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ILLUSTRATIVE LESSON MATERIALS. A SUPPLEMENT TO SCIENCE FRAMEWORK FOR CALIFORNIA PUBLIC SCHOOLS, PRELIMINARY.

CALIFORNIA STATE DEPT. OF EDUCATION, SACRAMENTO

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THE SAMPLE LESSONS IN THIS SECTION ARE MEANT TO ILLUSTRATE THE TYPE OF INSTRUCTION WHICH CAN RESULT WHEN THE GOALS, OBJECTIVES, STRATEGIES, AND TECHNIQUES DISCUSSED IN THE "SCIENCE FRAMEWORK" ARE IMPLEMENTED. THE INVESTIGATIONS HAVE BEEN USED SUCCESSFULLY IN CLASSROOMS BY THE TEACHERS WHO SUBMITTED THEM. THEY ARE CATEGORIZED ACCORDING TO THE EDUCATIONAL LEVELS OF (1) ELEMENTARY SCHOOL, (2) JUNIOR HIGH SCHOOL, AND (3) SECONDARY SCHOOL. THE UNIQUENESS OF EACH LESSON IS TYPICAL OF THE UNIQUE PERSONALITY OF EACH TEACHER AND STUDENT, AND REFLECTS THE UNIQUENESS OF EACH TEACHER-STUDENT RELATIONSHIP. INCLUDED FOR EACH LESSON ARE (1) STATEMENTS OF CONCEPTS SOUGHT, (2) MATERIALS LIST, AND (3) DISCUSSIONS OF INSTRUCTIONAL AND EVALUATIVE PROCEDURES. EXTENSIVE USE IS MADE OF TEACHER-PUPIL AND PUPIL-PUPIL DIALOGUE IN PROVIDING PERSPECTIVE FOR THE LESSON. THE "SCIENCE FRAMEWORK FOR CALIFORNIA PUBLIC SCHOOLS" IS AVAILABLE UNDER SEPARATE COVER. (DS)

Illustrative Lesson Materials

A Supplement to
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FOR
CALIFORNIA PUBLIC SCHOOLS

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CALIFORNIA STATE DEPARTMENT OF EDUCATION
Max Rafferty—Superintendent of Public Instruction
Sacramento 1968

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California State Board of Education

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on Science Education

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ILLUSTRATIVE MATERIALS

The sample lessons submitted in this section are meant to illustrate the type of instruction which can result when the goals, objectives, strategies, and techniques, discussed in the previous pages, form the framework of science education. These investigations have actually been used successfully in classrooms by the teachers who submitted them. They are arranged here in the order of increasingly higher levels of education, starting with the elementary school level, continuing into junior high, and concluding with senior high school level. They reflect ingenuity, imagination, and an awareness of the principles and philosophy of sound science education. The uniqueness of each lesson is typical of the unique personality of each teacher, of each child or student, and reflects the uniqueness of each teacher-student relationship. Their originality should be an inspiration, but they are not meant to be imitated in content. Rather, they are meant to show actual classroom experiences in which teachers have attempted to translate into their instruction the goals set forth in this framework.

a. Elementary School Level

The following lessons utilize materials from well known elementary school science programs. The first is adapted from Science - A Process Approach developed by the American Association for the Advancement of Science and the second is adapted from Teachers Manual for Classroom Laboratory published by Harcourt, Brace and World. Original materials are modified for purposes of this report with permission of the respective publishers.

EARTH'S MAGNETIC FIELD, REVOLUTION, AND ROTATION (GRADE 6)

GOALS

GOAL III → Process: Interpreting Data

GOAL IV → Conceptual Themes → Theme A, Theme B, Theme F

GOAL III — Process: Interpreting Data

Operational Objectives

At the end of this lesson the child will be able to

1. identify true north from a shadow path.
2. identify the magnetic declination.
3. identify true north using magnetic north and the magnetic declination.

→ To Strategy (next page)

GOAL IV — Conceptual Themes

At the end of the lesson the child

Theme A — Operational Objectives

1. when asked to demonstrate what causes the sun apparently to move across the sky, will be able to show with models, how this effect is caused by the earth's rotation
2. with models, can demonstrate why the end of the sticks' shadow moves in an arc from east to west.
3. given a stick, will be able to find true north and magnetic at a given point on the playground.

→ To Strategy (next page)

Theme B — Operational Objectives

1. when asked what determines north, gives an answer that indicates that the axis of the earth is involved in direction finding.
2. given models, can demonstrate what day and night are.

→ To Strategy (next page)

Theme F — Operational Objectives

1. when given models, can show how early scientists might have figured out the direction of the earth's rotation by movement of shadows.

→ To Strategy (next page)

Overall Strategy

The children will work with models of the earth, and sun, and with a stick. After they have worked with rotation of the earth, the causes of night and day, and shadow movement, they will put their new experiences into practice in an investigation on the playground. They will take their recordings of their observations back into the classroom, where they can now use the models to determine how to best interpret the data. They will, hopefully, develop explanations which make the playground observations meaningful.

Vocabulary

Shadow path, declination, shadow stick, true north, compass north or magnetic north.

Materials

One or more protractors
One or more magnetic compasses (the larger the better)
One globe of the earth
One electric extension cord with light bulb socket and light

For each group of three or four children:

One sheet of cardboard or heavy paper (butcher's paper or wrapping paper, about 60 cm square)
Masking tape
One shadow stick made by gluing a straight 6.5 mm (one-fourth inch) dowel about 30 cm long into a hole drilled in the center of a square block with dimensions about 8 cm x 8 cm x 2 cm. See Figure 2.
Drawing compasses (optional)

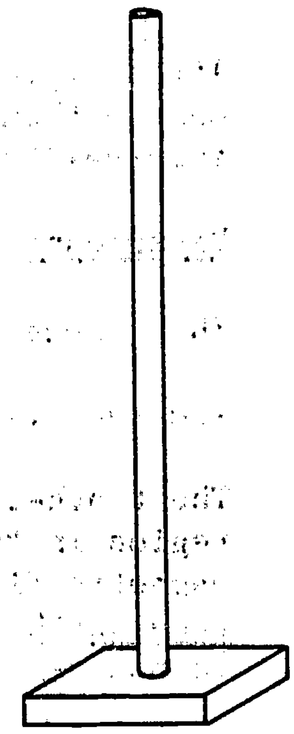


Figure 2

Techniques

Motivating:

The teacher asks the class about direction finding.

A typical question posed by the teacher might be:

> "Have you heard anyone talk about how to find which way is north, if you were out in the woods?"

Possible answers: (from students)

1. "Moss grows on the north side of trees."

2. "The sun sets in the west."

3. "I'd use a compass."

After discussion of these ideas, the teacher tells the class that this lesson will enable them to find true north and that this method is used by the Air Force in survival training.

Background Development:

The teacher asks the class: "What do we mean when we say North?"

The idea is developed that north means toward the north pole.

The teacher then brings out the idea that a compass is a magnet and points to a region in the Arctic Ocean on Prince of Wales Island, because of the earth's magnetic field. The teacher tells the class that in this lesson they will find true north. The term "declination," meaning variation from true north, is introduced.

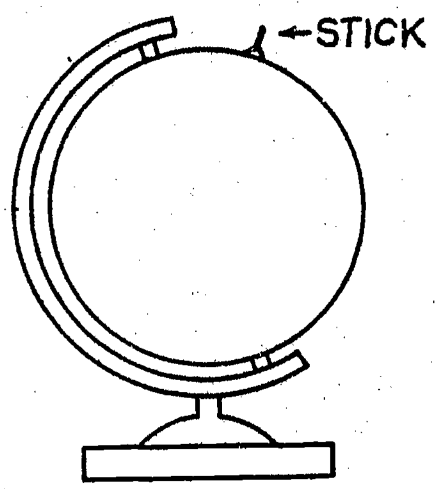


Figure 3

With modeling clay, or otherwise, fasten a short (about 2 cm long) piece of matchstick perpendicular to the surface of the globe at your locality. Place an electric light horizontally at a distance of several feet away from the globe.

Call the children's attention to the shadow of the stick and rotate the globe a little from side to side so they can see how the shadow moves. Be careful not to clip the stick off by running it under the support ring.

Ask the children what the globe is supposed to represent. (The earth.) What does the light represent? Some of them should see that the light represents the sun. Now show them a shadow stick and say: Suppose the shadow stick were sitting out in the sun on the playground. What would it correspond to on the globe? (The matchstick.)

Why does the sun rise and set? (The earth rotates.) As the earth rotates, what happens to shadows of trees and buildings? (They move.) Can we make the matchstick shadow move on the globe? (Yes, by rotating the globe.)

Again, rotate the globe a little from side to side and ask the children to observe the shadow closely. Ask them what they observe. Without drawing conclusions at this time, put the globe (with matchstick attached) away for future reference.

Instructional Procedure

Activity 1

Divide the class into teams of three or four children each. Give each team a shadow stick and a sheet of heavy paper or cardboard about 60 cm square. Have each team place the paper on a level surface in the sun (probably outdoors on the playground). It will be convenient (but not essential) if the paper is oriented with its edges approximately parallel to the north, south, east, and west directions. Have the children fasten the paper down so it won't blow away, and mark where the corners lie on the surface so the paper can be replaced after it is taken up. Masking tape may be used to fasten the paper down and mark the corners.

Place the shadow stick (Figure 2) near the center of the south side of the sheet, and draw around the base so it can be kept in the same place. Wax pencil will be satisfactory for this even when the surface beneath is rough.

At intervals throughout the day, the children are to mark on the paper the position of the shadow of the top end of the shadow stick. These intervals may be chosen to fit in conveniently with the school schedule, such as once an hour. There should be at least six such observations, with about half of them before and half after noon.

Have the children remove the shadow stick and place the compass in the center of the space marked for the base of the shadow stick. See Figure 4. Then have them draw a line in the direction the compass points, CF in Figure 4.

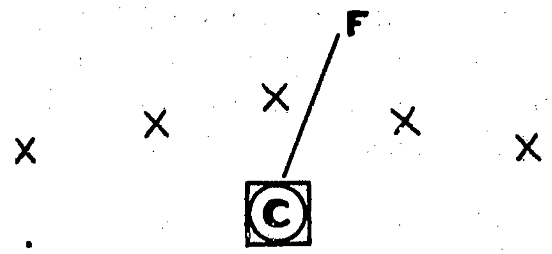


Figure 4

Ask the children to remove their papers from the playground and take them back to the classroom.

Activity 2

When the children are in the classroom, ask them to draw the "shadow line" by connecting the points they have marked on the paper. Also have them locate point C under the position of the dowel in the shadow stick base by connecting opposite corners of the square. See Figure 5.

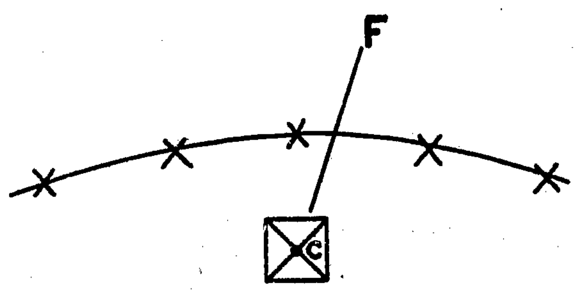


Figure 5

Now bring out the globe and the light. Ask the children again: What is the globe like? (The earth.) What is the light like? (The sun.) What is the little stick like? (The shadow stick.) When the globe rotates, the shadow of the matchstick moves. What is that like? (The moving shadow of the shadow stick.) Can you show me on the globe something like the shadow line you have drawn? The children should be able to identify the line traced by the tip of the shadow of the matchstick as corresponding to their shadow paths.

Rotate the globe from side to side so the matchstick shadow moves. What do the children notice about the matchstick shadow line? Have them rotate the globe being careful not to clip off the matchstick by running it under the support ring of the globe (Figure 3). The basic fact that they need to see for this exercise is that the shadow path is symmetric with respect to the north-south line (meridian) going through the matchstick. The shadow path for the matchstick will curve slightly toward the south, as shown in Figure 5. Another useful fact is that the matchstick shadow is shortest when pointing true north. These facts may be observed by some of the students. In any case you should reinforce their observations and make sure that these facts are understood by all the children.

A drawing on the chalkboard (like Figure 5), showing the shadow path of the matchstick on the globe may help their understanding. Ask the children if this drawing (Figure 6) looks like their shadow path drawings. What is the difference? (Their drawings have no true north line.) Ask the children: Looking at the chalkboard drawing and looking at your own shadow-path drawings, how do you think you should draw in the true north line?

