Scientific Method

I. <u>Scientific Method</u>:

A. Pure Science -

B. Applied Science -

II. <u>Steps of the Scientific Method</u>:

1. Identify a problem:

2. Make observations and collect info about the problem
   -
   -
   -
   -
   -

   } Reliable & Credible resources

3. Formulate a hypothesis
   - <u>Hypothesis</u>:

4. Experiments -
   a.
   b.

   - Variables:
     1. <u>Independent variable</u>:
     2. <u>Dependent variable</u>:
   - Control:

5. Organizing and interpreting data
6.
7. Interpret data -
8. Draw conclusions and report results
   -

Scientific Method

Analyze Data

The doctor tells you that she will call you in 24 hours with test results. The next day, a lab technician identifies the growth in the experimental petri dish. The data are recorded in your chart. The doctor uses the data to draw her conclusions. A conclusion is a logical answer to a question based on data and observations of the test materials.

The next step in the search for an answer is to accept or reject the hypothesis. The doctor calls you and tells you that the experimental dish shows that your sore throat was caused by another kind of bacterium. You don't have strep throat. The doctor has had to reject her original hypothesis. Your doctor must now revise her hypothesis to include a different cause of your sore throat.

Report Results

The last step in solving a problem scientifically is to do something with the results. Your doctor may prescribe an antibiotic for you to take. An antibiotic is a drug that kills bacteria. Your doctor also may use the data in a paper she is preparing on different kinds of sore throats found in adolescents. She may have begun to notice some common factors in her data. Your sore throat may be part of a trend of sore throats caused by a new bacterium. Your doctor wants to publish her paper to find out whether other doctors have noticed the same thing. Sharing results is part of the scientific method.

Theories and Laws

Observing something you cannot explain and performing an experiment that allows you to make some conclusions results either in support or in rejection of your hypothesis. When experimentation results in the same conclusions over and over again, you may develop a theory that explains your conclusions. A **theory** is an explanation of things or events based on many observations. A theory is not a guess or someone's opinion, nor is a theory a vague idea. Hypotheses that have been tested over and over again and cannot be shown to be false support theories. You have already read about the theory of spontaneous generation. Theories can be changed a new data uncover new information.

Laws

Large amounts of data in science often show a trend. A scientific **law** based on these repeating data tells us how nature works. A law is reliable description of nature based on many observations. In physical science, you might learn about the law of gravity. Laws may change, as more information becomes known.

Scientific methods help answer questions. Your questions may be as simple as "Where did I leave my house key?" or as complex as "What can we do about air pollution?" Will these methods guarantee that you will get an answer? Not always. Often they just lead you to more questions, but that is the work of science.

Questions: Use the reading, notes and former labs to complete the following questions.

1. List the steps of the scientific method that the doctor used and describe her steps to show evidence.
2. Compare and contrast a law and a theory.
3. How are graphs useful in a scientific investigation?
4. Why is it important that scientists communicate the results of their experimentation to other scientists?
5. How is the invention of new tools, such as the electron microscope, influenced the progress of science?

The Capture-Recapture Method

Problem: Every year, a team of ecologists estimates the population size of a rare species of trout that lives in Grass Lake. Grass Lake is polluted, but efforts are being made to clean it up. The biologists make their estimation using the capture-recapture method. The biologists float on rafts and capture fish on baited hooks. The fish are marked, tallied, and thrown back into the water. The ecologists repeat the procedure a week later. Imagine you are an ecologist on the team trying to answer this question: What is the size of the trout population in Grass Lake?

Materials: A bag of toothpicks, stopwatch, and masking tape

Prediction: The capture-recapture method will produce an accurate estimate of a population size.

Procedure:

1. For the first sampling, go with your group to the designated area. The borders of this area represent the shores of Grass Lake.
2. Spread the toothpicks within the borders of the lake. Each toothpick represents a trout.
3. Choose one person in your group to be the timekeeper and bookkeeper. The others are the ecologists.
4. For two minutes (if you're outside) or one minute (if you're inside), the ecologists will capture the toothpicks with their hands. At the end of the time period hand the toothpicks to the timekeeper/bookkeeper. This person will tally up the number of trout (toothpicks).
5. Then mark the toothpicks you picked up. These are now marked trout in the total population.
6. Give your toothpicks to the timekeeper/bookkeeper. This designated person will throw the marked toothpicks back in Grass Lake. They should be randomly scattered across Grass Lake.
7. Again, the ecologists will spend 1 or 2 minutes (depending on your location) capturing toothpicks, and return them to the timekeeper/bookkeeper.
8. Some of the toothpicks you've captured will probably be marked, indicating they have been previously captured. Separate these from the unmarked toothpicks.
9. Tally and record the number of toothpicks, marked and unmarked, captured by the group during the second sampling. These are the total trout captured.

