following questions are to guide you through the ideas of a "Controlled Experiment."

1. What is the scientific method? _____

_____

2. Read the list below. **Put the steps of the scientific method in order from 1-6**

_____Run a controlled experiment
_____Make a hypothesis
_____Collect data
_____Make a conclusion
_____Organize and Analyze data
_____Form a problem

3. Why do scientists form a hypothesis? _____

_____

4. Why do scientists run experiments? _____

_____

5. **Go to the section: What is a controlled experiment?**
   a. What two groups are used in an experiment? _____ and _____
   b. In a controlled experiment which **group** receives no experimental treatments? _____
   c. In a controlled experiment which **group** is tested and receives experimental treatments? _____

6. A variable is a factor that can be changed in an experiment. **What three variables did we list in our notes?**
   a. _____
   b. _____
   c. _____

7. Which variables stay the same and are not changed by the experimenter? _____
8. Which variable is the 1 factor that changes between a control group and experimental group? _____
9. Which variable is can be measured or observed by the experimenter? _____

10. Read the following scenario: Pick out the variables from reading below.
A biology student planted 3 alfalfa bean plants in 3 identical containers. They were both planted with the same amount of soil and grown in the same amount of light. During the experiment the biology student used different quantities of water each day. **With your knowledge of how plants grow and after you read the section on experimenting, answer the following questions pertaining to the above experiment.**
   a. What are the controlled variables? _____
   b. What is the independent variable? _____
   c. Based on your prior knowledge of plants if you were to test the independent variable, what changes might you observe and be able to measure. List 2 factors that might result from this test.
      a. _____
      b. _____

Biology
Scientific Investigation Handout

Name_____
Date_____Hour_____

Understanding the Experiment

You are given several experimental scenarios. During experimentation biologists use the scientific method to test their hypothesis. When scientists perform experiments, they must be careful to manipulate or change only one condition at a time, keeping all other conditions in the experiment the same. In the following passages carefully read each and try to determine a problem for the experiment, if the hypothesis was tested and supported and try to determine the control, independent and dependent variables.

1. Suppose you observed that bees prefer a yellow flower that produces more nectar over a purple flower that produces less nectar. List two separate hypothesis you might make about bees and flowers.
   a.

   b.

2. Using the graph on page 20 (Figure 1.16) (blue book), answer the following questions:
   a. Identify the independent variable (x):

   b. Identify the dependent variable (y):

   c. Is the information described on the graph, qualitative or quantitative?

   d. Based on the graph describe when are paramecium better fit to survive?

   e. Hypothesize why you think that the high temperature side of the graph drops off more rapidly than the low temperature side?

3. A group of scientists wish to see if using a new, environmentally friendly pesticide is effective in preventing insect damage to soybeans. Three different soybean plots are planted. The first plot contains soybeans treated with traditional pesticide. The second plot is treated with new environmentally friendly pesticide. The third is left untreated.
   a. Identify which plot is the control:

   b. Identify the independent variable:

   c. Identify the dependent variable:

   d. Explain if the following statement can be a reasonable conclusion: **The environmentally friendly pesticide is safe and should be sold at the local hardware store.**

Writing Hypotheses

Name: Date: Hr:

Purpose: to learn when and how to write hypotheses.

Most students believe that they are going to be experimenting anytime they are given a laboratory assignment in science. However, more often than not, students are doing something other than experiments. This is not necessarily bad. A good deal of science is observational and descriptive. For example, the study of bio-diversity usually involves looking at wide variety of specimens and maybe sketching and recording their unique characteristics. However, there are other times when we science teachers are trying to teach students how scientists work and how we can verify things which others may say or believe is so without any proof.

To learn about what is not known or to verify a notion, the so-called "scientific method" might be carried out and an actual experiment may be conducted. It does not matter that your experiment has been done a thousand times before or that your teacher already knows the results. What matters is that you don't know the results and that you can independently find a verifiable answer. In real experiments, real hypotheses should be written before the actual experiment.

What Is a Real Hypothesis?