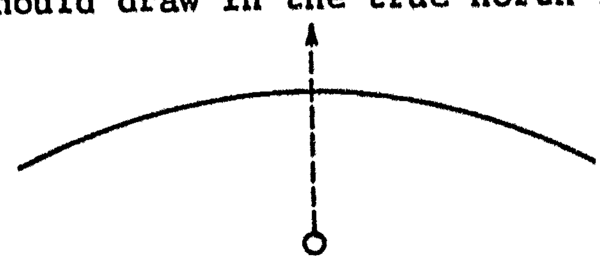


Figure 6

Someone may notice that the north line on the chalkboard figure is the line from C to the nearest point on the shadow path. The children should include this line in their drawings. See line CD in Figure 7.

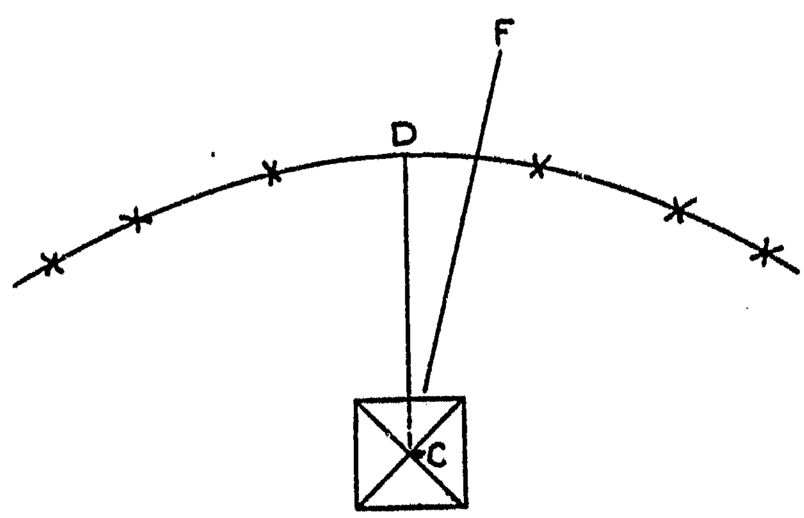


Figure 7

Activity 3

It will probably be clear to the children that the method used at the end of Activity 2 to determine true north is not accurate. In this activity a more accurate procedure is suggested, depending on the symmetry of the line on the board (Figure 6).

Ask the children again about the chalkboard figure (Figure 6) and remind them that the shadow path is symmetric with respect to the line pointing north from the matchstick. What about the shadow path on your papers? They should see that, when the shadow path was in the position where the data were taken, it was a symmetric about the earth's north-south line. Can you find a line going through point C, Figure 7, about which the shadow line is symmetric? Some of the children may say that the line CD is a line of symmetry. Agree that this is true, except for errors in determining CD.

Is there a more accurate way to determine the line of symmetry on the papers? All suggestions should be considered carefully and any that can be built into a valid procedure should be used. One possibility is to find two points, A and B, that are the same distance from C, i.e., AC=BC. This may be done with sufficient accuracy by measuring with a ruler, moving the ruler until AC is some convenient distance and then making BC the same length as AC. Large drawing compasses could be used or a string with a loop to guide a pencil point.

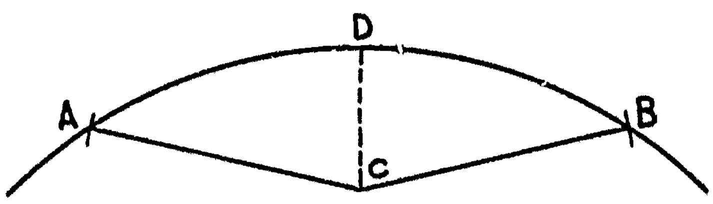


Figure 8

The angle ACB can be bisected easily with a protractor by adjusting it so the angle reading for the line AC is the same as the angle reading for the line BC. See Figure 9. Then the 90° line in the middle is on the bisector, which is the line of symmetry.

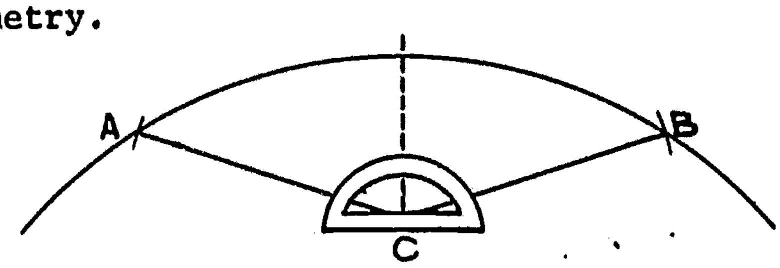


Figure 9

Another method is to draw the straight line AB and find its midpoint by measuring. The line connecting C with this midpoint is the line of symmetry.

Still another way is to find a point E (Figure 10) such that AE = EB. This can be done with large drawing compasses or by the string-pencil method.

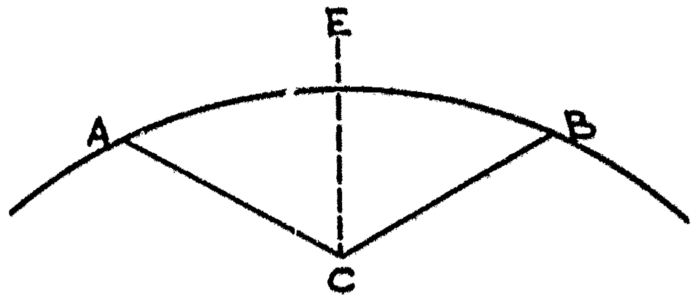


Figure 10

Have the children draw the line CE, preferably in a different color than the line CF in Figure 7. CE would coincide with CD except for errors in measurement.

Generalizing Experience

The children's papers now show a line CE pointing to true north and a line CF pointing toward the magnetic north. Figure 11 shows the situation one may expect in the Western United States. In the Eastern United States (see Figure 1), the line CF would be to the left of the line CE.

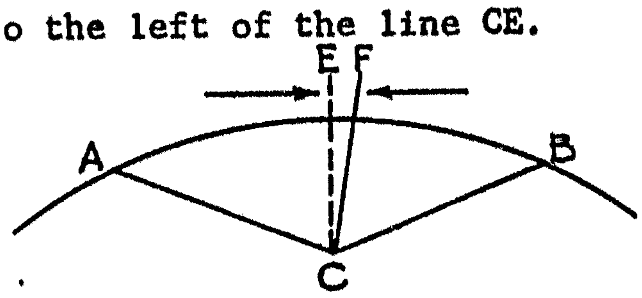


Figure 11

Have the children exhibit their drawings. Call particular attention to the lines CE and CF. Are they similar on all the drawings? Examine particularly situations that appear to differ markedly from the others and try to find explanations.

Have the children measure the angle between CE and CF with a protractor. This angle is known as the <u>magnetic declination</u>.

Have each team report its result and write it on the board. There will be some disagreement. Which measurement shall we choose? Taking an average will quite likely be suggested, and this should be done. Tell the children that the class will use this average of the measurements for the declination.

How can we use the declination? The children may suggest the possibility of using it to find true north when compass north is known. The declination stays practically the same over a wide locality, so the declination they measured in the playground can be used elsewhere in the vicinity. Some children will probably see that true north can be found by adding the declination angle to compass north.

Appraisal

Draw a large circle on the board to represent a compass dial and have the needle point 45° to the left of upright. Tell the children that the drawing represents a magnetic compass. Then draw a broken line at 25° to the left of upright and tell them that the broken line represents true north. Ask them how they might measure the magnetic declination shown in this drawing.

Erase the lines showing magnetic and true north, and draw a new magnetic north line 20° to the right of upright, telling the children what it represents. Draw two broken lines, one at 30° to the right and one at 20° to the left of upright. Ask them which broken line represents true north when the magnetic declination is 10°.

Draw a symmetrical shadow path at about point C on the board, but orient the path to the left of upright. Have the class determine true north from this drawing.

On the globe, change the stick to a location in the southern hemisphere and ask the class to suggest what changes would have to be made for this system to work in Chile.

Point to a place on the globe farthest away from the light, and ask what time the class thinks it is, at this point.

Rotate the globe from east to west and ask what portion of a full rotation takes place from 12:00 A.M. to 6:00 A.M.

Go out to the playground, and have the teams show how, without paper, pencils, or other classroom supplies, they might find north if they were lost in the woods.

Different Rates of Mixing (Grade 6)

Reference: The investigation in this lesson uses Investigation 5: "Motion of Molecules" from Hy Ruchlis's Teacher's Manual for Classroom Laboratory: Concepts in Science 6, Harcourt, Brace & World, Inc., 42 (1966), New York.

Note: (Although both lessons start by using identical materials and initial procedures, the objectives and design for this lesson are quite different from those given in the original reference.)

This is a play-by-play account of a lesson which was developed in a sixth grade of an urban school which serves culturally-deprived and middle socio-economic level families.

Objectives:

To arrange a learning situation in which children will:

1. become aware of the possibilites for erring inherent in jumping to conclusions.

2. understand and appreciate the importance of analysis in scientific investigation.

3. understand the role of an hypothesis.

4. gain skill and ability in designing and executing a simple research experiment to test the hypothesis.

5. verify, as a result of investigation, that the rate of mixing in water is directly related to the temperature of that water.

Classroom Organization:

The class of 32 pupils was divided into six investigation teams. While they were studying their spelling words, two "laboratory assistants," Nancy and Lewis, were assembling, preparing, and distributing the following:

For the teacher:

an electric hot plate
a pan of hot water
a plastic tumbler
a ladle
2 bottles of identical green food coloring (liquid)

For each team:

paper towels (to protect desk tops)
2 plastic vials (test tubes or small jars would serve just as well)
1 rack for the vials

After the spelling period had ended, the pupils cleared their tables while the "lab assistants" filled one vial about two-thirds full of cold water, for each team. The teacher filled the other vial, for each team, about two-thirds full of hot water.

Building for Participation and Involvement

Teacher's Commentary	Class--In Action
I attempt to get the child to participate, then become intellectually involved, and finally, make a personal commitment.	Each team was asked to identify and label the vial containing hot water. The teams were then asked to identify and label the vial containing cold water.
I have arranged the situation wherein the possibility exists that the dyes could be different, since they come from two different sources.	The two "lab assistants" were each given a different bottle of liquid food-coloring. Nancy was instructed to dispense one drop of "her dye" into each vial of cold water. Lewis was instructed to dispense one drop of "his dye" into each vial of hot water. The class was asked to observe what happened in each vial and to look for differences. After a sufficient time for observation, discussion, and comparison, each team reported its
Team participation achieved.	observations. All teams reported that the color mixed more rapidly and more completely in the hot water than in the cold water.
The teacher purposely has induced the pupils to jump to conclusions before all factors have been analyzed.	The class was then asked to explain why the differences occurred. "The hot one mixed first, because it's hotter," responded Dennis.
Not enough children at this point have seemed particularly concerned with the teacher-contrived problem. I proceed to encourage more to participate.	(About one-fourth the class nodded or showed by facial and other expressions that they agreed with Dennis's conclusion.) The teacher asked for a show of hands of those who agreed with Dennis's conclusion. (About half the class now raised their hands.)

Teacher's Commentary

I was seeking not only participation, but also involvement through commitment.

By now almost all pupils had made a commitment of one kind or other. Having made a commitment, each was now ready to be faced with a problem:

Class--In Action

The teacher then asked, "How many disagree with Dennis's idea?" (About one-fourth the classmates raised their hands.) The teacher repeated his questions: "Who agrees?" "Who disagrees?" "Who is not sure?"
"WHY was heat the cause of the difference in the results?" the teacher asked.

Building the Problem

Various answers were forthcoming.

"I read about it in a book," said one.
"I know, but I don't know how I know what I know," said another.
"Everything else on the table is the same, except the temperature of the water, so it has to be the only thing that's different--the heat," said a third.

Here was the untested assumption which I had wanted to come from the class. The rest of the lesson was built on the necessity of proving their conclusion, by proving false another premise, which might have been possible.

I pressed for another suggestion:

In a dramatic fashion the teacher pressed on, "Are you sure the water is tne only thing on your table that varies?"
Kathy seemed perplexed as she replied, "But Mr. R__, how could it be anything else? All the rest of the stuff is the same!" (Several children agreed.)
"Are you sure?" continued the teacher. (More perplexed expressions appeared in the classroom.)

Analyzing Factors in the Problem:

I had hoped that the class would be able to analyze the factors related to this experience without my assistance, but they were unable to do so. In order to pursue my goals, it was necessary for me to guide the class in identifying and analyzing factors in this situation.