	Total trout captured	Total marked trout in population	Marked trout recaptured
1st sampling			
2nd sampling			

10. Take off the markings on the toothpicks, put them back in the bag and return to Mrs. Kosney.
11. Multiply the number of total trout captured (step 9) by marked trout in total population (step 4). Divide this product by the marked trout recaptured (step 9). The result is the estimate of the trout population in Grass Lake.

$$\frac{\text{Marked trout recaptured}}{\text{Total trout captured}} = \frac{\text{Marked trout in total population}}{X}$$

X = the size of the trout population in Grass Lake

Analysis

1. To get an accurate estimate, why is it important that trout caught during the first sampling are returned to the lake unharmed?
2. What are possible sources of error with the capture-recapture method? How can these errors be minimized?
3. Could the capture-recapture method be used to accurately estimate the size of any population? Explain.
4. Grass Lake is currently polluted, what are some possible pollutants found in lakes?

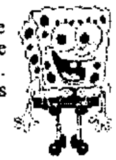
Conclusion

What is your estimate of the trout population in Grass Lake? Show the calculations you performed to obtain your estimate.

Scientific Method
Bikini Bottom Experiments

The Bikini Bottom gang loves science class and wanted to do a little research. Read the description for each experiment and use your knowledge of the scientific method to answer the questions.

Flower Power



SpongeBob loves to garden and wants to grow lots of pink flowers for his pal Sandy. He bought a special Flower Power fertilizer to see if will help plants produce more flowers. He plants two plants of the same size in separate containers with the same amount of potting soil. He places one plant in a sunny window and waters it every day with fertilized water. He places the other plant on a shelf in a closet and waters it with plain water every other day.

(1) What did SpongeBob do wrong in this experiment? Explain.

(2) What should SpongeBob do to test the effectiveness of Flower Power fertilizer? Write an experiment.

Super Snails

Gary is not the smartest snail in Bikini Bottom and believes he can improve his brain power by eating Super Snail Snacks. In order to test this hypothesis, he recruits SpongeBob and several snail friends to help him with the experiment. The snails ate one snack with each meal every day for three weeks. SpongeBob created a test and gave it to the snails before they started eating the snacks as well as after three weeks. Analyze the data in the chart and determine whether or not the Super Snail Snacks create smarter snails!

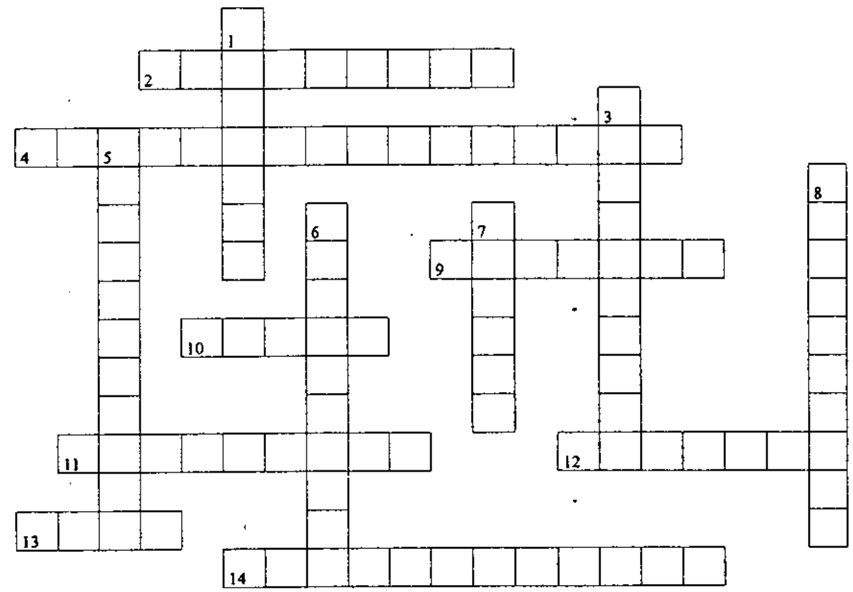
(3) Based on the data provided, do the Super Snail Snacks work? Explain your answer.

Test Results

Snail	Before	After
Gary	64%	80%
Larry	78%	78%
Barry	82%	84%
Terry	72%	70%

Scientific Method Review

Use the clues to help you fill in the puzzle.



