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ABSTRACT

This guide contains experiments in the fields of Physical Science, Earth Science, and Biological Science designed to be used with any series of texts in a sequence for disadvantaged youth in the middle school. Any standard classroom can be used, with minor modifications and inexpensive equipment and materials. All students could participate, probably working in small groups. The main reason for proposing laboratory work for this age and type of pupil is that they can very easily lose interest in school and school work. A program of this type would stimulate a disadvantaged youngster not only, perhaps, to explore the sciences further upon entering high school, but also to complete his schooling with his middle-class counterpart. Although no school or program can by itself hope to overcome the manifold effects of the disadvantaged, the science teacher has the ready-made advantage of being able to create interest in his subject, particularly in school children attending a middle school. The teaching tactic of involving the learner in a variety of "discovery" activities capitalizes on the middle school disadvantaged child's natural curiosity about the world. (JM)

LABORATORY EXPERIENCES FOR DISADVANTAGED YOUTH IN THE MIDDLE SCHOOL

by

John H. Baillie

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LABORATORY EXPERIENCES FOR DISADVANTAGED YOUTH IN THE MIDDLE SCHOOL

by

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Within recent years, we have been made quite aware that there are two Americas. One is the middle-class syndrome that most of us are involved in, while the other is a land of hopelessness, dirt, and dispair, sudden violence, and many missed meals. This latter is the America this paper will attempt to deal with.

The problem has arisen of how tc provide a program of schooling for students in grades five through eight that will be relevant, feasible, and educationally sound in terms of curriculum, instruction, learning, and even the basic grade organization. Recently, some authorities have expressed a dissatisfaction with the goals and functions of our present junior high school system because of the apparent failure to fulfill its responsibilities.

It is quite apparent that today's youngsters are maturing much earlier than previous generations physically, socially, and mentally. In addition to the early maturation of youngsters, there are practical problems of increasing enrollments and building costs facing the school districts of today.

Out of this morass is emerging a new educational phenomena, the middle school. This school is more than merely a reorganized junior high school, or one that has shown a dissatisfaction with the program and organization of the upper grades of elementary school. It is an effort to reorganize the total school structure.

The youth served in this school are in the middle, that is they are between childhood and adolescence. The organizational pattern for grades is changed from the traditional 6-3-3 or 8-4 to a new pattern including grades five through eight or six through eight as one unit. This makes it apparent that there could be three distinct types of schools emerging in the future, one for childhood, one for the in-between or middle group, and one for the adolescent.

The purposes of a middle school can be three fold:

(1) First, the middle school can provide a program adapted to the needs of the individual child.

(2) Second, the middle school can promote a smooth flow of educational experiences from the time a child enters school until he leaves, and

(3) Third, the middle school can facilitate the introduction of educational innovations in both instruction and curriculum.

Across the nation, there is no pattern evident which shows a widespread adoption of the concept of the middle school. Most adoptions are in small school districts, and probably economics plays the biggest factor with a new junior or senior high school being built and the old building readily available for use. While the interest in the middle school concept has not yet assumed the proportions of a full-scale movement, the possibility still exists.

Now we take a disadvantaged youngster and place him in the environment alluded to above. Poverty has no beginning and regretfully no end. It threatens to take American life out of its polyethylene sterility and to introduce it to the tragic conditions that too many people must endure.

The lot of disadvantaged youngsters in our affluent nation is to live in ugly, barren, crowded surroundings, to lack parental supervision and companionship, to be fed irregularly and then poorly, and in general to shift and care for themselves. Unless this vicious cycle is broken, these children are doomed to live the hopeless and uncertain lives of their parents. In too many cases, limited and inferior schooling combine with extreme deprivation to plague these youngsters.

One of the assumptions we make in education is that the school can hardly do what the family atmosphere fails to stimulate. One reason a deprived child is disadvantaged is that he does not bring to school the same motivations and experiences that a middle-class child does.

Poverty affects a child's health, his growth, his self-confidence, his social attitudes, and his life span. It affects the ways in which others view a child, and the way they act towards him. It follows a child to school where far too often, failure is institutionalized. It is this failure that the innovative science teacher can attempt to break.

The disadvantaged child has poverty as an attendant at his birth, which weakens his chances to survive, it delays his first words, hinders his first steps, and limits the scope of his world. Middle class Americans can hardly imagine the things some of these children experience, such as rat bites and malnutrition.

Poverty and educational deprivation are found together. Where one exists, the other is usually present. But there is also a causal relationship. Ignorance breeds and maintains poverty and poverty cripples educational attainment and breeds more ignorance.

The Elementary and Secondary Education Act was passed in 1965. Title I of this act dealt specifically with educationally culturally, and economically deprived youth. Educators across the nation saw this as a golden opportunity to develop programs to help educationally disadvantaged children, and the Federal government has spent millions of dollars on these, mostly in reading programs. In the 1967-68 school year, over nine million children were able to participate and this represents an enormous amount of hope for those youngsters who are held back in their learning efforts by poverty and its attendant social, cultural, and physical deprivations.

Problems have developed though, because some educators have not planned their programs thoroughly or have tried to do too much for too many with too little. In some schools, money has been spent on the expansion of old curricula or on glamorous equipment. The Federal government has now suggested a shift to prototype or exemplary programs which concentrate on a fewer number of children. It is felt that this is a far more effective way to demonstrate successful compensatory techniques, which, after they are proven, can be spread across the nation to serve more of the children who need them.

It is quite apparent that among the hundreds of different programs and approaches labeled as compensatory education, some efforts are paying off and others are not. Those that are successful involve the student as something other than a passive participant in the learning process.

Disadvantaged children invariably suffer from a number of forms of deprivation, not just one. They do not need new textbooks, curricula, medical care, adequate nutrition or a reduction in class size, but all of these and other educational remedies together. Success with these children requires a concentration of services on a limited number of children.

No school or program can by itself, hope to overcome the manifold effects of the disadvantaged. This is where the science teacher can bring into full force the tools of his trade. Of the one teacher in any school, the science teacher has the ready-made advantage of being able to create interest in his subject, particularly in school children attending a middle school. Students of this age have a built-in curiosity of the world, and a creative and innovative science teacher can help bring a disadvantaged child out of his shell and stimulate an interest in school.

To date, curricular programs in any subject have not been written specifically for the middle school. In science, there are available curriculum materials for both the elementary level and for junior high school students. These materials are primarily written for the science-oriented student, and a youngster with the type of background previously described would have difficulty in keeping up with most of these programs. Most of these programs are laboratory-oriented, and this does offer the greatest promise for a disadvantaged child.

Textbooks which are currently in use in the middle grades, five through eight, do not carry experiments in their pages, other than very simple ones which usually have the answers immediately following the exercise. There are few commercial outlets which prepare experiments designed for the level of the students which would be involved. This means that if a school is to have laboratory experiences in their science program for disadvantaged youngsters, the individual teacher would have to develop his own.

One important teaching tactic or skill is that of involving the learner in a variety of "discovery" activities which provide practice in the investigative procedures that are characteristic of science. In the early grades, these are experiences in observing, classifying, developing systems, making inferences, and acquiring other generalizable intellectual skills. In high school science, this level of inquiry is raised through open-ended experiments and laboratory experiences designed to raise questions and generate new thoughts and ideas. This leaves those students in the middle with the opportunity to adapt and learn from others.

The laboratory approach is crucial throughout the school year, and its general nature should change from illustrative in the early grades, to investigative in the later grades. This means the actual involvement of the student in the learning process, by taking him out of the passive role he has traditionally played and putting him into a very active part of the learning process. For the disadvantaged youngster in the middle school, this perhaps holds the key to his future. It is expected that some of these innovations will be successful and some will fail. But even the failures have a purpose, for the only way to find out if something works is to try it.

The experiments which follow are examples of what this writer would use as supplementary exercises for students in the middle school, if others were not readily available. They are designed to serve mainly as a guide, and science teachers could further develop them and others of their own design. These experiments would be duplicated and handed out to each student as they appear here. They by no means, represent a complete set of laboratory experiments, but are a start only and could be added to at any time.

These experiments can be classified in the fields of Physical Science, Earth Science, and Biological Science. The experiments which are presented were adapted and revised from standard texts and laboratory manuals currently in use. They are designed to be used with any series of texts, and would not follow any particular sequence of order. They could be used as the topic arose from class discussion. The content is not entirely original, just the form, as the ideas were borrowed from many different writers.

It is felt that any standard classroom could be used, without elaborate scientific facilities being provided. Student desks would have to be replaced by tables, and a small outlay would be necessary for some equipment and supplies not readily available. All students could participate in this program probably working in small groups. This way, slower students could learn from the more capable. It is also possible for the slow student to work at his own rate, thus enabling the more able student to broaden his background by going even further than the experiments suggest.

Many times, materials can be brought to school by the students, thus cutting down on the cost of equipping a science laboratory. This also helps keep up student interest. The main reason for proposing laboratory work for this age and type of pupil is that they can very easily lose interest in school and school work. A program of this type would stimulate a disadvantaged youngster to not only perhaps further explore the sciences upon entering high school, but also to complete his schooling with his middle class counterpart.

Parents of these children have proven that they are capable of acting as social work assistants, peace keepers, teachers' aides, and even research assistants. Now let's give the children a chance to prove themselves.

PHYSICAL SCIENCE

Experiment 1
THE EFFECT OF HEAT ON MELTING TIME

MATERIALS:

Balance, weights, thermometer, beaker, stand with iron gauze screen, burner, ice cubes, water, timer.

PROCEDURE:

Do the following steps in the order given:

1. Set up the burner, stand, and screen. Heat the screen to redness.

2. While the screen is heating, weigh a beaker containing three large ice cubes.

3. Note the time. Heat the beaker containing the ice until about half the ice melts. Stir the ice and water gently with the thermometer and note the temperature.

4. Note the time. Quickly remove the beaker, pour off the water, and weigh the remaining ice. By subtraction, find the weight of the ice melted in the time used.

5. Weigh an amount of ice water equal to the weight of the ice melted, using the same beaker. Note the temperature of the water. Heat it for an amount of time equal to the time used in number 3. Stir before reading the temperature. Note the temperature.

6. Bring the water to boiling temperature. Just as the water starts to boil, note the time. Boil the water for the same amount of time as before. Quickly remove the beaker, be careful, and weigh it. Find the amount of water that was boiled away.

OBSERVATIONS:

Noting what you did, all the weights obtained, time used, and temperature changes, what are your observations?

Can you organize them so that the results of these experiments can be compared?

CONCLUSIONS:

Answer this question in a general way. When equal amounts of heat were applied for equal amounts of time, what was the effect on ice, water, and boiling water?

Experiment 1- Page 2
THE EFFECT OF HEAT ON MELTING TIME

RECORDS:

Weight of beaker with ice __________.

Weight of equal amount of ice _______.

First time _________.

Second time ________.

Third time _________.

Weight of ice melted __________.

Amount of water boiled away _________.

First temperature ___________.

Second temperature ___________.

Third temperature ___________.

PHYSICAL SCIENCE

Experiment 2
HEAT TRANSFER

MATERIALS:
Rods of aluminum or copper or both, iron rod, thick soldering wire, candle, string, paper clips, wooden spring clothespin, burner, support.

PROCEDURE:
1. First support the aluminum rod by holding it with the clothespin two inches from one end. At that same end and at the middle of the rod attach paper clips. Do this by tying a thread to each clip. Fasten the thread to the rod with a drop of melted candle wax. Next, heat the rod at the other end. Continue heating it until the drops of wax melt or until you are sure they will not do so.

   Note the time it took for this to happen. ___________

2. Repeat the experiment using a rod made of another metal.

   Note the time it took for the reaction to occur. ___________

3. Repeat the experiment using a solder wire. Put a piece of thick cardboard under the wire to catch possible drops of melted metal. See if you can melt the wax supporting the paper clips without melting away the wire.

   Note the time it took for this to happen. ___________

OBSERVATIONS:
Did you see evidence that heat travels along any of the rods?

Did any rod become red hot?

Is the melting point of wax a good indication that a certain temperature has been reached?

How long did it take to melt the wax at the end of the rod as at the middle?

If it took longer at the end, where did the lost heat go?

Is heat applied to solder conducted or is it used to melt the solder, or both?

CONCLUSIONS:
In how many ways was heat transferred? Start with the chemical change at the burner.