"Look at the materials on your tables," urged the teacher.
"Let's list all the things that are on your tables."
The children did this: "Towel"--"Two vials"--"Vial holder"--"Hot water"--"Cold water"--and "The dye."

Teacher's Commentary	Class--In Action
I had wanted the children to realize that the dye, although the same color, might be different in the two vials, and thus be a variable, since the dye came from two different bottles.	"Is the dye the same in both vials?" queried the teacher. "Sure," retorted Harry and some of the others. "Where did the dye in the cold water come from?" I asked. "From Nancy," agreed the class.
So I asked leading questions.	"Where did the dye in the hot water come from?" "From Lewis's bottle," they all agreed. "Are the dyes the same?" I asked again. "Yes," they answered. "How do you know?" I pursued. "Because they are the same color," came the reply.
Some signs of confusion now appear, but one student persisted.	"Does that make them the same?" I asked again. "Sure, they are the same," argued Raymond. "They have the same color."
I tried to make him analyze.	"Do two things having the same color have to be the same thing?" I asked.
Another student begins to offer a suggestion...	"No!" replied Kathy. "In art we can make a same green by using water color, or tempera, or oils."
By this time each pupil was awake to the problem, as one which he or she would have to answer.	"Well, they look the same!" "But maybe they are different?" (These were typical responses now.) Melody asked to examine both bottles. "They're both the same to me!" she exclaimed.
To lead them to look for possible clues for differentiation of the dyes, I began to look at the under side of each bottle. I had served as the agent to confront them with the problem.	"It's a trick!" "It's a trick!" Danny announced. "They aren't the same kind of dye." The teacher neither agreed, nor disagreed, but asked, "How do you know?"

Leading Students to Propose an Hypothesis:

Dennis had a keen sense of logic and was thus able to clarify the problem for the class.	Dennis went to the board and argued that the rate of mixing had to be due to either difference in temperture of the water, or to differences in dye.

Teacher's Commentary	Class--In Action
The term, hypothesis, was used without explaining its meaning to the class. The children seemed to understand its meaning through the context.	At this point the teacher helped the class write two hypotheses on the board: Hypothesis A: The difference in rate of mixing is due to the difference in temperature of the water. Hypothesis B: The difference in rate of mixing is due to differences in the dyes themselves.

Designing an Experiment to Test the Hypothesis:

After identifying the four factors which might need further investigation (hot water, cold water, Dye A, and Dye B), the teams were asked to:

1. Accept either Hypothesis A or B.
2. Design an experiment to test the hypothesis selected.
3. Check the research design with the teacher for safety factors.
4. Carry out the investigation to test the hypothesis.
5. Report the results to the class when asked to do so.

The assignment contained ample provision for individual differences. The criterion for success was that of individual participation rather than that of achieving any predetermined level of sophistication as defined by me.

In the meantime, I circled among the six teams to note their wide range of ideas and skill in working as a team, and individually, in handling materials.

After much huddling and conferring, the six teams developed their own designs for the experiment:

Teams 1 and 3: Decided to dispense 1 drop of dye from the same bottle into the vial of hot water and into the vial of cold water.

Team 2: Decided to repeat the experiment, and then to reverse the dyes. The dye first added to the hot water would be added to the cold water in the second trial, and vice versa.

Team 5: Decided to use cold water in both vials and place "Nancy's dye" in one vial and "Lewis's dye" in the other. After recording the result, they repeated the experiment, using hot water instead of cold.

Team 4: Decided to repeat the experiment, but to substitute ink from Ann's pen for the dye. Carla argued: "If the hot water makes the dye mix faster, it should also make the ink mix faster."

Teacher's Commentary

I had not anticipated that any team would decide to ask for a substitute for the dye, but naturally I encouraged Team 4 to pursue its investigation.

Dennis has a keen notion of the role of falsification in a scientific investigation. Michael's level of development is less sophisticated. Both, however, test their hypothesis. Dennis is unable to communicate to Michael. If Dennis can learn to overcome his fear of mathematics, and also learn to communicate to others, he will probably become an outstanding scientist someday.

Class--In Action

Team 6: Disputed over procedure and underlying logic. Dennis wanted to hold the temperature constant and vary the dyes, in order to prove his hypothesis that the difference in rate of mixing was due to difference in temperature of the water.
Michael, on the other hand, argued that if they were testing for difference due to heat, they would have to use water of different temperatures. Michael finally gave in with the comment, "Nuts!" while Dennis went ahead to prove his hypothesis "true" by trying to see if his investigation could make it come out false. After Dennis couldn't prove his hypothesis wrong, so therefore it was right, Michael tried out his design.

Reporting and Sharing Conclusions:

During the discussion period which followed, all teams reported that:

Hypothesis A is correct: "The difference in rate of mixing is due to difference in heat, or temperature."

Hypothesis B was rejected.

Dennis contributed: "We really cannot tell if the dyes are the same or not, from our experiments. We can only tell that they do not act differently when the water in both vials is about the same temperature.

Teacher's Commentary

Evaluation:

By the end of the lesson the children were well aware of the danger inherent in jumping to conclusions before all the facts were investigated. They enjoyed analyzing the factors which might have been the cause of the phenomenon observed. They had a working understanding of the role of a hypothesis in scientific investigation. They were able to plan and execute an experiment to test their hypotheses, and they had become familiar with some experiences which would later prepare them to understand such abstract concepts as molecular motion and Kinetic Theory. They had enjoyed the experience of an adventure in science.

Junior High School Level

The following lesson plans have been used successfully with students ranging from slightly below average to the gifted level. They include materials from the fields of physics, chemistry, biology, and health science. The emphasis is on student involvement in all processes of science, including data collecting, graphing, forming hypotheses, and planning and carrying out the student-designed experiment.

Goals

No attempt has been made to classify the six experiments which follow, under any special goal. Rather, the following goals have all been kept in mind:

1. To involve the students in their science education.
2. To provide opportunities for creative, process-oriented thinking.
3. To enable students to form hypotheses and test their hypotheses within the limits of their background and laboratory materials.
4. To provide opportunities for handling scientific apparatus.
5. To let the students enjoy science.
6. To open new horizons in science education for the student.
7. To provide opportunities for interaction of ideas within a group.

8. To confront the students with some of the "unsolvable" aspects of science.

9. To encourage them to synthesize facts and concepts in applying them to a new problem.

10. To provide "barriers" to make them conscious of their own limitations and thus to encourage independent or classroom pursuit of science studies.

11. To develop appreciation for the fact that science can progress through a series of failures.

12. To encourage careful observation and measurement.

13. To accentuate the close relationship between mathematics and science.

14. To encourage the large conceptual pattern rather than the minute, isolated fact.

15. To provide opportunities to summarize findings and to try to bring order out of apparent chaos.

16. To encourage the students to apply the same thought processes to other areas of their lives.

A Tale of Heredity and Eggs
(Junior High School Biology)

Overall Strategy

Although this lesson takes off on the subject of heredity, its real purpose is to place the students in a situation where they must form an hypothesis. Teams of three or four students are presented with one hard-boiled egg and one raw egg. They are not allowed to touch them, but must draw upon their past experience and imagination in order to find ways for listing distinguishing differences between the two eggs. Their problem is to propose hypotheses of the "IF...THEN" nature, which are possible for them to use.

The teacher serves as a resource person, and visits each team to see if the students need help or are realistic and using safety measures in their plans. The student planning sessions should extend over two days so students may bring in testing materials. Common substances such as beakers, balances, lights, etc., should be available around the room. Students should be encouraged to innovate and test their new ideas. Emphasis should not necessarily be on success in detecting egg differences but in devising and testing hypotheses.

There will be wide differences in the variety and number of tests carried out. There will be accidents with eggs which add to the excitement of the experimentation. The teams should be required to write up their findings, both positive and negative, in a clear, concise manner.

Teacher Goals

1. To provide students with an experience in an hypothesizing and testing situation.

2. To encourage creative, original thinking.

3. To demonstrate the experimental science possibilities in using common everyday materials.

4. To provide opportunities for students to work with a team and compete with other teams.

5. To encourage the development of simple test materials and devices.

Evaluation

Upon finishing this investigation the student should be able to:

1. Work more effectively in team situations.

2. Use simple science equipment with skill.

3. Test other similar-appearing materials to detect subtle differences.

4. Seek out other problems which can be tackled by hypothesis and testing.

The Experiment:

In the year 1940, there was a great scientist called Dr. Gregor Mendel who set out to rediscover the laws of heredity. In his country they could not grow peas, so Dr. Mendel chose to experiment with chickens. After long years of crossing thousands of different types, he wound up with a very strange breed of chicken. These chickens were bred to lay only HARD-BOILED EGGS.

Those of you who have read your textbook carefully on page __ to page __ know that hereditary traits are carried from parent to offspring by particles called genes. These genes can either be dominant or recessive. In the case of Dr. Mendel's new chickens they carried recessive genes for laying hard-boiled eggs, usually listed as "e e." Normal chickens had dominant genes for raw eggs and are genetically listed as "E E."

Last year, Dr. Mendel absent-mindedly left his laboratory unlocked, and all the "HARD-BOILED" chickens escaped. Eventually they spread throughout the world so that today, when hens and roosters are mated, the genetic makeup of the newly hatched chickens might possibly look like this: (See next page.)

PARENT:	Rooster Ee	Hen ee
First Generation of Hens	Ee Ee Raw Egg Layers	ee ee Hard-boiled Egg Layers

Thus one-half the eggs now laid on a typical egg ranch could be hard boiled. That is why this science class has been hired by the Egg Growers' Association to find fast, simple, and sure methods of separating raw and boiled eggs.

Step I--Forming Hypotheses (Educated Guesses)

Form teams of _____ and pool your brain power to list all the ways you can imagine to separate boiled from raw eggs. Of course, you are not allowed to crack or harm the eggs in any way that will prevent their sale.

1. 4.

2. 5.

3. 6.

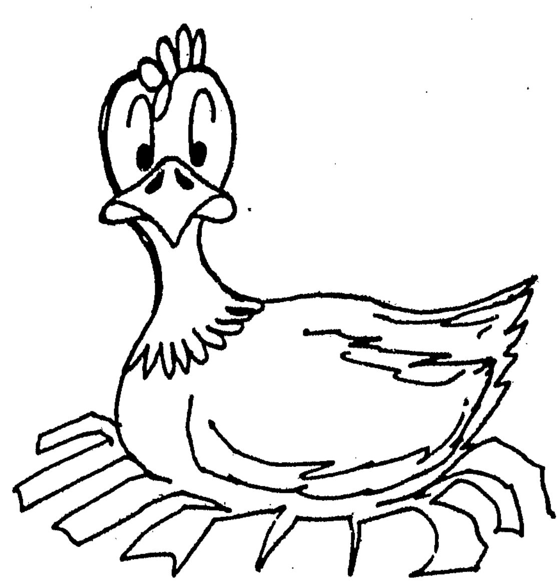
Step II--Testing your Hypotheses

You will now be issued one raw and one boiled egg that look similar. Go through your list in Step I and try out each of your egg-checking methods. As new ideas occur to your team, add them to the original list. Describe your results below:

1. 4.

2. 5.

3. 6.



Ecolab Corporations
or
How Different Can You Be??
(Junior High School Biology)

A. CONGRATULATIONS: By virtue of your superior talent your class has been selected to participate in a novel ECOLOGICAL LABORATORY. You will form corporations of not over five to plan and actually perform an imaginative experiment involving a LIVING plant or animal in a novel environmental situation.

B. PROCEDURE:

1. Your teacher will select corporation presidents.

2. You will join a corporation of your choice--limit five.

3. Your corporation will select a "catchy" name and elect a secretary, a chief engineer, and a supply sergeant.

4. You will combine your massive I.Q.'s and dream up a world-shaking ecolab project.

5. You will be given time to submit a one-page proposal giving your corporation name, corporation members, what your propose to do, and a sketch of how you visualize it. This is one-fifth your grade.

6. Your secretary will prepare a superb four-to-seven-page notebook detailing in words and sketches your corporation title, officers, plans, problems, results, and materials used. This must be turned in the day of your oral report. Research on your animal is required.

7. Your corporation must supply practically all of the material needed--special permission must be sought to use school material.

8. After approval of your project, you will be given class time and space to carry it out. It will be done in our classroom.

9. Your team behavior during class time will count toward your grade.

10. Your entire team will receive the same grade. If one "goofs up," all grades will be lowered.

11. Your entire team will prepare to report your ecolab results back to the class during a time to be scheduled. DO RESEARCH ON YOUR CHOSEN ANIMAL OR PLANT.