Clues:

1. The _?_ is the part of an experiment that is not being tested and is used for comparison.
2. The _?_ describes the steps you use during an experiment.
3. After an experiment, scientists write a _?_ which summarizes their experiment and results.
4. The _?_ _?_ is a process used by scientists to find answers to questions or solve a problem.
5. The _?_ variable is the part of the experiment that is being tested or the part that is changed by the person doing the experiment.
6. The _?_ is an educated guess.
7. Scientists use their data to make charts and _?_ to communicate the results of an experiment.
8. After the scientist makes a hypothesis, they perform an _?_ to collect data.
9. The first step of the scientific method is to define or identify the _?_.
10. Sometimes scientists make a mistake, or _?_, and need to do an experiment again.
11. The _?_ variable is the part of the experiment that is affected by the independent variable.
12. After the experiment, scientists organize and _?_ the data.
13. The information collected during an experiment is called _?_.
14. Scientists make _?_ to help them make a hypothesis or collect data during an experiment.

Organizing Data Tables

The best time to create a data table is before you record data. A well-planned data table lets you record data neatly and quickly while doing your experiment. In your science work, you will collect two main kinds of data. **Quantitative data** are numbers, usually measurements with units. Temperature in degrees Celsius, length in centimeters, and mass in grams are examples of quantitative data. **Qualitative data** are recorded as descriptions. The color of a flower, the movements of an insect, and the patterns in a rock are examples of qualitative data. Each kind of data needs a certain kind of data table.

Tables for Quantitative Data

A **data table** is organized in columns and rows. The first column of a data table usually describes the contents of each row. All the other columns need headings, so you know the quantity and unit of the data in that column. When you plan how to organize a data table, consider the following:

- The purpose of the table: what you want other people to learn from the table
- The kind and number of items that will be in the table: the number of values for the independent variable, dependent variable, units for each value, total number of trials, and averages of those trials
- The clearest way to set up the table so that recording data and reading it back are quick and easy

The example shows a table you might make for an experiment involving the temperature of ice water.

EXAMPLE

TEMPERATURE OF A CUP OF WATER WITH ICE

Time (s)	Temperature (°C)			Average (Mean)
	Trial 1	Trial 2	Trial 3	
0 (ice added)				
30				
60				
90				

Running more than one trial for your experiment makes your data more reliable.

Tables for Qualitative Observations

Imagine you are planning to observe the behavior of African mountain gorillas in the wild for the next two months. Most of your data will be qualitative, or descriptive, and you'll need a way to keep it organized for a long time. If you plan in advance, you can record keep track of your observations quite easily (even if you're just observing a plant growing over a period of two weeks).

- Keep your observation table in a bound notebook, so loose pa don't get lost.
- Record the date and time of the observation every time you make an observation.
- Leave enough space so you can write down all of your observations.
- Think up some shortcuts for noting observations that you mal over and over again, and keep a record of what those shortcut mean (in the example, M means male, F means female, and e individual gorilla has a code number, such as "A-2")

EXAMPLE

GORILLA BEHAVIOR AND POPULATIONS IN THE VIRUNGA AREA OF CENTRAL AFRICA

Date/Time	Gorillas Seen	Observations
2/15 7:31 a.m.	5 total: A-1, A-2, B-3, C-4, C-5	Small troop: 2 F w/2 infants (< 3 months old) led by old silver back M about 1.7 m tall; adults ate leaves, buds, stalks, berries; infants clung to mother's fur and nursed.
2/16 11:02 a.m.	4 total: A-3, B-2, B-4, C-1	Small troop: 1 adult M, 2 F, 1 young M; animals resting after morning meal; saw m but not frightened.
2/17 8:45 p.m.	5 total: A-1, A-2, B-3, C-4, C-5	Same troop seen on 2/15; they have made nests of twigs and leaves; all are asleep, infants next to their mothers.