A hypothesis is a tentative statement that proposes a possible explanation to some phenomenon or event. A useful hypothesis is a **testable** statement which may include a prediction. A hypotheses should not be confused with a theory. Theories are general explanations based on a large amount of data. For example, the theory of evolution applies to all living things and is based on wide range of observations. However, there are many things about evolution that are not fully understood such as gaps in the fossil record. Many hypotheses have been proposed and tested.

When Are Hypotheses Used?

The key word is **testable**. That is, you will perform a test of how two variables might be related. This is when you are ...ng a real experiment. You are testing variables. Usually, a hypothesis is based on some previous observation such as ...icing that in November many trees undergo color changes in their leaves and the average daily temperatures are dropping. Are these two events connected? How?

Any laboratory procedure you follow without a hypothesis is really not an experiment. It is just an exercise or demonstration of what is already known.

How Are Hypotheses Written?

1. Chocolate may cause pimples.
2. Salt in soil may affect plant growth.
3. Plant growth may be affected by the color of the light.
4. Bacterial growth may be affected by temperature.
5. Ultra violet light may cause skin cancer.
6. Temperature may cause leaves to change color.

All of these are examples of hypotheses because they use the tentative word "may.". However, their form is not particularly useful. Using the word may does not suggest how you would go about proving it. If these statements had not been written carefully, they may not have even been hypotheses at all. For example, if we say "Trees will change color when it gets cold." we are making a prediction. Or if we write, "Ultraviolet light causes skin cancer." could be a conclusion. One way to prevent making such easy mistakes is to formalize the form of the hypothesis.

Formalized Hypotheses example: **If** SKIN CANCER is **related** to ultraviolet light , **then** *people with a high exposure to ...y light will have a higher frequency of skin cancer.*

If LEAF COLOR CHANGE is **related** to temperature , **then** *exposing plants to low temperatures will result in changes in leaf color.*

Notice that these statements contain the words , **if** and **then**. They are necessary in a formalized hypothesis. But not all if-then statements are hypotheses. For example, "If I play the lottery, then I will get rich." This is a simple prediction. In a formalized hypothesis, a tentative relationship is stated. For example, if the FREQUENCY OF WINNING is **related** to frequency of buying lottery tickets. "Then" is followed by a prediction of what will happen if you increase or decrease the frequency of buying lottery tickets. If you always ask yourself that if one thing is related to another, then you should be able to test it.

Formalized hypotheses contain two variables. One is "independent" and the other is "dependent." The independent variable is the one you, the "scientist" control and the dependent variable is the one that you observe and/or measure the results. In the statements above the dependent variable is in ALL CAPS and the independent variable is underlined.

The ultimate value of a formalized hypothesis is it forces us to think about what results we should look for in an experiment.

Rewrite the first four hypotheses using the formalized style shown above. Single underline the dependent variable and double underline the independent variable in the If clause of each hypothesis. When you are done, write one more original hypothesis of your own using this form.

1. _____

2. _____

3. _____

4. _____

Situations: Read the situation below and design an experiment.

John Smith has been hired by the city of Virginia Beach to investigate the recent shark attacks off the resort's coast. He has a budget of $40,000, a 25 foot boat, and three graduate student assistants to help him. A helicopter has also been donated by a local television station, should he need one.

* * *

1. List 2 hypotheses John and his crew may have come up with for the recent shark attacks.
   a. If _____, then _____
   b. If _____, then _____
2. What materials will John need to perform this experiment (How will they spend the $40,000?).

   _____

   _____
3. Where should they perform the experiment (Hint: Where do sharks like to live)? _____
4. Pick one of the two hypotheses and determine the following:
   a. Control Group: _____
   b. Experimental Group: _____
   c. Dependent Variable: _____
   d. Independent Variable: _____
5. What type of data do you think John will collect (What will be the results of the experiment?)?

   _____
6. What conclusions will John be able to make from the results of the experiment?

   _____

HYPOTHESIS WORKSHEET **Name:** **Date:** **Hr**

Write a hypothesis for each of the following research problems. Identify the dependent and independent variable for each.

