IV. Experiments and Controls: Testing the Hypothesis

A. INTRODUCTION:
   1. Experiments are used to test the validity of hypotheses.
   2. Physicists rely on experiments to decide whether or not their hypotheses are valid.

B. EXPERIMENTS PRODUCE DATA
   1. The process of scientific research starts when a scientist sees something that does not fit in with what is already known about nature
      a. This poses a problem about how nature works. To solve the problem, a hypothesis is formed.
      b. The experiment is used to test the hypothesis.
   2. The purpose of experiments is to collect DATA, or facts, that will show if the hypotheses are valid.
      a. The data scientists collect help them reach their conclusions.
   3. The method of science consists of asking the questions: (THE SCIENTIFIC METHOD)
      What do I want to know? (PROBLEM)
      What do I think the answer might be? (HYPOTHESIS)
      What must I do to tell if the hypothesis is valid? (EXPERIMENT)
      What happened during the experiment? (DATA)
      Do the data show if the problem is solved? (CONCLUSION)

C. THE SCIENTIFIC PAPER: A scientist reports on the results of the experiment in journals or special magazines.
   1. A scientific paper stars with a PURPOSE.
      a. Tells the reader what the paper is all about.
      b. Describes the hypothesis being tested and may give some information about how the hypothesis was formed.
   2. The next part of the scientific paper is the EQUIPMENT List.
      a. Equipment tells what supplies and instrument were used.
      b. It is essential that exactly the items that are used be listed, including brand names.
      c. Any scientist should get exactly the same data by doing the same experiment.
   3. Next part on the scientific paper is the PROCEDURE.
      a. The procedure tells exactly what the scientist did.
      b. The procedure is the experiment.
      c. The procedure gives enough information so that another scientist could take the same supplies and go through the whole experiment in exactly the same way. The weighings, mixings, heatings, or coolings are all described in detail.
   4. The DATA, or facts, come next.

a. Tells what happened.
b. Whenever possible, data are presented in tables and graphs. The original numbers are included.
c. The Data are the amounts, distances, lengths, temperatures, and so on that the scientist measured.

5. Following the data is a DISCUSSION.
   a. The scientist talks about the data and what they may mean.
   b. The discussion may include references to other papers and how this data fits in with them.
   c. Calculations with the data are also done during the discussion phase.
6. The last step in a scientific paper is the CONCLUSION.
   a. Tells whether the data support the hypothesis or not. Should the hypothesis be valid or completely rejected.
   b. Often, the conclusion shows how the hypothesis may be changed to fit new data. The new hypothesis is tested with other experiments.

D. EXPERIMENTS NEED CONTROLS:
1. The control is used to compare.
2. Controls are used to determine whether or not new factors added to experiments caused the results.
   a. Scientists must be able to compare results with and without the factor.
   b. So they conduct the experiment with the factor.
   c. Then they conduct the same experiment without the factor.
3. Scientists use a control when performing an experiment. The results of a procedure with a factor are compared with the results of the same procedure without the
4. factor.
   a. It is as if controlled experiments had two parts.
   b. In the first part of the experiment, something is observed.
   c. In the second part, that same thing is observed with a factor added.
   d. Then the two parts of the experiment are compared.

E. QUESTIONS:
1. How do scientists test their hypotheses?
2. When does the process of scientific research start?
3. What is the purpose of an experiment?

4. Where does a scientific paper tell what the experiment is for?

5. What part of the paper gives details about the supplies and instruments?

6. Where does a scientific paper tell what the scientist did?

7. What part of a paper shows what happened?

8. Where does a scientific paper state whether or not the hypothesis was valid?

9. What is the purpose of a control in an experiment?

10. The following ads could appear in a newspaper.

    OUR BELTED RADIALS ARE 40% STRONGER

    Or

    OUR CIGARETTES CONTAIN 27% LESS COAL TARS

    What are missing from these claims?

F. ACTIVITY: TESTING HYPOTHESES WITH A SPRING AND WEIGHTS (Materials: Spring, large weight, small weight, string, paper clip, tape)
   1. Hang the large weight on the end of a spring.
   2. Pull the weight down about 1 hand width and let it go.
   3. The weight bounces up and down.
   4. Count how many times per minute the weight hits the bottom of it's bounce.
   5. How many times per minute did the large weight hit the bottom of it's bounce when pulled down 1 hand width?
   6. Form a hypothesis about how many times per minute the small weight will bounce.
   7. What is your hypothesis on how fast the small weight will bounce when pulled down 1 hand width?
   8. Hang the small weight on the spring. Pull it down the width of your hand and let it go. Count the bounces carefully for one minute.
   9. How many times did the small weight bounce per minute when pulled down 1 hand width?
   10. Scientists are often unsatisfied with one trial. Why not just take one trial with each weight?
   11. Count the bounces per minute again for each weight.
   12. How many bounces were there per minute for each weight on their second trials?
   13. What would happen if you tested the same thing again and again?

14. What did the data show about your hypothesis on the bounce rate of the small weight?

15. Even if you didn't guess right, what did you learn?

16. Use the large weight and spring again. Form a hypothesis about how fast the large weight will bounce if it were pulled down 3 hand widths instead of 1 hand width.

17. What is your hypothesis on the bounce rate of the large weight if it were pulled down 3 hand widths?

18. What should you do with the hypothesis for question 17?

19. Pull the large weight down 3 hand widths. Release it and count the bounces for one minute.

20. How many times did the larger mass bounce per minute when pulled down one hand widths?

21. How many times did the larger mass bounce per minute when pulled down three hand widths?

22. Look at your answers to questions 20 and 21. Decide the validity of your hypothesis on how fast the mass will bounce when pulled down a longer distance.

23. What is the test of a hypothesis called?

24. Why are hypotheses tested?

G. KEY FACTS and CONCEPTS:
   1. Hypotheses are test by experiments.
   2. Experiments are written up as scientific papers.
   3. Scientific papers are divided into the following parts: Purpose, equipment, procedure, data, discussion, and conclusion.
   4. Controlled experiments have two parts. With the factor and without.
   5. In experiments, controls are used to set up comparisons to determine the effects of changes.
   6. The control allows the experimenter to know if an added factor is causing the effect