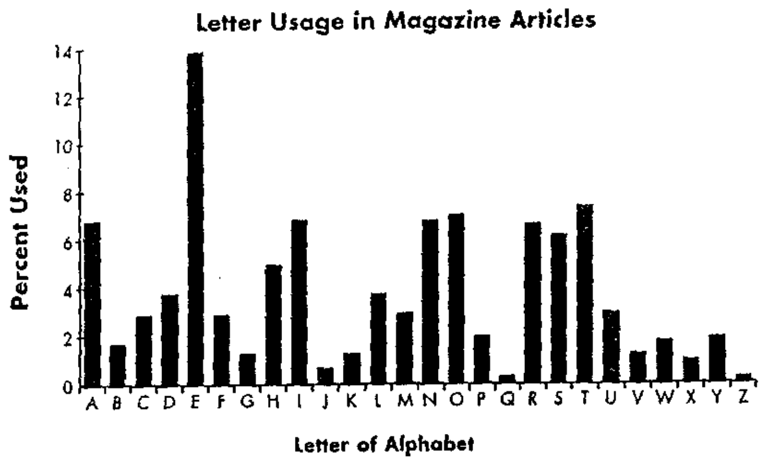
Source: Based on Whitfield, Philip, The Simon and Schuster Encyclopedia of Anin

Directions: Read the article, highlight important aspects, and answer the following questions.

1. **What is the function of a data table?**
2. **Why is it important to diagram legible data tables?**
3. **Contrast quantitative and qualitative data.**

Interpreting a Bar Graph

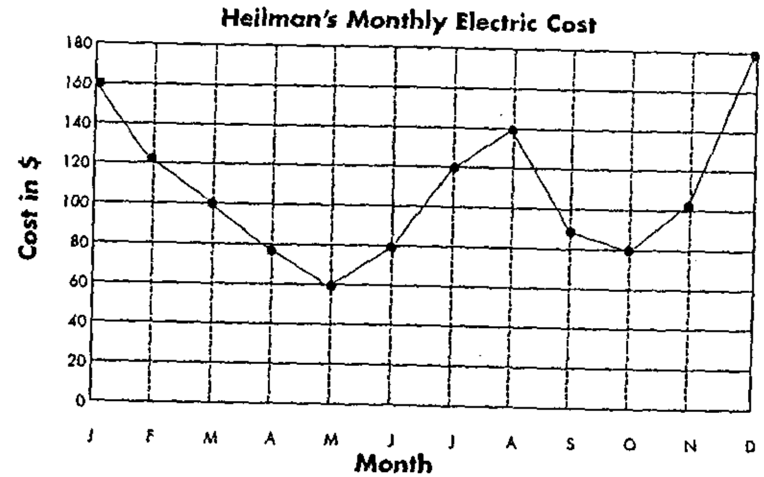
Several students chose a written article from a magazine and calculated the average percent of occurrence for each letter of the alphabet. Below is the graph of their results.



1. What information does this graph display? ______
2. Which letters are used the most? ______ Why? ______
3. Are any of the letter usages surprising? ______
   Why might this be? ______
4. What popular TV game show uses this information? ______
5. Who else might use the information displayed on this graph? ______
6. In an article that contains 1,000 letters, *predict* the number of vowels. ______
7. Choose an article with 1,000 letters and find the number of vowels. Compare your answer with your prediction. ______

Interpreting a Line Graph

The Heilman family, who lives in the Midwest, recorded its electric bill each month for a year. Below is a line graph which shows the monthly bills.



1. What does this graph tell the Heilman family? ______
2. Explain the large fluctuations in the graph. ______
3. Why was the cost the lowest in May? ______
4. What month had the greatest cost? ______
   Why? ______
5. If the Heilmans lived in Michigan, how would the graph differ at different times of the year? ______
   If they lived in Florida, how would this be different? ______
6. How could the Heilmans use this graph? ______

B6

Searching the Depths
Environmental Science

To collect data, scientists often do field research. But in some "fields," conditions make it impossible for humans to visit without special equipment. For instance, as divers go deeper into the ocean, they must deal with decreasing temperatures, diminishing light, and increasing pressure. At depths where pressure is more than the human body can stand, research must be done from within a small submarine, called a submersible.

One such submersible is *Alvin*, operated by Woods Hole Oceanographic institution. Built in 1964 to reach depths of more than 5000 feet, *Alvin* is carried on a large research vessel. The submersible is equipped with lights, video cameras, and robot arms. There are instruments to monitor water temperature and depth, plus a communication system for keeping in touch with the research vessel at the surface.

Alvin became internationally famous after being used in the expedition that located and photographed the remains of the RMS Titanic in 1986. However, *Alvin's* main purpose is to conduct scientific research. The years from 1971 to 1976 were spent surveying the bottom of the Atlantic Ocean, doing both geological and biological surveys. As part of the French-American Mid-Ocean Undersea Study, *Alvin* and two French submersibles carried scientists to the Mid-Altantic Ridge. This was the first time humans saw this geographically active area up close.

In 1988, Alvin enabled biologists and oceanographers to conduct detailed studies of several "hot smokers" along the Juan de Fuca Ridge in the Pacific Ocean. These are vents where an active volcano spews lava directly in to the ocean at depths of several thousand feet. These vents support surprisingly diverse communities of organisms at depths that are usually lifeless. Using *Alvin's* remote-controlled temperature probe, scientists learned that the temperature inside a vent is greater than 275°C.

After more than 3000 dives, *Alvin* has been used for further study of undersea vents and to perform tests on specialized underwater research equipment. *Alvin* has even run errands, making a special dive just to recover a rock drill that was lost by another expedition.

Respond:

1. What problems of deep-sea research does *Alvin* help scientists overcome?
2. List two environmental expeditions that *Alvin* has successfully accomplished.
3. What information did they find from the Juan de Fuca Ridge exploration?
4. How can *Alvin* be used to study the ecology of the ocean?
5. *Alvin* is important in accomplishing which step of the scientific method?

Environmental Science Notes

Area	Scientist	Subject
Water	Hydrologist	Flow of Earth's Waters
	Oceanographer	Ocean environment
Air	Meterologist	Weather and the atmosphere
	Climatologist	Global weather patterns
Land	Geologist	Structure and history of Earth
	Seismologist	Movements of Earth's surface
Organisms	Biologist	Structure and behavior or organisms
	Ecologist	Interactions of organisms and their environment
	Paleontologist	Prehistoric life and fossils
	Anthropologist	Structure of human societies

B7

Environmental Interactions: Bottled Ecosystems

Introduction: The various systems on Earth (the atmosphere, hydrosphere, biosphere, lithosphere, and cryosphere) are interrelated; changes in one system control or regulate changes in another. This project will help you to see the connection among all these entities and help you to understand the relationship between living things and the environment in which they live. You will perform this lab over a period of time to understand how abiotic and biotic factors interact.

Vocab:

Word part	Meaning
-sphere	Round
Atmo-	Vapor or air
Hydro-	Water
Bio-	Life
Litho-	Stone or rock
Cryo-	Crust

Materials:

- Clean, empty, 2-L soda bottles (set-up)
- Water
- Comp book
- Seeds
- Soil
- Pen

Protocol:

1. Clean soda bottle set-up
2. Add water to the aquatic portion of the bottle. Make sure the rope is touching the water.
3. Put the terrestrial bottle on the aquatic portion. Add soil and seeds.
4. Put your name on your ecosystem.
5. Place ecosystem in appropriate place.

Data Collection: (record the following information into your b/w comp book)

Ecological Interactions: Bottled Ecosystem

Group members: Lab station # ___

Color of bottle biome:

Hypothesis: If I create a bottled ecosystem, the following interactions (between abiotic and biotic factors) will occur....

Data table: (4 columns, 9 rows)

Date	pH of water	Change in pH	Detailed Observations

Bottled Ecosystem: Final Lab Write-up

This write up will demonstrate your knowledge of terrestrial and aquatic ecosystems using the bottle ecosystem lab. You will individually create a 2 page (single-spaced, 12 point font) write-up using the following format. I prefer it to be typed! The final draft will be due on ________________. It will count toward your Final grade. Use color on all diagrams and rulers on all charts and graphs.

Introduction: (10 points)

- Explain how various systems on Earth (the atmosphere, hydrosphere, biosphere and lithosphere) are interrelated; specifically demonstrate how changes in one system control or regulate changes in another. Specific examples are required.
- Discuss how the bottled ecosystem helped you to observe how these systems interact.

Experiment: (20 points)

- Roughly explain the experiment (set-up and multiple observations)
- Draw and color your experimental set-up. Label biotic and abiotic factors. Diagram the abiotic cycles within this ecosystem.

Data: (5 points)

- Create an organized data table that depicts all of the information you collected.

Data Analysis: (10 points)

- Diagram a chart showing pH over the last nine weeks
- Explain or infer any abnormalities or any patterns you observed.

Data Analysis Questions: (15 points)

- Explain what would happen if decomposers (worms) or producers (plants) were significantly decreased in an ecosystem using the following statement: "a vital part of an ecosystem is the stability of its producers and decomposers".

Conclusion: (20 points)

Explain the following and how this lab helped you to understand it. (After performing this lab, I am able to explain...)

- Rising temperatures affects an ecosystem
- Abiotic cycle (such as nitrogen cycle) can effect biotic factors.

TOTAL POINTS POSSIBLE: 80