12. Your oral report will involve your entire team. Make it different by using audio visual aids of all sorts and a big dose of humor and initiative.

C. SUGGESTIONS FOR ECOLAB PLANTS AND ANIMALS:

Remember this should be organized and completed in less than three days. Use special care with warm blooded animals. No harm should be done to any creature. (ants, snails, lizards, mice, frogs, snakes, birds, earthworms, caterpillars, moths, butterflies, seedlings, plants, beetles, fish, molds, cactus, shrimp, mosquitoes, flies, planaria, pigeons, turtles, or ???????)

D. ECOLAB GRADING: Will be done on the following point system:

Corporation Activity	Maximum Points	Your team's score
1. Imagination, Originality, and Neatness of proposal--See No. 5 above	20	
2. Corporation Plan Notebook--See No. 6 above	20	
3. Team work--ability to cooperate together. Demerits for excessive noise, wandering to other teams and wasting time	20	
4. Project Success or Failure--How well you carried out your plan. Don't hurt your creature.	15	
5. Class Lecture--points for use of audio visual aids, humor and successful penetration of class ignorance barrier--TELL FACTS YOU LOOKED UP ABOUT YOUR CREATURE. BE DIFFERENT AND BE INTERESTING.	25	

E. TEAM RECORDS:

CORPORATION NAME ______________________________

CAPTAIN ______________________________

1. ____________________ 3. ____________________

2. ____________________ 4. ____________________

Camphor Task Force
(Junior High School Chemistry)

1. Captain________________ 2. Secretary________________ 3. ________________

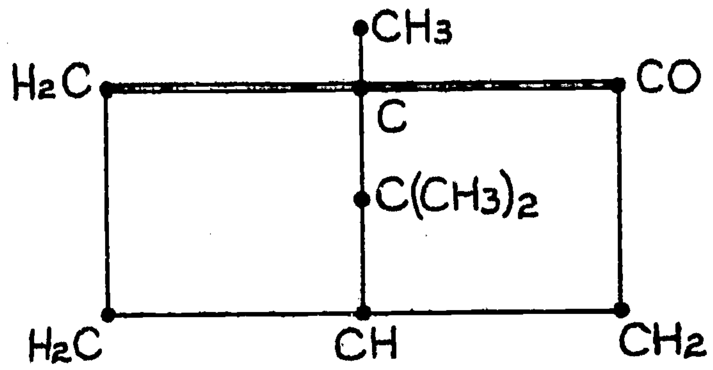
4. ________________ 5. ________________ 6. ________________

(Best Task Force Report Gets Four Points on Next Exam for Each Member.)

A. PURPOSE: The invaders from planet "?" have been dropping strange squares of plastic wrapped materials on the Earth near Portolá. Central Intelligence has assigned this class to analyze this material. It is plainly marked "camphor" but that may camouflage a more deadly purpose. Your task force is to find out all it can about the characteristics of this strange matter. This must be done within the limits of Portolá's science facilities.

B. PRELIMINARY REPORT: Our chemist tells us that it is an organic substance which means it has a carbon base and was probably derived from a living substance. However, he says it may have been made synthetically from turpentine. He gives the molecule this shape:

Looks like this



C. TASK FORCE PRELIMINARY JOB: Start out by describing these common characteristics:

1. Formula (Hint--add the atoms in the molecule.)
2. Molecular weight
3. Smell
4. Texture (How does it feel?)
5. Color
6. Luster (How does it reflect light?)
7. Specific gravity (Does it float or sink in H_2O? H_2O has a specific gravity of 1.)
8. Acid or base (Use litmus or pH paper.)

9. Solubility (In water or "?")

10. Hardness (Think of Moh's Mineral Scale from Geology.)

11. Flammability (Try only at Bunsen Burner at front--on asbestos with teacher's permission.)

12. Conductivity (Electrical--see if it can complete an electrical circuit.)

D. CREATIVE THINKING: Now you are on your own. Be ingenious and different. Describe what you TRIED and discovered. This is the most important part of the experiment.

1.

2.

3.

4.

5.

Resiliency and Elasticity
or
How High Will I Bounce???
(Junior High School Physics)

PREVIEW: All objects in your surroundings differ in their physical characteristics. Today's lab deals with the properties of resiliency and elasticity which involves an object being able to return to its original form when compressed. Imagine a rubber ball and yourself being tossed out of a 20-story window. Both you and the ball would be deformed on impact with the sidewalk, but only the ball is elastic and resilient enough to resist being deformed, bounce back, and restore its former shape. Let's test a few objects to check their "resilasticity."

MATERIALS NEEDED: Meter stick, various balls such as golf, ping pong, tennis, rubber, or hopefully, super ball.

PROCEDURE: You will work in teams to fill out the data records below by dropping each ball onto the table top or floor and recording the return bounce. To avoid error, you are asked to drop any given ball three times at each of the five heights to establish the average bounce back. For example: You would drop the golf ball three times from the height of 80 centimeters. If your bounce backs were 46, 44, and 42 centimeters, your average would be 44 centimeters. Upon completion of your three data records, use the graph paper provided to graph your results.

DATA RECORD NUMBER 1--The ball used was a ______________________.

TRIAL	100 cm. drop	80 cm. drop	60 cm. drop	40 cm. drop	20 cm. drop
1.	cm.	cm.	cm.	cm.	cm.
2.	cm.	cm.	cm.	cm.	cm.
3.	cm.	cm.	cm.	cm.	cm.
Bounce Average	cm.	cm.	cm.	cm.	cm.

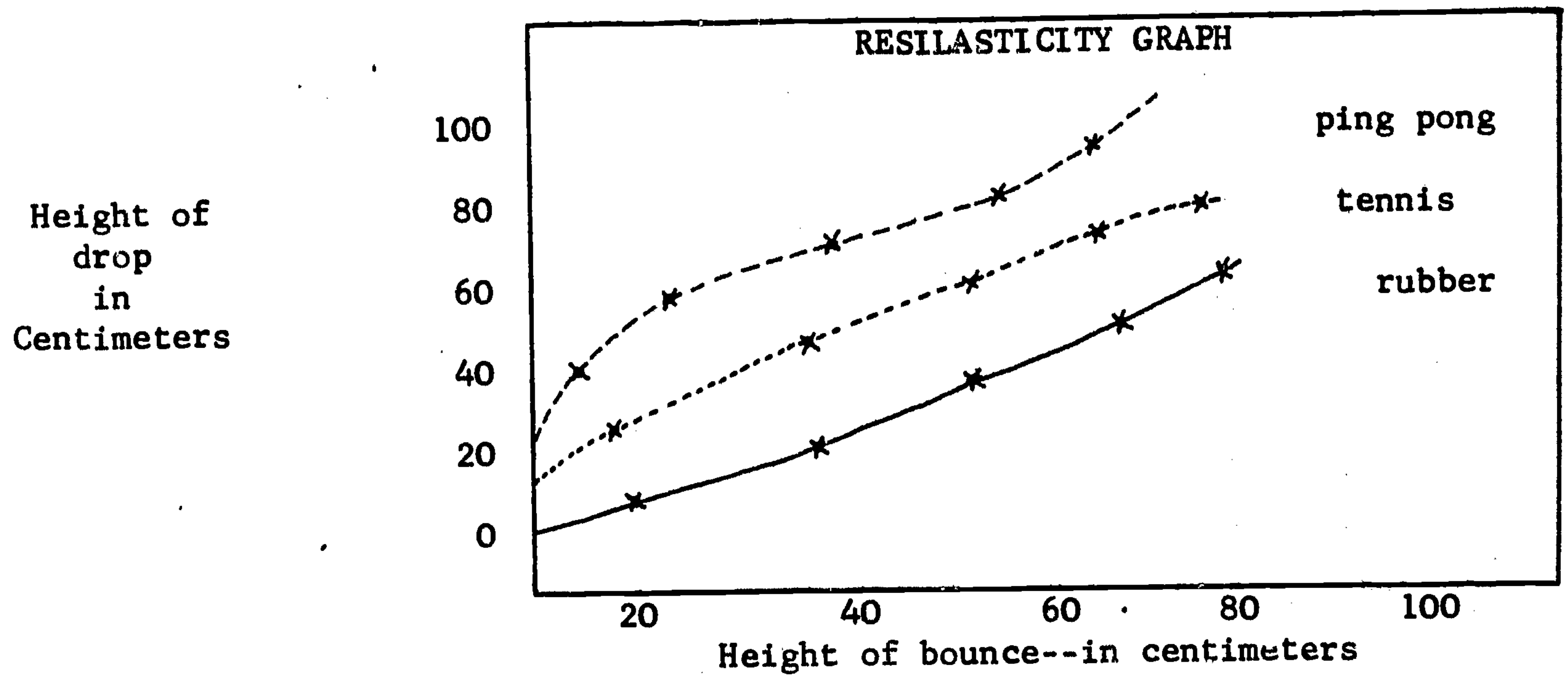
DATA RECORD NUMBER 2--The ball used was a ______________________.

TRIAL	100 cm. drop	80 cm. drop	60 cm. drop	40 cm. drop	20 cm. drop
1.	cm.	cm.	cm.	cm.	cm.
2.	cm.	cm.	cm.	cm.	cm.
3.	cm.	cm.	cm.	cm.	cm.
Bounce Average	cm.	cm.	cm.	cm.	cm.

DATA RECORD NUMBER 3--The ball used was a ______________________________.

TRIAL	100 cm. drop	80 cm. drop	60 cm. drop	40 cm. drop	20 cm. drop
1.	cm.	cm.	cm.	cm.	cm.
2.	cm.	cm.	cm.	cm.	cm.
3.	cm.	cm.	cm.	cm.	cm.
Bounce Average	cm.	cm.	cm.	cm.	cm.

SAMPLE GRAPH--This is provided as a guide only--use separate colors for each ball.



PREDICTIONS:--Use your graph to predict how high any of the balls you used will bounce from any given height. Check each teammate's prediction by actual trial.

<u>Muscle Fatigue Experiment</u>
(Junior High School Health Science)

A. <u>T.V. Commercial</u>

Are you weak, run down, weary? Do you have poor muscle tone, dark circles under dull eyes, and skin pallor? Are you bored, clumsy, irritable, cry easily, yawn constantly and go to sleep even in this exciting health science class? Then you, my teen-age friend, are suffering from

FATIGUE

B. <u>Fatigue Facts</u>

No, we are not promoting a new wonder product called Anti-Fatigue. Actually, chronic (serious) fatigue is a common teen-age problem. It can result from strenuous physical and mental activities, over-excitement, lack of sleep and rest, excessive growth or a medical condition. Chronic fatigue can affect your behavior, your growth, your success in school, and even your resistance to disease.

The 600-odd muscles of your body work in pairs to do the work of your body. Scientists estimate that the muscles help the average person walk over eight miles per day and can support 1000 times their own weight during times of stress. The muscles' tendency to fatigue is related to their size, their blood supply, and to the exercise they have received. Unused muscles tend to shrink and waste away.

Today's experiment will let you demonstrate for yourself how fatigued muscles lose their efficiency.

C. <u>Organizing the Experimental Teams</u>:

1. You will work in teams of four and take turns being the recorder, the timer, and the two victims.

2. Two teammates will peform the fatigue tasks <u>at the same time</u> while the other two record and time. Switch after each test.

3. For timing we will use a kitchen clock with a second hand displayed in the room.

4. The muscle tests are designed to cause simple fatigue. If for some reason any activity overtires you, eliminate it.

5. Between each trial, rest exactly ten seconds.

6. Try to give the same effort on the third trial as you did on the first.

7. Don't expect perfect results. Those of you who are in good physical shape may actually improve with practice on the third trial, instead of letting fatigue slow you down.

8. Fill out the form in part "D." Only one form is to be turned in for the entire team.

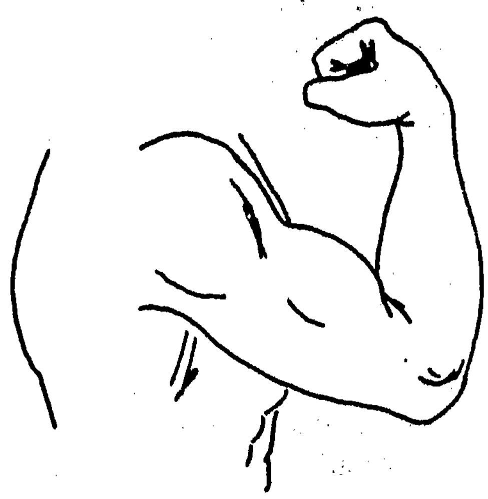
Team Members:

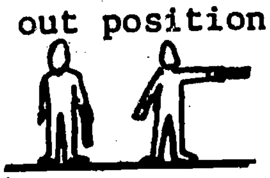
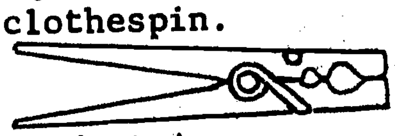
1.______________________________

2.______________________________

3.______________________________

4.______________________________



D. **Fatigue Activities**	First Trial Number in First 30 Seconds	Rest	Second Trial Number in Second 30 Seconds	Rest	Third Trial Number in Third 30 Seconds
1. Fist clenching--place your forearm completely on the table and open and close your fist as rapidly as you can. 		10 SECONDS ONLY		10 SECONDS ONLY	
Student A					
Student B					
Student C					
Student D					
2. Arm lifting--holding onto either your textbook or a 1000 gram weight, raise your arm from the straight down position to a straight out position at 90°. 					
Student A.					
Student B					
Student C					
Student D					
3. Clothespin squeezing. Use your thumb and index finger to completely squeeze and release the clothespin. 					
Student A					
Student B					
Student C					
Student D					

E. Fatigue Freedom

You and your teammates are now free to design a fatigue test of your own. Your test must be safe, should not cause exhaustion, and be achievable with materials in the classroom. You may use muscles involved in moving arms, legs, fingers, toes, jaw, tongue, eyelid, or "?" If you have any doubts about your fatigue test, get your teacher's approval. Fill out the form below on back of this paper.

1. Description and sketch of test.
2. Results--Collect data and organize in the form of part "D" above. You may change the timing of exercise and rest periods to suit the needs of your experiment.
3. Interpretation of data--what you concluded. Go into detail in telling where your experiment succeeded, failed, or could be improved.

Halitosis Under Control--
Using the Scientific Method
(Junior High School Health Science)

Overall Strategy

This lesson grows out of a lesson on health and allows the students to set up a controlled experimental situation. While maintaining the control idea, this investigation provides wide latitude in choice of medium and materials that inhibit or speed up bacterial growth. From the planning date to the final results--date requires all, or part, of ten class periods. The students are encouraged to ignore their prejudgements and record all results as they really happen. Much excitement is generated by the occurrence of changes in composition, flotation, coloration above and beyond odor changes.

Teacher Goals

To provide practice in setting up controlled experiments.

To encourage close observation of changes in matter.

To provide experience in systematic recording.

To promote student confidence in manipulation of variables.

To encourage student decisions and predictions.

Evaluation

Upon finishing this investigation the student should be able to:

1. Set up controlled experiments using other materials and variables.

2. Detect and record changes in an experimental situation.

3. Attempt to predict the results of experiments based upon his choice of variables.

A. Bad Breath Story

Man is a social animal and in his contacts with others he is concerned with personal cleanliness. A common problem for adults, as well as teen-agers, is halitosis--defined by the dictionary as being a condition of foul or offensive breath.

This condition can be a temporary one due to eating strong foods such as onions or can be a more serious one due to growth of bacteria in the mouth or digestive tract. The bacteria have ideal living conditions in the warm, moist, food-laden environment you provide. As part of their life processes they produce the gas which is the essence of bad breath.

Your textbook talks about ways you can avoid halitosis. Today's experience is designed to set up a CONTROLLED experiment whereby you can simulate halitosis as a result of bacteria growth on some medium. You will use bacteria growing on a medium in a test tube of water as your control. In a second test tube you will use the same medium but try to add some ingredient that will increase bacteria growth and cause greater "halitosis." In three other test tubes you will set up the same situation but in each one you will add a different mouthwash or disinfectant to try to slow up the rotting.

Since our classroom doesn't have a $200,000.00 smellometer, we will use two amazing scientific devices you were born with--your nose and your eyes. We will judge the results of our bacteria growth by the change in the smell and appearance over a seven-day period.

B. Serendipity Warning

Serendipity in science involves unexpected results leading to a lucky discovery. Your test tubes will provide you with many unpredictable surprises. Record them faithfully and try to hypothesize how they could have happened.

C. Organizing the Lab

1. You will be formed into teams of four or five.

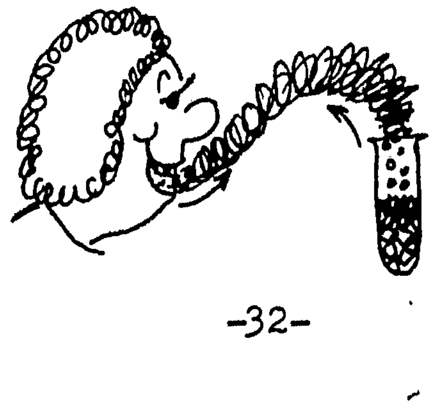
2. Your team will be given a planning session one day prior to the lab to decide who brings in what.

3. Your teacher will provide you with
   a. five clean test tubes and a test tube rack
   b. copious quantities of water and compassion

4. Your team will bring in
   a. your noses, your eyes, and a good lab behavior.
   b. some medium for bacteria growth--this can be uncooked beans, peas, corn, potatoes, cereal, bread, eggs, dog food, cheese, or "?"
   c. three different kinds of antiseptics, mouthwashes, dentifices, or "?" to slow down bacteria growth
   d. something to try to speed up rotting
   e. cotton to serve as plugs for the test tubes. This allows air in but keeps new bacteria out and cuts evaporation.
   f. felt pens to mark your test tubes.

5. Once you decide on a medium, you must use it in all five test tubes.

6. Fill all test tubes to the 2/3 way mark. Use a 2 to 1 ratio of water to antiseptic in test tubes 2, 3, 4, and 5.



D. Recording Your Results:

1. Medium used was ________________.

2. Turn in one report per team.

3. Describe smell, appearance, and serendipity results.

Test Tube Number--All 2/3 Full

Day Start	1--Control Medium + Water	2 Medium + Water + Speeded Up By________.	3 Medium + Water + Slowed Down By________.	4 Medium + Water + Slowed Down By________.	5 Medium + Water + Slowed Down By________
1st					
2nd					
3rd					
4th					
5th					
6th					
7th					

C. Senior High School Level.[5]

PROLOGUE

SCIENCE IS AN ATTITUDE,
A METHOD, AN ACTIVITY OF MAN
INTERESTED IN FINDING OUT
MORE ABOUT HIS NATURAL ENVIRONMENT

	INVESTIGATION	CONCEPT DEVELOPED	NATURE OF THE ACTIVITY
1.	IT'S A REGULAR HAPPENING	NATURAL EVENTS TEND TO REPEAT THEMSELVES	SWING PENDULUMS, CARTESIAN DIVERS SHAKE BOTTLES
2.	THE TALE OF THE RED RUBBER BALL	THERE IS PATTERN OR ORDER TO EVENTS IN THE NATURAL WORLD	DIFFERENT KINDS OF BALLS ARE DROPPED
3.	CURIOSITY TURNS YOU ON	SCIENCE IS AN ACTIVITY BASED ON CURIOSITY	DISCUSSION OF RESULTS OF INVESTIGATION TWO
		SCIENCE PROGRESSES ON CURIOSITY	
		A HYPOTHESIS IS A PREDICTION AS TO THE POSSIBLE SOLUTION OF A PROBLEM	
4.	SCIENCE IS LIKE ICE SKATING	SCIENCE IS A CONTINUAL TESTING OF HYPOTHESES	TWO BALLS ARE DROPPED TO COMPARE RATE OF FALL
		THE PURPOSE OF AN EXPERIMENT IS TO SUPPLY EVIDENCE TO SUPPORT OR REJECT AN HYPOTHESIS	
		THE MAJOR ACTIVITY OF SCIENCE IS THE FORMATION AND USE OF THEORIES	
5.	FIVE CENTS OFF REGULAR PRICE	ALL EXPERIMENTS MUST BE CONTROLLED EXPERIMENTS	COMPARISON OF SUPER-MARKET SALES PRICES
6.	GIANT SIZE, LARGE ECONOMY	ACCURACY IS ENHANCED BY QUANTITIVE MEASUREMENTS	MEASUREMENT, METRIC SYSTEM
7.	40,000 SEMI-SKILLED JOBS LOST PER WEEK	DATA TABLES SIMPLIFY THE RECORDING OF DATA	CHARTING EARNING POTENTIAL VS EDUCATION

	INVESTIGATION	CONCEPT DEVELOPED	NATURE OF THE ACTIVITY
8.	DO SCIENTISTS DRAW PSYCHEDELIC PICTURES?	GRAPHS SIMPLIFY THE INTERPRETING OF DATA	GRAPHING UNEMPLOYMENT RATES
9.	DON'T STOP ME MAN I'M REALLY SWINGING	SUMMARY OF CONCEPTS FROM FIRST EIGHT INVESTIGATIONS	TIMING THE ROLL OF BALLS
10.	SCIENCE IS WHERE THE ACTION IS!	SUMMARY OF CONCEPTS FROM FIRST EIGHT INVESTIGATIONS	GENERAL DISCUSSION OF SCIENTIFIC METHOD

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It Is A Regular Happening

Science is where the action is!

Space age. Atomic age. Air age. Computer age. Electronic age. No matter how you look at your world, you are and you will be living in a scientific age.

Science has already transformed our environment and our lives radically. More radical changes will be coming as man learns to manipulate the smallest parts of atoms, explores the bottoms of oceans, and travels to distant planets.

But the most striking transformation will be in man himself. Before long, we will be able to control our own physiology. (how the body functions), including our brain; reproduce without benefit of sex; direct the heredity of individuals; greatly extend the length of life.

The citizen of tomorrow who expects to compete and survive in an age of science must understand how science operates. Science is not bridges, pills, supersonic planes, and freeze-dry foods.

Science is a way. Science is a way of solving problems. Science is a way of solving problems about our world.

Science is active. Science is an activity. Much of the activity of science takes place in a laboratory. A laboratory can be hundreds of miles in the atmosphere, under the surface of the sea, out in a forest primeval, or even in your family room. You do not always need water, gas, tables, or a white coat. That is the image television gives you. You do not even need a scientist.

All we need is you.

Of course, it would help if we had the cooperation of your mind, because science is a mental activity. It is also a physical activity (LABOR-atory), so you will need to dirty your hands.

The school will provide most of the materials for your laboratory activity. You are to treat the materials with care. Anyone who damages or misuses the materials will be banned from further laboratory work.

Use the materials wisely and a wiser person you will be.

A. A Real Swinging Set

You will be given a short length (about 12-18") of string or heavy thread, a piece of tape, a paper clip book, and some washers.

Tape the end of the string to the edge of a table. Attach the paper clip hook to the other end of the string. Hang one washer on the string. Pull the washer back about six inches and let go. What you are swinging back and forth is called a pendulum.

Count the number of swings in one minute (you can count for 30 seconds and multiply by two). Repeat this at least two more times. Record your count below:

Trial 1 ______________ swings per minute

2 ______________ swings per minute

3 ______________ swings per minute

1. What do you notice about the number of swings in trials 1, 2, and 3?

____

2. If you were to repeat the procedure ten more times, how many swings per minute do you think you would get? ______________________

____

This time pull the washer back at least 12 inches. You do not need a ruler. Just pull the washer twice as far back as before. Count the number of swings in one minute at least three times. Record your counts below:

Trial 4 ______________ swings per minute

5 ______________ swings per minute

6 ______________ swings per minute

3. What do you notice about the number of swings in the above trials?

____

4. If you were to repeat the procedure a hundred more times, how many swings per minute would you get? ______________________

____

Add another washer to the hook and set the pendulum swinging. Count the number of swings per minute three times. Record your counts below:

Trial 7 ______________ swings per minute

8 ______________ swings per minute

9 ______________ swings per minute

5. What do you notice about the number of swings in the above trials compared to your two previous trials? ______________________

____

Add a third washer to the hook and set the pendulum swinging. Count the number of swings per minute three times. Record your counts below:

Trial 10 ______________ swings per minute

11 ______________ swings per minute

12 ______________ swings per minute

6. What do you notice about the number of swings in the above trials compared to all your previous trials? ______________________________

____

7. How many swings do you think you would get if you added more washers?

____

8. What kind of counts are some of your other classmates getting?

____

9. If a person in Norway were to do what you just did, how many swings do you think he would get? ______________________________

____

10. No matter how often you repeat the same procedure, what results will you get? ____

____

B. Who Stole the Sand From Surfer Beach?

You will be given a jar which has been filled with water. Some other items will also be in the water, such as gravel, a ping pong ball, and some pieces of plastic.

Shake the contents of the jar. Then set the jar down on its base.

1. In what order did the contents settle? ______________________

____

Shake the contents again and set the jar down on its base.

2. Did the contents settle in the same order again? ____________

3. What can you say when you repeat a procedure? ______________

____

Shake the contents again, but set the jar down on its cap.

4. Do the contents settle in the same order as when the bottle is set on its base? ______

Shake the contents and set the jar on its side.

5. How do the contents settle as compared to number 2 and number 4?

______

6. If you had a ping pong ball and threw it into a sink full of water or into a lake, what would you expect the ball to do? ______

______

7. Explain your answer to number 6. Note: you are not to try and explain why a ping pong ball floats. You are to explain why you stated the answer you did. ______

______

C. The Yellow Submarine

You will be given another jar almost full of water. There is a small sealed vial floating in the water. The top of the jar is sealed with a piece of rubber. In case you are curious, this device is known as a Cartesian Diver.

1. Push the piece of rubber and describe what happens. ______

______

2. Release the piece of rubber and describe what happens. ______

______

3. Repeat number 1 and number 2 and describe what happens. ______

______

4. No matter how often you push or release the rubber, what will happen?

______

5. Would you predict that everyone else in class is getting the same results? ______

6. If someone in Argentina were to do what you just did, would he get the same results? ______

7. Explain your answer to number 5 and number 6. Note: you are not to try to explain why the vial moves. You are to explain why you stated the answer you did. ______________________________

____

D. The Same Old Things

1. You have just discovered one of the most basic concepts of science. When an event is repeated, what happens? ______________________________

____

____

2. Can you think of one word that means the same thing as number 1?

____

3. One of the reasons scientific knowledge advances so rapidly and is so dependable is that once an event is discovered and explained, we have full faith that the event, under the same conditions, will ______________

____

CONCEPT SUMMARY (In one sentence, explain what you have just learned about events in science--not about pendulums, ping pong balls, or Cartesian Divers.):

____

____

____

____

The Tale of the Red Rubber Ball

Shades of a toy store, but obtain an assortment of balls from the teacher. They will include a golf ball, a hollow, practice golf ball, a marble, a steel ball (pinball type), a couple of rubber balls, and whatever else can be found in the toy box at the moment.

In order to successfully and accurately complete the next series of investigations and so that we all agree on certain terms, it will be necessary to first describe the properties of the balls.

1. What is meant by the word "properties"? ______________________________

   ____

2. Make a list of the balls to be used and describe their properties.

Name of Ball	Properties
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________

3. Take any one ball in your hand. Release the ball. What happened?

   ____

4. Take the same ball in your hand again, but before you release the ball, make a prediction as to what you think will happen.

   ____

5. Why did you make the prediction you made. (Hint: what idea did you learn in the last investigation?)______________________________

   ____

6. Now release the ball. What happened? ____________________

____

7. Repeat the procedure again, at least six more times. What happened each time? ____________________

____

8. What do you think will happen if you were to repeat the procedure a thousand times, a million times? ____________________

____

9. Why did you make the statement you made? ____________________

____

10. If you were to take another ball and release it, what do you think would happen? Go ahead and try, if you wish. ____________________

____

11. If you were to take any one ball, stand on a chair, and release the ball from a new height, what do you think would happen? Go ahead and try, if you wish. ____________________

____

12. Can you make a general statement about what happens when balls are released? ____________________

____

13. Will your statement always hold true if the conditions remain the same? Why? ____________________

____

14. What general statements(s) can you make about the way events happen in our world? ____________________

____

15. Take two balls of approximately the same size and weight, like the small white baseball and the yellow ball. The question is, "Which ball will hit the floor first?" But, before you try it, make a prediction as to what you think will happen. (Note: You are not being graded on the accuracy of your guess, so go ahead. Don't be afraid.) ____________________

____

16. All right, release the two balls at the same time and from the same height. What happened? ______________________________

____

17. Repeat the procedure at least three more times. Did the same thing happen each time? Why? ______________________________

____

18. If you were to repeat the identical procedure a billion times, under the same conditions, what would happen? Why? ______________________________

____

19. What general statement can you make about the way things happen in our world? ______________________________

____

20. From what you have discovered in these past two investigations, you should have no problem completing these sentences:

    A. If an event is repeated under the same conditions, you will always get

    ____

    B. Everything that happens has a ______________________________

    C. There is ______________________________ in the universe.

Curiosity was born when man was born. The first caveman probably wondered about the lightning in the sky, the cold that surrounded his naked body or the ability of birds to fly. Man has not stopped wondering. If there is a man today who does not wonder, he is not a man!

In this investigation you tried and recorded the results to two different procedures: 1. you released one ball and 2. you released two balls of approximately the same size and weight at the same time. These were simple tasks, but they should have aroused your curiosity.

People who succeed in school; people who succeed in life have a curious nature. They ask questions--and they do something about it. They don't moan and complain.

Curiosity is the backbone of science. Science is not a neat package of information to be memorized. Science is the excitement of finding out about the natural world. However, the only way to find out is to be curious.

Are you a curious person? If you are, you will like science!

21. List below the curiosities you may have about the way balls behave. Do you have any questions? Is there anything else you might like to try? Is there anything puzzling you? ______________________________

____

____

____

____

____

____

____

CONCEPT SUMMARY: (What concept did you discover from this investigation? Note: Do not make a statement about how balls behave. Make a statement about how events in nature behave.): ______________________________

____

____

____

The Tale of the Curious Student

Curiosity may have killed the cat, but not man. Man's progress through history has been pushed by his curiosity, by his desire to know. Knowledge brings food to the stomach, shelter for the body, and happiness to the mind.

If you listed your curiosities at the end of the last investigation, it is only proper that you be given an opportunity to satisfy your curiosity.

1. As far as the balls are concerned, what are you curious about? (Please put each specific curiosity on a separate line. You will find these on line 21 of Investigation 2.)

____

____

____

____

____

What you have just done is the backbone and the very heart of science. The word science comes from the Latin, scire, which means "to know." There is only one way "to know" anything and that is to be curious.

Science is not a body of information neatly packaged for students to memorize. Rather science is an activity. Science is an activity invented by man, for the purpose of knowing more about his universe. Scientists are curious people and it is their curiosity which has contributed so much to the knowledge of our universe.

Curiosities give rise to questions; questions give rise to problems. This is they way the activity of science always begins. But then the scientist does a seemingly unscientific thing. He makes a guess, an educated guess. We call an educated guess a hypothesis.

Based on what he already knows, the scientist makes what he thinks is the correct guess or prediction to the solution of his problem.

In other words, the science of curiosity, begins with two questions:

1. "What do I want to know?" (The Problem or Question)

2. "What do I think may happen?" (The Question or Hypothesis)

We are now to make some educated guesses concerning the curiosities you have listed under No. 1. Here are some suggestions to make your task easier:

1. There are really no right or wrong answers in science. Some answers are only more correct than others. There is no premium for being right in this class. There is a premium for being curious. For this reason, you should not be afraid to guess in this class. However, you should use some common sense before you make a prediction. The scientist does not make haphazard guesses. He makes logical guesses, based on what he already knows.

2. Do not be misled by the notion that a hypothesis is untrustworthy simply because it is a guess. Every great step in the process of scientific discovery has been made in exactly this way. Hypotheses (hypothesis, singular; hypotheses, plural) are the methods by which scientists ask narrow, specific questions. A hypothesis, however, is not stated as a question. A hypothesis is stated as a prediction.

3. The ideal hypothesis is one where, a) the situation or past knowledge is indicated, and b) the specific prediction is made. To be more specific, you should start your hypothesis with the word "if," followed by the situation. Then, use the word "then" to complete the prediction. For instance, here is a good hypothesis.

   > "If two balls of the same size are dropped at the same time from the same height, then they will both hit the ground at the same time."

   Note in the above statement that the situation (the first part of the hypothesis)

   a) begins with the word, "if"

   b) ends with a comma

   c) is very specific as to what is going to be done (size, time, distance)

   and that the prediction (the second half of the hypothesis)

   a) begins with the word, "then"

   b) ends with a period

   c) is very specific as to what is going to happen

We are now ready to state some hypotheses. Refer back to the curiosities you have listed under No. 1. Bear in mind that you have already learned that:

1. If an event is repeated under identical conditions, you will always get the same results.

2. Everything that happens has a cause.

3. There is order in the universe.

2. State each of the curiosities (preferably in order as they appear under question No. 1) in the form of an hypothesis.

____

____

____

____

____

So far, you have:

1. Stated the problem(s). "What do I want to know?"

2. Stated the hypotheses. "What do I think may happen?"

3. We now have a list of hypotheses. What do you think ought to be done to each hypothesis? ______________________________

____

____

4. What do scientists call this step? ______________________________

____

CONCEPT SUMMARY: You have learned a number of concepts in this investigation. They are:

1. Science is an ______________________________

2. Science progresses on human ______________________________

3. Scientific problems, which arise out of human curiosity, are solved by first making educated guesses, called ______________________________

Science Is Like Ice Skating

Science is an activity. It is an activity engaged in by men curious about their environment. Thus far you have learned that the activity consists of:

1. "What do I want to know?" (Stating the problem or question)

2. "What do I think may happen?" (Stating the hypothesis or guess)

You also said that each hypothesis must be tested or

3. "How do I tell what may happen?" (The test or experiment)

The scientist must test his hypothesis to see if he has guessed correctly. The test is called the experiment and the results of the experiment are the data.

4. "What happened?" (The results or data)

The excitement of experimenting and testing a hypothesis is what separates the scientist from the non-scientist. All people observe, ask questions, and many even guess at answers. But often the curiosity stops right there.

The scientist will always ask, "Where's the evidence?" This, then, is the purpose of an experiment--to provide evidence which will either support or reject the hypothesis.

Suppose we take one of your hypotheses and test for its validity. Validity means something will stand the test of evidence. Science does not stand for hearsay, rumors, superstition, mysticism, or prejudices.

Let us further suppose that everyone was curious as to what would happen if a big ball and a small ball were dropped simultaneously.

Wait! Before you run the experiment, what are you supposed to do? That's right.

1. State the hypothesis. ____________________________

   ____

2. Is that the only hypothesis you could have stated? Could something else happen with the same two balls? What are the other possible hypotheses?____________________________

   ____

   ____

   ____

3. All right, now you can try the experiment once. Record the data.

4. Want to try the experiment again? Fine, that's exactly what a scientist would do. Why would a scientist do an experiment over and over again?

5. Record your data from trying the experiment over and over again.

6. Why don't you try different size balls? Data.

7. How about different heights (stand on chair and keep balls together)? Data.

We now come to the last of the ground rules for scientific curiosity.

5. "What do the results tell me?" (The summary or conclusion)

8. Study and analyze your data carefully. You are to summarize the results of our experiment. The summary must answer the hypothesis. Using one sentence, if possible, what does the data tell you?

Note that we summarized the experiments. We did not draw a conclusion. Perhaps this is a trivial point to be picking on, but scientists do not draw conclusions. Conclusions imply the end, and science is a never-ending search for answers about our universe. Remember, science is an activity and it continues as long as man is curious.

To illustrate, science takes the summary of an experiment and does either one of two things to it.

First, if the data supports the hypothesis, then we have a <u>theory</u>. A theory is a valid hypothesis. You might say that a hypothesis and a theory are the extremes of science. At one end we have a hypothesis, which is just a guess. At the other extreme we have a theory, which is a scientific statement (or generalization) supported by evidence.

9. Theories are the backbone of scientific progress. With a theory, more accurate predictions are now possible. For instance, what would happen if a basketball and a B-B shot were dropped simultaneously?

____

____

____

10. However, theories are not an end in themselves. Will a theory ever change? If so, how? ________________________

____

____

Second, if the data rejects the hypothesis, then you do what a determined beginning ice skater would do.

11. What's that? ________________________________

12. Thus, you might say that science is the process of continually testing

____

Regardless of which of the two roads are taken by science, the result is the same. Science continues forward in its search for knowledge. Remember, science is an activity, an activity of the mind!

Science will: 1. continually test hypotheses and 2. continually change and modify theories.

Let us pause for a moment and summarize what has been said so far. There are certain general steps taken in the process of solving scientific problems. They are:

1. Problem ("What do I want to know?")

2. Hypothesis (What do I think may happen?")

3. Experiment ("How do I tell what may happen?")

4. Data ("What happened?")

5. Summary ("What do the results tell me?")

In addition, two directions can be taken after the summary. They are:

1. Testing another hypothesis, because the data rejects the hypotheses.

2. Formation of a theory, because the data supports the hypothesis.

13. In the space below, draw a simple diagram showing how the above seven steps are related to each other.

14. You have just completed investigating the dropping of a large vs. small ball. You are probably quite satisfied that what you have discovered is correct. Would it surprise you to know that there is a major error in what you have just done? What is it? (Hint: Is size the only factor?) ______________________________________

____

15. Are you curious about anything else? Is there anything else you might like to try? Remember, science progresses by continually testing hypotheses. Anything puzzling you? If so, state them.

____

____

____

____

CONCEPT SUMMARY: You have learned a number of concepts in this investigation.

They are:

1. Science is a continual testing of ____________________

2. The purpose of an experiment is to ____________________

3. The major activity of science is the formation and use of ________

____

Five Cents Off Regular Price

Balls. We take them for granted. It's the first toy given to us when we are born and the only toy we use continually through life. We see golf balls, basketballs, baseballs, bowling balls, and beach balls. Have you ever wondered why a golf ball is the size and weight it is? Why is a bowling ball heavy and a beach ball light? Must a football be oval and a baseball round?

We are so familar with balls that when they are used in an experiment we are unable to see our errors. For instance, in the last investigation, you dropped a large ball and a small ball. You did it over and over again, quite satisfied when an event is repeated under the same conditions you get the same results. And then you either summarized that one sized ball always hit the floor first or that size does not affect the rate of fall.

But, you were in error.

1. Could some other factor, other than the size of the ball, have affected how fast the balls fell? What? ____________________

   ____

2. Each of the factors you have just listed is really a potential hypothesis, your guess as the correct solution of the problem. Would you test all the hypotheses at once? Why? ____________________

   ____

   ____

As you have already discovered, the purpose of an experiment is to provide evidence which will either support or reject the hypothesis. But, it is possible to collect the wrong evidence and never know it. If a hypothesis is to be valid, then the experimental procedure must be valid too.

Unfortunately, there are no set rules of experimental procedure. Each experiment is designed differently to suit each hypothesis.

However, there is one absolute rule all experimenters must adhere to. All experiments must be <u>controlled</u> experiments.

What is a control experiment? Let's see if you can tell.

3. What is wrong with dropping a whole collection of different balls, recording the results, and summarizing by saying, "Large balls bounce higher."

   ____

   ____

4. On the other hand, a student takes one large beach ball and drops it. After repeating the experiment over and over again, each time accurately recording his data, he summarizes by saying, "Large balls bounce higher." Is there anything wrong with his summary statement. What?

____

____

5. What is wrong with this statement, "Seymour tires last 54% longer?"

____

____

6. A housewife left a piece of meat out on a counter during a two week vacation. When she returned, she found little white worms crawling all over the meat. She concluded that rotting meat turns into worms. Is she correct? Why? ____

____

____

7. Freddy Barber buys a new Banger GT and it turns out to be a lemon. She concludes that all Banger GT's are lousy, and encourages her friends not to buy one. Would you? Explain.

____

____

In case you still do not understand what is a control, here is an example of control applied to daily life. You will be asked to go to your local market to price a number of items. These items will have all been selected because they currently are carrying messages across the front of the product advertising a price discount. You are to report on the following data.

5.

Name of Product	Advertised Discount	Price	Store

6. Using the word, "control," comment on the above prices.

CONCEPT SUMMARY: (Note: the concept summary has nothing directly to do with balls or prices):

Giant Size, Large Economy Size

Giant size, large economy size, king size, family size. Such units of size are absolutely useless. They have no standard, no control. What one company considers to be a giant sized box of detergent may be another thing with another company. And a giant size box of detergent is not going to be the same as a giant size box of potato chips.

In your last investigation (Five Cents Off Regular Price), you learned that advertised specials are frequently meaningless. "5¢ off regular price" is as meaningless as "Large balls bounce higher" or "Family size." They have no control, no basis for comparison.

It is very important that experiments have a control. A control is a check or a comparison to the experiment. It is an identical experiment, except that it lacks the one thing being tested.

However, we still have a major problem. We may all agree that a control is necessary, but can we agree on the correct control or the amount of the control. For instance, as soon as we say, "How much?", we run into a question. Just how much is "much?" What if everyone decided for himself how much it was? What if every store decided how much was a pound? What if every gasoline station decided how much was a gallon?

This certainly does not seem very scientific.

> "I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of Science..."
>
> Lord Kelvin (1824-1907)

Take the piece of wood you have been furnished and make a ruler of it. You will have to mark off some units on the stick. Decide on a unit of length. The width of your thumb could be used.

1. Measure the width of your table and record it.

___

2. Record the results of the entire class in the space below.

3. Do you think the tables are all the same width or different?

____

4. Do the results listed under #2 show the the tables are all the same width?

____

5. Explain the relationship between the answers to questions 3 and 4.

____

____

6. What should we do to have a closer relationship between questions 3 and 4?

____

____

7. Do you think your answer to question 6 would also apply to weights and volumes? ______________________________

A group of scientists decided that if they started with a new system of weights and measures, maybe everyone would agree to use the one system. Thus, in the 18th century, a standard system of measurement was developed by a group of French scientists.

This is the <u>metric system</u>, used throughout the rest of the world.

You will be given a meter stick. Examine the side with metric units.

8. How many numbered divisions are there? ______________________

____

9. What are these divisions called (Hint: note the number and use it as a prefix to the word meter.)

____

10. How many divisions is each of the numbers divided into?

____

11. How many divisions (lines) is the entire stick divided into?

____

12. What are these small divisions called? ______________________

13. When you drive along the roads of the rest of the world, the distances are not marked in miles. They are marked in distances equal to 1000 meters or

____

14. You have just learned the four major units of distance in the metric system. How are these four units related to each other? ______________

____

You will be shown (or furnished) a cube that will hold a liter of liquid. The liter is the unit of volume in the metric system.

15. What are the internal dimensions of the cube in centimeters?

____

16. What is the volume of this cube in cubic centimeters (cc)?

____

17. Fill the cube with water. How many liters of water does it hold?

____

18. How many milliliters of water does the cube hold? ______________

19. What do you notice about your answer to questions 16 and 18?

____

20. What advantage is there to your answer to question 19?

____

The third part of the system is weight. The unit of weight is the gram. To see how much this is, make some measurements.

As there are many kinds of balances, instruction on how to use yours will be given in class. Weigh a clean, dry graduated cylinder. Record the weight. Fill the graduate to the highest mark. Record this volume. Weigh the cylinder filled and record the weight.

Weight of empty cylinder __________

Weight of filled cylider __________

Volume of liquid __________

21. What was the volume of water in milliliters? __________

22. What was the volume of water in cubic centimeters? __________

23. What is the weight of the water in grams? __________

24. About how much does a cubic centimeter of water weigh? __________

25. Would it be easier or harder to estimate the weight of a known volume of water in the English system or the metric system? Explain. __________

26. List several advantages of the metric system. Can you think of any disadvantages? __________

28. Now that we have all agreed on a standard unit of measurement, measure the width of your table again. What is its width in

millimeters __________

centimeters __________

meters __________

29. Record the results of the entire class in the space below.

CONCEPT SUMMARY: (In one sentence summarize what you have learned about measurement, not the metric system. The English system you presently use would also be applicable to your summary.): ______________________________

____

40,000 Semi-skilled Jobs Lost Per Week

Let us review for a moment what we have learned. From your investigations you have discovered that:

1. There is order or pattern to the universe.

2. Science is something people do. It is an activity whereby man searches for knowledge (the pattern) about the universe.

3. The motivation for scientific searching is curiosity.

4. Hypotheses are proposed as possible solutions to curiosities.

5. Science is a continual testing of hypotheses.

6. The purpose of the test, or the experiment, is to provide information which will either support or reject the hypothesis.

7. All experiments must be controlled experiments.

8. The accuracy of experimental results can be enhanced if the results are expressed in numbers.

In our last investigation we used numbers extensively. If you will look at questions 2 and 29 in the last investigation (#6 - Giant Size, Economy Size), you can see the large number of numbers we used.

Numbers enhance accuracy, but if the numbers are recorded in a complicated and confusing manner, as they appeared under questions 2 and 29, then we run the risk of having the numbers misinterpreted.

1. Can you make a suggestion as to how many, many numbers can be arranged in a neat, simple, and understandable manner? ______________________

____

You will be given our familar collection of rubber balls. As you will have already noted from our previous investigations, each ball bounces a different height.

What kind of a ball bounces the highest - solid ball, a hollow ball, a light ball, a heavy ball, a large ball, a small ball? This is our problem.

2. Using the format you learned previously, state a hypothesis to the problem.

____

____

It would be in order at this time to make mention of the unpardonable sin of science - dishonesty. Some of you will probably drop the balls, then come back to write the hypothesis. Others may drop the balls differently to cause one ball to bounce higher than the other.

Science has a built-in checking system, other scientists (or in this case, other classmates). You prove nothing by dishonest research, except that when your hypothesis and data are compared to those of the honest researchers, you will be driven to ridicule.

Inasmuch as honesty is required of your scientific investigations, you should design a method of recording data that is simple to use and read, free from misinterpretation, clear, and concise.

The method used is in the form of a data table, a chart, so to speak, to record numbers.

Examples will be shown to you in class.

There are certain rules to the design of data tables. They are:

1. Number each table.
2. Use a title that is fully descriptive of everything in the table.
3. The table must be in tabular form (enclose all data in a box).
4. Put your largest headings at the top and work down to the smallest.
5. Each column should have a complete, but brief designation.
6. Put all your units in the heading (the heading implies the legend along the side also).

Here's a typical data table, which may be appropriate for this experiment. You are not obligated to use it. Feel free to design a better table.

3. Fill in the headings in the table provided below (or attach your own).

Table No. ____________________

Title: ____

____

Now, do the experiment and record your data.

4. Should the initial height for every ball be the same? Why? What do you call this procedure?

____

____

Looking at the data table, one would have to agree:

1. A data table records and expresses information in an accurate, clear, and concise manner.

2. The table is a much simpler method of describing data than is a descriptive paragraph (like an English assignment) about what happens everytime a ball is bounced.

Let's try another data table. This time you design the table, fill in the appropriate headings, and record the data from the information given below.

1. If you complete less than eight years of education, your expected lifetime income will total $143,000.

2. If you complete eight years of education, your expected lifetime income will total $184,000.

3. If you complete 1 to 3 years of high school, your expected lifetime income will total $212,000.

4. If you complete 4 years of high school, your expected lifetime income will total $247,000

5. If you complete 1 to 3 years of college, your expected lifetime income will total $293,000.

6. If you complete 4 years of college, your expected lifetime income will total $417,000.

This means that compared to an eighth grade dropout,

a. an eighth grade graduate earns 28% more
b. a high school dropout earns 48% more
c. a high school graduate earns 80% more
d. a jr. college graduate earns 105% more
e. a college graduate earns 191% more

When you compare this to a high school dropout,

f. a high school graduate earns 16% more
g. a jr. college graduate earns 38% more
h. a college graduate earns 96% more

The data above surely looks confusing, doesn't it? But, if it is all put into a simple data table, you can understand the entire message at one glance

5. In the space provided below, put all of the essential data above into a data table. To help you, it is suggested that you start with the data on lines 1 to 6 first. Then add (a) to (d) in the next column. And (f) to (h) in the last column.

Now that we have all the data in a table, it is still possible that the table could be difficult and confusing to read. This is especially so if there are many, many columns and hundreds of numbers. Samples of these types of data tables will be shown in class.

6. Can you suggest a way in which data, in a data table, can be simplified?

____

____

CONCEPT SUMMARY (In one sentence, summarize the key concept you have learned from this investigation.) ______________________________

____

____

Do Scientists Draw Pictures?

We have already stressed the importance of making accurate measurements. Recording these measurements however, under the stress of a fast moving experiment, is another story. For this reason, well designed data tables are essential, especially during the progress of an experiment.

When all the data have been collected, a data table may appear very confusing because of the many, many columns and the hundreds of numbers that are in it. It is important that every measurement be recorded during an experiment but in the final analysis, only certain numbers may be of value.

Scientists use a simple method of illustrating data. To summarize the information contained within a data table, the scientist illustrates his results.

1. What does he use? ______________________________

Here is the same data table you used in the last investigation to record the results of your bouncing ball experiment.

2. Copy the data from your last investigation in the table below.

Table No. ____________________

Title: ______________________________

____

As you can see, you have over 40 numbers in your table. If a graph is used, any outsider will be able to understand your data at a glance.

Examples of graphs will be shown in class. Note that the graphs shown to you all follow basic rules:

1. Number each graph.
2. Use a title that is fully descriptive of everything in the graph.
3. Label each axis.
4. Indicate the units of each axis.
5. Ideal units are multiples of 1, 2, and 5.
6. The units must be consistent along each axis.
7. Clearly differentiate each line when more than one appears.

Here is a typical graph which may be appropriate for illustrating the data. You are not obligated to use it. Feel free to design a better graph.

3. Using the rules listed above, complete the graph.

Graph No. ____________________

Title: ______________________________________

____

As you can see, a graph is like a picture. It illustrates many, many numbers and shows their relationships to each other in a very simple and understandable way.

Let's try another graph. This time you design the graph from the data given below.

The Growth in the World Population

Year	Millions of People
1900	1500
1925	1900
1950	2500
1975	3900
2000	6300

4. In the space provided below, graph the above information. Be sure you follow all the rules.

Here's one more data table, a little more complicated, but when you graph it, it will look very simple.

We live in a scientific and technological world. You will hear this repeated over and over throughout this course. Science refers to making discoveries. Technology refers to applying scientific discoveries for the benefit of mankind. For instance, discovering a new chemical to stop a disease germ is science. Making the drug is technology. Designing a new electronic circuit is science.

Applying this circuit to a new computer or machine is technology.

No matter where you turn today, you will be surrounded by science and, especially, technology. Pencils, hairpins, instant hair curlers, plastic dishes, paper clothes, gasoline additives, birth control pills, and guitar amplifiers; These are examples of technology we see constantly. Examples of technology which are not so obvious include gigantic machines which are fully automated and need but one man to watch. The machine and the men can easily replace ten men formerly needed to make whatever the machine now makes.

These machines, products of the "age of automation," have often been blamed as the cause of unemployment. Using some scientific reasoning, let's see if there is any truth to this.

The usual unemployment rates count only those able and willing to work and looking for work.

In the United States, this rate is about 4% today. This can be a misleading figure.

To measure the total problem of joblessness in the slum ghettos, the U.S. Labor Department developed a "sub-employment index." This index counts the regular unemployed; the jobless who have dropped out of the labor market in despair; those who have low paying part-time jobs and are still trying to get full-time jobs, along with society's "drop-outs," and those known to be living in the slum ghettos but who do not show up in the employment or unemployment counts.

These are the results:

Table No. 1
Unemployment and Sub-unemployment
Rates in Selected Cities,
by percent

City	Unemployment rate, %	Sub-employment rate, %
East Harlem	9.0	33.1
Central Harlem	8.1	28.6
Bedford-Stuyvesant	6.2	27.6
Boston (Roxbury)	6.9	24.2
New Orleans	10.0	45.3
Philadelphia	11.0	34.2
Phoenix	13.2	41.7
St. Louis	12.9	38.9
San Antonio	8.1	47.4
San Francisco	11.1	24.6
United States	3.7	-

5. In the space provided below, graph the above information. Be sure you follow all the rules.

In a previous investigation, it was mentioned that 40,000 jobs were being eliminated each week. These, however, are unskilled jobs.

In the past three years, the United States economy has developed 4,348,000 new jobs.

Of the country's new jobs, 50% were white-collar, 37.6% were blue-collar (factory) jobs, and 14% were service.

In New York City, as a typical urban area where slum ghettos are found, 74% of the jobs were white-collar, 23.4% service and only 2.6% blue-collar.

6. In the space provided below, graph the information from the last two paragraphs.

7. From the information in the graph above, what would you say is the relationship between science and technology and the future trend of job types?

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8. What kind of jobs are increasing each year in urban (city) areas?

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9. Where are most of the slum ghettos found? ______________________________

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10. Comment on your answer to 8 and 9. ______________________________

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11. Comment on your answer to #10 in relationship to: 1) education and 2) understanding science.

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CONCEPT SUMMARY: (In one sentence, summarize the main idea you have learned from this investigation. Note: it has nothing to do with unemployment or the population explosion. These were just examples chosen to illustrate the concept.): ______________________________

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Don't Stop Me Man, I'm Really Swinging

Why stop when we're doing so well? Whoever thought a collection of balls could be put to such good use? One last gasp, then no more balls (for awhile)!

Many of you have caught on to the spirit of science and you've begun to ask questions out of curiosity. Back in investigation 7, some of you asked, "What would happen if balls were rolled down a hill instead of dropped?"

Well, stop wondering. Let's try it.

Obtain the usual assortment of balls. In addition, obtain a length of corrugated roofing to use as a runway for the balls. Two meter sticks can also be substituted for a runway. Use your own books to elevate one end of the runway. Place another book at the other end to stop the ball.

A metronome will be used in class for a timing device. Thus, your data will consist of the number of ticks it takes a ball to roll down the runway.

Take your time and do this investigation well.

Turn in, on your own paper, a fully written-up experiment. Use everything you've learned from the past eight investigations.

In case you've forgotten, the assignment you turn in must have:

1. Problem or title
2. Hypothesis (Use the "if--------, then--------" form.)
3. Materials & Method (List the equipment you use and the procedure of the experiment.)
4. Results (Show your results in a data table and make a graph of your data.)
5. Summary (Does your data support or reject your hypothesis? State a one sentence conclusion.)

CONCEPT SUMMARY: Attach to your assignment a separate last page in which you discuss the following:

1. What is meant when it is said that there are two sides to science:

    a. Science is an activity.
    b. Science is a body of information.

Science Is Where The Action Is!

On a separate page, you have been keeping score, so to speak. You have a list of all the concepts you have learned so far. Check your list. Are these the concepts you have discovered from the investigations?

1. There is order in the universe.
2. Science is an activity.
3. Science progresses on curiosity.
4. A hypothesis is an educated guess as to the possible solution of a problem.
5. Science is a continual testing of hypotheses.
6. The purpose of an experiment is to supply evidence to support or reject an hypothesis.
7. The major activity of science is the formation and use of theories.
8. All experiments must be controlled experiments.
9. Accuracy is improved when quantitative measurements are made.
10. Data tables simplify the recording of data.
11. Graphs simplify the interpretating of data.

A. Science is Two-Faced

Putting everything together then, you can see that a principle function of science is to unscramble the universe and discover its pattern or order. Man has already uncovered certain patterns to the universe. His discoveries have resulted in certain brilliant ideas; indeed, they are man's Great Ideas!

The Great Ideas of science, the pattern or order around which everything functions in our universe, is the subject of this course, but more about this later.

You have now learned that there are two aspects of science.

1. Science is a body of information about our universe. This knowledge is the result of work by people called scientists.
2. Science is an activity, in which scientists are constantly adding to and modifying the body of knowledge. The success of the activity is based on curiosity.

Of the two aspects of science, the second one listed above is of greater value to you. The first aspect is important too, but information changes as new discoveries are made. If you are to adjust continually to a changing world, you should have an attitude of curiosity, of discovery, of wanting to continually modify your knowledge. This is where the action, the excitement of science can be found!

The twelve concepts you have learned so far all have to do with the second aspect of science, that of science as an activity. It is something people do.

A scientist, or even a student of science like you, does not follow the steps of solving scientific problems like a recipe. A good cook does not use a recipe. He experiments around to find the right combination necessary to produce the right flavor. A scientist is no different. He knows that the ground rules for solving scientific problems are:

State the Problem	(What do I want to know?)
Make an Educated Guess	(What do I think may happen?)
Test the Guess	(How do I tell what may happen?)
Collect the Results	(What happened?)
Summarize the Results	(What do the results tell me?)

But, he also knows that these ground rules are not done in any particular order.

For instance, there are ground rules in baseball, such as: 1) when a ball is thrown into the dugout, the runner is granted one extra base, 2) when a ball is touched by a spectator, the runner cannot advance beyond the next base, or 3) when a game is halted on account of rain, 45 minutes must elapse before play can be definitely postponed. Chances are the above ground rules may never occur during a game, but if one does, then that particular ground rule applies.

It's no different in solving scientific problems. All scientists guess; all scientists look for problems; all scientists collect results; all scientists experiment; and all scientists draw conclusions. There is no sequence. Each is done only when the particular situation arises.

B. Let's Take A Closer Look

Confronting situations in everyday life is no different. The method of science can be invaluable to assist in making daily decisions. You may even use it at parties. How many of you have ever played this common game?

Depending upon the class situation, we may even try it. A piece of string is tied to both wrists of one person. Another piece of string is tied to one wrist of another person. Then the string is passed behind the string (between the arms) of the first person before the string is tied to the second wrist. The problem is to free the couple without untying the string.

To try and free yourself, you try different ways. That's the test or experiment. You make guesses as to what you think may work. That's the hypothesis. You wind up in all kinds of hilarious positions. Those are the results. Finally you may conclude that it just can't be done or you discover how it's done. All the while you make use of the ground rules of solving problems.

1. If you were to analyze what you did after the game, could you diagram the method you used?

Try it in the space below.

You started with the problem. Then you went around and around as you guessed, tested, and analyzed your results. From time to time, you summarized your results. The summary only gave rise to another problem.

Science is no different. Good problems lead to further problems. This is why science is a continual testing of problems about our natural world.

In summary, it can be said that

SCIENCE IS A WAY OF SOLVING PROBLEMS
SCIENCE IS A WAY OF THINKING

Can you use this way of thinking to discuss a current controversy?

C. 27% Less Cavities

A current controversy of great proportions concerns the fluoridation of water. Proponents claim that adding a chemical, fluoride, reduces the formation of cavities. Opponents of the plan claim:

1. Fluoridation causes cancer, heart disease, diabetes, liver and kidney ailments, etc.
2. Fluoridation causes the bones to become brittle and hardens the arteries.
3. Fluorine is used in rat poisons and insecticides. The gradual accumulation of fluoride will damage the body. It is a form of mass murder.
4. Fluoridation causes unsightly stains on the teeth.
5. Fluoridation is mass medication.
6. As a medication, fluoridation is against religious freedom.
7. Fluoridation is "unconstitutional and an illegal invasion of individual rights."

8. Fluoridation is a form of "socialized medicine."
9. An accident in the water plant might cause a harmful overdose of fluorides.
10. Fluoridation is wasteful. Only one-tenth of one percent of the water is drunk by children.
11. Fluoridation is promoted by the big chemical companies which make huge profits out of it.

Whenever an election is held to decide if fluoride should be added to the water, the charges fly back and forth. Emotions run high.

Can you, however, objectively discuss the controversy? Go ahead.

D. Science is "in"

If a lesson is to be learned from the discussion we have just had, it is that the ground rules of science can be used in one's daily life. All too often people react impulsively, act according to their own prejudices, make snap judgments, draw conclusions without any valid test or data. It's even common for people to make summary statements without any regard as to how it is related to a bigger problem.

Is it so strange that some people are prejudiced, bigoted, irrational? If they would only put their prejudices to a valid test!

Is it also so strange that so many forward-thinking young people are flocking to science? For science is where the action is!

Science is where the jobs are. The daily want ads are filled with a need for people who want the action of thinking and creating for a better tomorrow.

We are in the midst of a great scientific revolution. It is a revolution that bursts full of action, but also brings its problems. Our scientific advances have outdistanced our social advances. Our human relations need to catch up with our scientific advances.

On the other hand, the process of science can also aid our human relationships. The process of science is a way of objective thinking. We can no longer live safe and free when we allow prehistoric emotions of hate, fear, and greed to divide us. Young people today are demanding reform. They want to face these conflicts. Are you a big enough man to face the conflicts of today?

Young people today want to face up to a world which will accept their responsibility of helping to get human relations caught up with scientific advances. The bright new world of tomorrow is ripe for the "big man" who understands his responsibility.

But the most exciting action in tomorrow's world will be new ideas. The action of science is the process of search, of curiosity, of challenge. The world moves faster every day. The man of tomorrow who has no fire, no motivation, no desire is dead. The "big man" of tomorrow will be open to new ideas.

New ideas can come only from active people, dynamic people, ambitious people, turned-on-people--who like to ask, why? what? how? People who ask, people who question are the only ones who will be able to understand and contribute to the world and their own happiness. Understanding brings success, and success brings happiness.

TOMORROW'S WORLD BELONGS TO THOSE WHO
GENERATE AND UNDERSTAND NEW IDEAS!

IDEA SUMMARY (What major idea have you learned from the past ten investigations and especially the last investigation?): ____________________

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