1. What effect does high temperature have on radish germination?

Independent Variable:	Dependent Variable:

2. What effect does studying with music have on student test scores?

Independent Variable:	Dependent Variable:

3. What effect does food color have on the amount of food fish eat?

Independent Variable:	Dependent Variable:

4. What effect does light have on plant growth?

Independent Variable:	Dependent Variable:

5. What effect does smiling have on teacher giving no homework?

Independent Variable:	Dependent Variable:

Write a problem for each of the following hypotheses. Identify the dependent and independent variable for each.

6. If plants are watered, then growth height will increase.

Independent variable:

Dependent variable:

7. If chocolate is given to teachers, then amount of homework will decrease.

Independent variable:

Dependent variable:

8. If trees have leaves, then bird nests will increase.

Independent variable:

Dependent variable:

9. If acid rain is in water, then fish population will increase.

Independent variable:

Dependent variable:

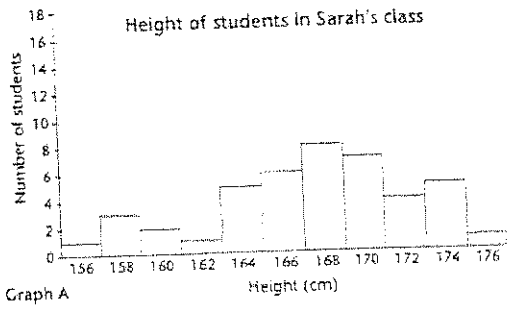
10. If calcium is given, then bone strength will increase.

Independent variable:

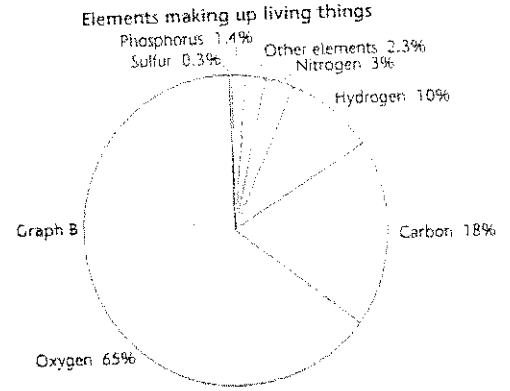
Dependent variable:

Graphing

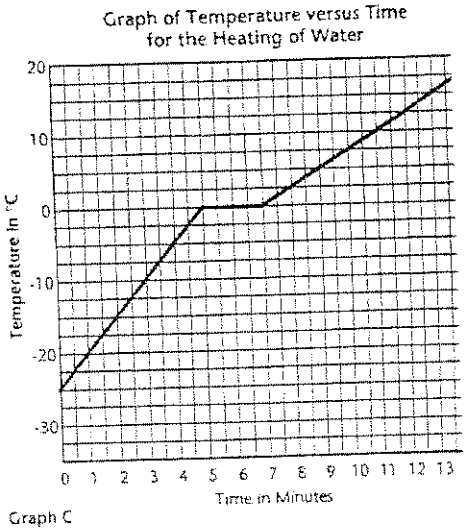
Use the graphs to answer the following questions.



Graph A



Graph B



Graph C

1. What type of graph is graph A? _____
2. What information is shown on graph A? _____
3. What height do the greatest number of students in Sarah's class have in common? _____
4. What type of graph is graph B? _____
5. What information is shown in graph B? _____
6. What element makes up the largest part of living things? _____
7. What type of graph is shown in C? _____
8. What does graph C show? _____
9. What is the responding variable in graph C? _____
10. What is the manipulated variable in graph C? _____
11. On what axis is the manipulated variable plotted? _____
12. On what axis is the responding variable plotted? _____

Graphing

Choose the term from the word list that best completes each statement. Write the term in the blank at the left of each statement.

graph	vertical	responding	line graph
horizontal	manipulated	bar graph	x-axis
hatch marks	pie graph	y-axis	percentages

_____ 1. A visual display of data or information is a _____ .

_____ 2. Information that is collected by counting can best be displayed on a _____ .

_____ 3. In a line graph, the _____ axis is called the y-axis.

_____ 4. In a line graph, the responding variable is plotted on the _____ .

_____ 5. A graph that shows information as parts of a circle is a _____ .

_____ 6. The type of graph that is useful for showing trends or continuous change is a _____ .

_____ 7. Information in a pie graph is often shown as _____ .

_____ 8. Information that remains constant and does not depend on changes in the value of another variable is called the _____ variable.