Experiment 3
COOLING EFFECTS OF DIFFERENT SUBSTANCES

MATERIALS:

Two 250-milliliter flasks, one-hole stoppers to fit, thermometers to fit holes in the stoppers, candle, facial tissue, aluminum foil, tape, boiling water, cardboard.

PROCEDURE:

1. Blacken the outer surface of one flask with smoke from a candle. Wrap the other flask first in four layers of tissue and then with aluminum foil. Hold the covering materials in place with tape. Wet the thermometers and insert them in the stoppers so that the bulbs will extend into the flasks. Put the flasks on a piece of cardboard.

2. Pour boiling water into each flask until it reaches within two inches of the top. (If you wet the insulation, start over.) Put the stoppers and the thermometers in the flasks.
   Read the temperature. ___________

   At five-minute intervals note the temperatures.

   First reading ____________ Fifth reading __________

   Second reading ____________ Sixth reading __________

   Third reading ____________ Seventh reading __________

   Fourth reading ____________ Eighth reading __________

OBSERVATIONS:

Using a sheet of graph paper, make a graph of the results which you have observed above. Put the time intervals at the bottom and the temperature readings along the left side.

CONCLUSIONS:

Is this an exact experiment or a method of observing cooling under two particular conditions?

How many other arrangements could you have used? Please explain your answers.

What is the effect of insulating and reflecting materials in preventing heat loss?

PHYSICAL SCIENCE

Experiment 4
SIMPLE STEAM ENGINE

MATERIALS:

Flask, one hole stopper to fit, glass tube bent to an L shape and drawn to a jet, stand, burner, small pinwheel or paddle wheel.

PROCEDURE:

1. A small paddle wheel can be made from the cover cut from a can. Make a hole at the center with a nail or drill. Cut in from the edge along straight line drawn to the center (radii) and make 8 blades. Bend them at right angles to the surface at the center. A toy pinwheel will also serve, if one is available.

2. Support the flask firmly on the stand. Fill it about one-third full of water. Put the stopper and tube in place. Heat the water to boiling. When steam is shooting rapidly from the jet, hold the paddle wheel or pinwheel in the path of the escaping steam.

   What do you observe?

OBSERVATIONS:

Why does drawing the outlet tube to a jet increase pressure of steam in the flask?

What effect has increased pressure upon the speed of the escaping steam?

Can you cause the paddle wheel to spin rapidly?

Does the steam condense to water?

CONCLUSIONS:

Can expanding steam be used to do work? Give reasons for your answer.

In how many places was heat lost without doing work? (There are several.)

PHYSICAL SCIENCE

Experiment 5
ELECTRIC CURRENTS

MATERIALS:
Galvanometer, voltmeter, simple coil, doorbell wire, bar magnet, a wet cell made of zinc and copper strips in a glass of salt solution.

PROCEDURE:
1. Connect the coil to the galvanometer. Produce a current by thrusting the magnet through the coil.
What do you observe?

Observe the amount of movement of the galvanometer needle. About how far did the needle move?

Vary the experiment in these ways:
(a) change poles of the magnet and repeat the experiment. What did you observe?

(b) leave the magnet still and move the coil. What did you observe?

(c) move the coil and magnet in opposite directions and in the same direction. What did you observe?

2. Connect the voltmeter to the wet cell. Show that a current is produced. What reading did you obtain from the voltmeter?

Change the wires to opposite metal strips. What reading did you get?

OBSERVATIONS:
Under what conditions can current be produced by using a magnet and coil and a wet cell?

CONCLUSION:
You know that producing a current requires the use of energy. What are the two sources of energy used in these experiments?

PHYSICAL SCIENCE

Experiment 6
HEAT FROM ELECTRICITY

MATERIALS:
Six-inch length of 18, 20, or 22 gauge iron wire, copper wire connectors, two dry cells, water glass, paper centigrade thermometer, balance or graduated cylinder, pocket battery tester, watch.

PROCEDURE:
1. Wind the iron wire into a short coil around a pencil. Connect its ends to the copper connectors.

2. Pour 100 grams, or 100 milliliters, or water into glass. Insulate the glass with paper. Measure the temperature of the water. ________

   Put the iron heating coil in the water. Attach the copper connectors to the dry cells in a series circuit. Immediately note the time. ________

   Let the current flow for five minutes. Disconnect the wires and remove the coil. Measure the temperature of the water. ________

   The number of calories of heat produced is about equal to the temperature change in degrees times 100. Why is this so?

3. Use the battery tester to measure the current that flows through the coil and the connectors. What does this read? ______

   Also measure the voltage of the current in amperes. What is this measurement?

   ____

   The number of watts used equal volts times current, measured in amperes. How many watts were used in this experiment? ______________

OBSERVATIONS:
Do the mathematical work called for in number two in this section.

CONCLUSIONS:
Does an iron heating coil produce a measurable amount of heat under these conditions? Please explain your answer.

Find the number of calories produced by one watt of electricity per minute. Use this formula: Total calories ÷ (watts x no. minutes) = calories per watt per minute.

In what ways is heat lost during this experiment? Why is your result likely to be inaccurate?

PHYSICAL SCIENCE

Experiment 7
CHANGES IN PITCH

MATERIALS:
Simple stringed instrument; i.e., guitar, ukulele, or a homemade model; triangular wood block; table knife.

PROCEDURE:
1. Loosen all the strings so they will not produce a clear sound when plucked. Observe the strings. In turn, tighten each string. Pluck it several times as you tighten it. Note the effect of increasing the tightness of each string below.

2. Lay the handle of a table knife across the strings at one end of the instrument. As you pluck the strings rapidly, slide the knife handle from one end of the strings to the other and then back. Write below what you can see and hear happen.

3. Put the triangular block of wood under the strings so that it supports them on its upper edge. Pluck the strings in turn. Tell below what happens.

OBSERVATIONS:
What effect does tightening a string have on its pitch?

Do all strings produce the same tone when they are about equally tightened?

How was the pitch changed by moving the knife handle along the strings?

Was the change in pitch regular or in steps?

What was the effect of shortening the strings by use of the wooden block?

CONCLUSIONS:
State three conditions that affect tones produced by vibrating strings, using these three words: tension, thickness, length.

PHYSICAL SCIENCE

Experiment 8
VIBRATIONS FROM SOUND

MATERIALS:
Doorbell, dry cells, switch, strong string three feet long.

PROCEDURE:
1. Connect the doorbell to the dry cells.

2. Bend the clapper away from the bell. Tie one end of the string to the clapper.

3. Close the switch. Hold the doorbell in one hand and pull the string tight, in line with the clapper. Write your observations in the space below.

4. With a little experimenting, you can cause the string to vibrate in one large wave and several smaller waves. Tell below if you were successful, and how you achieved this success.

OBSERVATIONS:
Did the string vibrate in more or fewer waves as its tightness was increased?

Could you see smaller, fuzzy vibrations along the string? By this I mean vibrations which are not distinct.

CONCLUSIONS:
Which vibrations observed can be compared to those which produce the fundamental tone?

Which can be compared to those that produce overtones?

Can you hear the string vibrating?

PHYSICAL SCIENCE

Experiment 9
WORKING WITH FORCES

MATERIALS:
Spring balance, brick (or heavy block of wood), plastic cover for brick, string, ruler, board.

PROCEDURE:
1. Tie the string around the brick. Loop the string over the hook of the balance. Lift the brick up one foot. What is the force required to do this?__________

2. Change the position of the string so that it can be used to drag the brick on the board. Tie the end of the string to the hook of the balance. With the spring balance pull on the brick slowly so that it barely starts. Move it one foot. What is the force required to move the brick?

3. Jerk violently on the string and note the approximate force needed to make the brick leap about one foot along the board. What is you reading of the force required? ____________

4. Wrap the brick in plastic so that the lower surface is smooth. Find the force required to drag the brick along the board a distance of one foot. What is the required force? __________

OBSERVATIONS:
Is more force required to lift the brick or to slide it?

Work the four problems for which you collected information, using this formula: W = fd (work=force x distance.)

In which experiment was the most work done?

In which experiment was the least work done?

What three kinds of resistance did you overcome in doing work?

CONCLUSIONS:
What is a force?

In what directions did you apply force in each experiment?

At what one point in these experiments did the brick have potential energy?

At what points did it have kinetic energy?

PHYSICAL SCIENCE

Experiment 10
WORKING WITH PULLEYS

MATERIALS:
Board three feet long, baking powder can, weights (or sand), tacks, string, spring balance, pencil, books, ruler.

PROCEDURE:
1. Support one end of the board on books, raising it nine inches above the table. Put tacks into the upper end of the board, four inches apart. To each tack fasten a string six feet long. Lay the strings on the board. Loop the loose ends around a pencil to keep them four inches apart.

2. Fill the can with enough weight (or sand) and paper to make it weigh one pound. Next, lay the can on the board and loop the strings over it. Bring the ends of the strings back to the upper end of the board.

3. With the spring balance, pull on the strings and cause the can to roll up the board. How much force is needed to accomplish this task? __________

OBSERVATIONS:
Find the mechanical advantage of the plane. This can be done by dividing the length of the board by its height.

Find the mechanical advantage of the pulley which you have constructed. The can itself is the pulley when it is rolled. To find the mechanical advantage divide the weight of the can by the force used to roll it up the plane.

CONCLUSIONS:
Can you find evidence for the following statement: Using two simple machines together gives a mechanical advantage equal to the mechanical advantage of one machine times that of the other? Divise your own experiment to prove this, and tell your results.

PHYSICAL SCIENCE

Experiment 11
SERIES AND PARALLEL ELECTRICAL CIRCUITS

MATERIALS:
Two dry cells, two miniature sockets, two 3-volt lamps, copper wire, simple switch.

PROCEDURE:
1. Connect the cells in a series circuit using the copper wire. This can be done by connecting the center post of one battery to the outside post of the other one. Connect two wires to the remaining posts.

2. Screw the lamps into the sockets. Connect the two sockets in a series circuit so that current flows from one to another, and connect the two to the wires. What do you notice happening?

3. Disconnect the lamp sockets. Connect each socket in a parallel circuit to each of the two wires leading from the dry cells. Now unscrew first one bulb, then the other. What do you notice happening?

4. With both lamps in place in the parallel circuit connection, lay a short wire across the two bare lead wires. What happens?

   What do you call this reaction?

5. Connect the switch first in the main or lead circuit. Close and open it. What happens?

   Now connect it in one lamp circuit. Close and open it. What happens?

OBSERVATIONS:
How bright were the lamps in each kind of circuit?

In which type of circuit could one lamp be turned off without turning off the other? Why didn't the other lamp go out in this circuit?

CONCLUSIONS:
In what ways is the parallel system of connecting lamps in a circuit better?

What happened to the light when you short-circuited the main lines?

How does a switch work?

On the back draw a brief, but complete diagram of how you did the experiment.

PHYSICAL SCIENCE

Experiment 12
TEMPERATURE AND EXPANSION
WITH ELECTRICITY AND HEAT

MATERIALS:

Nichrome wire (about #18), copper wire, four dry cells, two water glasses, thermometer, a model thermostat or bimetallic bar, burner.

PROCEDURE:

1. Cut two lengths of nichrome wire, one four inches long and the other eight inches long. Wind each into a coil on a pencil.

2. Set up two glasses of water at seventy degrees fahrenheit. Connect two pairs of cells in series. Connect the nichrome wires to the cells, using the copper wires. Put the nichrome wire coils immediately into the glasses of water. Insert the thermometers at the same time, and watch them carefully. What was the temperature on the thermometer before you inserted it into the water? ____________
Describe what happens.

3, Heat the bimetallic bar over a burner and observe how it bends and straightens as it is heated and cooled. What causes this reaction?

OBSERVATIONS:

How much did the water temperature increase in each glass?

Which metal of the bimetallic bar expanded most?

What effect was produced by this expansion?

CONCLUSIONS:

Does a short or a long wire let more current flow through it?

How do you know?

What is the effect of causing two metals in one bar to expand at different rates?

How does the diameter of a wire affect the current flowing through it?

PHYSICAL SCIENCE

Experiment 13
LIGHT IMAGES

MATERIALS:
Magnifying glass, candle, waxed paper, ruler.

PROCEDURE:

1. Darken the room. Light the candle. Hold the magnifying glass near the candle so that the candlelight shines through it on the wall. How far must the candle be from the glass for this to occur? ____________________

   Now how far away from the lens is the candle? ____________________

   What do you notice about the image which is formed?

2. Hold a square of waxed paper three feet from the candle, and hold the lens between the candle and the paper. What do you notice?

   Hold the lens close to the paper and move it toward the candle until a sharp, small image appears on the paper. How far from the candle is the lens? ____

OBSERVATIONS:
Which image was larger?

Which image was brighter?

What conditions are necessary to project an enlarged image?

What conditions are necessary to project a reduced image?

Which corresponds to a projector?

Which corresponds to a camera?

CONCLUSIONS:
What conditions permit the projection of enlarged and reduced images through the use of a convex lens?

PHYSICAL SCIENCE

Experiment 14
ENERGY FROM MOTION

MATERIALS:
Yard stick (or meter stick), one small rubber ball, two medium sized rubber balls, some strong string, two coat hangers, wire cutters, pliers, ring stand.

PROCEDURE:
1. Cut three pieces of coat hanger wire six inches long. Make a bend at one end to form a hook.

2. Push one wire through the small ball and one wire through one of the larger balls. Now make a small loop at the ends of the wires you have just pushed through.

3. Tie one end of the string to a ring on the stand. Tie the other end of the string to the small loop of the wire in the small ball so that it will swing and just miss touching the base of the stand. This arrangement is called a ballistic pendulum. What is the meaning of a ballistic pendulum?

4. Now place the third ball on the stand so that it will be hit by the swinging small ball.

5. Pull back the small ball so that it is one-foot high, measured from the table top. Keep the string tight. Let the small ball go so that it strikes the larger ball. Measure the distance the larger ball is moved, and record it below.

6. Now put the larger ball back, and this time hold the smaller ball two-feet high. Let the smaller ball swing and measure the distance it moves the larger ball this time. Record the information below.

7. Now exchange the small ball for the other larger one, and swing it twice as you did above; once from a one-foot height, and then from a two-foot height. Be sure you hit the other large ball each time and record the distance it moves below.

8. Try hitting the two larger balls, one in front of the other and touching, with the swinging small ball. Record your results below.

OBSERVATIONS:
Where did the extra kinetic energy of the small ball come from to move the larger ball farther the second time than the first time?

When the larger ball struck the smaller ball, what was different?

Why was the kinetic energy of the moving large ball greater than that of the moving small ball?

What two things does kinetic energy depend on?

CONCLUSIONS:

How can potential energy of position be changed to kinetic energy?

What effect does the mass and the distance an object falls have on the amount of work done?

PHYSICAL SCIENCE

Experiment 15
THE EFFECT OF HEAT ON TEMPERATURE

MATERIALS:
Water, beaker, candle in a holder, matches, thermometer, ring stand, wire gauze, balance, weights, watch.

PROCEDURE:
1. Place the beaker on the wire gauze on the ring stand.

2. Place the thermometer in one ounce of water in the beaker. What is the temperature reading? ______________

3. Weigh the candle. What is the weight? ______________

4. Light the candle. Place the candle under the beaker, and heat it slowly.

5. When the temperature has risen six degrees, blow out the candle.

6. Weigh the candle. What is its weight? ______________

OBSERVATIONS:
How much of the candle is used during the six degree temperature rise?

CONCLUSIONS:
Use your watch and do the entire experiment over again. How many minutes and seconds are needed to raise the temperature of the water six degrees?

Is the same amount of time and candle needed to raise two ounces of water six degrees? How can you test your answer?

Experiment 1
BORAX BEAD TEST

MATERIALS:

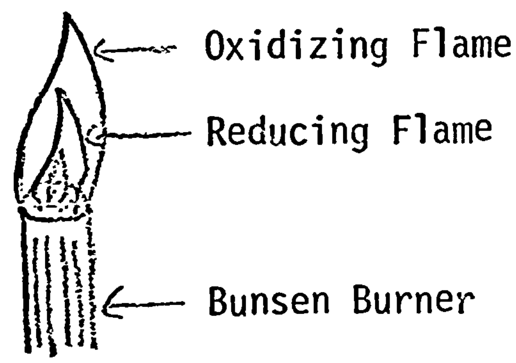
Glass tubing with platinum or nichrome wire protruding from one end, borax, bunsen burner, unknown samples.

PROCEDURE:

Dip the wire loop into borax, and then heat it until a clear, glassy bead results. Then touch this borax bead to a small amount of a powdered mineral and reheat it in reducing and oxidizing flames (see diagrams below). The bead will change colors when different elements are heated (see table below). Note the color of the bead for each flame, both when it is hot and when it is cold.

TABLE OF BEAD COLORS

	Oxidizing Flame		Reducing Flame	
Metal	Hot	Cold	Hot	Cold
Chromium	yellow	green	green	green
Cobalt	blue	blue	blue	blue
Copper	green	blue	colorless	brown
Iron	yellow	green	green	green
Manganese	violet	brownish-to-violet	colorless	colorless
Nickel	violet	brown	colorless-to-gray	colorless-to-gray



You will be given small samples of three minerals on which you are to conduct borax bead tests. Be sure that your wire is cleaned for each test. Record your observations, telling what element you think each unknown contains, and what led you to your conclusion.

UNKNOWN

(1)

(2)

(3)

Do you think this test is conclusive for identifying the composition of a substance? Why?

EARTH SCIENCE

Experiment 2
SIMPLE FLAME TESTS

MATERIALS:
Platinum or nichrome wire, glass tubing, hydrochloric acid, bunsen burner, unknown samples.

PROCEDURE:
Cut off about three inches of the wire from the spool. Heat the end of a piece of glass tubing in a flame, and then insert the wire into the end of the tubing. Keep the glass tubing in the flame until the wire becomes firmly attached to the glass. After the glass has cooled, bend the free end of the wire into a small loop.

Dip the wire into the hydrochloric acid, and then heat it in the flame. This cleans the wire of impurities which might be present.

Below is a table of common minerals, and the characteristic color they give off when heated in an open flame.

ELEMENT	FLAME COLOR
Strontium	crimson
Lithium	crimson
Calcium	orange
Sodium	intense, persistent yellow
Barium	pale green
Copper	emerald green
Potassium	violet

A simple flame test is conducted by dipping the wire loop into a small amount of a given substance, heating that in an open flame, and observing the color emitted by the specimen. Be sure that the wire is cleaned each time that it is used.

You will be issued four unknown substances. Conduct a simple flame test on each substance and then record your observations. Tell what element you think each unknown contains, and what led you to your conclusion.

UNKNOWN

(1)

(2)

(3)

(4)

Do you think this test is conclusive for identifying the composition of a substance? Why?

EARTH SCIENCE

Experiment 3
SPECIFIC GRAVITY

MATERIALS·
Piece of iron, scales, beaker, dissecting pan, thread, rocks and minerals.

PROCEDURE:
The following procedure can be used for finding the specific gravity of any object of reasonable size. It is suggested for the first experiment that all students determine the specific gravity of the same material (iron), but each group should work with a different form of shape of this substance. All groups should come out with about the same answer.

1. First, weigh the object for which you want to find the specific gravity. Record its weight in the blank which follows.
   The weight of my specimen is ____________ grams.

2. Then find the volume of water which the object will displace.
   A. Place the beaker in the dissecting pan on the scale and fill it with water. Add more water until it bulges over the top and is about to break over the edge.

      Submerge the specimen in the beaker of water. This can be done more carefully if the object is lowered into the water with a thread. Floating objects must be pushed down to the surface of the water to displace their complete volume. Remove the beaker, the object and the remaining water.

   B. Weigh the catch basin (dissecting pan) with its displaced water. Record this weight in the blank which follows.
      The weight of the catch basin with H_2O is ________g.

   C. Pour the displaced water out. Dry and weigh the empty catch basin. Record its weight in the blank which follows.
      The weight of the dry catch basin is _______g.

   D. Subtract "C" from "B" to find the weight of the displaced water.
      The weight of the displaced water is ______g.

3. Calculate the specific gravity of the object. Use the formula shown below. Since one gram of pure water takes up one cubic centimeter of space, the number of grams of water is equal to the volume of the water. This is approximately true when you are not working with pure water.
   What is the volume of this displaced water if each gram takes up one cubic centimeter of space? __________ cc.

   Specific Gravity = Weight divided by volume (W/V)
   The specific gravity of iron is ___________.

4. Following the procedure ourlined above, and on a separate sheet of paper, find specific gravity of the following common rocks and minerals:

Agatized Wood	Amazonite	Pitchblende	Calcite	Calcocite	Flint
Galena	Malachite	Molybdenite	Basalt	Tourmaline	Volcanic Cinder
Granite	Hornblende	Conglomerate	Gneiss	Glauconite	Sandstone
Limestone	Marble	Slate			

5. Write a short paragraph explaining your concept of specific gravity.

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Experiment 4
FOSSIL IDENTIFICATION

MATERIALS:
Box of prepared fossils; hand lens, geologic time chart.

PROCEDURE:
Carefully examine the sixteen (16) specimens which you have been handed; then using your geologic time chart and the specimens draw simple sketches of the fossils. Put the period to which the fossil belongs at the bottom of the sketch, and the name of the fossil at the top. After this is completed answer the questions on the back page.

---

1. ______________ 2. ______________ 3. ______________ 4. ______________

______________ ______________ ______________ ______________

---

5. ______________ 6. ______________ 7. ______________ 8. ______________

______________ ______________ ______________ ______________

---

9. ______________ 10. ______________ 11. ______________ 12. ______________

______________ ______________ ______________ ______________

---

13. ______________ 14. ______________ 15. ______________ 16. ______________

______________ ______________ ______________ ______________

QUESTIONS:

1. Which of the fossils is the oldest? Name it, and the period to which it belongs.

2. What phylum does the above fossil belong to?

3. Which of the fossils is the youngest? Name it, and the period to which it belongs.

4. What phylum does the above fossil belong to?

5. There are two types of corals in your fossil set. What is the main difference between the two corals?

6. What type of climate do you think the present state of Texas had during the Pennsylvanian Period?

7. Name the type of preservation of:

   (a) The Fern

   (b) The Shark Tooth

   (c) The Dinosaur Bone

8. How many of the fossils are marine? Why do you think the number of marine fossils is greater than the number of land fossils?

9. What class of rocks most commonly contain fossils? Name three common rocks which are found in this class that would be likely to contain fossils.

EARTH SCIENCE

Experiment 5
TOPOGRAPHIC MAPS

MATERIALS:
Topographic map of Soda Canyon Quadrangle, Colorado; hand lens; wall map of the U.S.; U.S. Geological Survey map symbol sheet.

PROCEDURE:
Examine carefully the topogaphic map which you have. Using the map, now answer the following questions.

1. In which part of Colorado is this area located? ______________________

2. State the scale of this map as a fraction. ______________________

3. State the contour interval. ______________________

4. What is the principal river on the map? ______________________

5. What directions does the river flow? ______________________

6. How can you tell what direction the river flows?

7. Are the river's valley walls steep, moderate, or gentle? ____________

8. How did you determine your answer to the above question?

9. About how wide is the floodplain of the river's valley? ____________

10. Name the canyons of two tributaries that enter the river valley.

    ____________________ and ____________________

11. How do the contour lines show the steep slope of the valley in Johnson Canyon?

12. Name two cliff dwellings which are found outside the limits of Mesa Verde National Park. ____________________ and ____________________.

13. How do you know that the cliff dwellings on the map are built into cliffs?

14. Name a spring which is found on the map. ______________________

15. How is it shown that the region represented by the map is almost entirely uninhabited?

16. How does the map show that the region is largely forested?

17. Notice the trail that starts near the south central margin of the map, just north of the scale, and goes northeast to Trail Canyon. Why does it zigzag so much just south of the word "Trail" in Trail Canyon?

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Experiment 6
EQUATORIAL.MOUNT FOR A TELESCOPE

MATERIALS:

- Flat-topped milk carton; cork; coat-hanger; pin; straw; small mirror; wire cutters; razor blade.

PROCEDURE:

Punch a small hole in the top of the milk carton about one inch from the edge. Now punch another hole in the side of the carton, directly under the first hole, and about one inch from the top edge. Cut a six-inch length from the coat-hanger and punch it through both holes in the milk carton. Punch the cork onto the top part of the coat-hanger wire, trying to get it on as straight as possible. Cut the straw in half, and stick a pin squarely through the middle of the straw. Now stick the pin into the cork at right angles to the wire. You have now made a model of an equatorial mount for a telescope. The mirror is used to sight through the straw in any position.

Lay the mirror on the top of the milk carton and sight through the straw until you can locate the "north star" which the teacher has drawn on the chalkboard. In order to differentiate the ends of your "telescope", color one end with your pencil. The uncolored end will then be the viewing end.

The operation of your equatorially mounted straw is simple. Turning the straw on the pin is equivalent to turning a telescope on the declination axis. The wire represents the polar axis, and when the cork is turned it is equivalent to turning a telescope on its polar axis. By using the above two motions you will be able to see any object in the classroom. Try this out for yourself.

If the straw is aimed straight up and the polar axis then turned until the straw is horizontal, the straw will not point directly east or west. This represents the apparent path of a star which crosses the zenith.

Again focus your straw on the "north star". Revolve the instrument around its polar axis. What do you notice about the "north star"?

How do you account for this?

Around the "north star" you will notice several other stars. Aim the polar axis of your instrument at this, and adjust the straw so you are able to see one of the other stars. If by revolving the polar axis the star disappears, it is not circumpolar. How many of the stars on the chalkboard are circumpolar?

Tell whether the following stars are circumpolar or not, and why?

1. 2. 3. 4. 5.

Experiment 7
STREAK TEST FOR MINERALS

MATERIALS:
Unglazed porcelain tile; steel file; pyrite; unknown mineral samples.

PROCEDURE:
1. Rub a sample of pyrite across the unglazed porcelain tile. This will leave a streak (the powder a mineral leaves when it is rubbed on a rough surface) on the tile. What color is the streak of pyrite? ____________
Is the streak of pyrite the same color as the mineral sample? __________

2. Below you will find a table of common minerals, their external colors, and the streak they leave when rubbed on unglazed procelain tile. Study this table carefully.

MINERALS	EXTERNAL COLOR	STREAK
apatite	blue-green	white
calcite	blue or white	white
chalcopyrite	brass yellow	greenish black
fluorite	green, purple white	white
galena	lead gray	lead gray
hematite	steel gray, red-brown	brownish red
limonite	brown	orcher yellow
talc	gray or green	white
magnetite	black	black
malachite	bright green	pale green
pyrite	pale brass yellow	greenish black

You have samples of several of these minerals listed above. Using the tile, and the table above make an identification of each unknown mineral.

1. __________ 2. __________ 3. __________ 4. __________

5. __________ 6. __________ 7. __________ 8. __________

9. __________ 10. __________

OBSERVATIONS:
1. What is the most common color of the streak?

2. Do you notice any streaks that seem to be different from the external color of the mineral? Give examples.

3. Can the above streaks be used for identification?

4. Is a white streak conclusive for identification of a mineral?

5. Is the streak test for any mineral conclusive for its identification? Why?

6. Did any of your mineral samples scratch the tile? ______ What does this mean?

7. Devise a way to use the steel file and conduct a streak test. Explain fully. Do you still get the same results as you did above?

EARTH SCIENCE

Experiment 8
IDENTIFYING MINERALS BY LUSTER

MATERIALS:
Samples of different minerals.

PROCEDURE:
1. Luster refers to the way that minerals reflect light. Some have a very shiny metallic look so we say they have a metallic luster. Other kinds of lusters are adamantine, a brilliant or flashing appearance; vitreous, a glassy appearance; resonous or waxy; pearly; satiny; silky; and dull.

   What would be the luster of a dime? ________ Ice? ________ Dirt? ________

2. Below is a table of lusters and common minerals. You will be given some unknown mineral samples to identify using this table.

LUSTER	MINERAL
metallic	galena, pyrite, chalcopyrite
adamantine	diamond, corundum
vitreous	transparent quartz, calcite
resinous	sulfur
pearly	talc
satiny	asbestos
dull	kaolinite

Some minerals allow light to pass through them, so they are called transparent. In contrast, some do not allow any light to pass through them, and are called opaque.

3. In the blanks which follow put the name of the mineral, which you have identified by means of its luster.

   1.________ 2. ________ 3. ________ 4. ________

   5.________ 6.________ 7.________ 8. ________

OBSERVATIONS:
1. What did you observe about the ability of different minerals to reflect light?

2. Which of the minerals you identified would be opaque?

3. Would different types of light affect the luster of a mineral?

4. Is the luster of a mineral a conclusive test for identifying it? Why?

Experiment 9
IDENTIFYING MINERALS BY CLEAVAGE AND FRACTURE

MATERIALS:

Magnifying glass; hammer; knife; chipped glass; Indian arrowhead; mineral samples.

PROCEDURE:

1. Cleavage refers to the tendency of some minerals to break along certain parallel lines. Minerals which have the property of cleavage will show one or more directions of cleavage when they are broken. Cleavage planes are smooth, and therefore should be easy to identify.

2. Many minerals do not show the property of cleavage when they are broken. The term used to describe how these minerals break is fracture. The surface of the mineral does not appear smooth, but may appear fibrous, earthy, even, or uneven.

3. Take a piece of muscovite (mica) and try to split it with the knife blade. How does it split?

   How many different examples of parallel planes do you observe in the mica? What is the nature of the cleavage surface of the mica?

4. Examine carefully a sample of obsidian. This is a mineral which exhibits fracture. Describe the surface of the obsidian.

   Wrap a piece of glass in a paper towel and hit it with the hammer. Describe the surface of the glass.

   Describe the surface of an Indian arrowhead. Does it exhibit fracture or cleavage?

   If a mineral exhibits concentric arcs or shells when it is fractured, we say that it has conchoidal fracutre. This would resemble a conch shell which is found along a sea coast.

5. You have several different minerals before you. Tell whether they exhibit cleavage or fracture. If the mineral exhibits cleavage, count how many planes of cleavage are exhibited.

   1. asbestos ______________ 2. galena ______________ 3. calcite ____________

   4. clay __________________ 5. quartz ______________ 6. ice ________________

   For those minerals which exhibit fracture, tell whether it is fibrous, earthy, even, or uneven

OBSERVATIONS:

1. What is the cleavage of galena?

2. What is the cleavage of calcite?

3. How many directions of cleavage are there in galena? ______ in calcite? _________

4. What is the fracture of quartz?

5. Are the properties of fracture and cleavage conclusive for identifying minerals? Why?

EARTH SCIENCE

Experiment 10
IDENTIFYING MINERALS BY HARDNESS

MATERIALS:
Knife; penny; steel file; glass; mineral samples.

PROCEDURE:

1. Hardness is a very important characteristic used in the study and identification of minerals. The hardness of a mineral is its resistance to scratching. It is usually determined by seeing what substance will scratch the mineral.

2. Experiment with a steel file, penny, knife blade, and your fingernail. Determine which of these objects is the hardest, and list them in decreasing order of hardness.

   A. ________________ B. ____________ C. ______________ D. ______________

3. Now take the mineral samples, and complete the following table.

Scratched by Fingernail	Scratched by Penny	Scratched by Knife	Glass scratches Mineral

4. The relative hardness of the mineral is usually indicated by a number from 1 to 10. Below is given Mohs' Hardness Scale, which lists common minerals in order of increasing hardness.

1. talc	6. feldspar
2. gypsum	7. quartz
3. calcite	8. topaz
4. fluorite	9. corundum
5. apatite	10. diamond

5. The following list will be a helpful guide to the hardness of some common minerals.

graphite 1.5	sulfur 2	kaolinite 2.5
mica 2 - 2.5	halite 2.5	galena 2.5
calcite 3	malachite 4	chalcopyrite 4
fluorite 4	limonite 4 - 5.5	hematite 5 - 6
hornblende 5 - 6	magnetite 6	pyrite 6.5
feldspar 6.5	quartz 7	zircon 7.5

6. Take the mineral samples and try to identify them by their relative hardness.

   1. ____________ 2. ______________ 3. ______________ 4. ________________

   5. ____________ 6. ______________ 7. ______________ 8. ________________

OBSERVATIONS:

1. What do you think the hardness of your fingernail is? ____________

2. What is the hardness of the penny? ____________ the knife blade? ______________

   the file? ____________

3. Using the penny, knife, file, glass, and your fingernail, how can you determine the hardness of minerals? Is it a conclusive test for mineral identification?

EARTH SCIENCE

Experiment 11

CRYSTAL PRODUCTION BY EVAPORATING A LIQUID

MATERIALS:

Sodium chloride; magnifying glass or microscope; microscope slide; shallow dish; test tube; medicine dropper; scale.

PROCEDURE:

1. Carefuuly weigh out one (1) gram of salt and place it in a test tube half full of water. What happens to the grains of salt?

   How do you know the salt is still in the water?

2. Keep adding salt to the water until no more will dissolve. You now have what is called a saturated solution.

3. Pour a little of the saturated salt solution on a microscope slide and view it under a magnifying glass or microscope. Carefully watch what happens. Describe below what you observe.

4. Now carefully take two crystals of salt and dissolve them in one drop of water. Evaporate the water and count the number of salt crystals you now have.

5. Now try the same procedure using Epsom salts, and record your results below.

OBSERVATIONS:

1. When you added more salt to the water in the test tube (saturated solution), what happended to the height of liquid in the test tube.

2. When you are viewing the saturated solution through the magnifying glass where does the growth of crystals start first?

3. Why does the growth start at this particular spot first?

4. What could you do to speed up the rate of evaporation of water?

5. What did you observe formed on the microscope slide after viewing it for awhile?

6. What is the shape of the particles you observed in number 5?

7. How do these particles differ from the salt crystals you initially poured in the water?

8. What happens to the shape and size of the crystals if the rate of evaporation is speeded up? Try an experiment to determine this. Tell what you did and record your observations below.

EARTH SCIENCE

Experiment 12
THE PULL OF GRAVITY

MATERIALS:
Large ball.

PROCEDURE:
1. See if you can overcome the Earth's pull of gravity. Jump in the air, with both feet off the ground. Did you overcome the pull of gravity? ________

2. Take the ball and hold it in your hand at arm's length. Is the Earth pulling on the ball? __________ How do you know?

   If the Earth is pulling on the ball, how much is it pulling?

   What do you do to overcome the force of attraction the Earth has on the ball?

3. Hold the ball until your arms tire, and then release it. Does it fall? _____ Why?

4. Now throw the ball gently into the air. As the ball goes up, does it travel against the pull of gravity? ________

   What did you have to apply to the ball to make it overcome the force of gravity for a brief period?

5. Now throw the ball slightly harder. What happens to it? Why?

OBSERVATIONS:
1. Could anyone throw a ball into space?

   Why?

2. Are you able to determine the point at which the ball begins to fall back toward the Earth?

3. What makes the ball fall back to the Earth, instead of rising higher?

4. How can the pull of gravity be overcome?

EARTH SCIENCE

Experiment 13
MEASURING DISTANCES FROM A BASELINE

MATERIALS:
Sheet of cardboard about 1½ft. by 2½ ft.; large piece of white paper; straight pins; plates I and II; tape measure.

PROCEDURE:
1. Place a large sheet of cardboard on top of your desk, and make sure that it will remain steady in one postion.

2. Glue or tape a piece of white paper to the cardboard. Now carefully draw a straight line along the bottom of the paper, about one inch from the edge of the cardboard.

3. Tape or glue Plates I and II on the line so that the vertices are exactly two feet apart.

4. Place upright straight pins at each vertex and at each degree mark on the curved lines or arcs. The distance between the vertex pins is called the base line.

5. Now sight across the top of a vertex pin to the object drawn on the chalkboard. What angle does this object make with the base line? ________________
Behind which pin on the arc does the object appear? ________________
If your line of sight falls between pins, estimate to the nearest half-degree. Now repeat the above procedure at the other end of the base line.
What angle does the object make with the base line now? ______________
Behind which pin on the arc does the object appear? ______________

6. You are now able to make a scale drawing. You have the length of the base line and the size of the angle at each end of it. The sides of the angles will cross at the object, that is they intersect. If you let one inch equal two feet on your drawing, how far is the object from the base line on your drawing?

   How far is the object on the chalkboard from your baseline? __________

7. Measure the actual distance across the room from your desk to the object.______
How far off was the figure you obtained in number six (6)? ___________

8. This device can easily be made into a range finder. On the right side only, remove all the pins from the arc except the pin at 90^{0}. Notice the object on the demonstration table. Move your desk until you are able to sight the object in line with the vertex pin and the 90^{0} pin. Don't move your desk again. Now sight the object from the other end and measure the angle as before. Make a scale drawing and determine the distance, on your drawing, from your desk to the object. ______________
How far do you calculate the distance from your desk to the object to be?

9. Measure the actual distance across the room from your desk to the object. How far off was the figure you obtained in number eight (8)? ___________

10. Now locate objects which are a given distance from you, and fill in the table below.

Distance	Angle	Distance	Angle
2 feet		18 feet	
4 feet		20 feet	
6 feet		22 feet	
8 feet		24 feet	
10 feet		26 feet	
12 feet		28 feet	
14 feet		30 feet	
16 feet			

11. Make scale drawings to determine the angles for each distance, on a separate sheet of paper.

12. Name a table which lists the distances in one column and the corresponding angles in the other, past the 30 feet mark which you did in number 10. Do this up to about 50 feet.

13. Check the distances, not all of them, that you have in numbers 10 and 12. When is your instrument accurate?

    When is it not accurate?

OBSERVATIONS:

1. How could you determine the accuracy of your range finder?

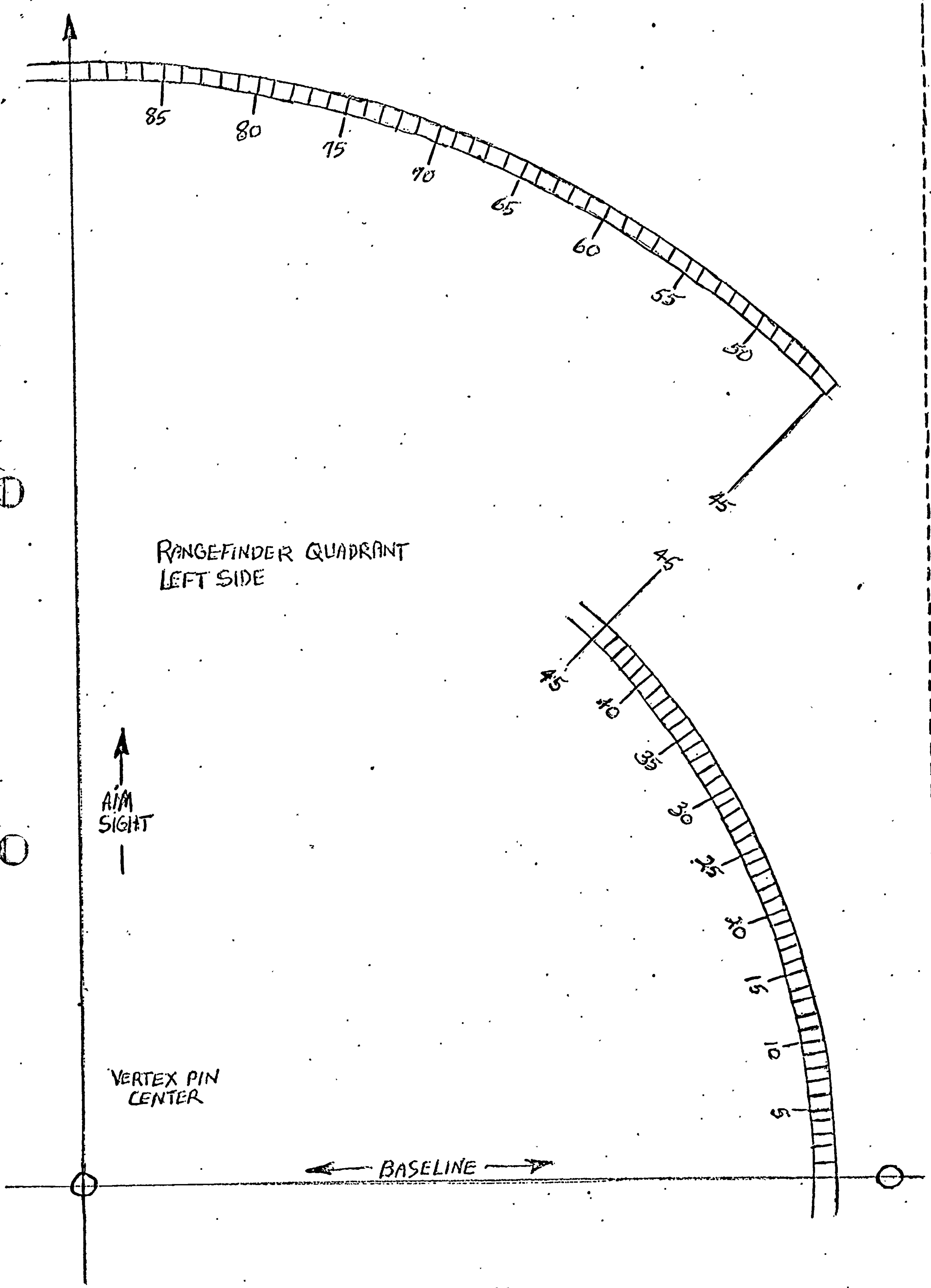
2. How accurate is your range finder?

3. What is the advantage of using a range finder?

4. In the two tables you made, how does the angle change as the distances increase?

5. What could you do to get accurate measurements for objects which are far away?

PLATE I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80
75
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45
RANGEFINDER QUADRANT
LEFT SIDE
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25
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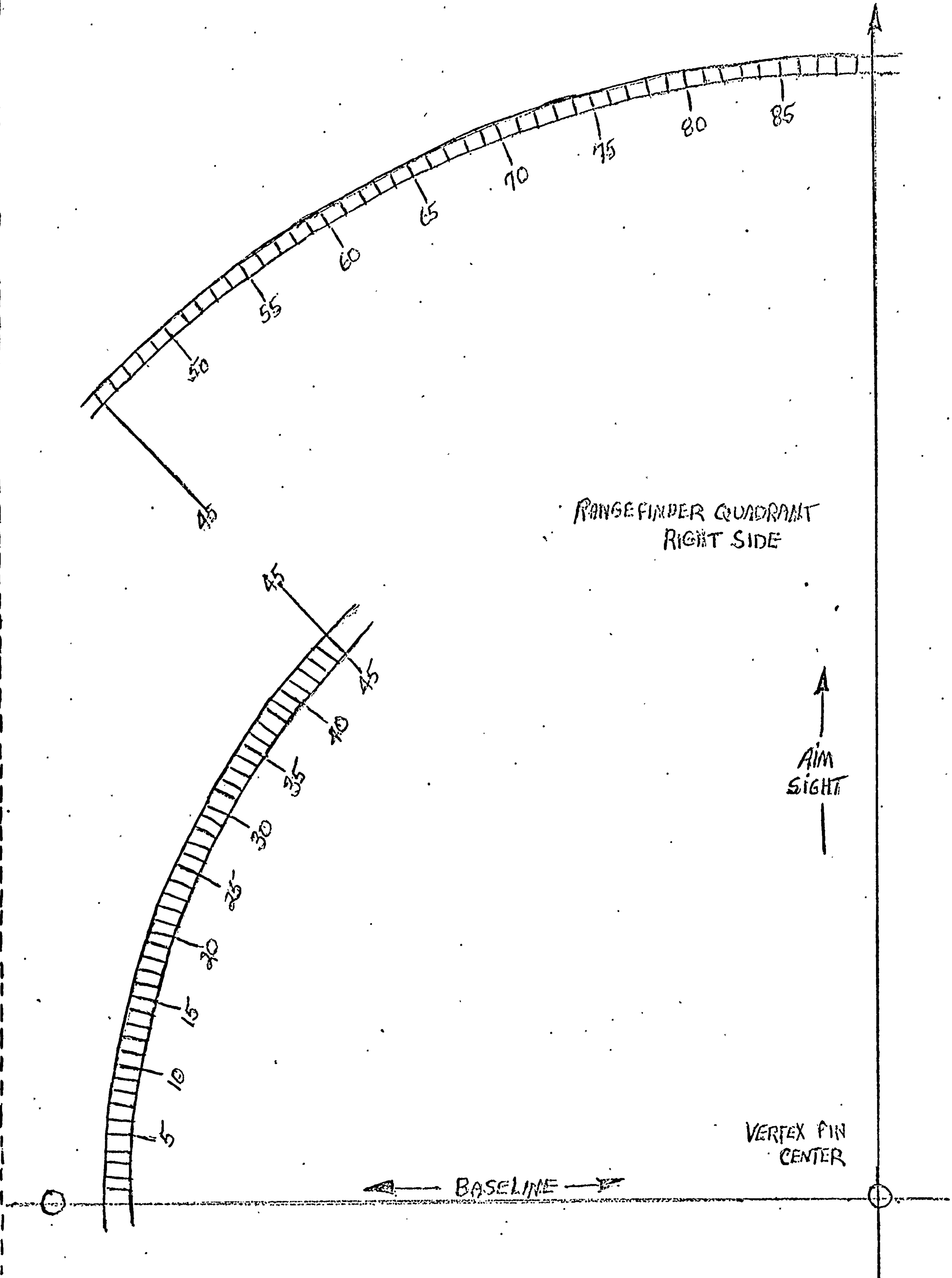
5
AIM
SIGHT
VERTEX PIN
CENTER
BASELINE



45
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RANGEFINDER QUADRANT
RIGHT SIDE
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25
20
15
10
5
AIM
SIGHT
VERTEX PIN
CENTER
BASELINE

EARTH SCIENCE

Experiment 14
CHARTING PLANETARY ORBITS

MATERIALS:
Compass; protractor; ruler.

PROCEDURE:
1. With your compass, draw a circle four inches in diameter. Place a dot at the center to represent the position of the sun. The circle you have drawn will represent the path of the earth as it travels around the sun. This is called a scale drawing, as the two inches from the earth to the sun represents a certain distance. We shall call this distance one astronomical unit (1 a.u.).

2. Pick any point on your circle and place a dot which will represent the earth. Draw a line from the earth to the sun. Now we want to add the orbit of Venus to our drawings. Johannes Kepler, a German astronomer, knew that the largest angular separation between Venus and the sun is 48°.

3. Draw a 48° angle on your paper, with the earth at the vertex of the angle, and the sun-earth line as one side of the angle. Can you draw a circular path for Venus about the sun so that Venus can appear 48° from the sun, but never any more? _______
How will you do this?

4. You will be able to draw the orbit of Mercury in exactly the same way. The greatest angular separation between Mercury and the sun is about 24°. Describe the method you will use to draw the orbit of Mercury, then draw Mercury's orbit.

5. We will have to use a somewhat different method to draw the orbit of Mars. Mars takes 687 days to travel around the sun, as compared to 365 days for the earth. Therefore every 687 days Mars is in the same place in its path about the sun, no matter where the earth is. This means that Mars will appear to be off in one direction on a given day as seen from the earth. 687 days later, with the earth somewhere else, Mars will appear in another direction. Because Mars has returned to the same place in space, we are able to get a fix on it.

6. Using the same circle you did previously, and the same point for the earth, place another dot to represent the earth 687 days later when Mars would be back in the same place. Where will the earth be?

7. To make our work easier we will call the time for one trip of the earth around the sun 360 days. In 687 days, the earth makes one complete trip and goes 327 days of the next 360 day trip. And so the angle through which it travels on the second trip is 327/360 of a complete circle, or 327°. How many degrees are left to go? _________
Measure this angle, and put another dot representing the earth in this second position.

8. If we know the angle between the sun and Mars at two different times, which we have just determined above, we can calculate its orbit. The first angle between the sun and Mars is 119°, and then 687 days later is 156°. Draw these angles on your diagram. Notice that the lines cross. What do you think this point represents?

   Draw a circle to represent Mar's orbit.

OBSERVATIONS:

1. Recall that two inches on your diagram represents 1 a.u. How many astronomical units is Venus from the sun?

2. How many astronomical units is Mercury from the sun?

3. How many astronomical units is Mars from the sun?

4. Venus has been calculated to be 26 million miles from the earth. Using this information, calculate how many miles are in one astronomical unit.

5. How many miles is Mercury from the sun?

6. How many miles is Mars from the sun?

7. Would it be possible for you to calculate the orbits of the other planets? If it is, what information would you need?

EARTH SCIENCE

Experiment 15
ILLUSTRATING WAVE MOTION WITH A RIPPLE TANK

MATERIALS:
Large cake pan; black paper; tissue paper; wooden dowel; three paraffin blocks.

PROCEDURE:
1. Scientists have two different theories about how light reaches us from space. One way is by particles, and the other way is by waves. We will do some simple experiments to show how light could travel in waves.

2. Line the inside bottom of your cake pan with black paper. Pour water into the tray to a depth of about half an inch. Now put paper tissues all around the inside edge of the tray to make a "beach" of tissues. The purpose of the paper is to keep the waves from reflecting too much. You have now constructed a ripple tank.

3. Dip the eraser end of your pencil into the water at regular intervals. Practice until you make good waves. The waves you are making are called point source waves. Get a good rhythm so that you have a regular army of ripples moving outward. Study the way the waves move by watching them closely in the tank. What characteristics can you observe from your observations?

4. Each wave you make has a crest and a trough. In a series of regular waves the distance from the top of one crest to the top of the next crest is called the wavelength of the wave. Watch the waves as they strike the paper "beach". How frequently do they strike?

   The rate at which the waves hit a given place is called the frequency of the wave.

5. Take the wooden dowel and make some straight wave fronts by gently rocking it back and forth at one end of the ripple tank. Pulse the waves with a steady beat and observe them closely. Is there any way you can measure the wavelength and frequency? If there is, please describe it.

6. Let's examine what happens to a wave passing the edge of a barrier. Place one of the paraffin blocks against the edge of the ripple tank at about the halfway mark. With the dowel, produce some straight wave fronts at one end of the tank as you did previously. What happens to the edge of the waves as they pass the edge of the block?

7. Now set up a double barrier in the ripple tank, using two paraffin blocks, so that there is a narrow opening between them. This opening should be about--as wide as your finger. Fit the paraffin blocks snugly against the edges of the tank by putting paper tissue in each corner of the front of the barrier. This will also prevent reflection. Again make straight waves with the dowel and watch them carefully as they pass the opening in the barrier. Describe the shape of the waves that come out of the opening.

8. Now construct a barrier that has two small openings instead of one. Try to get the openings about four inches apart. Use three blocks of paraffin, and make sure they are securely in place. Again make straight waves with the dowel and describe the waves that pass through the double openings.

OBSERVATIONS:

1. Is the separation between the troughs the same as it is between the crests?

2. How is the frequency of the waves related to the rate at which you move the dowel or the eraser on the pencil?

3. Explain what you think causes the shape of the waves which passed through the double barrier in number 7.

4. In number 8, after the waves pass the barrier do they overlap or do they pass through one another? What do you think causes this?

BIOLOGICAL SCIENCE

Experiment 1
A LOOK AT SIMPLE CELLS

MATERIALS:
Single-edge razor blade, cork, apple, onion, tomato, potato, tweezers, medicine dropper, microscope slides, cover glasses, microscope, water.

PROCEDURE:
1. With the razor blade make the thinnest shavings you possibly can from each of the plant materials.

2. As you make each shaving, pick it up with the tweezers and put it in a drop of water on a microscope slide.

3. Lay a cover glass on the shaving to keep it moist and flat.

4. Now carefully place each slide on the microscope and adjust it so you can clearly see the slide.

OBSERVATIONS:
1. Below, draw a picture of what you see under each slide.

2. Which of the plant materials show cell formation the most clearly?

3. Label the parts of the cell, on your drawing, using the clearest slide.

4. See if you can devise a simple, and harmless, experiment to view some of your body cells and describe it below. Check with your teacher, and then, if approved try it out and record your results.

Experiment 2
DOES SALIVA HELP DIGEST STARCH?

MATERIALS:
Teaspoon, starch, beakers, water, burner, pan, test tubes, medicine dropper iodine solution, filter paper, funnel.

PROCEDURE:
1. Put a teaspoonful of starch in a beaker half full of cold water and stir the mixture thoroughly.
2. Now heat the beaker to boiling.
3. Cool the beaker by filling it with cold water.
4. Pour a small amount of the mixture into a test tube and add a drop of iodine solution.
5. Heat a beaker 3/4 full of water to boiling, and set it aside for later use.
6. Now put a piece of filter paper in the bottom of the funnel, and place it over an empty test tube.
7. Collect saliva in the funnel until the test tube is one-fourth full of clear saliva.
8. Pour a little of the saliva into another test tube and add a drop of iodine solution.
9. Fill the test tube that contains saliva with the starch mixture and mix the two liquids thoroughly.
10. Stand the test tube in the beaker of warm water which you have heated. This temperature should be about that of your body.
11. Pour some of the starch-saliva mixture into another test tube and add a drop of iodine solution.

OBSERVATIONS:
1. In procedure #3, had all of the starch dissolved?
2. In procedure #4, when you added iodine, what happended? What does this show?
3. When you added iodine to the saliva solution in step 8, what happened?
4. When you added the starch solution to the saliva solution in steps 9 and 10, what happended? How do you know?
5. In the last step, #11, what happened? What does this experiment show?
6. Do step #11 over again, by adding one more drop of iodine solution and record your results below.

BIOLOGICAL SCIENCE

Experiment 3
THE EFFECT OF LIGHT ON GREEN PLANTS

MATERIALS:
Geranium or nasturtium plant, cork or black paper, pins, beakers, water, burner, alcohol, iodine solution, dish, cardboard.

PROCEDURE:
1. Over the weekend, keep a geranium or nasturtium plant in the dark.

2. On Monday, pin two slices of cork, or black paper, on opposite sides of a leaf. Do this to two separate leaves.

3. Set the plant in bright sunlight for several hours. Leave overnight.

4. Break off one of the covered leaves, and dip it in a beaker of boiling water for a short period of time. Be sure you remove the corks before doing this.

5. Now put the leaf in a beaker half full of alcohol, and set this beaker in the beaker of boiling water. DO NOT PUT THE BEAKER WITH ALCOHOL DIRECTLY OVER THE BURNER, IT WILL CATCH FIRE QUITE EASILY.

6. Let the leaf stay in the alcohol for five to ten minutes.

7. Take the leaf out of the alcohol and soak it in an iodine solution which you have prepared in the dish. Then spread it out on the cardboard to dry.

OBSERVATIONS:
1. What did you observe when you removed the corks in step #4?

2. What happened to the leaf when you placed it in the boiling water?

3. What happened to the leaf when you put it in the alcohol bath?

4. Did a change take place when you put the leaf in the iodine solution? If so, what?

5. What material does this show to be present in the leaf?

Experiment 4
TESTING FOODS FOR SUGARS, MINERALS, AND PROTEINS

MATERIALS:

Bread, peaches, butter, cheese, hard-boiled egg, meat, nuts, corn syrup, apple, beans, milk, burner, tin-can lids, test tubes, dilute nitric acid, ammonium hydroxide, butcher paper, test-tube holder, Fehling's or Benedict's solution.

PROCEDURE:

1. Put a small piece of cooked egg white in a test tube. Add a few drops of nitric acid. BE CAREFUL NOT TO SPILL THE ACID.
2. Heat the test tube gently. Pour out any extra acid into a dish.
3. Add about one inch of ammonium hydroxide to the test tube.
4. Repeat the above steps, using all of the foods listed above.
5. Put a small piece of the cheese on a tin can lid. Heat it as hot as possible. Keep it hot until only ashes are left.
6. Heat the other solid foods as you did the cheese in step #5. If it becomes apparent that no ashes will form after a period of time, you may discontinue heating for that particular food.
7. Fill a test tube 1/3 full of Fehling's or Benedict's solution, and add a few drops of corn syrup.
8. Heat the liquid in the test tube.
9. Repeat steps #7 and #8, using all of the foods listed above.

OBSERVATIONS:

1. When you heated the test tube containing the acid and the egg white, what happened?
2. After you added the ammonium hydroxide to the test tube, what happened?
3. What did the ashes represent when you heated the cheese?
4. When you heated the liquid containing the Fehling's solution and the corn syrup, what happened?
5. What group of foods does this represent? ____________________
6. List below the foods you found to be sugars, proteins, and minerals, and make a separate column for those you were unable to classify.

BIOLOGICAL SCIENCE

Experiment 5
MAKING A WATER-DROP MICROSCOPE

MATERIALS:
Tin shears, hammer, nail, block of wood, tin can, water, glass plate, file, medicine dropper, flashlight.

PROCEDURE:
1. Cut a two-inch by five-inch strip from the side of a large tin can using the tin shears.

2. With a hammer and a nail, punch a small round hole in the middle of the metal strip. Be sure that the hole is round. Take a small file, and smooth any rough edges on the metal strip.

3. Bend each end of the strip back, one inch from the end. Be sure that both bends are equal, and that the strip will stand level.

4. Arrange two stacks of books with a glass plate between them. Place your microscope on the glass plates, and put the flashlight beneath it.

5. With a medicine dropper, place one drop of water in the hole.

6. Take the prepared slides your teacher has, and put one of them beneath the hole in your microscope.

7. Focus your microscope by slowly pushing the metal strip up and down.

OBSERVATIONS:
1. Draw pictures below of what you observed on three different slides through your microscope.

2. How does your microscope compare with a standard laboratory one for viewing objects?

3. About how many power do you feel your microscope is? How did you determine this?

BIOLOGICAL SCIENCE

Experiment 6
GROWTH OF PLANTS

MATERIALS:
Beans or corn seeds, sawdust, four shallow pans, water.

PROCEDURE:
1. Place about two inches of sawdust in each of the shallow pans. Thoroughly wet the sawdust in the other pan, but leave the sawdust in one pan dry. Plant ten (10) seeds about one inch deep in each pan.

2. Set the pans in a warm place for seven days, being sure to keep the sawdust in the one pan moist. Do not moisten the sawdust in the other pan.

3. Count and record the number of seeds that germinate in each pan, putting the day of germination down. Use the forms below to record your information. Check the pans each day for new plants.

(a)

Moist Pan	Date Planted	Dates Germinated and Number of Plants

(b)

Dry Pan		

4. Place about two inches of wet sawdust in two shallow pans. Plant ten (10) seeds in each.

5. Set one pan in a warm place and the other in a refrigerator, or other cold area, where the temperature will be below 60 F., but not below freezing.

6. Keep the sawdust moist in both pans. After seven days count and record the number of seeds that germinate in each pan. Use the form provided below. Be sure to keep a daily check on the pans.

(c)

Warm Pan	Date Planted	Dates Germinated and Number of Plants

(d)

Cold Pan		

OBSERVATIONS:
1. How many seeds germinated in each of the above situations?

(a) __ (b) ______ (c) ________ (d) _________

OBSERVATIONS:

2. How does the evidence you collected help show some of the necessities for plant growth and life?

3. Can you think of any additional experiments you could do to show that there are other things necessary for plant growth in addition to the ones you have mentioned above?

4. Make colored drawings of what you observed in each of the four pans that the seeds were planted in. Label the different objects in your drawings.

(a) (b)

(c) (d)

Experiment 7
BACTERIA CULTURE GROWTH

MATERIALS:
Potato, water, sugar, unflavored gelatin, beef bouillion, salt, soda, jar lids, aluminum foil, Seran wrap, cloth.

PROCEDURE:
1. In this experiment you will prepare some bacteria cultures which you will then test for their resistance to certain household antiseptics.

2. Preparation of home-made potato dextrose medium:
   Grate raw potato until you have obtained the amount necessary to fill one cup. Boil this in three cups of water for about one hour. Strain the remaining potato out by passing it through a cloth. This should result in a cloudy solution about one cup in volume. To this add one tablespoon of sugar and one envelope of unflavored gelatin. A bouillion cube should also be added, preferably beef bouillion. Mix thoroughly and cook in a pressure cooker for twenty (20) minutes.

3. Preparation of a gelatin medium:
   Mix together the following ingredients thoroughly:
   1 package of unflavored gelatin
   1 quart of boiling water
   1 cube of beef bouillion
   pinch of salt
   pinch of soda

   Pressure cook the above ingredients for twenty (20) minutes.

4. While the medium is cooking prepare six (6) jar lids by wrapping them in aluminum foil and boiling them for ten (10) minutes to sterilize them.

5. When the medium is finished cooking, pour it into the six containers you have just prepared. This should be just enough to cover the bottom of the lid.

6. Cover the containers immediately with Seran wrap, and number them from 1 to 6.

7. After the containers have cooled and solidified, expose them as follows:
   #1 to the air for 20 minutes, then recover.
   #2 touch lightly with your fingers, then recover.
   #3 cough into, then recover.
   #4 add some animal hairs, then recover.
   #5 Put a live fly into, if available, otherwise something else, then recover.
   #6 don't open. This container will serve as a control.

8. Keep the containers in a warm dark place, until your bacteria begin to grow. Check them each day to see if anything new has appeared.

9. Special Directions:
   If difficulties are experienced in maintaining the cultures, the following tips may help you.
   1. Wash the hands thoroughly with soap and hot water before beginning any culture work with bacteria.
   2. Minimize all air movements, i.e., close windows, cut off electric fans, etc.

PROCEDURE:

3. Sterilize all equipment you will be working with.
4. Before beginning culture work, wipe off the table top with an alcohol solution.
5. Do not place cultures in direct sunlight or in situations of extreme heat or cold.
6. Since the available food supply is exhausted within a few days, cultures reach their maximum growth and development in that time. The organisms then begin to die off or produce spores. To maintain thriving cultures it is necessary to transplant some of the organisms to a fresh medium.
7. Pathogenic organisms or cultures containing unidentified organisms must be handled with extreme care to avoid infection. When your experiment is finished, burn the mediums and the bacteria on them, and thoroughly sterilize any dishes used by boiling.

OBSERVATIONS:

Part (a) Record what you have observed in dishes 1 through 5. Draw a colored picture of any organisms which might have appeared. If after two weeks nothing has shown up, give your reasons below why you think your experiment failed.

Dish	Date Started	Procedure Followed	Drawings
1			
2			
3			
4			
5			

OBSERVATIONS:

Part (b) Bring dish #6 to school and your teacher will innoculate it with some commercially prepared bacteria. After you have a good growth started, one that covers the surface, cut some small paper circles and soak them in the following materials:

(1) iodine or some other antiseptic.
(2) soap suds.
(3) alcohol.
(4) toothpaste.
(5) your choice, but please list. __________
(6) your choice, but please list. __________

Place these circles in on top of the growth of bacteria, very carefully. Observe to see what effect they have on the cultures, and record your observations below.

Spots	Date Placed	Result	If failure, reason why
1			
2			
3			
4			
5			
6			

Experiment 8
USING THE MICROSCOPE

MATERIALS:
Microscope, slides, and objects prepared by the teacher.

PROCEDURE:

1. The purpose of this experiment is to give you an opportunity to get familiar with the microscope, and to learn its assets and limitations. If you have any questions concerning this experiment, ask your teacher for help.

2. Examine the objects with the naked eye. Draw the left object below, as it appears to you.

3. Place the slide on the stage of the microscope and focus the left 'e' under the low power.
   (a) Draw the image as it appears to you. If it is necessary, move the slide so that you can get a drawing of the entire image.

   (b) List the ways in which the object and the image differ. There should be at least three differences for each.

4. Still under low power, move the object in the following ways and describe how the image moves.

MOVE THE OBJECT	YOUR PREDICTION ABOUT HOW THE IMAGE WILL MOVE	IMAGE ACTUALLY MOVES
Toward you		
Away from you		
To the left		
To the right		
Counterclockwise		

Attempt to explain anything which does not seem to fit together from the observations you have made of the image when it w s made to move differently.

PROCEDURE:

5. Focus the tail of the 'e' under high power and sketch the image. (Remember to move any object you wish to focus under high power into the middle of the low power field first, or you may never find what you are looking for under the high power.)

6. Return to low power. Focus alternately back and forth on the two letters. There is one observation that you can make that will enable you to draw an important conclusion about the difference between the two letters.

OBSERVATIONS:

1. Judging from what you have recorded in items #2, #3, and #5, the image which your unaided eye sees and the image it sees with the help of the microscope lens-system are very different.

   What does the 'e' actually look like?

2. Is one image under the microscope more true than the other?

3. In Procedure #6, what is the one observation that you can make concerning the two letters? What is your conclusion about the difference between the two letters?

BIOLOGICAL SCIENCE

Experiment 9
DISSECTION OF THE EARTHWORM

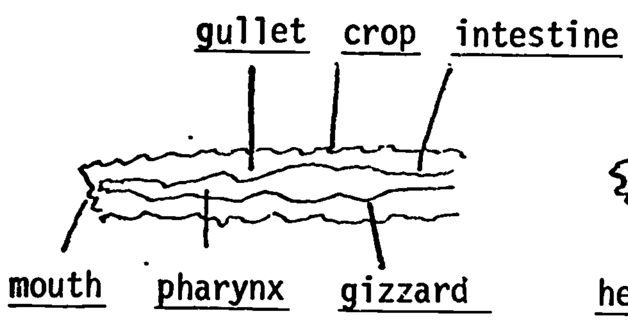
MATERIALS:
Dissection pan, dissecting kit, prepared earthworm specimen, pins.

PREPARATORY INFORMATION:
The tissues of an earthworm are arranged to make organs. The organs work together in systems. The body of an earthworm has a head end and a tail end. The head end has clusters of nerve cells that might be considered the beginning of a brain. Although the worm does not have developed eyes, certain cells in its outer skin are sensitive to light. The worm can distinguish between materials that are food, and those that are not food even though it has no organs of taste, smell, or hearing.

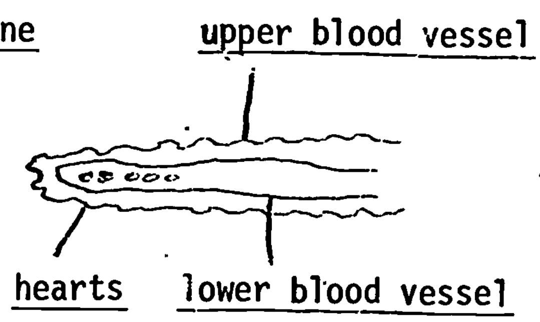
The digestive system of the earthworm is a tube with the mouth at one end, and the anus at the other. Food materials are pulled into the mouth by a muscular upper lip. From the mouth, the food passes into an enlargement of the tube that is called a pharynx. You have a pharynx between your mouth and your esophagus. The walls of the earthworm's pharynx are thick and muscular. They contract and push the food on into its esophagus. From the esophagus, the food goes into a sac-like enlargement called the crop. So far not much has happened to the food. Worms have no teeth, but the next place after the crop is the gizzard, where the food is ground up. The walls of the gizzard are very thick and muscular. After the bits of leaves and other materials from the soil have been gound up in the gizzard, they pass on and into the straight intestine where most of the digestion takes place. Blood vessels in the walls of the intestine absorb digested food and waste materials pass out through the anus.

Worms are the first animals in the animal tree to have red blood. Their blood is carried throughout the body in two main blood vessels, one above the digestive tract, the other below it. If you look at an earthworm carefully, you can see the pulsation, or up and down movements, of these vessels through the skin. Five pairs of smaller blood vessels near the head end of the worm connect the two main vessels. These are often called hearts because they help in the circulation of the blood. Branching vessels from the main blood vessels go out to all parts of the body and end in capillaries in the organs and the body wall. The blood is returned to the main vessel to be again circulated.

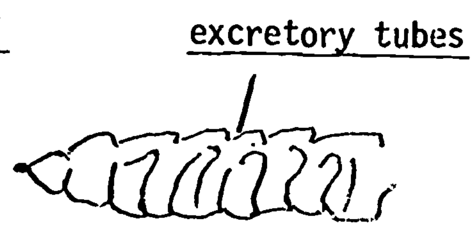
SYSTEMS OF THE EARTHWORM



DIGESTIVE SYSTEM



CIRCULATORY SYSTEM



EXCRETORY SYSTEM

PROCEDURE:

1. Put about a quarter of an inch of water in the bottom of the dissecting pan.

2. Pin out the earthworm, carefully, on its bottom side with a pin at each end. The bottom side is rounded and lacks small projections on it. The upper side has projections on it, and is flattened. The bottom side also has a dark line running down it lengthwise, which is the bottom blood vessel. Pin the earthworm so this entire line is visible, straight, and uppermost.

3. With the scissors cut into the body wall in the dark line, just behind the enlarged part. Be careful not to allow the points of the scissors to cut beyond the body wall. Continue to cut forward to the fourth ring.

4. The body wall surrounds a cavity filled with a fluid. Running the entire length of the earthworm and separated from the body wall by the cavity is a second tube, the digestive tract. You will discover that it is attached to the cavity by a series of thin membranes. Separate the body wall from the digestive tract and other organs of the body cavity along the entire length of the cut you have made. Do this with either the scissors or the scalpel.

5. Pin the body wall out on each side so as to expose the organs.

6. DIGESTIVE SYSTEM: In rings four and five, find and identify the relatively thick muscular PHARYNX. This is followed in rings six to fourteen by the ESOPHAGUS, which, however, is largely obscured by the large yellowish white lobes of the SEMINAL VESICLES. The latter may be moved aside to observe, but should not be torn. Beyond the esophagus is a large thin-walled part called the CROP, which lies in segments fifteen and sixteen. The crop is immediately followed in rings seventeen and eighteen by a thick-walled, but similarily shaped part, the GIZZARD. Behind the gizzard the digestive tract takes the form of a long straight tube of almost uniform diameter, extending to the anus. This is called the INTESTINE.

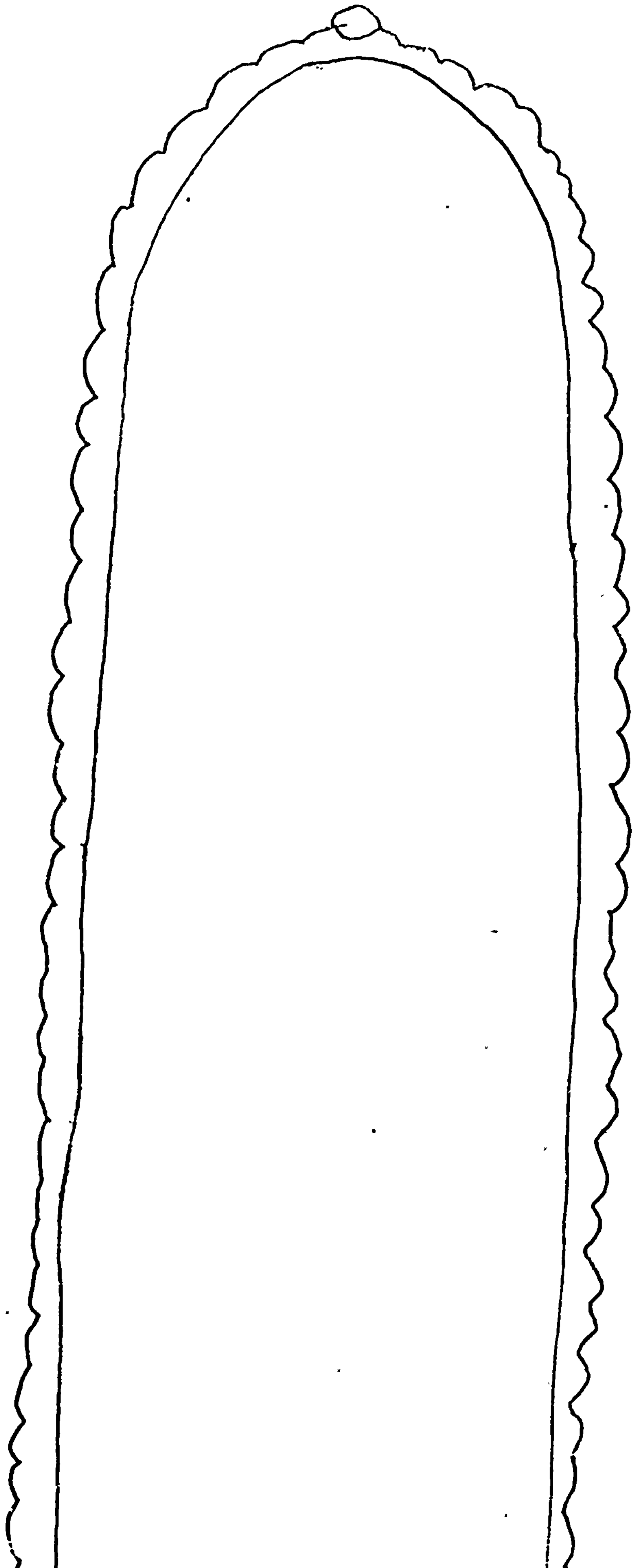
7. EXCRETORY SYSTEM: The excretory system of the earthworm consists of a series of coiled tubes called NEPHRIDIA, occuring in pairs, one on each side in each ring, except the first three rings and the last. Find and identify the coiled tubes.

8. CIRCULATORY SYSTEM: Identify the BOTTOM BLOOD VESSEL running along the bottom side of the intestine. Follow this blood vessel forward as it passes over the gizzard and crop. Push aside the lobes of the seminal vesicles to see this vessel as it passes over the esophagus. Note that, as it goes over the esophagus, it gives off five pairs of large vessels, one pair to a ring, which run around the esophagus to its top side. These have been called "hearts" because they aid in pumping the blood, but are better called AORTIC LOOPS. The blood flows forward in the bottom blood vessel. Cut across the esophagus where it joins the pharynx and raise its forward end to see where the aortic loops join the SUBINTESTINAL VESSEL, the upper blood vessel.

9. Continue your cut into rings three and two, and with needles, carefully tease the boy wall away from the pharynx, to which it is attached. Watch for a pair of minute white bodies, which are the "BRAIN" of the earthworm.

OBSERVATIONS:

In the outline below draw the internal structures of the earthworm which are underlined on these pages. Include the MOUTH on your drawing. Do not put anything in the drawing which you could not find. Be sure to label the drawing.



BIOLOGICAL SCIENCE

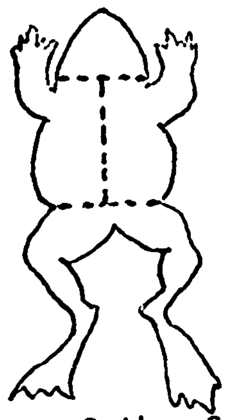
Experiment 10
DISSECTION OF THE FROG

MATERIALS:
Frogs, dissecting pan, dissecting kit, medicine dropper, dry cells, wire.

PROCEDURE:
1. Pithing is a process whereby you can kill the frog painlessly. This is done by running a dissecting needle into the frog's brain. Take a living frog and bend its head forward quite sharply. You will notice a slight ridge at the base of the head. Insert the needle just behind this ridge and run it forward into the brain. Move the handle of the needle in a circular motion to destroy the brain tissue. Be sure the frog is dead before proceeding further.

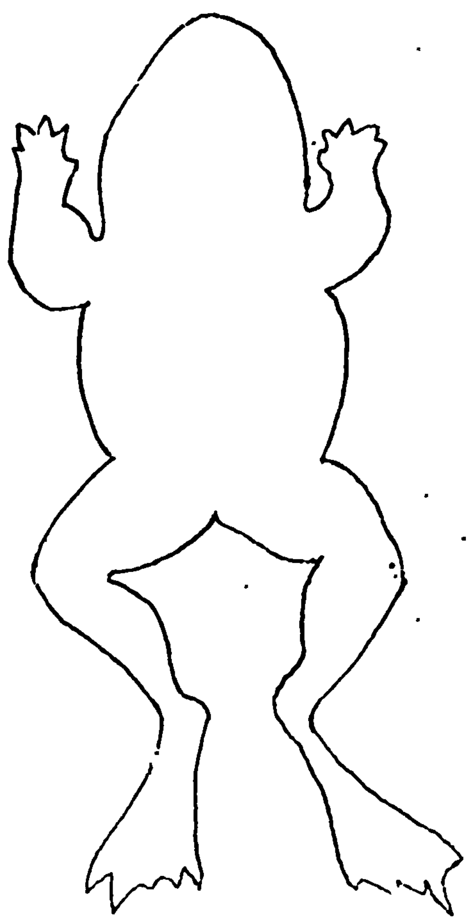
2. Lay the frog on its back in the dissecting pan, and pour a few milliliters of water in the pan. Using either the scissors or the scalpel, cut its jaws apart at the hinge in order to open the mouth wide. Look for the tongue in the floor of the mouth.

3. Using the scissors, and following the diagram below, carefully cut around and remove the skin of the frog on its stomach. This will expose a large muscular wall. Then with the scalpel and scissors very carefully remove this muscular wall, being extremely careful not to injure the organs lying just beneath. When the frog is opened up, examine the interior of its body. Female frogs will have a large mass of black and white eggs in them.



CUT ON THE DOTTED LINES

4. In the outline of the frog below, draw and label all the parts you can recognize from the dissection you have just made. You may use any reference available to you.



PROCEDURE:

5. Obtain a medicine dropper from the teacher and remove the rubber bulb on its end. Place the pointed end of the glass tube into the frogs throat and blow gently. The lungs should fill up like balloons.

6. Place the large part of the dissecting needle in the frog's mouth and push it as far as you can. The needle will go into the gullet (esophagus), then the stomach, and on toward the intestine.

7. If the frog's heart is still beating, remove it with either the scissors or the scalpel, and lay it in an evaporating dish which contains a warm water and salt solution. To help stimulate the heart to beat faster, you may touch it with the sharp end of a dissecting needle. Keep adding the salt solution to make the heart beat for a longer period of time.

8. Sever one of the rear legs of the frog and attach it to a burrett clamp on a ring stand. Get a dry cell and hook up wires to the terminals. Attach one of the wires to the ringstand, and the other wire to the leg where it was cut off from the body. If you can locate the right spot on the leg, (a nerve), it will jerk the leg back and forth in a series of muscular spasms.

9. Remove the entire food tube and stretch it out in your dissecting pan.

OBSERVATIONS:

1. Draw a picture of the food tube which you removed in procedure #9. Give an approximation of its overall length.

2. Where is the tongue of the frog attached?

3. Why is the tongue sticky in a living frog?

4. Why is the tongue of the frog forked?

5. Which jaw of the frog has teeth in it?

6. Is the frog's body cavity divided by a muscular wall, or a diaphragm?

7. Draw a colored picture below, of the lungs of the frog.

OBSERVATIONS:

8. Draw a picture of the frog's heart below.

9. Does the frog have red blood, and if not, what color is it?

10. How many parts, or lobes, is the frog's liver divided into?

11. Is the frog you dissected a male or a female? How can you be sure?

12. Examine a living frog to answer the following questions: Where are frogs found?

13. Is the frog warm or cold to the touch?

14. How does the frog's skin feel to touch it?

15. How does the frog move?

16. How many eyelids can you find on the frog?

17. Where is the frog's ear located?

18. What type of feet does a frog have, and what are they used for?

BIOLOGICAL SCIENCE

Experiment 11
DISCOVERING THE NATURE OF SEEDS

MATERIALS:
Lima bean seeds, water, paring knife.

PROCEDURE:
1. The night before you begin this experiment, soak half a dozen lima bean seeds in water so that the seed covering will be soft.

2. With the paring knife, break open the coatings of the seeds and open them.

3. Carefully examine both the interior and the exterior of the seed.

OBSERVATIONS:
1. What type of coating does a dry lima bean seed have?

2. What function does the seed coat serve?

3. Describe the contents of the seed's interior.

4. What function do you think the different parts of the seed's interior have?

5. Name five seeds that we eat for food.

6. Draw a picture below, of the interior of the seed, and label the parts.

BIOLOGICAL SCIENCE

Experiment 12
STUDYING STEMS AND LEAVES

MATERIALS:
Two stalks of celery with yellow leaves, four glass jars, paring knife, water, food coloring of three different colors (any colors except yellow and green.)

PROCEDURE:
1. Fill a glass jar with water colored with food coloring.

2. Cut diagonally across one stalk of celery near the bottom, and place the stalk in the jar containing colored water. Set the jar in bright sunshine.

3. Now make two cuts in a second stalk of celery, from the bottom of the stalk to within an inch or two of the top. The stalk will then be divided into three sections along most of its length, but the part that bears the leaves will be intact.

4. Fill each of three glass jars with water of a different color. Place each section of the stalk in a different jar, and set the jars in the sunshine.

5. The next day, closely examine both stalks of celery.

6. Remove the stalks from the glass jars and cut across the stalk.

OBSERVATIONS:
1. What part of a plant is the celery stalk?

2. When you observed the celery stalks after leaving them overnight, what did you find?

3. What did you observe when you cut the celery stalks?

4. What function do the celery "strings" serve?

BIOLOGICAL SCIENCE

Experiment 13
GROWING PLANTS WITHOUT SOIL

MATERIALS:

Two large flower pots, two deep pans, two square wire mesh screens, four seedlings of fast growing plants, two one-gallon jugs, commercial liquid fertilizer, distilled water, gravel.

PROCEDURE:

1. Place a wire mesh screen at the bottom of each pot, and fill the pots with gravel.
2. Carefully plant two seedlings in each pot, without damaging the roots.
3. Prepare two watering solutions in the following manner: Into one jug, pour the liquid fertilizer, diluted according to the instructions on the label. Into the second jug, pour distilled water.
4. Place each flower pot in a deep pan, and water one pot with distilled water and the other with the liquid fertilizer. Let the liquid rise nearly to the rim of the dish.
5. Let the pots stand for about 15 minutes, then take them out, letting whatever liquid they still hold run into the pan below.
6. Place the pots in a well-lighted part of the room. The watering solution in the pans can then be poured back into the jugs for use later.
7. Repeat the watering of the plants about three times a day. If the plants start to wilt, increase the watering to five times a day.
8. In about a week or ten days, the plants should show some changes. Keep a close watch on them daily.

OBSERVATIONS:

1. Is there any difference in the color of the two sets of plants? If so, what?
2. Is the one set taller than the other?
3. Does one set have more leaves than the other?
4. Is one set beginning to wilt?
5. Does either set have any areas of discoloration? Where?

Experiment 13 - Page 2
GROWING PLANTS WITHOUT SOIL

OBSERVATIONS:

6. Why have the above changes you mentioned occured?

7. Record your weekly observations in the table below:

Week	Plant Watered With Distilled Water			Plant Watered With Fertilizer Solution	
Height	Number of Leaves	Color	Height	Number of Leaves	Color
1					
2					
3					
4					
5.					

BIOLOGICAL SCIENCE

Experiment 14
STUDYING LIGHT AND PLANT GROWTH

MATERIALS:

Bean seeds, corn seeds, potatoes with "eyes", flower pots, potting soil, dark closet, rulers.

PROCEDURE:

1. Plant duplicate pots of corn seeds, bean seeds, and potato "eyes". These should be planted about ½ inch deep in the soil and watered so the soil is moist.

2. Lable the pots as follows: bean-light, bean-dark; corn-light, corn-dark; potato-light, potato-dark. The bean-light will be placed where it can receive light, and the bean-dark will be placed in the dark, and so forth. The plants that receive light will serve as a control and enable the experimenter to observe what a normal plant looks like.

3. Place the light-plants on a classroom window sill that receives light, and keep them there for the duration of the experiment.

4. Place the dark-plants in a closet. If no closet is available, place them under a cardboard carton, but be sure that no light can enter.

5. Water both sets of plants as needed to keep the soil moist. The temperature of both sets of plants should be about equal.

6. In about two weeks the plants will have grown enough for good observation. Place the light and dark-plants of each kind next to each other.

OBSERVATIONS:

1. When the light and dark-plants are placed next to each other, what do you observe?

2. Do plants grow in the dark? Explain.

3. What can you conclude from the appearance of a plant grown in the dark?

4. What makes plants green?

5. If the dark-plants are not green, what can you surmise?

BIOLOGICAL SCIENCE

Experiment 15
BREEDING AND RAISING FRUIT FLIES

MATERIALS:
Pint glass-jar with lid, plastic funnel large enough to set on top of the jar, ripe bananas or grapes, magnifying glass, paper towels.

PROCEDURE:
1. Place a half of a very ripe banana in the bottom of the glass jar.

2. Place a funnel in the top of the jar. Put the jar in a light warm place, but not in the direct sunlight.

3. After some flies have appeared in the jar, remove the funnel, place a paper towel in the jar, and screw on the cap.

4. Punch some small holes in the lid of the cap, so the insects can get oxygen.

5. Count the number of flies in the jar and record that number and the date.

6. At intervals during the day, examine the jar to see if any eggs have been laid. They are small, white, football-shaped, and have two long projections at one end.

7. Continue to watch the jar each day and note new developments.

OBSERVATIONS:
1. Complete the following table as you make you observations:

STAGES IN THE LIFE CYCLE OF FRUIT FLY

Form	Date	Description: Color	Size	Other
Egg				
Larva				
Pupa				
Fly				

2. How many life forms does the insect go through?

BREEDING AND RAISING FRUIT FLIES

OBSERVATIONS:

3. How long does it stay in each form?

4. How long does it take a fruit fly to develop from an egg at room temperature?

5. What did the larvae eat?

6. What did the pupae eat?

7. Make color drawings below of each of the life stages of the fruit fly:

(a) egg

(b) larva

(c) pupa

(d) fly

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