_____ 9. In a line graph, the manipulated variable is plotted on the _____ axis.

_____ 10. Numbers that are left off a graph to save space can be shown using lines called _____ .

_____ 11. A variable that changes as a result of the other variable is called a _____ variable.

_____ 12. In a line graph, the horizontal axis is also called the _____ .

THE NATURE OF SCIENCE -- "CONPTT" GRID
IS IT REALLY SCIENCE?

Prepared by Iowa Science Educators

CRITERIA	WITHIN THE REALM OF SCIENCE	OUTSIDE THE REALM OF SCIENCE
CONSISTENT	Experimental results and observations are the same.	Experimental results and observations are NOT the same
OBSERVABLE	The phenomenon (event) or evidence for the event can be observed by the human senses or by extensions of those senses.	The phenomenon (event) or evidence for the event can NOT be observed by the human senses or by extensions of those senses.
NATURAL	A natural cause or naturally occurring mechanism is used to explain how or why an event happens.	A natural cause or naturally occurring mechanism CANNOT be, or IS NOT used to explain how or why an event happens.
PREDICTABLE	Accurate predictions and conclusions are based on natural causes NOT on presupposed or assumed information.	Accurate predictions and conclusions are NOT based on natural causes but usually on presupposed or assumed information.
TESTABLE	Controlled experiments can be designed to test the natural cause of the event (phenomenon).	Controlled experiments CANNOT be designed to test the natural cause of the event (phenomenon).
TENTATIVE	Explanations (laws, theories, hypotheses) of the cause (mechanism) for the event are subject to change as evidence shows the need.	Explanations of the cause of the event in question are NOT subject to change.

STUDENT ACTIVITY

IS IT SCIENCE? IS IT A SCIENTIFIC STATEMENT?

During the quick review of the six criteria that determine whether something is science or not science, or whether a statement is scientific or not scientific, only one criterion was applied to each statement. To qualify as science or as a scientific statement, all six criteria must be used and all must be satisfied. Remember: If most but not all are satisfied, then one may have identified a protoscience. If none are satisfied, then one may have identified a non-science or a pseudoscience.

Take one of the statements given to you in class, or you may find another one on your own, and qualify it as scientific or non-scientific, based on the six CONPTT criteria. You may wish to use the THE NATURE OF SCIENCE -- "CONPTT" GRID -- IS IT REALLY SCIENCE? for reference (above). Do this assignment on the special worksheet to be provided.

NAME_____ SN.___ DATE_____ PER.___

WORKSHEET: IS IT SCIENCE? IS IT A SCIENTIFIC STATEMENT?

STATEMENT: (Write down the statement you wish to qualify as being scientific or non-scientific):

_____

_____

_____

Before considering the six CONPTT criteria, indicate your opinion:
I think this statement is [ ] scientific [ ] non scientific

INSTRUCTIONS: Using the six CONPTT criteria, and referring to your statement above, EXPLAIN how each criterion is satisfied or not satisfied as science, and indicate whether this places the statement within or outside the realm of science.

CRITERIA	Explain or Demonstrate how each criterion is satisfied or not satisfied scientifically:
CONSISTENT	[ ] Within [ ] Outside the realm of science
OBSERVABLE	[ ] Within [ ] Outside the realm of science
NATURAL	[ ] Within [ ] Outside the realm of science
PREDICTABLE	[ ] Within [ ] Outside the realm of science
TESTABLE	[ ] Within [ ] Outside the realm of science
TENTATIVE	[ ] Within [ ] Outside the realm of science

On the basis of the CONPTT criteria, I now consider my statement to be....
[ ] scientific [ ] proto-scientific [ ] pseudoscientific [ ] non-scientific

Just because a statement is non-scientific, does it mean that the statement is not true?_____. Explain your answer: