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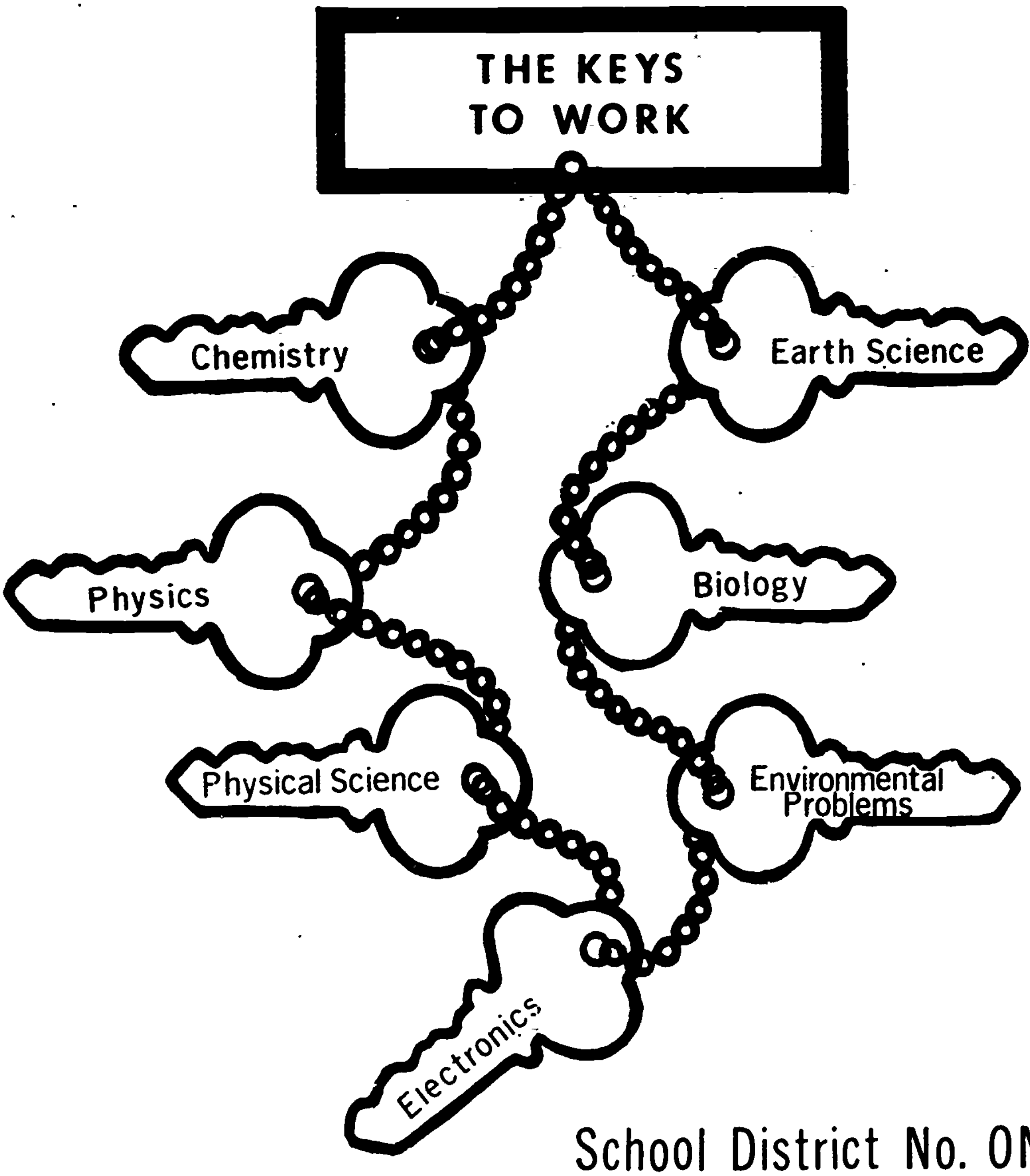
ABSTRACT

The curriculum guide attempts to assemble select activities that represent skills related to careers in science. These learning activities are designed to give junior and senior high school students opportunities to explore concepts and processes in many science-related careers. The broad areas covered are biology, chemistry, physics, and earth science. Each area is divided into sub-topics with individual lessons that span junior and senior high school science activities. Biology includes ecology, genetics, microbiology, zoology, botany, and human biology. Chemistry examines both the structure and behavior of matter, chemical families, nuclear energy, organic chemistry, and measurement. Physics contains lessons in motion, energy, and mechanics. Lessons in earth science are concerned with earth, ancient earth history, atmosphere-weather, water and supply, determination of places and times, and astronomy. Each unit or sub-topic lists all possible careers relevant to that area, and each lesson is organized into grade level, activity, procedure, results, discussion of results, and, in some lessons, an application section. A bibliography concludes the guide. (JB)

CAREER ACTIVITIES IN SCIENCE

Grades 7-12



School District No. ONE
Powell, Wyoming

CAREER ACTIVITIES IN SCIENCE

GRADES 7 - 12

POWELL PUBLIC SCHOOLS
SCHOOL DISTRICT NO. 1
POWELL, WYOMING 82435

J. NEAL LARGE, SUPERINTENOENT OF SCHOOLS

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MERLIN S. OLSON, DIRECTOR, CAREER EDUCATION
SUMMER OF 1974

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WYOMING STATE DEPARTMENT OF EDUCATION
DIRECTOR, PAUL SIZEMORE

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CAREER STATEMENT

THE BASIC KNOWLEDGE OF THE WORLD IN WHICH WE LIVE IS UNDERGOING AN EXCITING CHANGE AS A DIRECT RESULT OF THE BREAKTHROUGHS IN ALL SCIENTIFIC FIELDS. BECAUSE OF THIS INCREASED IMPORTANCE OF SCIENCE AND TECHNOLOGY IN OUR TIMES, AN UNDERSTANDING OF THE FUNDAMENTAL PRINCIPLES UNDERLYING MODERN SCIENCE IS ESSENTIAL FOR ALL STUDENTS.

JUNIOR HIGH SCHOOL IS OFTEN THE STARTING POINT FOR STUDENTS WHO ELECT SCIENTIFIC CAREERS IN LATER LIFE. HOWEVER, THE CONTENT AND PROCESSES OF SCIENCE CAN BE USED TO CHALLENGE AND FURTHER A STUDENT'S UNDERSTANDING OF SCIENCE, REGARDLESS OF HIS FUTURE VOCATIONAL OR PROFESSIONAL PLANS. BECAUSE OF THE IMPACT OF SCIENCE ON THE PERSONAL, SOCIAL, AND ECONOMIC LIVES OF ALL PEOPLE IN OUR COUNTRY, A SCIENTIFICALLY LITERATE CITIZENSHIP IS ESSENTIAL.

IT IS IMPORTANT THAT OUR SCHOOLS MAKE SCIENCE AS MEANINGFUL AS POSSIBLE TO ALL STUDENTS. ONE OF THE MOST MEANINGFUL WAYS TO TEACH SCIENCE IS TO RELATE IT TO THE OCCUPATIONS THAT NEED TO HAVE A BASIC UNDERSTANDING OF SCIENCE. THE UNITS OR ACTIVITIES IN THIS BOOKLET ARE PRACTICAL EXAMPLES OF THE MANY DUTIES AND RESPONSIBILITIES INVOLVED IN A PARTICULAR CAREER OR CAREERS DEALING WITH SCIENCE.

MERLIN S. OLSON, DIRECTOR
CAREER EDUCATION

INTRODUCTION

HAVE YOU EVER BEEN ASKED BY A STUDENT, "WHY DO I NEED TO KNOW THIS?" IF YOU HAVE, THEN YOU WILL FIND THIS BOOKLET HELPFUL.

OUR PURPOSE WAS TO SHOW THAT THE ACTIVITIES WE TEACH REALLY DO RELATE TO CAREERS, AND THAT THESE ACTIVITIES GIVE OUR STUDENTS OPPORTUNITIES TO EXPLORE CONCEPTS AND PROCESSES IN MANY SCIENCE-RELATED CAREERS.

THIS PUBLICATION IS AN ATTEMPT TO PUT TOGETHER A FEW SELECT ACTIVITIES THAT REPRESENT SKILLS RELATED TO CAREERS. THESE ACTIVITIES WERE DRAWN FROM A CROSS-SECTION OF MATERIALS USED IN GRADES 7-12. OUR MAIN INTENT WAS NOT TO WRITE NEW ACTIVITIES BUT TO RELATE EXISTING ACTIVITIES TO CAREERS.

UNIT---CAREERS---ACTIVITIES

INITIALLY THE OBJECTIVE WAS TO IDENTIFY THE UNITS COVERED IN ALL AREAS OF SCIENCE 7-12; SECONDLY A NUMBER OF CAREERS WERE PLACED IN EACH UNIT; AND FINALLY ALL PRESENT ACTIVITIES WERE SCREENED TO PROVIDE EXPLORATION IN THOSE RELATED TO CAREERS.

THE USES AND EXAMPLES OF THE EVERYDAY APPLICATION OF THE PRINCIPLES OF SCIENCES HELP TEACHERS AND THEIR STUDENTS BETTER APPRECIATE THE PRACTICAL VALUE OF EDUCATION.

THIS BOOKLET REPRESENTS ONLY THE FIRST STEP IN A SERIES OF STEPS MEANT TO ENCOURAGE SCIENCE TEACHERS TO BECOME MORE REALISTIC IN THEIR APPROACH TO CAREER-RELATED ACTIVITIES WHICH SHOULD END FOREVER THE TRADITIONAL LAMENT OF THE YOUNG PERSON, "WHAT GOOD IS IT?"

THE TOTAL SCIENCE PROGRAMS IN GRADES 7-12 FOR SCHOOL DISTRICT #1, ARE COVERED IN THE BROAD CATEGORIES WHICH INCLUDES BIOLOGY, EARTH SCIENCE, CHEMISTRY AND PHYSICS. FOR CLARITY AS TO THE UNITS TAUGHT WE SUBDIVIDED EACH SUBJECT INTO VARIOUS TOPICS. MANY OF THESE ARE EXPLORED AT VARIOUS DEPTHS FROM JUNIOR HIGH THROUGH HIGH SCHOOL. THEY ARE LISTED BELOW.

BIOLOGY

A. ECOLOGY
B. GENETICS
C. MICROBIOLOGY
D. ZOOLOGY
   1. INVERTEBRATE
   2. VERTEBRATE
E. BOTANY
F. HUMAN BIOLOGY
   1. ANATOMY
   2. PHYSIOLOGY

CHEMISTRY

A. STRUCTURE OF MATTER
B. BEHAVIOR OF MATTER
C. CHEMICAL FAMILIES
D. NUCLEAR ENERGY
E. ORGANIC CHEMISTRY
F. MEASUREMENT

PHYSICS

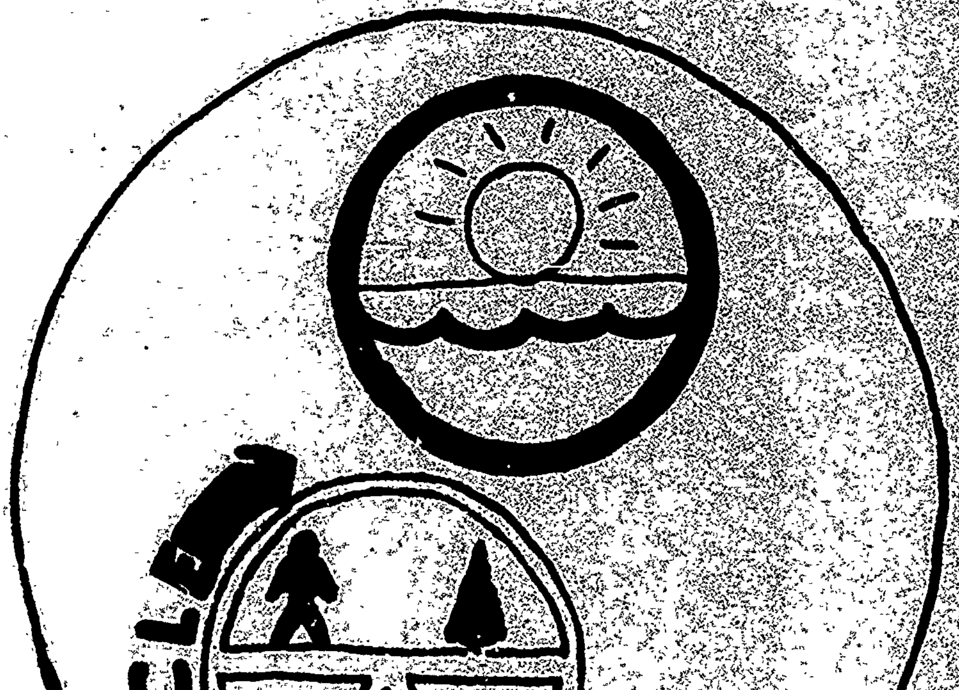
A. MOTION
B. ENERGY
   1. OPTICS
   2. ELECTRICITY
   3. HEAT
   4. CHEMICAL
   5. NUCLEAR
   6. SOUND
C. MECHANICS

EARTH SCIENCE

A. EARTH AND WHAT IT'S MADE OF
B. CHANGES IN THE EARTH'S SURFACE
C. ANCIENT EARTH HISTORY
D. ATMOSPHERE-WEATHER
E. WATER AND SUPPLY
F. LOCATING PLACES AND KEEPING TIME
G. ASTRONOMY

IN ORDER TO EMPHASIZE ALL THE MANY CAREERS, WE HAVE LISTED EVERY POSSIBLE LEVEL OF OCCUPATION INTO EACH OF THE SUBDIVISIONS FROM THE ABOVE TABLE. WE FEEL THAT TOO OFTEN STUDENTS ASK, "WHY DO I NEED THIS?" AND FOR THAT REASON WE WANTED TO BE AS COMPLETE AS POSSIBLE.

ECOLOGY



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BIOLOGY - ECOLOGY

BIOLOGIST	CHEMIST
ENGINEERING TECHNICIAN	GEOGRAPHY
LANDSCAPE ARCHITECT	LIFE SCIENTIST
OCCUPATIONAL THERAPIST	PSYCHOLOGIST
RECREATION LEADER	SOCIAL WORKER
SOCIOLOGIST	ELEMENTARY TEACHER
TEACHER SECONDARY-COLLEGE	TECHNICAL WRITER
URBAN PLANNER	VETERINARIAN
TRAVEL AGENTS	REAL ESTATE SALESMEN
AGRIBUSINESS TECHNICIAN	AGRICULTURE EXTENSION WORKER
DAIRY PRODUCTION TECHNICIAN	FARM CROP PRODUCTION TECHNICIAN
FARMER	FISH & WILDLIFE TECHNICIAN
FISH CULTURE TECHNICIAN	FORESTER
FORESTRY AID & FOREST PRODUCT TECHNICIAN	LIVESTOCK PRODUCTION TECHNICIAN
ORCHARD TECHNICIAN	HORTICULTURIST
PARKS LAND MANAGEMENT TECHNICIAN	RANGE MANAGEMENT
SOIL CONSERVATIONIST	SOIL SCIENTIST
CARPENTER	CEMENT MASON
STATIONARY ENGINEER	

ECOLOGY
LEVEL: JUNIOR HIGH

ACTIVITY: ESTIMATING POPULATIONS

MATERIALS: (PER TEAM)
PAPER CUP FILLED WITH WHITE BEANS
RED BEANS 10

PROCEDURES:

A. (HAND OUT TO EACH TEAM A CUP OF WHITE BEANS.) TRY TO PLAN TWO OR THREE METHODS FOR ESTIMATING THE NUMBER OF BEANS WITHOUT COUNTING ALL OF THEM. WRITE OUT BRIEF DESCRIPTIONS OF THE METHODS AND NUMBER THEM IN YOUR NOTEBOOK. USE EACH ONE TO MAKE AN ESTIMATE, AND RECORD THE RESULTS IN A CHART SIMILAR TO THIS:

	PROCEDURE A (YOUR METHODS)			PROCEDURE B (POPULATION-CENSUS METHOD)	PROCEDURE C (ACTUAL COUNT)
	1	2	3		
NUMBER OF BEANS					

B. A POPULATION-CENSUS METHOD IS USED BY ECOLOGISTS WHO MUST ESTIMATE SIZES OF CERTAIN POPULATIONS. IN USING THIS METHOD, THE BIOLOGIST ADDS SOME MARKED INDIVIDUALS TO A POPULATION. HE ASSUMES THAT THE MARKED ANIMALS WILL MIX WITH THE ANIMALS ALREADY THERE. APPLYING THIS METHOD HERE, YOU WOULD ADD 10 RED BEANS TO THE CUP OF WHITE BEANS. THEN YOU WOULD MAKE SURE THAT THE BEANS ARE WELL MIXED. A SAMPLE OF BEANS SHOULD CONTAIN ABOUT THE SAME RATIO OF RED BEANS/WHITE BEANS THAT THE WHOLE CUP OF BEANS HAS. SUPPOSE A SAMPLE OF 20 BEANS, CONTAINING 2 RED BEANS AND 18 WHITE ONES, IS TAKEN. HERE THERE IS A RATIO OF 2/18. YOU ALREADY KNOW THAT THERE ARE 10 RED BEANS IN THE CUP. FROM THIS INFORMATION YOU CAN SET UP AN EQUATION:

$$\frac{2 \text{ RED}}{18 \text{ WHITE}} = \frac{10 \text{ RED}}{X \text{ WHITE}}$$

X STANDS FOR THE TOTAL NUMBER OF WHITE BEANS. BY SOLVING THE EQUATION (FINDING THE VALUE OF X), YOU WILL LEARN THAT THE CUP CONTAINS ABOUT 90 WHITE BEANS--WITHOUT HAVING TO COUNT THEM.

$$2X = 180 \text{ (10 TIMES 18)}$$
$$X = \frac{180}{2} = 90 \text{ WHITE BEANS}$$

TRY THIS METHOD, AND ENTER THE RESULTS IN YOUR CHART.

C. COUNT THE WHITE BEANS ONE BY ONE. COMPARE THE COUNT WITH YOUR VARIOUS ESTIMATES.

INTERPRETATION: WHICH METHOD OF ESTIMATING DID YOU FIND MOST ACCURATE?

ECOLOGY
LEVEL: JUNIOR HIGH

ACTIVITY: POND SUCCESSION ACTIVITIES

PROCEDURES:

A. TAKE STUDENTS ON A FIELD TRIP TO OBSERVE CHANGES IN A LOCAL POND. IF POSSIBLE FIND A POND WHICH IS BEING FED BY A FAST STREAM SO A COMPARISON CAN BE MADE ABOUT TWO DIFFERENT ENVIRONMENTS. A FEW OF THE ACTIVITIES ON SUCCESSION WHICH COULD BE DONE INCLUDE:

(A) SAMPLE A STRIP ACROSS A POND TO NEARBY HIGH LAND, IDENTIFY THE PLANT ZONES AND PREPARE A PROFILE OF THE STRIP.

(B) HAVE STUDENTS DISCUSS AND REPORT BACK WHAT GRANDPARENTS OR PARENTS REMEMBER ABOUT CHANGES WHICH HAVE OCCURRED IN THE AREA.

(C) TAKE SOIL SAMPLES FROM DIFFERENT PLACES IN THE POND AND MAKE AN ANALYSIS OF WHAT SEDIMENTS ARE FOUND? WHAT IS THE SIZE OF THE SEDIMENT? WHAT DOES THIS INDICATE ABOUT THE RATE OF SUCCESSION IN THIS AREA?

(D) POSSIBLE QUESTIONS FOR DISCUSSION COULD INCLUDE:

1. HOW DOES A POND CHANGE TO DRY LAND?

2. HOW LONG DOES IT TAKE? WHAT DETERMINES THE LENGTH OF TIME REQUIRED?

3. IN WHAT WAYS CAN YOU PREDICT THE LENGTH OF TIME REQUIRED?

4. WHAT ARE THE STAGES OF SUCCESSION IN A POND? WHAT INDICATIONS DO YOU SEE OF THESE STAGES?

5. HOW IS ANIMAL LIFE OF A POND AFFECTED BY THE CHANGE?

6. HOW DO THE ACTIVITIES OF MAN AFFECT THE RATE OF FILLING OF A POND?

7. HOW DOES A CHANGING ENVIRONMENT AFFECT THE ORGANISMS OF THAT AREA?

(E) IF POSSIBLE TAKE ANOTHER FIELD TRIP TO AN OLDER POND WHICH SUPPORTS MORE PLANT GROWTH. MAKE COMPARISONS OF THE TWO PONDS.

ECOLOGY
LEVEL: JUNIOR HIGH

ACTIVITY: FIELD STUDIES OF A GRASSLAND AREA

MATERIALS: THERMOMETER
LAB SHEETS
METERSTICK
MOUSE TRAPS
PEANUT BUTTER
GRASS & WEED IDENTIFICATION GUIDES (COUNTY AGENT HAS SEVERAL TYPES FOR WYOMING)

TO THE TEACHER: THIS ACTIVITY IS DONE OUT IN THE FIELD SO THAT SOME FIELD TECHNIQUES IN BIOLOGY CAN BE INTRODUCED. IT IS BEST TO FIND A FIELD WHICH HAS NOT BEEN PASTURED OR USED BUT ANY GRASS FIELD CAN BE USED. IF NOT IN A REGULAR GRASSLAND AREA BE SURE STUDENTS ARE AWARE YOU ARE WORKING NOT WITH A NATURAL BIOME IN THAT AREA. FOR THE TRAPPING EXERCISE I USE REGULAR MOUSE TRAPS BUT LIVE TRAPS WOULD BETTER SO AS NOT TO UPSET THE NATURAL BALANCE. THIS ACTIVITY SHOULD INCLUDE 2 OR 3 DAYS AT LEAST IN THE FIELD. FIRST TO IDENTIFY THE PHYSICAL AND BIOTIC ENVIRONMENT; SECOND TO STUDY FIELD TRAPPING AND ON THIRD DAY, DO SPECIFIC STUDY OF A SPECIFIC AREA OF THE GRASS-LAND.

PROCEDURES:

A. HAVE STUDENTS SPREAD OUT FROM A POINT AND INVESTIGATE AND ANSWER THE FOLLOWING INFORMATION ON THE PHYSICAL ENVIRONMENT.

LOCATION OF STUDY:______________________________

DATE:____________________ TEMPERATURE:____________________

WIND DIRECTION:______________ AMOUNT__________________EST.

TIME OF DAY:__________________ CLOUD CONDITIONS______________

SOIL CONDITIONS:______________________________

WHAT IS THE NATURE OF THE SOIL? (DARK OR LIGHT) (SANDY, CLAY OR LOAM)

INDICATORS AS TO HOW MUCH WATER IS AVAILABLE:____________________

IS THE AREA WELL DRAINED?______________HOW CAN YOU TELL?________

THE TEACHER SHOULD DEMONSTRATE HOW TO TEST SOIL TYPE BY TAKING HANDFUL AND SQUEEZING IT TO SEE IF IT STICKS TIGHT (CLAY), LOOSE (SAND) OR IN BETWEEN.

B. INVESTIGATE THE GENERAL BIOTIC COMMUNITY IN THE AREA. ANSWER THE FOLLOWING FROM YOUR OBSERVATIONS:

IS THERE A GREAT VARIATION IN PLANT TYPES BETWEEN WET AND DRY AREAS?

ARE THERE ANY WOOD PLANTS PRESENT?______________________________

ARE THERE ANY SIGNS OF MAMMALS?__________ IF SO, WHAT?____________

WHAT INVERTEBRATES DO YOU FIND?______________________________

NAME TWO DOMINANT PLANTS OF GRASSLAND?______________________

NAME TWO DOMINANT ANIMALS OF GRASSLAND. ONE VERTEBRATE AND ONE INVERTEBRATE. ____________________AND____________________

PROCEDURES:

C. BEFORE LEAVING THE AREA HAVE 5 MOUSE TRAPS AVAILABLE FOR EACH TEAM. HAVE THEM BAIT THE TRAPS WITH A SMALL AMOUNT OF PEANUT BUTTER. DETERMINE A STARTING LANDMARK THEN DISPERSE TEAMS IN A FAN SHAPE FROM THAT POINT. GET STUDENTS TO SELECT A LANDMARK SO THEY CAN WALK TOWARD IT IN A STRAIGHT LINE. HAVE THEM PLACE TRAPS 20 PACES APART IN A STRAIGHT LINE. TEACHER WILL PROBABLY HAVE TO DEMONSTRATE HOW TRAPS ARE SET. ON THE SECOND DAY FIRST HAVE STUDENTS PICK UP TRAPS AND ANSWER THE FOLLOWING:

(A) HOW MANY MICE DID YOU CATCH?____________________

(B) HOW MANY TRAPS WERE SPRUNG BUT HAD NO MICE?__________ INVESTIGATE THE AREA FOR TRACKS OF OTHER ANIMALS. DO YOU BELIEVE YOUR TRAP WAS SPRUNG BY A MOUSE?________ IF NOT, WHAT SPRUNG IT AND WHY DO YOU BELIEVE THIS?____________

COLLECTIVELY GATHER ALL INFORMATION AND DETERMINE AN ESTIMATED MOUSE POPULATION FOR THE AREA.

(C) TO WHAT PEOPLE WOULD THIS KIND OF INFORMATION BE IMPORTANT TO?______________________________

STUDY SKINS CAN BE MADE FROM MICE CAUGHT AFTER YOU RETURN FOR THOSE STUDENTS WHO WANT TO.

PROCEDURES:

D. ESTABLISH A SQUARE IN THE GRASS 50 CENTIMETERS SQUARE. USING YOUR GUIDE KEYS, IDENTIFY THE DIFFERENT KINDS OF PLANTS YOU FIND IN YOUR SQUARE AND LIST THE NAMES ON YOUR DATA SHEET. (SEE BELOW) ANY YOU CAN'T IDENTIFY NUMBER IT AN UNKNOWN AND COLLECT A SAMPLE TO KEY OUT WHEN YOU GET BACK TO CLASS. NOW COUNT ALL THE PLANTS OF EACH DIFFERENT KIND YOU FIND ON YOUR PLOT AND PUT IT ON YOUR DATA SHEET. THE REST OF THE DATA SHEET CAN BE FINISHED IN CLASS OR HOME. YOUR TEACHER WILL EXPLAIN HOW TO FIND % OF AREA.

1

DATA SHEET

STUDENT:______________________ DATE:______________________

LOCALITY:______________________ VEGETATIONAL TYPE:______________________

SOIL TYPE:______________________

SPECIES	NO.	% AREA	GROWTH TYPE*	IMPORTANCE**	HEIGHT

* GROWTH TYPE: A=ANNUAL HERB; P=PERENNIAL HERB; S=SHRUB; T=TREE.

** IMPORTANCE: D=DOMINANT; C=COMMON; U=UNCOMMON; R=RARE.

ECOLOGY
Level: High School

ACTIVITY: Interrelationships of Producers and Consumers

Introduction:
In nature there are so many varying conditions in the surroundings that it is often diff cult to determine which variables affect what we observe and which do not. One way to decrease the number of these varying conditions is to place organisms in containers and then seal them off from the atmosphere.

Pupose:
The purpose of the exercise is to obtain data that will enlarge our understanding of the relationships between producers and consumers--especially their place in the carbon cycle.

Background Information:
An indicator is a substance that shows the presence of a chemical substance by changing color. Bromthymol blue is an indicator that changes to a green color in the presence of an acid. Carbon dioxide (CO_2) is a gas that forms an acid when dissolved in water. Therefore, in this experiment bromthymol blue can used to indicate, indirectly, the presence of CO_2.

Materials:
Screw-cap culture tubes, 20 x 150 mm or longer, 4
Elodea (Anarcharis), 2 pieces
Container of melted paraffin
Glass-marking crayon, 1
Test-tube rack, 1
Small water snails, 2
Bromthymol blue solution
Pond water

Procedure:
Number the screw-cap culture tubes from 1 to 4.
Fill each tube with pond or aquarium water until the water surface is approximately 20 mm from the top. Add 3 to 5 drops of bromthymol blue solution to each tube. To Tube 1 add a small snail; to Tube 2 add a small snail and a leafy stem of elodea; to Tube 3 add elodea only; do not add anything to Tube 4.
Place a cap on each tube and screw it down tightly. Dip the cap end of each tube in melted paraffin. After allowing the paraffin to cool and harden, test the seal by turning the tubes upside down for about five minutes. There should be no leakage.
If all tubes are watertight, place them in strong, indirect light--NOT direct sunlight. Make observations each morning and afternoon. Record any changes in the color of the indicator (bromthymol blue) and in the condition of the plants and snails.

Discussion:
In which tube did the organisms die first? (1) Since these organisms usually survive well in an aquarium or pond, we might suspect that being cut off from air might have had something to do with their death. What substance in air may have been needed? (2) Another possibility is that death may have resulted from the accumulation of a poisonous

DISCUSSION (CONT.)
MATERIAL IN THE WATER. WHAT DOES THE INDICATOR SHOW? (3) NOW RECALL WHAT YOU HAVE READ ABOUT PHOTOSYNTHESIS AND THE CARBON CYCLE. USING THIS INFORMATION AND YOUR ANSWERS TO THE PREVIOUS QUESTIONS, EXPLAIN THE DATA YOU RECORDED WHILE OBSERVING THE OTHER TUBES THAT CONTAIN ORGANISMS. (4) DID THE INDICATOR CHANGE COLOR IN TUBE 4? IF SO, HOW MIGHT YOU EXPLAIN THIS (KEEPING IN MIND THE SOURCE OF THE WATER)? (5) CONSIDERING THIS EXERCISE AS AN EXPERIMENT, WHAT WOULD YOU CALL TUBE 4? (6) WHAT RESULTS MIGHT YOU HAVE EXPECTED IF ALL TUBES HAD BEEN KEPT IN TOTAL DARKNESS? (7)

ECOLOGY
LEVEL: HIGH SCHOOL

ACTIVITY: DEVELOPMENT OF ORGANISMS IN A COMMUNITY

PROBLEM:
THE POPULATION OF PLANTS OR ANIMALS IN A COMMUNITY WILL CHANGE AS THE ENVIRONMENTAL CONDITIONS CHANGE. WHAT KINDS OF ORGANISMS WILL APPEAR AS A COMMUNITY OF LIVING ORGANISMS BEGINS TO DEVELOP?

MATERIALS:
ONE-GALLON WIDE-MOUTH GLASS JAR OR BATTERY JAR, GLASS COVER PLATE, EYE DROPPER, MICROSCOPE OR MICROPROJECTOR, MICROSCOPE SLIDES AND COVER GLASSES.

PROCEDURE:
WASH THE GLASS JAR IN WARM SOAPY WATER AND RINSE THOROUGHLY. FILL THE JAR ABOUT HALF FULL OF GRASS AND LEAVES COLLECTED FROM A DRIED-UP DITCH OR POND, AND FILL THE JAR WITH COOL POND WATER THAT HAS BEEN FILTERED AND BOILED. COVER THE JAR WITH THE GLASS PLATE SO THAT AIR CAN GET IN, AND LEAVE THE JAR IN A LIGHTED PLACE BUT NOT IN DIRECT SUNLIGHT OR NEAR A RADIATOR.

OBSERVE THE MATERIAL IN THE JAR DAILY FOR THE APPEARANCE OF A CLOUDY SCUM, EITHER ON TOP OF THE WATER OR ON THE LEAVES OR GRASS. EACH DAY, PLACE DROPS OF THE WATER, TAKEN FROM THE TOP, SIDES, AND BOTTOM OF THE JAR, ON A CLEAN GLASS SLIDE AND EXAMINE UNDER THE LOW AND HIGH POWERS OF THE MICROSCOPE OR MICROPROJECTOR. BE SURE TO ADJUST THE LIGHT CAREFULLY, AS SOME TINY ORGANISMS MAY NOT BE SEEN OTHERWISE.

OBSERVATIONS:
RECORD THE TYPE OF ORGANISMS OBSERVED IN THE FOLLOWING TABLE.

NUMBER OF DAYS	TYPES OF MICROSCOPIC PLANTS	TYPES OF MICROSCOPIC ANIMALS
2		
4		
6		
8		
10		

INTERPRETATION:
FILL IN THE BLANK WORDS IN THE FOLLOWING PARAGRAPH IN THE NUMBERED SPACES AT THE RIGHT.

THE STUDY OF THE RELATIONSHIP OF LIVING ORGANISMS TO THEIR ENVIRONMENT IS KNOWN AS (1). THE ENVIRONMENT AFFECTING LIVING ORGANISMS DEPENDS ON SUCH FACTORS AS (2), (3), AND (4). THE NATURAL ENVIRONMENT IN WHICH A PARTICULAR FORM OF LIFE IS FOUND IS CALLED ITS (5), AND THE TOTAL NUMBER OF EACH KIND OF ORGANISM PRESENT MAKES UP A (6). ALL THE PLANTS AND ANIMALS LIVING TOGETHER IN ONE KIND OF HABITAT MAKE UP A (7). SINCE ANIMAL LIFE MUST HAVE FOOD ON WHICH TO LIVE, THE FIRST ORGANISMS

1 ____________
2 ____________
3 ____________
4 ____________
5 ____________
6 ____________
7 ____________

THAT DEVELOPED IN THE COMMUNITY IN THIS EXPERIMENT WERE ONE-CELLED (8). THE NEXT GROUP OF ORGANISMS TO APPEAR WERE PROBABLY ONE-CELLED (9). WHEN THE COMMUNITY CONTINUED WITH LITTLE CHANGE OF ITS LIVING ORGANISMS FOR A LONG PERIOD OF TIME, IT IS CALLED A (10) COMMUNITY.

8 ____________

9 ____________

10 ____________

APPLICATION:

THE PLANTS AND ANIMALS IN ANY COMMUNITY OF LIVING ORGANISMS ARE DEPENDENT ON EACH OTHER. MAKE A DIAGRAM TO SHOW THE FOOD CHAIN AMONG THE DIFFERENT ORGANISMS OBSERVED IN YOUR EXPERIMENTAL COMMUNITY.

WHY IS IT IMPORTANT FOR SOMEONE WORKING IN AGRICULTURE TO KNOW WHAT A FOOD CHAIN IS?

THERE ARE MANY OTHER OCCUPATIONS WHERE FOOD CHAINS WOULD BE USEFUL. NAME SEVERAL.

ECOLOGY
LEVEL: HIGH SCHOOL

ACTIVITY: POLLUTANTS IN THE AIR

PROBLEM:
THE AIR AROUND US CONTAINS MANY POLLUTANTS, SUCH AS BACTERIA, DUST PARTICLES, AND CHEMICAL SUBSTANCES. HOW CAN YOU DETERMINE THE AMOUNT OF DUST PARTICLES IN THE AIR?

MATERIALS:
STICKY FLYPAPER
SMALL BOXES
MAGNIFIER

DIRECTIONS:
CUT 2" X 2" SQUARES OF FLYPAPER AND PUT EACH SQUARE IN A SMALL BOX WITH THE STICKY SIDE UP. COVER ONE BOX AND LEAVE THE OTHER BOX OPEN. PLACE BOTH BOXES ON AN OUTSIDE WINDOW LEDGE WHERE THEY WILL NOT BE BLOWN AWAY. PUT A FRESH PIECE OF FLYPAPER IN THE BOXES EVERY DAY. EXAMINE THE FLYPAPER SQUARES WITH A MAGNIFIER DAILY. (YOU MAY WISH TO USE LOW POWER ON THE MICROSCOPE TOO)

OBSERVATIONS:
FILL IN THE FOLLOWING TABLE TO DETERMINE HOW THE NUMBER OF DUST PARTICLES IN THE AIR CHANGES DAY BY DAY.

DAY	NUMBER OF DUST PARTICLES ON EXPOSED PAPER	NUMBER OF DUST PARTICLES ON COVERED PAPER	AVERAGE NUMBER OF DUST PARTICLES IN AIR
FIRST			
SECOND			
THIRD			
FOURTH			
FIFTH			

INTERPRETATION:

FILL IN THE BLANK WORDS IN THE FOLLOWING PARAGRAPH IN THE NUMBERED SPACES AT THE RIGHT.

THE AIR WE BREATHE CONTAINS MANY HARMFUL SUBSTANCES KNOWN AS (1). THESE ARE USUALLY THE RESULT OF MAN'S CONVERSION OF (2) INTO (3). IN MANY LARGE CITIES, AIR POLLUTION IS RESPONSIBLE FOR THE FORMATION OF (4) WHICH IRRITATES THE EYES AND BREATHING PASSAGES. THIS CONDITION MAY BE PRODUCED WHEN CERTAIN (5) ARE RELEASED BY THE EXHAUST FROM AUTOMOBILES AND ARE ACTED UPON BY (6) BY MEANS OF A (7) REACTION. THE ATMOSPHERIC CONDITION MOST

1__________
2__________
3__________
4__________
5__________
6__________
7__________

LIKELY TO PRODUCE THIS TYPE OF AIR POLLUTION IS A LAYER OF (8) AIR WHICH KEEPS THE AIR NEAR THE GROUND FROM (9). THE EFFECTS OF AIR POLLUTION ARE MOST SEVERE ON PEOPLE SUFFERING FROM (10) DISEASES.

8____________

9____________

10____________

APPLICATION:

MANY HOMES AND BUILDINGS TODAY ARE AIR-CONDITIONED. EXPLAIN WHY AIR CONDITIONING MAKES THESE PLACES MORE COMFORTABLE TO BE IN AND THE AIR MORE SUITABLE FOR BREATHING.

WHAT CAREERS MIGHT NEED TO KNOW HOW TO CLEAN UP POLLUTED AIR?

WHAT EFFECT WILL A THERMAL INVERSION HAVE, IF IT OCCURS IN A HEAVY INDUSTRIAL AREA, ON PERSONS ALREADY HAVING RESPIRATORY DIFFICULTIES?

ECOLOGY
LEVEL: HIGH SCHOOL

ACTIVITY: PERCENTAGE OF OXYGEN IN AIR

PURPOSE: TO FIND THE PERCENTAGE OF OXYGEN IN A SAMPLE OF AIR.

MATERIAL: PHOSPHORUS METHOD:

BATTERY JAR
BURET CLAMP
50 ML METRIC RULER
THERMOMETER
PHOSPHORUS, WHITE
CLAMP
EUDIOMETER
RING STAND
COPPER WIRE, BARE, NO. 16, 60-CM LONG

PYROGALLIC ACID METHOD:

BALANCE, PLATFORM
EUDIOMETER, 50 ML
RUBBER STOPPER, SOLID NO. 0
SOLUTION OF SODIUM HYDROXIDE (1.0 M).
BATTERY JAR
GRADUATED CYLINDER
PYROGALLIC ACID

INTRODUCTION:

IF A VOLUME OF AIR IS MEASURED ACCURATELY AND THEN THE OXYGEN REMOVED BY CHEMICAL MEANS, THE PERCENTAGE OF OXYGEN IN THE ORIGINAL SAMPLE MAY BE COMPUTED EASILY. WHITE PHOSPHORUS UNITES READILY WITH OXYGEN AND FORMS A WHITE SMOKE OF DIPHOSPHORUS PENTOXIDE. THE WHITE SMOKE GRADUALLY SETTLES AND DISSOLVES IN THE WATER. THE VOLUME OF GAS REMAINING, SUBTRACTED FROM THE ORIGINAL VOLUME OF AIR, GIVES THE VOLUME OF OXYGEN REMOVED.

AN ALTERNATE METHOD THAT GIVES QUICKER RESULTS IS TO ADD A MIXTURE OF PYROGALLIC ACID AND SODIUM HYDROXIDE SOLUTION TO A MEASURED VOLUME OF AIR CONTAINED IN A STOPPERED EUDIOMETER. THIS MIXTURE RAPIDLY UNITES WITH THE OXYGEN IN THE AIR. THE STOPPERED TUBE IS INVERTED A FEW TIMES TO MIX THE CHEMICALS THOROUGHLY WITH THE ENCLOSED AIR. THE STOPPERED END IS THEN THRUST UNDER WATER IN A BATTERY JAR. AS SOON AS THE STOPPER IS REMOVED, WATER IS FORCED IN TO TAKE THE PLACE OF THE REMOVED OXYGEN. THE VOLUME OF GAS REMAINING IN THE TUBE, SUBTRACTED FROM THE VOLUME OF AIR USED, GIVES THE VOLUME OF OXYGEN.

PROCEDURE: PHOSPHORUS METHOD

ADD SUFFICIENT WATER TO A 50-ML EUDIOMETER SO THAT 40 TO 50 ML OF AIR WILL BE ENCLOSED WHEN THE TUBE IN INVERTED IN A BATTERY JAR OF WATER. IT IS A GOOD PLAN TO FILL SEVERAL LARGE VESSELS WITH WATER THE DAY BEFORE THE EXPERIMENT, SO THAT THE WATER WILL BE AT ROOM TEMPERATURE. DETERMINE ACCURATELY THE VOLUME OF AIR ENCLOSED IN THE EUDIOMETER. MEASURE THE DIFFERENCE IN WATER LEVELS, IF ANY, IN MILLIMETERS. RECORD THE TEMPERATURE OF THE WATER AND ALSO THE BAROMETER READING IN THE ROOM. COMPUTE THE VOLUME OF DRY AIR ENCLOSED AT S.T.P.

CUT A STICK OF PHOSPHORUS UNDER WATER SO AS TO GET A PIECE WITH FRESHLY CUT SURFACES THE SIZE OF A SMALL BEAN. CAUTION: DO NOT HANDLE PHOSPHORUS WITH THE FINGERS. THRUST ONE END OF A FLEXIBLE, BARE, COPPER WIRE, ABOUT 60 CM LONG, INTO THE PIECE OF PHOSPHORUS WHILE IT IS STILL UNDER WATER. NOW PUSH THE WIRE, WITH THE PHOSPHORUS ON THE END, UP INTO THE EUDIOMETER TO WITHIN SEVERAL CENTIMETERS OF THE TOP. OBSERVE THE REACTION WHICH BEGINS AT ONCE. ALLOW AT LEAST 24 HOURS FOR 21 REACTION TO BE COMPLETED.

INITIAL DATA

VOLUME OF AIR ENCLOSED IN EUDIOMETER..............	ML
DIFFERENCE IN WATER LEVELS.........................	MM
EQUIVALENT DIFFERENCE IN LEVELS IN MM OF MERCUR	MM
TEMPERATURE.......................................	°C
BAROMETER READING.................................	MM
WATER VAPOR PRESSURE..............................	MM
VOLUME OF DRY AIR ENCLOSED AT S.T.P...............	ML

FINAL DATA

VOLUME OF GAS REMAINING...........................	ML
DIFFERENCE IN WATER LEVELS........................	MM
EQUIVALENT DIFFERENCE IN LEVELS OF MM OF MERCURY	MM
TEMPERATURE.......................................	°C
BAROMETER READING.................................	MM
WATER VAPOR PRESSURE..............................	MM
VOLUME OF GAS REMAINING AT S.T.P..................	ML
VOLUME OF DRY O_2 REMOVED.........................	ML
PERCENTAGE OF O_2 IN SAMPLE OF AIR TAKEN...........	%
ACCEPTED PERCENTAGE OF O_2 IN AIR..................	%
PERCENTAGE ERROR..................................	%

WHEN THE WHITE SMOKE HAS DISAPPEARED, REMOVE THE COPPER WIRE, MEASURE THE DIFFERENCE IN LEVELS, AND READ THE VOLUME OF THE GAS REMAINING. RECORD THE TEMPERATURE OF THE WATER AND THE BAROMETER READING. COMPUTE THE VOLUME OF DRY GAS REMAINING AT S.T.P.

PROCEDURE: PYROGALLIC ACID METHOD

EXACTLY 50 ML OF AIR WILL BE TAKEN AS THE SAMPLE IN THIS METHOD. THAT VOLUME OF SODIUM HYDROXIDE SOLUTION WILL BE USED WHICH IS JUST EQUAL TO THE VOLUME BETWEEN THE 50-ML MARK ON THE EUDIOMETER TUBE AND THE BOTTOM OF THE RUBBER STOPPER WHICH IS USED TO CLOSE IT. THIS VOLUME IS EASILY DETERMINED AS FOLLOWS: (1) FILL THE TUBE WITH WATER TO THE 50-ML MARK. (2) INSERT THE RUBBER STOPPER. (3) INVERT THE TUBE AND READ FROM THE GRADUATIONS THE VOLUME OF AIR WHICH WAS BETWEEN THE 50-ML MARK AND THE STOPPER BEFORE THE TUBE WAS INVERTED. THIS IS THE VOLUME OF SODIUM HYDROXIDE SOLUTION TO USE WITH THE TUBE. (4) EMPTY THE WATER OUT OF THE TUBE.

ADD 0.5 G OF PYROGALLIC ACID POWDER TO THE TUBE. ACCURATELY MEASURE IN A GRADUATED CYLINDER THE REQUIRED VOLUME OF SODIUM HYDROXIDE SOLUTION AND POUR IT INTO THE TUBE. QUICKLY CLOSE THE TUBE WITH THE RUBBER STOPPER. INVERT THE TUBE A FEW TIMES TO MIX THE CONTENTS. PLACE THE STOPPERED END OF THE TUBE UNDER WATER IN A BATTERY JAR AND THEN REMOVE THE STOPPER. NOTE HOW THE WATER IS FORCED IN TO REPLACE THE OXYGEN. ALLOW THE TUBE TO COOL FOR A FEW MINUTES. NOW RAISE OR LOWER THE TUBE SO THAT THE LEVEL OF WATER IN THE TUBE IS THE SAME AS THAT IN THE BATTERY JAR. READ THE VOLUME OF GAS REMAINING IN THE TUBE. IT IS NOT NECESSARY TO CORRECT THE GAS TO S.T.P. IN THIS METHOD BECAUSE THE OPERATIONS ARE ALL DONE WITHIN A FEW MINUTES. THE VOLUME OF GAS REMAINING, SUBTRACTED FROM THE ORIGINAL VOLUME OF AIR, 50 ML, GIVES THE VOLUME OF OXYGEN. THE VOLUME OF OXYGEN DIVIDED BY THE VOLUME OF THE SAMPLE TAKEN AND MULTIPLIED BY 100 % WILL GIVE THE PERCENTAGE OF OXYGEN IN AIR. REPEAT THE EXPERIMENT SEVERAL TIMES UNTIL CONSISTENT RESULTS ARE OBTAINED.

DATA TABLE

	1	2	3
Volume of gas remaining............	ML	ML	ML
Volume of oxygen removed..........	ML	ML	ML
Percentage of oxygen.............	%	%	%
Accepted percentage of oxygen in air	%	%	%
Percentage error.................	%	%	%

ECOLOGY
LEVEL: HIGH SCHOOL

ACTIVITY: NOISE ACTIVITY

MATERIALS:

- OSCILLOSCOPE
- DECIBELMETER (AVAILABLE FROM CITY OFFICES)
- STETHOSCOPE
- SPHYGMOMANOMETER
- AUDIOMETER
- SMALL 3-4 INCH SPEAKER
- 3-4 SOUND TAPES (VARIOUS SOUNDS SUCH AS AIRPLANES, HIWAY TRAFFIC, JACK HAMMERS, CITY NOISES)
- 3-4 TAPE RECORDERS

PROCEDURES:

A. SET UP OSCILLOSCOPE WITH THE SMALL SPEAKER CONNECTED TO SHOW VERTICAL INTERFERENCE.

B. TALK INTO THE SPEAKER WHILE OUTLINING DIRECTION OF ACTIVITY.

C. USE DECIBELMETER TO SHOW THE VARIOUS READINGS.

D. CHECK HEART BEAT AND BLOOD PRESSURE OF SOME STUDENTS NOW TO SHOW THE NORMAL. RECORD.

E. TURN ON AT FULL VOLUME THE SOUND RECORDINGS AND HAVE STUDENTS TRY TO READ SOME PREPARED INFORMATION RELATING TO SOUND. WHILE THIS IS BEING DONE CHECK THE BLOOD PRESSURE AND HEART BEAT LEVELS AGAIN.

QUESTIONS:

1. HOW DOES NOISE DIFFER FROM SOUND AS SEEN ON THE OSCILLOSCOPE?
2. WHAT DIFFERENCES DID YOU DISCOVER ON BLOOD PRESSURE AND HEART BEAT BEFORE AND DURING THE DEMONSTRATION?
3. WHAT EFFECTS MIGHT THIS HAVE IF YOU WERE SUBJECTED TO LONG PERIODS OF INTENSE NOISE ON YOUR MENTAL WELL BEING?
4. WHAT CAREERS WOULD YOU EXPECT WOULD ENCOUNTER LOUD DISTURBING NOISES?
5. THERE ARE SEVERAL CAREERS DEVOTED TO WORKING WITH DAMPENING NOISES OR PRODUCING PLEASING SOUNDS. CAN YOU THINK OF SOME?
6. HOW DO CONTINOUS NOISES EFFECT YOUR WORK EFFICIENCY?
7. WHAT LONG TERM EFFECTS WILL CONTINUOUS LOUD SOUNDS HAVE ON YOUR HEARING?

ADDITIONAL ACTIVITIES

1. VISIT VARIOUS INDUSTRIAL SITES AND RECORD NOISE LEVELS WITH A DECIBELMETER.
2. TAKE A TOUR OF YOUR SCHOOL AND IDENTIFY AREAS OF NOISE DISTURBANCES.
3. INVITE YOUR LOCAL POLICE CHIEF TO SPEAK ON NOISE ORDINANCES AS PROPOSED BY YOUR COMMUNITY.

ECOLOGY
LEVEL: HIGH SCHOOL

ACTIVITY: CONSTRUCTION OF AN ELECTROSTATIC PRECIPITATOR

INTRODUCTION:

SMOKE, THE RESULT OF INCOMPLETE COMBUSTION AND THE MOST OBVIOUS OF THE ATMOSPHERIC POLLUTANTS, IS A COLLOIDAL DISPERSION OF A SOLID IN A GAS. WHAT IS THE COLLOIDAL STATE? IMAGINE THE REPEATED SUBDIVISION OF A SOLID IMMERSED IN A LIQUID TO FORM THE SMALLEST POSSIBLE VISIBLE PARTICLES. DEPENDING ON THE RELATIVE DENSITY OF THE SOLID AND THE LIQUID, THE SUBDIVIDED PARTICLES EITHER FLOAT TO THE SURFACE OF THE LIQUID OR SINK TO THE BOTTOM. IN EITHER CASE, THEY CAN EASILY BE SEPARATED OUT OF THE LIQUID BY FILTRATION.

IMAGINE FURTHER SUBDIVISION OF THESE PARTICLES INTO INDIVIDUAL ATOMS AND MOLECULES. AT THIS POINT, THE TWO PHASES SOLID AND LIQUID ARE NO LONGER DISTINGUISHABLE; INSTEAD, THERE EXISTS A TRUE SOLUTION. NO MATTER HOW LONG A TRUE SOLUTION STANDS, THE DISPERSED PARTICLES DO NOT THEMSELVES SEPARATE OUT, NOR CAN THEY BE SEPARATED OUT BY FILTRATION.

BETWEEN THE EXTREMES OF A COARSE SUSPENSION AND A TRUE SOLUTION IS A RANGE OF PARTICLE SIZES SO SMALL THAT THEY DO NOT FORM AN OBVIOUSLY SEPARATE PHASE, YET NOT SO SMALL THAT THEY ARE IN TRUE SOLUTION. THIS IS THE COLLOIDAL STATE.

THE DIVIDING LINES BETWEEN COLLOIDS AND SOLUTIONS AND BETWEEN COLLOIDS AND CLEARLY SEPARATE PHASES ARE NOT SHARP, SINCE A CONTINUOUS RANGE OF PARTICLE SIZES IS POSSIBLE. A DISPERSION IS CALLED A COLLOID, HOWEVER, WHEN THE PARTICLE SIZES RANGE BETWEEN 10^{-7} CM AND 10^{-4} CM.

COLLOIDAL PARTICLES, INVISIBLE UNDER A MICROSCOPE, USUALLY DO NOT SEPARATE OUT AT ANY APPRECIABLE RATE. THE REASON IS THAT TWO OPPOSING FORCES ARE ALWAYS PRESENT IN A COLLOIDAL DISPERSION: <u>GRAVITY</u>, WHICH TENDS TO PULL THE PARTICLES DOWN; AND <u>BROWNIAN MOTION</u>, THE CONSTANT RANDOM COLLISIONS OF THE PARTICLES WITH MOLECULES OF THE MEDIUM IN WHICH THE PARTICLES ARE DISPERSED. THUS SMOKE PARTICLES IN AIR MAY TEND TO SETTLE OUT UNDER THE INFULENCE OF GRAVITY; BUT BECAUSE OF THE NUMEROUS "DETOURS" THAT THEY MAKE AS A RESULT OF BROWNIAN MOTION, THEIR RATE OF SETTLING MAY BE SO SLOW AS TO BE UNNOTICEABLE.

MOST COLLOIDAL PARTICLES ARE ELECTRICALLY CHARGED. THERE IS DISAGREEMENT CONCERNING THE SOURCE OF THE CHARGE. ONE FACTOR PROBABLY INVOLVED IS SURFACE AREA. REPEATED SUBDIVISION OF A SOLID CAN INCREASE ITS ORIGINAL SURFACE AREA MANY FACTORS OF 10.

WHY?

CALCULATE THE SURFACE AREA OF A CUBE 1 CM ON EACH SIDE. NEXT CALCULATE THE AMOUNT OF SURFACE AREA FORMED WHEN THE SAME CUBE IS SUBDIVIDED INTO CUBES THAT ARE 10^{-5} CM ON EACH SIDE.

HOW DO THE TOTAL SURFACE AREAS COMPARE?

THE LARGER THE SURFACE AREA FOR A GIVEN VOLUME, THE MORE ATOMS ON THE SURFACE, RELATIVE TO THE NUMBER OF ATOMS IN THE INTERIOR. INTERIOR ATOMS CAN FORM BONDS WITH OTHER ATOMS IN THREE DIMENSIONS. SURFACE ATOMS, HOWEVER, CANNOT. AS A RESULT, THE VALENCE, OR COMBINING POWER, OF SURFACE ATOMS USUALLY IS NOT SATISFIED, AND THEY CAN ATTRACT ELECTRICAL CHARGES.

These charges may result from friction, as is probably the case with water droplets in the atmosphere, or from the adsorption of ions. But whatever the source, all the particles of a given colloid have a charge of the same sign.

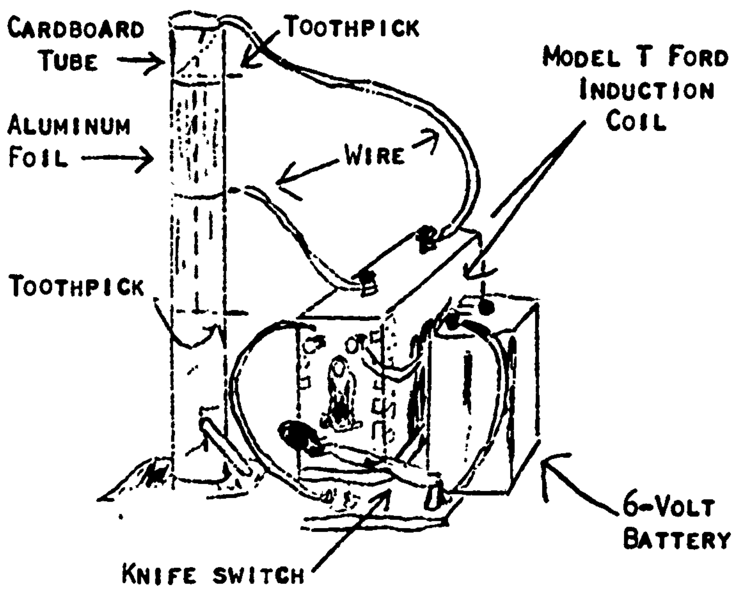
What happens when particles having the same charge are near one another?

How would this phenomenon affect a colloid?

Smoke, as a colloidal suspension of solids in a gas, exhibits the properties found in most colloids--including charge. A simple, but ingenious device that takes advantage of this fact is the electrostatic precipitator, which is widely used in industry to free gases of dust, smoke, and liquid droplets. While it is not always economical to install them, precipitators can in some instances recover valuable materials that otherwise would be lost through stacks.

Here is how the electrostatic precipitator works: air and gases containing dust or smoke particles are channeled between wire electrodes and plates carrying opposite charges. In passing, the colloidal particles receive a charge from the electrodes. They are then attracted to the plates.

ELECTROSTATIC PRECIPITATOR



Materials Needed

- Cardboard tube, about $1\frac{1}{2}$ in. diameter, 1 ft. long (tube in kitchen toweling or wax paper, or mailing tube)
- Wire (such as bell wire) 6 ft. long
- 6-volt battery (or four 1.5-volt dry cells)
- Strip of aluminum foil, 4 in. X 6 in.
- Two toothpicks
- Model T Ford induction coil
- Knife switch

PROCEDURE:

ABOUT $1\frac{1}{2}$ IN. FROM ONE END OF THE CARDBOARD TUBE, CUT A HOLE 1 IN. IN DIAMETER. BEGINNING $1\frac{1}{2}$ IN. FROM THE OTHER END OF THE TUBE, WRAP THE STRIP OF ALUMINUM FOIL, ARRANGING THE 6-IN. DIMENSION LENGTHWISE WITH THE TUBE. TAPE THE FOIL IN PLACE AT THE POINT OF OVERLAP.

THRUST THE TOOTHPICKS THROUGH THE TUBE, PLACING ONE JUST BELOW AND THE OTHER JUST ABOVE THE STRIP OF FOIL. CUT TWO 2-FT. PIECES OF THE BELL WIRE. INSIDE THE TUBE, HOOK ONE PIECE ON THE TOOTHPICK NEAR THE LOWER END OF THE ALUMINUM FOIL, AND LOOP IT TWICE AROUND THE UPPER TOOTHPICK. THE WIRE SHOULD EXTEND UP THE MIDDLE OF THE TUBE, AWAY FROM THE SIDES. CONNECT THE FREE END OF THE WIRE TO ONE HIGH-VOLTAGE TERMINAL OF THE INDUCTION COIL.

STRIP ABOUT 4 IN. OF INSULATION FROM ONE END OF THE SECOND PIECE OF WIRE. WRAP THE BARE WIRE AROUND THE ALUMINUM FOIL AT MIDPOINT, TWISTING IT TO HOLD IT IN PLACE. CONNECT THE FREE END OF THIS WIRE TO THE OTHER HIGH-VOLTAGE TERMINAL OF THE INDUCTION COIL.

COLLECTION OF DATA:

STAND THE TUBE ON END, ALUMINUM FOIL UP. HOLD AN INCENSE STICK OR OTHER SMOKE SOURCE IN THE HOLE IN THE TUBE. OBSERVE THE SMOKE COMING FROM THE UPPER END OF THE TUBE.

CONNECT THE COIL TO THE KNIFE SWITCH AND THE BATTERY.

WHAT HAPPENS WHEN THE KNIFE SWITCH IS CLOSED? WHY? WHEN IT IS OPEN? WHY?

QUESTIONS:

1. BESIDES THOSE IN INDUSTRY, WHAT APPLICATIONS FOR THE ELECTROSTATIC PRECIPITATOR CAN YOU SUGGEST?

2. ASSUME THAT YOU WANT TO REMOVE PARTICLES LARGER THAN COLLOIDAL SIZE FROM GASES OR AIR. IN WHAT WAYS MIGHT YOU ACCOMPLISH SUCH REMOVAL?

BIOLOGY - GENETICS

BIOLOGIST	CHEMIST
LIFE SCIENTIST	OCCUPATIONAL THERAPIST
PHYSICIAN	PRACTICAL NURSE
REGISTERED NURSE	TEACHER SECONDARY-COLLEGE
TECHNICAL WRITER	VETERINARIAN
AGRIBUSINESS TECHNICIAN	AGRICULTURAL EXTENSION WORKER
DAIRY PRODUCTION TECHNICIAN	FARM CROP PRODUCTION TECHNICIAN
FARMER	FISH & WILDLIFE TECHNICIAN
FISH CULTURE TECHNICIAN	FORESTER
LAB ANIMAL CARE TECHNICIAN	LIVESTOCK PRODUCTION TECHNICIAN

GENETICS

LEVEL: JR. HIGH OR HIGH SCHOOL

ACTIVITY: DON'T CROWD ME, BABY (A POPULATION GENETICS ACTIVITY)

HAVE YOU EVER BEEN ASKED, "WOULD YOU RATHER BE PAID A MILLION DOLLARS A DAY, OR A PENNY THE FIRST DAY AND THEN DOUBLE THE AMOUNT EACH SUCCEEDING DAY?" SINCE THE LENGTH OF TIME IS IMPORTANT, LET'S IMAGINE THAT THIS WOULD HAPPEN FOR 33 DAYS.

1. WHICH WOULD YOU TAKE?

LET'S SEE WHICH WAY WOULD MAKE YOU RICHER.

2. IF YOU TAKE A MILLION DOLLARS A DAY, HOW MUCH WOULD YOU HAVE AT THE END OF 33 DAYS?

3. IF YOU TAKE A PENNY THE FIRST DAY AND DOUBLE THE AMOUNT EACH SUCCEEDING DAY FOR 33 DAYS, HOW MUCH WOULD YOU HAVE? USE TABLE 1 FOR YOUR CALCULATIONS AND ANSWER.

A PENNY IS VERY LITTLE COMPARED TO A MILLION DOLLARS. BUT IF YOU STARTED WITH A PENNY AND DOUBLED IT EACH DAY, YOU COULD HAVE OVER A MILLION DOLLARS IN A VERY SHORT TIME. THAT'S A LOT OF MONEY!

A PENNY CAN GROW SO FAST BECAUSE NUMBERS INCREASE RAPIDLY WHEN YOU DOUBLE THEM. JUST LOOK AT YOUR NUMBERS IN TABLE 1.

IN THE TIME IT HAS TAKEN YOU TO READ THIS SENTENCE (FIVE SECONDS), ABOUT 165 MORE PEOPLE HAVE BEEN ADDED TO THE WORLD'S POPULATION. BY THE TIME YOU FINISH WORKING ON THIS INVESTIGATION, ABOUT 10,500 MORE PEOPLE WILL HAVE BEEN ADDED.

IF YOUR DATA FROM TABLE 1 ARE PLOTTED ON A GRAPH, IT WILL LOOK LIKE GRAPH 1 ON THE FOLLOWING PAGE.

THE INCREASE IN THE WORLD'S POPULATION CAN BE COMPARED WITH THE INCREASE OF THE PENNY. COMPARE GRAPH 2 WITH GRAPH 1.

WHAT HAPPENS WHEN A POPULATION BECOMES TOO CROWDED?

THE WORLD POPULATION NOW STANDS AT MORE THAN 3.5 BILLION PERSONS, AN ALL-TIME RECORD. IF THE PRESENT UPWARD TREND CONTINUES, THIS NUMBER WILL ALMOST DOUBLE BY THE YEAR 2000.

SCIENTISTS HAVE PREDICTED THAT WIDESPREAD HUNGER WILL STRIKE US WITHIN THE NEXT 20 YEARS. SHOULD WE DO ANYTHING ABOUT IT?

SOME SAY WE SHOULD NOT CONTROL THE POPULATION GROWTH BECAUSE:

A. A SUFFICIENT NUMBER OF PEOPLE ARE NECESSARY TO SUPPORT A NATIONAL ECONOMY.

B. IT IS A MAN'S RIGHT TO HAVE AND TO SUPPORT CHILDREN.

C. POPULATION CONTROL IS A FORM OF GENOCIDE (THE DELIBERATE DESTRUCTION OF A GROUP OF PEOPLE).

D. THE FOOD SUPPLY CAN KEEP UP WITH THE GROWTH IN POPULATION.

OTHERS SAY WE SHOULD CONTROL THE GROWTH OF POPULATION BECAUSE:

A. THE GROWTH OF POPULATION WILL BECOME GREATER THAN THE AVAILABLE FOOD SUPPLY IN ABOUT 15 YEARS.

B. IT IS BETTER TO IMPROVE THE QUALITY OF PEOPLE THAN THE QUANTITY OF PEOPLE.

C. DEVELOPMENTS IN TECHNOLOGY WILL NOT KEEP UP WITH THE GROWTH IN POPULATION.

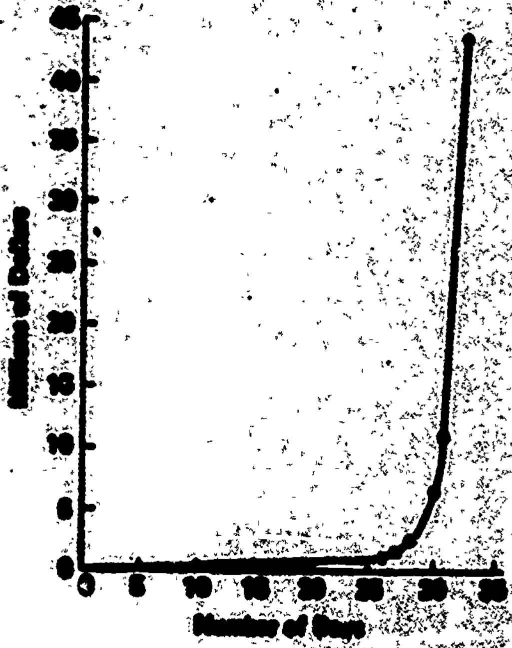
D. OVERCROWDING LEADS TO A BREAKDOWN OF MAN'S ENVIRONMENT.

WHAT DO YOU THINK?

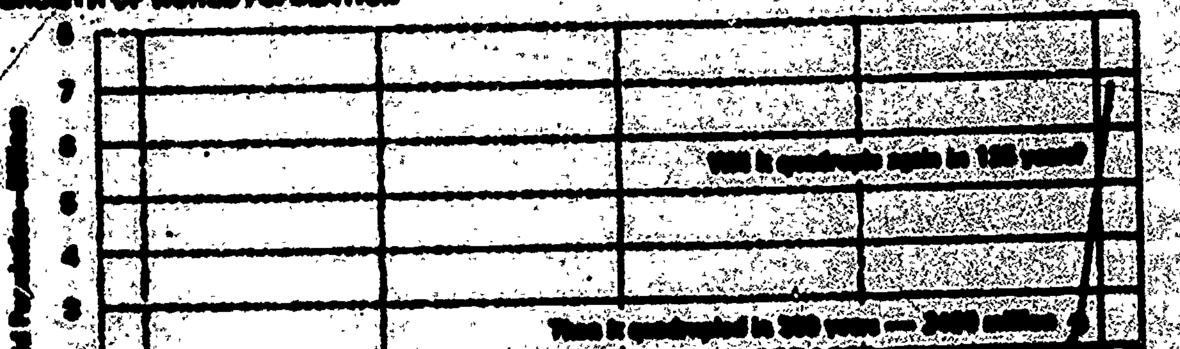
CONCEPT SUMMARY. (WHAT GENERAL CONCEPT HAVE YOU LEARNED FROM THIS INVESTIGATION?)

26

GRAPH NO. 1
THE INCREASE OF A PENNY THAT IS DOUBLED DAILY



GRAPH NO. 2
GROWTH OF WORLD POPULATION



GENETICS
LEVEL: HIGH SCHOOL

ACTIVITY: LOOKING FOR MUTATIONS IN FRUITFLIES

PROBLEM: THE BEST INTRODUCTION TO THE STUDY OF MUTATIONS IS THE BREEDING OF THE FRUITFLY, DROSOPHILA MELANOGASTER.

MATERIALS:
12 1/2-PINT MILK BOTTLES-USE 10 FOR CULTURE BOTTLES, 1 FOR AN ETHERIZER, AND 1 FOR A MORGUE.

CAMEL-HAIR PAINT BRUSH NO. 1-FOR HANDLING THE FLIES.

COTTON AND CHEESECLOTH-FOR MAKING PLUGS.

CORK STOPPER-ABOUT NO. 28, TO FIT ETHERIZER.

YEAST-1 PKG. DRY YEAST TO 25 CC WATER.

CULTURE MEDIUM-SEE RECIPE BELOW.

TWO STRAINS OF DROSOPHILA-ONE WILD-TYPE AND ONE "DUMPY WING."

PROCEDURE:

MAKING THE EQUIPMENT: CUT 5 X 5 INCH SQUARE FROM THE CHEESECLOTH AND FILL WITH ENOUGH COTTON TO MAKE A PLUG THAT FITS THE MILK BOTTLES. PLUG SHOULD FIT JUST TIGHT ENOUGH SO THAT IT WON'T FALL OUT. GLUE SOME COTTON TO THE BOTTOM OF THE LARGE CORK STOPPER AND FIT INTO MILK BOTTLE; THIS IS THE ETHERIZER. THE MORGUE IS SIMPLY A BOTTLE WITH SOME DENATURED OR METHYL ALCOHOL IN IT TO KILL THE UNWANTED FLIES.

HANDLING THE FLIES: TAP THE CULTURE BOTTLE SHARPLY ON THE TABLE, REMOVE PLUG, AND PLACE THE MOUTH OF THE ETHERIZER OVER CULTURE BOTTLE. TAP GENTLY UNTIL ALL THE FLIES ARE IN THE ETHERIZER. PUT TWO DROPS OF ETHER ON THE ETHERIZER COVER; REMOVE ETHERIZER BOTTLE FROM CULTURE BOTTLE, REPLACING COTTON PLUG IN CULTURE BOTTLE AND ETHERIZER COVER ON BOTTLE WITH THE FLIES. THIS TAKES A LITTLE PRACTICE.

ALWAYS REMOVE FLIES FROM ETHERIZER AS SOON AS THEY ARE QUIET! IF THE FLIES ARE OVER-ETHERIZED THEY BECOME STERILE OR DIE. IF THE WINGS STICK STRAIGHT UP, THE FLIES ARE DEAD.

POUR THE FLIES ONTO A 3 X 5 WHITE CARD AND, USING THE FINE PAINT BRUSH, SEPARATE THE FLIES INTO MALE AND FEMALE.

TO KEEP THE STOCK CULTURE GOING PUT ABOUT 5 MALES AND 5 FEMALES INTO A CULTURE BOTTLE WITH FRESH MEDIUM TO WHICH YEAST HAS BEEN ADDED-ADULT FLIES EAT THE YEAST. BE SURE NOT TO DROP THE FLIES ON THE FOOD; ALWAYS PLACE THEM ON THE PAPER-TOWEL STRIP.

KEEP CULTURES AT 70° TO 77°F., BEING CAREFUL NEVER TO EXPOSE THE BOTTLES TO DIRECT SUNLIGHT. CULTURES MAY BE KEPT IN THE DARK.

The larvae appear in 4-7 days and the pupae will appear 1-3 days after that, depending upon the temperature. Too high temperature will cause sterility!

Mating the flies. All genetics experiments depend upon starting with virgin females. Virgin flies are obtained by removing all the flies from a culture that has many flies emerging. After 10 hours, new flies collected will be virgins. Do not use flies which have not completely expanded their wings and are still white; they become sterile if etherized.

Select a wild-type (+) virgin female and place in a culture bottle with two dumpy-winged (dp) males. (Make up two bottles of this cross.) Next, select a dumpy-winged (dp) female and put in a culture bottle with two wild-type (+) males. (Again, make a duplicate.) After 3 days remove these flies.

The offspring from the above cross are the F_1 generation. F_1 female is crossed with F_1 male to produce the F_2 generation. In addition, back crosses are made: F_1 male x dp female and F_1 female x dp male. Record the results. What kind of mutation is dumpy?

Other experiments: Try such mutants as white eye (w), bar eye (B), and miniature (m).

Induced lethal mutations: Ask a doctor or dentist friend to expose some (+) males to varying dosages of X rays. The test is made with Muller-5 flies. This has two marker genes on it: apricot eye (W^A) and Bar eye (B). Cross the irradiated males with Muller-5 females. Cross the F_1 females with wild-type males. The F_2 will look like this: Bar eye females; wild-type females; Apricot and Bar males-the wild-type males will be missing if a lethal was present on the X chromosome. If the + males are present look carefully for visible mutations, for example white eye.

An excellent source book: Genetics Notes. James F. Crow, Burgess Pub. Co.

CULTURE MEDIUM RECIPE

Corn Meal	30 gms	Dextrose Syrup	60 ml
Rolled Oats (slow cooking)	8 gms	Agar	8 gms
Methyl p-hydroxybenzoate	3.5 ml	Water	500 ml
Propionic Acid	1.5 ml		

Boil rolled oats, syrup, and agar in 350 ml water. Mix the rest of the water with the corn meal and add to the mixture when it starts to boil. Stir continuously while cooking for 15 minutes. Allow to cool for 5 min. and add the propionic acid and the benzoate. Pour a layer about 3/4 of an inch deep into the culture bottles, using a funnel so that medium is kept off the sides of the bottle. Plug bottles and allow to cool. When cool, insert 1x8 inch strips of paper toweling.

Or order Formula 4-24 Instant Drosophila Medium from Carolina Biological Supply.

GENETICS
LEVEL: HIGH SCHOOL

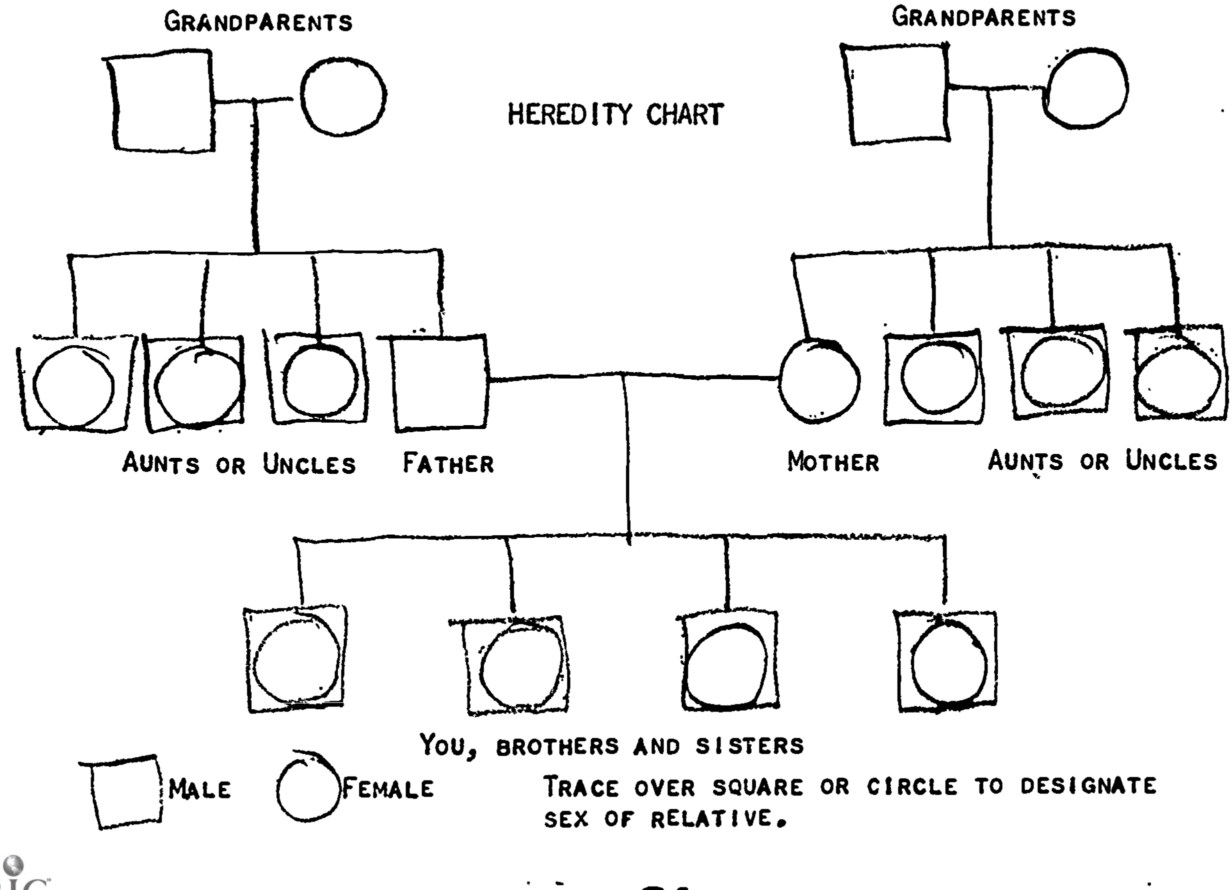
ACTIVITY: INHERITANCE OF CHARACTERISTICS.

HUMANS HAVE TWO MAIN TYPES OF ATTACHMENT OF THE EAR TO THE FACE, ONE TYPE WILL HAVE THE LOBE ATTACHED AND ONE WILL HAVE THE LOBE FREE. CHECK YOUR CLASSMATES' TYPES OF EARS UNTIL YOU CAN EASILY DISTINGUISH ONE TYPE FROM THE OTHER.

1. WHICH EAR TYPE IS MORE PREVALENT IN YOUR CLASS?____________ (THIS WILL VARY WITH EACH CLASS.) HAVE EACH MEMBER OF YOUR CLASS CHECK FIVE PEOPLE AT RANDOM, TRYING TO PICK DIFFERENT PEOPLE FROM THOSE PICKED BY ANOTHER CLASSMATE. YOU MIGHT DO THIS BY SURVEYING OTHER CLASSROOMS.

2. WHICH TYPE IS MORE PREVALENT IN YOUR SAMPLING?____________ (ANSWERS WILL VARY) FILL IN THE PEDIGREE CHART BELOW WITH INFORMATION FROM YOUR OWN FAMILY. USE THE LETTER F FOR FREE-TYPE EARS, AND THE LETTER A FOR ATTACHED-TYPE EARS.

3. DO YOU THINK THIS CHARACTERISTIC IS INHERITED?____________ (THIS WILL DEPEND UPON CHART FINDINGS.) EXPLAIN____________
____
(THE ANSWER WILL BE BASED UPON THE PEDIGREE CHART.)



TRACE OVER SQUARE OR CIRCLE TO DESIGNATE SEX OF RELATIVE.

GENETICS
Level: High School

ACTIVITY: Natural Selection Study

Find two shade-loving plants, such as ivy, and two sun-loving plants, such as geraniums. Put each of the four plants in a separate pot and raise them in their usual environment until they are growing well. Place one of each type of plant in a place where they will get direct sunlight most of the day, and place the other two in dark or dim light. Observe for a week or two. What did you observe?____

Explain in terms of the survival of the fittest.________________

____

____

GENETICS
Level: High School

ACTIVITY: Mutations in Plants

Problem:

One of the theories that explains why plants and animals have changed is based on mutations that may suddenly appear in one generation. What is one possible cause of mutations in plants?

Materials:

Seeds of fast-growing plants, such as radish or clover;

flower pots	hand lens
marking pencils	small brush
rubber gloves	glycerin
alcohol	colchicine powder

CAUTION: COLCHICINE IS POISONOUS. IT MAY CAUSE SKIN IRRITATION IF HANDLED WITHOUT RUBBER GLOVES, AND IT IS VERY DAMAGING TO THE EYES.

Procedure:

Germinate several seeds in two flower pots. When the seedlings are about one inch in height, paint the stems and leaves of the seedlings in one pot with a solution of 1 gram of colchicine in 50 milliliters of glycerin, 25 milliliters of alcohol, and 25 milliliters of water. Mark this flower pot as experimental and mark the flower pot with the untreated plants as control. Water both pots regularly and allow the plants to grow and develop flowers. Examine the plants carefully with the hand magnifier and note any significant differences.

Observations:

Fill in the results of your observations in the table below, and write your conclusion.

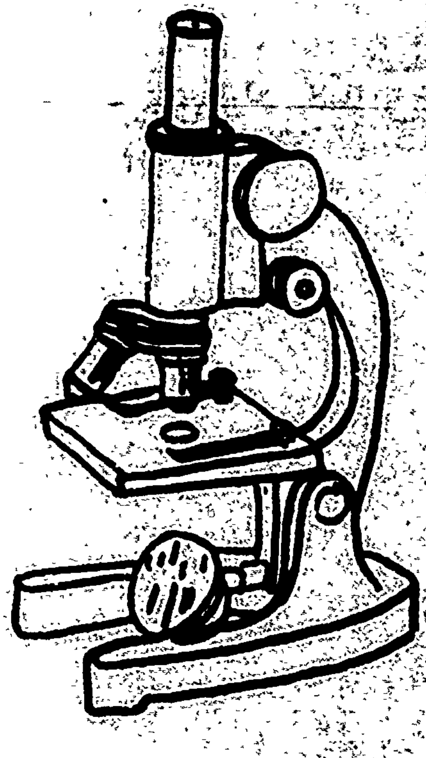
Mutations Produced in Plants

Characteristics in the	Control plant	Experimental plant	Mutations
Leaves			
Stems			
Flowers			

Application:

Since chemical substances seem able to cause mutations, as shown in our experiment, what might be some changes produced in the offspring of humans if the mother uses certain harmful drugs while the child is developing?

MICROBIOLOGY



BIOLOGY - MICROBIOLOGY

ASTRONAUTS	BIOLOGIST
CHEMIST	DENTAL HYGENIST
DENTIST	DIETITIANS
HOME ECONOMIST	LIFE SCIENTIST
MEDICAL LAB WORKERS	MEDICAL RECORD LIBRARIAN
MEDICAL TECHNOLOGIST	OCEANOGRAPHER
PHARMACIST	PHYSICIAN
PRACTICAL NURSE	REGISTERED NURSE
SOCIAL WOR. R	ELEMENTARY TEACHER
TEACHER SECONDARY-COLLEGE	TECHNICAL WRITER
VETERINARIAN	DELIVERY MAN
HOSPITAL ATTENDENT	AGRIBUSINESS TECHNICIAN
AGRICULTURE EXTENSION WORKER	DAIRY PRODUCTION TECHNICIAN
FARM CROP PRODUCTION TECHNICIAN	FARMER
FISH & WILDLIFE TECHNICIAN	FISH CULTURE TECHNICIAN
FORESTER	FORESTRY PRODUCTION TECHNICIAN
LAB ANIMAL CARE TECHNICIAN	PARKS LAND MANAGEMENT TECHNICIAN
SOIL SCIENTIST	FOOD PROCESSING TECHNICIAN
DENTAL LABORATORY TECHNICIAN	STEVEDORE

MICROBIOLOGY

Level: Junior High

ACTIVITY: Can You Make "Life"?

Materials (per team):

Water source (nonchlorinated water preferred) (If chlorinated place in open container and let it sit several days before used)
Clean jar (pint size)
Dried grass or hay
Microscope
Medicine dropper
Microscope slides
Cover glasses

Procedures:

A. Wash and thoroughly rinse the jar.

B. Fill the jar with clean water to within an inch of the top.

C. Carefully remove any insects or other visible forms of life from a small handful of dried grass.

D. Place the dried grass in the jar of water and cover with a loose-fitting top.

E. Place the jar in a place where it will not be disturbed for 4 or 5 days.

F. Hold the jar containing water and grass up to the light. What do you see?

G. With the medicine dropper, take a drop of water from near the top, at the edge of the jar. Place the drop of water on a microscope slide and cover with a cover glass. Examine under the microscope, beginning, with the low-power objective. Make a record in your notebook of what you see.

H. Examine water from other areas in the jar.

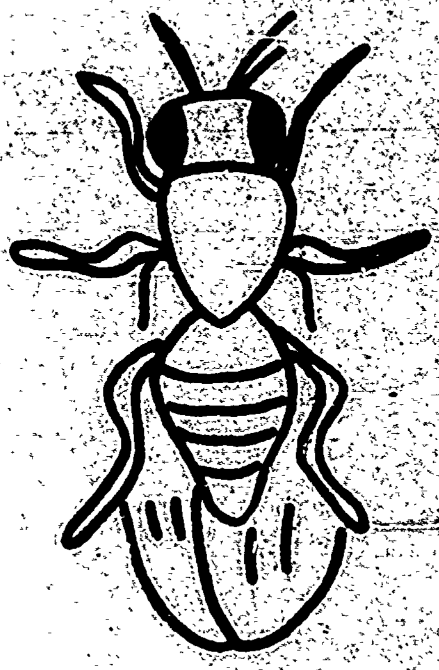
I. Repeat Procedures G and H at the beginning of each class period for 2 or 3 days after it has set that long.

Interpretations:

1. Compare your observations with others. Prepare a list of questions these observations may suggest about what is happening in the grass-water mixture.

2. If you saw objects moving on your slide. Where do you think they came from considering what was put in the jar to start with?

GENETICS



Questions for Discussion after Investigation

1. Where did moving objects come from?
2. Are the objects alive?
3. How do you define life?
4. If alive, what do they need to live?
5. What determines their individual characteristics?
6. What determines how many of each kind will grow there?
7. How do they reproduce?
8. How does the environment affect the organisms and how does the organisms affect their environment?

If time allows students to further test where they came from, Examples might be:

1. Tighten lids on jars.
2. Boil water first.
3. Try different kinds of grass.

MICROBIOLOGY
LEVEL: JUNIOR HIGH

ACTIVITY: WHAT CAUSES THINGS TO DECAY?

MATERIALS: SAND	DEAD ANIMAL PARTS
VIALS	DEAD PLANT PARTS
STICKS	MASKING TAPE

PROCEDURE:

TAKE ENOUGH SAND TO FILL A VIAL ABOUT 3/4 FULL. POUR IT OUT ON A PAPER TOWEL. MOISTEN THE SAND. (DO NOT USE TOO MUCH WATER & MAKE IT MUDDY) REPLACE THE SAND IN THE VIAL, WEDGE THE MOIST SAND AWAY FROM A SMALL AREA OF THE VIAL WITH A WOODEN STICK. PLACE A DEAD INSECT, PIECE OF MEAT, OR ANY PIECE OF AN ANIMAL IN THIS CAVITY. GENTLY PUSH THE SAND AGAINST THE DEAD ORGANISM TO HOLD IT IN PLACE AGAINST THE VIAL WALL SO IT CAN BE SEEN FROM THE OUTSIDE. ON THE OTHER SIDE OF THE VIAL DO THE SAME THING BUT THIS TIME PLACE IN A PLANT PART, SEED OR BERRY. FINALLY THE VIAL SHOULD BE TIGHTLY CAPPED. HAVE EACH GROUP MARK THEIR VIAL WITH MASKING TAPE. HAVE SOME STUDENTS PREPARE A VIAL BUT DO NOT MOISTNE THE SAND WHICH CAN ACT AS A CONTROL FOR MOISTURE. HAVE STUDENTS RECORD OBSERVATIONS FOR THE NEXT 3 OR 4 WEEKS. CAUTION STUDENTS NOT TO DIRECTLY INHALE FROM THE VIALS.

INTERPRETATIONS:

1. HAVE THERE BEEN ANY CHANGES IN THE ORGANISMS?____________
   COULD YOU SAY THAT ANY ORGANISM DISAPPEARED?____________
   IF SO, WHERE DO YOU THINK THEY WENT?____________
2. WHAT CHANGES IN THE APPEARANCE OF THE WATER HAS OCCURRED?
   ____
   THE SAND?__________________
   WHAT MIGHT HAVE CAUSED THE CHANGES?____________
   ____

PROCEDURES:

ALLOW STUDENTS AFTER 6 OR 7 WEEKS TO OPEN THE VIALS AND EXAMINE THE CONTENTS. AFTER EXAMINING THEM LET THEM USE MICROSCOPES AND BI-SCOPES TO VIEW THE CONTENTS.

INTERPRETATIONS:

3. HAVE YOU NOTICED AN ODOR?____________WHERE DID THE ODOR COME FROM?____________
   IDENTIFY THE NEW ORGAINISMS YOU FOUND IN THE VIAL.____________
   ____________ WHERE DID THEY COME FROM?
   ____

OTHER POSSIBLE ACTIVITIES:

1. STUDY MOLD AND SEE WHERE IT GROWS BEST, IN LIGHT OR DARK PLACES.
2. TRY THE TESTS IN PLACES OF DIFFERENT TEMPERATURES TO SEE WHAT EFFECT IT HAS ON DECOMPOSITION.
3. USE THE LIQUID AS A FERTILIZER AND SEE HOW IT CHANGES ANOTHER PLANTS GROWTH.
4. HOW DOES HUMIDITY EFFECT THE RATE OF DECAY IN AN AREA.

MICROBIOLOGY
LEVEL: JUNIOR HIGH

ACTIVITY: INVESTIGATION OF PLANT & ANIMAL CELLS

MATERIALS:

MICROSCOPE	SLIDE
COVER GLASS	SCISSORS
NEWSPAPER	TOOTH PICK (FLAT TYPE)
IODINE STAIN	PIECE OF ONION

PROCEDURES: PART 1 STUDY OF ONION SKIN CELLS

CUT AN ONION LENGTHWISE. REMOVE A THICK SCALE AND PEEL THE SKIN FROM THE INNER SURFACE. CUT A SQUARE (1/4") SECTION OF SKIN AND MOUNT IT ON A SLIDE IN A DROP OF WATER. ADD A COVER GLASS. EXAMINE THE LIVING CELLS UNDER LOW POWER AND HIGH POWER. (A) WHAT COLOR IS THE LIVING PROTOPLASM?________________ (B) DO YOU FIND ANY MOTION IN THE CELL?________________

RAISE ONE SIDE OF THE COVER GLASS AND ADD A DROP OF IODINE STAIN. THIS WILL KILL THE CELLS, BUT WILL ENABLE YOU TO SEE THEIR PARTS MORE CLEARLY. EXAMINE THE STAINED SECTION UNDER LOW POWER. NOTE ESPECIALLY THE CELL WALLS AND THE NUCLEI. THESE NUCLEI APPEAR AS YELLOWISH, SPHERICAL BODIES. (C) ARE THE CELLS IDENTICAL IN SHAPE?___ __________(D) ARE THEY SIMILAR IN GENERAL FORM?________________ (E) ARE THE NUCLEI ALWAYS IN THE SAME POSITION IN THE CELL?__________ IN THE SPACE BELOW, DRAW A SMALL GROUP OF CELLS, MAKING EACH CELL ABOUT AN INCH LONG. SHOW THE CELL WALL AND NUCLEUS OF EACH CELL AND LABEL: CELL WALL; NUCLEUS.

SELECT ONE CELL WHICH SHOWS THE CONTENTS CLEARLY. MOVE IT TO THE CENTER OF THE MICROSCOPE FIELD. USING HIGH POWER, EXAMINE ALL PARTS OF THE CELL. AS YOU STUDY THE CELL, SHIFT THE FOCUS WITH THE FINE ADJUSTMENT AND NOTE THAT THE CELL HAS THICKNESS AS WELL AS LENGTH AND WIDTH. YOU SHOULD SEE THE GENERAL CYTOPLASM FILLING MOST OF THE CELL AND ITS OUTER EDGE, THE PLASMA MEMBRANE. THE CAVITIES IN THE GENERAL CYTOPLASM ARE VACUOLES, EACH BOUNDED BY A VACUOLAR MEMBRANE OF THE GENERAL CYTOPLASM. THE DROPLETS IN THE GENERAL CYTOPLASM ARE OIL DROPLETS. DRAW A SINGLE CELL FROM THE HIGH POWER FIELD, MAKING IT ABOUT TWO INCHES LONG. INCLUDE THE NUCLEUS. LABEL: PLASMA MEMBRANE; GENERAL CYTOPLASM; VACUOLAR MEMBRANE; VACUOLE; OIL DROPLET; NUCLEUS.

SINGLE ONION CELL

NUCLEUS OF ONION CELL

7

In the space to the right of this cell, (on previous page) show the nucleus enlarged to about the size of a quarter. Show the nuclear membrane, dense nucleoplasm, and nucleolus (there may be several nucleoli). Label: nuclear membrane; nucleoplasm; nucleolus

Part 2 Human cheek cells

Scrape the inside of your cheek with a clean toothpick. Smear the material on a slide. Add a drop of iodine stain and a cover glass. Examine under low power, noting the masses of cells and individual cells. Find the outer edge of the general cytoplasm which is hardened to form the plasma membrane. Study several different cells under high power. (f) Do they seem to have a definite shape? ____________ (g) Do they appear to have a cell wall? ____________ (h) Is a central vacuole present? ____________

Draw several cells in a mass under low power and a single cell under high power in the spaces below. In the drawing from high power, label: plasma membrane; general cytoplasm; nucleus.

Human cheek (L.P.)

Human cheek (H.P.)

MICROBIOLOGY
Level: High School

ACTIVITY: Let's Brush Those Teeth (An experiment concerning bacteria, protozoa and fungi of the mouth.)

Materials:

Clean slides and cover glasses
Bunsen burner
Tooth picks
Methylene blue stain

Microscope should be equipped with substage condenser, iris diaphragm, 10X, objective and a high dry objective of at least 40X.

For observation of detail in the larger bacteria and resolving the smaller bacteria, an oil immersion objective is necessary.

Procedure:

Obtaining the Specimen

Place a small drop of saliva from the mouth or a drop of distilled or tap water on a microscope slide. With a toothpick, remove some of the tartar which may be present at the base of the teeth along the gum line. Introduce the pick into the drop on the slide, mix thoroughly and allow to dry.

Fixation

Each preparation is quickly passed two or three times, through the flame of a Bunsen burner. This procedure "fixes" the bacteria to the slide and thus prevents removal during the staining process.

Staining

Bacteria stain best with basic dyes, (i.e. compounds of color bases). One of the best dyes for staining bacteria is methylene blue. Loeffler's methylene blue containing ethyl alcohol and potassium hydroxide is most commonly used.

Place a few drops of the methylene blue on each prepared slide and leave for approximately 4-5 minutes. Rinse the slides briefly in cool running tap water from the faucet or dip into a container of water several times to remove the excess dye. Drain the water from the slide and allow to completely dry. If in a hurry, the slides can be blotted dry with facial tissue, being careful not to rub off the preparation.

Mounting

The bacteriologist in examining preparations of bacteria usually uses the oil immersion objective which does not require the use of a cover glass. However, for use with a high dry objective such as the 43X, a cover glass is necessary. For temporary mounts, a drop of immersion oil can be placed on the preparation and covered with a cover glass. For permanent preparations, xylol-balsam or one of the synthetic mounting media can be used.

REMARKS:

BACILLUS FORMS (LACTOBACILLI) CONTRIBUTE TO DECAY OF THE TEETH BY THEIR ACTION ON CARBOHYDRATE FOODS, ESPECIALLY SUGAR, TO PRODUCE ACIDS. NEGLECT OF DECAY MAY LEAD TO ABSCESSED TEETH, GINGIVITIS AND PYORRHEA. THE FUSIFORM BACILLUS AND SPIROCHETE ARE FOUND IN VINCENT'S ANGINA. THIS ULCERATIVE INFLAMMATION IS SOMETIMES TERMED TRENCH MOUTH SINCE THERE WERE SO MANY INFECTIONS OF SOLDIERS DURING WORLD WAR I.

THE PROTOZOA, TRICHOMONAS TENAX 6-12 MICRONS IN LENGTH, IS PRESENT IN CASES OF DENTAL CARIES. ACCORDING TO ZINSSER MICROBIOLOGY, "TRANSMISSION OF THIS ORGANISM, NO DOUBT, USUALLY OCCURS DURING KISSING BUT CONTAMINATED DISHES, GLASSES AND THE LIKE MAY BE INVOLVED ESPECIALLY DURING MEALS WHEN THOSE BEING USED BY AN OLDER PERSON CONTAIN AS WELL THE FOOD BEING GIVEN TO AN INFANT." IT IS PROBABLY TRUE THAT MANY TYPES OF BACTERIA ARE TRANSMITTED FROM ONE PERSON TO ANOTHER IN A SIMILAR MANNER.

IN THE CASE OF AN UNDETERMINED TYPE OF INFECTION OR FOR CONFIRMATION, YOUR DENTIST OR ORAL SURGEON MAY SEND A SPECIMEN TO THE MEDICAL LABORATORY.

THE BACTERIOLOGIST VERY OFTEN STAINS THE SPECIMEN WITH METHYLENE BLUE EXACTLY AS DESCRIBED IN THIS EXPERIMENT. IN ADDITION, HE MAY USE GRAM STAIN NAMED AFTER A DANISH BACTERIOLOGIST. GRAM FOUND THAT IF A PREPARATION WAS TREATED WITH A SOLUTION OF IODINE AFTER BEING STAINED WITH THE BASIC DYE, CRYSTAL VIOLET, MANY KINDS OF BACTERIA WOULD RETAIN THE VIOLET STAIN EVEN AFTER BEING TREATED WITH ALCOHOL. THE GROUP OF BACTERIA WHICH REMAIN PURPLE ARE KNOWN AS GRAM-POSITIVE. THOSE WHICH ARE DECOLORIZED ARE TERMED GRAM-NEGATIVE. IN ORDER THAT THEY CAN BE SEEN AFTER DECOLORIZATION, THEY ARE COUNTERSTAINED WITH THE RED BASIC DYE, SAFRANIN. THE LACTOBACILLUS IS AN EXAMPLE OF A GRAM-POSITIVE BACTERIA; THE FUSIFORM BACILLUS OF A GRAM-NEGATIVE.

MICROBIOLOGY
LEVEL: HIGH SCHOOL

ACTIVITY: THE PREPARATION AND MICROSCOPIC OBSERVATION OF STAINED MICROORGANISMS

PROCEDURE:

GENERAL PREPARATION OF SMEAR

A. CLEAN SLIDES BY APPLYING BON-AMI TO THE WET SLIDES. LET THEM AIR DRY AND CLEAN WITH A DRY CLOTH. HOLD THE SLIDE BY GRASPING THE EDGES.

B. WITH A WAX PENCIL DRAW A CIRCLE ABOUT THE SIZE OF A NICKEL ON THE SLIDE. TURN THE SLIDE OVER, NOW IT IS EASY TO FIND THE SMEAR WHILE STAINING.

C. STERILIZE A WIRE LOOP BY HEATING TO REDNESS IN A BUNSEN FLAME. LET THE LOOP AIR-COOL.

D. WITH A STERILIZED NEEDLE TRANSFER SOME OF THE CULTURE TO A DROP OF WATER ON THE SLIDE. MIX THE TWO TOGETHER. IF A BROTH IS USED TRANSFER A LOOPFUL OF SUSPENSION TO THE SLIDE.

E. NEXT LET THE FILM AIR-DRY. THE SLIDE SHOULD NOT BE HEATED TO SPEED UP DRYING.

F. AFTER AIR DRIED-HEAT-FIX BY PASSING SLIDE FILM-SIDE UP QUICKLY THROUGH THE FLAME.

G. LET THE SLIDE AIR COOL.

GRAM-STAIN PROCEDURE

A. FLOOD THE SLIDE WITH GRAM'S CRYSTAL VIOLET. ALLOW TO STAIN 1 MIN.
B. WASH GENTLY WITH TAP WATER.
C. FLOOD THE SLIDE WITH GRAM'S IODINE. ALLOW TO ACT 1 MINUTE.
D. WASH GENTLY WITH TAP WATER.
E. RINSE SMEAR WITH GRAM'S ALCOHOL UNTIL DECOLORIZED (30 SECONDS)
F. WASH GENTLY WITH TAP WATER.
G. COUNTER-STAIN WITH GRAM'S SAFRANIN. ALLOW STAIN TO ACT 20 SECONDS.
H. WASH GENTLY WITH TAP WATER AND BLOT DRY.

INTERPRETATIONS:

THE PRIMARY STAIN IS CRYSTAL VIOLET. THIS IS FOLLOWED BY AN IODINE SOLUTION THAT BEHAVES AS A MORDANT AND HELPS FIX THE PRIMARY-DYE TO GRAM-POSITIVE ORGANISMS. THE SMEAR IS THEN DECOLORIZED, USUALLY WITH ALCOHOL, AND COUNTERSTAINED WITH A CONTRASTING DYE SUCH AS SAFRANIN. ORGANISMS THAT RETAIN THE PURPLE PRIMARY STAIN ARE DESIGNATED GRAM-POSITIVE; GRAM-NEGATIVE CELLS LOSE THE PRIMARY STAIN WHEN DECOLORIZED WITH ALCOHOL AND STAIN WITH THE RELATIVELY WEAK SECONDARY PINK DYE, SAFRANIN.

MICROBIOLOGY
LEVEL: HIGH SCHOOL

ACTIVITY: DEMONSTRATION OF AN ARTIFICIAL EPIDEMIC

SOME DISEASES ARE TRANSMITTED FROM MAN BY DIRECT CONTACT WITH SOME CONTAMINATED OBJECT (FOMITE). BY STUDYING THE INCIDENCE AND DISTRIBUTION OF A DISEASE, VERY OFTEN THE FOCI OF INFECTION CAN BE FOUND.

PURPOSE:
TO ILLUSTRATE ONE METHOD OF DISEASE TRANSMISSION.

MATERIALS:
WRAPPED CANDY KISSES
STERILE SALINE
10 ML STERILE PIPETTES
TRYPTICASE SOY AGAR OR NUTRIENT AGAR
24 HOUR BROTH CULTURE OF SERRATIA MARCESCENS
1 ML STERILE PIPETTES
STERILE PETRE PLATES

PROCEDURE:
1. BEFORE PROCEEDING, PLAN THE ORDER OF HANDSHAKES FOR THE WHOLE TABLE. EACH STUDENT WILL BE FURNISHED WITH A WRAPPED PIECE OF STICKY SUGAR CANDY. ONE OF THE PIECES AT EACH TABLE WILL HAVE BEEN CONTAMINATED WITH A CULTURE OF SERRATIA MARCESCENS. DO NOT UNWRAP THE CANDY UNTIL YOU ARE READY TO BEGIN THIS EXPERIMENT.
   A. WASH YOUR HANDS WITH SOAP AND WATER AND DRY WITH A CLEAN PAPER TOWEL.
   B. HOLD THE UNWRAPPED PIECE OF CANDY IN YOUR RIGHT HAND FOR TWO MINUTES.
   C. SHAKE HANDS WITH ANY TWO PERSONS AT YOUR TABLE. KEEP A RECORD IN THE FORM OF A MAP OF THE TABLE AND SHOW BY MEANS OF NUMBERED ARROWS WITH WHOM EACH PERSON SHOOK HANDS AND THE CHRONOLOGICAL ORDER OF EACH HANDSHAKE. (THERE WILL BE 16 HANDSHAKES NUMBERED CONSECUTIVELY 1 TO 16.)
   D. IMMEDIATELY AFTER SHAKING HANDS WITH TWO PERSONS PLATE THE BACTERIA PRESENT ON YOUR HAND IN THE FOLLOWING MANNER:
      1. PLACE 5 ML STERILE SALINE IN A STERILE PETRI DISH.
      2. TAKE A STERILE SWAB, MOISTEN IT IN THE STERILE SALINE IN THE PETRI DISH AND SWAB THE PALM OF THE RIGHT HAND, ENDEAVORING TO REMOVE AS MANY OF THE BACTERIA AS POSSIBLE INTO THE SALINE IN THE PETRI DISH.
      3. PLATE 1 AND 0.1 ML SAMPLE OF THE SALINE WASH.
      4. INCUBATE AT 32^{o} FOR 48 HOURS.
   E. INDICATE ON THE MAP OF THE DESK, THE NUMBER OF SERRATIA MARCESCENS CULTURED FROM EACH INDIVIDUAL. TRACE THE COURSE OF THE "EPIDEMIC" AT YOUR TABLE AND SHOW WHICH PIECE OF CANDY WAS CONTAMINATED.

QUESTIONS:

1. LIST FOUR OTHER METHODS WHEREBY DISEASES ARE TRANSMITTED TO MAN.

MICROBIOLOGY
LEVEL: HIGH SCHOOL

ACTIVITY: ISOLATING AND TESTING ANTIBIOTIC PROOUCERS

DISCOVERING NEW ANTIBIOTICS ANO TESTING THEM GIVES US AN OPPORTUNITY TO LEARN NEW SCIENCE TECHNIQUES.

PROBLEM:

TRYING TO ISOLATE ANTIBIOTIC PROOUCERS FROM SOIL OFFERS A CHANCE TO LEARN SOME THEORETICAL BIOLOGY, GAIN TECHNICAL SKILLS OF WIDE APPLICATION, ANO OISCOVER SOME NEW ANTIBIOTIC. ANY SOIL SAMPLE WILL CONTAIN BOTH BACTERIA AND FUNGI THAT PRODUCE SOME TYPE OF ANTIBIOTIC SUBSTANCE. THE PROBLEM IS TO ISOLATE THE BEST PRODUCERS, AND TO GET PURE CULTURES OF THESE ORGANISMS. THIS OEMANDS THE DEVELOPMENT OF CERTAIN TECHNIQUES: WORKING UNDER STERILE CONDITIONS, MAKING THE PROPER SELECTIVE MEDIUM FOR ISOLATING ANO GROWING THE ORGANISM OF INTEREST.

MATERIALS:

PRESSURE COOKER
PIPETTES--5 ML
NUTRIENT AGAR--GET THE REAOY-MADE KIND FROM A SUPPLY HOUSE.
TEST ORGANISM--BACILLUS-SUBTILIS--FROM A SUPPLY HOUSE.
PETRI PLATES
BACTERIOLOGICAL LOOPS--NICHROME WIRE IN A THIN, LONG METAL HANDLE.

PROCEOURE:

THE FOUNDATION OF ALL BACTERIOLOGICAL WORK IS STERILE TECHNIQUE. GLASSWARE AND INSTRUMENTS, WATER AND NUTRIENT, MUST BE FREE OF BACTERIA AS WELL AS CHEMICALLY PURE. CONTAMINATION--BACTERIAL OR CHEMICAL--LEAOS TO FAULTY OATA AND FAILURE.

THERE ARE TWO MAJOR WAYS OF STERILIZING: DRY HEAT AND AUTOCLAVING. GLASSWARE--PIPETTES ANO PETRI PLATES ARE STERILIZED BY ORY HEAT. WRAP THE PLATES (5 AT A TIME, WITH THEIR COVERS ON) IN BROWN WRAPPING PAPER AND HEAT IN A 320°F OVEN FOR 3-4 HOURS. LIQUIOS--WATER, NUTRIENT MEDIA, ETC.--ARE STERILIZED BY STEAMING IN A PRESSURE COOKER FOR 15 MINUTES AT 15 POUNOS PRESSURE. THE MATERIAL SHOULO BE IN TEST TUBES OR FLASKS, PLUGGED WITH NONABSORBENT COTTON.

THE NUTRIENT AGAR MEDIA RECOMMENDED FOR THE ISOLATION OF FUNGI ARE: MYCOLOGICAL AGAR, CZAPEK SOLUTION AGAR, CORNMEAL AGAR, OR PRUNE AGAR. TO RESTRICT FUNGI AND ALLOW UNRESTRICTED BACTERIAL GROWTH USE BACTO-W.L. DIFFERENTIAL MEDIUM (B 425).

MAKE UP THE AGAR AS OIRECTED ON THE PACKAGE. THE AGAR MUST BE MELTEO BUT NOT TOO HOT WHEN YOU START THE EXPERIMENT.

AOD STERILE WATER TO THE VARIOUS SOIL SAMPLES AND SHAKE THOROUGHLY. LET THE MATERIAL SETTLE BRIEFLY ANO POUR OFF THE WATER INTO A STERILE TEST TUBE. THIS IS THE CONCENTRATED SOLUTION OF BACTERIAL AND FUNGAL SPORES. THE SUCCESS OF THE EXPERIMENT OEPENDS ON GETTING THE RIGHT DILUTION OF THIS CONCENTRATE.

MAKE SERIAL DILUTIONS OF 1/10, 1/100, 1/1,000, 1/10,000, 1/100,000, 1/1,000,000. THIS IS DONE BY STERILIZING 6 COTTON-PLUGGED TEST TUBES CONTAINING 9 ML WATER EACH. USING STERILE PIPETTES, MEASURE 1 ML OF THE CONCENTRATE INTO TEST TUBE # 1. THIS MAKES THE 1/10 DILUTION. TAKE 1 ML OF THIS DILUTION AND PIPETTE IT INTO TEST TUBE # 2. THIS IS 1/100 DILUTION. PIPETTE 1 ML OF THIS DILUTION INTO THE NEXT TEST TUBE AND CONTINUE IN THIS WAY UNTIL ALL THE DILUTIONS HAVE BEEN MADE.

IN ORDER TO AVOID CONTAMINATION, AND TO KEEP THE DILUTIONS AS ACCURATE AS POSSIBLE, IT IS WISE TO USE A CLEAN, STERILE PIPETTE FOR EACH STEP.

PIPETTE 1 ML OF EACH DILUTION INTO SEPARATE PETRI PLATES OPENING THE COVER JUST ENOUGH TO ALLOW THE INSERTION OF THE PIPETTE. TAKING THE SAME CARE TO KEEP THE PLATES COVERED, POUR ENOUGH MELTED NUTRIENT AGAR INTO THE PLATES TO COVER THE BOTTOM TO A DEPTH OF ABOUT 1/4" AND, WITH THE COVER REPLACED, SWIRL THE PLATE SO THAT THE DILUTION MIXTURE AND THE AGAR BECOME THOROUGHLY MIXED. SET ASIDE TO COOL AND HARDEN. POUR SEVERAL PLATES WITH NUTRIENT AGAR ONLY AND PUT ASIDE FOR LATER USE. ALLOW THE SEEDED PLATES TO INCUBATE, UPSIDE DOWN, IN A WARM PLACE FOR 24 HOURS.

SELECT A PLATE WITH WELL SEPARATED COLONIES. MAKE A HEAVY SUSPENSION OF THE TEST ORGANISM, BACILLUS SUBTILIS, IN STERILE WATER AND PIPETTE 1 ML ONTO THE SURFACE OF THE SELECTED PLATE. MAKE SURE THE SUSPENSION IS EVENLY DISTRIBUTED. SET THE PLATE ASIDE TO INCUBATE FOR 24 HOURS. A CLEAR RING AROUND A COLONY AFTER INCUBATION INDICATES THAT THERE IS ANTIBIOTIC ACTIVITY.

FLAME THE LOOP OVER A BUNSEN BURNER OR ALCOHOL LAMP UNTIL RED HOT. LET COOL AND THEN PICK UP SOME OF THE COLONY AND STREAK ON A STERILE AGAR PLATE. INCUBATE FOR 24-36 HOURS. WHEN GOOD GROWTH IS ATTAINED, STREAK SEVERAL TEST ORGANISMS AT RIGHT ANGLES TO THE GROWTH STREAK.

BIOLOGY - ZOOLOGY

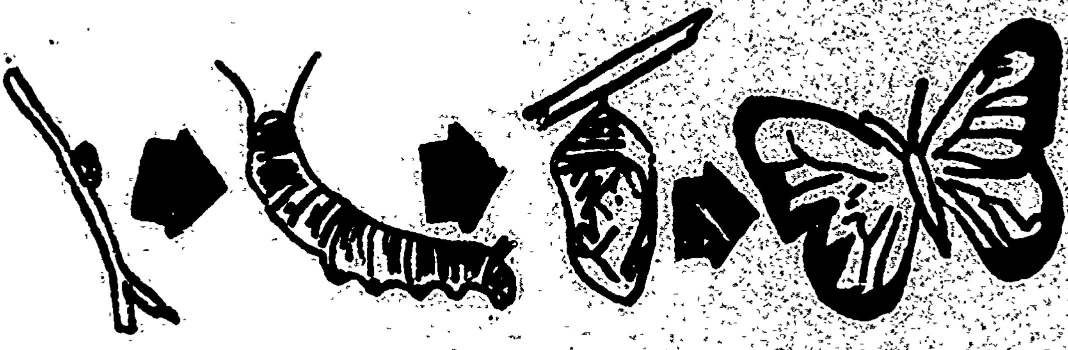
INVERTEBRATE:

Building Custodian
Fish Culture Technician
Forestery Production Technician
Orchard Technician
Parks Lanc Management Technician
Food Processing Technician
Biologist
Home Economist
Life Scientist
Physician
Registered Nurse
Elementary Teacher
Technical Writer
Agribusiness Technician
Farm Crop Production Technician
Fish & Wildlife Technician
Forester
Lab Animal Care Technician
Horticulturist
Range Management
Biochemistry
Chemist
Landscape Architect
Oceanographer
Fractical Nurse
Social Worker
Teacher secondary-college
Veterinarian
Dairy Production Technician
Farmer

VERTEBRATES:

X-Ray Technician
Fish Culture Technician
Lab Animal Care Technician
Range Management
Biochemistry
Chemist
Oceanographer
Recreation Leader
Registered Nurse
Teacher secondary-college
Veterinarian
Shoe Repairman
Agriculture Extension Work
Farmer
Fish & Wildlife Technician
Forester
Livestock Production Technician
Food Processing Technician
Biologist
Home Economist
Physician
Practical Nurse
Elementary Teacher
Technical Writer
Meat Cutter
Agribusiness Technician
Farm Crop Production Technician

INVERTEBRATE ZOOLOGY



ZOOLOGY: INVERTEBRATE
LEVEL: JUNIOR HIGH

ACTIVITY: STUDYING INSECTS AND THEIR BEHAVIOR

MATERIALS: INSECT (MEAL WORM BEATLES ARE GOOD)
MAGNIFYING GLASS
METRIC RULER
CLOCK
HEAT SOURCE
LIGHT SOURCE

PROCEDURES:

A. DETERMINE THE APPEARANCE OF YOUR INSECT AND ANSWER THE FOLLOWING:

1. SIZE LENGTH ________CM
   WIDTH ________CM

2. COLOR________________

3. BODY SHAPE (ROUND, FLAT OR ?) ______________

4. NUMBER OF LEGS __________

5. NUMBER OF ANTENNAE __________

6. SPECIAL CHARACTERISTICS ____________________

B. DRAW A SKETCH OF YOUR INSECT

C. DESCRIBE WHAT YOUR INSECT DOES IN 3 MIN. PERIOD.

D. USE YOUR IMAGINATION AND INITIATIVE TO PUT YOUR INSECT IN A NOVEL SITUATION AND CHECK ITS RESPONSE NEAR A STRONG LIGHT, HEAT, DARKNESS, LOUD NOISES, PRODDING OR? AVOID HARMING YOUR INSECT.

TEST YOU MADE INSECTS RESPONSE

E. IS THIS INSECT OR COULD IT BE A PEST? ________________

HOW COULD IT BE CONTROLLED? ________________

WHAT DOES IT EAT?________________

WHAT OCCUPATIONS MIGHT BE CONCERNED IF THERE WERE MANY OF YOUR INSECTS?________________

ZOOLOGY
LEVEL: HIGH SCHOOL

ACTIVITY: THE LIVING INVERTEBRATE HEART

PURPOSE:

THE PURPOSE OF THIS EXERCISE IS TO OBSERVE THE BEATING INVERTEBRATE HEART AND THROUGH YOUR OWN OBSERVATIONS AND EXPERIMENTS TO DETERMINE ITS RATE AND THE EFFECTS OF CHANGES IN THE ENVIRONMENT AND THE EFFECTS OF DRUGS ON THE RATE OF HEARTBEAT.

MATERIALS (PARTS A, B, AND C):

A SMALL BEAKER OF POND WATER CONTAINING DAPHNIA
SLIDE AND COVER GLASS
SOME BRISTLES OR PIECES OF BROKEN COVER GLASS TO SUPPORT THE COVER GLASS AND PREVENT DAPHNIA FROM BEING CRUSHED (CAUTION: IF YOU USE PIECES OF GLASS, HANDLE THEM WITH A PAIR OF FORCEPS, NOT WITH FINGERS)
SIMILAR BEAKER CONTAINING WARM WATER (36°C)
WATCH WITH A SWEEP SECOND HAND
STEREOSCOPIC DISSECTING MICROSCOPE
CHLORPROMAZINE SOLUTION
GRAPH PAPER
WIDE-MOUTHED MEDICINE-DROPPER PIPETTE (FOR "FISHING OUT" A SINGLE DAPHNIA)
THERMOMETER
LARGE BEAKER OF ICE, WATER, AND SALT INTO WHICH THE SMALL BEAKER CONTAINING DAPHNIA WILL FIT IN ORDER TO LOWER ITS TEMPERATURE
SMALL DISHES INTO WHICH TO TRANSFER THE COOLED OR WARMED DAPHNIA
DEXEDRINE SULFATE SOLUTION
5% ALCOHOL

PROCEDURE:

WORK IN TEAMS OF TWO STUDENTS, FOLLOWING THE SPECIAL INSTRUCTIONS BELOW.

PART A - THE HEARTBEAT AT ROOM TEMPERATURE

STUDENT A: TAKE THE TEMPERATURE OF THE WATER IN THE CONTAINER OF DAPHNIA AND RECORD IT IN YOUR NOTEBOOK.
STUDENT B: PLACE ONE OF THE DAPHNIA ON A SLIDE IN A DROP OF WATER. PLACE THREE OR FOUR PIECES OF BROKEN COVER GLASS OR BRISTLE IN THE DROP AND COVER WITH A COVER GLASS. PLACE THE SLIDE UNDER THE MICROSCOPE AND BRING THE HEART INTO FOCUS.
STUDENT A: LOOK THROUGH THE MICROSCOPE AT THE BEATING HEART AND GET READY TO COUNT HEARTBEATS.
STUDENT B: LOOK AT THE WATCH (WITH SWEEP SECOND HAND) AND, WHEN READY, SAY, "GO."
STUDENT A: BEGIN TO COUNT THE HEARTBEATS USING THE METHOD OUTLINED FOR YOU BY YOUR TEACHER.
STUDENT B: AT THE END OF 15 SECONDS, SAY, "STOP."
STUDENT A: COUNT THE DOTS ON YOUR PIECE OF PAPER AND GIVE THE COUNT TO YOUR TEAM-MATE.
STUDENT B: MULTIPLY THE COUNT BY 4 (15 SECONDS x 4 = 1 MINUTE) AND RECORD THE CALCULATION.

REPEAT THIS PROCEDURE AT LEAST THREE TIMES. CALCULATE THE HEARTBEATS PER MINUTE AND TAKE THE AVERAGE OF YOUR THREE TRIALS. RECORD THIS AVERAGE COUNT IN YOUR NOTEBOOK.

PART B - THE HEARTBEAT AT OTHER TEMPERATURES

RAISE OR LOWER THE TEMPERATURE OF THE WATER IN THE BEAKER CONTAINING DAPHNIA BY PLACING THE SMALL BEAKERS CONTAINING DAPHNIA IN EITHER THE LARGER BEAKER OF WARM WATER OR IN THE BEAKER CONTAINING ICE, WATER, AND SALT.

PLACE THE BULB OF THE THERMOMETER IN THE SMALL BEAKER OF DAPHNIA AND VERY GENTLY (SO AS NOT TO HARM THE DAPHNIA) ROCK THE SMALL BEAKER TO MAKE THE TEMPERATURE OF THE WATER THE SAME THROUGHOUT THE BEAKER. WATCH THE THERMOMETER UNTIL THE DESIRED TEMPERATURE IS REACHED. YOUR PARTICULAR TEMPERATURE WILL BE ASSIGNED TO YOU AS FOLLOWS.

TWO TEAMS DETERMINE THE RATE OF HEARTBEAT AT 30° BELOW ROOM TEMPERATURE BY TRANSFERRING THE DAPHNIA AND SOME OF THE COOLED WATER TO A PREVIOUSLY COOLED DISH AND OBSERVING THE DAPHNIA UNDER THE DISSECTING MICROSCOPE. BE SURE TO MAKE THE OBSERVATIONS BEFORE THE TEMPERATURE RISES.

TWO TEAMS DETERMINE THE RATE OF HEARTBEAT AT 25° BELOW ROOM TEMPERATURE.

TWO TEAMS DETERMINE THE RATE OF HEARTBEAT AT 20°BELOW ROOM TEMPERATURE.

TWO TEAMS DETERMINE THE RATE OF HEARTBEAT AT 15° BELOW ROOM TEMPERATURE.

TWO TEAMS DETERMINE THE RATE OF HEARTBEAT AT 10° BELOW ROOM TEMPERATURE.

TWO TEAMS DETERMINE THE RATE OF HEARTBEAT AT 5° BELOW ROOM TEMPERATURE.

TWO TEAMS DETERMINE THE RATE OF HEARTBEAT AT $36^{\circ}C$.

EACH TEAM IS TO ENTER ITS FINDINGS IN A TABLE ON THE BLACKBOARD PATTERNED AFTER THE ONE FOLLOWING.

TEMPERATURE	AVERAGE HEARTBEATS PER MINUTE	INITIALS OF TEAM MEMBERS

WHEN ALL THE DATA ARE COMPLETE, COPY THEM FROM THE BLACKBOARD INTO YOUR OWN DATA BOOK.

USING GRAPH PAPER MAKE A GRAPH OF THE DATA, PLOTTING RATE OF HEARTBEAT ALONG THE HORIZONTAL AXIS AGAINST TEMPERATURE ALONG THE VERTICAL AXIS. DID ALL MEMBERS OF THE CLASS RECORD A SIMILAR RATE OF HEARTBEAT AT ROOM TEMPERATURE? (1) AT LOWER TEMPERATURES? (2) AT HIGHER TEMPERATURES? (3) HOW DO YOU ACCOUNT FOR THIS? (4)

FROM YOUR GRAPH, WHAT EFFECT DOES LOWER TEMPERATURE HAVE ON HEARTBEAT? (5) IS THERE AN EQUAL DIFFERENCE BETWEEN EACH 5° DROP IN TEMPERATURE, OR IS THERE A TEMPERATURE AT WHICH THE DROP IS MORE PRONOUNCED? (6) WHAT EFFECT DID HIGHER TEMPERATURE HAVE ON THE HEARTBEAT? (7)

PART C - THE HEARTBEAT AND CHEMICAL COMPOUNDS

THERE ARE A NUMBER OF SUBSTANCES KNOWN AS TRANQUILIZERS, WHICH ARE BELIEVED TO QUIET THE NERVES. ONE OF THESE IS CHLORPROMAZINE. OTHER SUBSTANCES KNOWN AS STIMULANTS HAVE AN OPPOSITE EFFECT. DEXEDRINE SULFATE IS ONE OF THESE. HERE ARE SOME INVESTIGATIONS YOU CAN MAKE. ADD TO SEPARATE MOUNTS OF DAPHNIA, CHLORPROMAZINE SOLUTION AND DEXEDRINE SULFATE SOLUTION, INSTEAD OF WATER.

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WHAT IS THE EFFECT OF CHLORPROMAZINE ON THE HEART RATE OF DAPHNIA? (8) DO ALL TRANQUILIZERS HAVE THE SAME EFFECT? (9) WHAT IS THE EFFECT OF DEXEDRINE SULFATE ON THE HEART RATE OF DAPHNIA? (10) WHAT IS THE EFFECT OF 5% ALCOHOL ON THE RATE OF HEARTBEAT? (11)

COULD DAPHNIA BE USED TO TEST THE CONCENTRATION OF TRANQUILIZERS, STIMULANTS, AND OTHER DRUGS OF UNKNOWN CONCENTRATION? (12) BIOASSAY IS A TECHNIQUE USING LIVING ORGANISMS TO DETERMINE QUANTITIES OF SUSPECTED MATERIALS AND EVEN TO IDENTIFY THEM.

ZOOLOGY
LEVEL: HIGH SCHOOL

ACTIVITY: ANIMAL BEHAVIOR

PURPOSE:

THE PURPOSE OF THE PRESENT EXERCISE IS TO STUDY SOME OF THE BEHAVIORAL CHARACTERISTICS OF TWO KINDS OF INSECTS, AN ADULT FLY (A FRUIT FLY) AND A LARVAL FORM (CATERPILLAR) OF EITHER A MOTH OR A BUTTERFLY. THE BEHAVIOR OBSERVED IN THESE INSECTS WILL THEN BE COMPARED WITH SOME SIMPLE EXAMPLES OF HUMAN BEHAVIOR THAT MOST PEOPLE MAY NOT EVEN THINK OF AS BEHAVIOR. IN CONDUCTING THESE STUDIES OF MAN AND INSECTS, KEEP IN MIND THE POSSIBILITY THAT IN SOME RESPECTS THE BEHAVIORAL PATTERNS MAY BE SIMILAR.

MATERIALS:

- TEST TUBE CONTAINING SEVERAL FRUIT FLIES
- ONE LIVING CATERPILLAR
- PLANT MATERIAL KNOWN TO BE A SOURCE OF FOOD FOR THE CATERPILLAR AND SOME PLANT MATERIAL KNOWN NOT TO BE A SOURCE OF FOOD FOR THIS CATERPILLAR
- FOOD COLORING
- LIQUID CHLORINE BLEACH (CLOROX OR A SIMILAR BRAND)
- RUBBING ALCOHOL
- DEODORANT
- PARAFFIN
- LIGHT BULBS OF DIFFERENT COLORS OR COLORED CELLOPHANE WRAPPED OVER WHITE LIGHT BULBS
- SOURCES OF HEAT AND COLD
- PAPER WITH A CIRCLE OF 15-CM DIAMETER

PROCEDURE:

PART A - REACTIONS OF FRUIT FLIES TO LIGHT

HOLD THE TEST TUBE OF FRUIT FLIES HORIZONTALLY ABOUT 30 CM (1 FT) FROM A GLOWING LIGHT BULB. DO THE FLIES TEND TO MOVE TOWARD OR AWAY FROM THE LIGHT? (1) WHEN HANDLING THE TUBE OF FLIES, SLOWLY TURN IT VERTICALLY AND THEN HORIZONTALLY, OR AT AN ANGLE, BUT DO NOT JAR OR TAP THE TUBE OR OTHERWISE DISTRUB THE FLIES. WHY? (2) CHANGE THE POSITION OF THE TUBE AND HOLD IT 100 CM FROM THE LIGHT. NOTE THE FLIES' REACTION. IS IT THE SAME AS AT 30 CM? (3) BY MOVING THE TUBE CLOSER TO AND FARTHER FROM THE LIGHT, DETERMINE THE OPTIMUM DISTANCE AT WHICH THE FLIES RESPOND TO THE STIMULUS OF THE LIGHT. (4) WHAT IS THE MINIMUM DISTANCE? (5) WHAT IS THE MAXIMUM DISTANCE? (6)

WHAT DO THE ABOVE OBSERVATIONS INDICATE ABOUT FRUIT FLY BEHAVIOR IN RELATION TO THE BRIGHTNESS OR INTENSITY OF THE LIGHT? (7) USING COLORED LIGHT BULBS OR COLORED CELLOPHANE, DETERMINE THE REACTION OF FLIES TO LIGHTS OF DIFFERENT COLORS. DO THE FLIES REACT EQUALLY WELL TO LIGHT OF ANY COLOR? (8) DOES THE POSITION OF THE TUBE DETERMINE IN ANY WAY IN WHAT DIRECTION THE FLIES TEND TO MOVE? (9)

IN ADDITION TO EMITTING LIGHT, THE ELECTRIC BULBS ALSO EMIT HEAT. WHAT EFFECT DO YOU SUPPOSE THE EMISSION OF HEAT MAY HAVE ON YOUR OBSERVATIONS CONCERNING FRUIT FLIES AND LIGHT? (10) DEVISE A SIMPLE EXPERIMENT THAT WILL TEST THE REACTION OF THE FLIES TO HEAT OR COLD ALONE BUT NOT TO LIGHT. DO THE FLIES REACT TO DIFFERENT TEMPERATURES BY THEIR DIRECTION OF MOVEMENT? (11)

DO THE REACTIONS OBSERVED IN THE FLIES SEEM TO BE INBORN OR LEARNED? (12) HOW COULD YOU DETERMINE WHETHER THE REACTIONS EXHIBITED BY THE FRUIT FLIES ARE LEARNED OR INBORN? (13)

PART B - FOOD REACTIONS OF A CATERPILLAR

ON A PIECE OF PAPER MARKED WITH A 15-CM CIRCLE, ARRANGE FOUR ITEMS OF POSSIBLE FOODS OF THE CATERPILLAR AT OPPOSITE POINTS AROUND THE CIRCLE. USE ONE PIECE OF A PLANT NORMALLY EATEN BY THE CATERPILLAR, AND THREE PIECES OF DIFFERENT PLANT MATERIALS KNOWN NOT TO BE A SOURCE OF FOOD FOR THIS INSECT. PLACE THE CATERPILLAR IN THE CENTER OF THE CIRCLE. HOW DOES THE CATERPILLAR MOVE IN RESPONSE TO THE PRESENCE OF ITS FOOD? (14) WHAT FACTORS PRESENT IN THIS EXPERIMENT TEND TO COMPLICATE THE RESULTS AND MAKE IT LESS ACCURATE? (15)

CONTINUE YOUR OBSERVATIONS BY ALTERING THE DISTANCES OF THE FOOD MATERIALS FROM THE CENTER OF THE CIRCLE IN ORDER TO DETERMINE THE DISTANCE THROUGH WHICH THE LARVA IS ABLE TO LOCATE ITS SPECIFIC FOOD. ROTATE THE POSITIONS OF THE VARIOUS FOOD MATERIALS DURING THE COURSE OF THE OBSERVATIONS. WHAT IS THE POINT OF DOING THIS? (16)

PREPARE A CHART WITH THE FOUR FOOD ITEMS LISTED ACROSS THE TOP AND THE DISTANCE FROM THE CENTER OF THE CIRCLE LISTED DOWN THE LEFT SIDE. RECORD THE NUMBER OF TIMES THE CATERPILLAR MOVES TO EACH FOOD SOURCE AND THE DISTANCES THROUGH WHICH IT MOVES.

WHEN THE LARVA CAN LOCATE ITS FOOD IN AT LEAST 80% OF THE TRIALS, ASSUME THAT DISTANCE TO BE OPTIMUM. WHAT IS THIS DISTANCE? (17)

IN NATURE, WHAT WOULD BE THE EFFECT OF REMOVING A CATERPILLAR A CONSIDERABLE DISTANCE FROM ITS FOOD SOURCE? (18)

HOW DO YOU SUPPOSE A CATERPILLAR LOCATES ITS FOOD - BY ITS ODOR, COLOR, OR SHAPE? ATTEMPT TO ANSWER THESE QUESTIONS BY THE FOLLOWING EXPERIMENTS.

<u>COLOR</u>. DYE THE PLANT MATERIALS DIFFERENT COLORS WITH FOOD COLORING AND ATTEMPT TO DETERMINE IF COLOR PLAYS AN IMPORTANT ROLE IN FOOD LOCATION. GIVE THE RESULTS OF THIS TEST. (19)

<u>ODOR</u>. TO DETERMINE IF ODOR PLAYS A PART, SOAK BITS OF THE PLANT FOOD MATERIAL IN LIQUID CHLORINE BLEACH OR RUBBING ALCOHOL TO DISGUISE THE NATURAL ODOR. YOU MIGHT TRY SEVERAL BRANDS OF STANDARD DEODORANTS. TRY DIPPING THE FOOD IN MELTED PARAFFIN. ARE ANY OF THESE METHODS OF ALTERING THE NORMAL ODOR OF THE PLANT SUCCESSFUL IN PREVENTING THE LARVA FROM LOCATING ITS FOOD? (20)

<u>SHAPE</u>. IS THE SHAPE OF THE FOOD MATERIAL OF POSSIBLE IMPORTANCE? DEVISE AN EXPERIMENT THAT WILL MEASURE THE CATERPILLAR'S ABILITY TO LOCATE ITS FOOD BY SIGHT ALONE, IRRESPECTIVE OF COLOR AND ODOR. DOES FOOD SHAPE SEEM TO DETERMINE THE WAY IN WHICH THE CATERPILLAR FINDS ITS FOOD? (21)

ON THE BASIS OF YOUR EXPERIMENT, DOES THIS PARTICULAR CATERPILLAR LOCATE ITS FOOD PRIMARILY BY ODOR OR SIGHT? (22) DO THESE EXPERIMENTS ADEQUATELY DEMONSTRATE THE METHOD BY WHICH THIS PARTICULAR CATERPILLAR IS ABLE TO LOCATE ITS FOOD? (23)

VERTEBRATE ZOOLOGY

ZOOLOGY
LEVEL: HIGH SCHOOL

ACTIVITY: CAPILLARY CIRCULATION

PURPOSE:

THE PURPOSE OF THIS EXERCISE IS TO SEE AND TO UNDERSTAND THE FUNCTION OF THE CAPILLARIES AS THAT PART OF THE CIRCULATORY SYSTEM WHERE EXCHANGES OF MATERIALS OCCUR BETWEEN THE BLOODSTREAM AND THE CELLS OF THE BODY.

MATERIALS:

GOLDFISH IN A BOWL OR AN AQUARIUM
HALF OF A PETRI DISH
TWO HALVES OF A MICROSCOPE SLIDE
MEDICINE-DROPPER PIPETTE
MILLIMETER RULER
DIP NET
TWO WADS OF ABSORBENT COTTON (ONE THIN AND ONE THICK)
COMPOUND MICROSCOPE OR STEREOSCOPIC DISSECTING MICROSCOPE

PROCEDURE:

SOAK THE THIN WAD OF COTTON AND SPREAD IT ON THE BOTTOM OF THE PETRE DISH TOWARD ONE END. AT THE OTHER END PLACE THE HALF-SLIDE.

SOAK THE THICK WAD OF COTTON IN WATER AND HAVE IT READY FOR THE NEXT STEP.

USING YOUR NET, REMOVE THE FISH FROM THE WATER. PLACE IT IN THE PETRI DISH IN SUCH A POSITION THAT ITS HEAD AND BODY LIE ON THE MOIST COTTON AND ITS TAIL ON THE HALF-SLIDE.

NOW PLACE THE THICK, SOAKED WAD OF COTTON OVER THE BODY OF THE FISH, AND THE OTHER HALF-SLIDE OVER THE TAIL SO THAT THE TAIL IS SANDWICHED BETWEEN THE TWO.

IF THE FISH FLIPS ITS TAIL OUT, AS IT MAY, SIMPLY PUT IT BACK BETWEEN THE GLASS SLIDES. YOU MAY HAVE TO DO THIS MORE THAN ONCE DURING THIS STUDY. ALSO YOU WILL HAVE TO REMEMBER FROM TIME TO TIME TO PLACE A FEW DROPS OF WATER (USING THE MEDICINE DROPPER) ON THE COTTON TO KEEP IT MOIST CONSTANTLY.

REMOVE THE CLIPS FROM THE STAGE OF YOUR MICROSCOPE AND THEN PLACE THE PETRI DISH ON THE STAGE SO THAT THE FISH'S TAIL IS OVER THE HOLE IN THE STAGE.

FOCUS THE MICROSCOPE ON THE TAIL. THEN MOVE THE DISH AROUND UNTIL YOU FIND A PART OF THE TAIL IN WHICH YOU CLEARLY SEE THE CAPILLARIES AND FLOWING BLOOD. THE CAPILLARIES ARE THE SMALLEST IN DIAMETER OF THE BLOOD VESSELS YOU CAN SEE HERE.

LOOK FOR A SMALL ARTERY (ARTERIOLE) AT A POINT WHERE IT DIVIDES. THE TWO FORKS OF THIS DIVISION ARE THE CAPILLARIES. MEASURE THE DIAMETER OF THE ARTERIOLE, AND RECORD. (1) MEASURE THE DIAMETER OF EACH OF THE CAPILLARIES COMING FROM THE ARTERIOLE AND RECORD EACH. (2) IS THE SUM OF THE DIAMETERS OF THE CAPILLARIES GREATER OR LESS THAN THE DIAMETER OF THE ARTERIOLE FROM WHICH THEY AROSE? (3) IN WHICH VESSELS WOULD THERE BE THE GREATEST AMOUNT OF SURFACE FOR THE VOLUME OF BLOOD FLOWING THROUGH, IN THE ARTERIOLE OR IN THE CAPILLARIES THAT SPRING FROM IT? (5) ON THE BASIS OF THESE MEASUREMENTS AND YOUR OBSERVATIONS, WOULD YOU EXPECT THE BLOOD TO BE FLOWING MORE SLOWLY OR MORE RAPIDLY IN CAPILLARIES THAN IN ARTERIOLES FROM WHICH THE CAPILLARIES ARISE? (6) DO YOUR OBSERVATIONS BEAR OUT YOUR CONCLUSION IN QUESTION 6? (7)

THE SMALL OBJECTS WHICH YOU SEE MOVING THROUGH THE CAPILLARIES ARE RED BLOOD CELLS. WHAT IS THEIR SHAPE? (8) HOW MANY OF THEM CAN PASS SIDE BY SIDE THROUGH THE CAPILLARIES? (9) CAN YOU FORMULATE A HYPOTHESIS TO ACCOUNT FOR ANY ADVANTAGE TO THE ANIMAL IN HAVING THE RED BLOOD CELLS PASS THROUGH THE CAPILLARY AS THEY DO? (10)

TRACE A CAPILLARY IN THE DIRECTION OF THE BLOOD FLOW UNTIL IT JOINS WITH ANOTHER ONE TO FORM A SLIGHTLY LARGER VESSEL (VENULE). MEASURE THE LENGTH OF A TYPICAL CAPILLARY, AND RECORD. (11) DOES THE BLOOD MOVE MORE RAPIDLY OR LESS RAPIDLY AFTER IT FLOWS FROM THE CAPILLARIES INTO A LARGER VENULE? (12) IS THE DIAMETER OF THE VENULE THE SAME OR DIFFERENT FROM THE DIAMETER OF THE ARTERIOLE FROM WHICH THE CAPILLARIES ARISE? (13)

WHY IS IT ADVANTAGEOUS THAT THE CAPILLARIES HAVE AS THIN WALLS AS POSSIBLE? (14) WOULD YOU EXPECT MUCH EXCHANGE BETWEEN RED BLOOD CELLS AND THE BODY CELLS IN ARTERIES OR VEINS? WHY? (15)

MEASURE THE DISTANCE BETWEEN CAPILLARIES IN THE TAIL. WOULD-YOU ASSUME THAT METABOLISM IS AS HIGH IN THE FISH'S TAIL AS IT WOULD BE, FOR EXAMPLE, IN SOME OF THE BODY MUSCLES? WHY? (16) IN VIEW OF YOUR ANSWER TO QUESTION 16, WOULD YOU ASSUME THAT CAPILLARIES WOULD BE CLOSER TOGETHER IN MUSCLE THAN IN THE TAIL REGION YOU ARE OBSERVING? (17) WHAT CHARACTERISTIC OF RAW MAMMALIAN MEAT (MUSCLE) IN GERNERAL WOULD LEAD YOU TO BELIEVE YOUR ANSWER TO QUESTION 17 RELATES TO MUSCLES IN ANIMALS OTHER THAN FISH? (18)

ZOOLOGY
LEVEL: HIGH SCHOOL

ACTIVITY: EFFECT OF TEMPERATURE ON GOLDFISH RESPIRATION RATE

PURPOSE:

TO DETERMINE THE INFLUENCE OF WATER TEMPERATURE ON THE RESPIRATION RATE OF GOLDFISH. COLD-BLOODED ANIMALS ARE LITERALLY AT THE MERCY OF THEIR ENVIRONMENT. LOWERING OF THE BODY TEMPERATURE IN RESPONSE TO REDUCED TEMPERATURE OF THE ENVIRONMENT MAY RESULT IN THE CRYSTALLIZATION OF PROTEINS IN THE BLOOD, RESULTING IN DEATH. AN INCREASE IN BODY TEMPERATURE MAY SPEED UP METABOLISM TO SUCH AN EXTENT THAT THE TISSUES ARE LITERALLY BURNED UP.

EFFECT OF WATER TEMPERATURE ON THE RESPIRATION RATE OF THE GOLDFISH.

THE RESPIRATORY CYCLE IN THE FISH IS ACCOMPLISHED WHEN THE WATER, LADEN WITH OXYGEN, ENTERS THE MOUTH AND IS FORCED OUT OVER THE GILL FILAMENTS WHEN THE MOUTH IS CLOSED. THE OXYGEN DISSOLVED IN THE WATER ENTERS THE CAPILLARIES, AND THE EXCESS CARBON DIOXIDE IN THE CAPILLARIES IS RELEASED INTO THE WATER. THE OPERCULUM OPENS TO ALLOW THE CARBON-DIOXIDE LADEN WATER TO LEAVE THE GILL CHAMBER, THUS COMPLETING THE RESPIRATORY CYCLE. THEREFORE, THE COUNTING OF THE MOVEMENTS OF THE OPERCULUM IS ONE METHOD OF COMPUTING THE RESPIRATORY RATE OF THE GOLDFISH.

MATERIALS:

ONE HALF GALLON MILK CARTONS CUT IN HALF LENGTH WISE.
GOLDFISH; THERMOMETER THAT CAN BE IMMERSED IN WATER; CRUSHED ICE, TIMING DEVICE; WARM WATER.

PROCEDURE AND OBSERVATIONS:

PUT A GOLDFISH IN A MILK CARTON WITH SUFFICIENT WATER TO COVER THE DORSAL FIN. PUT A THERMOMETER AT ONE EDGE OF THE AQUARIUM SO YOU CAN READ IT WITHOUT DISTURBING THE FISH.

IN ORDER TO REDUCE THE SHOCK FACTOR AND AVOID EXCITING THE FISH, ADD CRUSHED ICE SLOWLY TO THE AQUARIUM. CONTINUE TO ADD THE ICE UNTIL THE WATER TEMPERATURE IS REDUCED TO NEAR FREEZING.

NOW OBSERVE THE MOVEMENT OF THE OPERCULUM COVERING THE GILLS. USE YOUR TIMING DEVICE AND COUNT THE MOVEMENTS OF THE OPERCULUM AT THE LOWEST TEMPERATURE FOR ONE MINUTE. RECORO THIS RATE IN THE TABLE PROV DED.

SLOWLY ADD WARM WATER TO THE AQUARIUM AT THE END OPPOSITE THE THERMOMETER. REMOVE SOME OF THE WATER ANO ICE SO THAT THE WATER VOLUME REMAINS CONSTANT. AVOID EXCITING THE FISH WHEN YOU ARE ADDING THE WATER. (A) EXPLAIN WHY THIS IS NECESSARY.______________

______________________________ CONTINUE TO ADD WARM WATER UNTIL A FIVE-DEGREE RISE IN TEMPERATURE OCCURS. WAIT A FEW SECONDS FOR THE FISH TO ADJUST TO THE CHANGE, THEN COUNT AND RECORD THE RATE OF OPERCULUM MOVEMENT AT THIS TEMPERATURE. CONTINUE ADDING WARM WATER TO THE AQUARIUM, REMEMBERING THAT SOME WATER WILL HAVE TO BE REMOVED, AND RECORD THE RATE AT EACH FIVE-DEGREE TEMPERATURE INTERVAL UNTIL THE WATER TEMPERATURE REACHES 92°F. IF YOU USE A CENTIGRADE THERMOMETER, CONVERT THIS TEMPERATURE.

AFTER THE EXPERIMENT REMOVE THE GOLDFISH AND PLACE IT IN AN AQUARIUM AT ROOM TEMPERATURE AND WELL AERATED. CALCULATE THE AVERAGE RATE OF OPERCULUM MOVEMENT FOR THE GOLDFISH, RECORD IN THE TABLE PROVIDED, AND CONSTRUCT A GRAPH BASED ON THE AVERAGES.

(B) DISCUSS YOUR OBSERVATIONS OF THE FISH DURING THIS EXPERIMENT.

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(C) AT WHICH TEMPERATURE DID THE GREATEST NUMBER OF OPERCULUM MOVEMENTS OCCUR?______________________

DEGREES FAHRENHEIT	FISH #1	FISH #2	FISH #3	FISH #4	AVERAGE RATE
32					
37					
42					
47					
52					
57					
62					
67					
72					
77					
82					
87					
92					

INTERPRETATION:

WHAT IS THE RELATIONSHIP BETWEEN THE INCREASE IN WATER TEMPERATURE AND RESPIRATION RATE IN THE GOLDFISH?______________

LIST THE FACTORS WHICH, IN ADDITION TO WATER TEMPERATURE, COULD INFLUENCE THE RESPIRATION RATES IN YOUR GOLDFISH. __________

____

EXPLORE OTHER FACTORS SUCH AS THE EFFECT OF HEAT OR EXTREMELY COLD TEMPERATURES ON THE ENZYMES INVOLVED IN RESPIRATION, OR THE EFFECT OF OXYGEN STARVATION ON INTERNAL TISSUES OF THE FISH.

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FISH ARE ADAPTED FOR AN AQUATIC LIFE AND LIVE IN BOTH WARM AND COLD WATERS. IN TERMS OF YOUR RESULTS, DISCUSS HOW THE RESPIRATION RATES OF FISH IN THESE ENVIRONMENTS COULD VARY.

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ZOOLOGY
LEVEL: HIGH SCHOOL

ACTIVITY: STUDY OF POPULATIONS

MATERIALS: GRAPH PAPER

PROCEDURE:

THE FOLLOWING GRAPHS COULD BE USED AS AN EXERCISE IN GRAPHING OR TO STUDY THE GROWTH OF POPULATIONS.

DATA ON THE POPULATION OF PHEASANTS ON PROTECTION ISLAND

YEAR	POPULATION SIZE IN SPRING	POPULATION SIZE IN FALL
1937	8	40
1938	30	100
1939	90	425
1940	300	825
1941	600	1520
1942	1325	1900

RING-NECK PHEASANTS WERE INTRODUCED ON PROTECTION ISLAND, OFF THE COAST OF WASHINGTON STATE, IN 1937. COUNTS OF THE POPULATION WERE MADE EACH SPRING AND FALL FOR THE NEXT FIVE YEARS. PLOT THE DATA ON GRAPH PAPER. HOW CAN YOU EXPLAIN THE REGULAR FLUCTUATIONS SHOWN ON YOUR GRAPH? NOW, USING A PENCIL OF A DIFFERENT COLOR, CONNECT ALL THE POINTS REPRESENTING SPRING COUNTS, SKIPPING THE FALL COUNTS. WHAT DOES THIS TELL YOU ABOUT THE POPULATION? REMEMBERING THAT THIS IS A NATURAL POPULATION, WHAT DO YOU THINK THE COUNTS AFTER 1942 MIGHT HAVE SHOWN IF THEY HAD BEEN MADE?

DATA ON A POPULATION OF ENGLISH FIELD MICE IN A WOODS NEAR OXFORD, ENGLAND.

MONTHS	AVERAGE NUMBER OF MICE CAUGHT PER 100 TRAPS PER NIGHT
MAY 1927	1
JUNE	1.3
JULY	2.3
AUGUST	3
SEPTEMBER	6.5
OCTOBER	3.2
NOVEMBER	2.5
DECEMBER	2.3
JANUARY 1928	6
FEBRUARY	5.5
MARCH	5
APRIL	5.7

PLOT THE DATA ON GRAPH PAPER USING A VERTICAL SCALE.

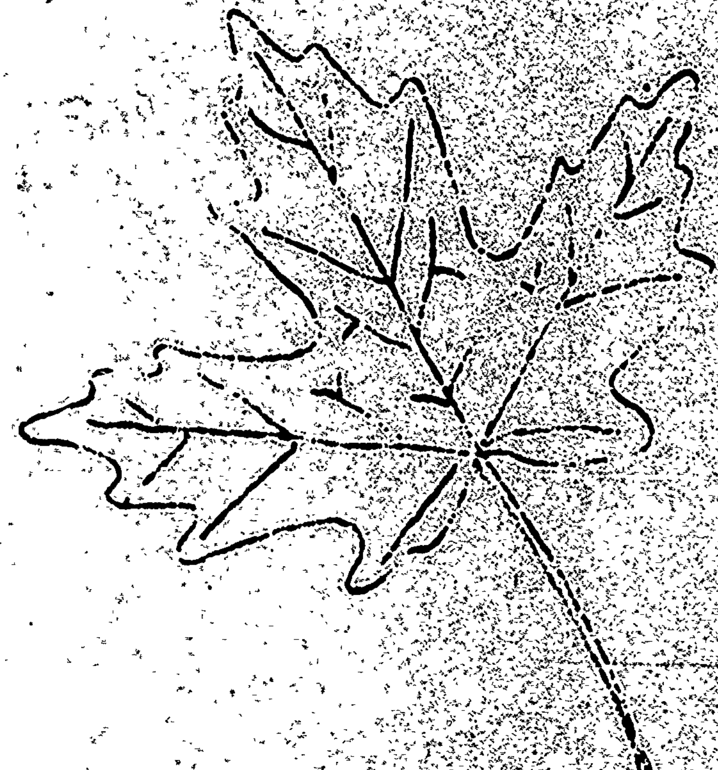
Days	Population Of colony (in thousand)
0	1
7	1.5
14	2.5
21	4
28	8
35	16
42	22
49	32
56	40.5
63	50.3
70	55
77	62.5
84	72
91	72.5
98	71
105	82
112	78
119	81

DATA ON THE POPULATION IN A COLONY OF BEES

PLOT THE DATA ON GRAPH PAPER

WHY WOULD PEOPLE IN MOST AREAS OF BIOLOGY NEED TO HAVE AN UNDERSTANDING OF GRAPHING AND POPULATIONS?

BOTANY



BIOLOGY - BOTANY

Architects
Biologist
Dietitians
Landscape Architect
Oceanographer
Elementary Teacher
Technical Writer
Radiology
Agriculture Extension Worker
Farm Crop Production Technician
Fish & Wildlife Technician
Forester
Livestock Production Technician
Horticulturist
Range Management
Soil Scientist
Carpenter

Biochemistry
Chemist
Home Economist
Life Scientist
Recreation Leader
Teacher secondary-college
Veterinarian
Agribusiness Technicians
Dairy Production Technician
Farming
Fish Culture Technician
Forestery Production Technician
Orchard Technician
Parks Land Management Technician
Soil Conservationist
Food Processing Technician

BOTANY
LEVEL: JUNIOR HIGH

ACTIVITY: ACTIVITIES WITH GROWING PLANTS AROUND HOME.

TO THE TEACHER: THIS ACTIVITY IS TO PROVIDE STUDENTS AN OPPORTUNITY TO EXPLORE WITH DIFFERENT PROBLEMS WHICH COULD ARISE FROM GROWING HOUSE PLANTS. STUDENTS NEED TO PREPARE A RECORDING CHART IN A NOTEBOOK SO THEY CAN WRITE THEIR OBSERVATIONS AS THIS PROJECT IS CARRIED ON. ENCOURAGE STUDENTS TO WRITE WHY SOMETHING HAPPENS RATHER THAN JUST RECORDING OBSERVATIONS. MANY REGULAR ACTIVITIES IN CLASSROOM BOTANY CAN BE TIED INTO THIS PROJECT.

PROCEDURE:

HAVE EACH STUDENT BRING A PLANT FROM HOME, GROW A PLANT FROM SEEDS, BRING AN ONION, CARROT OR SWEET POTATO THAT CAN GROW IN WATER. EACH STUDENT SHOULD PROVIDE A CONTAINER AND PLANT. THE TEACHER SHOULD HAVE SOIL AVAILABLE FOR THOSE WHO DO NOT HAVE IT. STUDENTS SHOULD, WITH A PIECE OF MASKING TAPE, PUT THEIR NAMES ON THE CONTAINERS. STUDENTS SHOULD RECORD STARTING CONDITIONS IN THEIR NOTEBOOKS.

ACTIVITIES THAT YOU CAN DO WITH THIS PLANT INCLUDE:

PART 1: CONDITIONS NECESSARY FOR GROWTH OR GERMINATION.

OBSERVE HOW STUDENTS WILL WATER PLANTS AND COMPARE THE DIFFERENT EFFECTS IT HAS ON THE PLANTS. SOME MAY WANT TO TRY GROWING THEM DARK TO SEE WHAT EFFECT THIS HAS. SOME WILL ALSO WANT TO USE ARTIFICIAL LIGHT WHERE OTHERS WILL WANT TO USE A WINDOW SILL TO GET SUNLIGHT. ALL OF THESE OBSERVATIONS CAN LEAD TO GOOD DISCUSSION AS TO WHAT CAUSED THE DIFFERENCES. RECORD ALL OBSERVATIONS.

PART 2:

BUY A COMMERCIAL PLANT FERTILIZER FROM A GARDEN STORE. FOLLOW THE DIRECTIONS ON THE CONTAINER AND MIX UP SOME FERTILIZER AND LET SOME EXPERIMENT BY PUTTING FERTILIZER ON THEIR HOUSE PLANTS. OBSERVE THE DIFFERENCES. STUDENTS COULD TRY DIFFERENT AMOUNTS EACH WEEK TO SEE WHAT HAPPENS. THE TEACHER SHOULD HAVE A PLANT WHICH COULD BE USED AS A CONTROL OR POSSIBLY SOME WON'T WANT TO USE PLANT FOOD. RECORD AND DISCUSS OBSERVATIONS.

PART 3: CUTTINGS AND ROOTING HORMONES

HAVE STUDENTS TAKE SEVERAL CUTTINGS FROM THEIR PLANT TO POSSIBLY ROOT NEW PLANTS. THE TEACHER SHOULD HAVE SOME PLANTS AVAILABLE FOR CUTTINGS IF SOME STUDENTS PLANTS HAVE DIED OR DO NOT WANT TO LEND TO MAKE CUTTINGS. THE CLASS THEN CAN TEST EFFECTS OF COMMERCIAL ROOTING HORMONES WHICH ARE FOUND IN GARDEN SUPPLY STORES. TREAT SOME OF THE CUTTINGS WITH A HORMONE LEAVING SOME AS IS. PLANT BOTH THE TREATED AND UNTREATED CUTTINGS IN WET SOIL. EXAMINE THEM WEEKLY FOR ROOT DEVELOPMENT AND RECORD THE OBSERVATIONS IN THE STUDENTS' NOTEBOOKS.

PART 4: RESPONSE TO PRUNING

HAVE STUDENTS SELECT ABOUT ONE HALF OF THE BRANCHES OF THEIR PLANT AND CUT THE TIPS OFF. LEAVE THE OTHER BRANCHES UNTREATED. OBSERVE, COUNT ALL THE BRANCHES AND MAKE DRAWINGS OF OBSERVATIONS. DESCRIBE THE EFFECT OF REMOVING THE TIPS FROM BRANCHES. DISCUSS WHAT IS THE ADVANTAGE OF PRUNING HOUSE PLANTS.

PART 5: TRANSPLANTING

HAVE STUDENTS TRANSPLANT THEIR PLANTS FROM ONE CONTAINER TO ANOTHER. OBSERVE WHAT HAPPENS TO PLANTS. WHY IS A LOT OF WATER NECESSARY IN THE NEW CONTAINER? EXPLAIN CHANGES IN THE PLANT.

BOTANY
Level: Junior High & Above

ACTIVITY: Trees and Their Importance

Materials: Identification of trees, booklets (County Agent & Forest Service have many good aids)
Ink print replicas of tree leaves
Meterstick
Tape measure
String

Introduction:

Trees are found everywhere. We think of trees as plants that give us shade and add beauty to our environment. We often forget that they are plants that obtain maximum growth in a given number of years, after which growth is slow and ends in decay and death. Have the class list all the uses for wood that they know. What parts or percentage of their home or school is constructed of wood or wood by-products? It has been estimated that 36 billion board feet of lumber are used each year. This will, of course, increase with population increases. Does this mean we will run out of trees? If it was necessary, how much could your city property contribute to satisfy this demand? How much income could this add to your city? What kind of program could be put into effect for harvesting and replenishing this resource? Use the following activity to see if you can answer these questions.

Procedure:

Divide your class into teams of 3-4. Have each team member select 4 or 5 leaf prints of trees found in your town. Pick a different area near school or home and ask each team to find the following information:

A. Name each tree found. (This is necessary as each type of wood has a different value per board foot). Each team member using his or her leaf replicas should be able to identify the tree. If a tree is found where identification cannot be made, leaves are collected and brought back to class for classification there.

B. Determine the diameter of the tree at 4 1/2 feet above the ground. With a tape measure or a string measure around the tree (circumference) and then figure diameter. (One-third of circumference for a rough estimate).

C. Determine the number of "saw logs" in each trunk. (A "saw log" is 16 feet long). This can be done by one member of the team standing by the tree and the other members standing a distance from the tree, and compare his height with the tree trunk.

D. Determine how many trees have lost their value for lumber because of old age and decay. How are these trees disposed of? Is this an added cost to the owner or city? Are there younger trees growing in the area to insure a continuing supply of shade and beauty?

E. Determine from the following table the number of board feet per species. Current lumber values, per board foot, can be obtained from a lumber dealer for each type of wood. Find the value of lumber found in your area.

Sum up your project by combining results of all teams, and propose a local harvesting - planting program.

Possible Recording Chart

Kind of tree & Location	Dia.	# of Saw logs	Board feet	Price per thousand board feet

Table to obtain Board Feet in a Tree:

1. Find column headed by tree diameter you estimated
2. Find line with number of saw logs you estimated
3. Read the number where the column and line intersects. This is the board-foot volume of the tree.

	Diameter	10	11	12	13	14	16	18	20	22	24	26	28	30
No. of Saw Logs	1	39	49	59	71	83	110	140	180	220	270	320	370	420
	1 1/2	51	64	78	96	112	150	200	250	300	370	440	510	590
	2	63	80	98	120	141	190	250	310	390	470	560	650	760
	2 1/2	72	92	112	138	164	220	290	370	460	560	660	780	900
	3			127	156	186	260	340	430	530	640	770	900	1050
	3 1/2					201	280	370	470	580	710	850	1000	1160

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BOTANY
Level: High School

ACTIVITY: Effects of Various Visible Light Wavelengths on the Growth of Green Plants

Problem:

Do seed plants grow better in one wavelength of light, or do they grow equally as well in all wavelengths? Basically, all wavelengths of the visible spectrum can be used in photosynthesis. You can experiment with the relative degree of effectiveness of the various visible light wavelengths on the growth of seed plants by covering green plants with sheets of colored cellophane.

Materials:

Healthy bean seedlings (4-in.)
Others may be substituted

Cellophane paper
(white or clear, red, blue, green).

Procedure:

Use four healthy potted bean or other seedlings. Wrap each of the seedlings with cellophane paper. Be sure to fasten the paper so that light from the outside does not reach the plant. Or cut the top and bottom out of milk cartons. Paste the cellophane over one end of the carton and cover the plant. The plant wrapped in clear cellophane acts as a control for the experiment. Place the covered plants in a well-lighted area of the room so that each one receives the same amount of light daily. Water the plants regularly and allow them to grow for one week. Examine the plants, observing the condition of the leaves and stems, their size, and intensity of chlorophyll. Prepare a table and record your results.

Remove a leaf from each of the plants, experimental and control. Use the iodine test to determine the difference in the amount of starch produced by each leaf. Account for any differences you found in starch production.

You might extend your experimentation to include an alga or submerged plant.

Analysis and Conclusions:

Discuss your results in terms of the ability of the plant to receive energy from the specific color and wavelength of radiation it was supplied in the experiment.

Why would the botanist or greenhouse operator need to understand the effect of light on plants?

BOTANY
LEVEL: HIGH SCHOOL

ACTIVITY: SEPARATION OF THE PIGMENTS THAT OCCUR IN LEAVES (PAPER CHROMATOGRAPHY)

PURPOSE:

IN THIS EXERCISE WE SHALL USE THE SIMPLEST KIND OF CHROMATOGRAPHY TO SEPARATE SOME OF THE PIGMENTS THAT OCCUR IN LEAVES.

MATERIALS AND EQUIPMENT (PER TEAM):

PAPER CLIP	ACETONE
CORK (TO FIT THE LARGER TEST TUBE)	MORTAR AND PESTLE
FILTER PAPER	CHEESECLOTH
SCISSORS	CLEANSING TISSUE
TEST TUBE, 25 X 200 MM	FUNNEL
SOLVENT (8% ACETONE, 92% PETROLEUM ETHER)	FUNNEL SUPPORT
TEST-TUBE RACK	TEST TUBE, 18 X 150 MM
SPINACH LEAVES	PENCILS, 2
FINE SAND	PIPETTE, WITH A VERY FINE TIP

PROCEDURE:

ASSEMBLE THE APPARATUS, BUT DO NOT ADD THE SOLVENT YET. BEND A PAPER CLIP INTO A LONG J AND FORCE INTO THE BOTTOM OF THE CORK. CUT A STRIP OF FILTER PAPER SO THAT ITS WIDTH IS SLIGHTLY LESS THAN THE INSIDE DIAMETER OF THE LARGER TEST TUBE. THE STRIP SHOULD ALMOST REACH THE BOTTOM OF THE TUBE. PLACE SEVERAL SPINACH LEAVES, A LITTLE FINE SAND, AND 5 ML OF ACETONE IN THE MORTAR AND GRIND.

USE CHEESECLOTH IN A FUNNEL. POUR FILTRATE INTO FUNNEL. COLLECT FILTRATE IN SMALL TEST TUBE. CAP WITH CORK.

SUPPORT THE STRIP OF FILTER PAPER ACROSS TWO PENCILS. USE THE TIP OF A PAPER CLIP TO PUT A DROP OF PIGMENT FILTRATE ON THE PAPER. PLACE A DROP OF FILTRATE ON FILTER PAPER.

HANG STRIP ON CORK AND PLACE INTO TEST TUBE WITH SOLVENT. DO NOT LET IT TOUCH GLASS. BE SURE SOLVENT IS BELOW THE FILTRATE SPOT. (1 CM BELOW).

WHEN THE UPPER EDGE OF THE SOLVENT ALMOST REACHES THE HOOK, REMOVE THE CORK (WITH THE FILTER PAPER ATTACHED) FROM THE TUBE AND HOLD IT UNTIL THE SOLVENT HAS DRIED.

STUDYING THE DATA:

(1) WHAT WAS THE COLOR OF THE FILTRATE? (2) IS THERE ANY EVIDENCE THAT MORE THAN ONE PIGMENT IS DISSOLVED IN THE ACETONE? (3) HOW MANY BANDS OF COLOR CAN YOU SEE? (4) WHY CAN'T YOU SEE THESE PIGMENTS IN THE LEAF? (5) SUGGEST A HYPOTHESIS TO EXPLAIN THE CHANGE OF COLOR THAT OCCURS WHEN A LEAF DIES? (6) HOW DO YOU KNOW THAT ALL THE PIGMENTS WERE SOLUBLE IN THE SOLVENT YOU USED? (7) FROM WHAT POINT DID ALL THE PIGMENTS START AS THE SOLVENT BEGAN TO RISE? (8) WHAT CAN YOU SAY ABOUT THE TIME IN WHICH ALL THE PIGMENTS WERE MOVING? (9) IN WHAT CHARACTERISTIC, THEN, MUST THE PIGMENTS HAVE DIFFERED?

FOR FURTHER INVESTIGATION, TRY 100% ACETONE AS A SOLVENT, 100% PETROLEUM ETHER AS A SOLVENT. USING SOME OF THE SOLVENTS LISTED ABOVE, TRY SEPARATING OTHER PIGMENTS, SUCH AS THOSE IN THE BLACK OR BLUE INKS OF BALL-POINT PENS.

BOTANY
LEVEL: HIGH SCHOOL

ACTIVITY: AN EXERCISE IN GRAFTING

PROCEDURE:

A TOMATO PLANT CAN BE GRAFTED ONTO A POTATO PLANT. FIRST, PLANT A PIECE OF IRISH POTATO, MAKING CERTAIN THAT THE PIECE HAS ONE OR MORE EYES, SO THAT IT WILL SPROUT. PLACE THE PIECE OF POTATO IN MOIST SOIL, WATERING, BUT NOT SOAKING, WHEN NECESSARY, WHEN THE POTATO HAS GROWN SO THAT THE STEM IS ABOUT PENCIL THICKNESS, AND HAS A GOOD ROOT SYSTEM, IT IS READY FOR GRAFTING.

IN THE MEANTIME, GROW A TOMATO PLANT OR YOU MIGHT GET ONE FROM A GREENHOUSE. CHOOSE A TOMATO PLANT THAT IS ABOUT THE SAME THICKNESS AS THE POTATO PLANT. SLICE A FOUR OR FIVE-INCH PIECE OF THE TOMATO PLANT OFF THE TOP. SLICE THE POTATO STEM DIAGONALLY WITH AN UPWARD SLICE, SO THAT IT MATCHES THE CUT MADE IN THE TOMATO STEM. REMOVE MOST OF THE LEAVES FROM THE TOMATO STEM TO PREVENT LOSS OF WATER. FIT THE PIECES TOGETHER, AND HOLD THEM TOGETHER BY MEANS OF A TOOTHPICK INSERTED LENGTHWISE IN THE STEM.

WRAP THE GRAFT LOOSELY WITH STRING. THE IDEA IS TO KEEP THE GRAFTED SECTIONS TOGETHER SO THAT THEY CAN HEAL. KEEP THE PLANT IN A SHADY SPOT UNTIL THE GRAFT HEALS, WHICH SHOULD BE ABOUT A WEEK. USE PLENTY OF WATER, BUT DO NOT SOAK THE SOIL. LEAVE THE BINDING MATERIAL AROUND THE GROWTH FOR ABOUT TEN TO FOURTEEN DAYS. IF YOU ARE CAREFUL TO POLLINATE THE BLOSSOMS OF THE TOMATO PLANT, YOU SHOULD BE ABLE TO HAVE BOTH TOMATOES AND A POTATO ON YOUR PLANT.

WHAT TYPE OF CAREERS WOULD YOU NEED TO KNOW HOW TO GRAFT PLANTS?

BOTANY
LEVEL: HIGH SCHOOL

ACTIVITY: HOW MOLECULES ENTER A ROOT

MATERIALS:		
	RING STAND	BATTERY JAR OR LARGE BEAKER
	GLASS TUBE	CORK BORER
	ONE HOLE CORK	PARAFFIN
	MOLASSES	CARROT

CELL WALLS ARE ON THE OUTSIDE OF PLANT CELLS. THEY ARE NOT SOLID WALLS, BECAUSE LIQUIDS CAN PASS THROUGH THEM. INSIDE THE CELL WALL IS A MEMBRANE. MOLECULES OF WATER, FOOD AND OTHER THINGS CAN PASS THROUGH, BUT MOST THINGS LARGER THAN MOLECULES CANNOT GET THROUGH.

DEMONSTRATION OR LAB ACTIVITY:

GET A LARGE, STRAIGHT CARROT. USING A CORK BORER REMOVE A CORE ABOUT ONE-HALF INCH IN DIAMETER FROM THE CENTER, GOING AS DEEP AS YOU CAN. FILL THE CAVITY ALMOST FULL WITH MOLASSES.

INSERT GLASS TUBING IN A ONE-HOLE STOPPER. THEN PUT THE STOPPER WITH THE TUBE FIRMLY INTO THE CORE OF THE CARROT. SEAL AROUND THE TOP OF THE STOPPER WITH MELTED PARAFFIN. (NOTE: IF THE CARROT HAS BEEN CLEANED SO THAT THE ROOTLETS ARE GONE, CUT OFF THE TIP.)

ATTACH THE TUBE TO A RING STAND WITH CLAMPS. NOW PUT A JAR UNDER THE CARROT AND FILL IT WITH WATER. MARK THE LEVEL IN THE TUBE EACH DAY FOR TWO OR THREE DAYS. HOW DOES THIS DEMONSTRATION SHOW WHAT HAPPENS TO WATER IN ROOTS?

WHY WOULD PEOPLE WORKING IN BOTANY NEED TO UNDERSTAND HOW MOLECULES BEHAVE?

HUMAN BIOLOGY

BIOLOGY - HUMAN BIOLOGY

ANATOMY:

- Physical Therapist
- Psychologist
- Practical Nurse
- Rehabilitation Counselor
- Singer
- Elementary Teacher
- Technical Writer
- Radiologist
- Astronaut
- Chemist
- Dental Hygenist
- Dietitians
- Life Scientist
- Medical Record Librarian
- Occupational Therapist
- Barber
- Fireman
- Model
- Stewardesses
- Dental Laboratory Technician
- Optical Mechanic
- Physician
- Recreation Leader
- Registered Nurse
- Restaurant Manager
- Speech Pathologist
- Teacher secondary-college
- X-Ray Technician
- Anthropology
- Biologist
- Dancing
- Dentist
- Home Economist
- Medical Lab Workers
- Medical Technologist
- Optometrist
- Cosmetologist
- Hospital Attendent
- Show Repairman
- Food Processing Technician
- Optician

PHYSIOLOGY:

- Physical Therapist
- Psychologist
- Practical Nurse
- Rehabilitation Counselor
- Singer
- Elementary Teacher
- Technical Writer
- Biochemistry
- Biologist
- Dentist
- Home Economist
- Medical Lab Workers
- Medical Technologist
- Optometrist
- Barber
- Cooks
- Hospital Attendent
- Stewardesses
- Dental Laboratory Technician
- Physician
- Recreation Leader
- Registered Nurse
- Restaurant Manager
- Speech Pathologist
- Teacher secondary-college
- Radiologist
- Chemist
- Dental Hygenist
- Dietitians
- Life Scientist
- Medical Record Librarian
- Occupational Therapist
- Pharamacist
- Cosmetologist
- Fireman
- Model
- Food Processing Technician

HUMAN BIOLOGY
LEVEL: JUNIOR HIGH

ACTIVITY: THE LIFE SCIENCE CAREERS IN MY AREA AND HOW IMPORTANT ARE THEY.

MATERIALS: PICTURES OF PEOPLE IN LIFE SCIENCE CAREERS
SCISSORS
DATA SHEET

INTRODUCTION: ALL OF US HAVE CERTAIN IDEAS ABOUT PEOPLE: WHAT THEY ARE LIKE, WHAT THEY CAN DO, IF THEY ARE IMPORTANT OR HELPFUL. DO YOU THINK YOUR IDEAS HAVE OR WILL CHANGE ABOUT PEOPLE? IN THIS ACTIVITY YOU CAN DISCOVER WHAT PEOPLE THINK ABOUT THE IMPORTANCE OF LIFE SCIENCE CAREERS IN YOUR AREA. (THIS ACTIVITY CAN BE RELATED TO ALL CAREERS.)

PROCEDURE:

HAVE STUDENTS IDENTIFY WHAT THEY BELIEVE ARE LIFE SCIENCE OCCUPATIONS IN THEIR COMMUNITY. AFTER THIS IS DONE, EACH STUDENT SHOULD DRAW OR CUT OUT PICTURES FOR 10 FLASH CARDS OF DIFFERENT OCCUPATIONS. THEN INTERVIEW PEOPLE TO GET THEIR VIEWS. BEFORE YOU START SHOWING THE PICTURES YOU SHOULD EXPLAIN TO THE PERSON YOU ARE TO INTERVIEW WHAT YOU ARE GOING TO DO. MAKE SURE THEY UNDERSTAND BEFORE YOU START. GIVE HIM OR HER A COPY OF THE DATA SHEET (SEE EXAMPLE). HAVE EACH PERSON RANK EACH OCCUPATION AS: (1) NOT AL ALL IMPORTANT; (2) NOT VERY IMPORTANT; (3) IN THE MIDDLE; (4) IMPORTANT; (5) VERY IMPORTANT; AND MARK THEIR DECISION ON THE DATA SHEET. BE SURE THE PERSON YOU INTERVIEW FILLS IN THE INFORMATION ON AGE AND SEX ON THE DATA SHEET. YOU WILL WANT TO INTERVIEW ALOT OF PEOPLE FROM A WIDE RANGE OF AGE GROUPS.

INTERPRETATIONS:

FIRST PLAN HOW YOU WILL ORGANIZE YOUR DATA. YOU MAY WANT TO ORGANIZE IT BY AGE GROUPS OR ADULTS AND STUDENTS OR BOYS, GIRLS, MEN AND WOMEN, ETC. COMPARE YOUR RESULTS. USE YOUR IMAGINATION. TRY TO THINK OF DIFFERENT WAYS TO COMPARE THE RESULTS. CAN YOU MAKE A BULLETIN BOARD DISPLAY OF THE SURVEY RESULTS? DO PEOPLE'S FEELINGS ABOUT PEOPLE CHANGE AS THEY GROW OLDER? DO BOY'S FEELINGS DIFFER FROM THOSE OF GIRLS? DO MEN'S FEELINGS DIFFER FROM THOSE OF WOMEN?

POSSIBLE LIFE SCIENCE CAREERS IN MOST COMMUNITIES:

PHYSICIAN	DAIRY FARMER
NURSE	MEAT CUTTER
BIOLOGY TEACHER	FARMER
DIETITIONS	RANCHER
OPTOMETRIST	VETERINARIANS
DENTIST	FISH & WILDLIFE BIOLOGIST
BARBER	RECREATION LEADER
COSMOTOLOGIST	MEDICAL LAB TECHNICIAN
FORESTER	FEED LOT MANAGER
HORTICULTURIST	RANGE MANAGER

EXAMPLE DATA SHEET

SEX ______ AGE ______	NOT AT ALL IMPORTANT	NOT VERY IMPORTANT	IN THE MIDDLE	IMPORT-ANT	VERY IMPORT-ANT
OCCUPATION					
1. FARMER					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					

HUMAN BIOLOGY
LEVEL: JUNIOR HIGH

ACTIVITY: HOW CAN WE TEST FOODS FOR NUTRIENTS?

MATERIALS:

POTATO	MEDICINE DROPPER
SODA CRACKER	SCALPEL
BREAD	TEST TUBES
KARO SYRUP	TEST TUBE HOLDER
MILK	GRADUATE
APPLE	BENEDICT'S SOLUTION
	WATER BATH

PROCEDURE: (STARCH TEST).

A. CUT A POTATO AND USE A SCALPEL TO GET SOME POTATO SCRAPINGS. PLACE A LEVEL TEASPOONFUL OF SCRAPINGS IN A TEST TUBE.

B. WITH A MEDICINE DROPPER, ADD JUST ENOUGH DILUTE IODINE SOLUTION TO COVER THE POTATO SCRAPINGS IN THE TEST TUBE. WAIT ABOUT 1 MINUTE AND THEN POUR OUT THE LIQUID AND OBSERVE WHAT HAS HAPPENED TO THE SCRAPINGS. RECORD YOUR OBSERVATION IN YOUR NOTEBOOK.

C. DO STEP B AGAIN USING THE FOLLOWING FOODS: 1/2 SODA CRACKER, 10 ML OF MILK, SMALL PIECE OF BREAD, LEVEL TEASPOON OF APPLE SCRAPINGS, 5 ML OF SYRUP. BE SURE TO USE A CLEAN TEST TUBE OR WASH YOUR TEST TUBE WELL AFTER USING EACH FOOD. RECORD YOUR OBSERVATIONS.

(SUGAR TEST)

D. USING A GRADUATE CYLINDER, MEASURE OUT 5 ML OF WHITE KARO SYRUP AND POUR IT INTO A TEST TUBE. ADD 5 ML OF BENEDICT'S SOLUTION.

E. PLACE THE TEST TUBE IN A BOILING WATER BATH.

F. AS SOON AS A DEFINITE COLOR CHANGE OCCURS, REMOVE THE TEST TUBE FROM THE BEAKER. A COLOR CHANGE TO GREEN, YELLOW OR RED INDICATES SUGAR IS PRESENT. TEST THE OTHER FOODS THE SAME WAY AND RECORD RESULTS IN YOUR NOTEBOOK.

INTERPRETATIONS:

1. DOES A POTATO CONTAIN STARCH? IF SO, HOW DO YOU KNOW?

2. DOES KARO SYRUP CONTAIN SUGAR? IF SO, HOW DO YOU KNOW?

3. IF YOU HAD SOMEONE IN YOUR HOME WHO COULD NOT EAT STARCH, HOW COULD YOU TELL IF A CERTAIN FOOD COULD BE EATEN BY THAT PERSON?

4. TO WHAT MAIN GROUP OF NUTRIENTS DO SUGAR AND STARCH BELONG?

HUMAN BIOLOGY
LEVEL: JUNIOR HIGH

ACTIVITY: DOES SALIVA HAVE AN AFFECT ON STARCH?

MATERIALS: (PER TEAM)

DIALYSIS MEMBRANE	WATER BATH
STARCH SOLUTION	TEST TUBE
IODINE SOLUTION	TEST TUBE HOLDER
BENEDICTS SOLUTION	MEDICINE DROPPERS
STRING	RUBBER BAND

TO THE TEACHER: THIS ACTIVITY CAN BE USED WITH A UNIT ON FOODS AND NUTRITION TO SHOW WHY FOOD HAS TO BE BROKEN DOWN. STUDENTS SHOULD BE ABLE TO TEST FOR SUGAR AND STARCH BEFORE THIS ACTIVITY IS RUN. STARCH SOLUTION SHOULD BE PREPARED BY ADDING 5 G. OF STARCH TO 500 ML OF WARM WATER. STIR THOROUGHLY, AND HEAT UNTIL THE CLOUDY MIXTURE BEGINS TO CLEAR, ONE SHOULD EXPLAIN HOW THE MEMBRANE IS THE SAME AS A CELL IN THE BODY.

PROCEDURES (DAY 1):

A. TEST 5 ML OF STARCH SOLUTION FOR SUGAR, USING 5 ML OF BENEDICT'S SOLUTION. RECORD RESULTS IN YOUR NOTEBOOK. TEST 3 ML OF SALIVA FOR SUGAR, USING 3 ML OF BENEDICT'S SOLUTION. RECORD RESULTS.

B. SECURELY TIE ONE END OF THE DIALYSIS MEMBRANE. PREPARE A MIXTURE CONTAINING 10 ML OF STARCH SOLUTION AND 4 ML OF SALIVA. CAREFULLY POUR THE MIXTURE INTO THE DIALYSIS MEMBRANE. RINSE THE OUTSIDE OF THE MEMBRANE WITH CLEAN WATER.

C. PLACE THE MEMBRANE IN A TEST TUBE, OR SMALL BEAKER. SUPPORT THE MEMBRANE BY FOLDING ITS UNTIED END OVER THE EDGE OF THE TEST TUBE. FASTEN WITH A RUBBER BAND. MAKE SURE THE CONTENTS DO NOT SPILL OUT THROUGH THE UNTIED END. FILL THE TEST TUBE OR BEAKER WITH WATER.

D. NEAR THE END OF THE CLASS PERIOD, REMOVE (WITH A MEDICINE DROPPER) ABOUT 3 ML OF THE MIXTURE FROM INSIDE THE MEMBRANE. TEST THIS SAMPLE FOR THE PRESENCE OF SUGAR AND STARCH, AND RECORD RESULTS ON YOUR CHART. WITH A CLEAN MEDICINE DROPPER, REMOVE ABOUT 3 ML OF WATER FROM THE TEST TUBE (OUTSIDE THE MEMBRANE), AND TEST FOR STARCH AND SUGAR. RECORD RESULTS. LEAVE THE DIALYSIS MEMBRANE IN THE CONTAINER OF WATER UNTIL THE NEXT DAY.

PROCEDURE (DAY 2):

AT THE BEGINNING OF THE PERIOD, REPEAT PROCEDURE D. RECORD RESULTS IN YOUR NOTEBOOK.

INTERPRETATIONS:

1. WHAT EFFECT DID THE SALIVA SEEM TO HAVE ON STARCH?

2. WHY DO YOU THINK IT IS IMPORTANT FOR FOOD TO BE DIGESTED INTO SMALL PARTICLES?

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HUMAN BIOLOGY
LEVEL: 7TH-10TH

ACTIVITIES:

A. MAPPING THE TASTE RECEPTORS IN THE TONGUE

CERTAIN PARTS OF THE TONGUE ARE SENSITIVE TO CERTAIN KINDS OF TASTES. THESE FOUR TASTES ARE SALTY, SWEET, SOUR, AND BITTER. YOU CAN MAP THESE AREAS ON THE TONGUE BY PLACING A SMALL AMOUNT OF DIFFERENT TASTING SUBSTANCES ON A FRIEND'S TONGUE AND NOTING THE AREAS WHERE HE TASTES THE SUBSTANCE.

FIRST, USE A SOLUTION OF VINEGAR IN WATER. APPLY THE SOLUTION TO THE BACK, SIDES AND TIP OF THE TONGUE WITH A SMALL BRUSH, GLASS ROD, OR TOOTHPICK. ASK YOUR FRIEND TO TELL YOU WHEN HE TASTES SOMETHING. NEXT, TRY A 10 PER CENT SOLUTION OF SALT. FOLLOW WITH ASPIRIN IN WATER FOR BITTER TASTE AND A 15 PER CENT SOLUTION OF CANE SUGAR FOR THE SWEET TASTE. SHADE IN THE AREAS IN WHICH TASTE RECEPTORS ARE PRESENT FOR EACH SUBSTANCE. BE SURE HE RINSES HIS MOUTH WITH WATER BETWEEN EACH TASTE TEST. COMPARE YOUR RESULTS WITH THOSE OF YOUR CLASSMATES.

B. HOW DO THE SENSES OF SIGHT AND SMELL AFFECT THE SENSE OF TASTE?

CHOOSE FIVE FOODS THAT HAVE DISTINCT SMELLS AND TRY TO IDENTIFY THEM WITH YOUR EYES CLOSED AND HOLDING YOUR NOSE. DESCRIBE YOUR RESULTS BELOW.____

____

C. HABITS

HAVE A FELLOW STUDENT DICTATE THE FOLLOWING PARAGRPPH TO YOU WHILE YOU COPY IT AS FAST AS YOU POSSIBLY CAN ON ANOTHER SHEET OF PAPER.

> "THE TERRIBLE TANAWANDA INDIANS ENTERED THEIR TEPEES WITH TERRIFIC HASTE. IT IS CERTAIN THAT THEY HAVE NO FIXED PATTERNS OF BEHAVIOR OR THEY WOULD NOT HAVE DONE SO WITH SUCH A STARTLING NOISE."

RECORD THE TIME IT TOOK YOU TO WRITE THE ABOVE PARAGRAPH__________

NOW HAVE THE STUDENT DICTATE THE PARAGRAPH AGAIN, BUT THIS TIME DO NOT CROSS ANY T OR DOT ANY I. TRY TO COPY THE PARAGRAPH AS QUICKLY AS POSSIBLE.

RECORD THE TIME IT TOOK YOU TO WRITE THE ABOVE PARAGRAPH.______

RECORD THE NUMBER OF DOTTED I'S AND CROSSED T'S.____________

WHAT WERE YOU FORCING YOURSELF TO DO THE SECOND TIME YOU WROTE THE PARAGRAPH (IN TERMS OF HABIT)? ______________________________

____

WHAT IS THE VALUE OF THIS HABIT?________________________________

____

D. REFLEX ACTION

SIT WITH ONE LEG CROSSED LOOSELY OVER THE OTHER. STRIKE YOUR LEG JUST BELOW THE KNEECAP WITH THE EDGE OF YOUR HAND. A REFLEX ACTION WILL CAUSE YOUR LEG TO JERK UP. TRY IT ON YOUR CLASSMATES ALSO.

E. SENSATION IN THE SKIN

PROBLEM:

WE KNOW THAT THE SENSE OF TOUCH IS LOCATED IN THE SKIN. BUT THERE ARE NERVE ENDINGS FOR OTHER SENSATIONS THAN TOUCH IN THE SKIN. WHERE ARE SOME OF THE DIFFERENT NERVE ENDINGS LOCATED IN THE SKIN?

MATERIALS: STRAIGHT PINS	CORK
NAILS	ICE
HOT WATER	

PROCEDURE:

PUSH TWO PINS THROUGH A CORK SO THAT THE POINTS STICK OUT ABOUT 1/4 INCH APART. BLINDFOLD A STUDENT AND PRESS THE POINTS OF THE PINS LIGHTLY AGAINST THE SKIN ON THE FINGERS AND ON THE BACK OF THE HAND, BEING CAREFUL NOT TO CAUSE PAIN. NOTE WHEN THE STUDENT CAN DETECT ONE POINT OR TWO POINTS. NOW USING A COLD NAIL AND A WARM NAIL, PRESS THE POINTS OF EACH ON DIFFERENT PARTS OF THE BACK OF THE HAND. DETERMINE WHEN THE SENSATIONS OF COLD OR WARM CAN BE CLEARLY FELT.

OBSERVATIONS:

ON A OUTLINE DRAWING OF THE HAND MARK THE PLACES WHERE THE PRESSURE OF THE SEPARATE PIN POINTS CAN BE FELT WITH A P, THE PLACES WHERE THE COLD NAIL CAN BE DETECTED WITH A C, AND THE PLACES WHERE THE WARM NAIL CAN BE FELT WITH A W. COMPARE THE NERVE-ENDING "MAPS" OF DIFFERENT STUDENTS.

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HUMAN BIOLOGY

LEVEL: JR. HIGH OR HIGH SCHOOL

ACTIVITY: LOCATING THE BLIND SPOT

THERE ARE NO CONES OR RODS IN THE RETINA AT THE AREA WHERE THE OPTIC NERVE FIBERS AND THE EYEBALL JOIN. THEREFORE, THERE IS NO SIGHT AND THIS AREA IS CALLED THE BLIND SPOT.

PROCEDURE AND OBSERVATIONS:

MAKE A CROSS ON THE LEFT SIDE OF A SHEET OF PAPER. ABOUT 3 INCHES AWAY PLACE A SMALL CIRCLE. CLOSE YOUR LEFT EYE AND HOLD THE PAPER ABOUT TWELVE INCHES FROM THE RIGHT EYE. LOOK AT THE CROSS; THE CIRCLE WILL BE SEEN BY INDIRECT VISION. GRADUALLY, BRING THE PAPER CLOSER TO THE EYE, OR FARTHER AWAY FROM IT, UNTIL YOU CAN NO LONGER SEE THE CIRCLE. MEASURE THIS DISTANCE. (A) WHY DOES THE CIRCLE DISAPPEAR AT THIS POINT?____________________

(B) IS THE DISTANCE THE SAME FOR ALL MEMBERS OF THE CLASS?_______

(C) IF NOT, EXPLAIN WHY THERE IS A DIFFERENCE.__________________

____

POSITIVE AND NEGATIVE AFTERIMAGES:

THE LENGTH OF TIME REQUIRED FOR A STIMULUS TO PRODUCE A SENSATION IS VERY SHORT. HOWEVER, THE SENSATION LASTS A GREAT DEAL LONGER THAN THE STIMULUS. FOR EXAMPLE, AN ELECTRIC SPARK MAY LAST ONLY 1/8,000,000 OF A SECOND, YET ITS VISIBLE IMAGE LASTS MUCH LONGER. THIS IS REFERRED TO AS AN AFTERIMAGE. WHEN THE AFTERIMAGE IS THE SAME COLOR AS THE ORIGINAL, IT IS CALLED A POSITIVE AFTERIMAGE. NEGATIVE AFTERIMAGES APPEAR IN THE COMPLIMENTARY COLORS OF THE ORIGINALS.

MATERIALS:

WHITE LIGHT SOURCE	COLORED LIGHT SOURCE
2 X 2-INCH RED-COLORED PAPER (ADDITIONAL COLORS MAY BE USED).	SHEET OF WHITE PAPER
	SHEET OF RED PAPER (ADDITIONAL COLORS MAY BE USED).

PROCEDURE AND OBSERVATIONS:

ADAPT YOUR EYES TO THE DARK BY SITTING IN A DARKENED ROOM FOR 10 MINUTES. THEN TURN ON THE LIGHT FOR A SECOND AND LOOK AT THE WHITE BULB. TURN OFF THE LIGHT. (A) WHAT KIND OF AFTERIMAGE APPEARED?________________________________

(B) HOW LONG DID IT LAST?____________________________

NOW REPEAT THE EXPERIMENT SUBSTITUTING COLORED LIGHTS FOR THE WHITE ONES. (C) DESCRIBE WHAT HAPPENED._______________________

(D) WHAT KIND OF AFTERIMAGE APPEARED?____________________

CLOSE YOUR EYES AND FOLLOW THE AFTERIMAGE. (E) DOES THE AFTERIMAGE FOLLOW THE EYE MOVEMENTS?_________ (F) EXPLAIN YOUR ANSWER._____

____

NOW LOOK INTENTLY FOR 20-30 SECONDS AT A SMALL RED (OTHER COLORS MAY BE SUBSTITUTED) CARD AND THEN AT A SHEET OF WHITE PAPER. (G) DESCRIBE WHAT HAPPENED._____________________________

(H) WHAT KIND OF AFTERIMAGE APPEARED?_______________________

LOOK AT THE RED CARD AGAIN. THEN LOOK AT A SHEET OF RED PAPER. (I) DESCRIBE WHAT HAPPENED.________________________

____

FOCUS YOUR EYES ON A COLORED OBJECT FOR 20-30 SECONDS. LOOK AT A WHITE SURFACE FOR A SECOND AND THEN CLOSE YOUR EYES. (J) DESCRIBE WHAT HAPPENED.______________________________

(K) WHAT KIND OF AFTERIMAGE APPEARED?____________________

____

WHAT CAREERS INVOLVE UNDERSTANDING THE ANATOMY AND PHYSIOLOGY OF THE EYE?

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HUMAN BIOLOGY
LEVEL: HIGH SCHOOL

ACTIVITY: EFFECT OF TOBACCO ON CELL LIFE

1. SOAK TWO CIGARETTES, A CIGAR, OR A QUANTITY OF SMOKING TOBACCO OVER NIGHT IN A TUMBLER OF WATER. FROM A CULTURE RICH IN PROTOZOA TAKE A DROP AND PLACE IT ON A GLASS SLIDE. ADD A DROP OF TOBACCO WATER. EXAMINE WITH LOW POWER OF A COMPOUND MICROSCOPE.

A. WHAT IS THE EFFECT OF A TOBACCO SOLUTION ON PROTOZOA?

B. ACCOUNT FOR THE ACTION OF TOBACCO SOLUTION ON ONE-CELLED LIFE.

C. DOES TOBACCO AFFECT LARGER ANIMALS LIKE MAN IN THE SAME WAY?

D. DOES TOBACCO SMOKING RETARD THE GROWTH OF YOUNG PEOPLE?

E. WHY DOES THE ATHLETIC COACH FORBID THE USE OF TOBACCO BY THE PLAYERS?

2. PLACE A GOLDFISH IN A BEAKER ONE-HELF FULL OF WATER. ADD A QUANTITY OF TOBACCO WATER.

A. DOES THE GOLDFISH ACT IN A NORMAL WAY?

B. HOW LONG A TIME ELAPSES BEFORE HE BECOMES UNCONSCIOUS?

C. DOES THE FISH RISE TO THE SURFACE OR SINK TO THE BOTTOM?

3. AS SOON AS THE GOLDFISH APPEARS TO BE "DEAD," PLACE HIM IN THE CLEAR WATER OF THE AQUARIUM.

A. HOW LONG BEFORE HE IS NORMAL AGAIN?

B. WHAT IS THE EFFECT OF TOBACCO WATER ON A GOLDFISH?

C. DOES TOBACCO DO AS MUCH HARM TO MAN AS TO GOLDFISH?

D. JUST HOW DOES TOBACCO AFFECT MAN?

E. WHICH IS MORE HARMFUL, SMOKING TOBACCO OR CHEWING TOBACCO?

HUMAN BIOLOGY
LEVEL: HIGH SCHOOL

ACTIVITY: TYPING BLOOD

IT IS A SIMPLE PROCEDURE TO TYPE YOUR BLOOD. FIRST WASH THE TIP OF YOUR MIDDLE FINGER WITH ALCOHOL. STERILIZE THE POINT OF A NEEDLE BY HOLDING IT IN A FLAME FOR A FEW SECONDS, OR OBTAIN A STERILE, DISPOSABLE BLOOD LACET (FROM ANY BIOLOGICAL SUPPLY HOUSE). STROKE THE MIDDLE FINGER TOWARD THE TIP, PRESSING AS YOU STROKE, UNTIL BLOOD IS FORCED TOWARD THE TIP. PRICK THE SKIN NEAR THE TIP TO DRAW A DROP OF BLOOD.

YOUR LOCAL HOSPITAL, DRUGSTORE OR BIOLOGICAL SUPPLY HOUSE CAN PROBABLY FURNISH YOU WITH SOME DATED SERUM CONTAINING AGGLUTININS. PLACE ONE DROP OF ANTI-A SERUM ON ONE SIDE OF A SLIDE AND ONE DROP OF ANTI-B SERUM ON THE OTHER SIDE. THEN PLACE ONE DROP OF BLOOD INTO THE ANTI-A SERUM AND MIX WITH A CLEAN TOOTHPICK. USING ANOTHER CLEAN TOOTHPICK, DO THE SAME ON THE OTHER HALF OF THE SLIDE WITH THE ANTI-B SERUM. DO NOT MIX THE TWO SERUMS WITH THE SAME TOOTHPICK. YOU MAY SEE (1) NO CLUMPING ON EITHER SIDE, (2) CLUMPING ON ONE OR THE OTHER SIDE, OR (3) CLUMPING ON BOTH SIDES. IN THE SPACE BELOW, DRAW WHAT YOU SAW ON THE SLIDE YOU PREPARED.

1. IF ANTI-A CLUMPED YOUR BLOOD, BUT ANTI-B DID NOT, WHAT IS YOUR TYPE? ____________
2. IF ANTI-B CLUMPED YOUR BLOOD, BUT ANTI-A DID NOT, WHAT IS YOUR TYPE? ____________
3. IF BOTH ANTI-A AND ANTI-B CLUMPED YOUR BLOOD, WHAT IS YOUR TYPE? ____________
4. IF NEITHER SERUM CLUMPED YOUR BLOOD, WHAT IS YOUR TYPE? ____________

TO THE TEACHER: ANSWER TO 1. TYPE A; 2. TYPE B; 3. TYPE AB; 4. TYPE O.

NAME THE PEOPLE IN THE MEDICAL PROFESSION, WHO SHOULD KNOW HOW TO TYPE BLOOD.

		RECIPIENT'S BLOOD			
		AB	A	B	O
DONARS BLOOD	AB	+	-	-	-
	A	+	+	-	-
	B	+	-	+	-
	O	+	+	+	+

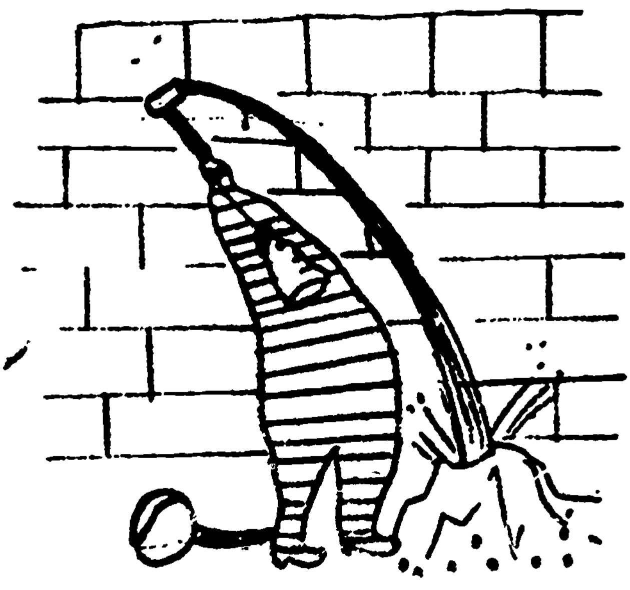
+ HAS ANTIGENS
- HAS NO ANTIGENS

TYPE	A	B	O	AB
ANTI-A	+	-	-	+
ANTI-B	-	+	-	+

IN TESTING FOR BLOOD

IF BLOOD COAGGULATES WITH ANTI-A SERUMS - THE TYPE IS A AND NOT B.
IF BLOOD COAGGULATES WITH ANTI-B SERUM - THE TYPE IS B.
IF BLOOD COAGGULATES WITH BOTH A AND B- THE TYPE IS AB.
IF THERE IS NO COAGGULATION - IT IS TYPE O.
RH TEST - IF BLOOD COAGGULATES IT IS RH POSITIVE.
IF IT DOES NOT COAGGULATE - IT IS RH NEGATIVE (USING ANTI-RH SERUM.)

STRUCTURE OF MATTER



CHEMISTRY - STRUCTURE OF MATTER

ARCHITECTS
BIOCHEMIST
BIOLOGISTS
CHEMIST
DENTAL HYGENIST
DENTIST
DIETITIANS
ENGINEERING TECHNICIAN
CHEMICAL ENGINEER
GEOLOGIST
GEOPHYSICIST
HOME ECONOMIST
INDUSTRIAL DESIGNER
INDUSTRIAL TRAFFIC MANAGER
LIFE SCIENTIST
MEDICAL LAB WORKERS
MEDICAL TECHNOLOGIST
METEROLOGIST
OCEANOGRAPHER
PHARMACISTS
PHOTOGRAPHER
PHYSICIANS
PHYSICIST
PRACTICAL NURSE
REGISTERED NURSE
ELEMENTARY TEACHER
TEACHER SECONDARY-COLLEGE
TECHNICAL WRITER
VETERINARIAN
TELEGRAPHER
TELEPHONER
BRICK LAYER
FLOOR COVERING INSTALLER
PAINTER
PLASTERER
ROOFER
SIGNAL MAINTAINER
STRUCTURAL STEEL WORKER
PHOTO ENGRAVER
STATIONARY ENGINEER
FBI AGENT
POLICEMEN & WOMEN
STEWARDESSES
AGRIBUSINESS TECHNCIAN
AGRICULTURE EXTENSION WORKER
DAIRY PRODUCTION TECHNICIAN
FARM-CROP PRODUCTION TECHNICIAN
FARMER
FISH & WILDLIFE TECHNICIAN
FISH CULTURE TECHNICIAN
FORESTER
FORESTERY PRODUCTION TECHNICIAN
LIVESTOCK PRODUCTION TECHNICIAN
ORCHARD TECHNICIAN
HORTICULTURIST
PARKS LAND MANAGEMENT TECHNICIAN
RANGE MANAGEMENT
SOIL CONSERVATIONIST
SOIL SCIENTIST
ELECTROPLATER
FOOD PROCESSING TECHNICIAN
COMPOSING ROOM OPERATOR
INDUSTRIAL MAINTENANCE MECHANIC
INSTRUMENT MAKER
MACHINE TOOL OPERATOR
PATTERN MAKER
TOOL & DYE MAKER
DENTAL LABORATORY TECHNICIAN
JEWLERS & JEWEL REPAIRMEN
OPTICIAN
OPTICAL MECHANIC
CEMENT MASON
GLAZIER
PAPER HANGER
PLUMBER-PIPE FITTER
SHEET METAL WORKER
STONE MASON
WELDER
POWER PLANT OPERATOR

STRUCTURE OF MATTER
LEVEL: JUNIOR HIGH

ACTIVITY: INVESTIGATION PHYSICAL & CHEMICAL PROPERTIES OF UNKNOWNS

MATERIALS:

SUGAR	(OTHER POWDERS WHICH COULD BE USED)
TABLE SALT	GROUND ALKASELTZER
BAKING SODA	TOOTH POWDER
CORNSTARCH	PLASTER OF PARIS
DRY POWDERED MILK	(ANY OTHER "WHITE" POWDER)
5 PLASTIC PAILS	BLACK CONSTRUCTION PAPER
PLASTIC SPOONS	HAND LENSES
SMALL PAPER CUPS	VINEGAR (WHITE)
ALUMINUM FOIL	IODINE DILUTE
EYEDROPPERS	STERNO CANS
WOODEN CLOTHES PIN ----------	(SQUEEZE TYPE)

PROCEDURE:

HAVE STUDENTS PREPARE IN THEIR NOTEBOOKS OR ON A SHEET OF PAPER A LAB RECORDING SHEET.

POWDER NUMBER	WHAT I THINK IT IS	WHY I THINK SO

HAVE STUDENTS NUMBER 5 CUPS. THE TEACHER SHOULD HAVE 5 DIFFERENT MYSTERY POWDERS IN PAIL IN THE BACK OF ROOM. HAVE STUDENTS GET MATERIALS IN THEIR CUPS. ON THE FIRST DAY LET THEM ONLY USE THEIR SENSES TO TRY TO GUESS WHAT THE POWDER IS. STUDENTS SHOULD RECORD ANY GUESS ON THE LAB SHEET AND WHY THEY THINK SO. AFTER THE CLASS HAS INVESTIGATED THE POWDERS DISCUSS ALL OF THE CLASS GUESSES AND REASONS. IF POSSIBLE RECORD THE CHOICES ON THE BOARD FOR FUTURE REFERENCE.

NEXT HAND OUT TO STUDENTS ONE HALF SHEET OF BLACK CONSTRUCTION PAPER AND A CUP OF WATER. LET STUDENTS INVESTIGATE PROPERTIES WITH THESE MATERIALS. THEY SHOULD REVISE THEIR GUESSES AND REASONS AFTER THIS IS DONE. REMIND STUDENTS THEY ARE TO FIND PROPERTIES OF A CERTAIN POWDER SO THEY CAN IDENTIFY IT IF IT IS MIXED WITH OTHER POWDERS.

IN THE NEXT SESSION STUDENTS SHOULD USE VINEGAR, IODINE AND HEAT TO CHECK SOME OF THE CHEMICAL PROPERTIES. WHEN USING HEAT, CUPS TO HOLD POWDERS OVER THE FLAME SHOULD BE FORMED OUT OF TINFOIL AND THEN HELD OVER THE FIRE WITH CLOTHES PINS. AFTER THESE TESTS, STUDENTS SHOULD HAVE IDENTIFIED THE POWDERS AND HAVE WAYS TO TELL THEM APART. IF THEY CAN NOT TELL WHAT THEY ARE, THEY SHOULD BE TOLD.

IN THE NEXT SESSION MIX THE POWDERS AND SEE IF THE STUDENTS CAN TELL WHICH POWDERS ARE IN THE MIXTURES FROM THE TESTS THEY HAVE RUN EARLIER.

STRUCTURE OF MATTER
LEVEL: JUNIOR HIGH

ACTIVITY: WHAT IS THE DIFFERENCE BETWEEN A MIXTURE AND A COMPOUND?

MATERIALS:

TEASPOON	RING STAND WITH CLAMP
SULFUR (S)	PYREX TEST TUBE
IRON FILINGS (Fe)	FILTER PAPER
CARBON DISULFIDE (CS_2)	RAG OR CLOTH
EVAPORATING DISH	BUNSEN BURNER
GLASS FUNNEL	HAMMER

PROCEDURE:

A. THOROUGHLY MIX 1 TEASPOON OF SULFUR WITH 1/2 TEASPOON OF IRON FILINGS IN A TEST TUBE. POUR SOME CARBON DISULFIDE (CS_2) ON THIS MIXTURE. CAUTION: DO NOT HAVE A BUNSEN BURNER GOING WHILE THE CARBON DISULFIDE IS BEING USED.

B. FILTER THE RESULTING MIXTURE THROUGH A FILTER PAPER.

C. MIX A SECOND MIXTURE OF SULFUR AND IRON, AS YOU DID BEFORE. HEAT TO A HIGH TEMPERATURE. ROTATE THE TEST TUBE AS YOU HEAT THE MIXTURE, SO THE TEST TUBE WILL HEAT EVENLY AND WILL NOT BREAK. HEAT UNTIL THE MIXTURE SHOWS NO MORE ACTIVITY. (DO NOT BREATHE THE FUMES.) THE MIXTURE WILL BEGIN TO GLOW AS THE CHEMICAL REACTION BEGINS.

D. LET THE TEST TUBE COOL. WRAP IT IN A CLOTH. BREAK IT WITH A HAMMER. THE CLOTH WILL PREVENT THE GLASS FROM FLYING. THE COMPOUND WILL THEN BE OUT OF THE TEST TUBE.

E. POUR SOME CARBON DISULFIDE ON THIS COMPOUND, AS YOU DID IN STEP A. TRY TO SEPARATE THE IRON FROM THE SULFUR BY FILTERING.

WHAT DO WE SEE?

1. DESCRIBE WHAT HAPPENED IN STEP A.

____

____

____

2. WHY WAS THE FILTER PAPER NECESSARY?

____

____

3. DESCRIBE WHAT YOU SAW AS THE IRON AND SULFUR MIXTURE WAS HEATED TO A HIGH TEMPERATURE.

4. DESCRIBE WHAT THE IRON AND SULFUR LOOKED LIKE AFTER THE CHEMICAL REACTION CAUSED BY HEATING HAD TAKEN PLACE.

5. COULD YOU SEPARATE THE IRON FROM THE SULFUR IN STEP E? IF NOT, WHY NOT?

WHAT DO WE LEARN?

1. EXPLAIN HOW THE IRON WAS CHANGED IN THIS EXPERIMENT AFTER THE IRON AND SULFUR MIXTURE WAS HEATED TO A HIGH TEMPERATURE.

2. COMPLETE THE FOLLOWING EQUATION:

   $\underset{\text{(IRON)}}{Fe} + \underset{\text{(SULFUR)}}{S}$ ________ $\underset{\text{(IRON SULFIDE)}}{\rule{3cm}{0.4pt}}$

3. HOW DO YOU KNOW IRON SULFIDE IS A COMPOUND?

4. DOES IRON SULFIDE LOOK LIKE EITHER IRON OR SULFUR? IF NOT, HOW IS IT DIFFERENT?

5. WHAT IS A MIXTURE?

6. WHY WERE THE IRON FILINGS AND SULFUR A MIXTURE RATHER THAN A COMPOUND?

STRUCTURE OF MATTER
LEVEL: HIGH SCHOOL

ACTIVITY: GROWING CRYSTALS

PROBLEM:
CRYSTALS ARE USED FOR MANY PURPOSES IN SCIENTIFIC RESEARCH AND IN INDUSTRY. FOR MANY PURPOSES, CRYSTALS GROWN UNDER CAREFULLY CONTROLLED CONDITIONS ARE MORE VALUABLE THAN CRYSTALS FOUND IN NATURE HOW CAN CRYSTALS BE GROWN IN THE LABORATORY?

MATERIALS:
ALUM (POTASSIUM ALUMINUM SULFATE)
PAN
HOT PLATE OR BURNER
FORECEPS
SOFT CLOTH
CLEAN GLASS JARS WITH SCREW LIDS
MAGNIFIER
SEWING THREAD

PROCEDURE:

POUR 100 GRAMS OF ALUM INTO A JAR CONTAINING 500 ML OF WATER. PUT THE JAR IN A PAN OF WATER AND HEAT THE PAN AND THE JAR, BUT DO NOT HEAT THE WATER TO THE BOILING POINT. STIR THE SOLUTION UNTIL ALL THE ALUM IS DISSOLVED. POUR SOME OF THIS SOLUTION INTO TWO SMALL JARS TO A DEPTH OF ABOUT 1 CM AND LET THESE STAND FOR A FEW DAYS UNTIL SMALL SEED CRYSTALS BEGIN TO FORM. AS YOU SEE NICELY SHAPED CRYSTALS FORMING, CAREFULLY REMOVE THE MOST REGULARLY-SHAPED ONES WITH A FORECEPS AND DRY THEM ON A PAPER TOWEL.

SEAL THE JAR CONTAINING THE BALANCE OF THE STOCK SOLUTION AND PUT IT IN A CLOSET WHERE THE TEMPERATURE REMAINS ABOUT THE SAME (AVOID EXTREME CHANGES IN TEMPERATURE FOR THE SOLUTIONS IN THIS ENTIRE EXPERIMENT). LEAVE THE JAR UNTIL SOME OF THE ALUM BEGINS TO SEPARATE ONTO THE BOTTOM OF THE JAR. IF THIS DOES NOT HAPPEN IN ABOUT TWO DAYS, ADD A FEW SMALL PIECES OF ALUM AND STIR THE SOLUTION UNTIL THEY DISSOLVE.

POUR OFF THE CLEAR LIQUID INTO A QUART JAR AND ADD ABOUT 25 MORE GRAMS OF ALUM. HEAT AND STIR AS BEFORE TO OBTAIN A SATURATED SOLUTION. CUT A PIECE OF CARDBOARD TO FIT INSIDE THE LID OF THE JAR, PASS A THREAD THROUGH THE CARDBOARD, AND TAPE THE THREAD IN PLACE. THE THREAD SHOULD BE LONG ENOUGH TO REACH ABOUT HALFWAY INTO THE SOLUTION. WHEN THE SOLUTION HAS COOLED, TIE A SEED CRYSTAL TO THE BOTTOM OF THE THREAD (OR FASTEN IT WITH A DROP OF AIRPLANE GLUE) AND HANG THE SEED CRYSTAL IN THE SOLUTION. CHECK THE JAR TWO OR THREE TIMES DURING THE NEXT HOUR TO BE SURE THE SEED CRYSTAL IS STILL IN PLACE

PLACE THE JAR IN A PLACE WHERE IT WILL NOT BE DISTURBED AND WHERE THE TEMPERATURE IS EVEN. WIPE THE GROWING CRYSTAL EACH DAY WITH A SOFT CLOTH TO PREVENT THE GROWTH OF SECONDARY CRYSTALS. WHEN THE CRYSTAL HAS REACHED THE SIZE WANTED, REMOVE IT FROM THE JAR, WIPE IT DRY WITH A CLEAN CLOTH, AND STORE IN A BOX LINED WITH COTTON.

OBSERVATIONS:

1. WHAT IS THE SHAPE OF THE ALUM CRYSTAL? ____________________

2. HOW DOES THE SHAPE OF THE CRYSTAL COMPARE TO THAT OF THE SEED CRYSTAL? ____________________

3. WHAT IS MEANT BY A SATURATED SOLUTION? ____________________

____

4. WHERE DOES THE MATERIAL FOR THE GROWTH OF THE CRYSTAL COME FROM?

____

5. WHAT OTHER CHEMICAL SALTS DO YOU THINK WILL FORM CRYSTALS FROM A SOLUTION? ____________________

INTERPRETATION:

FILL IN THE BLANK WORDS IN THE FOLLOWING PARAGRAPH IN THE NUMBERED SPACES AT THE RIGHT.

MOST MINERALS ARE CRYSTALLINE IN STRUCTURE. THAT IS THE (1) OR (2) MAKING UP THE CRYSTAL ARE ARRANGED IN DEFINITE GEOMETRIC PATTERNS. EACH SURFACE OF A CRYSTAL IS CALLED A (3), AND THE EDGES WHERE THESE JOIN FORM THE (4). THERE ARE (5) BASIC CRYSTAL SYSTEMS. THESE MAY BE DESCRIBED IN TERMS OF HOW THEIR (6), IMAGINARY LINES SHOWING THE DIRECTION IN WHICH THE ATOMS OR MOLECULES ARRANGE THEMSELVES, ARE ARRANGED. WHEN THREE AXES OF EQUAL LENGTH MEET AT 90° ANGLES, THE CRYSTAL FORMS A CUBE AND IS CALLED (7). A COMMON CRYSTAL EXAMPLE OF THIS SYSTEM IS SHOWN IN (8). IF THE THREE AXES ARE OF UNEQUAL LENGTH AND CROSS EACH OTHER AT ANGLES OTHER THAN 90°, THE CRYSTAL SYSTEM IS CALLED (9). A COMMON MINERAL WHICH IS AN EXAMPLE OF THIS IS (10).

1...............
2...............
3...............
4...............
5...............
6...............
7...............
8...............
9...............
10...............

APPLICATION:

1. EXPLAIN WHY A SOLID METAL, SUCH AS A BAR OF IRON OR COPPER, CAN BE CHANGED IN SHAPE BY STRETCHING OR HAMMERING.

2. WHAT CAREERS DO YOU THINK WOULD NEED TO KNOW SOMETHING ABOUT CRYSTAL GROWTH?

STRUCTURE OF MATTER
LEVEL: HIGH SCHOOL

ACTIVITY: CHEMISTRY AND NEW MATERIALS

PROCEDURES: A. FLOTATION PROCESS

POUR A TEASPOONFUL OF COOKING OIL INTO A LARGE BEAKER OF WATER. PREPARE A MIXTURE OF SAND AND IRON FILINGS. MIX THE FILINGS WITH THE SAND SO THAT ABOUT ONE TEASPOONFUL OF FILINGS IS MIXED WITH TEN TEASPOONSFUL OF SAND. YOUR RESULTS WILL BE BETTER IF THE FILINGS ARE VERY FINE. THIS SAND AND IRON MIXTURE REPRESENTS THE ORE. ADD THE ORE TO THE BEAKER OF WATER AND OIL AND STIR THOROUGHLY. MOST OF THE IRON FILINGS WILL FLOAT ON THE SURFACE. THE OIL AND THE SAND WILL STICK TO THE BOTTOM. YOU CAN FLOAT THE FILINGS RIGHT OFF THE TOP OF THE BEAKER BY GENTLY ADDING WATER TO THE BEAKER.

B. HOW MUCH DO WE DEPEND UPON SYNTHETIC SUBSTANCES? AS A CLASS STUDY, TAKE INVENTORY IN YOUR CLASSROOM OF THE VARIOUS ITEMS WHICH ARE SYNTHETIC SUBSTANCES SUCH AS PLASTICS, SYNTHETIC FIBERS, ALLOYS, AND SYNTHETIC RUBBER. EXTEND YOUR STUDY INTO YOUR HOME AND AUTOMOBILE. MAKE A LIST OF THESE OBJECTS BELOW.

OBJECT	SYNTHETIC MATERIAL
1. ______	1. ______
2. ______	2. ______
3. ______	3. ______
4. ______	4. ______
5. ______	5. ______
6. ______	6. ______

C. VEGETABLE FIBERS SUCH AS LINEN OR COTTON, BURN DIFFERENTLY THAN ANIMAL FIBERS, SUCH AS WOOL OR SILK. SYNTHETIC FIBERS BURN DIFFERENTLY THAN EITHER VEGETABLE OR ANIMAL FIBERS. EACH HAS A CHARACTERISTIC APPEARANCE IN FLAME AND A CHARACTERISTIC ODOR. TEST SAMPLES OF THESE FIBERS AND RECORD YOUR RESULTS IN THE SPACES BELOW.

MATERIAL	ODOR	BURNING CHARACTERISTICS
(A) LINEN	______	______
(B) COTTON	______	______
(C) WOOL	______	______
(D) SILK	______	______
(E) RAYON	______	______
(F) DACRON	______	______
(G) ORLON	______	______
(H) NYLON	______	______

STRUCTURE OF MATTER
Level: High School

ACTIVITY: Electron Configuration of Atoms

Procedures: Complete the following statements forming accurate and complete sentences.

1. Since the nucleus has a positive charge due to its protons, and a neutral atom contains an equal number of protons and of negatively charged electrons, we might expect electrons to be held in an atom by the ____________________ 1

2. The simple "opposites attract" theory is not satisfactory for explaining the motion of electrons about the nucleus of an atom because we know that atoms ____________________ 2

3. For any wave motion, the speed of propagation equals the product of ____________________ 3

4. The energy of a photon, E, may be represented by the expression, E = ____________________ 4

5. When excited atoms radiate energy, the radiation is evolved in units called ____________________ 5

6.- When excited atoms return to their normal states and the light they emit is passed through a spectroscope, we may observe a (n) ____________________ 6

7. Energy transitions within an atom do not occur continuously, but are in ____________________ 7

8. The kinds of spectra which are explained satisfactorily by the Bohr concept of the atom are ____________________ 8

9. A space orbital is ____________________ 9

10. The interpenetration of one free atom by another is prevented by ____________________ 10

11. The quantum number which indicates the average distance of the electron from the nucleus of the atom is the ____________________ 11

12. The number of orbital shapes possible in the 3rd energy level is ____________________ 12

Procedures: 13-16. For each sublevel type, furnish the required information.

Sub-level	Number of space orbitals	Maximum number of electrons	Lowest energy level having this sublevel type	
s	....	....	....	13
p	....	....	....	14
d	....	....	....	15
f	....	....	....	16

Procedures: Write answers to the following in the spaces provided. Make complete statements where appropriate.

17. What is the most stable state of an atom called? ______________ 17

18. Under what conditions may two electrons occupy the same space orbital? ______________ 18

19. What is an electron pair? ______________ 19

20. What name is given to an outer shell containing eight electrons? ______________ 20

21. (a) Which sublevels of the 3rd energy level are filled in the element argon (Ar-atomic number 18)? ______________ 21A
(b) In the element krypton (Kr-atomic number 36)? ______________ 21B

22. When do successive electrons entering the 2p orbitals start to pair up? ______________ 22

23. Which sublevel in the M shell has a higher energy than the 4s sublevel? ______________ 23

24. In what order do successive electrons usually enter the sublevels of the atoms of the fourth series? ______________ 24

25. Which atoms in the fourth series have structures which appear to be irregular because of the stability of (a) a half-filled 3d sublevel? ______________ 25A
(b) a completely filled 3d sublevel? ______________ 25B

26. Write the electron-dot symbol for an atom having an atomic number of 13 and a mass number of 27 ______________ 26

27. In which series of elements do electrons enter the 4f sublevel? ______________ 27

28. Complete the following table

Symbol-Atomic Number	Electron Configuration Notation	Electron-Dot Notation	Orbital Notation 1s	2s	2p	3s	3p	3d	4s
Li-3									
B-5									
N-7									
F-9									
Mg-12									
Si-14									
S-16									
Ar-18									
Ca-20									
Sc-21									

STRUCTURE OF MATTER
LEVEL: HIGH SCHOOL

ACTIVITY: CHARGED PARTICLES IN SOLUTION

THE TRANSFER OF ELECTRONS RESULTS IN OBJECTS BECOMING EITHER POSITIVELY OR NEGATIVELY CHARGED. IF TWO OBJECTS HAVE UNLIKE CHARGES, THE OBJECTS WILL ATTRACT EACH OTHER. IF THE CHARGES ARE THE SAME, THE OBJECTS WILL REPEL EACH OTHER.

DURING THIS INVESTIGATION YOU WILL STUDY THE EFFECT OF ELECTRICITY ON PARTICLES IN SOLUTION.

MATERIALS: (PER TEAM)

2 PAPER CLIPS	2 LENGTHS OF BELL WIRE (10-INCH)
250-ML BEAKER	150 ML OF DISTILLED WATER
12-INCH LENGTH OF DIALYSIS TUBING	6-VOLT BATTERY
10 ML OF IODINE-POTASSIUM IODIDE SOLUTION-(KI)	

PROCEDURES:

SET UP THE APPARATUS AS FOLLOWS:

A. UNFOLD TWO PAPER CLIPS SO THEIR LENGTHS ARE DOUBLED. REMOVE THE INSULATION FROM THE ENDS OF BOTH BELL WIRES. FASTEN A WIRE TO ONE END OF EACH UNFOLDED PAPER CLIP.
B. HALF-FILL A BEAKER WITH DISTILLED WATER. MOISTEN THE IALYSIS TUBING, AND TIE A KNOT IN THE MIDDLE OF IT. HOLD UP THE ENDS OF THE TUBING AND FILL EACH HALF WITH DISTILLED WATER TO A DEPTH OF ABOUT 4 INCHES. CAREFULLY LOWER THE DIALYSIS TUBING INTO THE BEAKER OF WATER AND FOLD THE FREE ENDS OF THE TUBING OVER THE EDGE. INSERT A PAPER CLIP ELECTRODE INTO THE WATER IN EACH HALF OF THE TUBING. ATTACH THE FREE ENDS OF THE WIRES TO THE BATTERY.

NOTE: ELECTRICITY FROM THE BATTERY WILL SUPPLY ELECTRONS TO ONE PAPER CLIP AND REMOVE ELECTRONS FROM THE OTHER. THUS ONE PAPER CLIP WILL HAVE EXCESS ELECTRONS AND BE NEGATIVELY CHARGED, WHILE THE OTHER WILL BE POSITIVELY CHARGED.

C. ADD 10 ML OF THE BROWN-COLORED (KI) SOLUTION TO THE WATER IN THE BEAKER. ALLOW THE PAPER CLIPS TO REMAIN CONNECTED TO THE BATTERY FOR ABOUT TWENTY MINUTES.
D. MARK OR LABEL EACH END OF THE TUBING WITH A + (POSITIVE) OR - (NEGATIVE) SIGN TO MATCH THE POLES ON THE BATTERY. DISCONNECT THE BATTERY AND REMOVE THE ELECTRODES FROM THE TUBING. LIFT THE TUBING OUT OF THE BEAKER AND OBSERVE ANY CHANGES THAT MAY HAVE OCCURRED IN EACH HALF.

INTERPRETATIONS:

1. WHAT HAPPENED TO THE WATER IN THE TUBING THAT WAS CONNECTED TO THE POSITIVE SIDE OF THE BATTERY? WHAT HAPPENED ON THE NEGATIVE SIDE?

2. DO YOU THINK THAT PARTICLES OF THE BROWN-COLORED SOLUTION HAVE A POSITIVE CHARGE OR A NEGATIVE CHARGE?

INTERPRETATIONS (CONT.)

3. FROM THE RESULTS OF THIS INVESTIGATION, WHAT EVIDENCE DO YOU HAVE THAT:

   A. NEUTRAL ATOMS MIGHT LOSE ELECTRONS AND BECOME POSITIVELY CHARGED?

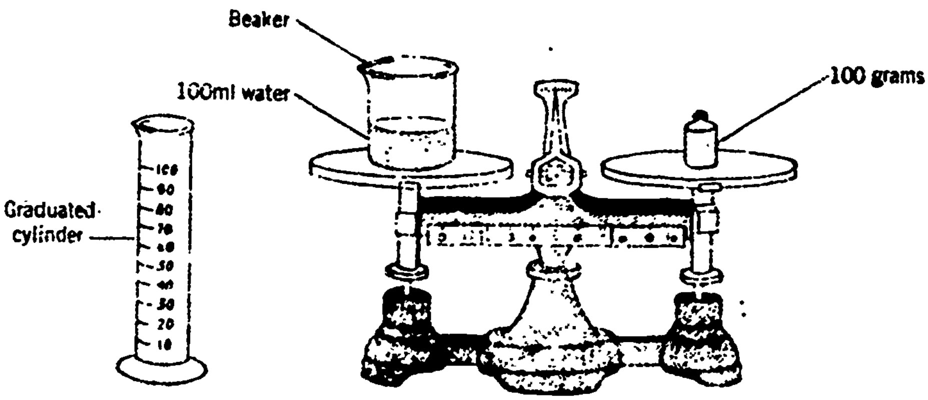
   B. NEUTRAL ATOMS MIGHT GAIN ELECTRONS AND BECOME NEGATIVELY CHARGED?

STRUCTURE OF MATTER
LEVEL: HIGH SCHOOL

ACTIVITY: DENSITIES OF LIQUIDS

PROBLEM: EACH FORM OF MATTER HAS A CERTAIN MASS OR WEIGHT. THE DENSITY OF A SOLID CAN BE DETERMINED BY COMPARING THE WEIGHT OF ONE CUBIC CENTIMETER (CM^3) OF THE SUBSTANCE TO THE WEIGHT OF ONE CM^3 OF WATER. HOW CAN THE DENSITY OF A LIQUID BE DETERMINED?

INVESTIGATION:
THE WEIGHT IN GRAMS OF 100 MILLILITERS OF EACH LIQUID TESTED WAS FOUND, AS SHOWN BELOW. THE RESULTS OF THE EXPERIMENT ARE SHOWN IN THE TABLE BELOW.



LIQUID TESTED	VOLUME IN MILLILITERS	WEIGHT IN GRAMS	DENSITY PER CM^3
WATER	100	100	1.00
COOKING OIL	100	92	0.92
RUBBING ALCOHOL	100	80	0.80
GLYCERIN	100	125	1.25
WHOLE MILK	100	103	1.03

INTERPRETATION:
ACCORDING TO THE RESULTS SHOWN IN THE TABLE, MARK EACH OF THE FOLLOWING STATEMENTS TRUE, FALSE, OR NOT PROVED IN THE SPACE PROVIDED.

1. THE VOLUME OF ONE MILLILITER OF ANY LIQUID EQUALS .... ONE CUBIC CENTIMETER.

2. THE WEIGHT OF ONE MILLILITER OF GLYCERIN EQUALS ONE GRAM. ....

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3. ALCOHOL AND WATER CAN BE MIXED WITHOUT SEPARATING. ....

4. IF COOKING OIL AND WATER ARE MIXED, THE OIL WILL FLOAT ON TOP OF THE WATER. ....

5. IF GLYCERIN AND ALCOHOL ARE MIXED, THE ALCOHOL WILL FLOAT ON TOP OF THE GLYCERIN. ....

6. WHOLE MILK HAS A GREATER DENSITY THAN SKIM MILK. ....

7. THE WEIGHT OF ONE MILLILITER OF WATER EQUALS ONE GRAM. ....

8. THE TEMPERATURE OF A LIQUID HAS AN EFFECT ON ITS DENSITY. ....

9. IF A LIQUID HAS A DENSITY GREATER THAN 1, IT WILL FLOAT ON WATER. ....

10. THE SAME VOLUME OF LIQUID MUST BE WEIGHED EACH TIME IN ORDER TO FIND ITS DENSITY. ....

APPLICATION:

EXPLAIN WHY MILK IS HOMOGENIZED TO PREVENT THE CREAM FROM SEPARATING OUT AND FLOATING ON TOP OF THE MILK.

STRUCTURE OF MATTER
LEVEL: HIGH SCHOOL

ACTIVITY: ATOMIC STRUCTURE

PURPOSE: TO ACQUAINT YOU WITH SOME BASIC IDEAS OF CHEMISTRY THAT WILL AID YOU IN BIOLOGY.

INSTRUCTIONAL OBJECTIVES: (FOLLOWING A LECTURE AND READING)

1. THE STUDENT WILL BE ABLE TO CORRECTLY DRAW THE ATOMIC STRUCTURE OF ANY ELEMENT FROM THE PERIODIC TABLE.

2. THE STUDENT WILL BE ABLE TO DRAW OUT AN EXAMPLE OF A CHEMICAL REACTION INVOLVING ONE REACTION IN A COVALENT BOND, AND ANOTHER REACTION IN A IONIC BOND.

3. THE STUDENT WILL BE ABLE TO WRITE A SHORT PARAGRAPH ON THE STRENGTH OF BONDS AND THE PARTS OF AN ATOM INVOLVED IN A BOND.

4. THE STUDENT WILL BE ABLE TO CONVERT A CHEMICAL FORMULA INTO WORDS, IN TERMS OF ATOMS.

MATERIALS:
<u>MODERN BIOLOGY</u>, PP 34-41

LEARNING ACTIVITIES:
REQUIRED: (#1 AND EITHER 2 OR 3)

1. CONVERT CHEMICAL FORMULA INTO WORDS, IN TERMS OF ATOMS. EXAMPLE: H_2O IS TWO ATOMS OF HYDROGEN COMBINED WITH ONE ATOM OF OXYGEN TO FORM ONE MOLECULE OF WATER. (HAND IN TO YOUR INSTRUCTOR.)

A. $C_6H_{12}O_6$

B. HCL

C. CO_2

D. H_2SO_4

E. NACL

F. CO

2. TAKE ANY TWO OF THE ABOVE AND DRAW THEIR STRUCTURAL FORMULA AND INDICATE IF IT IS AN IONIC OR COVALENT BOND. (MUST HAVE ONE OF EACH). HAND IN TO YOUR INSTRUCTOR.

3. DRAW THE ATOMIC STRUCTURE OF ELEMENTS #6, #27, #73. (HAND IN TO YOUR INSTRUCTOR).

OPTIONAL: (COMPLETE TWO AND HAND INTO YOUR INSTRUCTOR)

1. WRITE THE CHEMICAL SYMBOL FOR THE FOURTEEN MOST ABUNDANT ELEMENTS IN LIVING ORGANISMS.

2. COMPOSE A LIST OF CAREERS YOU FEEL THEIR KNOWLEDGE ON ATOMIC STRUCTURE WOULD BE HELPFUL.

3. DESIGN AN EXPERIMENT TO SHOW DISSOCIATION OF IONS.

4. WRITE A SHORT PARAGRAPH ON WHY YOU FEEL BASIC CHEMISTRY IS NECESSARY IN BIOLOGY AND ANY OTHER FIELD.

DEMONSTRATIONS OF LEARNING:
YOU WILL BE EVALUATED ON:

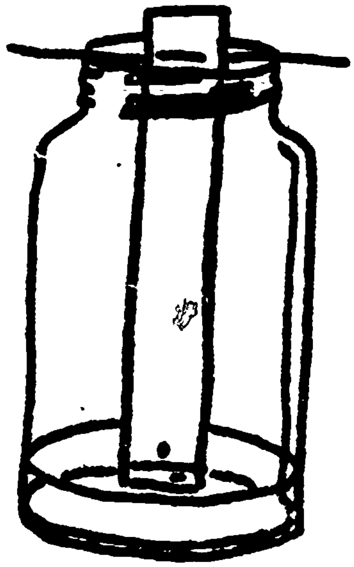
1. THE MATERIAL HANDED IN.

2. ORAL EXAM (FOUR QUESTIONS, ONE ON EACH OF THE INSTRUCTIONAL OBJECTIVES) YOU MUST ANSWER ALL FOUR TO THE SATISFACTION OF THE TEACHER.

(OR)

3. WRITTEN EXAM WHICH WILL INCLUDE SHORT ESSAY QUESTIONS ON THE INSTRUCTIONAL OBJECTIVES AND A TERMINOLOGY TEST FROM PP. 50 IN <u>MODERN BIOLOGY</u>. THE STUDENT MUST RECEIVE AN 80% TO COMPLETE THIS LAB.

BEHAVIOR OF MATTER



CHEMISTRY - BEHAVIOR OF MATTER

BIOCHEMIST
BIOLOGIST
CHEMIST
DENTAL HYGENIST
DENIST
DIETITIAN
ENGINEERING TECHNICIAN
CHEMICAL ENGINEER
GEOLOGIST
GEOPHYSICIST
HOME ECONOMIST
INDUSTRIAL DESIGNER
INDUSTRIAL TRAFFIC MANAGER
LIFE SCIENTIST
MEDICAL LAB WORKERS
MEDICAL TECHNOLOGIST
METEROLOGIST
OCEANOGRAPHER
PHARMACISTS
PHOTOGRAPHER
PHYSICIAN
PHYSICIST
PURCHASING AGENT
PRACTICAL NURSE
REGISTERED NURSE
SUPERMARKET MANAGER
ELEMENTARY TEACHER
TEACHER SECONDARY-COLLEGE
TECHNICAL WRITER
VETERINARIAN
FOOD PROCESSING TECHNICIAN
AIRCRAFT MECHANICS
AUTOMOBILE MECHANIC
COMPOSING ROOM OPERATOR
DIESEL MECHANIC
FARM EQUIPMENT MECHANIC
INDUSTRIAL MAINTENANCE MECHANIC
INSTRUMENT MAKER
MACHINE TOOL OPERATOR
OFFICE MACHINE REPAIRMAN
PATTERN MAKER
PRINTING PRESSMAN
TOOL & DYE MAKER
DENTAL LABORATORY TECHNICIAN
FURNITURE UPHOLSTERERS
JEWLERS & REPAIRMEN
OPTICIAN
OPTICAL MECHANIC
WATCH REPAIRMAN
BRICK LAYER
CEMENT MASON
TELEPHONE INSTALLER
FLOOR COVERING INSTALLER
INSULATION WORKER
PAINTER
PLUMBER-PIPE FITTER
LINEMAN
X-RAY TECHNICIAN
TELEGRAPHER-TELEPHONER
AUTO PARTS MAN
MANUFACTURER REPRESENTATIVE
DELIVERY MAN
BUILDING CUSTODIAN
COOKS
FIREMEN
HOSPITAL ATTENDENT
HOTEL HOUSEKEEPER
FBI AGENT
POLICEMEN & WOMEN
STEWARDESSES
AGRIBUSINESS TECHNICIAN
AGRICULTURE EXTENSION WORKER
DAIRY PRODUCTION TECHNICIAN
FARM-CROP PRODUCTION TECHNICIAN
FARMER
FISH & WILDLIFE TECHNICIAN
FISH CULTURE TECHNICIAN
FORESTER
FORESTERY PRODUCTION TECHNICIAN
LAB ANIMAL CARE TECHNICIAN
LIVESTOCK PRODUCTION TECHNICIAN
ORCHARD TECHNICIAN
HORTICULTURIST
PARKS LAND MANAGEMENT TECHNICIAN
RANGE MANAGEMENT
SOIL CONSERVATIONIST
SOIL SCIENTIST
SIGNAL MAINTAINER
STONE MASON
STRUCTURAL STEEL WORKER
TELEPHONE REPAIRMAN
WELDER
BOOKBINDER
BROADCAST TECHNICIAN
ELECTRO TYPERS
GASOLINE SERVICE STATION
TRUCKDRIVER (ATTENDANT,WAREHOUSE)
LITHOGRAPHIC OCCUPATION
LOCOMOTIVE ENGINEER
APPRENTICE ENGINEER
METER MAN-WOMAN
PROJECTIONIST
PHOTO ENGRAVER
POWER PLANT OPERATOR
STATIONARY ENGINEER
BOILER FIREMAN
STEVEDORE
POWER DISPATCHER
ELECTROPLATER
GLAZIER
PLASTERER
PAPER HANGER
ROOFER
SHEET METAL WORKER

BEHAVIOR OF MATTER
LEVEL: JUNIOR HIGH

ACTIVITY: SOLUTIONS - SUSPENSIONS AND DENSITY

MATERIALS:

FOOD COLORING (3 DIFFERENT COLORS)	PLASTIC BOXES WITH LIDS
PLASTIC PAILS	SQUEEZE BOTTLES
DROPPERS	ALCOHOL
COARSE SALT	VINEGAR (CIDER & WHITE)
VIALS	PAPER CUPS (SMALL)
CLEAR SODA STRAWS	CARDBOARD TRAYS

PROCEDURE:

PLACE WATER IN BUCKETS AND SCATTER THEM AROUND THE ROOM. HAVE EACH STUDENT TEAM TAKE A CARDBOARD TRAY, 5 VIALS, 2 DROPPERS AND A PLASTIC BOX WITH A LID. PASS OUT TO EACH STUDENT A SMALL AMOUNT OF EACH COLOR OF FOOD COLORING. ASK STUDENTS TO FILL VIALS WITH WATER AND TO JUST TEST WHAT HAPPENS WHEN FOOD COLORING IS PLACED IN WATER. AFTER STUDENTS HAVE PLAYED WITH THE SOLUTIONS ONE MIGHT SUGGEST SOME OF THE FOLLOWING ACTIVITIES TO TRY:

DOES DIFFERENT TEMPERATURE OF WATER CAUSE A CHANGE?
DOES HEIGHT FROM WHICH DROP FALLS MAKE A DIFFERENCE?
CAN YOU GET COLOR TO STAY IN MIDDLE OF VIAL?
CAN YOU MAKE SMOKE RINGS?
WHAT DIFFERENT COLORS CAN YOU MAKE FROM YOUR 3 COLORS? ETC.

AFTER STUDENTS HAVE TRIED TO ANSWER THE QUESTIONS AND A DISCUSSION IS HELD OVER THEIR ANSWERS, CLEAN UP ALL MATERIALS.

THE NEXT SESSION HAND OUT SALT TO THE STUDENTS IN PAPER CUPS. DO NOT HAND OUT ANY FOOD COLORING. ASK STUDENTS TO MIX UP DIFFERENT SOLUTIONS WITH DIFFERENT AMOUNTS OF SALT. DISCUSS WHAT HAPPENS. ASK WHAT FOOD COLORING WOULD DO IN SALT WATER? HAND OUT FOOD COLORING AND THEN AFTER DISCOVERY, ASK THEM TO TRY TO SOLVE QUESTIONS IN THE FIRST SESSION. DISCUSS DENSITY WITH STUDENTS. CLEAN MATERIALS.

FOR THIRD SESSION PREPARE 4 BUCKETS WITH EACH HAVING A DIFFERENT SALT WATER DENSITY AND COLOR--EACH ONE A DIFFERENT COLOR TO KNOW THEM APART. ASK STUDENTS TO EXPERIMENT WITH THE SOLUTIONS AND DISCOVER WHICH IS THE HEAVIEST TO THE LIGHTEST. THEN HAND OUT TO THE STUDENTS CLEAR SODA STRAWS AND ASK THEM TO GET 1, 2, 3 & 4 LAYERS IN THE STRAWS. AFTER THIS THE TEACHER CAN USE 4 DIFFERENT LIQUIDS SUCH AS ALCOHOL, VINEGAR AND WATER, AND ASK WHICH IS WHICH WHEN THE DENSITY IS KNOWN. (USE CIDER AND WHITE VINEGAR)

TO THE TEACHER: THIS LAB CAN BE USED TO SUPPORT WORK ON SOLUTIONS AND SUSPENSIONS. IT ALSO IS GOOD TO SUPPORT A DISCUSSION OF THE BEHAVIOR OF MOLECULES IN THE MOLECULAR THEORY.

BEHAVIOR OF MATTER

LEVEL: JUNIOR HIGH

ACTIVITY: WHAT ARE SOME COMMON SOLVENTS?

MATERIALS: TEST TUBE RACK
5 TEST TUBES
FORCEPS
5 GLASS STIRRING RODS
MEDICINE DROPPER
TEST TUBE BRUSH

SOLVENTS: WATER
ALCOHOL
CARBON TETRACHLORIDE

SOLUTES: SALT
SULFUR
RUBBER BANDS
IODINE CRYSTALS
OIL

PROCEDURE:

A. LABEL THE TEST TUBES #1, #2, #3, #4, AND #5 WITH A WAX PENCIL. IN #1 POUR 20 CC OF WATER. POUR 20 CC OF ALCOHOL INTO #2. POUR 20 CC OF CARBON TETRACHLORIDE INTO #3. POUR 20 CC OF CARBON DISULFIDE INTO #4. AND POUR 20 CC OF BENZENE INTO #5. (DO NOT BREATH THE FUMES OF CARBON TETRACHLORIDE.)

B. PUT A PINCH OF SALT IN EACH TEST TUBE AND STIR GENTLY. UNDER "WHAT DO WE SEE?" WRITE "YES" IF IT DISSOLVES, "NO" IF IT DOESN'T.

C. WASH EACH TEST TUBE THOROUGHLY, WITH A TEST TUBE BRUSH. REFILL WITH FRESH SOLVENTS. REPEAT STEP B, USING SMALL PIECES OF SULFUR. REPEAT AGAIN USING RUBBER BANDS, IODINE CRYSTALS, AND, FINALLY, A FEW DROPS OF OIL. (USE A MEDICINE DROPPER FOR OIL AND FORCEPS FOR THE SOLID CHEMICALS.) BE SURE TO RECORD YOUR RESULTS EACH TIME IN THE TABLE UNDER "WHAT DO WE SEE?".

WHAT DO WE SEE?

1. RECORD YOUR OBSERVATIONS IN THE TABLE.

SOLVENTS	SOLUTES				
	SALT	SULFUR	RUBBER	IODINE	OIL
WATER					
ALCOHOL					
CARBON TETRACHLORIDE					
CARBON DISULFIDE					
BENZENE					

2. DESCRIBE WHAT HAPPENED WHEN YOU PUT THE SULFUR IN WATER:

____

____

AND IN CARBON DISULFIDE:

____

____

3. TELL WHAT HAPPENED WHEN YOU PUT OIL IN WATER:

____

AND IN CARBON TETRACHLORIDE:

____

4. DID THE RUBBER DISAPPEAR COMPLETELY IN ANY OF THE SOLVENTS? IF SO, IN WHICH ONES?

____

WHAT DO WE LEARN?

1. WHICH SOLVENT DISSOLVED THE MOST SOLUTES?

____

2. FROM YOUR EXPERIMENT, WHAT DO YOU THINK THE SOLUTION CALLED "TINCTURE OF IODINE" IS MADE OF?

____

THINGS TO DO:

1. PUT A SMALL PIECE OF WOOL CLOTH IN A TEST TUBE CONTAINING A 5% SOLUTION OF SODIUM HYDROXIDE ($NaOH$). THEN WARM THE SOLUTION <u>VERY GENTLY</u>. TRY IT AGAIN, USING JUST WATER AND CLOTH.

2. TRY TO DISSOLVE SUGAR IN WATER, ALCOHOL, AND OIL (KEROSENE). DESCRIBE WHAT HAPPENS.

3. MAKE A REPORT TO YOUR CLASS ON HOW DIFFERENT SOLVENTS ARE USED TO REMOVE STAINS FROM CLOTHING.

7c

BEHAVIOR OF MATTER
LEVEL: HIGH SCHOOL

ACTIVITY: PHYSICAL AND CHEMICAL CHANGES

PURPOSE: TO STUDY THE DIFFERENCES BETWEEN PHYSICAL AND CHEMICAL CHANGES IN MATTER.

MATERIAL:

ASBESTOS SQUARE
BURNER AND TUBING
FUNNEL
RING STAND
WASH BOTTLE
WIRE GAUZE
BAKING POWDER
MAGNESIUM RIBBON
SANDPAPER FINE GRIT
FILTER PAPER
SULFURIC ACID, DILUTE (1:6)
WOODEN SPLINTS
BEAKERS, 100 ML, 150 ML
FORCEPS
RING, IRON
TEST TUBES
WATCH GLASS
ALKA-SELTZER TABLETS
COPPER FOIL
PLATINUM WIRE TEST ROD
ZINC, MOSSY
HYDROCHLORIC ACID DILUTE (1:4)
SOLUTION OF SILVER NITRATE (0.2M)

INTRODUCTION:

MATTER UNDERGOES MANY CHANGES. IN SOME CASES ONLY THE TEMPERATURE, PHYSICAL STATE, SIZE OF PARTICLE OR COLOR IS CHANGED. ICE MELTS AND WATER EVAPORATES. SUCH CHANGES ARE PHYSICAL.

IN OTHER CASES DIFFERENT SUBSTANCES WITH NEW CHARACTERISTIC PROPERTIES ARE FORMED. WOOD BURNS AND METALS TARNISH. SUCH CHANGES ARE CHEMICAL. HEAT, LIGHT, ELECTRICITY, AND SOLUTION ARE OFTEN INSTRUMENTAL IN STARTING CHEMICAL CHANGES. IN MANY CASES, TOO, THEY ARE PRODUCED AS THE IMMEDIATE RESULT OF SUCH CHANGES.

PROCEDURES:

1. EXAMINE THE PLATINUM WIRE TEST ROD. OBSERVE THE COLOR AND LUSTER OF THE METAL. HOLD THE WIRE IN THE FLAME OF YOUR BURNER FOR ABOUT TWO MINUTES. RECALL PART OF EXPERIMENT IN WHICH YOU DETERMINED THE HOTTEST PART OF THE FLAME. DOES THE APPEARANCE OF THE PLATINUM WIRE SUPPORT YOUR PREVIOUS CONCLUSION? DESCRIBE THE APPEARANCE OF THE WIRE WHILE HELD IN THE HOTTEST PART OF THE FLAME. ALLOW THE WIRE TO COOL AND RE-EXAMINE IT. CONCLUSION?

OBSERVATIONS:

2. SANDPAPER A PIECE OF MAGNESIUM RIBBON ABOUT 3 CM IN LENGTH TO REMOVE THE TARNISH. NOTE THE COLOR, LUSTER, AND FLEXIBILITY OF THE METAL. HOLDING ONE END WITH THE FORCEPS, IGNITE THE OTHER END IN THE BURNER FLAME. CAUTION: DO NOT LOOK DIRECTLY AT THE MAGNESIUM WHILE IT IS BURNING. COMPARE THE ASH, WHICH MAY BE COLLECTED ON THE ASBESTOS SQUARE, WITH THE ORIGINAL METAL.

OBSERVATIONS:

3. SIMILARLY CLEAN A PIECE OF COPPER FOIL AND HEAT IT IN THE OUTER CONE OF THE BURNER FLAME FOR 1-2 MINUTES. AVOID MELTING. LET IT COOL AND RE-EXAMINE IT. SEE IF YOU CAN SCRAPE OFF SOME OF THE BLACK SCALE FROM THE SURFACE OF THE COPPER. COMPARE THE PROPERTIES OF THIS SCALE WITH THOSE OF METALLIC COPPER. HEAT THE FOIL A SECOND TIME. RESULT? EXPLAIN.

OBSERVATIONS:

4. DIP ONE END OF THE PLATINUM WIRE INTO A TEST TUBE CONTAINING 4 OR 5 ML OF DILUTE SULFURIC ACID. OBSERVE CAREFULLY FOR ANY SIGNS OF CHEMICAL ACTION. RESULT? REMOVE THE PLATINUM WIRE, FLUSHING IT WITH WATER BEFORE LAYING ASIDE. ADD A SMALL PIECE OF ZINC TO THE ACID. RESULT? LET THE ACTION CONTINUE FOR ABOUT 5 MINUTES. WARM THE TUBE GENTLY, CAUTION.

WHEN THE REACTION IS PROCEEDING VIGOROUSLY, BRING THE FLAME OF A BURNING SPLINT TO THE MOUTH OF THE TEST TUBE. RESULT? THE DILUTE SULFURIC ACID IS A WATER SOLUTION OF HYDROGEN SULFATE. WHAT GAS DO YOU THINK IS BEING EVOLVED DURING THE REACTION? ACCOUNT FOR THE APPEARANCE OF A BLACK SUSPENSION IN THE LIQUID. FILTER TO REMOVE SUSPENDED MATTER, IF PRESENT. DO YOU BELIEVE A SECOND PRODUCT OF THE REACTION TO BE IN SOLUTION IN THE FILTRATE? USING AN APPROPRIATE TECHNIQUE, RECOVER THIS PRODUCT FROM A PORTION OF THE FILTRATE. COMPARE THE PRODUCT WITH THE ORIGINAL ACID AND WITH THE ZINC. SUGGEST THE PROBABLE NAME OF THE CRYSTALLINE SUBSTANCE. TRY WRITING A WORD EQUATION TO EXPRESS YOUR IDEA OF THE CHEMICAL REACTION THAT HAS TAKEN PLACE.

OBSERVATIONS:

5. TO 3 OR 4 ML OF SILVER NITRATE SOLUTION, ADD SEVERAL DROPS OF DILUTE HYDROCHLORIC ACID. RESULT? CAN YOU RECOGNIZE A PRECIPITATE? DESCRIBE IT. HYDROCHLORIC ACID IS A WATER SOLUTION OF HYDROGEN CHLORIDE. CONSULT THE SOLUBILITY TABLE IN THE APPENDIX AND SUGGEST THE PROBABLE NAME OF THE INSOLUBLE PRODUCT (THE PRECIPITATE). TRY WRITING A WORD EQUATION TO EXPRESS YOUR IDEA OF THE CHEMICAL REACTION THAT HAS TAKEN PLACE. WAS THERE ANY EVIDENCE OF A GASEOUS PRODUCT OF THIS REACTION? TRANSFER THE ENTIRE CONTENTS OF THE TEST TUBE TO A FILTER SETUP, FLUSHING WITH SMALL ADDITIONS OF WATER FROM THE WASH BOTTLE, IF NECESSARY, TO REMOVE ALL OF THE PRECIPITATE. DISCARD THE FILTRATE, UNFOLD THE FILTER PAPER AND EXPOSE THE PRECIPITATE TO DIRECT SUNLIGHT FOR SEVERAL MINUTES. RESULT? DO YOU THINK THIS CHANGE IS PHYSICAL OR CHEMICAL? DID YOU OBSERVE ANY EVIDENCE OF AN APPRECIABLE ENERGY CHANGE DURING THE REACTION?

OBSERVATIONS:

6. TO ONE-HALF AN ALKA-SELTZER TABLET OR TO 2 GRAMS OF BAKING POWDER IN A 100 ML BEAKER ADD 5 ML OF WATER. RESULT? AFTER THE REACTION PROCEEDS FOR 15 SECONDS, THRUST A BURNING SPLINT INTO THE UPPER PORTION OF THE BEAKER. RESULT? BOTH ALKA-SELTZER AND BAKING POWDER CONTAIN A SOLID SUBSTANCE, WHICH ACTS AS AN ACID, AND SODIUM HYDROGEN CARBONATE. WHAT GAS DO YOU THINK IS BEING EVOLVED DURING THE REACTION? WHY DID THE CHEMICALS WHICH DID NOT REACT IN THE DRY STATE BEGIN TO REACT?

OBSERVATIONS:

QUESTIONS: ANSWER IN COMPLETE SENTENCES.

1. WHAT KIND OF CHANGE OCCURS WHEN PLATINUM IS HEATED?

2. IS A NEW SUBSTANCE FORMED AS MAGNESIUM BURNS? JUSTIFY YOUR ANSWER.

3. HOW DOES THE SCALE WHICH FORMS WHEN COPPER IS HEATED DIFFER FROM THE COPPER?

4. WHAT DO YOU THINK WOULD BE THE ULTIMATE RESULT OF SUCCESSIVE HEATINGS AND SCRAPINGS OF THE COPPER?

5. DOES PLATINUM INTERACT WITH SULFURIC ACID?

6. DOES THE PRECIPITATE IN PART 5 SEEM TO BE A NEW SUBSTANCE? IS THIS A CHEMICAL OR PHYSICAL CHANGE?

7. THE PRECIPITATE IN PART 5 IS SILVER CHLORIDE. WHAT EFFECT DOES SUNLIGHT HAVE ON THE PRECIPITATE?

   DO YOU THINK SUCH A CHANGE MAY HAVE SOME RELATION TO PHOTOGRAPHY?

8. SUMMARIZE THE RESULTS OF THIS EXPERIMENT IN A DEFINITE, CONCISE CONCLUSION.

BEHAVIOR OF MATTER
LEVEL: HIGH SCHOOL

ACTIVITY: FLAME TESTS

PURPOSE: TO SHOW HOW CERTAIN METALS MAY BE IDENTIFIED BY THE COLOR THEY IMPART TO A FLAME.

MATERIALS:

BURNER AND TUBING
TEST TUBES
HYDROCHLORIC ACID DILUTE (1:4)
SODIUM CHLORIDE
0.5-M SOLUTIONS IN DISTILLED WATER OF THE A.R. GRADE NITRATES OF BARIUM, CALCIUM, LITHIUM, POTASSIUM, SODIUM, AND STRONTIUM, AND OF SODIUM CHLORIDE
UNKNOWN SOLUTIONS
2 COBALT GLASS PLATES
5-CM LENGTH OF NO. 24 PLATINUM WIRE, SEALED IN THE END OF A GLASS TUBE 10 CM LONG. IF PLATINUM WIRE IS NOT AVAILABLE, NICHROME WIRE (NOT AS SATISFACTORY AS PLATINUM) MAY BE USED. NICHROME WIRE SHOULD BE HELD WITH FORCEPS.

INTRODUCTION:

IF YOU WISH TO SECURE GOOD RESULTS IN THIS EXPERIMENT, YOUR TEST TUBES MUST BE SCRUPULOUSLY CLEAN. YOUR TEST TUBES MAY BE THOROUGHLY CLEANED BY USING THE CLEANING SOLUTION DESCRIBED IN THE TEACHERS' EDITION TO EXERCISES AND EXPERIMENTS IN CHEMISTRY. (CAUTION: THIS CLEANING SOLUTION IS EXTREMELY CORROSIVE AND MUST NOT BE SPILLED!) AFTER THE CLEANING SOLUTION HAS BEEN USED, THE TEST TUBES MAY BE RINSED THOROUGHLY IN TAP WATER AND THEN IN DISTILLED WATER.

SUGGESTION: HAVE STUDENTS EXAMINE SODIUM LINES PRODUCED IN A SPECTROSCOPE USING A SODIUM VAPOR LAMP AND THEN A SODIUM FLAME SOURCE. THIS MAY BE REPEATED WITH MIXTURES OF SODIUM AND POTASSIUM.

PROCEDURES:

1. CLEAN A PLATINUM WIRE BY DIPPING IT FIRST INTO SOME DILUTE HYDROCHLORIC ACID IN A TEST TUBE AND THEN HOLDING IT IN THE COLORLESS FLAME OF YOUR BURNER. REPEAT UNTIL THE WIRE IMPARTS NO COLOR TO THE FLAME. POUR 4 ML OF SODIUM NITRATE SOLUTION INTO A CLEAN TEST TUBE, AND DIP THE TIP OF THE CLEAN PLATINUM WIRE INTO THE SOLUTION, AND THEN HOLD IT IN THE FLAME. OBSERVE THE COLOR OF THE FLAME JUST ABOVE THE WIRE. HEAT ONLY THE TIP OF THE WIRE. IF YOU HEAT THE GLASS TUBE INTO WHICH THE WIRE IS SEALED, YOU WILL BREAK THE GLASS.

   CLEAN THE WIRE AS BEFORE AND THEN TEST A SOLUTION OF SODIUM CHLORIDE IN THE SAME MANNER. REPEAT THE TEST, DIPPING THE WIRE INTO A LITTLE DRY SODIUM CHLORIDE.

OBSERVATIONS:

2. Repeat Part 1, using in turn 4 ml of the solutions of the nitrates of lithium, strontium, calcium, barium, and potassium. Clean the wire thoroughly after each test. In the cases of lithium and strontium, observe which flame is more persistent and takes longer to burn off the wire. Also note the difference in the shades of color produced. When you have tested the calcium flame and then dipped the wire into hydrochloric acid and back into the flame when cleaning it, you often get an excellent flame of calcium momentarily. Record your observations in the accompanying table.

Observations:

3. If two salts are present in the same solution, the color of one flame may obscure that of the other. Sometimes it is possible to absorb one color and not the other. Examine the sodium flame through at least two thicknesses of cobalt glass. Repeat, using the potassium flame with the cobalt glasses.

Flame test a mixture of the solutions of the nitrates of sodium and potassium with a clean wire. Observe the color the mixture imparts to the flame when viewed without the cobalt glasses. Repeat the test, but observe the flame as seen through the cobalt glasses. Explain any differences observed. Record your observations as before.

Observations:

4. Secure an unknown solution from your instructor. Test it in the flame as in this experiment in order to identify the metallic ion present.

DATA TABLE

Metal in compound	Color of flame
Sodium	....
Lithium	....
Strontium	....
Calcium	....
Barium	....
Potassium	....
Sodium (Cobalt glass)	....
Potassium (cobalt glass)	....
Sodium and potassium	....
Sodium and potassium (cobalt glass)	....
Unknown metal	....

Conclusion:

The unknown metal was: ____________________

____

QUESTIONS: ANSWER IN COMPLETE STATEMENTS.

1. IS THE FLAME COLORATION A TEST FOR THE METAL OR FOR THE ACID RADICAL?

2. WHY DO DRY SODIUM CHLORIDE AND THE SOLUTIONS OF SODIUM NITRATE AND SODIUM CHLORIDE ALL IMPART THE SAME COLOR TO THE FLAME?

3. DESCRIBE THE TEST FOR SODIUM AND POTASSIUM WHEN BOTH ARE PRESENT.

4. HOW WOULD YOU CHARACTERIZE THE FLAME TEST WITH RESPECT TO ITS SENSITIVITY?

5. WHAT DIFFICULTIES MAY BE ENCOUNTERED IN THE USE OF THE FLAME TEST FOR IDENTIFICATION?

BEHAVIOR OF MATTER

Q

LEVEL: HIGH SCHOOL

ACTIVITY: SOLUBILITY OF CHEMICAL SALTS

PROBLEM: SCIENTISTS ARE FAMILIAR WITH HUNDREDS OF DIFFERENT KINDS OF CHEMICAL SALTS WHICH DIFFER IN THEIR PROPERTIES BY HAVING DIFFERENT COLORS, TASTES, AND CRYSTAL SHAPES. DO CHEMICAL SALTS ALSO DIFFER IN THEIR ABILITY TO DISSOLVE IN WATER?

MATERIALS:

TEST TUBES
GRADUATED CYLINDER
STIRRING ROD
POWDERED SAMPLES OF DIFFERENT SALTS, SUCH AS SODIUM CHLORIDE, IRON NITRATE, COPPER SULFATE, ETC.
TEST TUBE RACK
LABORATORY BALANCE
FLASHLIGHT

PROCEDURE:

PLACE SEVERAL TEST TUBES IN A TEST TUBE RACK AND POUR AN EQUAL AMOUNT OF WATER INTO EACH TEST TUBE. WEIGH OUT EXACTLY 25 GRAMS OF EACH SALT BEING TESTED. ADD THE SALT, A FEW GRAINS AT A TIME, TO THE WATER IN A TEST TUBE UNTIL NO MORE SALT WILL DISSOLVE WHEN THE WATER IS STIRRED. CAREFULLY WEIGH THE AMOUNT OF SALT LEFT OVER TO DETERMINE HOW MUCH SALT DISSOLVED IN THE WATER.

OBSERVATIONS:

RECORD YOU RESULTS IN THE FOLLOWING TABLE (INDICATE THE DEGREE OF SOLUBILITY OF EACH SALT BY WRITING GOOD, MEDIUM, OR POOR).

NAME OF SALT	MILLILITERS OF WATER	GRAMS OF SALT DISSOLVED	DEGREE OF SOLUBILITY
SODIUM CHLORIDE			
IRON NITRATE			
COPPER SULFATE			

1. WHY WOULD SHINING A BEAM OF LIGHT THROUGH A SOLUTION HELP YOU DETERMINE WHETHER THE SALT IS COMPLETELY DISSOLVED?

2. WHAT EFFECT DOES STIRRING THE SOLUTION HAVE ON THE RATE AT WHICH THE SALT DISSOLVES?

3. WHAT EFFECT WOULD HEATING THE WATER HAVE ON THE RATE AT WHICH THE SALT DISSOLVES?

INTERPRETATION:

FILL IN THE BLANK WORDS IN THE FOLLOWING PARAGRAPH IN THE NUMBERED SPACES AT THE RIGHT.

MANY SALTS ARE FORMED BY THE PROCESS OF (1) WHEN AN (2) IS ADDED TO A (3). THE PROCESS OF NEUTRALIZATION IS COMPLETE WHEN BLUE LITMUS PAPER WILL NOT TURN (4) IN THE SOLUTION AND RED LITMUS PAPER WILL NOT TURN (5). THE SALT FORMED IF HYDROCHLORIC ACID IS USED IN THE REACTION IS CALLED A (6). SIMILARLY, IF NITRIC ACID IS USED, THE SALT FORMED IS CALLED A (7), AND IF SULFURIC ACID IS USED, THE SALT FORMED IS A (8). THUS, WE SEE THAT SALTS DIFFER IN THEIR PROPERTIES, BUT THEY ALL CONTAIN ONE ELEMENT OR RADICAL FROM AN (9) AND ONE ELEMENT OR RADICAL FROM A (10).

1 ____________
2 ____________
3 ____________
4 ____________
5 ____________
6 ____________
7 ____________
8 ____________
9 ____________
10 ____________

APPLICATION:

IT IS ALSO POSSIBLE TO DISSOLVE LIQUIDS IN WATER. FOR EXAMPLE, IF YOU CAREFULLY MEASURE OUT 50 MILLILITERS OF WATER AND 50 MILLILITERS OF ALCOHOL AND POUR THE ALCOHOL IN THE WATER, YOU WOULD FIND THAT THE VOLUME OF THE MIXTURE IS LESS THAN 100 MILLILITERS. EXPLAIN HOW THIS IS POSSIBLE.

BEHAVIOR OF MATTER
LEVEL: HIGH SCHOOL

ACTIVITY: SEPARATING COMPONENTS OF MATTER

MATERIALS: (PER TEAM)
STRIP OF FILTER PAPER WITH DYE SPOT
PAPER CLIP
2 MASON JARS OR DRINKING GLASSES

PROCEDURES:

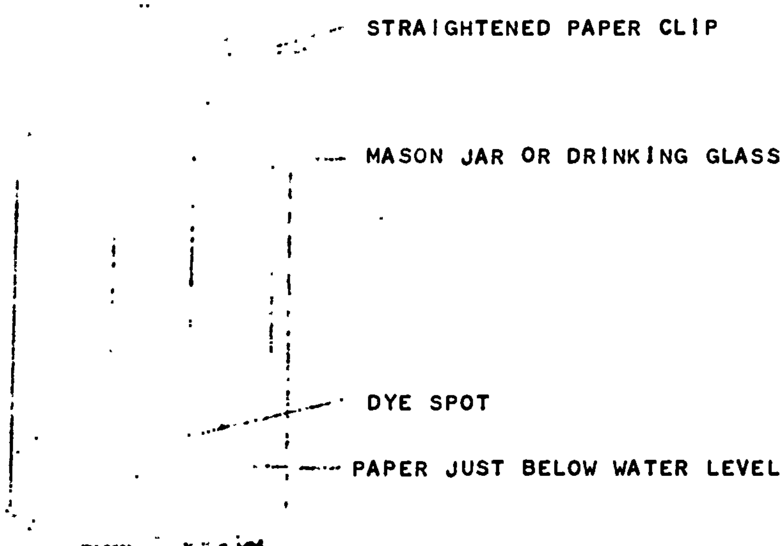
A. POUR ABOUT 20 ML OF WATER INTO ONE OF THE JARS. A SPOT OF GREEN DYE HAS BEEN PLACED NEAR ONE END OF THE FILTER PAPER. HOLD THE FILTER PAPER AGAINST THE OUTSIDE OF THE JAR SO THE DYE SPOT IS A SHORT DISTANCE ABOVE THE WATER LEVEL. PUSH A STRAIGHTENED PAPER CLIP THROUGH THE FILTER PAPER AT THE LEVEL EVEN WITH THE TOP OF THE JAR.
B.. LOWER THE FILTER PAPER INTO THE WATER UNTIL THE CLIP RESTS ON THE JAR, SEE PICTURE.
C. LEAVE THE FILTER PAPER IN THE WATER UNTIL THE PAPER IS SATURATED TO THE LEVEL OF THE PAPER CLIP.
D. REMOVE THE FILTER PAPER FROM THE WATER AND HANG IT IN AN EMPTY JAR TO DRY. DO NOT TOUCH THE PAPER.

INTERPRETATIONS:

1. HOW MANY SUBSTANCES WERE PRESENT IN THE ORIGINAL DYE?

2. WHAT PROPERTY OF MATTER DO YOU BELIEVE IS REPONSIBLE FOR THE SEPARATION?

3. SUGGEST A MODEL TO EXPLAIN HOW THE SEPARATION COULD OCCUR. YOU MIGHT SUGGEST DEMONS OR SOME OTHER THEORY TO EXPLAIN WHY THE SUBSTANCES IN THE DYE SEPARATED. MAKE YOUR OWN ILLUSTRATIONS, IF NECESSARY.



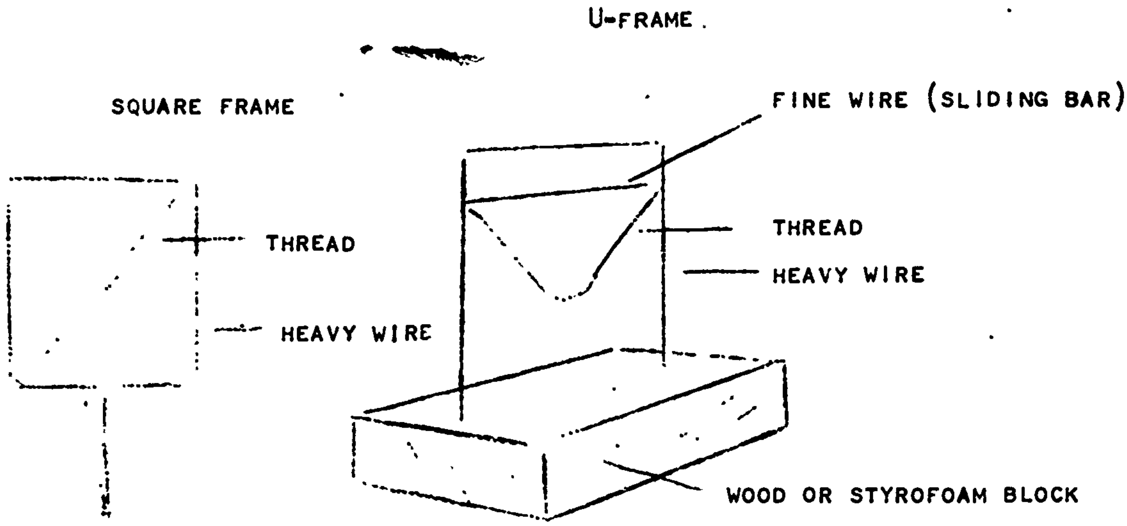
BEHAVIOR OF MATTER
LEVEL: HIGH SCHOOL

ACTIVITY: THE NATURE OF A FILM

MATERIALS: (PER TEAM)

THREAD
SOAP SOLUTION
SEVERAL TOOTH PICKS
SMALL PLASTIC OR GLASS FUNNEL
WIRE FRAMES
LARGE BEAKER OR PAN FOR SOAP SOLUTION

WIRE FRAMES TO BE USED IN PROCEDURES A-C.



PROCEDURES:

A. TIE A PIECE OF THREAD TO DIAGONALLY OPPOSED CORNERS OF THE SQUARE FRAME. DIP THE ENTIRE FRAME INTO THE SOAP SOLUTION. CAREFULLY RAISE THE FRAME OUT OF THE SOLUTION, AND OBSERVE THE BEHAVIOR OF THE THREAD. MAKE A SKETCH AND RECORD YOUR OBSERVATIONS. PUNCTURE THE FILM ON ONE SIDE OF THE THREAD WITH A CLEAN TOOTHPICK, AND OBSERVE WHAT HAPPENS TO THE THREAD. SKETCH WHAT YOU SEE AS ACCURATELY AS POSSIBLE. REPEAT, PUNCTURING ALTERNATE SIDES OF THE FILM.

B. SLIDE ONE END OF THE THREAD TO A DIFFERENT CORNER OF THE FRAME, AND REPEAT PROCEDURE A. RECORD YOUR OBSERVATIONS.

C. DIP THE U-FRAME (AND SLIDING BAR) INTO THE SOAP SOLUTION, AND REMOVE. GENTLY GRASP THE SLIDING BAR ON BOTH ENDS AND PULL IT SLOWLY TOWARD THE BLOCK. PREDICT WHAT WILL HAPPEN WHEN YOU RELEASE THE BAR. RELEASE THE SLIDING BAR AND OBSERVE THE EFFECT. WAS YOUR PREDICTION CORRECT? RECORD YOUR OBSERVATIONS.

D. FORM A FILM ON THE LARGE END OF THE GLASS FUNNEL BY GENTLY DIPPING IT INTO THE SOAP SOLUTION. COVER THE SMALL END OF THE FUNNEL WITH YOUR FINGER, AND RAISE THE FUNNEL FROM THE SOLUTION. BEFORE CONTINUING, PREDICT WHAT WILL HAPPEN TO THE FILM WHEN YOU REMOVE YOUR FINGER FROM THE FUNNEL. HOLD THE FUNNEL AT EYE LEVEL AND REMOVE YOUR FINGER. OBSERVE AND RECORD IN YOUR NOTEBOOK ANY CHANGE IN THE FILM.

E. REPEAT THE STEPS OF PROCEDURE D, AND THEN DIP THE FUNNEL INTO THE SOAP SOLUTION TO FORM A SECOND FILM. RECORD YOUR OBSERVATIONS CAREFULLY.

INTERPRETATIONS:

1. WRITE A DESCRIPTION OF A MODEL THAT RELATES THE BEHAVIOR OF WATER TO THE PARTICLES WHICH JOIN TOGETHER TO MAKE WATER DROPS. IN GIVING REASONS FOR YOUR STATEMENTS, YOU ARE CARRYING OUT A FUNDAMENTAL ACTIVITY OF SCIENCE: THE RELATING OF EXPERIMENTAL RESULTS AND THE INTERPRETATION OF THOSE RESULTS IN SUCH A WAY AS EITHER TO BUILD MORE CONFIDENCE IN THE MODEL OR TO PROVIDE EVIDENCE THAT MAKES THE MODEL UNSATISFACTORY.

2. THE FOLLOWING QUESTIONS SHOULD SERVE ONLY AS GUIDELINES, NOT AS RESTRICTIONS ON YOUR THINKING:

   A. IN PROCEDURES A AND B YOU PUNCTURED ONE-HALF OF THE FILM. WHAT DOES THE BEHAVIOR OF THE THREAD FOLLOWING A PUNCTURE SUGGEST ABOUT THE PROPERTIES OF ATOMS OR THE BEHAVIOR OF DEMONS?

   B. HOW CAN YOU ACCOUNT FOR THE BEHAVIOR OF THE FILM IN PROCEDURE C? HOW CAN YOU ACCOUNT FOR THE REACTION OF THE SOAP FILM AND SLIDING BAR AFTER IT IS RELEASED?

   C. WHY DOES A FILM FORMED ON THE LARGE END OF A FUNNEL BEHAVE AS IT DOES?

BEHAVIOR OF MATTER
LEVEL: HIGH SCHOOL

ACTIVITY: MEASUREMENT OF pH IN AQUATIC ECOSYSTEMS

MATERIALS (PER TEAM):

A. FOR STUDYING THE ACTION OF INDICATORS

BEAKERS, 50 OR 100 ML, 6
GRADUATED CYLINDER
GLASS STIRRING RODS, 6
BROMTHYMOL BLUE SOLUTION
HYDROCHLORIC ACID
GLASS-MARKING CRAYON
DISTILLED WATER, 100 ML
METHYL RED SOLUTION
PHENOLPHTHALEIN SOLUTION
SODIUM HYDROXIDE SOLUTION

B. FOR STUDYING THE pH OF DIFFERENT WATER SAMPLES

WATER SAMPLES, 3 OR MORE
GLASS-MARKING CRAYON
MICROSCOPE SLIDES, 1 PER SAMPLE
WIDE-RANGE pH TEST PAPER, 1 CM PER SAMPLE
TEST TUBES, 1 PER SAMPLE
GLASS STIRRING RODS, 1 PER SAMPLE

PROCEDURE A: THE ACTION OF INDICATORS

1. MARK THE SIX BEAKERS AS FOLLOWS: A-1, B-1, A-2, B-2, A-3, B-3.
2. INTO EACH BEAKER POUR 15 ML OF DISTILLED WATER, AND ADD A STIRRING ROD.
3. TO BEAKERS A-1 AND B-1 ADD A DROP OF METHYL RED SOLUTION; TO BEAKERS A-2 AND B-2 ADD A DROP OF BROMTHYMOL BLUE SOLUTION; TO BEAKERS A-3 AND B-3 ADD A DROP OF PHENOLPHTHALEIN SOLUTION.
4. IN YOUR DATA BOOK RECORD THE COLOR IN EACH BEAKER.
5. TO EACH OF THE THREE A BEAKERS ADD A DROP OF HYDROCHLORIC ACID AND STIR; TO EACH OF THE B BEAKERS ADD A DROP OF SODIUM HYDROXIDE SOLUTION (A BASE, OR ALKALI) AND STIR. IF NO COLOR CHANGES OCCUR, CONTINUE TO ADD ACID, ONE DROP AT A TIME, TO EACH A BEAKER, STIRRING AFTER EACH ADDITION. BE SURE TO KEEP EACH STIRRING ROD IN ITS OWN BEAKER.
6. IN THE SAME WAY, ADD BASE TO EACH B BEAKER. IF, AFTER STIRRING, A COLOR CHANGE REMAINS IN ANY BEAKER, RECORD THE NEW COLOR NEXT TO THE OLD AND THE NUMBER OF DROPS OF ACID OR BASE ADDED. WHEN A COLOR CHANGE HAS OCCURRED IN EITHER BEAKER OF ANY PAIR, YOUR WORK WITH THAT PAIR IS FINISHED. CONTINUE THE PROCEDURE UNTIL A COLOR CHANGE HAS OCCURRED IN ONE BEAKER OF EACH PAIR.

STUDYING THE DATA

1. ACCORDING TO THE BACKGROUND INFORMATION GIVEN ABOVE, APPROXIMATELY WHAT pH SHOULD DISTILLED WATER HAVE?
2. AS ACID IS ADDED TO THE A BEAKERS, WHAT HAPPENS TO THE pH VALUE?
3. AS A BASE IS ADDED TO THE B BEAKERS, WHAT HAPPENS TO THE pH VALUE?
4. KEEPING THESE IDEAS IN MIND AND REFERRING TO YOUR DATA, ARRANGE THE INDICATOR COLORS IN ORDER OF INCREASING pH.
5. YOUR TEACHER WILL GIVE YOU THE pH RANGE IN WHICH EACH INDICATOR CHANGES COLOR. WITH A WHOLE SERIES OF SUCH INDICATORS, THE APPROXIMATE pH OF SOLUTIONS CAN BE WORKED OUT.

Procedure B: The pH of Different Water Samples

Obtain samples of water from different aquatic environments. Among these should be tap water, aquarium water, and water from a pond or stream. Water might also be obtained from a swamp or bog, from a polluted stream, from a roadside ditch, etc. If seawater is not available, a solution approximating it can be made up in the chemistry laboratory. Arrange test tubes on a table, one tube for each water sample. Pour water from each sample into a separate test tube, and mark the tubes so that you can identify the source of the water.

Questions:

6. What is the pH range discovered in your samples?
7. According to your evidence, are natural waters more likely to be acid, or are they more likely to be alkaline?
8. Can you think of any reason for this? If so, state it.
9. What was the source of the sample that is farthest from neutral?
10. Can you explain why it is so acid or so alkaline?

BEHAVIOR OF MATTER
LEVEL: HIGH SCHOOL

ACTIVITY: HYDRONIUM ION CONCENTRATION, pH

PURPOSE: TO DETERMINE THE pH OF VARIOUS SOLUTIONS OF COMPARABLE CONCENTRATION, AND TO STUDY THE EFFECT OF DILUTION ON THE pH OF ACIDS AND A METALLIC HYDROXIDE.

MATERIALS:
BEAKER, 250 ML
TEST TUBES
SOLUTIONS OF ACETIC ACID (0.10M)
AMMONIA WATER (0.10M)
AMMONIUM ACETATE (0.10M)
PHOSPHORIC ACID (0.033M)
SODIUM CHLORIDE (0.10M)
SODIUM HYDROXIDE (0.10M)
H
GRADUATED CYLINDERS, 10 ML, 50 ML
pH PAPERS, WIDE RANGE, I.E. A & B, NARROW RANGE, I.E. D, HYDRION PAPERS OR EQUIVALENT pH PAPERS
HYDROCHLORIC ACID (0.10M)
SODIUM CARBONATE (0.050M)
SODIUM HYDROGEN CARBONATE (0.10M)

INTRODUCTION:

THE CONCENTRATION OF HYDONIUM ION IS USUALLY REPRESENTED BY THE EXPRESSION (H_3O^+) WHICH MEANS THE HYDRONIUM ION CONCENTRATION IN MOLES (GRAMIONS) PER LITER OF SOLUTION. A ONE MOLAR (1.0-M) SOLUTION OF HYDRONIUM IONS CONTAINS 1 MOLE, 19 G, OF HYDRONIUM ION PER LITER OF SOLUTION.

PURE WATER SLIGHTLY IONIZED AND CONTAINS 0.0000001 MOLE OF HYDRONIUM ION PER LITER. ITS HYDRONIUM ION CONCENTRATION, (H_3O^+) IS THEREFORE REPRESENTED AS 1.0×10^{-7} M OR 10^{-7} M. SINCE PURE WATER IS NEUTRAL, ITS HYDROXIDE ION CONCENTRATION IS ALSO 1.0×10^{-7} M OR 10^{-7} M. IN ANY WATER SOLUTION, THE PRODUCT OF THE HYDRONIUM AND HYDROXIDE ION CONCENTRATIONS IS KNOWN AS THE ION-PRODUCT OF WATER AND IS EQUAL TO 1.0×10^{-14}. THIS EQUILIBRIUM IS REPRESENTED BY THE EQUATION:

$$H_2O + H_2O \quad H_3O^+ + OH^-$$

FOR NEUTRAL WATER, (25°C)

$$K_w = 10^{-14} = (H_3O^+) \times 10^{-6}$$
$$= (1 \times 10^{-7})^3 (1 \times 10^{-7}) = 1 \times 10^{-14}$$

THE pH OF A SOLUTION IS DEFINED AS THE COMMON LOGARITHM OF THE RECIPROCAL OF THE HYDRONIUM ION CONCENTRATION. FOR NEUTRAL WATER,

$$pH = \log \frac{1}{0.0000001} = \log \frac{1}{10^{-7}}$$

THEREFORE: $pH = \log 10^7$, AND $pH = 7$.

IF THE HYDRONIUM ION CONCENTRATION IS GREATER THAN THAT OF PURE WATER, THE pH OF THE SOLUTION IS NUMBERICALLY LESS THAN 7. THUS, FOR A SOLUTION WHICH IS ACID SUCH AS 0.000001-M (1×10^{-6} M) HCl COMPLETELY IONIZED), THE pH IS 6. FOR ACIDIC SOLUTIONS, THEREFORE, THE pH IS SMALLER THAN 7. THE SMALLER THE pH THE LARGER THE HYDRONIUM ION CONCENTRATION. IF THE SOLUTION IS BASIC, ITS HYDRONIUM ION CONCENTRATION IS LESS THAT 10^{-7} M AND ITS pH IS LARGER THAN 7. FOR A 1×10^{-6} -M SOLUTION OF NaOH (COMPLETELY DISSOCIATED), THE HYDROXIDE ION CONCENTRATION IS 1×10^{-6}. ITS HYDRONIUM ION CONCENTRATION THEREFORE IS 1×10^{-8}, AND ITS pH IS 8.

$K_w = 10^{-14} = (H_3O^+) \times 10^{-6}$

$(H_3O^+) = 10^{-8}$; THE PH BEING 8

SUGGESTIONS:

THE TEACHER MAY WISH TO DEMONSTRATE THE USE OF A PH METER TO COMPLEMENT THE USE OF THE INDICATOR AND TO OBTAIN MORE EXACT PH READINGS.

PROCEDURE:

1. TEST FOR THE PH OF EACH OF THE SOLUTIONS BY DIPPING A STIRRING ROD INTO EACH OF THE SOLUTIONS AND APPLYING FIRST TO THE WIDE RANGE PH PAPER (A AND B) AND IF NECESSARY, TO THE NARROW (SHORT) RANGE PAPER (D). RECORD YOUR OBSERVATIONS AND COMPLETE DATA TABLE 1.

2. EFFECT OF DILUTION ON PH OF ACIDS AND HYDROXIDES. START WITH 5.0 ML OF STOCK (0.1-M) SOLUTIONS AND DILUTE TO 50 ML. SAVE 5 ML OF THE DILUTED SOLUTION IN A PROPERLY LABELED TEST TUBE AND USE ANOTHER 5.0 ML FOR THE NEXT DILUTION TO 50 ML. REPEAT THE DILUTION PROCESS 4 TIMES FOR EACH STOCK 0.1-M SOLUTION, IN EACH CASE SAVING THE 5.0 ML SAMPLE FOR TESTING WITH THE PH PAPERS AS IN PART 1. RECORD YOUR RESULTS IN DATA TABLE 2.

QUESTIONS:

1. WHICH OF THE SUBSTANCES AMONG THOSE HAVING A DEFINITE ACIDIC REACTION IS (A) THE STRONGEST ACID, (B) THE WEAKEST ACID?
(A)________________ (B)________________

2. WHY IS A 0.1-M SOLUTION OF NAOH A MUCH STRONGER BASE THAN A 0.1-M SOLUTION OF NH_3-AQ?________________

3. WHAT EFFECT DOES DILUTION HAVE ON THE PH OF (A) AN ACID, (B) A BASE? (A)________________
(B)________________

DATA TABLE 1

0.1-N SOLUTIONS	INDICATOR COLOR	NUMERICAL PH	STRENGTH AS ACID OR BASE
HCl			
$HC_2H_3O_2$			
H_3PO_4			
NACH			
NH_3			
NACL			
NA_2CO_3			
$NAHCO_3$			
$NH_4C_2H_3O_2$			

Indicator colors may vary from different manufacturers.

DATA TABLE 2

HCl	Calculated pH	Indicator color	Observed pH
1. 0.1 *M*			
2. 0.01 *M*			
3. 0.001 *M*			
4. 0.0001 *M*			
5. 0.00001 *M*			

NaOH	Calculated pH	Indicator color	Observed pH
1. 0.1 *M*			
2. 0.01 *M*			
3. 0.001 *M*			
4. 0.0001 *M*			
5. 0.00001 *M*			

$HC_2H_3O_2$	Indicator color	Observed pH
1. 0.1 *M*		
2. 0.01 *M*		
3. 0.001 *M*		
4. 0.0001 *M*		
5. 0.00001 *M*		

CHEMICAL FAMILIES
Level: High School

ACTIVITY: The Periodic Law

Directions: Write answers to the following in the spaces provided. Where appropriate, make complete statements.

1. Who did the pioneer work on the Periodic Table we use today?

2. What important use did he make of his Periodic Table?

3. In what order are the elements listed in our present Periodic Table?

4. How did Moseley account for the fact that the X-ray wavelengths obtained from two successive known elements sometimes had twice the expected variation?

5. State the periodic law.

6. What name is given to the elements in a vertical column of the Periodic Table?

7. What name is given to the elements in a horizontal row of the Periodic Table?

8. What name is given to elements whose atoms usually differ in electron configuration by the entrance of successive electrons in a d sublevel?

9. What name is given to elements whose atoms usually differ in electron configuration by the entrance of successive electrons in an f sublevel?

10. Compose two statements describing the periodicity of atomic radii.

11. In the reaction, A + energy--A^+ + e^-, (a) what kind of a particle is A^+?

    (b) What name describes the energy involved?

12. In Question 11, what kind of element is A generally if the quantity of energy (a) is low?

    (b) Is high?
    (c) Is of intermediate value?

13. How does the ionization energy vary with atomic number within a family of nontransition elements?

14. What causes the periodic variation of ionization energy across a row of elements in the Periodic Table?

15. Why is the ionization energy required to remove the second electron from the Na atom so very much greater than that needed to remove the first electron?

16. Why is the ionization energy needed to remove the first two electrons from the Mg atom relatively low?

17. Why is it easier to remove the first electron from the Al atom than it is to remove the first electron from the Mg atom?

18. In the reaction, A + e--A + energy, (a) what kind of a particle is A^-?

    (b) What name describes the energy involved?

19. Fill in the blocks with the symbols, atomic numbers, electron-configuration notation, and brief statements of properties of the elements of the second and third periods as has been done for beryllium and magnesium below.

20. In which shell is the differentiating electron between successive transition elements?

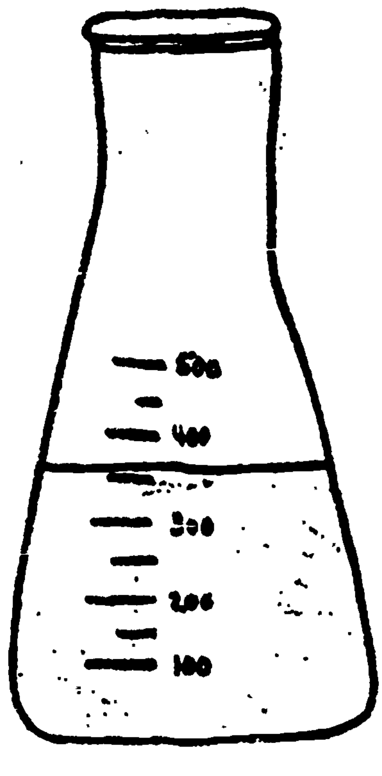
21. In which shell is the differentiating electron between successive rare-earth elements?

22. What are the present uses of the Periodic Table?

23. Fill in the blocks with the names, symbols, atomic numbers, electron configurations, and other designated information on following page.

		Be 4 Sil- very metal	$1s^2$ $2s^2$												
		Mg 12 Sil- very metal	$1s^2$ $2s^2$ $2p^6$ $3s^2$												

CHEMICAL FAMILIES



CHEMISTRY - CHEMICAL FAMILIES

CHEMIST	DENTAL HYGENIST
DENTIST	DIETITIANS
ENGINEERING TECHNICIAN	CHEMICAL ENGINEER
GEOLOGIST	GEOPHYSICIST
HOME ECONOMIST	MEDICAL TECHNOLOGIST
OCEANOGRAPHER	PHARMACIST
PHYSICIAN	PRACTICAL NURSE
REGISTERED NURSE	TEACHER SECONDARY-COLLEGE
TECHNICAL WRITER	VETERINARIAN
AGRIBUSINESS TECHNICIAN	AGRICULTURE EXTENSION WORKER
DAIRY PRODUCTION TECHNICIAN	FARM CROP PRODUCTION TECHNICIAN
FARMER	FISH & WILDLIFE TECHNICIAN
FISH CULTURE TECHNICIAN	FORESTER
LIVESTOCK PRODUCTION TECHNICIAN	SOIL SCIENTIST
ELECTROPLATER	DENTAL LABORATORY TECHNICIAN
JEWELERS - JEWEL REPAIRMEN	WELDERS

CHEMICAL FAMILIES
LEVEL: HIGH SCHOOL

ACTIVITY: THE PERIODIC TABLE

PROBLEM:
THE SCIENTIST USES THE PERIODIC TABLE FOR MANY PURPOSES. IT IS MOST USEFUL IN THE PREDICTION OF PROPERTIES OF ELEMENTS WHICH ARE DRAWN UP INTO GROUPS OF RELATED ELEMENTS OR "FAMILIES." HOW ACCURATELY CAN WE PREDICT SOME OF THESE PROPERTIES?

INVESTIGATION:
THE HALOGEN FAMILY (THE SALT-FORMERS) IS MADE UP OF FOUR ELEMENTS: FLUORINE (F), CHLORINE (CL), BROMINE (BR) AND IODINE (I). WHEN THE VARIOUS PROPERTIES OF THESE FOUR ELEMENTS ARE CLASSIFIED, THE RESULTS ARE AS LISTED IN THE FOLLOWING TABLE.

	ATOMIC MASS	ATOMIC NUMBER	DENSITY	SPECIFIC GRAVITY	APPEARANCE AT ROOM TEMP.	MELTING POINT	BOILING POINT
FLUORINE	19	9	1.69	1.11	PALE YELLOW GAS	-223°C	-188°C
CHLORINE	35	17	3.24	1.56	GREENISH YELLOW GAS	-103°C	-34.6°C
BROMINE	80	35	7.59	3.12	REDDISH BROWN LIQUID	-7.2°C	58.7°C
IODINE	127	53	11.27	4.93	GRAYISH-BLACK SOLID	113.5°C	184°C

INTERPRETATION:
1. FLUORINE IS THE MOST ACTIVE NONMETAL. CHLORINE IS LESS ACTIVE THAN FLUORINE, BUT MORE ACTIVE THAN EITHER BROMINE OR IODINE. WHAT PREDICTIONS COULD YOU MAKE CONCERNING THE ACTIVITY OF BOTH BROMINE AND IODINE?

2. HOW MANY ELECTRONS ARE IN THE OUTER ENERGY SHELL OF CHLORINE?

3. WHAT ARE THE VALENCES OF BOTH CHLORINE AND IODINE?

4. HOW DO YOU THINK THE VALENCE OF BROMINE AND IODINE COMPARE?

5. FLUORINE COMBINES EXPLOSIVELY WITH HYDROGEN. WHAT LIKELIHOOD IS THERE THAT THE OTHER HALOGENS WILL ALSO COMBINE WITH HYDROGEN?

6. CAN YOU ESTABLISH ANY RELATIONSHIP BETWEEN THE ATOMIC MASS OF AN ELEMENT AND ITS BOILING POINT?

7. WHAT MIGHT BE SIMILAR RELATIONSHIPS BETWEEN THE ATOMIC MASS AND ANY OTHER DATA LISTED IN THE TABLE?

8. ASTATINE, AN ELEMENT OF ATOMIC NUMBER 85 AND ATOMIC MASS 211, HAS ALSO BEEN CONSIDERED A HALOGEN. WHAT ARE SOME OF THE POSSIBLE PROPERTIES WHICH YOU THINK IT MIGHT HAVE?

DENSITY	SPECIFIC GRAVITY	APPEARANCE AT ROOM TEMP.	MELTING POINT	BOILING POINT
________	________	________	________	________

APPLICATION:

CONSULT A PERIODIC TABLE AND ANSWER THE FOLLOWING QUESTIONS:

1. IN THE SPACE AT THE RIGHT, ARRANGE THE FOLLOWING ELEMENTS IN ORDER OF THEIR CHEMICAL ACTIVITY:

ELEMENT	SYMBOL	AT. NO.
POTASSIUM	K	19
LITHIUM	LI	3
RUBIDIUM	RB	37

2. WHICH ELEMENT OF THE FOLLOWING WOULD CALCIUM (AT. NO. 20) MOST LIKELY REACT WITH? (CIRCLE THE PROPER ATOMIC NUMBER).

3 24 16 40 47

CHEMICAL FAMILIES
LEVEL: HIGH SCHOOL

ACTIVITY: BORAX BEAD TESTS

PURPOSE: TO LEARN HOW TO IDENTIFY METALS BY THE COLOR THEY IMPART TO A BORAX BEAD.

MATERIAL:

BURNER AND TUBING	DISH, EVAPORATING
5-CM LENGTH OF NO. 24 PLATINUM WIRE, SEALED IN THE END OF A GLASS TUBE 10 CM LONG	BORAX, POWDERED
	CHROMIUM (III) SULFATE
	COBALT (II) NITRATE
IRON (II) SULFATE	MANGANESE (II) SULFATE
NICKEL (II) CHLORIDE	UNKNOWN SALT

INTRODUCTION:

BORAX IS HYDRATED SODIUM TETRABORATE, $Na_2B_4O_7 \cdot 10\ H_2O$. WHEN IT IS HEATED STRONGLY, IT LOSES WATER OF HYDRATION AND FUSES TO FORM A COLORLESS GLASSY SOLID. A TINY TRACE OF CERTAIN METALLIC COMPOUNDS, WHEN FUSED AS OXIDES WITH SUCH A BORAX GLASS, IMPARTS A CHARACTERISTIC COLOR WHICH MAY BE USED TO IDENTIFY THE METAL. THE COLORED BEAD FORMED IN THE LOOP AT THE END OF A PLATINUM WIRE IS A METABORATE OF THE METAL.

PROCEDURE:

A. MAKE A BORAX BEAD AS FOLLOWS: BEND THE TIP OF A PLATINUM WIRE AROUND THE POINT OF A LEAD PENCIL TO FORM A LOOP ABOUT 3 MM IN DIAMETER. HEAT THE WIRE WHITE-HOT AND THEN DIP IT INTO SOME POWDERED BORAX. HOLD IT IN THE OXIDIZING FLAME OF YOUR BURNER UNTIL THE BORAX HAS MELTED TO A CLEAR GLASS. AVOID USING TOO MUCH BORAX AS A LARGE BEAD WILL SIMPLY DROP OFF THE WIRE. A CERTAIN AMOUNT OF EXPERIMENTATION IS NECESSARY TO GET THE BEST RESULTS.

OBSERVATIONS:

B. REHEAT THE BEAD IN THE LOOP OF WIRE AND TOUCH IT, WHILE HOT, TO A VERY SMALL FRAGMENT (NOT BIGGER THAN A TINY SPECK) OF COBALT (II) NITRATE. NOW HEAT THE BEAD AGAIN IN THE OXIDIZING FLAME. THE FIRST FRAGMENT WILL PROBABLY BE ENOUGH TO IMPART A DISTINCT COLOR TO THE BEAD. IF IT DOES NOT DO SO, ADD ANOTHER TINY SPECK OF THE COBALT (II) SALT. THE BEAD THAT FORMS SHOULD BE COLORED, BUT CLEAR AND TRANSPARENT. IF IT IS BLACK OR OPAQUE, TOO MUCH COBALT (II) NITRATE WAS USED. IN SUCH AN EVENT, YOU MUST MAKE A NEW BEAD AND START OVER. TO REMOVE THE BEAD FROM THE WIRE, HEAT IT STRONGLY, HOLD IT OVER AN EVAPORATING DISH, AND STRIKE THE HAND HOLDING THE WIRE AGAINST THE CLENCHED FIST OF YOUR OTHER HAND. MOST OF THE BEAD WILL BE DISLODGED AND DROP INTO THE EVAPORATING DISH. TRACES OF THE BEAD REMAINING CAN BE

REMOVED BY HEATING THE WIRE AND THEN PLUNGING IT INTO COLD WATER. (CAUTION: DO NOT DIP THE END OF THE GLASS HANDLE IN THE WATER. WHY?) THE SHATTERED FRAGMENTS OF THE BEAD CAN THEN BE RUBBED OFF BETWEEN THE FINGERS.

OBSERVATIONS:

C. BEFORE MAKING A NEW BEAD WITH A DIFFERENT METALLIC COMPOUND, CLEAN THE WIRE BY MAKING A BORAX BEAD AND SHAKING IT OFF INTO THE EVAPORATING DISH. REPEAT IF NECESSARY. THE MELTED BORAX REMOVES TRACES OF THE COLORED BEAD FROM THE PREVIOUS TEST.
   DETERMINE THE COLOR IMPARTED TO BORAX BEADS BY TRACES OF THE FOLLOWING COMPOUNDS: CHROMIUM (III) SULFATE, MANGANESE (II) SULFATE, AND NICKEL (II) CHLORIDE. RECORD YOUR RESULTS IN THE DATA TABLE.

OBSERVATIONS:

D. THE COLOR OF A BEAD, COLORED BY AN IRON COMPOUND, DEPENDS ON WHETHER THE BEAD IS HEATED IN THE OXIDIZING OR IN THE REDUCING FLAME OF YOUR BURNER. IRON (II) METABORATE HAS A DIFFERENT COLOR FROM IRON (III) METABORATE. ADD A TRACE OF IRON (II) SULFATE TO THE BORAX BEAD, AND THEN HEAT IT IN THE OXIDIZING FLAME OF YOUR BURNER. REPEAT, USING IRON (II) SULFATE, BUT HOLD THE BEAD IN THE REDUCING FLAME. ALLOW THIS SECOND BEAD TO COOL IN THE UNBURNED GAS JUST ABOVE THE TOP OF THE BURNER BEFORE YOU EXPOSE IT TO THE AIR. RECORD THE RESULTS IN THE DATA TABLE AS BEFORE.

OBSERVATIONS:

E. PROCURE AN UNKNOWN FROM YOUR INSTRUCTOR AND PROCEED TO IDENTIFY THE METAL IT CONTAINS BY THE BORAX BEAD TEST. RECORD YOUR RESULTS IN THE DATA TABLE.

OBSERVATIONS:

DATA TABLE

METAL PRESENT	BEAD COLOR (WHEN COOL)
COBALT	
CHROMIUM	
MANGANESE	
NICKEL	
IRON (OXIDIZING FLAME)	
IRON (REDUCING FLAME)	
UNKNOWN	

THE METAL PRESENT IN THE UNKNOWN WAS______________________________

QUESTIONS: ANSWER IN COMPLETE STATEMENTS

1. WHY IS THE IRON-BEAD COLOR DIFFERENT WHEN FORMED IN THE OXIDIZING FLAME RATHER THAN IN THE REDUCING FLAME?

2. WHAT COLORING ELEMENT WOULD YOU SUSPECT IN PALE-GREEN GLASS? WHAT WOULD BE THE LIKELY SOURCE?

CHEMICAL FAMILIES
LEVEL: HIGH SCHOOL

ACTIVITY: CONDUCTIVITY OF SOLUTIONS

MATERIALS: (PER TEAM)
8 JARS OR BEAKERS, 250-ML

CONDUCTIVITY INDICATOR, BATTERY-OPERATED

SOLUTIONS:
SODIUM CHLORIDE ($NaCl$)
SODIUM HYDROXIDE ($NaOH$)
TABLE SUGAR ($C_{12}H_{22}O_{11}$)
BARIUM CHLORIDE ($BaCl_2$)
HYDROCHLORIC ACID (HCl)
METHYL ALCOHOL (CH_3OH)
POTASSIUM BROMIDE (KBr)

PROCEDURES:

A. ARRANGE A SERIES OF EIGHT JARS OR BEAKERS, EACH CONTAINING ONE OF THE SOLUTIONS LISTED. LABEL EACH JAR. POUR SOME DISTILLED WATER INTO THE EIGHTH BEAKER. COPY THE CHART SHOWN BELOW.

B. PLACE THE TWO ELECTRODES OF THE CONDUCTIVITY INDICATOR IN ONE OF THE SOLUTIONS. RECORD YOUR OBSERVATIONS ON THE CHART. WIPE THE ELECTRODES CAREFULLY, AND TEST ANOTHER SOLUTION. RECORD YOUR OBSERVATIONS. REPEAT WITH EACH SOLUTION. DO NOT ALLOW THE ELECTRODES TO TOUCH AND TRY TO KEEP THEM THE SAME DISTANCE APART FOR ALL TRIALS.

		GLOW OF LIGHT BULB		
SOLUTION		BRIGHT	DIM	NONE
SODIUM CHLORIDE	$NaCl$			
HYDROCHLORIC ACID	HCl			
SODIUM HYDROXIDE	$NaOH$			
METHYL ALCOHOL	CH_3OH			
TABLE SUGAR	$C_{12}H_{22}O_{11}$			
POTASSIUM BROMIDE	KBr			
BARIUM CHLORIDE	$BaCl_2$			
WATER	H_2O			

INTERPRETATIONS:

1. WHICH ELEMENTS LISTED SEEM TO FORM COMPOUNDS THAT CONDUCT ELECTRICITY?
2. RECALL THAT ELEMENTS IN THE LITHIUM FAMILY LOSE ELECTRONS, AND ELEMENTS IN THE FLUORINE FAMILY GAIN ELECTRONS MORE EASILY THAN DO ELEMENTS IN OTHER FAMILIES. IS THE EASE WITH WHICH AN ELEMENT GAINS OR LOSES ELECTRONS RELATED TO THE CONDUCTING ABILITY OF A SOLUTION CONTAINING A COMPOUND OF THAT ELEMENT? IF SO, DESCRIBE THE RELATIONSHIP.
3. NAME SOME OTHER COMPOUNDS THAT SHOULD CONDUCT ELECTRICITY. IF YOU TEST YOUR HYPOTHESES, BE SURE TO CHECK WITH YOUR TEACHER FIRST.
4. COMPARE THE CONDUCTIVITY OF THE DRY CHEMICALS WITH THE CONDUCTIVITY OF THE SAME CHEMICALS IN SOLUTION. EXPLAIN ANY DIFFERENCES NOTED.
5. DESCRIBE A MODEL THAT MIGHT EXPLAIN WHY CERTAIN SOLUTIONS ARE ABLE TO CONDUCT ELECTRICITY WHILE OTHERS ARE NOT.

CHEMICAL FAMILIES
Level: High School

ACTIVITY: Ammonia, the Ammonium Ion, and the Nitrate Ion

Purpose: To prepare ammonia, study its properties, and to differentiate between the ammonia molecule and the ammonium ion. To learn how to identify the nitrate ion.

Material:

Balance, platform	Beaker, 250 ml
2 bottles, wide mouth	Burner and tubing
Clamp, buret	Clamp, test tube
Forceps	Glass bend
Glass plates	Graduated cylinder
Mortar and pestle	Ring stand
3 rubber stoppers, solid No. 2	Rubber stopper, 1-hole No. 4
Test tubes	Test tube, Pyrex
Wing top	Ammonium chloride
Ammonium sulfate	Calcium hydroxide
Iron (II) sulfate	Litmus papers, red and blue
Wooden splints	Ammonia-water solution, concentrated
Hydrochloric acid, concentrated	
Sulfuric acid, concentrated	
Solutions of:	
Potassium hydroxide (2.5 M)	Sodium hydroxide (2.5 M)
Sodium nitrate (0.5 M)	

Introduction:

Almost everyone is familiar with the penetrating odor of ammonia. Ammonia, NH_3, is a gas at ordinary temperatures and pressures. The ammonium ion, NH_4^+, is a radical with a positive charge of one which is never found alone, but always in conjunction with a negative ion. When a solution of a hydroxide reacts with an ammonium compounds, the products are a salt, ammonia, and water. If any ammonium hydroxide molecules are formed at all, they do not persist as such, but immediately decompose into ammonia and water. Some of the ammonia escapes from the solution as a gas; as a result, such mixtures have the readily detected odor of ammonia.

Procedure:

1. Put 0.5 g of dry ammonium chloride on one square of paper, and 0.5 g of calcium hydroxide on another square. Smell each of the chemicals in turn. Result? Then mix the chemicals, stirring them together. Put a small quantity of the mixed chemicals in the palm of one hand, and then rub your palms together for a half-minute. Now, CAUTIOUSLY, smell the mixture in your hand. Result? Hold a piece of wet, red litmus paper just above the chemical mixture in your palm. Result? Explain.

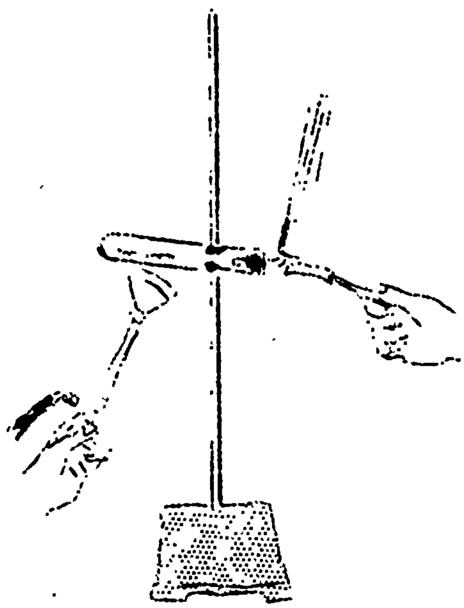
Observations:

2. REPEAT PART 1, USING AMMONIUM SULFATE INSTEAD OF AMMONIUM CHLORIDE.

OBSERVATIONS:

3. FIT A LARGE PYREX TEST TUBE WITH A RUBBER STOPPER AND L-TUBE AS SHOWN BELOW. GENTLY MIX 4 G OF AMMONIUM CHLORIDE AND 3 G OF CALCIUM HYDROXIDE IN A MORTAR, AND THEN ADD THE MIXTURE TO THE TEST TUBE. SPREAD THE MIXTURE IN THE TEST TUBE. WHY? CLAMP THE TEST TUBE IN THE POSITION SHOWN FOR COLLECTING THE GAS. THE ROUND END OF THE TEST TUBE SHOULD BE SLIGHTLY HIGHER THAN THE STOPPER END. WHY? (WHAT PRODUCTS ARE FORMED?) HEAT THE TEST TUBE GENTLY AND COLLECT THREE DRY, SMALL TEST TUBES OF THE GAS AND STOPPER THEM. THE COLOR CHANGE OF MOIST STRIPS OF RED LITMUS PAPER HELD ABOUT TWO INCHES FROM THE OPEN END OF A TEST TUBE WILL INDICATE WHEN IT IS FULL OF AMMONIA. WHAT PHYSICAL PROPERTIES OF AMMONIA HAVE YOU OBSERVED IN THIS PREPARATION?

OBSERVATIONS:



4. USING THE SAMPLE OF AMMONIA IN ONE SMALL TEST TUBE, DEVISE AND CONDUCT AN EXPERIMENT TO DETERMINE THE DEGREE OF SOLUBILITY OF AMMONIA IN WATER. DESCRIBE YOUR EXPERIMENT AND THE RESULTS YOU OBTAIN.

OBSERVATIONS:

5. Using the sample of ammonia in a second small test tube, devise and conduct an experiment to determine if ammonia burns and/or supports combustion. Describe your experiment, including the proper test tube position, and the results you obtain.

Observations:

6. Adjust the generator so that ammonia can be passed into a small beaker half-full of water for a few minutes. Do not let the end of the tube touch the surface of the water. Why? Using an appropriate technique, test the solution formed with litmus paper. Result? Then pour 10 ml of the solution formed into a test tube. Boil the solution for several minutes, using a low burner flame. From time to time test the solution, using a proper method, to determine whether all the gas in expelled from solution by boiling. Result?

Observations:

7. Investigate the possibility of a reaction between ammonium chloride and sodium hydroxide in solution. Determine the necessary conditions and the probable products of such a reaction. How could you identify the products? After devising a suitable technique, carry out the reaction, identifying the gaseous product. Describe your experimental method and your results. In a similar manner, investigate the possibility of a reaction between ammonium sulfate and potassium hydroxide in solution. Carry out the reaction, identifying the gaseous product. Describe your results.

Observations:

8. Add one gram of ammonium chloride crystals to a dry test tube. Using a low burner flame, heat the tube gently. At the same time, hold with forceps a strip of moist red litmus paper inside the mouth of the tube. Keep the litmus paper moist by adding a drop of water from a glass rod as needed. Look for first one, and then another, color change to occur in the litmus paper. Result? Why? What collects on the upper walls of the test tube? How did it get there?

OBSERVATIONS:

9. USING A LOW BURNER FLAME, CAREFULLY HEAT TWO WIDE-MOUTH BOTTLES UNTIL THEY ARE MODERATELY WARM TO THE TOUCH. ADD THREE DROPS OF CONCENTRATED HYDROCHLORIC ACID TO ONE BOTTLE AND COVER IT WITH A GLASS PLATE. WHAT HAPPENS TO THE CONCENTRATED HYDROCHLORIC ACID WHEN PLACED IN A WARM BOTTLE? TAKE THE OTHER BOTTLE TO A DISTANT CORNER OF THE LABORATORY AND THERE ADD THREE DROPS OF CONCENTRATED AMMONIA-WATER SOLUTION TO IT AND COVER WITH A GLASS PLATE. WHAT HAPPENS TO THE CONCENTRATED AMMONIA-WATER SOLUTION? BRING THE COVERED BOTTLE CONTAINING AMMONIA TO YOUR WORK PLACE AND INVERT IT OVER THE BOTTLE CONTAINING THE HYDROGEN CHLORIDE. REMOVE THE GLASS PLATES. RESULT? EXPLAIN.

OBSERVATIONS:

10. PREPARE A SOLUTION OF AMMONIUM CHLORIDE BY ADDING 0.5 OF THIS SALT TO 10 ML OF WATER. SIMILARLY PREPARE A SOLUTION OF AMMONIUM SULFATE. TEST EACH SOLUTION WITH RED AND BLUE LITMUS PAPERS. RESULTS? EXPLAIN THE RESULTS IN TERMS OF THE BRONSTED ACID-BASE CONCEPT.

OBSERVATIONS:

11. PLACE 5 ML OF FRESHLY PREPARED IRON (II) SULFATE SOLUTION IN A TEST TUBE. ADD 2 ML OF SODIUM NITRATE SOLUTION. MIX THE SOLUTIONS, AND THEN ADD 3 ML OF CONCENTRATED SULFURIC ACID, HOLDING THE TEST TUBE IN AN INCLINED POSITION SO THE ACID WILL RUN DOWN THE SIDE OF THE TUBE WITHOUT MIXING WITH THE CONTENTS. THE DENSE SULFURIC ACID SINKS TO THE BOTTOM OF THE TUBE. THE COLORED LAYER FORMED WHERE THE TWO LIQUIDS MEET SERVES AS TEST FOR A NITRATE. REPEAT THE TEST, USING 1 NITRIC ACID: 20 WATER (YOU PREPARE) INSTEAD OF SODIUM NITRATE SOLUTION. RESULT?

OBSERVATIONS:

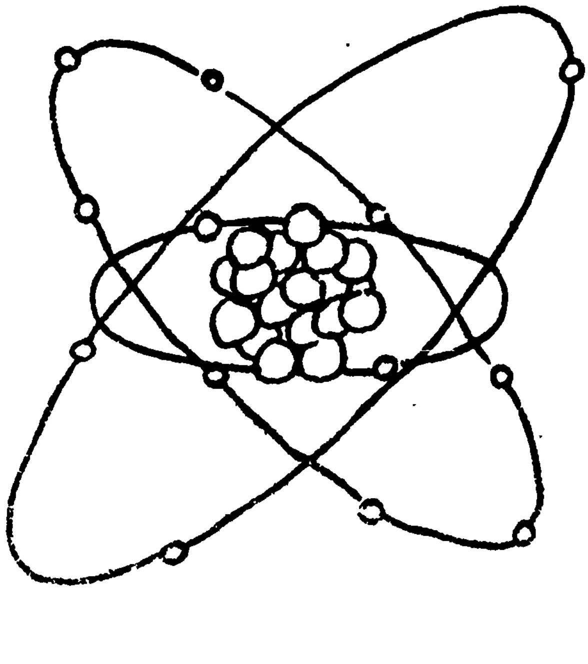
EQUATIONS:

WRITE IONIC EQUATIONS WHERE APPROPRIATE.

1. AMMONIUM CHLORIDE AND CALCIUM HYDROXIDE ______________________
2. AMMONIUM SULFATE AND CALCIUM HYDROXIDE ______________________
3. AMMONIA AND WATER ______________________
4. AMMONIUM CHLORIDE AND SODIUM HYDROXIDE ______________________
5. AMMONIUM SULFATE AND POTASSIUM HYDROXIDE ______________________
6. HEATING DRY AMMONIUM CHLORIDE ______________________
7. AMMONIA AND HYDROGEN CHLORIDE ______________________
8. AMMONIUM ION AND WATER ______________________

CHEMISTRY

NUCLEAR ENERGY



CHEMISTRY - NUCLEAR ENERGY

CHEMIST
CHEMICAL ENGINEER
PHYSICIST
TECHNICAL WRITER
RADIOLOGIST
ENGINEERING TECHNICIANS
GEOLOGIST
TEACHER SECONDARY-COLLEGE
VETERINARIANS
X-RAY TECHNICIANS

NUCLEAR ENERGY
LEVEL: HIGH SCHOOL

ACTIVITY: RADIOACTIVE ISOTOPES

PROBLEM:
RADIOACTIVE ISOTOPES, LIKE OTHER RADIOACTIVE SUBSTANCES, GIVE OFF RADIATIONS THAT CAN BE DETECTED WITH INSTRUMENTS. HOW IS A RADIOACTIVE ISOTOPE USED AS A TRACER ELEMENT TO CHECK ON ABSORPTION OF THE ELEMENT BY A PLANT?

MATERIALS:
YOUNG TOMATO PLANTS, 5 OR 6 INCHES HIGH
10 MICROCURIES OF RADIOACTIVE SODIUM PHOSPHATE (CONTAINING RADIOACTIVE PHOSPHORUS 32)
HEAVY ALUMINUM FOIL
WIDE-MOUTH BOTTLES LARGE ENOUGH TO HOLD THE ROOTS OF THE PLANTS
GEIGER COUNTER
PHOTOGRAPHIC PRINT PAPER

(CAUTION: THIS EXPERIMENT SHOULD BE DONE UNDER THE DIRECTION OF A TEACHER FAMILIAR WITH THE HANDLING OF RADIOACTIVE MATERIALS.) ALTHOUGH 10 MICROCURIES OF RADIOACTIVE PHOSPHORUS 32 IS RELATIVELY HARMLESS, ALL RADIOACTIVE MATERIALS SHOULD BE HANDLED CAREFULLY, SHOULD NOT BE SPILLED ON THE SKIN OR CLOTHING, AND SHOULD BE DISPOSED OF BY WASHING DOWN A DRAIN WITH LARGE AMOUNTS OF WATER.

PROCEDURE:
REMOVE A PLANT FROM THE SOIL, AND WASH THE ROOTS CAREFULLY IN RUNNING WATER. PLACE THE ROOTS OF THE PLANT IN A BOTTLE CONTAINING WATER AND 10 MICROCURIES OF RADIOACTIVE SODIUM PHOSPHATE. WRAP THE BOTTLE IN 3 OR 4 SHEETS OF HEAVY ALUMINUM FOIL, AND CHECK THE OUTSIDE RADIOACTIVITY WITH THE GEIGER COUNTER. AT 15-MINUTE INTERVALS, REMOVE A LEAF FROM THE BOTTOM AND THE TOP OF THE PLANT. AND PLACE EACH PAIR OF LEAVES ON A WRAPPED SHEET OF PRINT PAPER. WRAP THE LEAVES AND THE PRINT PAPER WITH A PIECE OF ALUMINUM FOIL AND LEAVE IN A DARK PLACE OVERNIGHT. DEVELOP THE PRINT PAPERS. REPEAT THE EXPERIMENT, USING LEAVES FROM A PLANT IN PLAIN WATER.

OBSERVATIONS:
1. WHAT IS THE PURPOSE OF THE PLANT IN THE BOTTLE OF PLAIN WATER?

2. WHY IS THE EXPERIMENTAL BOTTLE WRAPPED WITH SHEETS OF ALUMINUM FOIL?

3. DO THE TOP OR BOTTOM LEAVES OF THE PLANT SHOW AN INTAKE OF RADIOACTIVE MINERALS FIRST?

4. WHAT IS THE EFFECT OF THE LENGTH OF TIME THE PLANT IS IN THE RADIOACTIVE SOLUTION ON THE AMOUNT OF RADIATION SHOWN BY THE LEAVES?

INTERPRETATION:
THE STATEMENTS IN <u>COLUMN B</u> EXPLAIN WHY THE LEAVES FROM THE PLANT IN THE RADIOACTIVE WATER PRODUCE AN IMAGE ON THE PRINT PAPER. A NUMBER OF SUPPORTING REASONS THAT EXPLAIN WHY EACH STATEMENT IS TRUE

ARE GIVEN IN COLUMN A. MATCH THE LETTER OF THE CORRECT REASON IN COLUMN A WITH THE STATEMENT IT SUPPORTS IN COLUMN B AND WRITE THE LETTER OF YOUR ANSWER IN THE SPACE PROVIDED.

COLUMN A	COLUMN B	
A. ALL RADIOACTIVE ELEMENTS DISINTEGRATE AT A CONSTANT RATE.	1. SOME ELEMENTS CAN BE CHANGED INTO RADIOACTIVE ISOTOPES.	______
B. PHOTOGRAPHIC PAPER IS EXPOSED BY LIGHT OR RADIATIONS.	2. ISOTOPES HAVE THE SAME CHEMICAL PROPERTIES AS THE ORDINARY FORM OF THE ELEMENT.	______
C. ATOMS OF ISOTOPES HAVE THE SAME NUMBER OF ELECTRONS AND PROTONS AS ORDINARY ATOMS OF THE ELEMENT.	3. THE LEAVES OF THE PLANT ABSORB THE RADIOACTIVE ATOMS.	______
D. THE NUMBER OF NEUTRONS IN THE NUCLEUS OF AN ELEMENT MAY BE CHANGED IN AN ATOMIC REACTOR.	4. THE NUCLEI OF RADIOACTIVE ATOMS DISINTEGRATE.	______
E. RADIATIONS GIVEN OFF BY A RADIOACTIVE SUBSTANCE ARE IN THE FORM OF HIGH-ENERGY PARTICLES AND RAYS.	5. THE RADIOACTIVE ATOMS IN THE LEAVES GIVE OFF RADIATIONS.	______
F. LIVING ORGANISMS USE ATOMS OF RADIOACTIVE ISOTOPES AND ORDINARY ELEMENTS IN THE SAME WAY.	6. THE RADIATIONS EXPOSE THE PRINT PAPER TO FORM AN IMAGE.	______

APPLICATIONS:

RADIOACTIVE IODINE WITH A HALF-LIFE OF EIGHT DAYS IS ONE OF THE PRODUCTS FOUND IN THE FALLOUT PRODUCED BY ATOMIC-BOMB TESTS. THIS RADIOACTIVE ISOTOPE FINDS ITS WAY INTO FOOD EATEN BY COWS; AND AS A RESULT, THE MILK PRODUCED MAY CONTAIN A DANGEROUS AMOUNT OF RADIOACTIVE MATERIAL. EXPLAIN WHY SOME SCIENTISTS BELIEVE THAT IN TIMES OF A GREAT DEAL OF FALLOUT IT WOULD BE SAFER TO USE POWDERED OR CANNED MILK RATHER THAN FRESH MILK.

NUCLEAR ENERGY
LEVEL: HIGH SCHOOL

ACTIVITY: PROTECTION FROM RADIATIONS

PROBLEM:
YOU HAVE LEARNED THAT ONE WAY TO REDUCE THE RADIATIONS WHICH AN OBJECT ABSORBS IS TO INCREASE ITS DISTANCE FROM THE RADIATING SOURCE. IN SOME CASES, THIS METHOD OF REDUCING RADIATION IS IMPOSSIBLE, AS IN THE CASE OF SCIENTISTS WHO WORK WITH "HOT" MATERIALS. WHAT ARE THE EFFECTS OF SHIELDING MATERIALS IN REDUCING THE AMOUNT OF RADIATIONS ABSORBED?

MATERIALS:
GEIGER COUNTER WITH MOVABLE PROBE
MOUNTING FIXTURE
IRON PIPE
GRADUATED CYLINDER (100ML)
WRIST WATCH WITH A LUMINOUS DIAL
RADIOACTIVE SOURCES
SECTIONS OF LEAD PIPE
ALUMINUM TUBING
CARDBOARD CYLINDER FROM THE INSIDE OF A TISSUE ROLL
STOP WATCH OR A WATCH WITH A SWEEP SECOND HAND.

PROCEDURE:
CONNECT THE GEIGER COUNTER TO AN ELECTRICAL OUTLET AND TURN IT ON. LISTEN FOR CLICKS, OR WATCH FOR FLASHES--WICHEVER METHOD APPLIES TO THE GEIGER COUNTER IN USE. COSMIC RAYS AND "FALLOUT" WILL PRODUCE OCCASIONAL CLICKS AND FLASHES ON THE MEASURING INSTRUMENT. THESE READINGS ARE CALLED THE "BACKGROUND COUNT" AND MUST BE MEASURED OVER A PERIOD OF TIME. THEN THIS READING MUST BE SUBTRACTED FROM ANY SUBSEQUENT READINGS WHICH ARE MADE WITH RADIOACTIVE MATERIALS OVER THE SAME PERIOD OF TIME.

PLACE SOURCE A, SOURCE B, AND THE WATCH DIAL AT UNIFORM DISTANCES FROM THE PROBE. MEASURE THE READINGS FOR EACH OF THE THREE MATERIALS UNSHIELDED AND WITH EACH OF THE LISTED SHIELDS. RECORD YOUR DATA IN THE TABLE BELOW.

OBSERVATIONS:
READINGS AT 25 CM OVER A PERIOD OF 2 MINUTES.

	UNSHIELDED	SHIELDED BY LEAD PIPE	SHIELDED BY IRON PIPE	SHIELDED BY ALUMINUM TUBING	SHIELDED BY GRADUATED CYLINDER	SHIELDED BY CARDBOARD CYLINDER
SOURCE A	....	....	....	....	....	....
SOURCE B	....	....	....	....	....	....
WATCH DIAL	....	....	....	....	....	....

INTERPRETATION:
IN THE FOLLOWING GROUP OF STATEMENTS, PLACE THE LETTER OF THE TERM WHICH CORRECTLY COMPLETES EACH STATEMENT IN THE SPACE PROVIDED.

1. THE MOST EFFECTIVE SHIELD AGAINST RADIATION IS THE ________
(A) IRON; (B) GLASS; (C) CARDBOARD; (D) ALUMINUM.

2. THE LEAST EFFECTIVE SHIELD AGAINST RADIATION IS THE (A) IRON: (B) GLASS; (C) CARDBOARD; (D) ALUMINUM. ______

3. ONE WAY TO REDUCE THE RADIATIONS ABSORBED THROUGH GLASS IS TO (A) USE MORE SQUARES OF GLASS; (B) TURN THE DIAL TO THE MOST SENSITIVE READING; (C) USE A STRONGER SOURCE; (D) LESSEN THE DISTANCE BETWEEN SOURCE AND COUNTER. ______

4. THE CONTINUAL CLICKS WHICH ARE HEARD AS SOON AS THE COUNTER IS TURNED ON ARE DUE TO (A) RADIUM; (B) RADIOACTIVE SUBSTANCES WITHIN THE MACHINE; (C) COSMIC RAYS; (D) LEAD. ______

5. WHEN MAKING A READING FOR ANY GIVEN RADIOACTIVE SOURCE, THE BACKGROUND COUNT IS (A) ADDED TO THE READING; (B) SUBTRACTED FROM THE READING; (C) IGNORED; (D) MULTIPLIED BY THE READING. ______

6. IF THE ALUMINUM TUBING PRODUCED A LOWER READING THAN THE LEAD PIPE, YOU SHOULD SUSPECT (A) THAT THE ALUMINUM-SHIELDED SOURCE WAS CLOSER TO THE PROBE; (B) THAT THE LEAD-SHIELDED SOURCE WAS CLOSER TO THE PROBE; (C) THAT THE THICKNESS OF THE ALUMINUM WAS LESS; (D) THAT THE THICKNESS OF THE LEAD WAS LESS. ______

7. IF THE IRON SHOWED LESS SHIELDING POWER THAN THE CARDBOARD, YOU WOULD SUSPECT (A) THAT THE IRON WAS THICKER THAN THE CARDBOARD; (B) THAT THE CARDBOARD WAS THINNER THAN THE IRON; (C) THAT THE PROBE WAS CLOSER TO THE IRON-SHIELDED SOURCE; (D) THAT THE PROBE WAS CLOSER TO THE CARDBOARD-SHIELDED SOURCE. ______

APPLICATION:

1. X-RAY TECHNICIANS FREQUENTLY WEAR APRONS THAT ARE LINED WITH LEAD. SCIENTISTS WORKING AROUND NUCLEAR REACTORS DO NOT TAKE THIS PRECAUTION. WHAT PRECAUTIONS DO YOU THINK THE LATTER GROUP OF SCIENTISTS TAKE INSTEAD?

2. WHAT OTHER OCCUPATIONS WOULD NEED TO BE CONCERNED WITH EITHER THE USE OF RADIOACTIVE MATERIALS OR THE PROTECTION FROM HARMFUL RADIATIONS.

NUCLEAR ENERGY
LEVEL: HIGH SCHOOL

ACTIVITY: ENERGY FROM MATTER

STUDENT ACTIVITIES:

A. MAKE A SPINTHARISCOPE.

A SPINTHARISCOPE IS A DEVICE FOR OBSERVING THE EMISSION OF PARTICLES FROM A RADIOACTIVE SOURCE.

MATERIALS:

SMALL LENS SMALL BOX (AIR-TIGHT)
LUMINOUS WATCH DIAL CONTAINING A RADIOACTIVE SUBSTANCE.

SOME WATCHES USE PHOPHORESCENT PAINT, WHICH DOES NOT CONTAIN A RADIOACTIVE SUBSTANCE. SUCH WATCHES ARE NOT USEFUL FOR THIS ACTIVITY.

MOUNT THE LENS IN THE LID OF THE BOX. COLOR OR PAINT THE INSIDE OF THE BOX BLACK. AT THIS POINT, YOU SHOULD BE ABLE TO LOOK INTO THE BOX AND BE CONVINCED THAT IT IS LIGHT-TIGHT. IN THE MIDDLE OF THE FLOOR OF THE BOX PUT YOUR WATCH DIAL. THIS WILL CONTAIN RADIUM MIXED WITH SOME PHOSPHORESCENT ZINC SULFIDE SO THAT EACH TIME A RAY LEAVES THE RADIUM AND STRIKES THE ZINC SULFIDE, IT WILL FLASH. BY RAISING OR LOWERING THE BOX LID WITH THE LENS, YOU SHOULD BE ABLE TO FOCUS ON THE WATCH DIAL AND SEE THESE FLASHES. BE SURE TO ALLOW A FEW MINUTES FOR YOUR EYES TO BECOME ACCUSTOMED TO THE DARK BEFORE YOU MAKE YOUR OBSERVATIONS.

IF YOU CANNOT FIND THE ABOVE EQUIPMENT, PLACE THE WATCH DIAL UNDER A MICROSCOPE, OR A MAGNIFYING GLASS, IN A COMPLETELY DARK ROOM. YOU SHOULD BE ABLE TO SEE THE SMALL FLASHES.

WHAT KINDS OF PARTICLES ARE BEING EMITTED?

B. SET UP A DEMONSTRATION BY PLACING SEVERAL MOUSETRAPS IN A WASTEBASKET AND DROPPING SOME OBJECT IN THAT WILL TRIP ONE OF THEM.
   1. DO ALL THE TRAPS SPRING?
   2. WHAT MIGHT THIS FACT SHOW ABOUT THE TOTAL REACTIVITY OF OF A CHAIN REACTION?

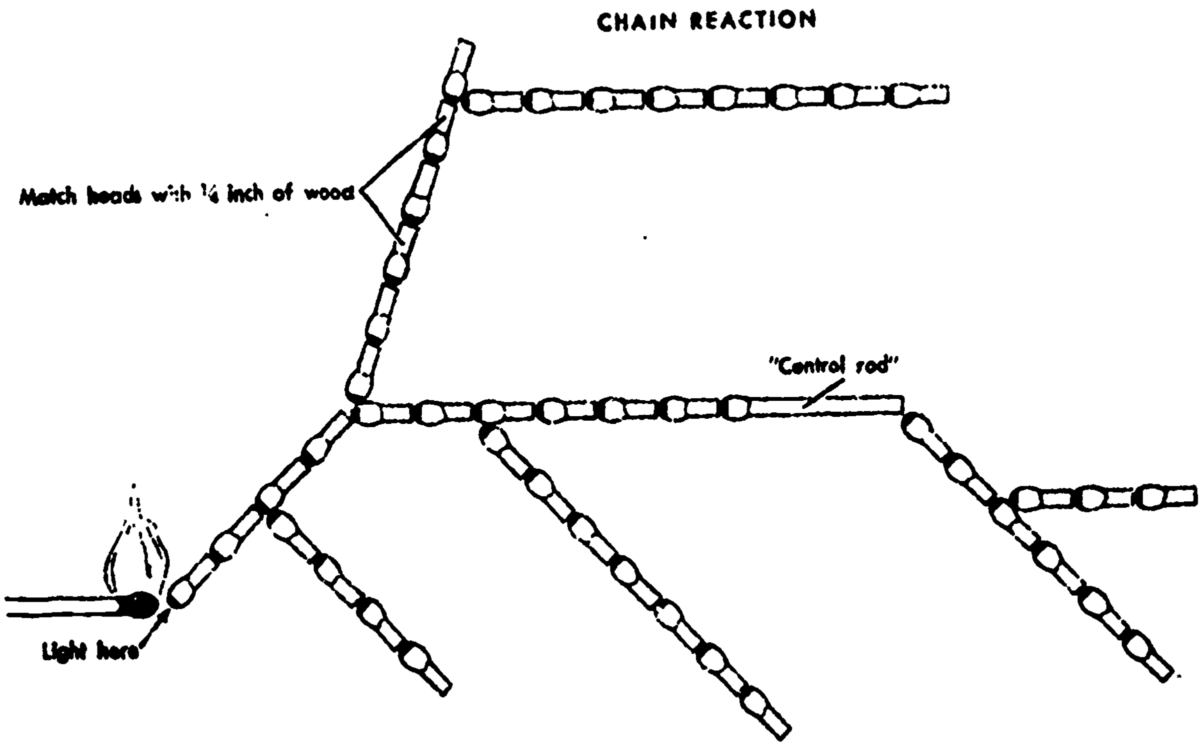
C. DO THE FOLLOWING EXPERIMENT AS ILLUSTRATED. CUT THE HEADS OFF WOODEN KITCHEN MATCHES AND LINE THEM UP IN A METAL PAN. INSERT A LONG MATCH AS SHOWN IN THE DIAGRAM TO ACT AS A "CONTROL ROD."

WHICH OF THE ABOVE TWO DEMONSTRATIONS OF THE REACTION IS THE BETTER ANALOGY OF THE ACTUAL REACTION?
EXPLAIN YOUR ANSWER.

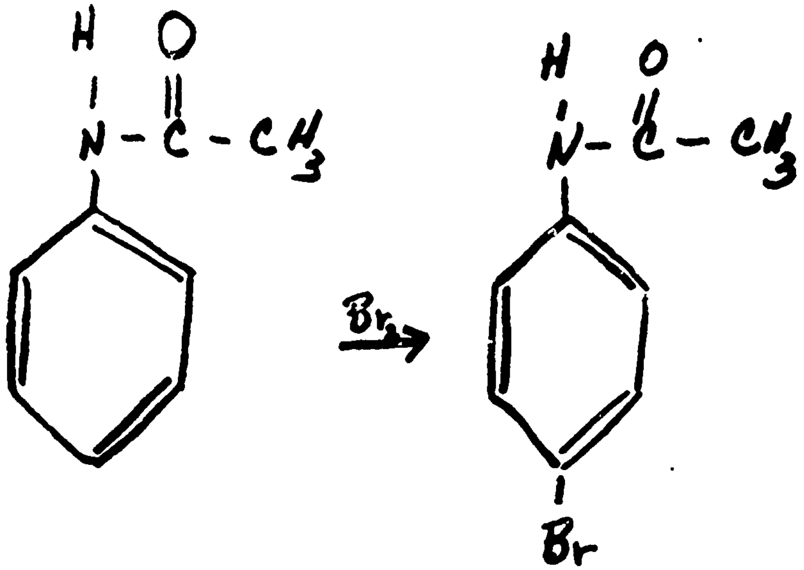
D. DESCRIBE ANOTHER SETUP TO DEMONSTRATE THE PRINCIPLE OF A CHAIN REACTION.

Group I		Group II		Group V		Group VII		Group VIII	
				nitrogen N 7	2 5				
sodium Na 11	2 8 1					chlorine Cl 17	2 8 7		
		calcium Ca 20	2 8 8 2					krypton Kr 36	2 8 18 8

	Group I	Group II	Group V	Group VII	Group VIII
Name of family	Sodium Family				
Nature of properties				Very active nonmetallic	
Direction of increasing activity		From top to bottom of table			


CHAIN REACTION
Match heads with ¼ inch of wood
"Control rod"
Light here

ORGANIC CHEMISTRY



CHEMISTRY - ORGANIC CHEMISTRY

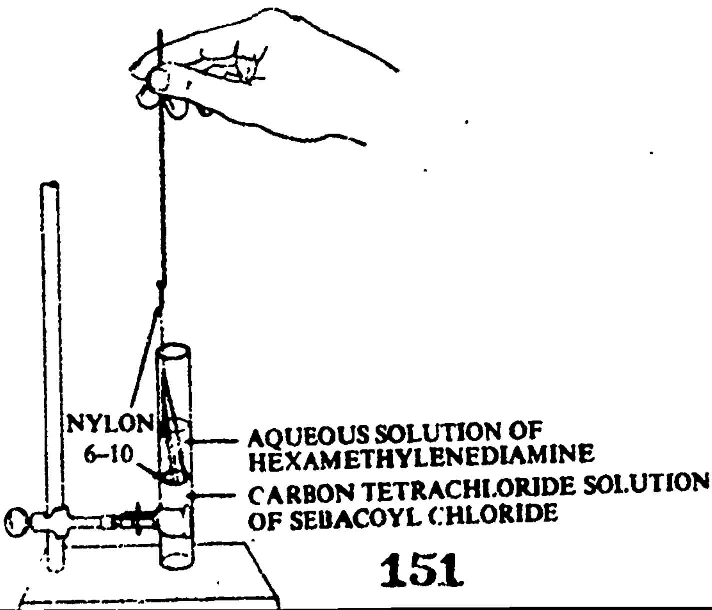
BIOCHEMIST
CHEMIST
DENTIST
ENGINEERING TECHNICIAN
GEOLOGIST
LIFE SCIENTIST
MEDICAL TECHNOLOGIST
PHARMACIST
PRACTICAL NURSE
TEACHER SECONDARY-COLLEGE
VETERINARIAN
AGRICULTURE EXTENSION WORKER
FARM CROP PRODUCTION TECHNICIAN
FISH & WILDLIFE TECHNICIAN
FORESTER
LIVESTOCK PRODUCTION TECHNICIAN
POWER PLANT OPERATOR (FUELS)
BIOLOGIST
DENTAL HYGENIST
DIETITIANS
CHEMICAL ENGINEER
GEOPHYSICIST
MEDICAL LAB WORKERS
OCEANOGRAPHER
PHYSICIAN
REGISTERED NURSE
TECHNICAL WRITER
AGRIBUSINESS TECHNICIAN
DAIRY PRODUCTION TECHNICIAN
FARMER
FISH CULTURE TECHNICIAN
LAB ANIMAL CARE TECHNICIAN
PARKS LAND MANAGEMENT TECHNICIAN
TRUCK DRIVER (FUELS)

ORGANIC CHEMISTRY
LEVEL: HIGH SCHOOL

ACTIVITY: PREPARATION OF NYLON 6-10

USING A COTTON SWAB (OR YOUR LITTLE FINGER) COAT THE INNER SURFACE OF A 15 MM x 60 MM VIAL (A LITMUS PAPER VIAL WILL DO NICELY) WITH A THIN LAYER OF SILICONE OIL(COATING THE INNER SURFACE OF THE SAMPLE VIAL PREVENTS NYLON FROM STICKING TO THE GLASS WALL AND INSURES A CONTINUOUS THREAD.) FILL THE VIAL ALMOST TO THE HALF MARK WITH A 5 % SOLUTION OF SEBACOYL CHLORIDE IN CARBON TETRACHLORIDE. HOLD THE VIAL IN AN INCLINED POSITION AND VERY SLOWLY ADD ONTO THE CARBON TETRACHLORIDE LAYER AN EQUIVALENT VOLUME OF A 5% AQUEOUS SOLUTION OF HEXAMETHYLENEDIAMINE. A REACTION PRODUCT WILL FORM IMMEDIATELY AT THE INTERFACE OF THE TWO IMMISCIBLE LAYERS. CLAMP THE VIAL TO A RING STAND. REACH THROUGH THE UPPER LAYER WITH A HOOK MADE FROM A 6-INCH LENGTH OF COPPER WIRE AND DRAW UP THE NYLON WHICH HAS FORMED (SEE DIAGRAM). THIS WILL EXPOSE FRESH REACTANTS FROM BOTH LAYERS TO PRODUCE ADDITIONAL POLYMER. SLOWLY AND STEADILY CONTINUE TO REMOVE A NEW MATERIAL AS ONE CONTINUOUS THREAD. THE THREAD MAY BE WOUND ONTO A PIECE OF CARDBOARD AS IT IS FORMED OR IT MAY BE LED INTO A 600-ML BEAKER FILLED WITH WATER. WHEN THE REACTANTS HAVE BEEN REDUCED TO ABOUT HALF OF THEIR INITIAL VOLUMES, STOPPER THE VIAL AND SHAKE VIGOROUSLY TO THOROUGHLY MIX THE REMAINDER OF THE TWO LAYERS. TRANSFER THE RESULTING WHITE OPAQUE MASS TO A BEAKER AND WASH ONCE WITH 95% ALCOHOL AND ONCE WITH WATER. SQUEEZE THE LUMP OF MATERIAL AS DRY AS POSSIBLE BETWEEN PAPER TOWELS AND EXAMINE IT. DOES IT HAVE AND TENSILE STRENGTH IN THIS FORM? TRANSFER THE DRIED NYLON MATTING TO A SMALL TEST TUBE AND TRY TO MELT IT OVER A LOW FLAME. DOES IT MELT EASILY? IF YOU SUCCEED IN MELTING IT, TRY DRAWING FROM THE MELT A THIN FIBER WITH THE WIRE USED IN THE FIRST PART OF THE EXPERIMENT. IF YOU ARE SUCCESSFUL IN DRAWING A FIBER FROM THE MOLTEN MATERIAL, COMPARE ITS STRENGTH WITH THAT OF THE THREAD PRODUCED FROM THE TWO LAYERS. ATTACH A SHORT LENGTH OF YOUR "ROPE" TO YOUR REPORT FORM.

REMOVING THE NYLON THREAD FROM THE INTERFACE OF TWO IMMISCIBLE LAYERS.



ORGANIC CHEMISTRY
LEVEL: HIGH SCHOOL

ACTIVITY: SYNTHESIZING A DYE

PROBLEM:

OF THE MANY THOUSANDS OF COMPOUNDS NOW PRODUCED THROUGH ORGANIC CHEMISTRY, THE SYNTHETIC DYES ARE PERHAPS THE MOST WIDELY USED. PERKIN BEGAN THE SCIENCE OF DYE PRODUCTION WHEN HE ACCIDENTALLY PRODUCED MAUVE (LILAC COLORED) FROM ANILINE IN 1856. FROM THIS TIME ON INTENSIVE EFFORTS HAVE BEEN MADE TO PRODUCE NEWER AND BETTER DYES, WITH OBVIOUS AND ASTONISHING SUCCESS.

CRUDE MATERIALS FROM COAL TAR ARE THE USUAL STARTING POINTS IN DYE SYNTHESIS. BENZENE (C_6H_6), NAPHTHALENE ($C_{10}H_8$), AND PHENOL (C_6H_5OH) ARE TYPICAL OF SUCH SUBSTANCES. IT IS FROM THESE SUBSTANCES THAT THE ALL-IMPORTANT INTERMEDIATES, LIKE ANILINE, ARE PRODUCED. THE INTERMEDIATES ARE THEN TREATED CHEMICALLY IN A VARIETY OF WAYS TO PRODUCE THE DYES.

THIS EXPERIMENT IS THE SYNTHESIS OF ANILINE FROM BENZENE, AND THE PREPARATION OF THREE IMPORTANT ANILINE DYES, MAUVE, ROSANILINE, AND ANILINE YELLOW.

MATERIALS:

ERLENMEYER FLASKS, TWO, 250 ML	BEAKERS, 400 ML, 25 ML, 150 ML
TEST TUBES,	WATCH GLASS
FUNNEL	FILTER PAPER
THERMOMETER, 0°-$110^{\circ}C$	MEDICINE DROPPER
BALANCE	RING STAND
RING	WIRE GAUZE, ASBESTOS CENTER
BURNER	GRADUATED CYLINDER, 25 ML
CONC. SULFURIC ACID	CONC. NITRIC ACID
CONC. HYDROCHLORIC ACID	BLEACHING POWDER, CACL(CLO)
MERCURY (II) CHLORIDE	SODIUM NITRITE
SODIUM ACETATE	SODIUM BISULFITE
TIN FOIL	BENZENE
ETHYL ALCOHOL	ANILINE

PROCEDURE:

ANILINE. THIS INTERMEDIATE IS PREPARED BY CONVERTING BENZENE TO NITROBENZENE, AND THEN BY REDUCING NITROBENZENE WITH NASCENT HYDROGEN. MIX 6 ML OF CONC. H_2SO_4 WITH 6 ML OF CONC. HNO_3 (CAUTION). AFTER THIS SOLUTION IS COOL, ADD IT IN SMALL PORTIONS TO 4 ML OF BENZENE IN A FLASK. SHAKE AFTER EACH ADDITION. NOW, WARM THE MIXTURE GENTLY FOR A FEW MINUTES. THE ALMOND-LIKE ODOR IS NITROBENZENE (CAUTION: THE VAPORS ARE TOXIC).

POUR THIS MIXTURE INTO 20 ML OF WATER IN A SMALL BEAKER, AND NOTE THE SEPARATE YELLOW, OILY LAYER OF NITROBENZENE. TRANSFER THIS LIQUID TO A TEST TUBE WITH A MEDICINE DROPPER. ADD A SMALL PIECE OF TIN AND 10 ML OF CONC. HCL. HYDROGEN IS LIBERATED WHICH REDUCES THE NITROBENZENE TO ANILINE, A DARK BROWN COMPOUND. IF THE REACTION IS SLOW, WARM GENTLY OR ADD MORE TIN AND ACID.

MAUVE. ANILINE MAY BE OXIDIZED READILY TO MAUVE, A BEAUTIFUL PURPLE DYE. DISSOLVE ABOUT ONE HALF TEASPOONFUL OF BLEACHING POWDER (THE OXIDIZING AGENT) IN 100 ML OF WATER, AND ADD A DROP OF ANILINE. FILTER THE RESULT AND EXAMINE USING STRONG LIGHT. TRY PRODUCING DIFFERENT DILUTIONS. RESULT? ADD SOME SODIUM BISULFITE SOLTUION TO A SMALL AMOUNT OF THE DYE SOLUTION. RESULT? WHY DOES THIS HAPPEN?

ROSANILINE. THIS COMPOUND IS THE COLOR BASE OF THE RED DYE, FUCHSIN, FAMILIAR TO STUDENTS OF BACTERIOLOGY. IT WILL BE PREPARED BY OXIDIZING ANILINE WITH MERCURY (II) CHLORIDE. TO A FEW DROPS OF ANILINE IN A DRY TEST TUBE ADD A SMALL AMOUNT OF MERCURY (II) CHLORIDE, AND WARM GENTLY FOR A FEW MINUTES. NOW, DISSOLVE THE PRODUCT IN ALCOHOL IN A SMALL BEAKER AND ADD A FEW DROPS OF HCL. NOTE THE COLOR.

ANILINE YELLOW. TO MAKE THIS DYE WE MUST SYNTHESIZE TWO COMPOUNDS, ANILINE HYDROCHLORIDE AND DIAZOAMINOBENZENE, AND THEN COMBINE THEM TO FORM THE DYE, AMINOAZOBENZENE HYDROCHLORIDE. FOR SUCCESS, EACH STEP MUST BE CARRIED OUT CAREFULLY.

ANILINE HYDROCHLORIDE: MIX 10 ML OF ANILINE WITH 10 ML OF WATER IN A BEAKER, AND ADD 20 ML OF CONC. HCL WITH STIRRING. HEAT TO THE POINT OF BOILING, THEN ALLOW TO COOL. FILTER THE CRYSTALS FORMED WHEN THE SOLUTION COOLS. FINALLY, DRY THE CRYSTALS ON A STEAM BATH. WHEN DRY, COVER AND SAVE THESE CRYSTALS.

DIAZOAMINOBENZENE: DISSOVE 5 ML OF CONC. HCL IN 100 ML OF WATER, ADD 4 ML OF ANILINE AND STIR IN A FLASK UNTIL DISSOLVED. MAINTAIN TEMPERATURE AT 25-30°C WHILE ADDING 2 GM OF $NANO_2$ IN SMALL PORTIONS. SHAKE BETWEEN ADDITIONS. LET STAND FOR FIVE MINUTES, THEN ADD A SOLUTION OF 5 GM PER 20 ML OF WATER OF $NAC_2H_3O_2$ (SOD. ACETATE). AFTER FIFTEEN MINUTES FILTER THE DARK YELLOW PRECIPITATE AND WASH WITH COLD WATER. DRY OVER A STEAM BATH UNTIL NEARLY DRY, THEN USE A WARM PLACE TO AIR DRY THE PRODUCT. (CAUTION! THIS COM POUND EXPLODES AT 150°C.) DO NOT STORE THIS PRODUCT.

AMINOAZOBENZENE HYDROCHLORIDE: MIX ONE GRAM OF DRY ANILINE HYDROCHLORIDE WITH TWO GRAMS OF DRY DIAZOAMINOBENZENE AND DISSOLVE IN ABOUT 5 ML OF ANILINE IN A TEST TUBE. HEAT FOR A HALF HOUR AT 30°C AND THEN FOR ANOTHER HALF HOUR AT 45°C. STIR FREQUENTLY DURING HEATING, AND DO NOT OVERHEAT! NOW ADD A SOLUTION OF 6 ML OF CONC. HCL PER 20 ML OF WATER WHILE STIRRING, AND COOL. FILTER AND WASH THE PRECIPITATE WITH DILUTE HCL. IT IS ANILINE YELLOW. TRY DYEING A PIECE OF WOOL BY DIPPING IN A HOT, SLIGHTLY ACID SOLUTION OF ANILINE YELLOW.

DISCUSSION:

1. STUDY THE CHEMISTRY OF THE ABOVE REACTIONS, AND WRITE OUT EQUATIONS FOR THE CHANGES OBSERVED.

2. OTHER DYES EASILY PREPARED ARE METHYL VIOLET, PHENOLPHTHALEIN, MALACHITE GREEN, AND FLUORESCEIN. TRY THESE TO EXTEND YOUR KNOWLEDGE.

3. STUDY MORDANT DYEING AND TRY SOME EXPERIMENTS TO SHOW THE PROCESS.

ORGANIC CHEMISTRY
LEVEL: HIGH SCHOOL

ACTIVITY: FATS AND OILS; SOAPS AND DETERGENTS

THE FATS AND OILS OF ANIMAL AND VEGETABLE ORIGIN ARE GLYCERIDES OR LONG-CHAIN FATTY ACID ESTERS OF THE TRIHYDRIC ALCOHOL GLYCEROL, $HOCH_2CH(OH)CH_2OH$.

$$\begin{array}{l} CH_2O\text{-}COR \\ CH\text{-}O\text{-}COR' \\ CH_2O\text{-}COR'' \end{array}$$

A GENERAL FORMULA FOR A FAT OR OIL

THE HYDROCARBON SEGMENTS INDICATED BY R, R', AND R" IN THE FORMULA ABOVE GENERALLY ARE DIFFERENT. THEY MAY VARY NOT ONLY IN LENGTH BUT ALSO IN DEGREE OF UNSATURATION. IF THE FATTY ACID COMPONENTS OF A GLYCERIDE ARE LONG-CHAIN (C_{12}-C_{18}) AND SATURATED, THE ESTER IS A SOLID OR A SEMISOLID AT ROOM TEMPERATURE AND IS CLASSIFIED AS A FAT. IF THE LONG-CHAIN ACID RESIDUES ARE UNSATURATED (I.E., CONTAIN ONE OR MORE DOUBLE BONDS), THE GLYCERIDE IS A LIQUID AT ROOM TEMPERATURE AND IS CLASSIFIED AS AN OIL. UNSATURATION IN THE ACID COMPONENTS OF A FAT LOWERS ITS MELTING POINT. CONVERSELY, SATURATING THE DOUBLE BONDS WITH HYDROGEN RAISES ITS MELTING POINT. THE LATTER PROCESS, WHEN APPLIED TO OILS, IS KNOWN AS HARDENING OR HYDROGENATION AND IS CARRIED OUT AS AN INDUSTRIAL PROCESS FOR THE MANUFACTURE OF MARGARINES AND COOKING FATS FROM VEGETABLE OILS.

A FAT OR AN OIL, WHEN SAPONIFIED (I.E., HYDROLYZED WITH ALKALI), PRODUCES GLYCEROL AND THE SODIUM OR POTASSIUM SALTS OF A MIXTURE OF FATTY ACIDS. THE LATTER ARE CALLED SOAPS.

$$\begin{array}{lcl} CH_2O\text{-}COR & & CH_2OH \quad RCOO^-Na^+ \\ CH\text{-}O\text{-}COR' + 3\ NaOH & \text{------------------} & CHOH + R'COO\ Na^+ \text{(SOAPS)} \\ CH_2O\text{-}COR'' & & CH_2OH \quad R''COO\ Na^+ \end{array}$$

A FAT OR OIL — GLYCEROL

THE SODIUM AND POTASSIUM SOAPS ARE SOLUBLE IN WATER AND ARE USED AS CLEANSING AGENTS. THE CALCIUM, MAGNESIUM AND FERRIC SALTS OF THE SAME FATTY ACIDS ARE INSOLUBLE IN WATER AND ARE NOT USEFUL AS SOAPS. THESE INSOLUBLE METAL SALTS PRECIPITATE AS A SCUM WHEN ORDINARY SOAP IS USED IN HARD WATER. SYNDETS (SYNTHETIC DETERGENTS) DO NOT FORM INSOLUBLE SALTS WITH THE METALLIC IONS NORMALLY PRESENT IN WATER.

ACIDIFICATION OF A SOLUTION OF SOAP WILL CAUSE THE FATTY ACID TO PRECIPITATE.

$$RCOO^-Na^+ + HCL\text{--}RCOOH + Na^+CL^-$$

PROCEDURE:

A. SOLUBILITY

NOTE THE ODOR AND APPEARANCE OF COTTONSEED OIL. TRY DISSOLVING A LITTLE IN WATER; IN ALCOHOL; IN CARBON TETRACHLORIDE. REPEAT THE TEST USING SAMPLES OF MARGARINE.

B. UNSATURATION TESTS

DISSOLVE 0.5 ML OF COTTONSEED OIL IN 5 ML OF CARBON TETRACHLORIDE IN A TEST TUBE. ADD A SOLUTION OF 5% BROMINE IN CARBON TETRACHLORIDE DROPWISE, COUNTING THE NUMBER OF DROPS REQUIRED UNTIL THE BROMINE COLOR NO LONGER IS DISCHARGED INSTANTLY. REPEAT THE TEST USING 0.5 G OF CRISCO OR SOME OTHER HYDROGENATED SHORTENING.

C. DRYING OILS

ON DIFFERENT PARTS OF A GLASS COVER PLATE PLACE ONE DROP OF EACH OF THE FOLLOWING OILS: (A) BOILED LINSEED OIL, (B) COTTONSEED OIL, (C) MAZOLA OR SOME OTHER CORN OIL. PUT AN IDENTIFYING MARK BY EACH AND LET THEM STAND IN YOUR LOCKER UNTIL THE NEXT LABORATORY PERIOD. OBSERVE AND REPORT THE CONDITION OF EACH OIL AT THAT TIME.

D. THE PREPARATION OF SOAP

SUPPORT ON AN IRON RING OR ON A TRIPOD A WATER BATH FILLED ABOUT TWO-THIRDS WITH WATER, AND HEAT THE WATER TO BOILING. DISSOLVE 2.5 G OF SODIUM HYDROXIDE IN 5 ML OF DISTILLED WATER AND 10 ML OF ORDINARY ALCOHOL (95%). ADD THE ALKALINE SOLUTION TO 5 G OF CRISCO IN A 150-ML BEAKER. COVER THE BEAKER WITH A WATCH GLASS AND HEAT THE MIXTURE ON THE WATER BATH. STIR FREQUENTLY TO PREVENT SPATTERING AND KEEP THE VOLUME OF THE SOLUTION FAIRLY CONSTANT BY ADDING SMALL AMOUNTS OF 50% ALCOHOL. IF THE MIXTURE FOAMS TOO MUCH ADD A SMALL AMOUNT OF UNDILUTED ALCOHOL. CAUTION! KEEP THE ALCOHOL AWAY FROM YOUR BURNER. THE REACTION IS COMPLETE WHEN THE OIL OR MELTED FAT HAS DISSOLVED AND GIVES A CLEAR HOMOGENEOUS SOLUTION (ABOUT ONE-HALF HOUR). DILUTE YOUR SOAP SOLUTION BY ADDING 15 ML OF WATER THEN POUR IT INTO A BRINE MADE BY DISSOLVING 30 G OF SODIUM CHLORIDE IN 100 ML OF DISTILLED WATER. STIR THE MIXTURE THOROUGHLY AND COLLECT THE PRECIPITATED SOAP ON THE BUCHNER FUNNEL. WASH THE SOAP TWICE WITH 10-ML PORTIONS OF COLD DISTILLED WATER.

DISSOLVE 2 G OF THE CRUDE SOAP IN 100 ML OF DISTLLLED WATER AND SET THE MIXTURE ASIDE AS YOUR TEST SOLUTION. PLACE THE REMAINDER OF THE SOAP IN AN EVAPORATING DISH, HEAT IT ON THE WATER BATH, AND STIR INTO THE SOAP JUST ENOUGH WATER TO FORM A THICK SOLUTION. ALLOW THE SOAP SOLUTION TO COOL. UNLESS THE AMOUNT OF WATER ADDED WAS EXCESSIVE, THE SOAP WILL SOLIDIFY INTO A CAKE SOMEWHAT RESEMBLING COMMERCIAL SOAP.

PERFORM THE FOLLOWING EXPERIMENTS ON SAMPLES OF YOUR TEST SOLUTION AND RECORD YOUR RESULTS ON THE REPORT FORM.

(A) ALKALINITY

TEST THE ALKALINITY OF YOUR DILUTE SOAP SOLUTION WITH PINK LITMUS PAPER AND COMPARE THE RESULT WITH THOSE OF SIMILAR TESTS MADE ON SOLUTIONS PREPARED FROM 0.5 G-SAMPLES OF IVORY FLAKES AND DREFT, EACH DISSOLVED IN 50 ML OF DISTILLED WATER. RECORD YOUR RESULTS.

(B) METALLIC SALTS OF FATTY ACIDS

TO A 10-ML PORTION OF YOUR SOAP SOLUTION ADD 1 ML OF A DILUTE (0.1%) CALCIUM CHLORIDE SOLUTION. SHAKE VIGOROUSLY AND OBSERVE. REPEAT THE TEST WITH DILUTE MAGNESIUM CHLORIDE AND FERRIC CHLORIDE SOLUTIONS. PERFORM THE SAME TESTS ON THE SAMPLES OF IVORY AND DREFT SOLUTIONS PREPARED IN (A). RECORD YOUR RESULTS.

(c) Precipitation of soap

To 50 ml of your soap solution add dilute hydrochloric acid dropwise until the solution is acid to Congo Red paper. Cool the mixture in ice, collect the precipitated acid on your suction funnel, and wash it with 20 ml of cold water. On your report form write an equation to show the reaction which took place. Assign a name to your product and show it to your laboratory instructor when handing in your written report.

Test the solubility of a small sample (0.25g) of your product in 2 ml of carbon tetrachloride. Also test the solubility of a small sample of stearic acid in the same solvent.

(d) Emulsifying action of soap

Shake 4 drops of mineral oil with 10 ml of soap solution. Repeat the experiment using 10 ml of water. Reexamine both mixtures after standing for 5 minutes. Record your results.

Drying oils

Describe the appearance of your oil samples after standing one week.

Boiled linseed oil.

Cottonseed oil.

Mazola or other corn oil.

Soaps and detergents

Tests performed	Your soap (brand X)	Detergents	
		Ivory	Dreft
(a) Alkalinity (litmus)			
(b) $CaCl_2$ solution			
$MgCl_2$ solution			
$FeCl_3$ solution			

(c) Equation for reaction with HCl

Solubility of product CCl_4.

Solubility of stearic acid in CCl_4.

(d) Emulsifying action of soap on oil.
Oil and soap mixture. (Result)

Oil and water. (Result)

QUESTIONS AND EXERCISES

1. DRAW FORMULAS AND GIVE NAMES FOR GLYCERIDES WHICH PROBABLY ARE PRESENT IN LARD; IN MAZOLA OIL.

2. COULD COTTONSEED OIL BE USED IN PAINTS AS A DRYING OIL? EXPLAIN

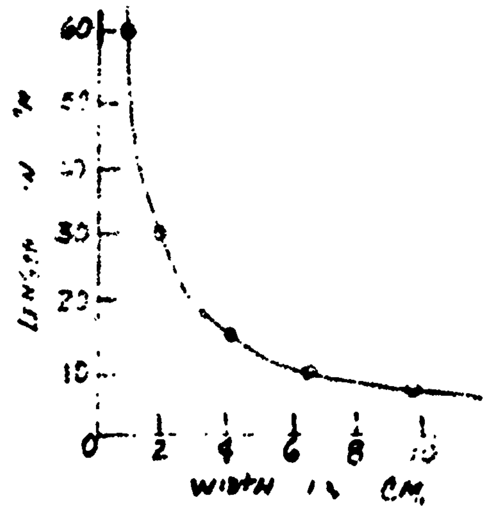
3. ASSUME THE AVERAGE MOLECULAR WEIGHT OF A FAT IS 890. WHAT FATTY ACID COMPONENTS PROBABLY PREDOMINATE?

4. WHY WAS THE DILUTE SOAP SOLUTION POURED IN A SOLUTION OF SODIUM CHLORIDE IN WATER.

5. HOW DOES SOAP FUNCTION AS AN EMULSIFYING AGENT FOR OIL IN WATER? DRAW A PICTURE OF AN OIL DROPLET AND SEVERAL SOAP MOLECULES TO ILLUSTRATE YOUR ANSWER.

6. SUPPOSE THAT YOU WANTED TO EMULSIFY A WATER-INSOLUBLE COMPOUND IN WATER. WOULD SOAP BE A REASONABLE CHOICE FOR THE EMULSIFYING AGENT IF THE WATER WERE SLIGHTLY ACIDIC? WHY? IF IT WOULD NOT BE A GOOD CHOICE, CAN YOU DRAW THE STRUCTURE OF AN ORGANIC MOLECULE THAT MIGHT BE MORE SUITABLE?

MEASUREMENT



MEASUREMENT

- Air Traffic Controller
- Architects
- Astronauts
- Astronomer
- Biologist
- Buyers (merchandise)
- Chemists
- Railroad Conductor
- Dentist
- Dietitian
- Draftsman
- Economist
- Editors
- Engineering Technicians
- Engineer
- Fashion Designer
- Geographer
- Map Maker (Cartographer)
- Geophysics
- Ground Radio Operator
- Guidance Counselor
- Historian
- Hospital Admistration
- Hotel & Motel Managers
- Industrial Designer
- Industrial Traffic Manager
- Interior Design & Decorator
- Landscape Architect
- Marketing & Research Personnel
- Mathematicians
- Signal Maintainer
- Structural Steel Worker
- Lithographic Occupation
- Meter Man-Woman
- Power Plant Operator
- Boiler Fireman
- Long Shoreman
- Power Dispatcher
- Computer Operators
- Life Insurance Salesmen
- Real Estate Agent
- Sales Clerks
- Fireman
- Practical Nurse
- Agribusiness Technician
- Dairy Production Technician
- Farming
- Fish Culture Technician
- Forestery Product Technician
- Livestock Production Technician
- Aircraft Mechanics
- Medical Lab Assistant
- Medical Record Librarian
- Medical Technology
- Merchant Marine Occupations
- Musician
- Occupational Therapist
- Oceanographer
- Optometrist
- Occupation Counselor
- Photographer
- Physical Therapist
- Physician
- Physicist
- Pilots
- Psychologist
- Public Relations
- Restaurant Manager
- Social Worker
- Speech Pathologist
- Audiologist
- Super Market Manager
- Surveyor
- Systems Analyst
- Elementary Teacher
- Secondary Teacher
- Urban Planner
- Veterinarian
- Vocational Counselor
- X-Ray Technician
- Radiologist
- Stone Mason
- Bus Driver
- Locomotive Engineer
- Photo Engraver
- Stationary Engineer
- Stevedore
- Taxi Driver
- Truck Driver
- Auto Parts Man
- Manufacturing Representative
- Delivery Man
- FBI Agent
- Policemen & Women
- Shoe Repair
- Agriculture Extension Worker
- Farm Crop Production Technician
- Fish & Wildlife Technician
- Forester
- Lab Animal Care Technician
- Air Conditioning and Refrigeration Mechanics
- Automobile Mechanics

MEASUREMENT

Composing Room Occupations	Diesel Mechanic
Farm Equipment Mechanic	Flight Engineer
Industrial Maintenance Mechanic	Roofer
Welder	Sheet Metal Worker
Airplane Dispatcher	Bookbinder
Plumber-Pipe Fitter	Plasterer
Paper Hanger & Painter	Operating Engineer (Construction)
Lineman	Lay Out Man
Instrument Maker	Machine Tool Operators
Millright	Pattern Maker
Business Machine Repairman	Printing Pressman
Set Up Man	Tool & Dye Makers
Appliance Serviceman	Dental Lab Technician
Furniture Upholsterer	Instrument Repairer
Jewelers	Jeweler Repair
Optician	Optical Mechanic
TV & Radio Technician	Watch Repairman
Boiler Maker	Brick Layer
Carpenter	Cement Mason
Telephone Installer	Construction Laborer
Electrical Repairman	Elevator Repairman
Floor Cover Installer	Glazier
Insulation Worker	Lather
Statistician	

MEASUREMENT

LEVEL: JUNIOR HIGH

ACTIVITY: WHO AM I? ACTIVITIES IN MEASURING ME.

MATERIALS: METERSTICK, TAPE MEASURE, TIME PIECE, SCALE, CALENDAR

PROCEDURE:

THIS ACTIVITY FOR JUNIOR HIGH STUDENTS IS TO MAKE THEM AWARE OF THEIR OWN GROWTH AND AT THE SAME TIME WORK WITH MEASUREMENT. TO DO THESE ACTIVITIES THE STUDENT WILL OBSERVE, MEASURE, AND RECORD DATA ABOUT THEMSELVES.

A. MEASURE HOW TALL YOU ARE EACH MONTH OF THE YEAR AND RECORD ON A GRAPH. HOW MANY CENTIMETERS TALL ARE YOU?______________ HOW MANY METERS WOULD THIS BE?______________

B. HOW WIDE ARE YOU? RECORD AT FIRST AND LAST OF YEAR:

BROW	WAIST
EAR TO EAR	THIGH TO THIGH
NECK	KNEE TO KNEE
SHOULDER TO SHOULDER	ANKLE TO ANKLE
CHEST	FOOT TO FOOT

C. WHAT IS YOUR CIRCUMFERENCE?

BROW	THIGH
NECK	KNEE
SHOULDER	CALF
CHEST	ANKLE
WAIST	FOOT

RECORD YOUR DATA TWICE A YEAR. (CAN BE DONE BOTH METRIC & ENGLISH)

D. WHAT IS YOUR PULSE RATE? COUNT THE PULSES OR BEATS FOR ONE MINUTE. DO THIS SEVERAL TIMES DURING THE YEAR AND RECORD.

AFTER BREAKFAST	AFTER EXERCISING
WHILE RESTING	WHILE STANDING
ON AWAKENING	

E. CAN YOU IDENTIFY 10 DIFFERENCES AND TEN SIMILARITIES IN THE TWO SIDES OF YOUR BODY. RECORD:

F. USING YOUR HEIGHT, WIDTH AND CIRCUMFERENCE AND DETERMINE AN APPROXIMATE SURFACE AREA OF YOUR BODY.

G. HOW MUCH DO YOU WEIGH? CHECK AT LEAST TEN DIFFERENT TIMES DURING THE YEAR AND RECORD. CAN YOU THINK OF A WAY TO COMBINE HEIGHT, WEIGHT WIDTH OR CIRCUMFERENCE?

INTERPRETATIONS:

HOW FAST ARE YOU GROWING?____________ ARE YOU ALIKE ON BOTH SIDES? ____________ WHAT PART OF ME IS GROWING MOST RAPIDLY?__________

MEASUREMENT
LEVEL: JUNIOR HIGH

ACTIVITY: MEASUREMENT OF TEMPERATURE

MATERIALS: THERMOMETERS — BEAKERS
ALCOHOL LAMPS OR HEAT SOURCE — RING STANDS
SAMPLES (WATER AT DIFFERENT TEMPERATURE)

INTRODUCTION:
"THERMO" MEANS HEAT; "METER" MEANS TO MEASURE. THEREFORE, A THERMOMETER IS AN INSTRUMENT USED TO MEASURE HEAT. THE DEGREE OF HEAT AN OBJECT HAS AT A GIVEN TIME IS ITS TEMPERATURE.

PROCEDURE:

A. GETTING AQUAINTED
EXAMINE THE THERMOMETER AND ANSWER THESE QUESTIONS:
1. WHAT IS THE LOWEST TEMPERATURE YOU CAN READ?______________
2. WHAT IS THE HIGHEST TEMPERATURE YOU CAN READ?______________
THIS GIVES YOU THE RANGE OF YOUR THERMOMETER.
3. HOW MANY LINES ARE THERE BETWEEN 10^{0} AND 20^{0}?______________
THIS MEANS THAT EACH MARK IS EQUAL TO HOW MANY DEGREES?_______
WHERE IS THE LEVEL OF THE MATERIAL IN THE TUBE NOW?_______
THIS READING GIVES YOU ROOM TEMPERATURE OR IN SCIENCE TERMS, AMBIENT TEMPERATURE. WHAT SCALE IS YOUR THERMOMETER?________

B. USING OUR INSTRUMENT
GIVEN 5 DIFFERENT SAMPLES OF LIQUIDS AT DIFFERENT TEMPERATURES, MEASURE YOUR SAMPLES USING BOTH A CENTIGRADE THERMOMETER AND A FAHRENHEIT TYPE.

SAMPLE 1. ____ ^{o}C ____ ^{o}F 3. ____ ^{o}C ____ ^{o}F 5. ____ ^{o}C ____ ^{o}F

2. ____ ^{o}C ____ ^{o}F 4. ____ ^{o}C ____ ^{o}F

C. HOW ARE CHANGES IN TEMPERATURE RECORDED
GIVEN A BEAKER WITH A CERTAIN AMOUNT OF WATER. OBSERVE THE WATER IN THE BEAKER AND RECORD ITS TEMPERATURE. HEAT THE BEAKER FOR 5 MINUTES. RECORD THE TEMPERATURE AFTER HEATING.

INITIAL TEMP.__________ CHANGE OF TEMP. IN 5 MIN. _________
FINAL TEMP. __________ RATE OF INCREASE OF TEMP. = ^{o}/MIN._______

D. CONVERT TEMPERATURES FROM ONE SCALE TO THE OTHER
ON SOME GRAPH PAPER, CONSTRUCT DIAGRAMS OF THE CELSUS (CENTIGRADE) AND FAHRENHEIT SCALES IN SUCH A WAY THAT THE BOILING POINT OF WATER IS ON THE SAME HORIZONTAL LINE ON EACH SCALES. DO THE SAME WITH THE FREEZING POINT. DIVIDE EACH SCALE INTO THE CORRECT NUMBER OF DEGREES BETWEEN THESE POINTS. LIMIT YOUR GRAPH TO THE TEMPERATURES BETWEEN 0^{o}F AND THE BOILING POINT OF WATER. YOU CAN NOW CONVERT A TEMPERATURE ON ONE SCALE TO THE CORRESPONDING TEMPERATURE OF THE OTHER SCALE. TO CHECK YOUR WORK USE THE FOLLOWING EQUATIONS:

$^{o}F = 9/5\ ^{o}C + 32$ $\quad$ $^{o}C = 5/9\ (^{o}F - 32)$ CHANGE: 73^{o}C TO ^{o}F = _____
96^{o}F TO ^{o}C = _____

MEASUREMENT

LEVEL: JUNIOR HIGH & ABOVE

ACTIVITY: HOW TO MEASURE A MOLECULE

MATERIALS:

CLEAN TRAY AT LEAST 16 INCHES WIDE
RUBBING ALCOHOL
TWO MEDICINE DROPPERS
METRIC SCALE RULER
DISTILLED WATER
USED AUTOMOBILE CRANKCASE OIL
1 OUNCE OF U.S.P. OLEIC ACID
FLAT BLACK PAINT

PROCEDURE:

FIRST CLEAN THE TRAY CAREFULLY AND PAINT IT WITH THE BLACK PAINT. AFTER IT HAS DRIED, RINSE IT WITH ALCOHOL.

NOW MAKE A 1% SOLUTION OF OLEIC ACID IN ALCOHOL (USING 99 DROPS OF ALCOHOL TO 1 DROP OF OLEIC ACID) AND PUT IT ASIDE. WHEN THE TRAY IS COMPLETELY DRY, HALF FILL IT WITH DISTILLED WATER. PLACE ONE DROP OF OIL ON THE WATER AND A THIN OIL SLICK WILL FORM. AS IT SPREADS YOU WILL FIRST SEE COLORS, THEN THE LAYER WILL APPEAR BLACK.

NOW LAY THE METRIC RULER ACROSS THE TRAY AND PLACE ONE DROP OF THE 1% OLEIC ACID SOLUTION ON THE CENTER OF THE OIL SLICK. SOME OF THE ALCOHOL WILL EVAPORATE AND THE REST WILL MIX INTO THE WATER LEAVING A CIRCLE OF OLEIC ACID ABOUT 20 CM ACROSS, WHICH WILL NOT SPREAD ANY FURTHER. MEASURE THE DIAMETER OF THE CIRCLE AND COMPUTE THE AREA. NOW RINSE THE TRAY WITH ALCOHOL AND TRY THE EXPERIMENT AGAIN, USING A 1/2% OLEIC ACID SOLUTION (1 DROP WITH 199 DROPS OF ALCOHOL). MEASURE THE CIRCLE AND COMPUTE THE AREA. IT WILL BE HALF THE AREA OF THE FIRST CIRCLE.

SINCE THE NUMBER OF MOLECULES IN THE 1/2% OLEIC ACID LAYER IS HALF THAT IN THE 1% AND THE CIRCLE IS HALF THE AREA, YOU HAVE FOUND A FUNDAMENTAL RELATIONSHIP. IN EACH CASE THE OLEIC ACID HAS SPREAD TO THE LEAST POSSIBLE THICKNESS, THAT OF ONE MOLECULE. THE MOLECULES ARE KNOWN TO BE STANDING ON END BECAUSE THEIR PARTICULAR STRUCTURE AND COMPOSITION MAKE ONE END TURN DOWN TOWARD THE WATER.

BY SIMPLE ARITHMETIC YOU CAN MAKE A GOOD APPROXIMATION OF THE THICKNESS OF THE LAYER, AND THEREFORE THE HEIGHT, OR GREATEST DIMENSION, OF EACH MOLECULE.

SINCE THE CIRCULAR LAYER IS ACTUALLY A SHALLOW CYLINDER, USE THE FORMULA FOR THE VOLUME OF A CYLINDER.

$$V = \pi R^2 H$$

SOLVING FOR HEIGHT:

$$H = \frac{V}{\pi R^2}$$

TO GET THE VOLUME, TEST YOUR DROPPER TO SEE HOW MANY DROPS IN 1CC. IF YOU FIND THERE ARE 50, THEN THE VOLUME OF A DROP IS 1/50 CC, OR, EXPRESSED AS A DECIMAL, .02 CC. THE VOLUME OF OLEIC ACID IN A DROP OF 1% SOLUTION THEREFORE IS 1% OF .02, OR .0002 CC. THIS CAN BE WRITTEN 2×10^{-4}. SUPPOSING YOUR CIRCLE HAS A DIAMETER OF 20 CM, AND THEREFORE A RADIUS OF 10 CM, BY SUBSTITUTING IN THE FORMULA YOU WILL GET:

$$\frac{.0002}{3.14 \times (10)^2}$$

SOLVE THIS AND YOU WILL FIND THE HEIGHT IN CENTIMETERS IS A NUMBER PRECEDED BY SIX ZEROS TO THE RIGHT OF THE DECIMAL POINT. WHAT IS ITS HEIGHT IN ANGSTROM UNITS?

OF COURSE, DROPS ARE NOT A VERY ACCURATE MEASURE, BUT THIS METHOD WILL RESULT IN A GOOD ESTIMATE.

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MEASUREMENT

LEVEL: JR. HIGH OR HIGH SCHOOL

ACTIVITY: MEASUREMENT OF LENGTH AND AREA

THIS INVESTIGATION WILL GIVE YOU AN OPPORTUNITY TO EXPERIENCE SOME OF THE DIFFICULTIES IN MEASURING THAT MIGHT HAVE CONFRONTED A STUDENT LIVING DURING THE EIGHTEENTH CENTURY. IT WILL ALSO ALLOW YOU TO USE SOME MODERN METHODS OF MEASUREMENT.

MATERIALS (PER TEAM):
YARDSTICK
METERSTICK

PROCEDURES:

MEASURE THE DESK OR TABLE IN INCHES, FEET, AND YARDS, USING A YARDSTICK. USING A METERSTICK, REPEAT THE MEASUREMENTS IN MILLIMETERS, CENTIMETERS, AND METERS.

INTERPRETATIONS:

1. WHICH SYSTEM OF UNITS DID YOU FIND MOST USEFUL? WHICH IS MOST ACCURATE?

2. WHAT IS MEANT BY THE STATEMENT THAT "ALL MEASUREMENTS ARE ESTIMATES"?

MEASUREMENT
LEVEL: JR. HIGH OR HIGH SCHOOL

ACTIVITY: USE OF BALANCE.

MATERIALS:

ONE STICK ABOUT TWO FEET LONG
BALANCE
A STACK OF BOOKS SLIGHTLY HIGHER THAN THE PAN OF THE SCALE

REST ONE END OF THE STICK ON THE LEFT HAND BALANCE PAN AND THE OTHER END ON STACK OF BOOKS. BE SURE THE BOOKS ARE HIGHER THAN THE SCALE PAN. BE SURE THAT JUST THE TIP OF THE STICK IS RESTING ON THE BALANCE PAN AND THAT THE STICK TOUCHES THE PAN AT ONLY ONE POINT. WEIGH THAT END OF THE STICK CAREFULLY. WRITE DOWN THE WEIGHT VALUE.

NOW REVERSE THE POSITION OF THE STICK SO THAT YOU WEIGH THE OTHER END. WEIGH THIS END CAREFULLY AND WRITE DOWN THIS WEIGHT VALUE.

ADD THE TWO WEIGHTS TOGETHER.

NEXT WEIGH THE WHOLE STICK. RECORD THE WEIGHT.

STATE POLICE OFFICERS SOMETIMES NEED TO WEIGH A WHOLE TRUCK ON THE HIGHWAY. CAN THEY PUT A BALANCE UNDER ONE WHEEL AT A TIME, ADD THESE WEIGHTS TOGETHER, AND SAY THAT IS THE WEIGHT OF THE WHOLE TRUCK? YOUR WEIGHING OF THE STICK IN THIS EXPERIMENT SHOWED THAT STATE POLICE OFFICERS CAN OBTAIN THE WEIGHT OF A TRUCK BY PLACING A SCALE UNDER ONE WHEEL AT A TIME AND THEN ADDING THE WEIGHTS TOGETHER.

Q. DO THE WEIGHTS OF EACH END WHEN ADDED TOGETHER EQUAL THE WEIGHT OF THE WHOLE STICK? WHY?

A. YES, THE SUM OF WEIGHTS OF EACH END IS THE WEIGHT OF THE WHOLE STICK. EACH TIME, THE BOOKS SUPPORTED HALF THE STICK, AND THE BALANCE SUPPORTED HALF THE STICK.

MEASUREMENT
LEVEL: HIGH SCHOOL

ACTIVITY: DETERMINING THE VOLUME OF SOLIDS

THE SPACE THAN AN OBJECT OR A SUBSTANCE OCCUPIES IS CALLED ITS VOLUME. IT IS RELATIVELY EASY TO DETERMINE THE VOLUME OF LIQUIDS BY USING A GRADUATED CYLINDER. DETERMINING THE VOLUME OF A SOLID REQUIRES DIFFERENT TECHNIQUES. TO DETERMINE THE VOLUME OF A RECTANGULAR OBJECT, YOU MUST MULTIPLY THE AREA OF THE OBJECT BY ITS DEPTH. FOR PRACTICE, SUPPOSE YOU WISH TO FIND THE VOLUME OF A RECTANGULAR OBJECT. THE AREA OF ONE OF THE RECTANGULAR SIDES IN 4 INCHES x 2 INCHES, OR 8 SQUARE INCHES. THE DEPTH IS 2 INCHES. THE VOLUME IS 8 SQUARE INCHES x 2 INCHES, OR 16 CUBIC INCHES. THUS THE DIMENSIONS INVOLVED ARE LENGTH, WIDTH, AREA, AND VOLUME. "CUBIC" SHOULD NOT BE A NEW TERM FOR YOU (SUGAR CUBES, ICE CUBES). CUBIC MEASUREMENT IS NECESSARY IN DETERMINING THE VOLUME OF SOLIDS.

MATERIALS (PER TEAM):

3 RECTANGULAR SOLIDS OF DIFFERENT SIZES
50- OR 100-ML GRADUATED CYLINDER
OVERFLOW CAN OR OLD TEA POT
GRAPH PAPER
STRAIGHT PIN OR FINE WIRE
SMALL PIECES OF WOOD (IRREGULAR SHAPES)
SUGAR CUBES
RULER CALIBRATED IN INCHES AND CENTIMETERS
YARD OF THREAD
NAILS, MARBLE, AND OTHER OBJECTS SMALL ENOUGH TO FIT IN GRADUATED CYLINDER

PROCEDURES:

A. IN YOUR NOTEBOOK, COPY THE CHART.
B. NUMBER THE SOLIDS. USE YOUR RULER TO DETERMINE THE VOLUME OF EACH SOLID IN CUBIC INCHES AND IN CUBIC CENTIMETERS. RECORD THIS DATA ON YOUR CHART.
C. PLACE THE GRADUATED CYLINDER UNDER THE SPOUT OF THE OVERFLOW CAN. FILL THE CAN WITH TAP WATER UNTIL WATER BEGINS TO FLOW FROM THE SPOUT. WHEN THE FLOW HAS STOPPED, EMPTY THE GRADUATED CYLINDER AND PLACE IT UNDER THE SPOUT AGAIN.
D. TIE A THREAD AROUND SOLID 1, AND LOWER IT CAREFULLY INTO THE WATER. IF THE SOLID DOES NOT SINK, HOLD IT UNDER WATER WITH A PIN OR OTHER SMALL PROBE.
E. KEEP THE SOLID COMPLETELY SUBMERGED UNTIL THE WATER HAS STOPPED FLOWING INTO THE CYLINDER. THEN CAREFULLY MEASURE THE AMOUNT OF WATER IN THE CYLINDER.

WATER HAS A SLIGHTLY CONCAVE SURFACE WHEN CONFINED IN A NARROW CYLINDER. THIS COULD CAUSE SOME ERROR IN DETERMINING VOLUME. THE ACCEPTED SCIENTIFIC PRACTICE IS TO TAKE THE READING AT THE LOWEST POINT OF THE CURVE. IT IS ALSO IMPORTANT THAT THE CYLINDER BE ON A LEVEL SURFACE. THE READING SHOULD BE TAKEN AT EYE LEVEL.

REPEAT PROCEDURES D THROUGH E TWO MORE TIMES. RECORD ON YOUR CHART THE VOLUMES FOR EACH OF THE THREE TRIALS WITH SOLID 1. CALCULATE THE AVERAGE VOLUME OBTAINED WITH EACH METHOD.

	Trial Number	Solids		
		1	2	3
Volume in cubic inches	1			
	2			
	3			
	Average			
Volume in cubic centimeters	1			
	2			
	3			
	Average			
Volume of displaced water in milliliters	1			
	2			
	3			
	Average			

F. Repeat Procedures B through E for Solid 2 and Solid 3. Be sure to record the data for each of the three trials with each solid.

G. On graph paper construct a graph. Use the vertical axis of the graph for volumes in cubic inches and the horizontal axis for the number of milliliters of water displaced (collected in the graduated cylinder). Plot the average of the three trials for each solid. Beginning at zero, draw a line connecting the three average points.

H. Using another piece of graph paper, repeat Procedure G, but plot the values for volume in cubic centimeters against volume of displaced water in milliliters.

Interpretations:

1. Note the relationship between the volumes in cubic inches, cubic centimeters, and milliliters. Which system--English or metric--seems to be the easiest to use in finding the volume of a solid?
2. Carefully compare the two graphs, and describe any differences or similarities.
3. In Procedure G were you able to draw a straight line from zero through the three average points? If not, how can you explain the results?

PROCEDURES (CONTINUED)

I. YOU MAY WISH TO DETERMINE THE VOLUMES OF OTHER OBJECTS. THE OVERFLOW CAN IS NOT NEEDED FOR OBJECTS SMALL ENOUGH TO BE PLACED DIRECTLY IN THE GRADUATED CYLINDER. POUR ENOUGH WATER INTO THE GRADUATED CYLINDER TO COMPLETELY SUBMERGE THE OBJECT. (USUALLY THIS CAN BE DONE IF THE CYLINDER IS ABOUT HALF-FULL.) READ AND RECORD THE VOLUME OF THE WATER. SUBMERGE THE OBJECT IN THE WATER, AND AGAIN TAKE A READING FROM THE CYLINDER. IF THE OBJECT FLOATS, HOLD IT UNDER THE WATER WITH A PIN OR FINE WIRE. WHAT IS THE VOLUME OF THE OBJECT?

PROBLEMS:

1. USE A RULER (ENGLISH AND METRIC) AND THE WATER-DISPLACEMENT METHOD TO MEASURE THE VOLUME OF EACH OF THE FOLLOWING:
   A. AN IRREGULAR SHAPED PIECE OF WOOD
   B. A CUBE OF SUGAR

2. WHICH METHOD OF MEASURING VOLUME DID YOU FIND MOST USEFUL IN PROBLEM 1? WHICH SYSTEM--ENGLISH OR METRIC--DID YOU FIND MOST CONVENIENT?

MEASUREMENT
LEVEL: HIGH SCHOOL

ACTIVITY: MASS AND VOLUME OF WATER

MATTER IS DESCRIBED AS ANY SUBSTANCE THAT HAS MASS (WEIGHT) AND OCCUPIES SPACE (VOLUME). FOR NOW WE WILL USE THE WORDS MASS AND WEIGHT AS IF THEY HAD THE SAME MEANING. LATER IN THE COURSE, UNDERSTANDING THE DIFFERENCE BETWEEN MASS AND WEIGHT WILL BECOME IMPORTANT.

THE RELATIONSHIP BETWEEN MASS AND VOLUME WILL BE EXAMINED IN THIS INVESTIGATION.

MATERIALS (PER TEAM):

BALANCE SENSITIVE TO 0.1 GRAM
SHEET OF ORDINARY GRAPH PAPER
50- OR 100-ML GRADUATED CYLINDER
RED PENCIL

PROCEDURE:

A. COPY THE CHART SHOWN.

TRIAL	MASS OF GRADUATED CYLINDER IN GRAMS	MASS OF GRADUATED CYLINDER AND WATER IN GRAMS	MASS OF WATER IN GRAMS	VOLUME OF WATER IN MILLILITERS
1				
2				
3				
4				
5				
AVERAGE				

B. WEIGH THE GRADUATED CYLINDER, AND RECORD ITS MASS ON THE CHART.

C. POUR SOME WATER INTO THE CYLINDER. WEIGH THE CYLINDER WITH THE WATER IN IT. RECORD THE COMBINED MASS ON THE CHART.

D. DETERMINE THE MASS OF THE WATER BY SUBSTRACTING THE MASS OF THE CYLINDER FROM THE MASS OF THE WATER AND THE CYLINDER.

E. DETERMINE THE VOLUME OF WATER IN THE CYLINDER. REMEMBER TO KEEP THE CYLINDER LEVEL AND TO TAKE READINGS AT THE LOW POINT OF THE MENISCUS (THE CURVE OF THE WATER'S SURFACE). RECORD ON THE CHART.

F. REPEAT PROCEDURES C, D, AND E FOUR MORE TIMES, USING A DIFFERENT VOLUME OF WATER IN EACH TRIAL. RECORD THE DATA ON THE CHART.

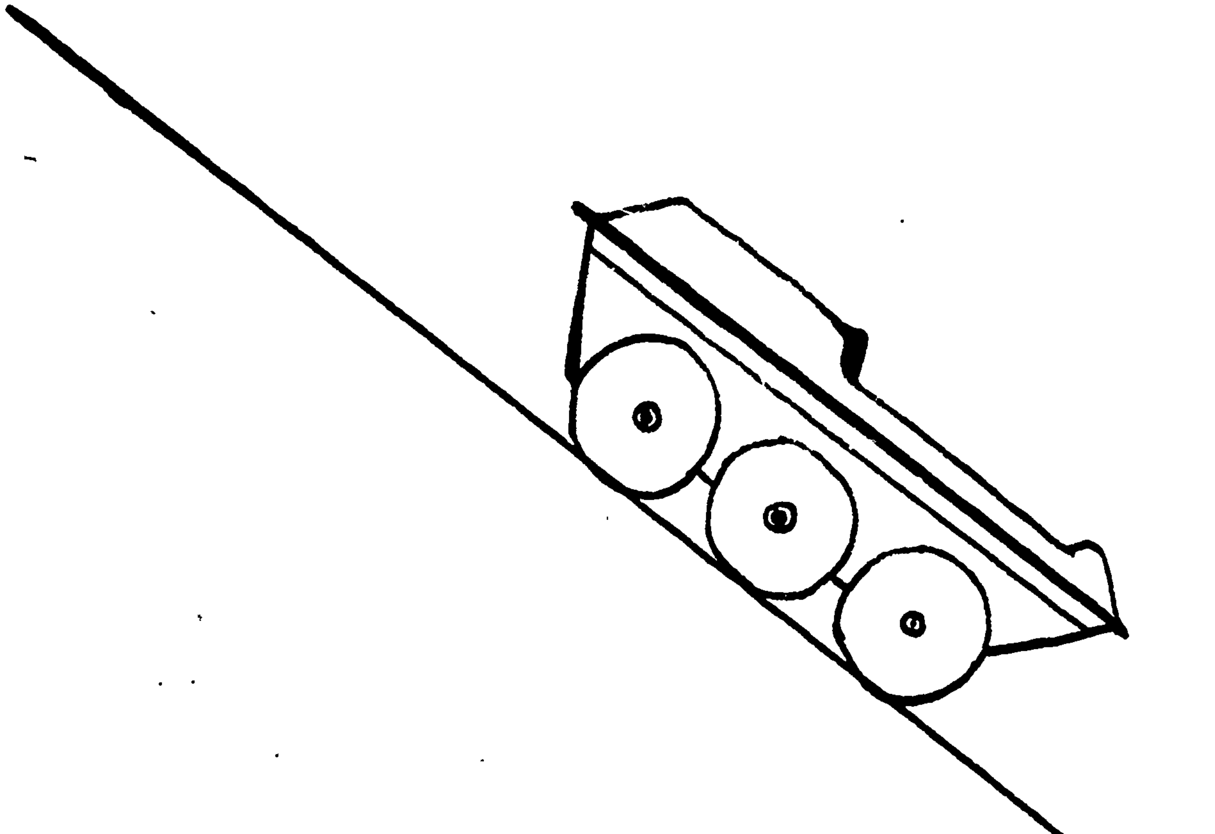
G. PLOT VALUES FOR THE MASS AND VOLUME OF WATER IN EACH TRIAL ON ORDINARY GRAPH PAPER. USE THE VERTICAL AXIS FOR MASS AND THE HORIZONTAL AXIS FOR VOLUME. THIS WILL GIVE YOU FIVE POINTS ON THE GRAPH. BEGINNING AT ZERO, DRAW A LINE CONNECTING THESE POINTS. CALCULATE THE AVERAGE MASS AND THE AVERAGE VOLUME OF WATER. USING A RED PENCIL, PLOT THIS POINT ON THE GRAPH. BEGINNING AT ZERO, DRAW A STRAIGHT RED LINE THROUGH THE AVERAGE POINT; EXTEND THIS LINE AS FAR AS POSSIBLE BEYOND THE AVERAGE POINT. KEEP THE GRAPH IN YOUR NOTEBOOK.

INTERPRETATIONS:

1. DIVIDE THE AVERAGE MASS OF WATER OBTAINED IN ALL TRIALS BY THE AVERAGE VOLUME FOR ALL TRIALS: $\frac{M}{V} = ?$ COMPARE THE AVERAGE VALUE FOR $\frac{M}{V}$ OBTAINED BY YOUR TEAM WITH THE AVERAGE VALUES OBTAINED BY OTHER TEAMS.

2. WHAT RELATIONSHIP APPEARS TO EXIST BETWEEN THE MASS OF WATER IN GRAMS AND ITS VOLUME IN MILLILITERS?

MOTION



PHYSICS - MOTION

ARCHITECTS
ASTRONOMER.
DENTIST
ENGINEER
MERCHANT MARINE
PILOT
TECHNICAL WRITER
X-RAY TECHNICIAN
POLICEMEN-WOMEN
FARMING
AIR CRAFT MECHANIC
INSTRUMENT MAKER
JEWELER REPAIR
LAY OUT MAN
LOCOMOTIVE ENGINEER
TRUCK DRIVER
TAXI DRIVER
STATIONARY ENGINEER

ASTRONAUTS
PHYSICAL CHEMIST
ENGINEERING TECHNICIAN
GEOPHYSICS
PHYSICIST
TEACHER SECONDARY-COLLEGE
VETERINARIAN
RADIOLOGIST
FBI AGENT
FISH CULTURE TECHNICIANS
FLIGHT ENGINEER
JEWELER
WATCH REPAIRMAN
OPERATING ENGINEER (CONSTRUCTION)
APPRENTICE ENGINEER
POWER DISPATCHER
BOILER FIREMAN

MOTION
LEVEL: JUNIOR HIGH

ACTIVITY: TO OBSERVE WHAT HAPPENS WHEN A MOVING BODY HITS A STATIONARY OBJECT.

MATERIALS: A RULER WITH GROOVE, A MARBLE, GRAPH PAPER, BLOCKS

BACKGROUND:

IF YOU OBSERVE THE MOTION OF A BODY, YOU CAN DISCOVER SEVERAL PROPERTIES OF THAT MOTION. AS YOU DO THIS EXPERIMENT, SEEK TO DISCOVER SEVERAL PROPERTIES OF MOTION. YOU ARE TO OBSERVE THE INTERACTIONS OF TWO BODIES - ONE MOVING AND ONE AT REST (STATIONARY). HOW IS A BODY AT REST DEFINED? THE MOVING BODY WHICH YOU ARE TO USE IS A MARBLE ROLLING DOWN AN INCLINED PLANE. GALILEO WAS PROBABLY THE FIRST TO USE THE INCLINED PLANE TO INVESTIGATE MOVING BODIES. AN INCLINED PLANE IS A SURFACE WHICH IS ON A SLANT (AT AN ANGLE TO THE HORIZONTAL). SINCE THE STATIONARY BODY IN THIS EXPERIMENT IS RESTING ON THE TABLE, ASSUME THAT, IF IT DOES CHANGE POSITION, THE CHANGE IS ALONG THE SURFACE OF THE TABLE. (NO CHANGE IN ALTITUDE.) THE POSITION (S) OF THE BODY CAN BE REPRESENTED ON A GRAPH, SINCE THE CHANGE TAKES PLACE IN REFERENCE TO ONLY TWO REFERENCE POINTS. THE POSITION OF THE BODY REMAINS CONSTANT IN REFERENCE TO THE THIRD REFERENCE POINT (ALTITUDE).

PROCEDURE:

PART 1- TAPE A PIECE OF GRAPH PAPER ONTO THE LAB BENCH OR TABLE TOP. PLACE ONE END OF RULER SO THAT IT JUST TOUCHES THE MIDPOINT OF ONE EDGE OF THE PAPER AND PROP THE OTHER END UP SO THAT IT IS APPROXIMATELY AT A 45° ANGLE. KEEP THIS SET-UP CONSTANT THROUGHOUT THE EXPERIMENT. PLACE THE BLOCK AT THE BASE OF THE RULER. MARK ITS POSITION BY DRAWING A LINE AROUND IT. LABEL THIS POSITION A. HOLD THE MARBLE AT THE TOP OF THE RULER. RELEASE THE MARBLE. OBSERVE. MARK THE NEW POSITION OF THE BLOCK BY DRAWING AROUND IT. LABEL IT B. PLACE THE BLOCK AT THE INITIAL POSITION A AND AGAIN RELEASE THE MARBLE. DRAW AROUND THE BLOCK. LABEL THE POSITION OF THE BLOCK C. REPEAT THE STEPS. LABEL THIS POSITION OF THE BLOCK D.

FIND THE CENTER OF POSITION A. DO THIS BY DRAWING DIAGONAL LINES. LABEL THIS POINT 0,0. NOW DRAW A LINE PARALLEL TO THE EDGE OF THE PAPER FROM 0,0. LABEL THE LEFT SIDE OF THE LINE L AND THE RIGHT ONE R. AT 0,0 DRAW A LINE AT RIGHT ANGLES TO LR. LABEL THIS LINE F. FIND THE POSITION (FINAL) OF THE CENTER OF THE BLOCK IN EACH TRIAL. DO THIS BY COUNTING THE SQUARES OF THE PAPER THAT THE CENTER OF THE BLOCK IS FROM THE LINE LR AND ALSO FROM LINE F. REPEAT THESE STEPS TO DETERMINE POSITIONS C AND D. MAKE A DATA TABLE:

POSITION	NO. OF SQUARES FROM LR L	R	FROM F L	R	NO. OF CM. FROM LR L	R	FROM F L	R
B								
C								

MEASURE WITH A RULER THE NUMBER OF CENTIMETERS (CM) BETWEEN POSITIONS A AND POSITION B; A AND C; A AND D. RECORD THESE DATA.

PART 2 - THIS TIME WORK WITH A LARGE BLOCK AND A MARBLE. PROCEED EXACTLY AS DIRECTED IN PART 1.

PART 3 - AGAIN USE THE LARGE BLOCK, BUT THIS TIME USE A LARGE MASS ON THE INCLINED PLANE.

DISCUSSION OF RESULTS: PART 1

1. HOW CAN YOU PROVE THAT A CHANGE IN POSITION OF THE BLOCK OCCURRED?
2. DID THE BLOCK MOVE WHEN THE MARBLE HIT IT? ON WHAT BASIS DID YOU DECIDE UPON YOUR ANSWER?
3. WHAT DIFFICULTIES DID YOU HAVE IN DETERMINING THE DISTANCE BETWEEN POSITION 1, 2, OR 3 AND O?
4. WERE YOUR RESULTS CONSISTENT? IF NOT, WHAT WERE YOUR SOURCES OF ERROR?
5. WHAT WERE THE CONSTANTS IN THIS STATION OF THE EXPERIMENT? LIST. WHAT WERE THE VARIABLES? LIST.

PART 2

1. WHAT WAS THE DIFFERENCE BETWEEN THE EXPERIMENT WHICH YOU DID IN PART 1 AND IN THIS PART 2?
2. WHAT WAS THE EFFECT OF INCREASING THE MASS OF THE BLOCK?

PART 3

1. WHAT WAS THE DIFFERENCE BETWEEN THE EXPERIMENT IN PART 2 AND 3?
2. WHAT WAS THE EFFECT OF INCREASING THE MASS OF THE MOVING BODY?

GENE 'ZATIONS:

WHAT ARE THE INTERACTIONS BETWEEN A MOVING BODY AND A BODY AT REST? WHAT FACTORS AFFECT THE DISTANCE WHICH THE BODY AT REST MOVES WHEN IT IS HIT BY A MOVING BODY?

MOTION
LEVEL: JUNIOR HIGH & ABOVE

ACTIVITY: PENDULUM ACTIVITIES

MATERIALS: PART 1 - CONE-SHAPED CUPS
SALT
SCISSORS
STRING OR LIGHT WIRE
PENDULUM STAND

PART 2 - STRING
TOY CAR
PENDULUM STAND

PROCEDURES: (PART 1)

CUT A SMALL HOLE IN THE BOTTOM OF A CONE-SHAPED CUP. THEN CUT THREE EVENLY-SPACED HOLES AT THE TOP RIM, PASS STRING THROUGH THEM, AND HANG THE CUP. WHEN THE CUP IS FILLED WITH SALT, IT WILL DROP THE SALT LIKE AN HOURGLASS. IF THE CUP IS USED AS THE BOB OF A PENDULUM, THE SALT WILL TRACE OUT THE SWING PATTERN OF THE PENDULUM. IN PLACE OF A CONE-SHAPED CUP, YOU CAN USE A FROZEN-JUICE CAN WITH A HOLE IN THE BOTTOM OR AN UPSIDE-DOWN DETERGENT BOTTLE. SALT PENDULUMS CAN BE HUNG FROM THE STANDARD PENDULUM SUPPORTS. THEIR MOVEMENT IS SLOWER AND MORE STATELY, HOWEVER, WHEN THEY ARE HUNG FROM THE CEILING. SPREAD A SHEET OR PLENTY OF PAPER BELOW TO CATCH THE SALT, AND TAPE ANY JOINTS IN THE PAPER WITH MASKING TAPE.

THE SALT PENDULUMS CAN BE USED IN ANY PENDULUM EXPERIMENT. LET CHILDREN TRY LOTS OF DIFFERENT WAYS OF HANGING AND SWINGING THE PENDULUMS. MANY DIFFERENT DESIGNS AND PATTERNS CAN BE MADE WITH SALT PENDULUMS.

OFTEN, CHILDREN COUPLE TWO SALT PENDULUMS TOGETHER, "JUST TO SEE WHAT WILL HAPPEN." IF THEY HAVE ALREADY WORKED WITH COUPLED PENDULUMS, THEY MAY TRY SOME OF THE ACTIVITIES AGAIN WITH SALT PENDULUMS AND GET A VISUAL RECORD OF THE MOTION OF COUPLED PENDULUMS.

A SIMPLE SALT PENDULUM CAN BE MADE BY HANGING A CAN OR CUP FROM A SINGLE STRING.

WHAT KINDS OF PATTERNS WILL A SIMPLE SALT PENDULUM MAKE?

A COMPOUND SALT PENDULUM CAN BE MADE BY HANGING THE CAN OR CUP FROM A "Y" SUSPENSION. THE KNOT MADE WHERE THE THREE STRINGS INTERSECT SHOULD BE A SLIP KNOT. EVERY TIME THE POSITION OF THE SLIP KNOT IS CHANGED, THE SAND WILL DROP IN A NEW PATTERN.

WHAT KINDS OF PATTERNS WILL A COMPOUND SALT PENDULUM MAKE?

PROCEDURES: (PART 2)

A RATHER INTERESTING EXPERIMENT COULD BE TRIED OUT TO DETERMINE THE APPROXIMATE CENTER OF GRAVITY OF A TOY AUTOMOBILE. SUSPEND THE AUTOMOBILE BY ITS FOUR CORNERS TO A HORIZONTAL ROD AND SET IT SWINGING THROUGH A SMALL ARC.

COUNT THE NUMBER OF VIBRATIONS OVER A PERIOD OF TWO OR THREE MINUTES. DETERMINE THE PERIOD OF ONE VIBRATION BY DIVIDING THE TOTAL ELAPSED TIME TAKEN IN SECONDS. USING THE FORMULA FOR THE SIMPLE PENDULUM CALCULATE THE LENGTH OF AN EQUIVALENT SIMPLE PENDULUM WHICH WOULD HAVE THE SAME PERIOD OF VIBRATION AS THE AUTOMOBILE.

$$L = \frac{GT^2}{4\ 2}$$ (REARRANGING TERMS)

WHERE G IS THE ACCELERATION OF GRAVITY AND T IS THE PERIOD OF THE PENDULUM JUST OBSERVED, L WILL GIVE THE APPROXIMATE LOCATION OF THE CENTER OF GRAVITY IN THE AUTOMOBILE AS MEASURED FROM THE POINT OF SUSPENSION. DOES IT FALL WITHIN THE LOWER PART OF THE TOY AUTOMOBILE AS IT SHOULD?

MOTION
LEVEL: HIGH SCHOOL

ACTIVITY: SPEED

THE TERM SPEED IS PART OF YOUR EVERYDAY VOCABULARY. WE TALK ABOUT THE SPEED OF AUTOMOBILES, JET AIRPLANES, AND EVEN THE SPEED OF SOUND AND OF LIGHT. THIS INVESTIGATION IS DESIGNED TO SHOW YOU A METHOD OF MEASURING SPEED.

MATERIALS (PER TEAM):
GROOVED SPEED-TRACK SYSTEM (A SINGLE LONG TRACK MAY BE USED, IF YOU CHOOSE 6 DIFFERENT TRACK LENGTHS.)
GRAPH PAPER
STEEL BALL ABOUT 1/2 INCH IN DIAMETER
TIMER

PROCEDURES:

A. HOLD THE STEEL BALL AGAINST THE STARTING POST IN TRACK 1. RELEASE THE BALL, AND DETERMINE THE TIME IT TAKES THE BALL TO REACH THE END OF THE TRACK. TIME CAN BE MEASURED WITH A CLICK TIMER, WITH A STOP WATCH, OR BY CAREFUL OBSERVATION OF A SWEEP SECOND HAND ON A WATCH OR CLOCK. TEAMWORK IS IMPORTANT! IT IS BEST TO MAKE SEVERAL TRIALS, AND CALCULATE THE AVERAGE TIME FOR ALL TRIALS.

B. REPEAT THE PROCEDURE, USING TRACKS 2 THROUGH 6. RECORD THE AVERAGE TIME FOR EACH TRACK.

C. MEASURE THE LENGTH OF EACH TRACK IN CENTIMETERS OR INCHES.

D. PLOT THE DATA ON A BAR GRAPH, USING THE HORIZONTAL AXIS TO SHOW DISTANCE TRAVELED AND THE VERTICAL AXIS TO SHOW TIME.

INTERPRETATIONS:

1. COMPARE YOUR GRAPH WITH THE APPEARANCE OF THE SPEED TRACK SYSTEM. DESCRIBE SIMILARITIES AND DIFFERENCES, AND SUGGEST AN EXPLANATION.

2. ASSUME THAT S = SPEED, D = DISTANCE, AND T = TIME. EXPLAIN EACH OF THE FOLLOWING EQUATIONS:

   A. $S = \frac{D}{T}$ B. $D = ST$ C. $T = \frac{D}{S}$

3. SUGGEST WAYS IN WHICH THE DESIGN OF THIS INVESTIGATION COULD BE IMPROVED TO YIELD MORE ACCURATE RESULTS.

4. IN YOUR OWN WORDS WRITE OUT A DEFINITION OF SPEED.

UNDERSTANDING FORCE:

FORCE WAS USED BY MAN LONG BEFORE HE REALIZED WHAT IT WAS. HE APPLIED FORCE WHEN HE LIFTED A STONE OR THREW A SPEAR. TODAY WE USE MANY DEVICES TO PRODUCE FORCE: JET ENGINES, ELECTRIC MOTORS, GASOLINE-POWERED ENGINES, AND ATOMIC ENERGY REACTORS. WE HAVE TALKED ABOUT THE ATTRACTIVE FORCES BETWEEN ATOMS AND BETWEEN MOLECULES, AND WE HAVE SEEN THAT THERE IS A FORCE CALLED GRAVITY.

ALL OF THESE EXAMPLES INVOLVE LIFTING, PUSHING, PULLING, OR ATTRACTING. FORCE IS ANY INFLUENCE THAT TENDS TO CAUSE MATTER TO MOVE. THE WORD TENDS IS IMPORTANT. FOR EXAMPLE, IF YOU ATTEMPT TO LIFT ONE END OF AN AUTOMOBILE YOU ARE EXERTING FORCE, EVEN THOUGH THE CAR IS TOO HEAVY TO LIFT. OR, IF YOU LEAN AGAINST A SOLID WALL YOU EXERT FORCE, EVEN THOUGH THE WALL DOES NOT MOVE.

IT TAKES FORCE TO COMPRESS, STRETCH, OR BEND A SPRING. THE ATOMS IN A SPRING ARE ARRANGED IN A PARTICULAR WAY. TO BEND THEM OUT OF THEIR PATTERN REQUIRES THAT THE ELECTRONS HOLDING THEM TOGETHER BE CROWDED IN SOME PLACES AND THINNED OUT IN OTHERS. WHERE THE ELECTRONS ARE CROWDED TOGETHER, THEY REPEL EACH OTHER MORE STRONGLY AND GIVE THE METAL SPRING A TENDENCY TO RETURN TO ITS ORIGINAL SHAPE. THE MORE YOU BEND THE MATERIAL OUT OF ITS NORMAL SHAPE, THE MORE CROWDED THE ELECTRONS BECOME AND THE GREATER IS THE TENDENCY OF THE MATERIAL TO RETURN TO ITS ORIGINAL SHAPE. ONE WAY TO MEASURE THIS TENDENCY IS TO OBSERVE THE EFFECT OF A SPRING ON A STEEL BALL.

1. WHAT CAREERS WOULD NEED TO KNOW SOMETHING ABOUT SPEED, TIME AND DISTANCE?

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Motion
Level: High School

ACTIVITY: Resolution of Forces

How can one force be separated into two forces?

The force of the wind against the surface of a kite seems to be effective in two directions. It produces a vertical lift against gravity, and at the same time, part of the force of the wind is exerted in a horizontal direction. This force tends to drag the kite with the wind.

Procedures:

The simple crane in Fig. 1 produces two forces at B which conbine to support the weight W.

1. What is the direction of the force exerted by the cord at B?
   From____________________to__________________

2. Is the boom AB under tension or compression?

3. What is the direction of the force exerted by the boom at B?
   From____________________to__________________

The force of the boom can be replaced by a spring balance attached at B and acting parallel to the boom.

By means of the parallelogram method, it is possible to compute the forces exerted by W on the supporting parts of the crane.

Set up the apparatus so that the boom AB (Fig. 1) is horizontal. Hang a 500-g weight on the end of the boom. Record the reading of the balance C. Measure angle ABC carefully. If a large protractor is not available, place a large piece of paper against the crane and accurately mark the size of angle ABC.

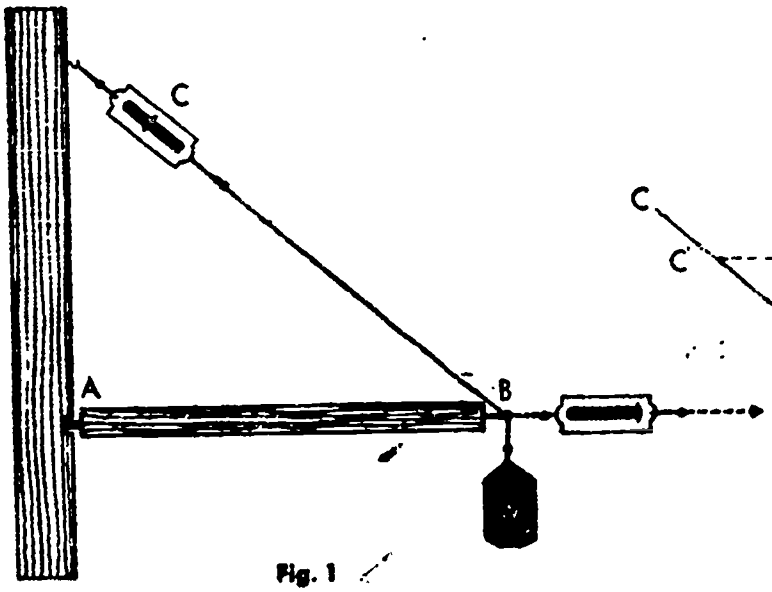


Fig. 1

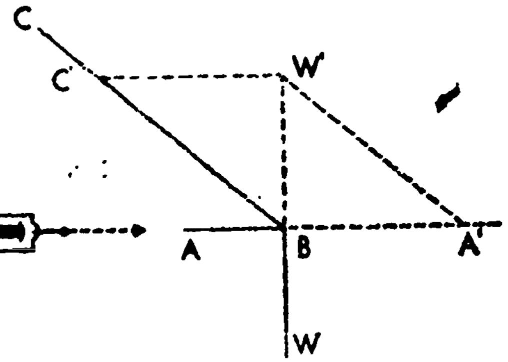


Fig. 2

On a sheet of notebook paper, construct this angle (Fig. 2). Extend the line WB vertically upward. On this line, mark off a distance from B to represent the weight W. Choose a scale to represent W as large as is convenient for your paper.

Record on the paper the scale you used. Call this line BW'. BW' is the resultant force.

4. BW' is what part of the parallelogram you are going to construct?

Extend AB. Through W' construct lines W'A' and W'C' parallel to BC and BA, respectively. Measure BC' and BA' and apply the same scale as you used in drawing BW'. Record the size of the force each line represents.

Attach a spring balance to the end B of the boom and pull out horizontally until the end A of the boom just leaves the support. Note the balance reading.

5. How does it compare with the force BA' that you computed?

In the second trial, fasten balance C to another position so that the boom AB is raised above the horizontal. Use the same weight and repeat the procedure above.

DATA

	First Trial	Second Trial
Weight	G	G
Balance reading of force BC	G	G
Computed force BC'	G	G
Balance reading of force BA	G	G
Computed force BA'	G	G

Discussion:

1. A ladder leans against a wall. Show by a diagram the direction of the components of the force of the ladder against the wall.

2. A street lamp weighing 60 lb is suspended in a crane similar to the one you used. If angle ABC is 45°, what are the forces in AB and BC?

3. What advantage is there in supporting a lamp by a crane of this type rather than by a single horizontal arm?

4. List several occupations that would need to be acquainted with the objects in this investigation.

MOTION
LEVEL: HIGHSSCHOOL

ACTIVITY: HOW DO WE CALCULATE THE ESCAPE VELOCITY OF A ROCKET?

SOME OF OUR EARTH SATELLITES HAVE "ESCAPED" FROM THE EARTH TO GO INTO ORBIT AROUND THE SUN. YET WE LEARN FROM OUR EQUATION FOR GRAVITATIONAL FORCE BETWEEN TWO BODIES THAT THE INFLUENCE OF GRAVITY, THOUGH IT MAY BECOME VERY WEAK, EXTENDS INDEFINITELY INTO SPACE. WHAT DOES IT MEAN, THEN, FOR A SATELLITE TO "ESCAPE"?

1. IT HAS BEEN FOUND THAT ANY TWO MASSES ATTRACT ONE ANOTHER WITH A(N) ______________ FORCE. IT IS THIS FORCE THAT KEEPS THE ______________ IN ORBIT AROUND THE EARTH AND THE EARTH IN ORBIT AROUND THE ______________.

2. WE HAVE SEEN THAT THE EQUATION BY WHICH WE CAN CALCULATE THIS FORCE IS GIVEN BY

$$F = \frac{GMm}{R^2}$$

WHERE M AND m ARE THE TWO ______________, R IS ______________, AND G IS THE GRAVITATION CONSTANT WHOSE VALUE IS ______________ NEWTON-METER^2 PER KILOGRAM^2.

3. THE POTENTIAL ENERGY OF A MASS IN THE GRAVITATIONAL FIELD OF THE EARTH WAS EARLIER CALCULATED ON THE ASSUMPTION THAT THE FORCE DID NOT CHANGE VERY MUCH. IF OUR DISTANCE FROM THE CENTER OF THE EARTH CHANGES, THIS ASSUMPTION WILL NO LONGER BE VALID. THE METHOD OF CALCULATING THE POTENTIAL ENERGY WHEN THE FORCE VARIES IS BEYOND THE MATHEMATICAL LEVEL OF THIS COURSE. TO MAKE THIS CALCULATION EASIER, IT TURNS OUT THAT WE SHOULD PLACE OUR ZERO OF POTENTIAL ENERGY AT INFINITY. SINCE AN OBJECT CLOSER TO THE EARTH IS GENERALLY SAID TO HAVE LESS POTENTIAL ENERGY, THIS MEANS THAT ANY OBJECT AT A FINITE DISTANCE MUST HAVE A NEGATIVE POTENTIAL ENERGY (SINCE THE POTENTIAL ENERGY AT INFINITY IS ZERO).

   IF WE ESTABLISH OUR ZERO OF POTENTIAL ENERGY AT INFINITY, THE POTENTIAL ENERGY AT ANY POINT IN THE GRAVITATIONAL FIELD IS THEN GIVEN BY A VERY SIMPLE EQUATION:

$$U_G = -\frac{GMm}{R}$$

   THE MINUS SIGN INDICATES THAT A BODY (GAINS, LOSES)______________ POTENTIAL ENERGY AS IT FALLS TOWARD THE EARTH (R BECOMES SMALLER). WHEN A BODY FALLS FROM INFINITY TO A DISTANCE R FROM THE EARTH'S CENTER, THERE IS A TOTAL (GAIN, LOSS) ____________ OF POTENTIAL ENERGY EQUAL TO GMm/R. FOR THE BODY TO RISE AGAIN FROM R TO INFINITY, IT MUST (ACQUIRE, GIVE UP)______________ THE SAME AMOUNT OF POTENTIAL ENERGY.

4. WHEN A ROCKET BEGINS ITS JOURNEY, IT HAS A LARGE AMOUNT OF ______________ENERGY. BUT THE HIGHER IT GOES, THE GREATER ITS ______________ENERGY BECOMES. SOME OF THE ____________ENERGY IT HAD DURING THE EARLY PART OF ITS FLIGHT IS TRANSFORMED INTO

____________ ENERGY AS IT GETS FARTHER FROM THE EARTH. WHEN ALL THE KINETIC ENERGY HAS BEEN TRANSFORMED TO POTENTIAL ENERGY, IT WILL STOP.

5. IF WE WANT IT TO "ESCAPE," WE MUST PROVIDE ENOUGH KINETIC ENERGY ON THE TAKE-OFF SO THAT IT CANNOT ALL BE TRANSFORMED INTO POTENTIAL ENERGY EVEN IF THE CRAFT TRAVELS TO INFINITY. THIS MEANS THAT

$$\frac{1}{2}\, mv^2 - \frac{GMm}{R}$$

MUST ALWAYS BE GREATER THAN ZERO. IF WE SET THE ABOVE EXPRESSION EQUAL TO ZERO, WE WILL HAVE THE MINIMUM CONDITIONS WHICH WOULD PERMIT THE ROCKET TO REACH AN INFINITE DISTANCE. IN THIS CASE, WE WOULD THEN HAVE

$$\frac{1}{2}\, mv^2 = \frac{GMm}{R}$$

WHICH, UPON SIMPLIFICATION, GIVES US

$$v^2 = \frac{2GM}{R}$$

AND,

SUBSTITUTING IN THIS EQUATION, WE HAVE

$$v^2 = \frac{(2)\,(6.67 \times 10^{-11})\,(6 \times 10^{24})}{6.38 \times 10^6} \qquad v^2 = 1.26 \times 10^8 \text{ m}^2/\text{sec}^2$$

$$v = 1.12 \times 10^4 \text{ m/sec}$$

AN OBJECT WHICH LEAVES THE EARTH WITH THIS VELOCITY WILL ALWAYS BE ABLE TO OUTRUN THE DECELERATION PRODUCED BY THE EARTH'S GRAVITY. WE CALL THIS THE ESCAPE VELOCITY.

NOTICE THAT WE HAVE ASSUMED THERE ARE NO OTHER FACTORS TO CONSIDER SUCH AS THE POSSIBLE EFFECT OF THE MOON OR THE SUN AND THE FRICTION OF THE ATMOSPHERE.

6. WHAT IS THE ESCAPE VELOCITY FOR A ROCKET LEAVING THE SURFACE OF THE MOON ($M = 7.34 \times 10^{22}$ KG AND $R = 1.74 \times 10^6$ M)?

ANS.________________

7. IF A ROCKET DOES NOT ESCAPE BUT GOES INTO ORBIT, IT SOMETIMES LOSES ENERGY THROUGH FRICTION OF THE ATMOSPHERE AND "FALLS IN" CLOSER TO THE EARTH. YOU MIGHT EXPECT THAT THE RESISTANCE OF THE ATMOSPHERE WOULD SLOW THE ROCKET DOWN, BUT WHAT ACTUALLY HAPPENS IS THAT THE VELOCITY OF THE ROCKET____________AS IT FALLS CLOSER TO THE EARTH. ITS ____________ENERGY IS THEREFORE INCREASING, BUT ITS____________ENERGY IS, HOWEVER, DECREASING. THE LOSS OF____________ENERGY IS GREATER THAN THE GAIN OF ____________ENERGY. THE DIFFERENCE IS CONVERTED INTO____________ OF THE ROCKET AND THE ATMOSPHERE.

PROBLEM SUMMARY: A ROCKET IS SAID TO HAVE ESCAPE VELOCITY WHEN ITS VELOCITY IS SUFFICIENT TO ALWAYS OUTRUN THE____________PRODUCED BY THE GRAVITY OF THE EARTH. WHAT TYPES OF CAREERS WOULD FIND THIS USEFUL?

MOTION
Level: High School

ACTIVITY: Analysis of Momentum

Materials (per team):

Track with force mechanism
2 steel balls
Sheet of carbon paper
8 marbles of the same weight
Sheet of tracing paper

Procedures:

A. Make sure the track is level. Place a marble in the groove about 5 cm from the launching point. Launch a second marble with a measured amount of force. Record the setting used on the force mechanism and the reaction that occurs between the 2 marbles.

B. Place 5 marbles in the middle of the grooved track so that they touch each other. Launch a marble with the same force setting used in Procedure A. Record the effect on the 5 marbles.

C. Place 5 marbles in the middle of the grooved track as in Procedure B. Shoot 2 marbles at the same time and with the same force setting used before. Record the effect on the 5 marbles. Repeat this procedure shooting 3 marbles at the same time, and record the effect on the other five.

D. Place a marble in the middle of the grooved track. Shoot one of the steel balls with the same force setting. Record your results.

Interpretations:

1. What happened to the momentum of the marbles launched in Procedures A, B, and C?

2. As a result of the collisions, how did the change in momentum of the steel ball in Procedure D compare with the change in momentum of the marbles that were launched in Procedures A, B, and C?

Problems:

1. Carefully study the results of each procedure. Recall that momentum is a property of a moving object and is equal to the mass of an object times its speed. From the results of the experiments you have performed, state a general law about momentum.

2. From your observations, predict what will happen if a steel ball is placed in the middle of the track and a marble is launched at it. Record your prediction.

PROCEDURES: (CONTINUED)

E. PLACE A STEEL BALL IN THE MIDDLE OF THE TRACK, AND LAUNCH A MARBLE AT IT. OBSERVE THE DIRECTION OF MOTION OF EACH AFTER THE COLLISION. ROUGHLY COMPARE THE SPEED OF THE MARBLE BEFORE AND AFTER THE COLLISION.

F. IN PREVIOUS PROCEDURES, THE DIRECTIONS IN WHICH THE MARBLES AND STEEL BALLS MOVED AFTER COLLISION WERE LIMITED BY THE TRACK. IN THIS PROCEDURE THE STEEL BALLS WILL BE FREE TO MOVE IN ANY DIRECTION ON A TABLE TOP AFTER THEY COLLIDE. PLACE THE CARBON PAPER ON THE TABLE, CARBON SIDE UP, AND LAY THE TRACING PAPER OVER IT. THE WEIGHT OF EACH BALL WILL LEAVE A TRACK ON THE BOTTOM OF THE TRACING PAPER. ROLL THE STEEL BALLS TOWARD EACH OTHER--ONE FROM EACH HAND. TRY TO RELEASE THE BALLS IN SUCH A WAY THAT THEY HAVE APPROXIMATELY EQUAL SPEED. MAKE SKETCHES OF SEVERAL COLLISIONS, USING CIRCLES TO REPRESENT THE STEEL BALLS AND ARROWS TO INDICATE THEIR MOVEMENTS. USE INK TO DRAW THE CIRCLE AND ARROW TOR ONE BALL. USE PENCIL TO DRAW THE CIRCLE AND ARROW FOR THE OTHER BALL.

INTERPRETATIONS: (CONTINUED)

3. WHAT THREE FACTORS SEEM TO DETERMINE THE RESULTS OF THE COLLISIONS YOU OBSERVED IN PROCEDURE E?

4. IN THE ANALYSIS OF MOTION, IT IS NOT ENOUGH TO KNOW THE SPEED OF AN OBJECT. YOU MUST ALSO KNOW THE EXACT DIRECTION IN WHICH AN OBJECT IS MOVING. THE COMBINATION OF SPEED AND DIRECTION IS VELOCITY. IN PROCEDURE F COULD YOU PREDICT WHAT DIRECTION EACH BALL WOULD TAKE AFTER THE TWO COLLIDED?

AS LONG AS YOU LIMIT THE DIRECTION OF MOTION WITH A TRACK, IT IS FAIRLY EASY TO PREDICT THE RESULT OF A COLLISION. WITHOUT THE TRACK THE OBJECTS HAVE GREATER FREEDOM OF MOVEMENT, AND THE MATHEMATICS BECOMES COMPLICATED.

PROBLEMS: (CONTINUED)

3. SUPPOSE THAT AN AUTO AND A LARGE, HEAVILY-LADEN TRUCK ARE EACH TRAVELING AT 50 MILES PER HOUR. WHICH WOULD HAVE THE GREATEST CHANGE IN DIRECTION AND SPEED IF THEY WERE TO COLLIDE HEAD-ON? BASE YOUR ANSWER ON YOUR PREVIOUS INVESTIGATION OF THE COLLISION BETWEEN A MARBLE AND A STEEL BALL.

MOTION
LEVEL: HIGH SCHOOL

ACTIVITY: ACCELERATION AND MEASURING ACCELERATION

IF YOU STOP A BICYCLE AT THE TOP OF A HILL AND THEN START COASTING DOWN THE HILL, YOU WILL EXPERIENCE A CONSTANT INCREASE IN SPEED. THIS MIGHT MAKE YOU WANT TO SLOW DOWN BY USING THE BRAKES. WHEN YOU ARE ON THE HILL GRAVITY CAN CAUSE YOUR SPEED TO INCREASE OR DECREASE; FRICTION CAN CAUSE IT TO DECREASE.

A BALL ROLLED UP A HILL DOES NOT MOVE AT A STEADY SPEED AND THEN SUDDENLY STOP. IT WILL GRADUALLY SLOW DOWN, STOP, AND THEN START ROLLING BACK DOWN THE HILL. LACKING BRAKES, THE BALL WILL CONTINUE INCREASING IN SPEED UNTIL IT REACHES THE BOTTOM OR UNTIL SOMETHING STOPS IT.

IT IS DIFFICULT TO DETERMINE THE SPEED OF A BALL ROLLING DOWN A HILL AT ANY ONE INSTANT OF TIME. IN THE NEXT INVESTIGATION YOU WILL ATTEMPT TO DETERMINE THE AVERAGE SPEED OF A BALL FOR DIFFERENT INTERVALS OF TIME, WHILE IT IS ONE THE SLOPE. FROM THESE AVERAGES YOU CAN DETERMINE THE ACCELERATION OF THE BALL.

MEASURING ACCELERATION

STUDY THE DIRECTIONS CAREFULLY BEFORE BEGINNING THE INVESTIGATION. YOUR RESULTS CAN BE ACCURATE ONLY IF EACH PERSON ON YOUR TEAM DOES HIS JOB CAREFULLY.

MATERIALS:

TRACK
MASKING TAPE
STRIP OF PAPER (AS LONG AS THE TRACK)
TIMER
GRAPH PAPER
MARKING GUIDE (CARD WITH SMALL HOLE IN IT)
STEEL BALL OR MARBLE
METRIC RULER

PROCEDURES:

A. SET THE TRACK AT A SLOPE OF ABOUT 5/100.
B. TAPE THE MARKING GUIDE TO THE TABLE NEAR THE RAISED END OF THE TRACK. SLIDE THE STRIP OF PAPER UNDER THE MARKING GUIDE.
C. HAVE ONE MEMBER OF YOUR TEAM PUT THE BALL AT THE TOP OF THE TRACK AND HOLD IT IN POSITION WITH A PENCIL. HAVE ANOTHER TEAM MEMBER GRASP THE END OF THE STRIP OF PAPER AND MOVE IT UNTIL IT IS EVEN WITH THE BALL. START THE TIMER AND RELEASE THE BALL AT THE INSTANT THE TIMER CLICKS. PRACTICE SLIDING THE STRIP OF PAPER ALONG THE TABLE SO THAT ITS END STAYS EVEN WITH THE BALL ROLLING DOWN THE TRACK.
D. NOW HAVE ANOTHER TEAM MEMBER PRACTICE MARKING THE MOVING PAPER STRIP THROUGH THE HOLE IN THE MARKING GUIDE. USE A BALL-POINT PEN, AND PRACTICE TAPPING THE STRIP IN TIME WITH EACH CLICK OF THE TIMER.
E. WHEN YOU HAVE PRACTICED ENOUGH TO MAKE YOUR RESULTS DEPENDABLE, TURN OVER THE PAPER STRIP AND MOVE IT INTO STARTING POSITION. HAVE THE MARKER BEGIN TAPPING THE PAPER THROUGH THE HOLE IN TIME WITH THE CLICKS. THIS WILL MARK THE BEGINNING POINT FOR YOUR RECORD. WHEN THE BALL IS RELEASED AND THE STRIP OF PAPER IS PULLED, THE MARKS ON THE PAPER WILL BE SEPARATED BY THE DISTANCE THE BALL HAS MOVED BETWEEN CLICKS.

F. MEASURE AND RECORD THE DISTANCES BETWEEN MARKS.

INTERPRETATIONS:

1. SINCE THE TIME INTERVAL FOR EACH DISTANCE YOU MEASURED IS ONE CLICK, THE AVERAGE SPEED FOR THAT INTERVAL IS NUMERICALLY EQUAL TO THE DISTANCE.

$$\text{AVERAGE SPEED} = \frac{\text{DISTANCE BETWEEN MARKS}}{\text{1 CLICK}}$$

   RECORD THE AVERAGE SPEED FOR EACH TIME INTERVAL CAREFULLY.

2. PREPARE A GRAPH OF YOUR DATA. PLOT THE AVERAGE SPEEDS ON THE VERTICAL AXIS AND THE TIME INTERVALS ON THE HORIZONTAL AXIS.

3. STUDY THE GRAPH. DOES THE SPEED INCREASE BY THE SAME AMOUNT FROM ONE TIME INTERVAL TO THE NEXT?

4. IF THE AMOUNT OF CHANGE FROM ONE TIME INTERVAL TO THE NEXT IS RELATIVELY CONSTANT, WHAT IS THE AVERAGE CHANGE IN SPEED PER TIME INTERVAL? WHAT IS THE ACCELERATION?

5. COMPARE YOUR GRAPH WITH THE GRAPHS PREPARED BY OTHER TEAMS. DESCRIBE AND EXPLAIN ANY SIMILARITIES AND DIFFERENCES.

6. IF THE SLOPE WAS INCREASED, WHAT WOULD BE THE EFFECT ON THE ACCELERATION?

MOTION
LEVEL: HIGH SCHOOL

ACTIVITY: GRAVITATIONAL FORCE

PROBLEM:
IS GRAVITATIONAL ACCELERATION THE SAME FOR ALL FALLING BODIES REGARDLESS OF THEIR MASS?

MATERIALS:
TWENTY IRON WASHERS
PAPER CLIP
STRING
STOP WATCH OR ANY WATCH WITH A SWEEP SECOND HAND.

PROCEDURE:
TIE THE PAPER CLIP TO ONE END OF THE STRING AND SLIP 10 WASHERS ONTO THE STRING. HANG THE STRING SO THAT IT IS AT LEAST A METER LONG BETWEEN THE POINT OF SUSPENSION AND THE WASHERS. SET THE WASHERS SWINGING AS A PENDULUM; TIME TEN PERIODS. (A PERIOD IS THE TIME REQUIRED FOR THE WASHERS TO SWING THROUGH AN ARC AND BACK AGAIN TO THE RELEASE POINT.) CALCULATE THE PERIOD OF THE PENDULUM. REPEAT THE EXPERIMENT BUT RELEASE THE WASHERS FROM A DIFFERENT HEIGHT THAN BEFORE. SLIP THE REMAINING WASHERS ONTO THE STRING AND REPEAT THE EXPERIMENT TO DETERMINE THE PERIOD WHEN THE GREATER MASS IS USED.

OBSERVATIONS:
1. THE PERIOD OF THE PENDULUM WITH 10 WASHERS (TRIAL 1)

2. THE PERIOD OF THE PENDULUM WITH 10 WASHERS (TRIAL 2)

3. THE PERIOD OF THE PENDULUM WITH 20 WASHERS (TRIAL 1)

4. THE PERIOD OF THE PENDULUM WITH 20 WASHERS (TRIAL 2)

INTERPRETATION:
1. IF THERE WERE NO FORCE OF GRAVITY, WHAT WOULD HAPPEN WHEN THE WASHERS ARE RELEASED AT THE TOP OF THEIR SWING?

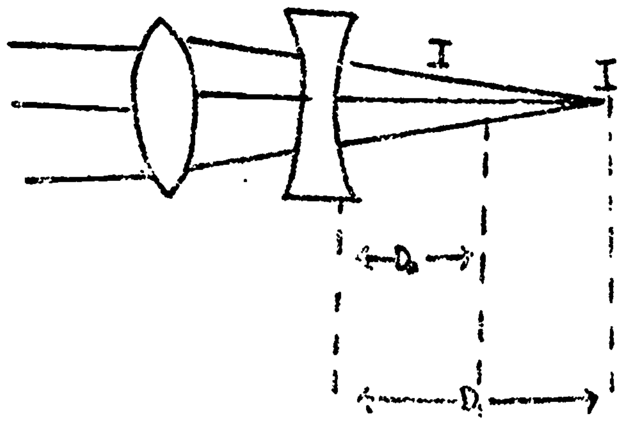
2. WHAT CAUSES THE PENDULUM TO SWING?

3. HAS THE PERIOD OF THE PENDULUM BEEN AFFECTED BY CHANGING THE MASS?

CONTINUING THE INVESTIGATION:
VARY THE LENGTH OF THE PENDULUM AND AGAIN DETERMINE THE PERIOD. IS THERE ANY CHANGE? IS THE PERIOD OF THE PENDULUM DIRECTLY OR INVERSELY PROPORTIONAL TO ITS LENGTH? IF THE LENGTH IS HALVED, HOW IS THE PERIOD AFFECTED? HOW LONG WOULD A PENDULUM BE, WHICH COULD BE USED AS A TIMING DEVICE, WITH A PERIOD OF 1 SECOND? (RECORD YOUR OBSERVATIONS IN THE SPACE AVAILABLE BELOW AND ON THE FOLLOWING PAGE; SHOW ALL YOUR CALCULATIONS.)

HOW WOULD THIS INVESTIGATION TIE IN WITH THE FOLLOWING CAREERS? A PILOT, AN AIRCRAFT DESIGNER, CONTRACTOR, SPACE TECHNOLOGY, PLUMBER, AND AERIAL DIVER?

OPTICS



PHYSICS - ENERGY - OPTICS & WAVES

- ARTIST & LAY OUT MEN (ADVERTISING)
- ASTRONAUTS
- DENTIST
- ENGINEER
- INTERIOR DESIGN & DECORATION
- OPTOMETRIST
- PHYSICIAN
- RADIO & TV ANNOUNCER
- ELEMENTARY TEACHER
- TECHNICAL WRITER
- X-RAY TECHNICIAN
- FARMING
- INSTRUMENT REPAIRER
- OPTICAL MECHANICS
- GLAZIER
- PAINTER
- BRAKEMAN
- LITHOGRAPHIC OCCUPATION
- POWER PLANT OPERATOR
- ARCHITECTS
- PHYSICAL CHEMIST
- ENGINEERING TECHNICIAN
- GEOPHYSICS
- MERCHANT MARINE
- PHOTOGRAPHER
- PHYSICIST
- SURVEYOR
- TEACHER SECONDARY-COLLEGE
- VETERINARIAN
- RADIOLOGIST
- INSTRUMENT MAKER
- OPTICIAN
- TV & RADIO TECHNICIAN
- PAPER HANGER
- SIGNAL MAINTAINER (RR)
- BROADCAST TECHNICIAN
- PICTURE PROJECTIONIST

[redacted]

ENERGY: (LIGHT-OPTICS)
LEVEL: JUNIOR HIGH

ACTIVITY: OBSERVING PATHWAYS OF LIGHT

MATERIALS: (PER TEAM)

RULER OR STRAIGHTEDGE	COIN
SMALL FLAT-SIDED CLEAR BOTTLE, WITH CAP	FLAT-BOTTOMED CUP (OPAQUE)
WATER	LENSES, 2

PROCEDURE:

A. LOOK AT A COIN OR SOME OTHER SMALL OBJECT ON YOUR WORKTABLE. YOU ARE ABLE TO SEE IT BECAUSE LIGHT FROM A SOURCE IS REFLECTED FROM THE OBJECT TO YOUR EYE. IN YOUR NOTEBOOK MAKE A SKETCH SHOWING THE PATH YOU THINK LIGHT TAKES FROM THE SOURCE TO THE OBJECT TO YOUR EYE.

INTERPRETATIONS:

1. SUGGEST A TEST TO PROVE THAT LIGHT MAKES IT POSSIBLE FOR YOU TO SEE THE OBJECT.

2. DOES ALL THE LIGHT LEAVING THE COIN COME TO YOUR EYES? EXPLAIN YOUR ANSWER.

3. DO YOU THINK THAT LIGHT FROM THE COIN FOLLOWS A STRAIGHT PATH OR A BENT PATH AS IT TRAVELS TO YOUR EYE?

PROCEDURES:

B. SIGHT AT THE COIN ALONG THE EDGE OF A RULER. HAVE ONE OF YOUR TEAMMATES VIEW THIS PROCEDURE FROM THE SIDE.

INTERPRETATIONS:

4. DOES THE RULER POINT DIRECTLY AT THE COIN?

5. IS THE PATH OF LIGHT TRAVELING FROM THE COIN TO YOUR EYE A STRAIGHT ONE?

PROCEDURES:

C. DRAW A STRAIGHT LINE ON A PIECE OF PAPER. FILL THE SMALL BOTTLE WITH WATER, AND CAP IT. LAY THE BOTTLE ACROSS THE LINE. LOOK AT THE LINE FROM SEVERAL DIFFERENT ANGLES AND POSITIONS.

INTERPRETATIONS:

6. DESCRIBE THE APPEARANCE OF THE LINE. DOES LIGHT FROM THE LINE FOLLOW A STRAIGHT PATH THROUGH THE BOTTLE AND THE AIR?

PROCEDURES:

D. PLACE A SMALL COIN IN THE CUP. PUT THE CUP ON THE DESK. THEN SLOWLY MOVE BACK JUST FAR ENOUGH SO THAT YOU CAN NO LONGER SEE THE COIN. REMAIN AT THIS POSITION WATCHING THE TOP OF THE CUP WHILE ANOTHER MEMBER OF YOUR TEAM VERY SLOWLY POURS WATER INTO IT. SIGHT AT THE COIN IN THE CUP ALONG THE EDGE OF YOUR RULER. HAVE A TEAMMATE OBSERVE FROM THE SIDE.

INTERPRETATIONS:

7. DESCRIBE AND EXPLAIN WHAT YOU OBSERVED IN PROCEDURE D.

8. WHAT DOES THIS TELL YOU ABOUT THE PATHWAY OF LIGHT?

PROCEDURES:

E. DARKEN THE ROOM, LEAVING ONE SHADE SLIGHTLY OPEN. STAND NEAR THE WINDOW WITH A LENS AND SHEET OF PAPER. HOLD THE LENS BETWEEN THE WINDOW AND THE PAPER. MOVE THE LENS BACK AND FORTH UNTIL THE IMAGE OF AN OBJECT OUTSIDE, SUCH AS A TREE, IS FOCUSED ON THE PAPER.

INTERPRETATIONS:

9. DESCRIBE THE APPEARANCE OF THE IMAGE ON THE PAPER.

PROCEDURES:

F. EXAMINE THE TWO LENSES AND DETERMINE WHICH ONE MAKES THE PRINT ON THIS PAGE APPEAR LARGER. HOLD THE LENS OF GREATER MAGNIFICATION NEAR YOUR EYE. HOLD THE OTHER A LITTLE FARTHER AWAY, IN LINE WITH THE CLOSER LENS. MOVE THE WEAKER LENS AWAY FROM YOU SLOWLY UNTIL YOU SEE THE IMAGE OF SOME OBJECT IN FRONT OF YOU IN FOCUS. THIS IS THE WAY A TELESCOPE WORKS.

INTERPRETATIONS:

10. DESCRIBE THE IMAGE OBTAINED IN PROCEDURE F.

11. IN WHAT WAYS ARE LENSES AND WATER SIMILAR IN THEIR EFFECTS ON LIGHT?

ENERGY (LIGHT-OPTICS)
LEVEL: JUNIOR HIGH & ABOVE

ACTIVITY: ACTIVITIES WITH LIGHT INTERFERENCE

MATERIALS: PART 1 - OIL, FLAT DISH
PART 2 - WIRE FRAME, SOAP

PART 3
2 PIECES OF FLAT GLASS
MERCURY VAPOR LAMP

PROCEDURES:

1. PLACE A DROP OF OIL ON THE SURFACE OF WATER CONTAINED IN A FLAT DISH AND ALLOW THE OIL TO SPREAD OVER THE SURFACE OF THE WATER. OBSERVE THE COLOR FRINGES THAT OCCUR WHEN ILLUMINATED BY WHITE LIGHT (SUCH AS SUNLIGHT). INTERFERENCE BETWEEN THE WAVES OF A CERTAIN COLOR MAY ELIMINATE THAT COLOR FROM THE REFLECTED LIGHT SO THAT INSTEAD OF WHITE LIGHT BEING REFLECTED, THE EYE WILL RECEIVE WHITE LIGHT MINUS THIS CERTAIN COLOR. IF BLUE LIGHT IS ELIMINATED, THEN THE COLOR REFLECTED TO THE EYE WILL APPEAR YELLOW. IN A DARKENED ROOM TRY REFLECTING A MONOCHROMATIC LIGHT FROM THE OIL FILM AND NOTE THE RESULT. HOW IS IT DIFFERENT FROM THE WHITE LIGHT EXPERIMENT?

2. BLOW A SOAP BUBBLE OR ALLOW A FILM OF SOAP SOLUTION TO FORM ON A STRETCHABLE WIRE FRAME. NOTICE THE COLOR FRINGES DUE TO REFLECTION FROM THE FRONT AND REAR SURFACES. ALSO, NOTICE THAT, AS THE FILM THINS OUT, THE COLOR TENDS TO DISAPPEAR COMPLETELY.

3. PLACE TOGETHER TWO FLAT PIECES OF GLASS, SUCH AS PLATE GLASS, ON A LEVEL SURFACE AND ALLOW LIGHT FROM A MERCURY VAPOR LAMP TO BE REFLECTED FROM THE GLASS TO THE EYE. THERE WILL BE ENOUGH IRREGULARITY IN THE TWO SURFACES TO GIVE THE NONPARALLEL FACES NEEDED TO SHOW INTERFERENCE. NOTE THE RESULTING FRINGES. APPLY PRESSURE TO ONE OR THE OTHER EDGES AND NOTE ANY CHANGE IN THE FRINGE PATTERN. ROTATE THE GLASS ON THE SURFACE AND WATCH FOR ADDITIONAL CHANGES.

ENERGY: OPTICS
Level: High School

ACTIVITY: The Color of Objects

Problem:
The color of any object we see depends on the colors of light absorbed and reflected by the object. How do different colors of light falling on an object affect the colors we see?

Investigation:
A box with a viewing hole and a light socket into which different colored light bulbs can be placed is arranged. The effects of different colored lights on variously colored objects placed in the box are given in the table below.

Color of Light bulb	Color of Object	Color seen by the Eye
WHITE	GREEN	GREEN
BLUE	RED	BLACK
RED	GREEN	BLACK
YELLOW	WHITE	YELLOW
GREEN	BLACK	BLACK

Interpretation:
According to the results given in the table, mark each of the following statements TRUE, FALSE, or NOT PROVED in the space provided.

1. A white object in yellow light reflects the yellow light waves. ____________
2. A green object in yellow light absorbs the blue light waves. ____________
3. A red object in blue light reflects the red light waves. ____________
4. A black object in white light absorbs all the light waves. ____________
5. A green object in red light reflects the red light waves. ____________
6. A black object in blue light absorbs the blue light waves. ____________
7. A red object in green light reflects the yellow light waves. ____________
8. A black object in green light reflects the green light waves. ____________

9. A GREEN OBJECT IN WHITE LIGHT REFLECTS THE GREEN LIGHT WAVES. ______

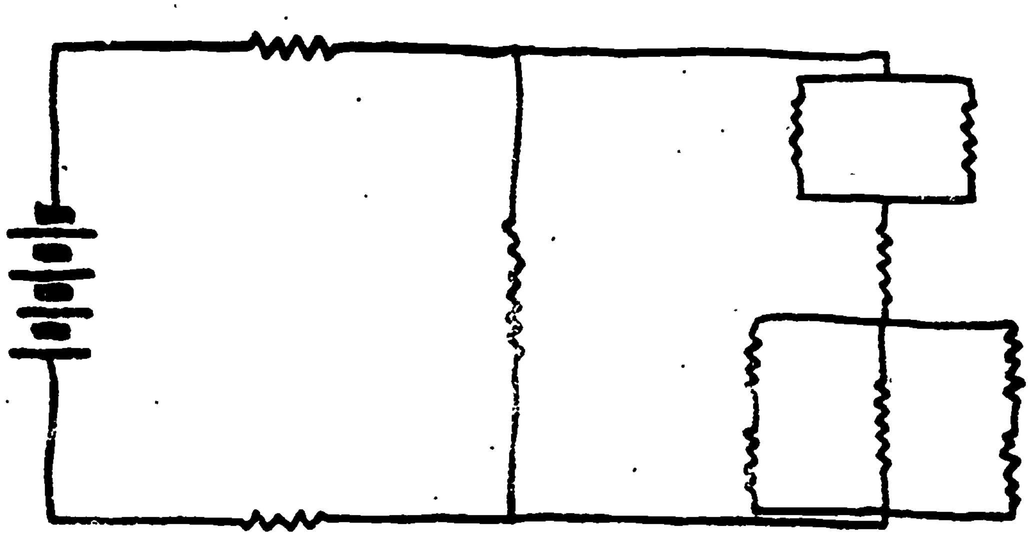
10. A RED OBJECT IN BLUE LIGHT ABSORBS THE BLUE LIGHT WAVES. ______

APPLICATION:

1. EXPLAIN WHY IT IS WISE TO EXAMINE THE COLOR OF A SUIT OR DRESS BEING PURCHASED IN SUNLIGHT RATHER THAN UNDER THE STORE LIGHTS IN ORDER TO SEE THE TRUE COLOR OF THE CLOTH.

2. WHAT CAREERS WOULD NEED TO BE CONCERNED WITH VIEWING OBJECTS OR ITEMS IN QUALITY LIGHT?

ELECTRICITY



PHYSICS - ENERGY - ELECTRICITY

Architects
Astronomer
Physical Chemist
Dentist
Engineering Technician
Engineer
Geophysics
Ground Radio Operator
Merchant Marine
Physician
Physicist

Elementary Teacher
Teacher secondary-college
Technical Writer
Veterinarian
X-Ray Technician
Radiologist
Computer Operators
Telegraphers
Telephoner
Tower Operator (R. R.)
Auto Parts Man
Building Custodian
Jeweler
Radio & TV Announcer
Watch Repairman
Central Office Craftsman (telephone)
Electrical Repairman
Lineman
Telephone Repairman
Airplane Dispatcher
Broadcast Technician
Gasoline Service Station Attendant
Locomotive Engineer
Meter Man-Woman
Photo Engraver
Stationary Engineer
Taxi Driver
Truck Driver

FBI Agent
Policeman-Woman
Stewardesses
Farm Crop Production Technician
Dairy Production Technician
Farming
Fish Culture Technician
Livestock Production Technician
Soil Scientist
Electroplater
Air Conditioning & Refrigeration Mechanics
Aircraft Mechanics
Auto Mechanic
Diesel Mechanic
Farm Equipment Mechanic
Flight Engineer
Industrial Maintenance Mechanic
Instrument Maker
Machine Tool Operators
Millright
Office Machine Repairman
Appliance Serviceman
Instrument Repairer
Jeweler Repair
TV & Radio Technician
Carpenter
Telephone Installer
Elevator Repairman
Signal Maintainer
Welder
Brakeman
Electro Typers
Truck Driver (warehouse)
Apprentice Engineer
Projectionist
Power Plant Operator
Boiler Fireman
Power Dispatcher

ENERGY: ELECTRICITY
LEVEL: JUNIOR HIGH

ACTIVITY: HOW CAN RESISTANCE BE USEFUL IN ELECTRICAL APPLIANCES?

MATERIALS:
- 2 DRY CELLS
- 3 FT. INSULATED ELECTRICAL WIRE
- GAS COLLECTING BOTTLE
- TWO-HOLE RUBBER STOPPER
- SWITCH
- 4" OF THICK COPPER WIRE
- 4" OF THIN COPPER WIRE
- 4" OF NICHROME WIRE
- 4" STRAND OF PICTURE-HANGING WIRE

PROCEDURE:

A. PUSH THE ENDS OF TWO ELECTRICAL WIRES THROUGH THE TWO HOLES OF A RUBBER STOPPER THAT FITS THE GAS BOTTLE OPENING. (A CORK STOPPER MAY BE SUBSTITUTED.) REMOVE INSULATION FROM THE ENDS OF THE WIRES.

B. CONNECT THE SWITCH AND THE TWO DRY CELLS IN SERIES.

C. TAKE THE SHORT PIECE OF THIN COPPER WIRE AND TWIST IT AROUND THE ENDS OF THE TWO WIRES YOU PUSHED THROUGH THE STOPPER. PLACE THE STOPPER IN THE BOTTLE AND CLOSE THE SWITCH. OBSERVE WHAT HAPPENS AND RECORD THE RESULTS IN THE TABLE BELOW.

D. REPEAT STEP C USING A THICKER PIECE OF COPPER WIRE.

E. REPEAT STEP C USING ONE STRAND TAKEN FROM ORDINARY PICTURE-HANGING WIRE.

F. REPEAT STEP C USING NICHROME WIRE.

WHAT DO WE SEE?
CHECK YOUR OBSERVATION FOR EACH MATERIAL.

MATERIAL TESTED	DID WIRE GLOW?	
	YES	NO
THICK COPPER WIRE		
THIN COPPER WIRE		
PICTURE WIRE		
NICHROME WIRE		

WHAT DO WE LEARN?

1. DID THE THIN COPPER WIRE GET HOTTER THAN THE THICK COPPER WIRE? EXPLAIN.

____

____

____

2. DID ALL OF THE MATERIALS TESTED GIVE THE SAME RESISTANCE? HOW DO YOU KNOW?

____

____

____

3. OF THE COPPER, PICTURE WIRE, AND NICHROME, WHICH DO YOU THINK IS THE BEST FOR WIRING A TOASTER? WHY?

____

____

____

4. THE THIN FILAMENT OF AN ELECTRIC LIGHT BULB MUST GET WHITE-HOT TO GIVE LIGHT. SHOULD THE FILAMENT BE ONE WITH A GREAT DEAL OR VERY LITTLE RESISTANCE?

____

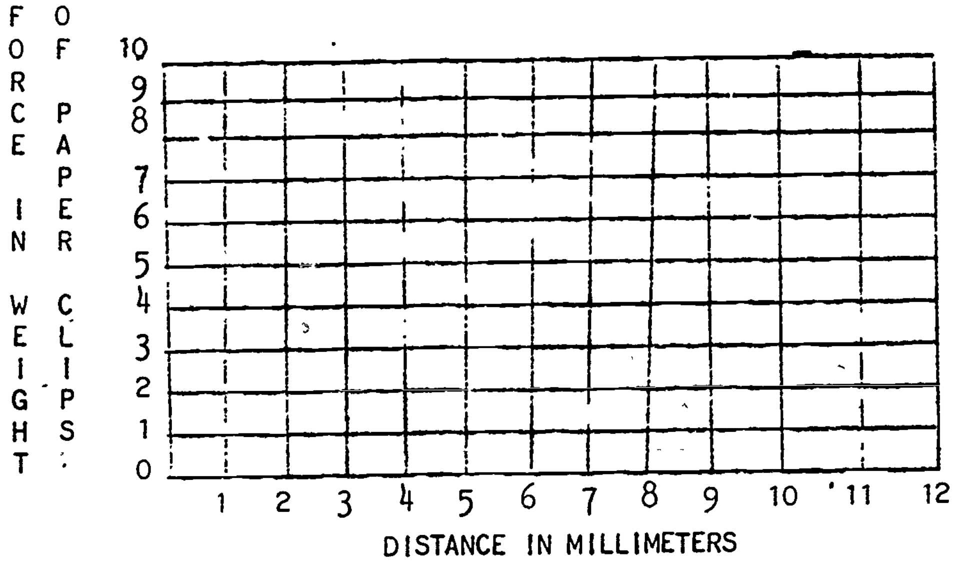
ELECTRICITY
LEVEL: HIGH SCHOOL

ACTIVITY: STRENGTH OF A MAGNETIC FIELD

PROBLEM:
A MAGNET IS SURROUNDED BY A FIELD OF FORCE KNOWN AS A MAGNETIC FIELD. WHAT HAPPENS TO THE STRENGTH OF THE MAGNETIC FORCE AS THE DISTANCE FROM THE MAGNET IS INCREASED?

MATERIALS:
RING STAND,
RING STAND CLAMP
3" GLASS MICROSCOPE SLIDES,
2" RING STAND RING
U-MAGNET OR BAR MAGNET
STEEL PAPER CLIPS

PROCEDURE:
SUPPORT THE MAGNET WITH THE CLAMP SO THAT IT IS POSITIONED OVER THE RING, AS SHOWN IN THE DIAGRAM. PLACE A GLASS SLIDE OVER THE RING AND GENTLY LOWER THE MAGNET SO THAT THE END RESTS SQUARELY ON THE SLIDE. TIGHTEN THE CLAMP TO HOLD THE MAGNET STEADY. PLACE TWO PAPER CLIPS HOOKED END-TO-END UNDER THE SLIDE SO THAT THEY ARE SUPPORTED BY THE MAGNETIC FORCE. NOW, CAREFULLY ADD PAPER CLIPS ONE AT A TIME UNTIL THE WEIGHT IS TOO HEAVY TO BE SUPPORTED. PLACE A SECOND SLIDE ON TOP OF THE FIRST, POSITION THE MAGNET AGAIN, AND REPEAT THE EXPERIMENT. RECORD THE TOTAL NUMBER OF CLIPS SUPPORTED AS THE DISTANCE IS INCREASED 1 MM AT A TIME (THE APPROXIMATE THICKNESS OF EACH SLIDE) IN THE TABLE.



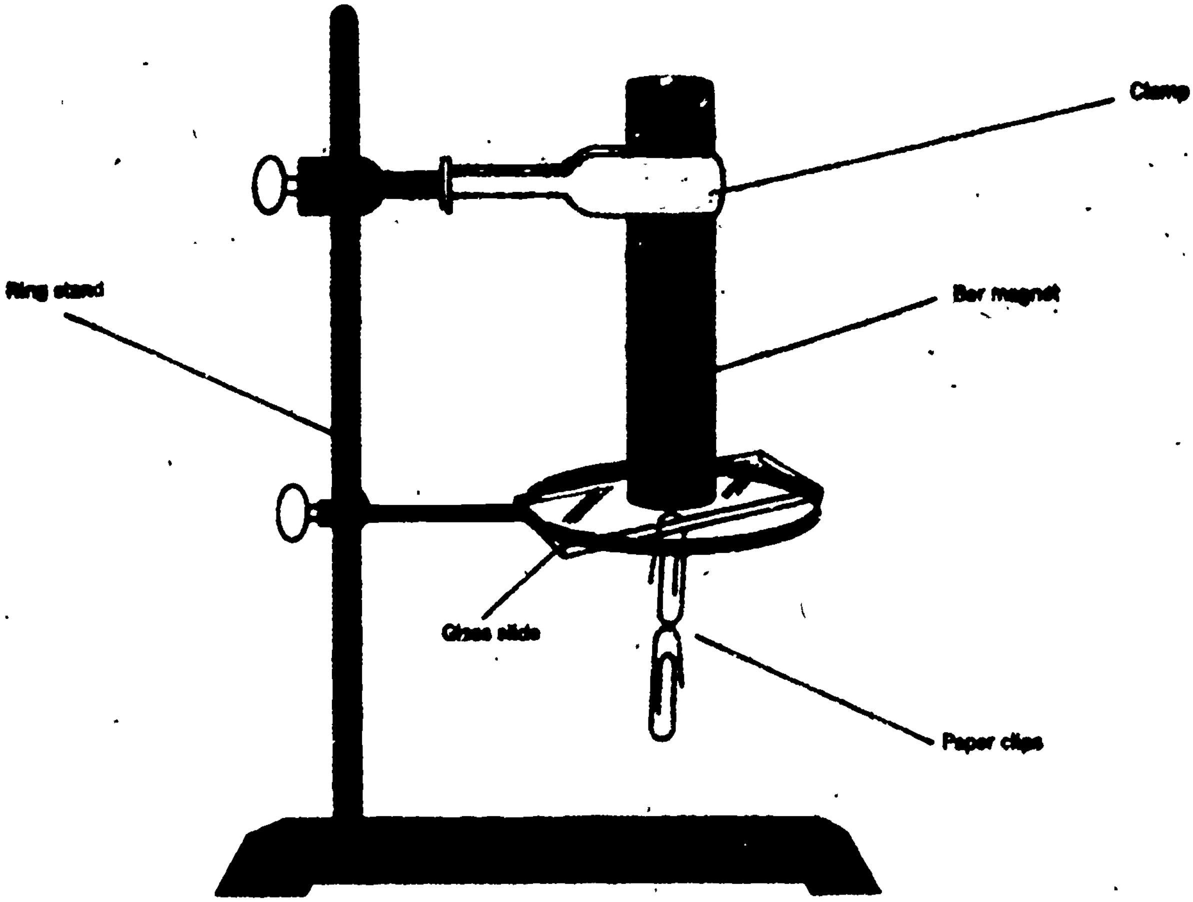


Fig. 7-7

OBSERVATIONS:

FILL IN THE RESULTS OF THE EXPERIMENT IN THE TABLE BELOW.

NUMBER OF SLIDES	DISTANCE FROM MAGNET IN MILLIMETERS	NUMBER OF PAPER CLIPS SUPPORTED
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

INTERPRETATION:

MAKE A GRAPH SHOWING THE RELATIONSHIP BETWEEN THE DISTANCE FROM THE MAGNET AND THE STRENGTH OF THE MAGNETIC FIELD.

APPLICATIONS:

1. WHAT INDUSTRIES WOULD BE CONCERNED WITH MAGNETIC FIELDS?
2. CAN YOU THINK OF SEVERAL OCCUPATIONS THAT WOULD NEED TO KNOW HOW A MAGNETIC FIELD BEHAVES?

ELECTRICITY
LEVEL: HIGH SCHOOL

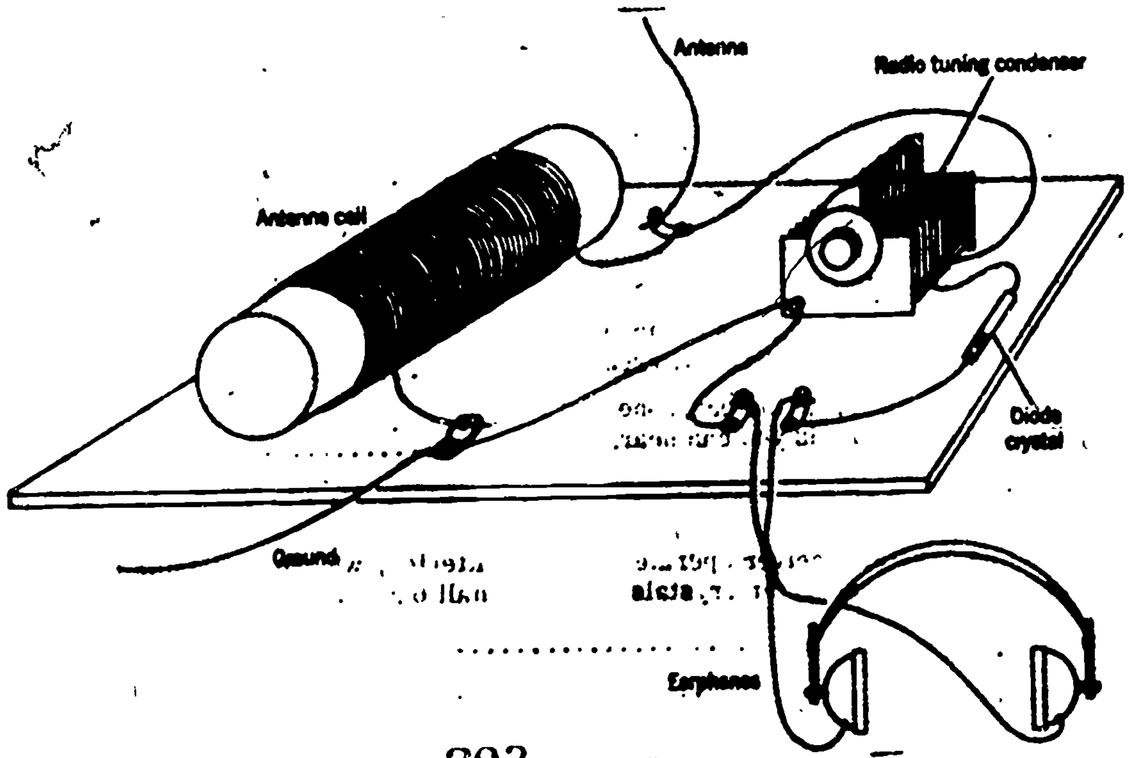
ACTIVITY: A RADIO RECEIVER

PROBLEM:
IF YOU HAVE EXAMINED THE INSIDE OF A RADIO RECEIVER, YOU KNOW THAT IT APPEARS VERY COMPLICATED. HOW IS A SIMPLE RADIO RECEIVER ASSEMBLED?

MATERIALS:

FINE COPPER INSULATED WIRE
50 FEET OF BARE COPPER WIRE
RADIO TUNING CONDENSER
WIRING CLIPS
HEAVIER COPPER INSULATED WIRE
EMPTY ROUND "OATMEAL" BOX
GERMANIUM DIODE CRYSTAL
EARPHONES

PROCEDURE:
WIND 60 TURNS OF FINE, INSULATED WIRE AROUND THE "OATMEAL" BOX TO MAKE AN ANTENNA COIL. FASTEN THE ENDS OF THE WIRE WITH TAPE, BUT LEAVE THE LEADS LONG ENOUGH TO CONNECT THE COIL TO THE OTHER PARTS. ASSEMBLE THE PARTS AND CONNECT THEM TOGETHER, USING THE HEAVIER WIRE, AS SHOWN. THE BANDED END OF THE DIODE CRYSTAL MUST BE ATTACHED AS SHOWN. A 50-FOOT BARE COPPER WIRE WILL SERVE AS AN ANTENNA TO LET YOU TUNE IN ON MOST LOCAL STATIONS BY ADJUSTING THE TUNING CONDENSER.



OBSERVATIONS:

1. WHY IS AN ANTENNA COIL NEEDED?

2. WHAT IS THE PURPOSE OF THE TUNING CONDENSER?

3. WHAT PART OF THE RADIO WAVE DOES THE GERMANIUM CRYSTAL SEPARATE OUT?

4. ON WHAT KIND OF CURRENT DOES THE EARPHONE OPERATE?

5. WHAT IS THE SOURCE OF ENERGY WHICH OPERATES THIS RADIO RECEIVER?

INTERPRETATION:

THE FOLLOWING STATEMENTS DESCRIBE THE OPERATION OF A CRYSTAL DIODE RECEIVER. COMPLETE EACH STATEMENT BY WRITING THE CORRECT WORD IN THE SPACE AT THE RIGHT.

1. THE SENDING STATION SENDS OUT MODULATED RADIO WAVES WHICH CARRY A __________ PATTERN. __________

2. THE RADIO WAVES WHICH FOLLOW THE CURVATURE OF THE EARTH ARE CALLED __________ WAVES. __________

3. THE RECEIVING __________ PICKS UP THE RADIO SIGNALS MOVING THROUGH SPACE. __________

4. THE ANTENNA COIL DETERMINES THE __________ OF THE RADIO WAVES THAT CAN BE RECEIVED. __________

5. THE __________ CONDENSER SEPARATES THE SIGNALS FROM DIFFERENT STATIONS. __________

6. THE __________ CHANGES THE INCOMING ALTERNATING SIGNAL INTO DIRECT CURRENT. __________

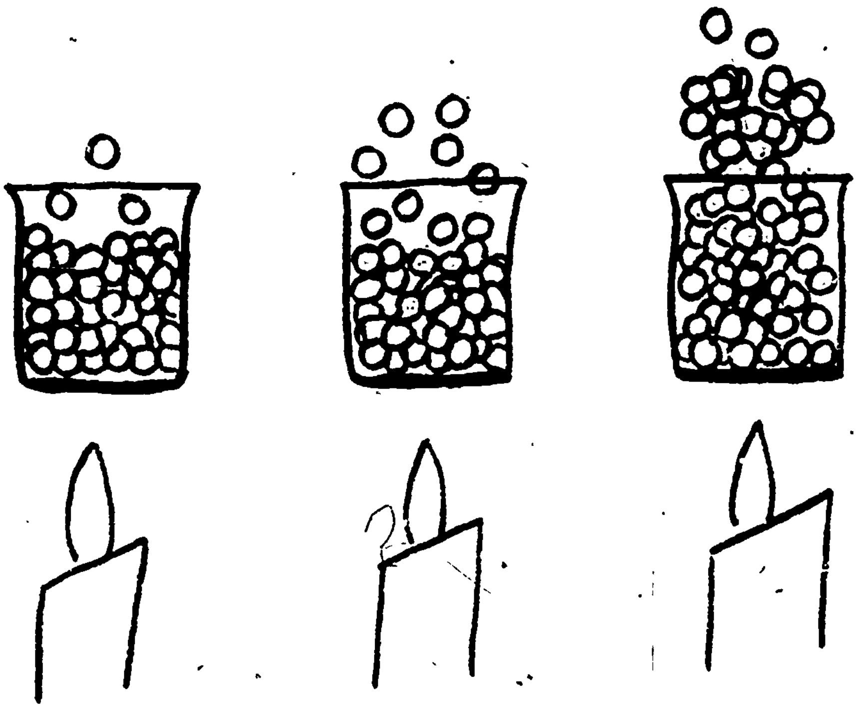
7. THE __________ IN THE EARPHONE VIBRATES TO PRODUCE THE SOUNDS YOU CAN HEAR. __________

APPLICATION:

1. ALTHOUGH THIS CRYSTAL RECEIVER OPERATES WITHOUT BATTERIES, WHY DO TRANSISTOR RECEIVERS, WHICH ALSO USE SEMICONDUCTOR CRYSTALS, NEED A SMALL BATTERY TO OPERATE?

2. TODAY WITH OUR WORLD-WIDE SYSTEMS OF COMMUNICATION THERE IS A GREAT NEED FOR SPECIALISTS IN RADIOS, TELEGRAPH, RADAR, TELEVISION, AND NAVIGATIONAL AIDS. WHAT OTHER RELATED CAREERS CAN YOU THINK OF THAT WOULD NEED TO UNDERSTAND BASIC CONCEPTS IN RADIO?

HEAT ENERGY



PHYSICS - ENERGY - HEAT

ARCHITECTS
PHYSICAL CHEMIST
ENGINEERING TECHNICIAN
GEOLOGIST
MERCHANT MARINE
PHARMACIST
PHYSICIST
TEACHER SECONDARY-COLLEGE
VETERINARIAN
RADIOLOGIST
FIREMAN
PLUMBER & PIPE FITTER
SHEET METAL WORKER
BRAKEMAN (TRAIN)
POWER PLANT OPERATOR
AGRIBUSINESS TECHNICIAN
FARMING
FISH CULTURE TECHNICIAN
LIVESTOCK PRODUCTION TECHNICIAN
SOIL CONSERVATIONIST
AIR CONDITIONING & REFRIGERATION MECHANICS
AUTO MECHANICS
FARM EQUIPMENT MECHANIC
INDUSTRIAL MAINTENANCE MECHANIC
INSTRUMENT REPAIRMAN
WATCH REPAIRMAN
LINEMAN
BOILER FIREMAN

ASTRONAUTS
DENTIST
ENGINEER
GEOPHYSICIST
METEOROLOGIST
PHYSICIAN
ELEMENTARY TEACHER
TECHNICAL WRITER
X-RAY TECHNICIAN
BUILDING CUSTODIAN
MACHINE TOOL OPERATORS
ROOFER
WELDER
APPRENTICE ENGINEER
STATIONARY ENGINEER
AGRICULTURAL EXTENSION AGENT
FISH & WILDLIFE TECHNICIAN
FORESTER
RANGE MANAGEMENT
SOIL SCIENTIST
AIRCRAFT MECHANICS
DIESEL MECHANIC
FLIGHT ENGINEER
INSTRUMENT MAKER
TV & RADIO TECHNICIAN
INSULATION WORKER
ELECTROTYPER

ENERGY: HEAT
LEVEL: JUNIOR HIGH

ACTIVITY: EXPLORING HEAT INSULATION MATERIALS

MATERIALS:

ICE CUBES	SAWDUST	MEDICINE CUPS
NEWSPAPER	SHREDDED PAPER	SALT
RAGS	KARO SYRUP	ALUMINUM FOIL
SAND	SPONGE	COOKING OIL
PENCIL SHAVINGS	STYROFOAM TRAYS	

PROCEDURE:

WHAT CAN YOU DO TO AN ICE CUBE TO KEEP IT FROM MELTING? ONE THING, OF COURSE, WOULD BE TO LEAVE IT IN A FREEZER. BUT WHERE CAN YOU PUT IT AT ROOM TEMPERATURE (ABOUT 70°F) TO MAKE IT MELT MORE SLOWLY THAN USUAL? HOW CAN YOU BUILD A GOOD ICE-CUBE KEEPER? HERE ARE SOME INVESTIGATIONS THAT WILL HELP YOU FIND A WAY.

FIRST OF ALL, HOW LONG DO YOU THINK IT USUALLY TAKES AN ICE CUBE TO MELT? IF YOU PUT AN ICE CUBE IN A DISH, WOULD IT BE ALL GONE IN 10 MINUTES, 30 MINUTES, OR AN HOUR? TRY IT. YOU MAY BE SURPRISED.

TESTING INSULATORS

MATERIALS THAT HELP KEEP THINGS COLD (OR WARM) ARE CALLED INSULATORS. MANY REFRIGERATOR WALLS CONTAIN FIBER GLASS, AN INSULATING MATERIAL MADE FROM THIN GLASS FIBERS. STYROFOAM, ANOTHER GOOD INSULATOR, IS USED TO MAKE PICNIC ICE CHESTS. IT IS MADE BY PUMPING A LOT OF AIR INTO A BATCH OF LIQUID PLASTIC BEFORE IT HARDENS.

BEFORE THERE WERE REFRIGERATORS, ICE WAS USED TO KEEP FOOD COLD IN THE KITCHEN ICEBOX. BLOCKS OF ICE WERE CUT FROM LAKES IN THE WINTER AND THEN PACKED WITH SAWDUST IN A THICK-WALLED ICE HOUSE. THE SAWDUST WAS SUCH A GOOD INSULATOR THAT THE ICE COULD BE STORED ALL SUMMER WITHOUT MELTING.

WHAT KIND OF INSULATION IS BEST TO USE IN AN ICE-CUBE KEEPER? YOU CAN USE FIBER GLASS, STYROFOAM, NEWSPAPERS, RAGS, SAWDUST (FROM A LUMBER YARD), OR SOMETHING ELSE. WHAT MATERIAL WILL KEEP AN ICE CUBE LONGEST?

YOU CAN EXPERIMENT TO FIND OUT BY WRAPPING ICE CUBES IN DIFFERENT INSULATORS. TRY TO USE THE SAME AMOUNT OF EACH MATERIAL. KEEP A RECORD OF THE ICE-CUBE MELTING TIMES ON A CHART. CAN YOU FIND AN INSULATOR THAT KEEPS AN ICE CUBE LONGER THAN SAWDUST? YOU CAN USE THE BEST INSULATOR FOR THE ICE-CUBE KEEPER.

INSULATOR	ICE-CUBE MELTING TIME
NEWSPAPER	
RAGS	
SAND	
PENCIL SHAVINGS	

HOW AN INSULATOR WORKS

AN ICE CUBE MELTS AS IT IS WARMED BY AIR OR ANYTHING ELSE TOUCHING IT. INSULATING MATERIALS HAVE TINY POCKETS OF AIR WITHIN THEM THAT SEPARATE THE ICE CUBE FROM THE WARM ROOM AIR. THESE TINY POCKETS, OR "DEAD AIR SPACE," SLOW DOWN THE MOVEMENT OF HEAT FROM THE ROOM AIR TO THE ICE CUBE.

DOES SHREDDED PAPER INSULATE BETTER THAN AN UNCUT PIECE? RIP UP ONE SHEET OF NEWSPAPER INTO LONG, THIN STRIPS. PUT THE STRIPS AROUND AN ICE CUBE, AND SHAPE THEM INTO A LITTLE BALL. TAKE A SECOND PIECE OF NEWSPAPER, AND WRAP IT TIGHTLY AROUND ANOTHER ICE CUBE. YOU CAN TELL WHEN THE ICE IS MELTED BY SQUEEZING THE PAPER.

SHOULD THE INSULATION IN YOUR ICE-CUBE KEEPER BE PACKED TIGHTLY OR LEFT LOOSE?

ARE LIQUIDS GOOD INSULATORS?

PUT AN ICE CUBE INTO A SMALL JAR OF KEROSENE OR KARO SYRUP. DOES THE ICE TAKE LONGER TO MELT IN THE LIQUID THAN IT DOES IN THE ROOM AIR? TRY OTHER LIQUIDS, AND SEE IF ANY OF THEM SLOW DOWN THE MELTING OF AN ICE CUBE. DOES A CUBE MELT MORE SLOWLY IN A LARGE OR SMALLER AMOUNT OF THE SAME LIQUID? WHAT HAPPENS TO THE MELT WATER?

WHICH ONE OF TWO ICE CUBES (ONE RESTING ON A SPONGE, THE OTHER ON A DISH) WOULD TAKE LONGER TO MELT? TRY THIS EXPERIMENT YOURSELF. IN YOUR ICE-CUBE KEEPER, IS IT IMPORTANT TO KEEP THE ICE CUBE FROM SITTING IN ITS MELT WATER?

i x6

ENERGY: HEAT
LEVEL: JUNIOR HIGH

ACTIVITY: TO DETERMINE IF MATERIALS RELEASE ENERGY WHEN THEY REACT WITH OXYGEN AND TO DETERMINE IF DIFFERENT MATERIALS PRODUCE DIFFERENT AMOUNTS OF HEAT ENERGY WHEN THEY REACT WITH OXYGEN.

MATERIALS:

TEST TUBE	RING STAND	MARSHMALLOW
CLAMP	PAPER	MATCH
SPLINT	BURNER	COTTON

PROCEDURE:

PLACE 10 ML OF WATER IN A TEST TUBE.
RECORD THE TEMPERATURE OF THE WATER.
BE SURE THAT THE TEST TUBE IS NOT POINTED TOWARD ANYONE.
IGNITE A WOODEN SPLINT AND QUICKLY HOLD IT WITH THE TONGS UNDER THE TEST TUBE.
KEEP ADJUSTING THE SPLINT SO THAT THE FLAME IS UNDER THE TUBE. AS IT STOPS BURNING, RECORD THE TEMPERATURE OF THE WATER. REPEAT THE PROCEDURE BUT THIS TIME USE A STRIP OF PAPER OF THE SAME MASS AND APPROXIMATE SHAPE AS THE WOODEN SPLINT. REPEAT THE EXPERIMENT WITH EACH OF THE FOLLOWING:
A SMALL MARSHMALLOW
A MATCH
COTTON

RESULTS:

PREPARE A TABLE FOR YOUR DATA. RECORD YOUR OBSERVATIONS.

DISCUSSION OF RESULTS:

1. DID ALL THE BURNING MATERIALS PRODUCE THE SAME INCREASE IN WATER TEMPERATURE? IF NOT, WHICH ONE PRODUCED THE LEAST? THE MOST? RANK ORDER THE MATERIALS ACCORDING TO THEIR ABILITY TO PRODUCE A CHANGE IN TEMPERATURE.

2. WHEN ANY ONE OF THE MATERIALS WAS BURNED, WAS HEAT GIVEN OFF? WHAT IS YOUR EVIDENCE? IS IT DIRECT OR INDIRECT EVIDENCE?

3. SINCE YOU WERE SIMPLY HEATING WATER IN A FLAME, WAS THERE ANY MATTER BEING MOVED? IF SO, WHAT AND HOW.

4. A CALORIE IS THE AMOUNT OF HEAT WHICH RAISES 1 GRAM OF WATER 1 DEGREE CENTIGRADE. HOW MANY CALORIES WERE PRODUCED BY EACH OF THE MATERIALS? (1 ML OF WATER HAS AN APPROXIMATE MASS OF 1 GRAM).

ENERGY: HEAT
LEVEL: JUNIOR HIGH

ACTIVITY: RADIANT ENERGY

MATERIALS: LIGHTED LAMP — GLASS SCREEN
REFLECTOR — RADIOMETER
CLEAR GLASS BOTTLE FILLED WITH WATER

BACKGROUND:

YOU HAVE LEARNED THAT ENERGY EXISTS IN DIFFERENT FORMS AND CAN BE CHANGED FROM ONE FORM INTO ANOTHER. RADIANT ENERGY WILL CAUSE THE BLADES IN A RADIOMETER, WHICH ARE BLACK ON ONE SIDE AND SHINY ON THE OTHER, TO SPIN. IS THE MECHANICAL ENERGY OF THE SPINNING BLADES PRODUCED BY THE LIGHT OR THE HEAT GIVEN OFF BY A LAMP?

PROCEDURE:

THE RADIANT ENERGY FROM A LIGHTED LAMP IS FOCUSED BY MEANS OF A REFLECTOR ON A RADIOMETER. WHEN A PIECE OF CLEAR GLASS IS PLACED BETWEEN THE LAMP AND THE RADIOMETER, THE BLADES CONTINUE TO SPIN. HOWEVER, IF A CLEAR-GLASS BOTTLE FILLED WITH WATER IS PLACED BETWEEN THE LAMP AND THE RADIOMETER, THE BLADES SLOW AND STOP.

INTERPRETATION:

MARK EACH OF THE FOLLOWING STATEMENTS WHICH EXPLAIN WHAT HAPPENS IN THE EXPERIMENT ACCORDING TO THE FOLLOWING KEY, WRITING THE LETTER IN THE SPACE PROVIDED.

(A) AN <u>OBSERVATION</u> (SOMETHING THAT IS TRUE BECAUSE IT CAN BE SEEN OR MEASURED IN THE EXPERIMENT)

(B) AN <u>ASSUMPTION</u> (SOMETHING THAT IS PROBABLY TRUE ALTHOUGH IT CANNOT BE SEEN OR MEASURED IN THE EXPERIMENT)

(C) A <u>CONCLUSION</u> (SOMETHING THAT APPEARS TO BE TRUE AS A RESULT OF WHAT IS LEARNED FROM THE EXPERIMENT)

1. THE BLADES IN THE RADIOMETER ARE BLACK ON ONE SIDE AND SHINY ON THE OTHER. ________

2. A BLACK SURFACE ABSORBS RADIANT ENERGY BETTER THAN A SHINY SURFACE. ________

3. RADIANT ENERGY IS COMPOSED OF BOTH HEAT AND LIGHT ENERGY. ________

4. CLEAR GLASS ALLOWS BOTH LIGHT AND HEAT ENERGY TO PASS THROUGH. ________

5. A CLEAR-GLASS BOTTLE FILLED WITH WATER ABSORBS THE HEAT ENERGY. ________

6. THE MECHANICAL ENERGY IN THE RADIOMETER IS PRODUCED BY THE HEAT IN THE RADIANT ENERGY. ________

7. THE AIR NEXT TO THE BLACK SIDES OF THE BLADES IS HEATED BY THE ABSORBED ENERGY. ________

8. THE AIR MOLECULES GAIN ENERGY AND MOVE AWAY FROM THE BLACK SIDES OF THE BLADES, CAUSING THEM TO SPIN. ________

9. THE TOTAL AMOUNT OF ENERGY PRODUCED BY THE SPINNING BLADES IS THE SAME AS THE ABSORBED HEAT ENERGY. ________

10. ENERGY IS NOT CREATED OR DESTROYED IN ORDINARY CHANGES IN FORM. ________

APPLICATION

THE INSIDE OF A PARKED AUTOMOBILE, WHEN IT STANDS IN THE SUN WITH THE WINDOWS ROLLED UP, BECOMES WARMER THAN THE OUTSIDE TEMPERATURE. EXPLAIN WHY THIS "GREENHOUSE EFFECT" TAKES PLACE.

ENERGY: HEAT
LEVEL: HIGH SCHOOL

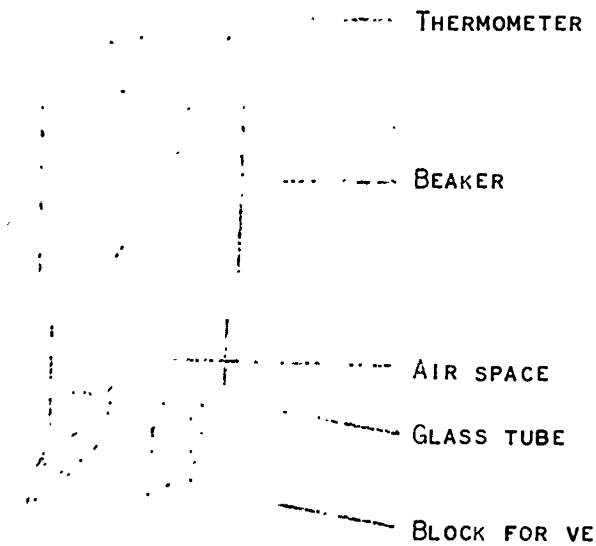
ACTIVITY: HEAT PRODUCED BY A CANDLE

PROBLEM:
WE HAVE LEARNED THAT AS A SUBSTANCE BURNS, HEAT ENERGY IS RELEASED. THUS, THE AMOUNT OF THE SUBSTANCE BURNED DETERMINES THE AMOUNT OF HEAT RELEASED. HOW MUCH HEAT IS PRODUCED WHEN ONE GRAM OF ORDINARY CANDLE IS BURNED?

MATERIALS:

- CANDLE
- CENTIGRADE THERMOMETER
- WOOD BLOCKS
- BEAKER
- LARGE GLASS TUBE
- SENSITIVE LABORATORY BALANCE

PROCEDURE:
WEIGH THE CANDLE CAREFULLY TO THE NEAREST 0.1 GRAM. POUR EXACTLY 1000 MILLILITERS OF WATER IN THE BEAKER AND ARRANGE THE EQUIPMENT AS SHOWN IN THE PICTURE. LET THE CANDLE BURN FOR FIVE MINUTES, AND NOTE THE TEMPERATURE OF THE WATER AT THE BEGINNING AND AT THE END OF THE EXPERIMENT. BLOW OUT THE FLAME, AND WEIGH THE CANDLE AGAIN. REPEAT THE EXPERIMENT AT LEAST FIVE TIMES. ENTER THE RESULTS OF EACH TRIAL IN THE TABLE BELOW, AND FIGURE OUT THE AVERAGE NUMBER OF CALORIES OF HEAT PRODUCED BY ONE GRAM OF THE BURNING CANDLE.



OBSERVATIONS:

TRIALS	WEIGHT OF CANDLE AT BEGINNING	WEIGHT OF CANDLE AT END	LOSS OF WEIGHT IN GRAMS	TEMP. OF WATER AT BEGINNING	TEMP. OF WATER AT END	INCREASE IN ^{o}C TEMP.
1						
2						
3						
4						
5						

INTERPRETATION:

ACCORDING TO THE RESULTS OF THE INVESTIGATION, COMPLETE EACH STATEMENT BY WRITING THE CORRECT WORD IN THE SPACE PROVIDED AT THE RIGHT.

1. THE AVERAGE INCREASE IN THE TEMPERATURE OF THE WATER IN FIVE TRIALS WAS . . . ____________________

2. THE NUMBER OF CALORIES OF HEAT PRODUCED IN EACH TRIAL IS FOUND BY MULTIPLYING . . . ____________________

3. THE AVERAGE NUMBER OF CALORIES OF HEAT PRODUCED IN FIVE TRIALS WAS . . . ____________________

4. THE AVERAGE NUMBER OF GRAMS OF CANDLE BURNED IN FIVE TRIALS WAS . . . ____________________

5. THE AVERAGE NUMBER OF CALORIES OF HEAT PRODUCED BY ONE GRAM OF CANDLE BURNED WAS ABOUT . . . ____________________

APPLICATION

1. ON THE BASIS OF THE INVESTIGATION, WRITE OUT THE WORD FORMULA THAT CAN BE USED TO DETERMINE HOW MANY CALORIES OF HEAT ARE PRODUCED BY A BURNING SUBSTANCE.

2. HAVE YOU EVER DIETED? HOW ARE THESE CALORIES RELATED TO WEIGHT GAIN OR LOSS IN US?

3. WHAT KIND OF WORK WOULD YOU EXPECT A DIETICIAN TO DO?

ENERGY: HEAT
LEVEL: HIGH SCHOOL

ACTIVITY: HEAT STORAGE

WE HAVE DEFINED A CALORIE AS THE AMOUNT OF ENERGY REQUIRED TO RAISE THE TEMPERATURE OF 1 GRAM OF WATER 1°C. WATER CAN STORE HEAT ENERGY. OTHER LIQUIDS, AS WELL AS METALS, CAN ALSO STORE HEAT ENERGY. BUT DIFFERENT MATERIALS HAVE DIFFERENT CAPACITIES FOR HEAT STORAGE. THE HEAT-STORING CAPACITY OF EQUAL WEIGHTS OF WATER AND A METAL WILL BE COMPARED DURING THIS INVESTIGATION. BEFORE PERFORMING THE INVESTIGATION, PREDICT WHICH HAS THE GREATER HEAT-STORING CAPACITY- A METAL OR WATER.

MATERIALS (PER TEAM):

2 STYROFOAM CUPS	GRADUATED CYLINDER
BALANCE SENSITIVE TO 1 GRAM	THREAD
METAL WEIGHT	PYREX BEAKER
BURNER	THERMOMETER

PROCEDURES:

A. LABEL THE STYROFOAM CUPS A AND B. POUR 40 ML OF TAP WATER INTO EACH CUP.
B. USING THE BALANCE, DETERMINE THE WEIGHT OF THE METAL TO THE NEAREST GRAM. TIE A 10-INCH LENGTH OF THREAD TO THE METAL. WEIGH OUT AN AMOUNT OF TAP WATER EQUAL TO THE WEIGHT OF THE METAL.
C. PLACE THE METAL OBJECT AND WATER FROM PROCEDURE B IN A BEAKER, AND HEAT TO ABOUT 80°C. (ALLOW THE THREAD ATTACHED TO THE METAL TO HANG OVER THE EDGE OF THE BEAKER.)
D. WHEN THE TEMPERATURE OF THE WATER HAS REACHED 80°C, TRANSFER THE METAL TO CUP A AND POUR THE HOT WATER INTO CUP B. STIR THE CONTENTS OF BOTH CUPS FOR ONE MINUTE. THEN RECORD THE WATER TEMPERATURE IN EACH CUP.

INTERPRETATIONS:

1. WHICH CONTAINS MORE HEAT ENERGY-METAL AT 80°C, OR AN EQUAL WEIGHT OF WATER AT 80°C?

2. USING THE KINETIC THEORY OF HEAT AND WHAT YOU HAVE LEARNED ABOUT THE STRUCTURE AND BEHAVIOR OF MATTER, EXPLAIN YOU ANSWER TO INTERPRETATION 1.

3. HOW WOULD KNOWING THE KINETIC THEORY OF HEAT BE USEFUL IN SOME CAREERS? EXPLAIN.

4. HOW WOULD THIS INFORMATION BE HELPFUL TO A REFRIGERATOR REPAIRMAN? EXPLAIN.

ENERGY: HEAT
Level: High School

ACTIVITY: Heat and Molecular Attraction

Materials: (per team)

3 pieces of cotton cloth (1 x 4 inches)	Rubber bands
20 ml ditto fluid (alcohol)	2 beakers
3 thermometers	Ring stand and clamps

Procedures:

A. Soak one piece of cloth in the ditto fluid; soak the second piece in water; and leave the third piece dry.
B. Remove the piece of cloth from the water, let it drip for about 30 seconds, and wrap it around the bulb of a thermometer. Repeat with the piece of cloth from the ditto fluid, using the second thermometer. Wrap the dry cloth around the third thermometer. Fasten each cloth with a string or a rubber band.
C. Mount the three thermometers on a ring stand. Read and record temperatures from each thermometer once per minute for five minutes.

Interpretations:

1. Using the kinetic theory of heat, explain the results of this experiment.

2. What information does this experiment yield about the attraction between alcohol molecules as compared with the attraction between water molecules?

3. What careers would need to know how heat affects molecular behavior? List below.

4. Why would a cement contractor be interested in how fast his cement set up? A hot dry day would have a different effect on his work than a hot humid day. Why?

Energy: Heat
Level: High School

Activity: Heat of Fusion (How much heat is required to melt one gram of ice?)

A change of state, such as a solid changing to a liquid or vice versa, is always accompanied by the absorption or the release of a quantity of heat energy. A glass of water cooled by a piece of ice not only because the ice is cold but also because heat is taken from the water as the ice melts.

Procedure:

Weigh the empty calorimeter (inside can). Weigh it again when it is about one-half full of warm water (about 30°C).

Wipe dry a piece of ice about the size of a walnut. Stir the warm water and record its exact temperature. Immediately drop the piece of ice into the water. Stir constantly, and if the temperature has not dropped to about 10°C after the ice has melted, add another small piece of ice. Repeat until a temperature near 10°C has been reached. As soon as the last piece of ice melts, stir the water thoroughly and read the thermometer.

Weigh the calorimeter and water to determine the weight of the ice which has been melted.

1. What substance (s) lost heat?

2. What is the temperature of ice just as it is melted?

3. The melted ice (ice water) was heated to what temperature?

4. The heat lost by the warm water accomplished what two things?

Make all the calculations required in the data.

DATA

Weight of calorimeter		G
Weight of calorimeter and water		G
Weight of water		G
Water equivalent of calorimeter (0.1 x weight of calorimeter)		G
Initial temperature of water and calorimeter		°C
Temperature of water and melted ice		°C
Weight of calorimeter, water, and melted ice		G
Weight of ice		G

CALCULATION OF HEAT LOSS

Weight of water plus water equivalent of calorimeter		G
Change in temperature of water and calorimeter		°C
Heat lost by water and calorimeter		CAL

 [redacted]

Heat lost by the warm ____________ and ____________ equals the heat required to ____________ the ice plus the heat required to raise the temperature of the ice water from ________ ^{o}C to ____________ ^{o}C.

Calculation of Heat Gained

Weight of ice water		g
Change in temperature of ice water		^{o}C
Heat absorbed by the ice water in warming to final temperature		cal
Heat absorbed which must have melted the ice		cal
Weight of ice		g
Heat used to melt 1 g of ice (heat of fusion of ice)		cal
Accepted value		cal
Percentage of error		%

Discussion:

1. Explain the meaning of the statement that the heat of fusion of ice is 80 cal ________________________

2. Which requires more heat to raise to a temperature of 20°C, 10 g of ice at 0°C, or 10 g of ice water at 0°C? ____________

3. Which would be more effective in an icebox, ice or ice-cold bricks? ____________
   Explain. ________________________

4. How many calories of heat will be required to melt 300 g of ice at 0°C and to heat the ice water formed to 40°C?

   Ans. ____________

5. What sources of error are there in your determination? ____________

6. What careers would find this information useful? ____________

7. How would an engineer use this lab? How about a heating technician?
   ____

ENERGY: HEAT
LEVEL: HIGH SCHOOL

ACTIVITY: COEFFICIENT OF LINEAR EXPANSION (HOW CAN THE COEFFICIENT OF LINEAR EXPANSION BE MEASURED?

NEARLY ALL SUBSTANCES EXPAND WITH RISE IN TEMPERATURE, THE AMOUNT OF EXPANSION PER DEGREE DEPENDING UPON THE TYPE OF SUBSTANCE. THIS RATE OF EXPANSION IN LENGTH IS KNOWN AS THE COEFFICIENT OF LINEAR EXPANSION.

PROCEDURE:

THERE ARE MANY VARIETIES OF APPARATUS FOR FINDING THE COEFFICIENT OF LINEAR EXPANSION, BUT MOST OF THE VARIATION OCCURS IN THE DEVICE WHICH MEASURES THE CHANGE IN LENGTH OF THE ROD. THE DEVICE SHOWN IN THE DIAGRAM CONSISTS OF A BENT LEVER ABC. AS THE ROD EXPANDS, IT PUSHES AGAINST C AND RAISES A. THE MOVEMENT OF C IS MULTIPLIED AS MANY TIMES AS THE SHORT ARM IS CONTAINED IN THE LONG ARM. MEASURE THE LEVER ARMS OF AB AND BC AND RECORD THEIR RATIO. CALL THIS THE MULTIPLYING FACTOR OF THE LEVER.

1. WHAT IS MEANT BY THE COEFFICIENT OF LINEAR EXPANSION?

____

IT CAN BE FOUND BY USE OF THE FORMULA,

$$K = \frac{E}{L\ (T_2 - T_1)}$$

WHERE <u>K</u> IS THE COEFFICIENT OF EXPANSION, <u>E</u> IS THE AMOUNT OF EXPANSION, <u>L</u> IS THE LENGTH AT THE BEGINNING, <u>T1</u> IS THE TEMPERATURE AT THE BEGINNING, AND <u>T2</u> IS THE FINAL TEMPERATURE.

FILL THE STEAM BOILER TWO-THIRDS FULL OF WATER AND HEAT OVER A BURNER. WHILE IT IS HEATING, REMOVE THE METAL ROD AND MEASURE ITS LENGTH. REPLACE THE METAL ROD AND RECORD THE READING OF THE POINTER ON THE SCALE. INSERT THE THERMOMETER INTO THE STOPPER PROVIDED IN THE APPARATUS AND READ THE INITIAL TEMPERATURE OF THE ROD. CONNECT THE STEAM BOILER TO THE TUBE BY MEANS OF A RUBBER HOSE AND ALLOW STEAM TO RUN THROUGH IT UNTIL THE POINTER SHOWS NO FURTHER CHANGE.

READ THE THERMOMETER AND THE POSITION OF THE POINTER ON THE VERTICAL SCALE.

2. FROM THE MOVEMENT OF A, HOW CAN YOU COMPUTE THE AMOUNT THE ROD HAS EXPANDED? ____

____

DATA

LENGTH L OF ROD		CM
INITIAL READING OF POINTER		CM
FINAL READING OF POINTER		CM
MULTIPLYING FACTOR OF LEVER		
TOTAL EXPANSION E		CM
INITIAL TEMPERATURE T_1		C
FINAL TEMPERATURE T_2		C
DIFFERENCE IN TEMPERATURE		C
COEFFICIENT OF LINEAR EXPANSION PER DEGREE CENTIGRADE		

DISCUSSION:

1. WHAT ARE THE POSSIBLE SOURCES OF ERROR IN THIS EXPERIMENT?__________

2. HOW COULD THE MULTIPLYING FACTOR OF THE BENT LEVER BE INCREASED?

3. THE COEFFICIENT OF LINEAR EXPANSION OF COPPER IS 0.0000168. HOW MUCH, IN INCHES, WILL A WIRE 500 FT LONG EXPAND IF ITS TEMPERATURE CHANGES FROM 15°C TO 40°C?

ANS.__________

4. DID YOU KNOW THAT ASPHALT-COMPOSITION STRIPS ARE INSERTED IN CONCRETE HIWAYS TO ALLOW FOR EXPANSION AND CONTRACTION OF THE CONCRETE CARRIED BY TEMPERATURE CHANGES? WHY WOULD A CONTRACTOR NEED TO KNOW THIS?__________

5. LIST SOME OTHER CAREERS WHERE THIS INFORMATION WOULD BE HELPFUL.

CHEMICAL ENERGY

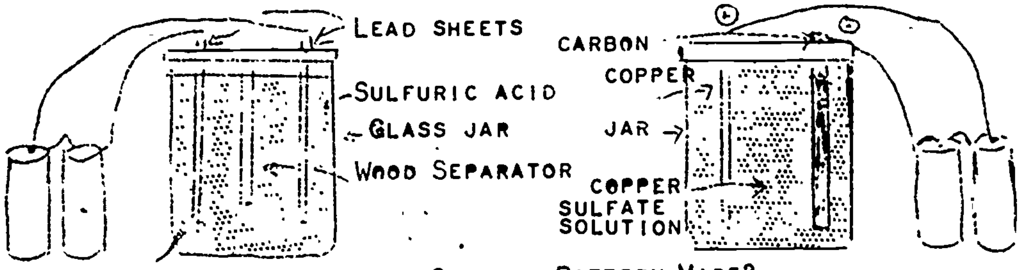
PHYSICS - ENERGY - CHEMICAL

- PHYSICAL CHEMIST
- DENTIST
- ENGINEER
- PHARMACIST
- PHYSICIST
- TECHNICAL WRITER
- X-RAY TECHNICIAN
- AIRCRAFT MECHANIC
- DIESEL MECHANIC
- TRUCK DRIVER
- DENTAL HYGENIST
- ENGINEERING TECHNICIAN
- GEOPHYSICS
- PHYSICIAN
- TEACHER SECONDARY-COLLEGE
- VETERINARIAN
- RADIOLOGIST
- AUTO MECHANIC
- FARM EQUIPMENT MECHANIC

CHEMICAL ENERGY

HOW MAY ELECTRICAL ENERGY BE CHANGED TO CHEMICAL ENERGY.

WE HAVE SEEN HOW CHEMICAL CHANGES CAN PRODUCE ELECTRICAL ENERGY. CAN WE REVERSE THE PROCESS AND USE ELECTRICAL ENERGY TO PRODUCE CHEMICAL CHANGES? WHAT USEFUL CHEMICAL CHANGES CAN WE BRING ABOUT?



HOW IS A STORAGE BATTERY MADE?

EXPERIMENT 1: STEP 1. ASSEMBLE THE SIMPLE STORAGE CELL SHOWN IN THE PICTURE. BEFORE CHARGING IT WITH THE DRY CELLS, CONNECT IT TO AN ELECTRIC LIGHT BULB.

DOES THE BULB LIGHT? STEP 2. REMOVE THE BULB AND CONNECT TWO DRY CELLS TO THE STORAGE CELL AS SHOWN. AFTER THE CELL HAS BEEN CHARGING FOR ABOUT 5 MINUTES, DISCONNECT THE DRY CELLS AND RE-CONNECT THE BULB.

DOES THE BULB LIGHT? STEP 3. REMOVE THE PLATES FROM THE SOLUTION AND NOTE THEIR COLORS. HOW DO THEY DIFFER.

THE SURFACE OF ONE OF THE TWO PLATES HAS BEEN CHANGED INTO A NEW SUBSTANCE, LEAD PEROXIDE. WAS THIS A PHYSICAL OR CHEMICAL CHANGE?

CONCLUSIONS: BEFORE CHARGING, THE CELL COULD NOT PRODUCE A CURRENT OF ELECTRICITY BECAUSE THE PLATES WERE__________. AFTER CHARGING, THE CELL COULD PRODUCE A CURRENT OF ELECTRICITY BECAUSE THE PLATES WERE __________, AND ONE WAS ACTED UPON BY THE ACID.

HOW IS ELECTROPLATING DONE?

USING A COPPER-PLATING TANK SET UP, CONNECT A CLEAN CARBON ROD TO THE WIRE FROM THE NEGATIVE TERMINAL OF THE BATTERY. ATTACH THE WIRE FROM THE POSITIVE TERMINAL TO THE COPPER PLATE. AFTER THE CURRENT HAS FLOWED FOR ABOUT THREE MINUTES, REMOVE THE CARBON ROD AND EXAMINE IT.

OBSERVATION:______________________________

REPLACE THE CARBON ROD AND REVERSE THE DIRECTION OF THE CURRENT FOR SEVERAL MINUTES.

RESULT:______________________________.

THERE ARE MANY CAREERS THAT APPLY TO THESE ACTIVITIES. CAN YOU NAME SEVERAL.

CHEMICAL ENERGY
LEVEL: HIGH SCHOOL

ACTIVITY: THE VOLTAIC CELL

PROBLEM:
WHAT MATERIALS ARE ESSENTIAL FOR A SIMPLE VOLTAIC CELL? WE ARE TO STUDY THE CHEMICAL ACTION WHICH IS ESSENTIAL IN A PRIMARY CELL. ARE THERE LIMITATIONS TO THE MATERIALS USED, OR CAN ANY METALS AND ANY SOLUTION BE USED?

MATERIALS:
- BATTERY JAR OR LARGE GLASS TUMBLER
- PORCELAIN ELECTRODE HOLDER
- D-C VOLTMETER (0-3 VOLT RANGE)
- ELECTRODES OF COPPER, COMMERCIAL ZINC, ZINC AMALGAM, CARBON, LEAD AND ALUMINUM
- COPPER CONNECTING WIRE
- SOLUTIONS OF SULFURIC ACID, HYDROCHLORIC ACID, SODIUM CHLORIDE AND SODIUM CARBONATE

PROCEDURE:

A. CHEMICAL ACTION IN THE CELL

FILL A TUMBLER ABOUT TWO-THIRDS FULL OF SULFURIC ACID. (DO NOT SPILL THE ACID ON YOUR HANDS OR CLOTHING.) DIP A STRIP OF COPPER INTO THE ACID.

1. IS THERE EVIDENCE OF CHEMICAL ACTION? ____________________

REMOVE THE COPPER AND IMMERSE THE COMMERCIAL ZINC.

2. WHAT DO YOU OBSERVE? ____________________

3. WHICH METAL IS APPARENTLY ACTED UPON TO A GREATER DEGREE BY THE ACID? ____________________

COMMERCIAL ZINC CONTAINS MANY IMPURITIES, SUCH AS IRON AND CARBON. WHEN THE ZINC IS PLACED IN ACID, THERE ARE SET UP SMALL CURRENTS BETWEEN THESE IMPURITIES AND THE ZINC. THE ZINC IS THUS CONSUMED EVEN WHEN THE CELL IS NOT IN USE. THIS DEFECT OF THE CELL IS CALLED <u>LOCAL ACTION</u>.

REMOVE THE COMMERCIAL-ZINC STRIP FROM THE ACID AND IMMERSE AN AMALGAMATED ZINC STRIP (ZINC COVERED WITH MERCURY). HANDLE THIS STRIP CAREFULLY, BECAUSE IT BREAKS EASILY.

4. HOW DOES THE ACTION COMPARE WITH THAT OF THE COMMERCIAL ZINC?

PLACE THE AMALGAMATED ZINC AND THE COPPER STRIPS IN THE ACID. DO NOT LET THEM TOUCH. CONNECT THE OUTER ENDS OF THE STRIPS TOGETHER BY MEANS OF A SHORT COPPER WIRE. WATCH THE ACTION IN THE CELL.

5. WHAT DO YOU OBSERVE?____________________________

THE CHEMICAL ACTION IN THE CELL HAS DEVELOPED AN ELECTROMOTIVE FORCE, OR DIFFERENCE IN POTENTIAL, BETWEEN THE TWO METAL STRIPS. IT IS THIS POTENTIAL DIFFERENCE WHICH CAUSES A CURRENT TO FLOW THROUGH A CONDUCTOR CONNECTED TO THE TWO METALS.

B. FACTORS DETERMINING THE NATURE OF THE EMF

REMOVE THE SHORT WIRE CONNECTING THE TWO PLATES AND DISLODGE ANY BUBBLES ON THE PLATES. CONNECT THE PLATES TO A VOLTMETER, CONNECTING THE COPPER PLATE TO THE POSITIVE TERMINAL AND THE ZINC TO THE NEGATIVE TERMINAL OF THE VOLTMETER. READ THE EMF WHEN THE PLATES ARE INSERTED ABOUT 6 CM IN THE ACID. RAISE THE PLATES UNTIL ABOUT 3 CM REMAINS IN THE ACID. READ THE VOLTMETER. FINALLY, RECORD THE EMF WHEN ABOUT 1 CM OF THE PLATES IS IN THE ACID.

6. HOW IS THE EMF AFFECTED BY THE AREA OF THE PLATE EXPOSED TO THE ACID?____________________________

INSERT THE PLATES FULL LENGTH AGAIN AND READ THE VOLTMETER WHEN THEY ARE SEPARATED AS FAR AS THE TUMBLER ALLOWS. MOVE THEM UNTIL THEY ARE ABOUT 1 CM APART AND RECORD THE EMF.

7. WHAT EFFECT ON THE EMF HAS THE DISTANCE BETWEEN THE PLATES?____________________________

USING ZINC AND COPPER PLATES, RECORD THE EMF WHEN THE ACID IS REPLACED BY DIFFERENT LIQUIDS, SUCH AS SALT SOLUTION, HYDROCHLORIDE ACID, SODIUM CARBONATE SOLUTION, AND TAP WATER. RINSE THE TUMBLER AND THE PLATES EACH TIME BEFORE USING A DIFFERENT LIQUID.

8. WHICH SOLUTION GIVES THE GREATEST EMF?____________________

USE THE FOLLOWING COMBINATIONS OF ELECTRODES IN SULFURIC ACID AND RECORD THE EMF FOR EACH PAIR: COPPER-ZINC, COPPER-CARBON, ALUMINUM-ZINC, ALUMINUM-LEAD, LEAD-COPPER. CARE MUST BE TAKEN TO HAVE THE POSITIVE STRIP CONNECTED TO THE POSITIVE TERMINAL OF THE VOLTMETER. IF THE NEEDLE IS DEFLECTED IN THE OPPOSITE DIRECTION, DISCONNECT AT ONCE AND REVERSE THE CONNECTIONS. RECORD THE POSITIVE AND NEGATIVE ELECTRODE FOR EACH COMBINATION.

DATA

POSITION OF PLATES	EMF (VOLTS)	ELECTROLYTES	EMF (VOLTS)
IMMERSED 6 CM		SALT	
IMMERSED 3 CM		HYDROCHLORIC ACID	
IMMERSED 1 CM		SODIUM CARBONATE	
SEPARATED		TAP WATER	
CLOSE			

ELECTRODES

TRIAL	POSITIVE METAL	NEGATIVE METAL	EMF (VOLTS)
1			
2			
3			
4			
5			

DISCUSSION

1. WHAT ARE THE ESSENTIAL REQUIREMENTS FOR ANY CELL? ____________________

2. WHAT IS MEANT BY THE ELECTROMOTIVE FORCE OF A CELL? ____________________

3. SUMMARIZE IN A STATEMENT THE FACTORS THAT AFFECT THE SIZE OF THE EMF OF A CELL? ____________________

4. WHICH WILL GIVE A HIGHER EMF, A LARGE DRY CELL OR A SMALL FLASHLIGHT CELL? ____________________

5. WHAT CAREERS WOULD NEED TO KNOW HOW A BATTERY FUNCTIONS? ____________________

6. THERE ARE MANY OTHER EXAMPLES OF SPECIAL BATTERIES. CAN YOU RECALL THEM AND THEIR SPECIFIC USES TODAY? ____________________

CHEMICAL ENERGY

LEVEL: HIGH SCHOOL

ACTIVITY: REFINING OIL

PROBLEM:

PETROLEUM OIL IS A SOURCE OF MANY USEFUL CHEMICAL COMPOUNDS FOR THE HOME, AGRICULTURE, AND INDUSTRY. HOW ARE THE VARIOUS SUBSTANCES NEEDED TO PREPARE THESE COMPOUNDS SEPARATED FROM THE CRUDE OIL?

MATERIALS:

- TWO ONE-INCH PYREX TEST TUBES
- STOPPERS
- BEAKERS
- TWO BUNSEN BURNERS
- GLASS TUBING
- RING STAND AND CLAMPS
- MINERAL OIL
- FINE STEEL WOOL
- SMALL DISH

PROCEDURE:

POUR A SMALL QUANTITY OF MINERAL OIL IN ONE TEST TUBE AND PACK SOME STEEL WOOL LOOSELY INTO THE TUBE ABOVE THE OIL BUT NOT TOUCHING THE LIQUID. ARRANGE THE EQUIPMENT, AS SHOWN IN FIG. 2-3. (CAUTION: THE OUTLET TUBE SHOULD EMPTY INTO A BEAKER PLACED AWAY FROM THE FLAMES.) PLACE ONE BURNER UNDER THE TUBE CONTAINING THE OIL AND HEAT WITH A SMALL FLAME. ALSO HEAT THE STEEL WOOL IN THE TUBE BY MOVING THE OTHER BURNER UP AND DOWN ALONG THE SIDE OF THE TUBE. GRADUALLY INCREASE THE HEAT OF BOTH BURNERS UNTIL THE OIL BEGINS TO BOIL. KEEP ON HEATING UNTIL A LIQUID BEGINS TO DRIP OUT OF THE OUTLET TUBE INTO THE RECEIVING BEAKER.

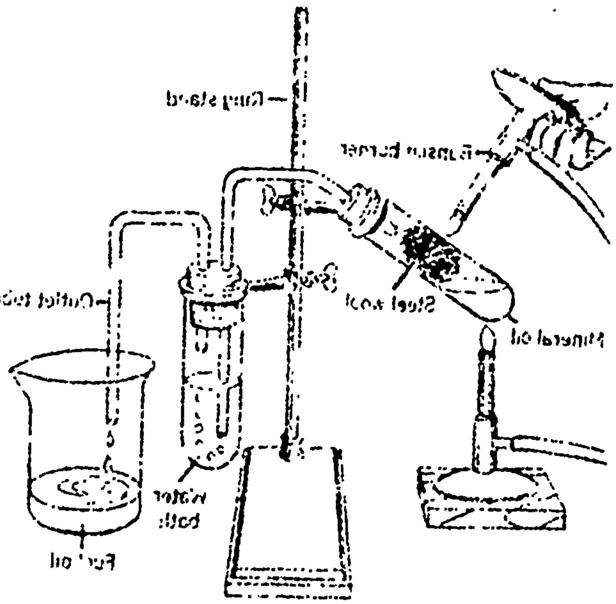


Fig. 2-3

Observations

1. What is given off when the oil begins to boil? ____________

2. What happens to this substance? ____________

____

3. What is deposited in the beaker? ____________

4. Describe the smell of this substance ____________

5. Place a few drops in a dish and try to light the liquid.

   Will it burn? ____________

Interpretation

Fill in the blank words in the following paragraph in the numbered spaces to the right.

The thick, crude oil obtained from the ground is known as (1). This oil must be (2) in order to obtain the useful products. This is usually done by (3) the oil to a high temperature. The steel wool in the experiment helped change the (4) given off into a simple form of (5). In addition to fuels, other useful products obtained from petroleum include (6), (7), (8), (9), and (10).

1 ____________

2 ____________

3 ____________

4. ____________

5 ____________

6 ____________ 7 ____________

8 ____________ 9 ____________

10 ____________

Application

1. Explain how various liquid products are obtained from petroleum by fraction distillation.

____

____

____

2. What careers would find this activity useful? List.

____

____

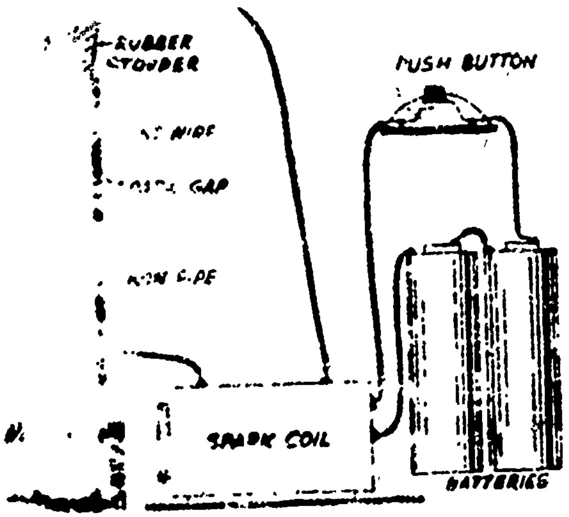
CHEMICAL ENERGY
LEVEL: HIGH SCHOOL

ACTIVITY: HOW ARE OTHER HOT GASES USED TO TRANSFER ENERGY?

PROBLEM:
STEAM ENGINES ARE LARGE AND HEAVY. BESIDES, THEY NEED A FURNACE, A BOILER, AND A SUPPLY OF WATER TO PROVIDE THE STEAM WHICH OPERATES THEM. THINK OF THE SAVING IN SPACE AND WEIGHT IF WE COULD PRODUCE A HOT GAS RIGHT INSIDE THE ENGINE CYLINDER! THAT IS JUST WHAT WE DO IN GASOLINE, DIESEL AND JET PROPULSION ENGINES.

A. HOW DO GASOLINE AND DIESEL ENGINES OPERATE?

SET UP THE APPARATUS AS SHOWN IN THE DIAGRAM BELOW. ADD GASOLINE OR PETROLEUM ETHER 1 DROP AT A TIME, TRYING DIFFERENT AMOUNTS FROM 1 TO 15 DROPS. BE SURE TO ALLOW THE FUEL TO EVAPORATE BEFORE YOU CLOSE THE BATTERY CIRCUIT.



1. (A) THE SHARPEST EXPLOSION TOOK PLACE WITH __________ DROPS.

   (B) WHEN WE USED __________ DROPS OR MORE, THERE WAS NO EXPLOSION BECAUSE THERE WAS TOO MUCH __________________ AND NOT ENOUGH __________________.

   (C) THE IRON PIPE CORRESPONDS TO THE __________________ OF THE ENGINE, AND THE RUBBER STOPPER TO THE __________.

STUDY THE DIAGRAM OF THE GASOLINE ENGINE. 197 (K)

2. (A) WHAT PART OF THE GASOLINE ENGINE (NOT SHOWN IN THE DIAGRAM) MEASURES AND MIXES THE FUEL AND AIR MIXTURE? ________.

(B) WHICH VALVE IS CLOSED DURING THE INTAKE STROKE? ________.

(C) WHICH VALVE IS CLOSED DURING THE EXHAUST STROKE? ________.

(D) DURING WHICH STROKES ARE BOTH VALVES CLOSED? ________ AND ________

3. (A) DURING THE COMPRESSION STROKE, THE PISTON MOVES UP—DOWN.

(B) DURING THE IGNITION OR "POWER" STROKE, THE PISTON MOVES UP—DOWN.

(C) DURING WHICH STROKE IS POWER DELIVERED BY THE ENGINE? ________

4. WHY IS A HEAVY FLYWHEEL NEEDED WITH THIS TYPE OF ENGINE? ________

5. (A) HOW IS THE FUEL IGNITED IN A DIESEL ENGINE? ________

(B) IN WHICH ENGINE, GASOLINE OR DIESEL, IS THE COMPRESSION GREATER? ________

(C) WHICH ENGINE, THEREFORE, MUST HAVE THICKER AND HEAVIER CYLINDER WALLS? ________

(D) WHAT FUEL IS USUALLY BURNED BY THE DIESEL ENGINE? ________

(E) HOW DO THE STROKES OF THE DIESEL ENGINE COMPARE WITH THOSE OF THE GASOLINE ENGINE? ________

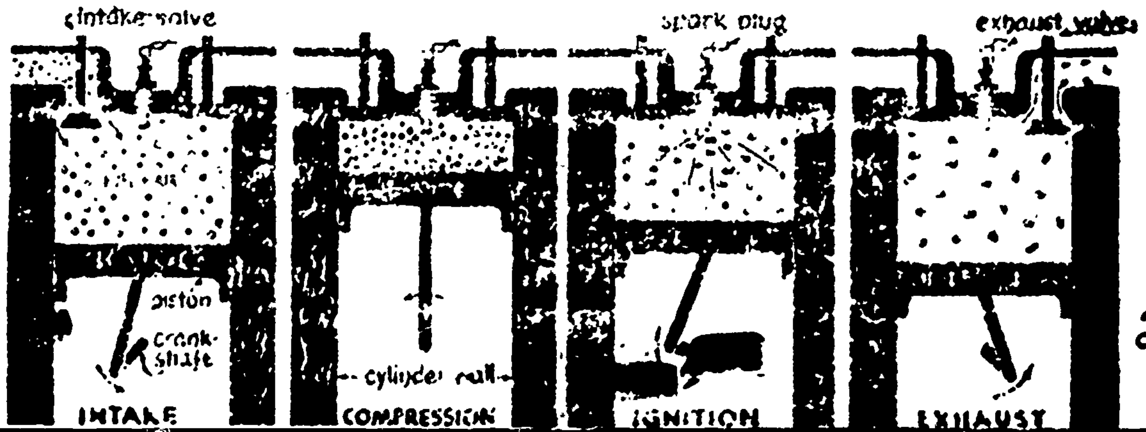
(F) GIVE ONE DISADVANTAGE OF A DIESEL ENGINE. ________

(G) NAME TWO KINDS OF TRANSPORTATION IN WHICH DIESEL ENGINES ARE WIDELY USED.

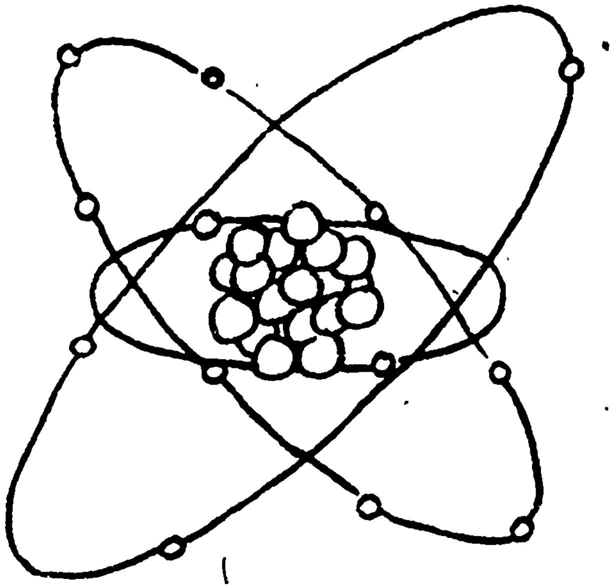
(1) ________

(2) ________

6. WHAT CAREERS DOES THIS ACTIVITY RELATE TOO? ________



NUCLEAR ENERGY



PHYSICS - ENERGY - NUCLEAR

Physical Chemist
Engineering Technician
Geologist
Merchant Marine
Physicist
Technical Writer
X-Ray Technician

Dentist
Engineer
Geophysicist
Pharmacist
Teacher secondary-college
Veterinarian
Radiologist

NUCLEAR ENERGY

Level: High School

ACTIVITY: Gc Mad With Power

When a car is pushed down the street, force acts over a distance, and work is done. Work can take many forms. We spent some time learning how simple machines could make work easier. We found that different kinds of matter acting together produce energy. Most of our engines run by burning fuel with air.

Are we really digging deep enough? The energy we have talked about so far comes from chemical reactions. Atoms form new combinations in chemical reactions. But chemical reactions are not enough to account for all the energy that is produced in our universe.

Procedures:

A. A Picture of Heat?

1. If chemical energy isn't enough, where could the rest come from?

Let's use a piece of equipment most people have seen around a long time: a piece of photographic film, 4 x 5 in a black envelope.

2. What form of energy is usually used with film?

Let's test to see if the film reacts with other forms of energy. Use a piece of chalk to mark off two areas on the film wrapper. Tape the radioactive specimen to a spot on one side of the chalk line. Leave it there overnight or longer.

When you remove the specimen, use the other part of the film to test with heat. Use a flame to heat the head of a 5-inch spike hot enough to make a brown mark on thin cardboard without making very much smoke. Put a piece of cardboard over the unused half of your film pack. Press the hot spike's head down onto the cardboard, with the film pack underneath. Hold it there about 10-15 seconds, long enough to make a brown mark on the cardboard.

At all times, handle that hot spike with care! It stays hot quite some time.

Now develop your film pack according to the directions given in class.

3. What do you see?

4. How did heat energy affect the film?

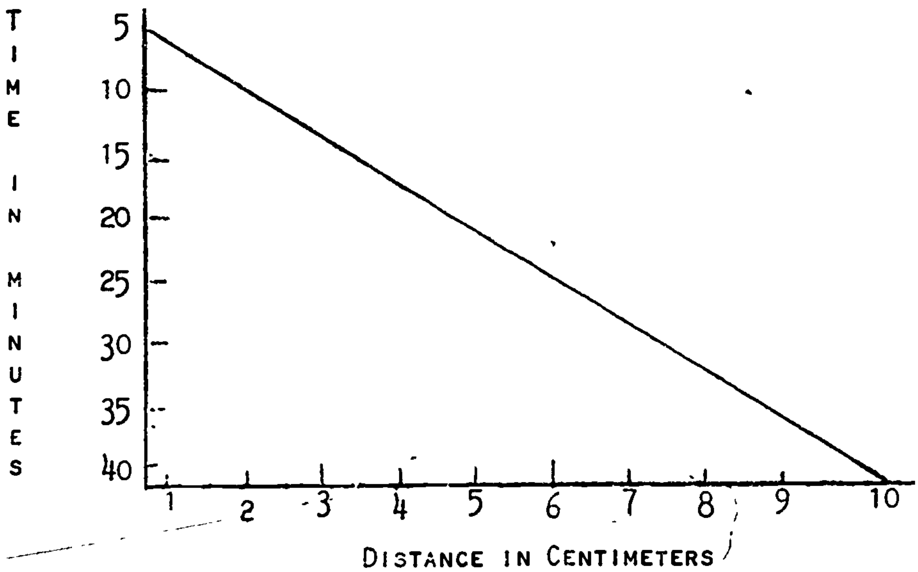
5. How did energy from the radioactive specimen affect the film?

NUCLEAR ENERGY
LEVEL: HIGH SCHOOL

ACTIVITY: INTENSITY OF RADIATIONS

PROBLEM:
ALL RADIOACTIVE SUBSTANCES GIVE OFF RADIATIONS WHICH TRAVEL FROM THE SOURCE IN ALL DIRECTIONS. WHAT HAPPENS TO THE INTENSITY OF THE RADIATIONS AS THEY MOVE AWAY FROM THE SOURCE?

INVESTIGATIONS
AN ELECTROSCOPE, WHICH DETECTS RADIATION BY DISCHARGING THE ELECTRIC CHARGE IN ITS LEAVES, IS PLACED AT VARIOUS DISTANCES FROM A PIECE OF RADIOACTIVE MATERIAL SUSPENDED. THE TIME IT TAKES FOR THE FULLY CHARGED ELECTROSCOPE TO DISCHARGE AT EACH DISTANCE IS MEASURED WITH A TIMER OR WATCH. THE TIMES AND DISTANCES CAN BE SHOWN IN A CHART LIKE THE ONE BELOW.



INTERPRETATION:
FILL IN THE BLANK WORDS IN THE FOLLOWING PARAGRAPH IN THE NUMBERED SPACES AT THE RIGHT.

RADIATIONS PRODUCED BY A RADIOACTIVE SUBSTANCE ARE OF THREE TYPES. THE NEGATIVELY CHARGED PARTICLES ARE ELECTRONS AND ARE CALLED (1). THE POSITIVELY CHARGED PARTICLES ARE HELIUM NUCLEI AND ARE CALLED (2). THE THIRD TYPE OF RADIATION, SIMILAR TO X RAYS, IS CALLED (3). AS THESE PARTICLES AND RAYS TRAVEL THROUGH THE AIR, THEY CAUSE THE ATOMS IN THE AIR TO LOSE OR GAIN (4) AND BECOME (5). THIS PROCESS, KNOWN AS (6), CAN BE DETECTED WITH AN ELECTROSCOPE; AND THE RATE OF DISCHARGE IS AN INDICATION OF THE (7) OF THE RADIATIONS. ACCORDING TO THE CHART, THE FARTHER AWAY THE ELECTROSCOPE IS FROM THE SOURCE, THE (8) THE RATE OF DISCHARGE.

1.................
2.................
3.................
4.................
5.................
6.................
7.................
8.................

THIS SHOWS US THAT AS THE DISTANCE FROM THE SOURCE (9), THE INTENSITY OF THE RADIATIONS (10).

9.................

10.................

APPLICATION:

EXPLAIN WHY SCIENTISTS, STUDYING THE RESULTS OF ATOMIC BOMB TESTS, PLACE AUTOMATIC RADIATION DETECTORS AT DIFFERENT DISTANCES FROM THE CENTER OF THE EXPLOSION.

SOUND

PHYSICS - ENERGY - SOUND

ARCHITECTS	ASTRONAUTS
ASTRONOMER, RADIO	DENTIST
PHYSICAL CHEMIST	ENGINEERING TECHNICIAN
ENGINEER	GEOLOGIST
GEOPHYSICIST	GROUND RADIO OPERATOR
INDUSTRIAL TRAFFIC MANAGER	INTERIOR DESIGN & DECORATION
MERCHANT MARINE	MUSICIANS
PHARMACIST	PHYSICIAN
PHYSICIST	SINGERS & SINGING TEACHERS
AUDIOLOGIST	SPEECH PATHOLOGIST
TEACHER SECONDARY-COLLEGE	TECHNICAL WRITER
VETERINARIAN	X-RAY TECHNICIAN
RADIOLOGIST	FBI AGENT
INDUSTRIAL MAINTENANCE MECHANIC	INSTRUMENT MAKER
APPLIANCE SERVICEMAN	TV & RADIO TECHNICIAN
WATCH REPAIRMAN	CARPENTER
CENTRAL OFFICE CRAFTSMAN (TELEPHONE)	TELEPHONE INSTALLER
TELEPHONE REPAIRMAN	BROADCAST TECHNICIAN

ENERGY (SOUND)
LEVEL: JUNIOR HIGH

ACTIVITY: ACTIVITIES WITH SOUND WAVES AND RESONANCE

MATERIALS:

(PART 1)
TUNING FORKS
RESONATING BOXES
PING PONG BALL
THREAD
RUBBER MALLET

(PART 2)
2 TUNING FORKS (SAME)
RUBBER BAND
MALLET

(PART 3)
TALL GRADUATED CYLINDER
TUNING FORK
SHEET OF PAPER

PROCEDURES: (PART 1)

1. THE PHENOMONEN OF RESONANCE CAN BE EASILY DEMONSTRATED BY USING TWO TUNING FORKS OF THE SAME FREQUENCY MOUNTED ON RESONATING BOXES. PLACE THE MOUNTED FORKS 2 FEET APART SO THAT THE OPEN ENDS OF THE BOXES FACE EACH OTHER. SUSPEND A PING PONG BALL BY MEANS OF A THREAD AND PIECE OF TAPE SO THAT IT RESTS AGAINST THE TIP OF ONE OF THE FORKS. WITH A RUBBER MALLET (RUBBER STOPPER ON A PENCIL) STRIKE THE OTHER FORK AND NOTE WHAT HAPPENS TO THE PING PONG BALL.
   WITH THE BALL REMOVED STRIKE ONE FORK, STOP ITS VIBRATION WITH YOUR HAND, AND LISTEN. THIS CAN BE REPEATED WITH VARIOUS DISTANCES BETWEEN THE FORKS. ORDINARY UNMOUNTED FORKS WILL WORK BUT MUST BE HELD CLOSE TO THE EAR TO HEAR RESONANCE.

(PART 2)

2. USING THE SAME TWO FORKS A BEAT NOTE CAN BE PRODUCED. SOUND BOTH FORKS AT THE SAME TIME BY STRIKING THEM. THERE SHOULD BE A NOTE OF CONSTANT PITCH GRADUALLY DYING AWAY IN INTENSITY. TIGHTLY WRAP A RUBBER BAND AROUND ONE PRONG OF ONE FORK. SET BOTH TO VIBRATING AGAIN. LISTEN FOR A RISE AND FALL IN THE INTENSITY OF THE SOUND. THE NUMBER OF BEATS PER SECOND WILL GIVE THE DIFFERENCE IN THE FREQUENCIES OF THE TWO FORKS. CHANGE THE LOCATION OR AMOUNT OF WEIGHT ADDED TO THE FORK. IS THERE A CHANGE IN THE BEAT FREQUENCY?

(PART 3)

3. RESONANCE IN AIR COLUMNS CAN BE PRODUCED BY VIBRATING A TUNING FORK OVER A TALL GRADUATED CYLINDER. THE EFFECTIVE LENGTH OF THE AIR COLUMN CAN BE CHANGED BY ADDING OR REMOVING WATER FROM THE CYLINDER. WITH A 250 CPS FORK START WITH AN AIR COLUMN ABOUT 1 FOOT LONG AND ADD OR SUBTRACT WATER A LITTLE AT A TIME UNTIL MAXIMUM RESONANCE HAS BEEN OBTAINED. REPEAT USING A FORK OF HIGHER FREQUENCY.

SHOULD THE AIR COLUMN BE SHORTER FOR RESONANCE WITH THIS FORK? CLOSED TUBES RESONATE BEST AT 1/4 WAVE LENGTH.

OPEN TUBES MAY BE RESONATED IN THE SAME MANNER. CHANGE THE EFFECTIVE LENGTH OF THE AIR COLUMN BY WRAPPING A SHEET OF PAPER AROUND THE TUBE AND SLIDING IT IN OR OUT ON ONE END. OPEN TUBES RESONATE BEST AT 1/2 WAVE LENGTH. HOW LONG SHOULD AN OPEN TUBE BE TO RESONATE TO A FORK OF 250 CPS?

Energy - Sound
Level: High School

ACTIVITY: In What Ways Do Sounds Differ?

We have little difficulty in recognizing a person's voice or distinguishing one musical instrument from another. What causes sounds to differ? Why are some sounds more pleasing than others? How are we able to hear them?

A. What Are Two Characteristics of a Musical Sound?

A. Obtain three tuning forks of different frequencies--256, 384, and 512. Strike one of the tuning forks very gently and note the loudness of the sound it produces. Strike the fork again, this time much harder, and note its loudness.

1. How does the second sound differ from the first one? ____________
2. What causes the difference that you observed? ____________

____

B. Sharply strike each tuning fork in turn on a rubber pad or stopper and immediately press its stem against the table top and note the sound it produces.

3. Which fork produces the shrillest sound (highest pitch)? ____________
4. Which fork produces the sound of lowest pitch? ____________
5. How is the pitch of a sound related to the frequency or rate of vibration of the sounding body? ____________

C. Blow over the mouth of an empty quart bottle and note the pitch of the sound produced. Pour a glass of water into the bottle and blow again. Pour more water into the bottle and blow again.

6. Label "low pitch" and "high pitch" on Diagram A.
7. What relation is there between pitch and the length of the air column? ____________

D. Pluck the string of a sonometer and note the pitch of the sound produced. Loosen the string, pluck it, and once more note the pitch of the sound.

8. How does changing the tension (tightness) of a string change the pitch of the sound produced? ____________

E. Slide the bridge under the string to the midpoint of the sonometer. Pluck the string and note that the pitch of the sound is an octave higher than that produced by the string vibrating as a whole.

9. Label "low pitch" and "high pitch" on Diagram B.

10. (A) How does the number of vibrations per second (frequency) of the half string compare with the number of vibrations of the whole string? ____________

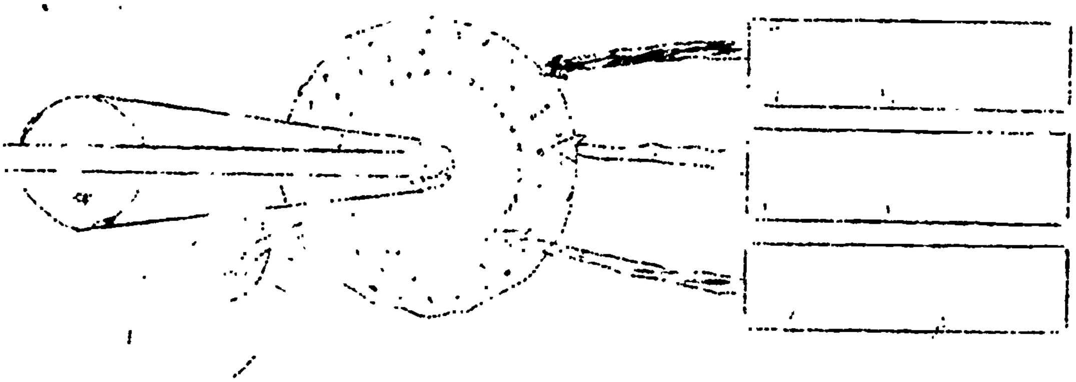
(B) The sound produced by the short string is said to be the ____________ of the sound produced by the long string.

11. Conslusions:

(A) The loudness of a sound depends upon ____________

(B) The pitch of a sound depends upon ____________

B. WHAT DISTINGUISHES A MUSICAL TONE FROM A NOISE?



A. FROM A HEIGHT OF ABOUT A FOOT, DROP SEVERAL SHEETS OF METAL ON THE TABLE TOP. REPEAT, USING A RULER AND A BUNCH OF KEYS.

12. WOULD YOU DESCRIBE THESE SOUNDS AS MUSICAL OR SIMPLY AS NOISE?____________________

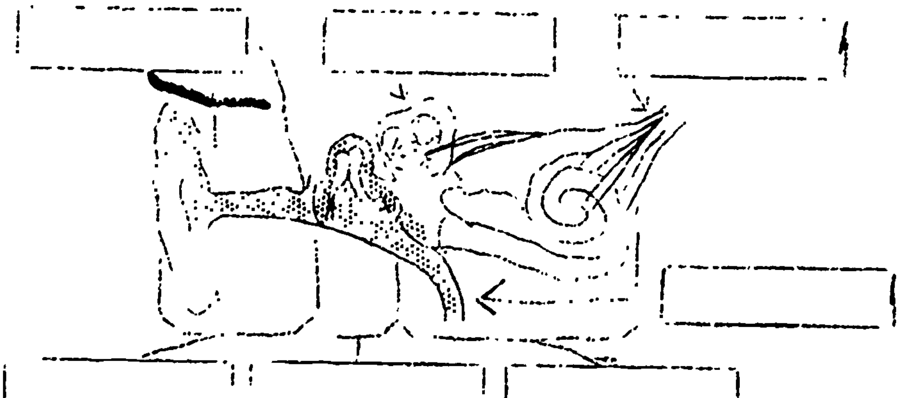
B. OBSERVE THE SPACING OF THE HOLES IN THE SIREN DISK LIKE THAT SHOWN IN THE DIAGRAM.

13. IN WHICH CIRCLE ARE THE HOLES SPACED UNEVENLY?______________

C. ROTATE THE DISK RAPIDLY AND BLOW A JET OF AIR ON EACH OF THE CIRCLES IN TURN.

14. (A) WHICH CIRCLES OF HOLES PRODUCE A MUSICAL SOUND?__________
    (B) WHICH CIRCLE OF HOLES PRODUCES A NOISY DISCORDANT SOUND?__________________
15. COMPLETE THE LABELING ON THE DIAGRAM.
16. CONCLUSION: THE CHIEF DIFFERENCE BETWEEN A NOISE AND A MUSICAL SOUND IS ____________________________

C. HOW DO WE DETECT SOUND?



17. ON THE DIAGRAM LABEL: THE OUTER EAR, INNER EAR, EARDRUM, AUDITORY NERVE, EUSTACHIAN TUBE, AND SEMICIRCULAR CANALS.

18. WHAT EFFECT DO SOUND WAVES HAVE UPON THE EAR DRUM? ____________

19. HOW DOES THE EAR DRUM TRANSMIT IMPRESSIONS TO THE INNER EAR?
____

20. WHAT CARRIES IMPRESSIONS FROM THE INNER EAR TO THE BRAIN? ____________

21. WHERE ARE THE IMPRESSIONS CREATED BY SOUND WAVES INTERPRETED?
____

22. WHAT IS THE PURPOSE OF THE EUSTACHIAN TUBE? ____________

RELATED QUESTIONS

1. WHAT CHARACTERISTIC OF A MUSICAL SOUND MAKES IT POSSIBLE FOR YOU TO DISTINGUISH BETWEEN TWO NOTES OF THE SAME PITCH WHEN PLAYED ON DIFFERENT INSTRUMENTS? ____________

2. (A) HOW DOES A VIOLINIST PLAY NOTES OF DIFFERENT LOUDNESS?
____

(B) HOW DOES A VIOLINIST PRODUCE NOTES OF DIFFERENT PITCH FROM THE SAME STRING? ____________

(C) HOW DOES A VIOLINIST TUNE HIS INSTRUMENT? ____________
____

3. THE AVERAGE SPEED OF SOUND CAN BE CONSIDERED AS 1100 FEET PER SECOND. IF YOU SEE A FLASH OF LIGHTNING AND FOUR SECONDS LATER HEAR THE THUNDER, THE LIGHTNING FLASH OCCURRED ____________ FEET FROM YOU.

4. (A) WHAT CHARACTERISTIC OF SOUND ENABLES US TO DISTINGUISH A SOUND FROM A RECORDING OF THE SAME SOUND? ____________

(B) WHAT IS MEANT BY A STEREO RECORDING? ____________
____

5. WHAT CAREERS WOULD BE RELATED TO THESE ACTIVITIES? LIST SEVERAL YOU MIGHT BE INTERESTED IN.

ENERGY - SOUND
LEVEL: HIGH SCHOOL

ACTIVITY: MEASURING THE VELOCITY OF SOUND BY PIPES

A WAVE MOTION CAN BE CLASSIFIED AS LONGITUDINAL OR TRANSVERSE DEPENDING UPON THE MODE OF VIBRATION OF THE WAVE. A WAVE IS SAID TO BE TRANSVERSE WHEN THE PLANE OF VIBRATION OF THE WAVES IS AT RIGHT ANGLES TO THE DIRECTION OF PROPAGATION. A WAVE IS SAID TO BE LONGITUDINAL WHEN THE PLANE OF VIBRATION IS PARALLEL TO THE DIRECTION OF PROPAGATION. SOUND WAVES ARE LONGITUDINAL SINCE THE PLANE OF VIBRATION IN SOUND IS PARALLEL TO THE DIRECTION OF PROPAGATION.

IF THE NUMBER OF VIBRATIONS OF A SOUND PER UNIT OF TIME IS CALLED ITS FREQUENCY, AND IF THE DISTANCE A SOUND TRAVELS DURING THE INTERVAL OF TIME EQUAL TO THE TIME FOR ONE VIBRATION IS CALLED THE WAVELENGTH OF THE SOUND, THEN THE VELOCITY OF THE SOUND WOULD EQUAL THE FREQUENCY TIMES THE WAVELENGTH. IF WE CAN MEASURE THE WAVELENGTH AND THE FREQUENCY OF A SOUND THEN WE CAN CALCULATE ITS VELOCITY BY MULTIPLYING THESE TWO QUANTITIES TOGETHER. STATING THIS MATHEMATICALLY:

$$\text{VELOCITY } (V) = \text{FREQUENCY } (F) \times \text{WAVELENGTH } (L)$$

WHEN A TUNING FORK IS STRUCK AND HELD OVER THE OPEN END OF A PIPE CLOSED AT ONE END, AND THE LENGTH OF THE PIPE CHANGED WHILE THE FORK IS HELD IN PLACE, A POINT WILL BE FOUND WHERE THE SOUND WILL BECOME LOUDER. AS THE LENGTH OF THE PIPE IS INCREASED OR DECREASED FROM THIS POINT THE LOUDNESS OF THE SOUND WILL DECREASE. AT THIS POINT THE SOUND IS LOUDER BECAUSE THE SOUND WAVE IS REFLECTED FROM THE CLOSED END OF THE PIPE AND ARRIVES BACK AT THE TUNING FORK AT JUST THE RIGHT TIME TO AID OR REINFORCE THE VIBRATION OF THE FORK. THIS REINFORCEMENT WOULD OCCUR IF THE SOUND WOULD ARRIVE BACK JUST AT THE POINT OR INSTANT THE FORK HAD COMPLETED ON-HALF VIBRATION AND WAS ABOUT TO COMPLETE THE SECOND HALF OF THE VIBRATION. DURING THE TIME THE FORK IS VIBRATING FOR ONE-HALF A VIBRATION, THE SOUND WILL HAVE TRAVELLED A DISTANCE EQUAL TO ONE-HALF A WAVELENGTH. SINCE THE SOUND HAS TO TRAVEL DOWN THE PIPE, BE REFLECTED FROM THE CLOSED END OF THE PIPE, AND TRAVEL BACK UP TO THE TOP OF THE PIPE AGAIN, THE LENGTH OF THE PIPE MUST REPRESENT ONE-HALF THE DISTANCE THE SOUND WILL TRAVEL IN ONE-HALF A VIBRATION. THE LENGTH OF THE AIR COLUMN IN THE PIPE MUST THEN BE ONE-FOURTH THE WAVELENGTH OF THE SOUND PRODUCED BY THE FORK. THE LENGTH OF THE AIR COLUMN CAN BE MEASURED VERY EASILY AND VERY ACCURATELY. IF THE FREQUENCY OF THE FORK IS KNOWN THEN IT IS VERY EASY TO CALCULATE THE VELOCITY OF SOUND IN AIR BY THE EQUATION:

$$V = FL$$

WHERE V = THE VELOCITY OF SOUND IN AIR; F = THE FREQUENCY OF THE TUNING FORK USED TO PRODUCE THE SOUND; AND L = THE WAVELENGTH OF THE SOUND THAT WAS PRODUCED.

PART 1

THE GRADUATE CYLINDERS WILL BE USED AS OUR PIPE, THE LENGTH OF THE AIR COLUMN CAN BE VARIED BY POURING WATER INTO THE TUBE TO MAKE IT SHORTER AND BY TAKING WATER OUT TO MAKE IT LONGER. STRIKE THE TUNING FORK WITH THE RUBBER HAMMER AND HOLD IT OVER THE MOUTH OF THE GLASS TUBE. ADD WATER SLOWLY AND LISTEN FOR A REINFORCEMENT OF THE SOUND AS THE WATER IS POURED INTO THE TUBE. WHEN THE LENGTH OF THE AIR COLUMN IS CORRECT FOR THE FREQUENCY OF THE FORK BEING USED, YOU WILL HEAR A VERY LOUD AND NOTICEABLE REINFORCEMENT OF THE SOUND. STOP POURING THE WATER WHEN YOU HEAR THIS REINFORCEMENT. MEASURE THE DISTANCE FROM THE WATER TO THE TOP OF THE TUBE. ADD TO THIS MEASUREMENT .4 THE RADIUS OF THE TUBE AND YOU HAVE THE EFFECTIVE LENGTH OF THE AIR COLUMN. THIS IS ONE-FOURTH THE WAVELENGTH OF THE SOUND PRODUCED BY THE FORK. MULTIPLY THIS LENGTH BY FOUR TO GET THE WAVELENGTH OF THE SOUND. READ THE FREQUENCY THAT IS STAMPED ON THE FORK; THIS IS THE VALUE FOR "F" IN THE EQUATION ON THE PRECEDING PAGE. SUBSTITUTING THESE VALUES FOR "F" AND "L" INTO THE EQUATION CALCULATE THE VELOCITY OF SOUND AT ROOM TEMPERATURE.

REPEAT THE ABOVE USING TWO OTHER FORKS OF DIFFERENT FREQUENCIES. TAKE AN AVERAGE OF THE VELOCITIES THAT YOU HAVE GOTTEN WITH THE DIFFERENT FORKS.

DATA AND CALCULATIONS

	FORK 1	FORK 2	FORK 3
1. LENGTH OF AIR COLUMN			
2. RADIUS OF TUBE			
3. RADIUS OF TUBE x 0.4			
4. SUM OF 1 AND 3			
5. WAVE LENGTH			
6. FREQUENCY OF FORK			
7. AVERAGE OF THE 3 VELOCITIES AT ROOM TEMPERATURE			
8. CORRECT VALUE OF V			

APPLICATIONS:

1. DOES THE VELOCITY OF SOUND VARY WITH ALTITUDE?

2. WHY WOULD MUSICIANS BE CONCERNED WITH WAVELENGTHS OF SOUND?

3. THERE ARE SEVERAL OCCUPATIONS THAT WOULD NEED TO KNOW THE NATURE OF WAVELENGTHS. NAME SEVERAL THAT YOU MIGHT BE INTERESTED IN.

ENERGY - SOUND
LEVEL: HIGH SCHOOL

ACTIVITY: WAVES IN THE RIPPLE TANK - PART II

HOW ARE WAVES REFRACTED?

WHEN WAVES MOVE FROM ONE MEDIUM INTO ANOTHER, THEIR SPEED USUALLY CHANGES. IF THEY ENTER THE SECOND MEDIUM AT AN ANGLE OTHER THAN 90°, THE WAVEFRONT WILL CHANGE DIRECTION. ACCORDING TO SNELL'S LAW, THE RATIO $\frac{\sin \theta_I}{\sin \theta_R}$, WHERE θ_I IS THE ANGLE OF INCIDENCE AND θ_R IS THE ANGLE OF REFRACTION, EQUALS A CONSTANT KNOWN AS THE INDEX OF REFRACTION.

PROCEDURE:

SET UP A RIPPLE TANK AND FILL IT WITH WATER TO A DEPTH OF ABOUT 2 CM. BE CAREFUL THAT THE TANK IS LEVEL. PLACE A PIECE OF GLASS ABOUT 30 BY 15 CM ON SUPPORTS SO THAT IT IS ABOUT 2 MM BELOW THE SURFACE OF THE WATER.

PLACE A STRAIGHT-WAVE GENERATOR IN SUCH A WAY THAT IT CREATES STRAIGHT WAVES WHICH MOVE TOWARD THE SHALLOW WATER OVER THE GLASS. AS THE WAVES ENTER THE SHALLOW WATER, THEY MOVE MORE SLOWLY. THE WAVELENGTH WILL BECOME SHORTER. IF THE WAVEFRONT ENTERS THE SHALLOW WATER AT AN ANGLE, THE END WHICH ENTERS FIRST WILL BE SLOWED FIRST AND THE WAVEFRONT WILL BE SO TURNED THAT IT BECOMES MORE NEARLY PARALLEL TO THE EDGE OF THE SHALLOW WATER.

OBSERVE THE PATTERN THROUGH A STROBOSCOPE AND ADJUST THE SPEED FOR A STATIONARY PATTERN.

1. DO THE WAVES IN THE DEEP AND SHALLOW WATER APPEAR STATIONARY AT THE SAME STROBE SPEED? ____________________
2. WHAT DOES THIS TELL YOU ABOUT THE FREQUENCIES OF THE WAVE IN DEEP AND SHALLOW WATER? ______________________________

USING A RULER, DRAW A LINE ON THE PAPER TO SHOW THE EDGE OF THE GLASS PLATE WHERE THE SHALLOW WATER BEGINS. NOW LAY THE RULER ON THE PAPER IN SUCH A WAY THAT IT INTERSECTS THE LINE BETWEEN DEEP AND SHALLOW WATER. ADJUST THE RULER UNTIL IT IS PARALLEL TO THE INCIDENT WAVEFRONTS. DRAW A LINE FROM THE DEEP-SHALLOW LINE ALONG THE WAVEFRONT.

NOW ADJUST THE RULER TO TOUCH THE POINT FORMED BY THE LINE YOU JUST DREW AND THE DEEP-SHALLOW LINE. TURN IT UNTIL IT IS PARALLEL TO THE WAVEFRONTS IN SHALLOW WATER. DRAW IN THIS LINE FROM THE DEEP-SHALLOW LINE.

MEASURE THE ANGLE THE INCIDENT WAVEFRONT MAKES WITH THE DEEP-SHALLOW LINE. ENTER THIS IN THE DATA TABLE UNDER θ_1.

MEASURE THE ANGLE THE WAVEFRONT IN SHALLOW WATER MAKES WITH THE DEEP-SHALLOW LINE. ENTER THIS IN THE TABLE AS θ_2. ALSO MEASURE AND RECORD THE WAVELENGTH IN BOTH DEEP AND SHALLOW WATER AND THE FREQUENCY.

REPEAT THESE STEPS AFTER SO ADJUSTING THE GLASS THAT THE WAVEFRONT MAKES AN ANGLE OF ABOUT 45° WITH THE DEEP-SHALLOW LINE.

Make a third set of measurements with the wavefronts hitting the deep-shallow line at a very large angle.

For each set of data, compute the ratio of sine θ_1/sine θ_2. According to Snell's law, the ratio should be a constant.

3. How closely does your data remain constant?________________
4. Can you suggest specific reasons why your data might not be constant?____

It can be shown by geometric proofs that the ratio of sine θ_1/sine θ_2 is equal to the ratio of V_1/V_2, where V is the velocity of the waves.

Compute the velocities of the waves from the equation $V = f\lambda$. Enter them in your table and compute the ratio V_1/V_2 for each case.

5. How closely do the ratios V_1/V_2 agree with the ratios sine θ_1/sine θ_2?____

6. Which of the ratios is more nearly constant?________________

DATA

Angle plate makes with wavefront	Small	Medium	Large
Incident angle θ_1			
Refracted angle θ_2			
Sine θ_1			
Sine θ_2			
Sine θ_1/sine θ_2			
Wavelength λ_1			
Wavelength λ_2			
Frequency			
Velocity V_1			
Velocity V_2			
V_1/V_2			

Discussion

1. An incident wave makes an angle of 30° with the deep-shallow line in deep water and an angle of 24° in the shallow water. What is the constant sine θ_1/sineθ_2. (This is called the index of refraction.)
2. The index of refraction for a given ripple tank set up is 1.35. If the speed of the waves in shallow water is 18 cm/sec, what is their speed in deep water?
3. If the wavelength of the waves in Question 2 is 3 cm in the deep water, what will be the wavelength in the shallow water?
4. Why would a sound engineer or an architect need to be acquainted with this activity?

ENERGY - SOUND
LEVEL: HIGH SCHOOL

ACTIVITY: WAVE FORMS

PROBLEM:

AS A SUBSTANCE VIBRATES, WAVES ARE PRODUCED IN THE MEDIUM SURROUNDING THE SUBSTANCE. SINCE AIR IS ORDINARILY AN INVISIBLE SUBSTANCE, SOUND WAVES TRAVELING THROUGH IT CANNOT BE SEEN. HOW CAN THE WAVES PRODUCED BY A VIBRATING OBJECT BE SHOWN?

MATERIALS:

CLEAR GLASS BAKING DISH, AT LEAST 12 INCHES IN LENGTH.
DESK LAMP
TUNING FORK
WHITE CARDBOARD
WOODEN BLOCKS

PROCEDURE:

PLACE THE GLASS DISH ON BLOCKS ABOUT 10 INCHES ABOVE A SHEET OF WHITE CARDBOARD, BEING SURE THE DISH IS LEVEL. POUR NOT OVER 1/2 INCH OF WATER IN THE DISH. ARRANGE A DESK LAMP SO THAT IT SHINES THROUGH THE WATER ONTO THE CARDBOARD, AS SHOWN IN PICTURE. STRIKE THE PRONGS OF A TUNING FORK, AND PLACE THE PRONGS IN THE WATER AT ONE END OF THE DISH. NOTE THE PATTERN OF WAVES SEEN ON THE CARDBOARD.

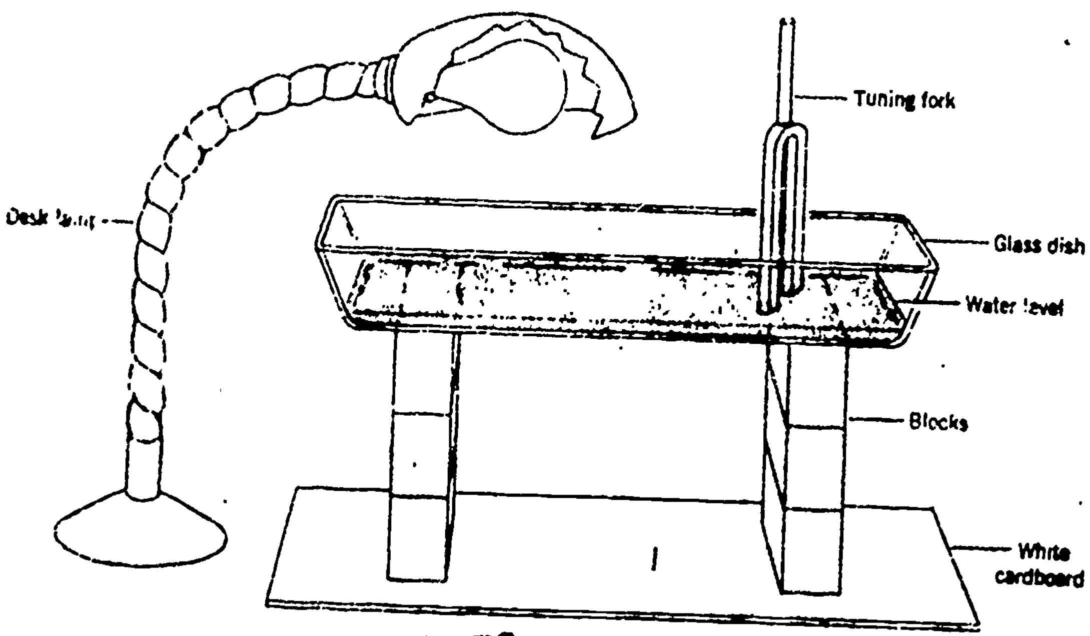
OBSERVATIONS:

1. DESCRIBE THE APPEARANCE OF THE WAVES PRODUCED IN THE WATER.

____

2. WHAT PART OF A WAVE DO THE DARK BANDS REPRESENT? ____________

3. WHAT PART OF A WAVE DO THE LIGHT BANDS REPRESENT? ____________



4. WHAT HAPPENS WHEN THE WAVES HIT THE OPPOSITE SIDE OF THE DISH?

____

5. WHAT HAPPENS WHEN THE REFLECTED WAVES MEET THOSE THAT ARE MOVING OUT FROM THE TUNING FORK? ______________________________

INTERPRETATION:

FILL IN THE BLANK WORDS IN THE FOLLOWING PARAGRAPH IN THE NUMBERED SPACES AT THE RIGHT.

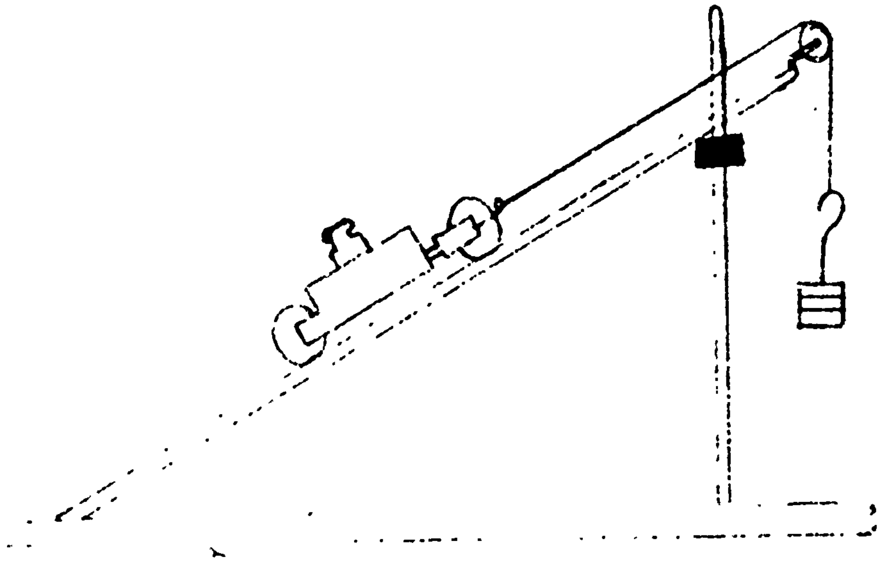
SOUND WAVES ARE PRODUCED WHENEVER ANY FORM OF MATTER (1). THE PART OF THE WAVE PRODUCED WHEN THE MOLECULES OF AIR ARE PUSHED TOGETHER IS THE (2) WAVE, AND THE PART OF THE WAVE PRODUCED WHEN THE MOLECULES ARE SPREAD APART IS THE (3) WAVE. THE WAVES MOVE OUT FROM THE SOURCE IN (4). WHEN A SOUND WAVE STRIKES A HARD OBJECT, IT IS (5) AND MAY BE HEARD AS A (AN) (6). WHEN REFLECTED SOUND WAVES STRENGTHEN THE ORIGINAL SOUNDS, THEY ARE SAID TO (7) THEM; AND WHEN THEY WEAKEN THE ORIGINAL SOUNDS, THEY ARE SAID TO (8). UNWANTED ECHOES MAY BE AVOIDED BY USING (9) MATERIALS AND BY DESIGNING THE ROOM SO THAT REFLECTIONS OF SOUND WAVES ARE (10).

1 ______________
2 ______________
3 ______________
4 ______________
5 ______________
6 ______________
7 ______________
8 ______________
9 ______________
10 ______________

APPLICATION:

EXPLAIN WHY THE SOUNDS YOU HEAR WHEN YOU ARE RIDING IN AN AUTOMOBILE SEEM DIFFERENT WHEN YOU ARE DRIVING ON AN OPEN HIGHWAY, ON A NARROW STREET, OVER A BRIDGE, OR THROUGH A TUNNEL.

MECHANICS



PHYSICS - MECHANICS

Air Traffic Controller
Architects
Astronauts
Railroad Conductor
Draftsman
Engineering Technician
Geologist
Industrial Engineer
Pharmacist
Physicist
Elementary Teacher
Technical Writer
X-Ray Technician
Auto Parts Man
FBI Agent
Policemen & Women
Stewardesses
Fish & Wildlife Technician
Forestery Product Technician
Livestock Production Technician
Soil Conservationist
Electroplater
Air Conditioning & Refrigeration Mechanics
Aircraft Mechanics
Composing Room Operators
Farm Equipment Mechanic
Industrial Maintenance Mechanic
Machine Tool Operators
Pattern Maker
Production Machine Operator
Tool & Dye Man
Assembler
Furniture Upholsterers
Jeweler Repair
Watch Repairman
Brick Layer
Cement Mason
Elevator Repairman
Glazier
Operating Engineer (construction)
Roofer
Signal Maintainer
Structural Steel Worker
Welder
Bookbinder
Broadcast Technician
Electric Typers
Truck Driver (warehouse)
Locomotive Engineer
Meter Men-Women
Photo Engraver

Farm-crop Production Technician
Dairy Production Technician
Physical Chemist
Dentist
Editor
Engineer
Geophysicists
Merchant Marine
Physician
Pilots
Teacher secondary-college
Veterinarian
Radiologist
Auto Salesman
Fireman
Shoe Repair
Farming
Fish Culture Technician
Lab Animal Care Technician
Range Management
Soil Scientist
Moulder
Millright
Auto Mechanic
Diesel Mechanic
Flight Engineer
Instrument Maker
Office Machine Repairman
Printing Pressman
Set-up Man
Appliance Serviceman
Dental Lab Technician
Jewelers
TV Technician (radio)
Boiler Maker
Carpenter
Construction Laborer
Floor Covering Installer
Lay Out Man
Plumber & Pipe Fitter
Sheet Metal Worker
Stone Mason
Telephone Repairman
Airplane Dispatcher
Brakeman
Bus Drivers
Gasoline Service Station Attendant
Lithographic Occupation
Apprentice Engineer
Projectionist
Power Plant Operator

PHYSICS - MECHANICS

STATIONARY ENGINEER
STEVEDORE
POWER DISPATCHER
LONG SHOREMAN

BOILER FIREMAN
TAXI DRIVER
TRUCK DRIVER

PHYSICS (MECHANICS)
LEVEL: JUNIOR HIGH

ACTIVITY: HOW CAN PULLEYS HELP US DO A JOB?

MATERIALS:

- "C" CLAMP
- METER STICK
- SPRING BALANCE
- SINGLE PULLEY
- STRING
- 100 GM WEIGHT

PROCEDURES:

A. ATTACH THE "C" CLAMP TO THE EDGE OF A TABLE OR DESK. TIE THE PULLEY TO THE "C" CLAMP. ATTACH ONE END OF THE CORD TO THE 100 GRAM WEIGHT AND RUN THE OTHER END THROUGH THE PULLEY. TIE THE SPRING BALANCE TO THE FREE END OF THE CORD.

B. PULL THE SPRING BALANCE SMOOTHLY AND OBSERVE THE FORCE NEEDED TO LIFT THE 100 GRAM WEIGHT. DO THIS STEP THREE OR FOUR TIMES TO GET AN AVERAGE, AND THEN RECORD YOUR AVERAGE IN THE DATA TABLE.

C. PLACE THE METERSTICK UPRIGHT ON THE FLOOR AND HAVE ANOTHER PERSON OBSERVE THE NUMBER OF CENTIMETERS THE WEIGHT RISES WHILE YOU OBSERVE THE NUMBER OF CENTIMETERS THE SPRING BALANCE MOVES IN THE OPPOSITE DIRECTION. RECORD YOUR READINGS IN THE DATA TABLE.

D. TIE ONE END OF THE CORD ON THE "C" CLAMP. RUN THE OTHER CORD THROUGH THE PULLEY AND ATTACH IT TO THE SPRING BALANCE. HOOK THE WEIGHT ON THE MOVABLE PULLEY.

E. PULL THE SPRING BALANCE SMOOTHLY SEVERAL TIMES TO LIFT THE 100 GRAM WEIGHT. RECORD YOUR AVERAGE READING.

F. PLACE THE METERSTICK ON THE FLOOR IN AN UPRIGHT POSITION AND OBSERVE THE DISTANCE IN CENTIMETERS THAT BOTH THE WEIGHT AND THE SPRING BALANCE TRAVEL, AS YOU DID IN STEP 3. YOUR PARTNER WILL HELP YOU IN THE OBSERVATIONS. RECORD IN THE DATA TABLE.

OBSERVATIONS:

1. RECORD YOUR OBSERVATIONS IN THE DATA TABLE.

	WEIGHT OF OBJECT	FORCE TO MOVE OBJECT	FORCE LOSS OR GAIN	DISTANCE WEIGHT MOVED	DISTANCE FORCE MOVED
FIXED PULLEY					
MOVABLE PULLEY					

INTERPRETATIONS:

1. DO YOU ALWAYS GAIN FORCE WHEN A PULLEY IS USED? EXPLAIN.

2. IN STEP C, WHEN THE SINGLE FIXED PULLEY WAS USED, NEITHER FORCE NOR DISTANCE WAS GAINED OR LOST. WHAT IS THE GAIN?

3. HOW MANY STRANDS ARE PULLING DIRECTLY ON THE LOAD IN THE FIXED PULLEY EXPERIMENT? HOW MANY IN THE MOVABLE EXPERIMENT?

4. WHAT DIFFERENCE DOES THE MOVABLE PULLEY MAKE?

5. WHAT IS THE MECHANICAL ADVANTAGE OF THE MOVABLE PULLEY?

6. WHEN FORCE WAS GAINED USING THE MOVABLE PULLEY, WHAT WAS LOST?

PHYSICS (MECHANICS)
LEVEL: JUNIOR HIGH

ACTIVITY: ACTIVITIES USING AN INCLINED PLANE

MATERIALS: BOARD
BLOCK
SPRING SCALE
TOY CAR OR TRUCK
STRING

PROCEDURE:

SET UP A SMOOTH BOARD ABOUT 1 METER LONG SO THAT ONE END IS ABOUT 20 CM HIGHER THAN THE OTHER. ACCURATELY MEASURE THE HEIGHT OF THE RAISED END TO THE UNDERSIDE OF THE BOARD. FROM THIS DETERMINE THE THEORETICAL MECHANICAL ADVANTAGE. RECORD YOUR ANSWER:

____

WEIGH A TOY CAR OR TRUCK WITH A SPRING SCALE. MEASURE THE FORCE NECESSARY TO PULL THE CAR UP THE INCLINE. FROM THESE TWO FORCES FIND THE ACTUAL MECHANICAL ADVANTAGE: ________________

WHY IS THIS LESS THAN THE ONE FOUND BY USING THE LENGTH AND HEIGHT?____

____

PUT WEIGHTS IN THE TRUCK OR CHANGE THE HEIGHT OF THE INCLINE AND THEN MAKE OTHER TRIALS. ON THE BASIS OF YOUR RESULTS HOW DOES THE FORCE REQUIRED TO MOVE THE BLOCK CHANGE AS THE MECHANICAL ADVANTAGE INCREASES?

____

____

PHYSICS (MECHANICS)
LEVEL: JUNIOR HIGH

ACTIVITY: HOW DOES FRICTION AFFECT EFFICIENCY? AND HOW CAN FRICTION BE REDUCED?

MATERIALS: SPRING BALANCE
FLAT BOARD (SMALL)
MEDIUM-SIZE NAIL
4 ROUND PENCILS
TWO BOOKS

PROCEDURE:

A. DRIVE THE NAIL INTO THE BOARD NEAR ONE END. ATTACH A SPRING BALANCE TO THE NAIL. PLACE ONE BOOK ON THE BOARD AND PULL THE BOARD GENTLY AND SMOOTHLY. OBSERVE THE READING ON THE SPRING BALANCE AS THE BOARD IS MOVING. DO THIS SEVERAL TIMES. RECORD THE AVERAGE READING IN THE DATA TABLE.

B. PLACE TWO BOOKS ON THE BOARD AND REPEAT STEP A. AFTER SEVERAL TRIALS, RECORD THE AVERAGE READING IN THE DATA TABLE.

C. NEXT, PUT THE FOUR PENCILS UNDER THE BOARD AND PUT ONE BOOK ON THE BOARD. PULL THE BOARD GENTLY AND SMOOTHLY, AND OBSERVE THE READING ON THE SPRING BALANCE AS THE BOARD IS MOVING.

D. REPEAT STEP C, USING TWO BOOKS. AFTER SEVERAL TRIALS, RECORD THE AVERAGE READING IN THE DATA TABLE.

OBSERVATIONS:

1. RECORD YOUR MEASUREMENTS IN THE DATA TABLE.

	FLAT SURFACE FORCE REQUIRED	ROLLER SURFACE FORCE REQUIRED
BOARD WITH ONE BOOK		
BOARD WITH TWO BOOKS		

Interpretations:

1. How did you reduce friction in this experiment?

   ____

   ____

   ____

2. How do you know that a heavier object produces more friction?

   ____

   ____

3. How do the sizes of the surfaces touching each other affect friction?

   ____

   ____

4. What are two things that waste the work put into a machine?

   ____

5. What affect do rolling objects, ball bearings, and lubricants have on friction?

   ____

   ____

   ____

MECHANICS
LEVEL: HIGH SCHOOL

ACTIVITY: PULLEYS (WHAT DETERMINES THE MECHANICAL ADVANTAGE OF A SYSTEM OF PULLEYS?)

MATERIALS:
2 SINGLE-SHEAVE PULLEYS
HORIZONTAL SUPPORT
SET OF HOOKED WEIGHTS
2 DOUBLE-TANDEM PULLEYS
SPRING BALANCE (500 G)
CORD

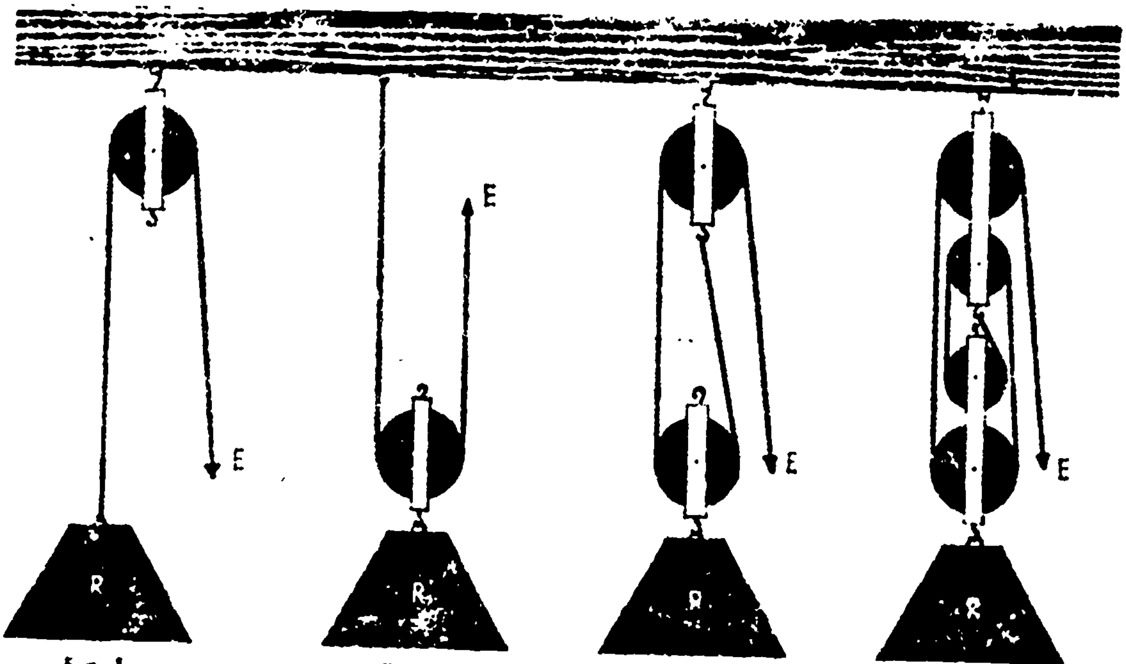


Fig. 1 Fig. 2 Fig. 3 Fig. 4

PROCEDURE:
A. SINGLE FIXED PULLEY

FASTEN A SINGLE PULLEY TO A HORIZONTAL SUPPORT (FIG. 1). PASS A CORD ABOUT A METER LONG THROUGH THE PULLEY AND FASTEN A 200-G WEIGHT R TO ONE END. HOOK WEIGHTS, E_1, TO THE OTHER END OF THE CORD UNTIL THE 200-G WEIGHT IS SLOWLY RAISED. (PLACE WEIGHTS IN A SCALE PAN IF WEIGHTS WITH HOOKS ARE NOT AVAILABLE.) REMOVE WEIGHTS, E_2, UNTIL THE 200-G WEIGHT IS SLOWLY LOWERED.

1. WHICH IS LARGER, E_1 OR E_2? ____________________

E_1 IS THE EFFORT INCREASED BY FRICTION, AND E_2 IS THE EFFORT DECREASED BY FRICTION. THE AVERAGE OF THESE TWO GIVES THE TRUE EFFORT E.

2. HOW DOES YOUR VALUE OF E COMPARE WITH R? ____________________
3. DOES THIS ARRANGEMENT GIVE A MECHANICAL ADVANTAGE? __________
4. HOW MANY STRINGS SUPPORT R? ____________________

B. SINGLE MOVABLE PULLEY

TIE THE END OF THE CORD TO THE SUPPORT (FIG. 2). FASTEN A 200-G WEIGHT AT R AND A SPRING BALANCE AT E. THE EFFORT IN THIS CASE WILL HAVE TO BE EXERTED UPWARD. FIND THE EFFORT REQUIRED WHEN THE WEIGHT IS BEING RAISED AND WHEN IT IS BEING LOWERED. FIND THE AVERAGE EFFORT.

5. HOW MANY STRINGS SUPPORT R?________________________

WEIGH THE PULLEY ON THE SPRING BALANCE. FOR R USE THE COMBINED WEIGHT OF THE 200-G WEIGHT AND THE WEIGHT OF THE PULLEY.

6. WHY?____
____

7. WHAT IS THE VALUE OF THE MECHANICAL ADVANTAGE AS GIVEN BY THE RATIO R/E?________________________

C. ONE FIXED AND ONE MOVABLE PULLEY

ARRANGE TWO SINGLE PULLEYS AS IN FIG. 3. USE A 500-G WEIGHT FOR R AND FIND THE WEIGHTS REQUIRED AT E TO RAISE AND LOWER R. FIND THE AVERAGE EFFORT. THE WEIGHT OF THE LOWER PULLEY MUST BE ADDED TO THE WEIGHT LIFTED.

8. WHAT RELATION DO YOU SEE BETWEEN THE RATIO R/E AND THE NUMBER OF STRINGS SUPPORTING R?________________________
9. HOW DOES THE MECHANICAL ADVANTAGE COMPARE WITH THAT OF ONE MOVABLE PULLEY?________________________
10. WHAT IS THE USE OF THE FIXED PULLEY?________________________

D. TWO FIXED AND TWO MOVABLE PULLEYS

WEIGH ONE OF THE DOUBLE BLOCKS ON THE SPRING BALANCE. ARRANGE TWO DOUBLE BLOCKS AS IN FIG. 4. FIND THE SAME DATA AS BEFORE, USING A 500-G WEIGHT FOR R.

DATA

	A	B	C	D
TOTAL WEIGHT LIFTED, R	G	G	G	G
EFFORT, WEIGHT GOING UP, E_1	G	G	G	G
EFFORT, WEIGHT GOING DOWN, E_2	G	G	G	G
EFFORT, AVERAGE, E	G	G	G	G
MECHANICAL ADVANTAGE R/E				
NUMBER OF STRINGS SUPPORTING R				

DISCUSSION:

1. WHAT IS THE DIFFERENCE BETWEEN A FIXED AND A MOVABLE PULLEY?

2. BY EXAMINING A SYSTEM OF PULLEYS, HOW CAN YOU DETERMINE THE THEORETICAL MECHANICAL ADVANTAGE?

3. A CAR IS TO BE PULLED OUT OF THE MUD BY THE USE OF TWO DOUBLE BLOCKS. ONE BLOCK IS FASTENED TO A TREE AND ONE TO THE CAR. SHOW BY DIAGRAMS TWO WAYS OF STRINGING UP THE TWO DOUBLE BLOCKS. WHAT IS THE MECHANICAL ADVANTAGE OF EACH?

   MA= MA=

4. WHAT CAREERS CAN YOU DISCOVER THAT WOULD REALLY NEED INFORMATION FROM THIS ACTIVITY?

MECHANICS
Level: High School

ACTIVITY: Archimedes' Principle-Buoyant Force (how can Archimedes' principle be verified?)

Fluids exert a buoyant (upward) force on both floating and submerged objects. Archimedes reasoned that the magnitude of this force must equal the weight (downward force) of the fluid displaced by the object.

Procedures:

A. Objects Denser than Water

To determine the buoyant force of water on a submerged object denser than water, the object is weighed in air and weighed again while submerged in water. Then, to verify Archimedes' principle, weigh the water displaced by the object. Enter your data in the table on the next page.

One method of weighing an object submerged in water is shown in the diagram. If your apparatus is different, your instructor will explain its use.

Materials:

Laboratory balance
Catch bucket
Object denser than water
Saturated salt solution or kerosene
Overflow can
Cord
Object less dense than water

To weigh the displaced water, use an overflow can and catch bucket. (See diagram below.) Weigh the empty catch bucket. Fill the overflow can with water and, when all the excess water has flowed out, gently place the object into the water, catching the overflow in the bucket. Weigh the bucket and water and subtract the weight of the empty bucket.

B. OBJECTS LESS DENSE THAN WATER

TO VERIFY ARCHIMEDES' PRINCIPLE FOR FLOATING OBJECTS, WEIGH THE OBJECT IN AIR, THEN GENTLY PLACE THE OBJECT IN A FILLED OVERFLOW CAN, ALLOWING IT TO FLOAT. CATCH THE OVERFLOW IN A CATCH BUCKET AND OBTAIN THE WEIGHT OF THE DISPLACED WATER AS BEFORE. NOTE THAT A QUIETLY FLOATING OBJECT DOES NOT MOVE UP OR DOWN, INDICATING THAT THE BUOYANT FORCE OF THE FLUID EXACTLY BALANCES THE WEIGHT OF THE OBJECT.

IF TIME PERMITS, REPEAT PROCEDURES A AND B WITH A LIQUID OF DIFFERENT DENSITY, SUCH AS SATURATED SALT SOLUTION OR KEROSENE.

DATA

	WATER		SECOND LIQUID	
	A	B	A	B
1. WEIGHT OF OBJECT IN AIR	G	G	G	G
2. WEIGHT OF OBJECT IN LIQUID	G	G	G	G
3. DIFFERENCE IN WEIGHT (1-2)	G	G	G	G
4. WEIGHT OF EMPTY CATCH BUCKET	G	G	G	G
5. WEIGHT OF BUCKET AND DISPLACED LIQUID	G	G	G	G
6. WEIGHT OF DISPLACED LIQUID (5-4)	G	G	G	G

DISCUSSION:

1. WHAT RELATION DO YOU FIND BETWEEN THE WEIGHT OF THE FLOATING BODY AND THE WEIGHT OF WATER THAT IS DISPLACED?

2. WAS THIS SAME RELATIONSHIP TRUE FOR THE SECOND LIQUID?

3. DID THE OBJECT DISPLACE A GREATER OR A LESSER VOLUME OF THE SECOND LIQUID? EXPLAIN.

4. AS A SHIP PASSES FROM FRESH WATER INTO SALT WATER, WILL IT FLOAT HIGHER OR LOWER IN THE WATER?

5. A PNEUMATIC LIFE RAFT WHICH WEIGHS 25 LB WILL DISPLACE WHAT WEIGHT OF WATER WHEN THERE ARE TWO PEOPLE WEIGHING 180 LB EACH IN THE RAFT?

   HOW MANY CUBIC FEET OF WATER WILL BE DISPLACED?

6. A FLAT-BOTTOMED BOAT 10 FT WIDE AND 20 FT LONG SINKS 2 IN. DEEPER WHEN LOADED. HOW HEAVY IS THE LOAD?

7. IF YOU WERE DESIGNING AND SELLING FISHING BOATS HOW WOULD YOU FIND THIS ACTIVITY HELPFUL? EXPLAIN.

MECHANICS
LEVEL: HIGH SCHOOL

ACTIVITY: WATER PRESSURE

PROBLEM:
THE PRESSURE OF A FLUID INCREASES AS THE DEPTH IS INCREASED. HOW CAN WE MEASURE SMALL CHANGES OF PRESSURE IN WATER?

MATERIALS:
RING STAND
U-TUBE
RUBBER TUBE
RULER
COLORED WATER
RING STAND CLAMP
LONG-STEMMED FUNNEL
RUBBER BALLOON
MASKING TAPE
GLASS JARS OF DIFFERENT SIZE AND SHAPE

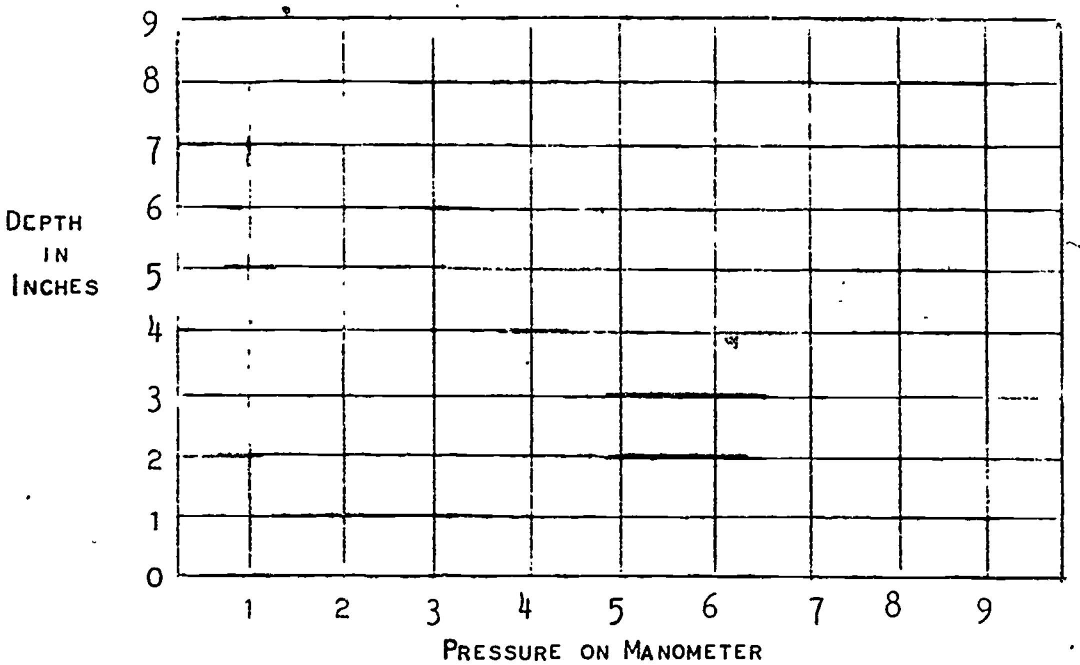
PROCEDURE:
CUT THE TOP OFF A BALLOON AND STRETCH THE LOWER HALF OVER THE MOUTH OF THE FUNNEL TO MAKE A RUBBER DIAPHRAGM. SUPPORT THE U-TUBE IN THE RING STAND AND POUR A LITTLE COLORED WATER INTO TUBE. MARK ONE ARM OF THE TUBE IN CENTIMETERS TO MAKE A MANOMETER SCALE. CONNECT THE FUNNEL TO THE OTHER ARM OF THE U-TUBE TO MAKE A SIMPLE MANOMETER. FILL THE GLASS JARS NEARLY FULL WITH WATER AND ATTACH THE RULER WITH TAPE TO THE SIDE OF THE JAR TO BE USED FIRST. GRADUALLY PUSH THE FUNNEL INTO THE WATER NOTING THE RISE IN THE MANOMETER TUBE AS THE DEPTH INCREASES. REPEAT THE EXPERIMENT FOR EACH OF THE DIFFERENT JARS.

OBSERVATIONS:
FILL IN THE FOLLOWING TABLE SHOWING THE DEPTH AND PRESSURE READINGS.

DEPTH OF WATER IN THE JAR	READING ON MANOMETER SCALE			
	JAR #1	JAR #2	JAR #3	JAR #4
1 INCH				
2 INCHES				
3 INCHES				
4 INCHES				
5 INCHES				
6 INCHES				

INTERPRETATION:

MAKE A GRAPH SHOWING THE RELATIONSHIP OF PRESSURE TO DEPTH AS SHOWN BY THE DATA IN THE TABLE.

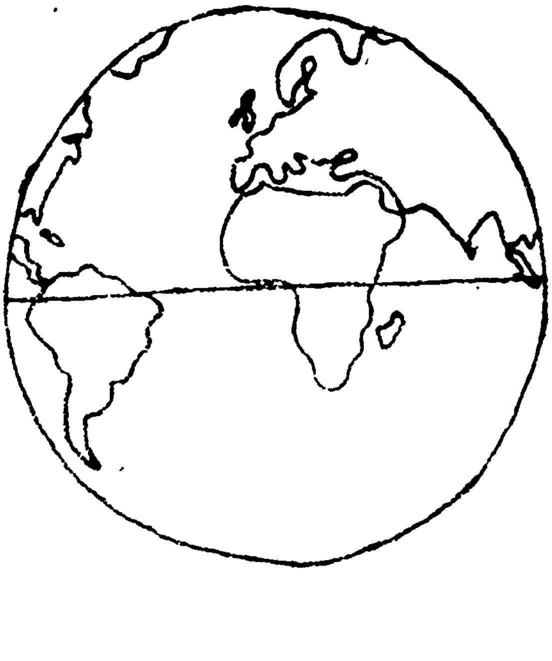


APPLICATIONS:

1. DIVERS WORKING AT GREAT DEPTHS IN THE WATER USUALLY WEAR HEAVY PROTECTIVE HELMETS AND SUITS. EXPLAIN HOW THE DIVER IS PROTECTED FROM THE GREAT PRESSURES AT THESE DEPTHS.

2. THERE ARE MANY CAREERS THAT NEED TO BE CONCERNED WITH PRESSURE. NAME SEVERAL THAT INTEREST YOU.

EARTH AND WHAT IT'S MADE OF



EARTH SCIENCE - EARTH & WHAT IT'S MADE OF

PETROLEUM ENGINEER
GEOPHYSICS
OCEANOGRAPHER
TEACHER SECONDARY-COLLEGE
URBAN PLANNER
AGRICULTURAL EXTENSION WORKER
FARM CROP PRODUCTION TECHNICIAN
FISH & WILDLIFE TECHNICIAN
FORESTERY PRODUCTION TECHNICIAN
ORCHARD TECHNICIAN
PARKS LAND MANAGEMENT TECHNICIAN
SOIL CONSERVATIONIST
CORE MAKER
JEWELER REPAIR
CEMENT MASON
PLASTERER
STRUCTURAL STEEL WORKER

GEOLOGIST
LANDSCAPE ARCHITECT
ELEMENTARY TEACHER
TECHNICAL WRITER
AGRIBUSINESS TECHNICIANS
DAIRY PRODUCTION TECHNICIAN
FARMING
FORESTER
LIVESTOCK PRODUCTION TECHNICIAN
HORTICULTURIST
RANGE MANAGEMENT
SOIL SCIENTIST
JEWELER
BRICK LAYER
OPERATING ENGINEER
STONE MASON

EARTH & WHAT IT'S MADE OF
LEVEL: JUNIOR HIGH

ACTIVITY: EXAMINATION OF SOIL PARTICLES AND 2 OF ITS PROPERTIES.

MATERIALS: (PER TEAM)
- MAGNIFYING LENSES
- STRAIGHT PIN
- METRIC RULER
- SOIL SAMPLES

A. CHARACTERISTICS OF SOIL

PROCEDURES:

A. PLACE A SMALL AMOUNT OF SOIL ON A SHEET OF PAPER. EXAMINE THE SOIL WITH A LENS. IF YOU ARE ABLE TO IDENTIFY ANY MINERAL PARTICLES IN THE SAMPLE WRITE THEIR NAMES IN A NOTEBOOK.

B. OBSERVE THE SHAPES OF SEVERAL SOIL PARTICLES. NOTICE ESPECIALLY WHETHER THEY HAVE SHARP OR ROUND EDGES. PREPARE SKETCHES OF THE PARTICLES IN YOUR NOTEBOOK.

C. USE THE PIN TO LINE UP ENOUGH PARTICLES ALONG THE EDGE OF A RULER TO EXTEND FOR ONE OR MORE MILLIMETERS.

INTERPRETATIONS:

1. HOW MANY PARTICLES ARE THERE IN A LINE 1 MM LONG? WHAT IS THE AVERAGE SIZE OF THE PARTICLES?
2. WHAT IS THE SIZE RANGE OF THE PARTICLES, FROM THE BIGGEST TO THE SMALLEST?

B. AS YOU HAVE DISCOVERED FROM THIS INVESTIGATION SOIL PARTICLES ARE OF DIFFERENT SIZES. IN THIS PART YOU WILL BE CONCERNED WITH ONE PROPERTY OF SOIL; THE WATER HOLDING CAPACITY OF SOIL. THIS PROPERTY CAN BE RELATED TO PARTICLE SIZE.

MATERIALS: (PER TEAM)
- DRY SAMPLES OF COARSE GRAVEL, FINE SAND, AND CLAY SOIL
- 6 SMALL STYROFOAM DRINKING CUPS
- TRANSPARENT FOOD WRAP
- 100 ML. GRADUATED CYCLINDERS
- RUBBER BANDS
- LARGE METAL PAN
- FOURPENNY (FINISHING) NAIL
- WATCH OR CLOCK WITH SWEEP-SECOND HAND
- MARKING PEN

PROCEDURES:

A. TAKE 3 STYROFOAM CUPS AND WITH A MARKING PEN, LABEL EACH ONE OF THE THREE CUPS A, B, AND C.

B. USE THE NAIL TO PUNCH 10 HOLES IN THE BOTTOM OF EACH CUP. IT IS IMPORTANT THAT THE HOLES ARE PUNCHED IN APPROXIMATELY THE SAME PATTERN IN EACH CUP.

C. FASTEN TRANSPARENT FOOD WRAP TIGHTLY OVER THE BOTTOM OF EACH CUP WITH RUBBER BANDS. AFTER FASTENING THE WRAP WITH RUBBER BANDS, PULL THE FOOD WRAP UPWARDS SO THAT IT IS HELD FLAT AGAINST THE BOTTOM OF EACH CUP. MAKE SURE

THAT THE FOOD WRAP IS NOT WORN OR PUNCTURED; IT MUST HOLD WATER INSIDE THE CUPS.

D. NOW ADD THE PROPER SOIL SAMPLE TO EACH CUP. EACH CUP SHOULD BE FILLED TO THE SAME LEVEL.

E. PREDICT WHICH SOIL SAMPLE YOU THINK HAS THE GREATEST WATER-HOLDING CAPACITY. WHICH HAS THE LEAST WATER-HOLDING CAPACITY? WRITE YOUR PREDICTIONS IN YOUR NOTEBOOK.

F. FILL A GRADUATED CYLINDER WITH WATER TO THE HIGHEST MARKED LEVEL. PLACE THE CUPS IN A PAN. SLOWLY POUR THE WATER INTO CUP A UNTIL THE SOIL IS COMPLETELY SOAKED (SATURATED) AND A LITTLE WATER IS STANDING ON TOP OF THE SOIL. IN YOUR NOTEBOOK, RECORD THE NUMBER OF MILLILITERS OF WATER REQUIRED TO COMPLETELY SOAK THE SAMPLE. REPEAT WITH CUPS B AND C.

INTERPRETATIONS:

1. WHICH SAMPLE HAS THE HIGHEST WATER-HOLDING CAPACITY? WHICH SAMPLE HAS THE LOWEST WATER-HOLDING CAPACITY?
2. HOW DOES THE PARTICLE SIZE OF EACH SAMPLE COMPARE WITH ITS WATER-HOLDING CAPACITY?

PROCEDURES:

G. TAKE THE OTHER 3 CUPS IN A PAN. LABEL THE CUPS D, E, AND F. HOLD THE CUP A OVER CUP D. QUICKLY REMOVE THE FOOD WRAP FROM SAMPLE A AND DISCARD IT AND ANY WATER THAT HAS LEAKED INTO IT. ALLOW THE REMAINING WATER IN THE SAMPLE TO DRIP INTO EMPTY CUP D, UNTIL IT DRIPS AT A RATE OF LESS THAN ONE DROP IN FIFTEEN SECONDS. REPEAT FOR SAMPLES B AND C. MEASURE AND RECORD THE AMOUNT OF WATER RECOVERED FROM EACH.

INTERPRETATIONS:

3. WHAT REASONS CAN YOU GIVE FOR ANY DIFFERENCES IN THE AMOUNT OF WATER ADDED TO AND RECOVERED FROM EACH SOIL SAMPLE?
4. WHAT PROPERTIES OF THE PARTICLES MAKING UP A SOIL SAMPLE WOULD AFFECT THE WATER-HOLDING CAPACITY?
5. HOW MIGHT THE WATER-HOLDING CAPACITY OF UNDISTURBED SOIL BE DIFFERENT FROM THE SOIL SAMPLES YOU USED?

EARTH & WHAT IT'S MADE OF
LEVEL: JUNIOR HIGH

ACTIVITY: WHAT ARE SOME SCIENTIFIC METHODS TO IDENTIFY ROCKS?

MATERIALS:

SANDSTONE	TALC	STREAK PLATE (UNGLAZED TILE)
LIMESTONE	MAGNETITE	PENNY
MARBLE CHIPS	NATIVE COPPER	NAIL
CALCITE	QUARTZ	GLASS
PYRITE	BOTTLE OF ACID	STEEL FILE
HEMATITE	MAGNET	

PROCEDURE:

1. PUT ONE OR TWO DROPS OF ACID ON EACH OF THE ROCKS AND OBSERVE WHAT HAPPENS. RECORD YOUR OBSERVATIONS IN COLUMN 1 OF THE CHART FOLLOWING.
2. TOUCH THE MAGNET TO EACH ROCK. RECORD THE RESULTS IN COLUMN 2.
3. RUB EACH ROCK SAMPLE FROM 5 THROUGH 10 ON THE STREAK PLATE (TILE). RECORD THE COLOR OF THE STREAK IN COLUMN 3.
4. THE HARDNESS KEY GIVEN BELOW WILL HELP YOU DETERMINE HOW HARD EACH ROCK IS. TEST EACH ROCK SAMPLE FROM 4 THROUGH 12 TO DETERMINE ITS HARDNESS. RECORD YOUR FIGURES IN COLUMN 4.

SCRATCHING MATERIAL	HARDNESS
SCRATCH WITH YOUR FINGERNAIL	LESS THAN 2.5
SCRATCH WITH A PENNY BUT NOT WITH YOUR FINGERNAIL	BETWEEN 2.5 AND 3.0
SCRATCH WITH A NAIL BUT NOT WITH A PENNY	BETWEEN 3 AND 5
SCRATCH WITH A PIECE OF GLASS BUT NOT WITH NAIL	BETWEEN 5 AND 6
SCRATCH WITH A STEEL FILE BUT NOT WITH GLASS	BETWEEN 6 AND 7
IF IT REMAINS UNSCRATCHED BY ANY OF THE ABOVE	MORE THAN 7

WHAT DO WE LEARN?

1. WHICH ROCKS REACTED WITH THE ACID? CAN YOU FIGURE OUT WHY THESE REACTED AND THE OTHERS DID NOT?

   ____

   ____

2. DO YOU THINK MANY ROCKS ARE ATTRACTED BY MAGNETS? WHY?

   ____

   ____

3. DO ALL ROCKS HAVE STREAKS? ______________________

4. WHICH ROCK WAS HARDEST? WHICH WAS SOFTEST?

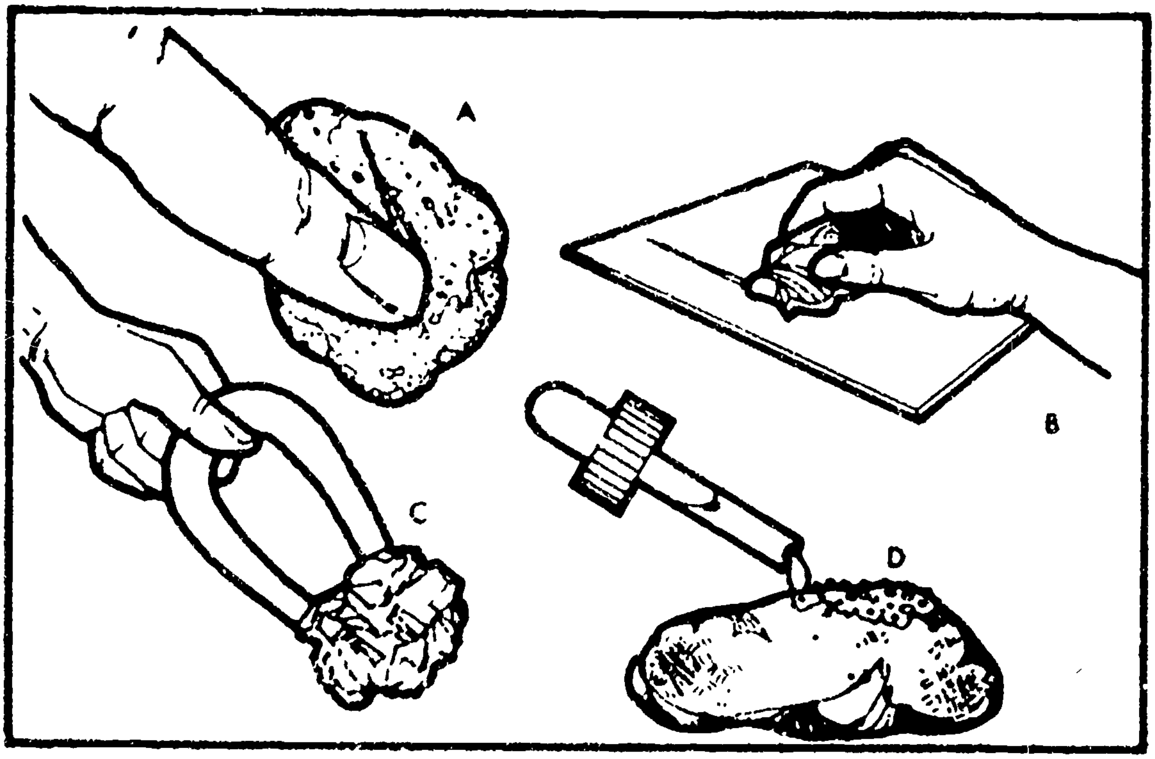
   ____

5. WHICH PICTURE ON THE FOLLOWING PICTURE SHOWS A TEST FOR LIMESTONE? ____ WHICH SHOWS A TEST FOR TALC? ____ WHICH SHOWS A TEST FOR MAGNETITE [redacted]

What Do We See?

Record your observations below.

Rock Sample No. and Name	1 (Did it bubble?)	2 (Was it attracted?)	3 Color	4 Hardness
1. Sandstone				
2. Limestone				
3. Marble				
4. Calcite				
5. Pyrite				
6. Hematite				
7. Talc				
8. Magnetite				
9. Native Copper				
10. Quartz				



EARTH & WHAT IT'S MADE OF
LEVEL: JUNIOR HIGH

ACTIVITY: STUDY OF KINDS OF ROCKS

MATERIALS: (PER TEAM)
SEDIMENTARY ROCK SET
MINERAL SET
BOTTLE DILUTE ACID
HAND LENS
METRIC RULER
IGNEOUS ROCK SET
METAMORPHIC ROCK SET

SEDIMENTARY ROCKS

MOST SEDIMENTARY ROCKS ARE MADE OF MATERIALS THAT COME FROM THE DESTRUCTION OF PREVIOUSLY EXISTING ROCKS. WHEN THIS MATERIAL IS DEPOSITED AND CEMENTED TOGETHER BY PRESSURE AND CHEMICAL ACTION, SEDIMENTARY ROCK IS FORMED. STUDY OF SEDIMENTARY ROCKS CAN PROVIDE INFORMATION ABOUT CONDITIONS THAT EXISTED LONG AGO WHEN THE ROCKS WERE FORMED.

PROCEDURES:

A. STUDY THE SEDIMENTARY ROCKS. COMPARE THEM WITH A LABELED SET TO FIND THE NAME OF EACH TYPE OF ROCK.

B. ARRANGE THE ROCKS IN ORDER ACCORDING TO THE SIZE OF THE PARTICLES OF ANCIENT DEPOSITED MATERIAL THEY CONTAIN. RECORD THE NAMES OF THE SEDIMENTARY ROCKS. THE NAME OF THE ROCK CONTAINING THE LARGEST PARTICLES SHOULD BE LISTED FIRST AND THE OTHERS ACCORDING TO DECREASING PARTICLE SIZE. BESIDE EACH NAME, MAKE A SMALL SKETCH OF THE SAMPLE, AND RECORD THE AVERAGE PARTICLE SIZE IN MILLIMETERS.

INTERPRETATIONS:

1. WHICH ROCK WAS FORMED FROM PARTICLES THAT WOULD SETTLE OUT OF RAPIDLY MOVING WATER?
2. WHICH ROCK WAS FORMED FROM PARTICLES THAT WOULD SETTLE OUT OF SLOWLY MOVING WATER?
3. WHICH ROCKS WERE MOST LIKELY FORMED IN AN OCEAN OR LAKE?

PROCEDURES:

C. FOR EACH TYPE OF ROCK, LIST THE MINERALS YOU THINK IT PROBABLY CONTAINS.

D. TEST EACH MINERAL WITH A DROP OF DILUTE ACID. OBSERVE AND RECORD ANY RESULTS AND THEN BLOT THE DROP WITH A WET PAPER TOWEL.

CAUTION: ACID CAN DAMAGE YOUR SKIN AND CLOTHING. BE CAREFUL NOT TO SPILL IT.

E. TEST EACH ROCK WITH A DROP OF DILUTE ACID, AND RECORD ANY RESULTS. THEN BLOT THE DROP WITH A WET PAPER TOWEL.

INTERPRETATIONS:

4. DID PROCEDURE E GIVE INFORMATION ABOUT THE MINERAL CONTENT OF THE SEDIMENTARY ROCKS? IF SO, WHAT ADDITIONAL INFORMATION WAS GAINED?

PROBLEM:

THE SEDIMENTARY ROCKS OF A CERTAIN ANCIENT RIVER BASIN CONSIST MAINLY OF SANDSTONES. THERE ARE SOME CONGLOMERATES FOUND IN THE NORTHERN PART OF THE AREA AND SOME SHALES IN THE SOUTH. DO YOU THINK THE RIVERS WHICH BROUGHT THE SEDIMENTARY MATERIAL TO THE AREA FLOWED FROM THE NORTH OR FROM THE SOUTH?

PLUTONIC IGNEOUS ROCKS

VOLCANIC ROCKS ARE NOT THE ONLY ONES FORMED FROM MELTED MATERIAL. ALL ROCKS FORMED FROM MOLTEN MATERIAL ARE CALLED IGNEOUS(IG-NEE-US) ROCKS. A COMPARISON OF DIFFERENT ROCKS CAN GIVE INFORMATION ABOUT THE DIFFERING CONDITIONS UNDER WHICH THEY WERE FORMED.

PROCEDURES:

A. EXAMINE THE IGNEOUS ROCKS AND CLASSIFY THEM INTO GROUPS ACCORDING TO THE CONDITIONS IN WHICH YOU THINK THEY WERE FORMED. IN A NOTEBOOK, RECORD WHAT YOU THINK THESE CONDITIONS WERE AND THE NAMES OF THE ROCKS IN EACH GROUP.

INTERPRETATIONS:

1. WHICH ROCKS DO YOU THINK WERE FORMED AT THE GREATEST DEPTH AND WHICH AT THE LEAST DEPTH? GIVE REASONS TO SUPPORT YOUR ANSWER.

PROCEDURES:

B. EXAMINE THE TWO ROCKS YOU HAVE NOT PREVIOUSLY STUDIED AND TRY TO DETERMINE THEIR MINERAL CONTENT. USE THE MAGNIFYING LENS IF NECESSARY.

INTERPRETATIONS:

2. COMPARED WITH THE VOLCANIC ROCKS, IS IT EASIER OR HARDER TO IDENTIFY THE MINERAL CONTENT OF THE TWO NEW IGNEOUS ROCKS? WHY?
3. WHAT MINERALS DO YOU THINK ARE IN THE TWO NEW IGNEOUS ROCKS?
4. HOW COULD YOU TEST TO SEE WHETHER IGNEOUS ROCKS CONTAIN CALCITE?
5. DO ANY OF THE IGNEOUS ROCKS CONTAIN CALCITE?

METAMORPHIC ROCKS

PREEXISTING ROCKS WHICH ARE CHANGED BY HEAT AND PRESSURE ARE CALLED METAMORPHIC ROCKS. METAMORPHIC ROCKS MAY BE FORMED FROM SEDIMENTARY OR IGNEOUS ROCKS. INSPECTION OF METAMORPHIC ROCKS CAN GIVE INFORMATION ABOUT THE DEGREE OF METAMORPHISM WHICH HAS TAKEN PLACE-THAT IS, THE AMOUNT OF CHANGE WHICH HEAT AND PRESSURE HAVE PRODUCED IN THE ROCKS.

PROCEDURES:

A. EXAMINE THE METAMORPHIC ROCKS AND ATTEMPT TO ARRANGE THEM IN ORDER OF INCREASING SHININESS. ASSUMING THAT ALL OF THESE ROCKS WERE ONCE SHALELIKE, DECIDE WHICH OF THEM HAS BEEN MOST ALTERED. RECORD YOUR RESULTS IN ORDER FROM LEAST CHANGED TO MOST CHANGED.

INTERPRETATIONS:

1. DO ALL SIDES OF THE METAMORPHIC ROCK SAMPLES REFLECT LIGHT EQUALLY?
2. WHAT MINERAL MIGHT ACCOUNT FOR THE MANNER IN WHICH METAMORPHIC ROCKS REFLECT LIGHT?
3. CAN YOU RECOGNIZE THIS MINERAL IN ANY OF THE ROCKS? IF SO, IN WHICH ONES?
4. WHAT OTHER MINERALS CAN YOU RECOGNIZE IN THE METAMORPHIC ROCKS? IN WHICH OF THE ROCKS DO THESE MINERALS APPEAR?
5. WHICH OF THE METAMORPHIC ROCKS MOST CLOSELY RESEMBLES GRANITE? IN WHAT WAYS?
6. HOW DOES THIS ROCK DIFFER FROM GRANITE?
7. DESCRIBE A CHARACTERISTIC STRUCTURE OF METAMORPHIC ROCKS.
8. HOW MIGHT THIS STRUCTURE BE RELATED TO THE PRESSURE THAT CAUSED THE METAMORPHISM?

EARTH AND WHAT IT IS MADE OF

Level: 7th - 9th

ACTIVITY: What's going on down there?
(A simple experiment on seismology)

MATERIALS: Two super-slinkies — Weight (lead sinker)
Marking pen — Paper

Introduction: The only way the geologists and geophysicist can study the interior of the earth is with the seismograph. We get information from inside the Earth in the same way we get information from light and sound in the form of waves. And just like a doctor listening to your chest, or a mechanic listening to your motor, we must first learn how to understand the waves coming from inside the Earth.

A. MY WAVE CAN BEAT YOUR WAVE

All waves have certain things in common. Waves traveling along springs will give us clues about waves in the Earth.

Lay a super-Slinky on the floor and have your partner pull it in a straight line out to at least 30 feet. All of the super-Slinky, including both ends, should be touching the floor. (You may have to go out in the hall to do this one.) Give your hand, holding the end of the super-Slinky, a quick jerk sideways. This sends one kind of wave down the Slinky.

1. Describe what you see as the wave goes down to the other end.

This is a crossways or transverse wave. Now try another kind of wave. Give your hand, holding the end of the super-Slinky, a quick jerk back and forth. This sends another kind of wave down the Slinky.

2. Describe what you see as this wave goes down the Slinky.

This second wave is a compression wave. Now let's race them.

Get two super-Slinkies, side by side, stretched out straight to the same distance, with your partner holding down both at one end. At exactly the same moment, send a transverse wave down one and a compression wave down the other. (If this is difficult to do alone, you may want another team-member to work with you, and someone to give the signal: "One-two-three.")

3. Which kind of wave got down to the end first?

4. If two such es start together from an earthquake, how will they be :eived a short distance away?

5. What will change if they come from a long distance away?

B. GET THE MESSAGE

Telephones, radios, television receivers, and record players all work by converting waves you can[illegible]ct into waves you see

OR HEAR. IN ORDER TO STUDY EARTHQUAKE PATTERNS WE MUST DETECT THE TRANSVERSE AND COMPRESSION WAVES COMING THROUGH THE EARTH.

TIE A WEIGHT TO THE END OF ABOUT A METER OF LIGHT STRING. CHOOSE A WEIGHT LIKE A LEAD SINKER SO YOU CAN ATTACH THE STRING AT THE TOP CENTER. HOLD THE END OF THE STRING. THE WEIGHT SHOULD HANG JUST OFF THE FLOOR, NEITHER SPINNING NOR SWINGING. SLOWLY MOVE YOUR HAND FROM SIDE TO SIDE.

6. WHAT DOES THE WEIGHT DO?

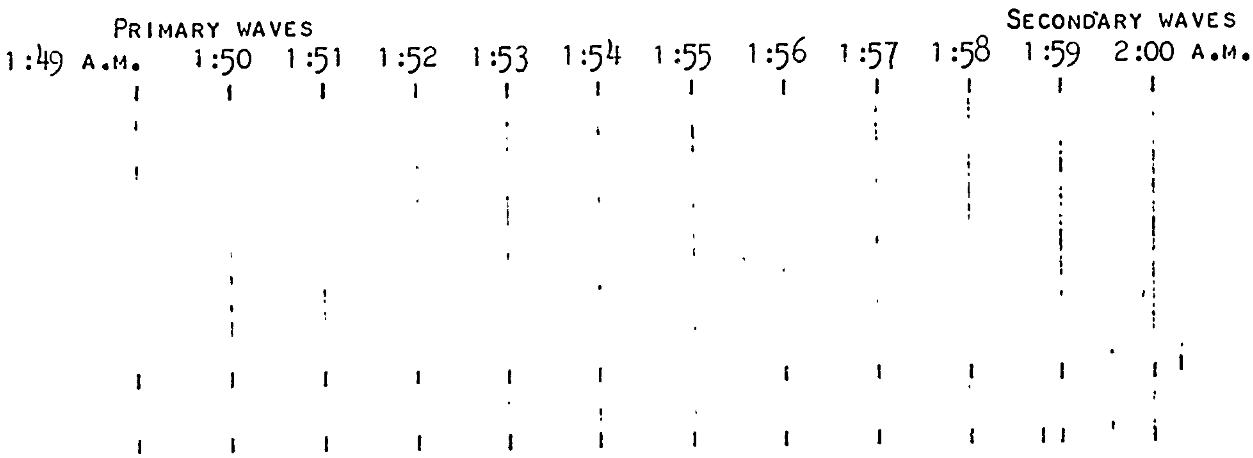
7. MOVE YOUR HAND FROM SIDE TO SIDE QUICKLY. WHAT DOES THE WEIGHT DO THIS TIME?

8. IF THE FLOOR MOVED SIDEWAYS, WHAT DO YOU THINK THE WEIGHT WOULD DO?

HOLD A MARKING PEN STRAIGHT UP AND DOWN OVER A PIECE OF PAPER. MOVE YOUR HAND FROM SIDE TO SIDE SLOWLY AS YOUR PARTNER PULLS THE PAPER WITH A STEADY MOTION. (DON'T TRY TO DO BOTH THINGS YOURSELF.)

9. DESCRIBE THE MARKS ON THE PAPER.

10. PULL THE PAPER AT THE SAME SPEED AGAIN. HOW DO THE MARKS CHANGE WHEN YOU MOVE YOUR HAND FASTER?



RUMANIAN EARTHQUAKE
NOVEMBER 10, 1940

THE SEISMOGRAPH IS AN INSTRUMENT THAT DRAWS EARTHQUAKE WAVES. IT HAS A WEIGHT, A PEN, AND A MOVING STRIP OF PAPER. IT RECORDS A WIGGLY LINE MINUTE BY MINUTE. JUST AS YOU GOT DIFFERENT-LOOKING RESULTS WHEN YOU MOVED YOUR HAND FASTER OR SLOWER, THE SEISMOGRAPH SHOWS A PICTURE OF THE DIFFERENT KINDS OF WAVES REACHING IT.

You found that compression waves move faster than transverse waves. They have been timed and their speeds compared. The data are in Table No. 1. The faster, compression wave is called the Primary wave. The slower, transverse wave is the Secondary wave.

Miles From Source	Time Between Primary And Secondary Waves	
	Minutes	Seconds
1,000	2	41
2,000	4	52
3,000	6	27
4,000	8	00
5,000	9	25
6,000	10	44
7,000	11	49

11. Look at the second column of Table No. 1. How much time was there between the first Primary wave and the first Secondary wave, if the seismograph was 2,000 miles from the earthquake?

12. Look at the record of the Rumanian earthquake of November 10, 1940. When did the big Secondary waves begin? Estimate the time in minutes and seconds between the beginning of the Primary waves and the beginning of the Secondary waves.

13. What time did you get?

14. What distance do you get?

A model seismograph may be built by suspending a weight from a support such as a ring stand. Fasten a pencil to the weight so that it just touches a paper underneath. Bump the table. What happens?

EARTH AND WHAT IT IS MADE OF
LEVEL: 8TH - 9TH

ACTIVITIES: INVESTIGATING ROCKS AND MINERALS

MATERIALS: SOLID GRANITE, CRUSHED GRANITE, MAGNIFIER, TEASING NEEDLE

TO THE TEACHER: HAVE THE STUDENTS EXAMINE A SOLID PIECE OF GRANITE. AFTER A FEW MINUTES HAVE EACH GROUP OBTAIN CRUSHED MATERIAL. THE STUDENTS ARE TO DIVIDE THE ROCK PIECES INTO PILES OF SIMILAR LOOKING MATERIALS AND DESCRIBE EACH PILE.

MOST DESCRIPTIONS WILL INVOLVE COLOR AND SHAPE.

STUDENTS SHOULD HAVE AT LEAST THREE PILES: QUARTZ, FELDSPAR, AND MICA.

MINERAL DESCRIPTION FOR THE TEACHER:

QUARTZ- TRANSPARENT, SHINY, GLASSY; BREAKS IRREGULARLY.

BIOTITE (MICA)- BLACK, SHINY, AND FLAKY.

MUSCONITE (MICA)- TRANSPARENT OR YELLOWISH, SHINY, AND FLAKY.

FELDSPAR- ROSE, PINK, MILKY OR COLORLESS; CHUNKY, BREAKS ANGULARLY.

HORNBLENDE- DULL, GREENISH-BLACK; ELONGATED.

EARTH AND WHAT IT IS MADE OF
LEVEL: 8TH - 9TH

ACTIVITY: INTERNAL TEMPERATURE OF THE EARTH

MATERIALS: GRAPH PAPER
COLORED PENCILS

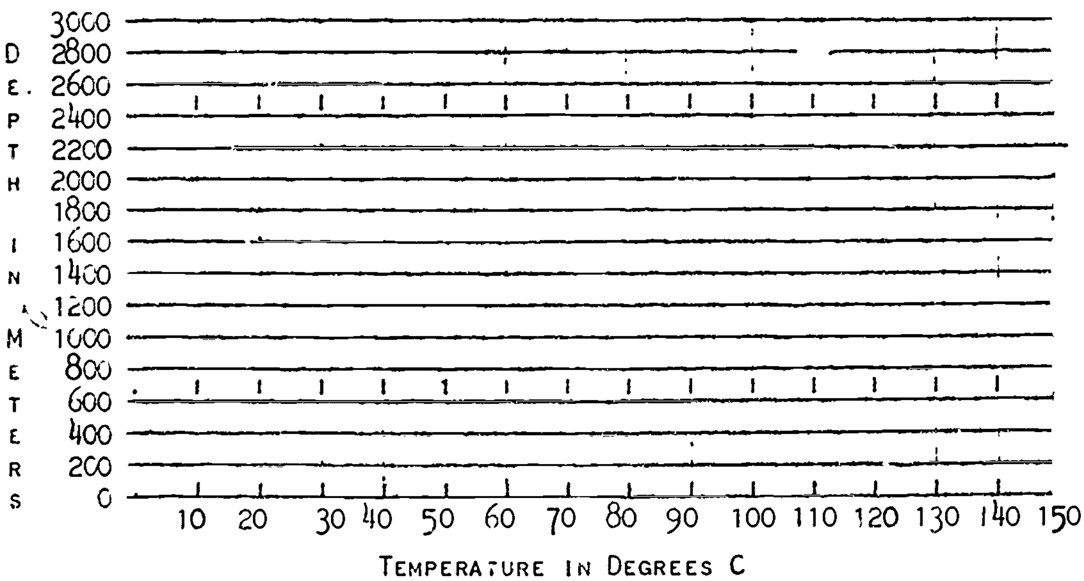
INVESTIGATION
THE DATA GIVEN IN TABLE I BELOW ARE AVERAGE TEMPERATURE MEASUREMENTS. THE RATE OF CHANGE IN TEMPERATURE IS KNOWN AS THE TEMPERATURE GRADIENT.

TABLE I

OIL FIELD A		OIL FIELD B		OIL FIELD C	
244 METERS	30°C	364 METERS	34°C	396 METERS	34°C
610	42	855	47	610	46
1000	54	1300	68	1050	62
1280	72	1580	80	1465	72
1700	88	1830	97	1830	84
2140	99	2380	108	2075	102

INTERPRETATION:

1. PLOT THE VALUES OF TABLE I ON THE GRAPH. IF POSSIBLE, USE DIFFERENT-COLORED PENCILS FOR EACH SET OF DATA.



2. AT THE 400-METER AND 2000-METER LEVELS, DRAW A HORIZONTAL LINE WHICH INTERSECTS THE THREE GRAPHS. THEN COMPLETE THE FOLLOWING TABLE.

OIL FIELD	TEMP. AT 400-M LEVEL	TEMP. AT 2000-M LEVEL	TEMP. GRADIENT PER KILOMETER
A			
B			
C			

3. WHAT IS THE AVERAGE TEMPERATURE PER KILOMETER FOR THE THREE OIL FIELDS? (NEAREST DEGREE)____________________
CALCULATIONS:

4. IS THE AVERAGE TEMPERATURE CONSTANT THROUGHOUT THE DEPTH, OR DOES IT CHANGE APPRECIABLY?____________________

____

5. WHAT IS THE AVERAGE TEMPERATURE GRADIENT PER KILOMETER OF DEPTH FOR EACH OF THE THREE OIL FIELDS? OIL FIELD A______
OIL FIELD B__________ OIL FIELD C__________

6. HOW DOES THE AVERAGE TEMPERATURE GRADIENT OBTAINED IN QUESTION 5 COMPARE WITH THAT OBTAINED FROM THE GRAPH?

____

____

7. ASSUMING THAT THE SAME GRADIENT PERSISTS WITH DEPTH, WHAT WOULD BE THE TEMPERATURE AT THE CENTER OF THE EARTH? (THE DIAMETER OF THE EARTH IS APPROXIMATELY 12,800 KILOMETERS.)

____

CALCULATIONS:

8. IS THE ESTIMATE OBTAINED IN QUESTION 7 REASONABLE?______
SUPPORT YOUR ANSWER____________________

____

____

____

____

____

EARTH AND WHAT IT IS MADE OF
LEVEL: 8TH-12TH

ACTIVITY: IDENTIFICATION OF MINERALS

MATERIALS: MINERALS TO BE TESTED
MINEROLOGY BOOK SUCH AS
DANA'S MANUAL OF MINEROLOGY

LABORATORY ON MINERALS

WHAT IS A MINERAL? A MINERAL AND ITS PROPERTIES ARE DETERMINED BY (1) CHEMICAL COMPOSITION (THE KINDS OF ATOMS PRESENT), WHICH IS FIXED WITHIN CERTAIN LIMITS, AND (2) CRYSTAL STRUCTURE (THE ARRANGEMENT OF THE ATOMS). THOUGH MANY SUBSTANCES SATISFY BOTH THESE REQUIREMENTS, WE DO NOT ORDINARILY REGARD THEM AS MINERALS UNLESS THEY OCCUR IN A NATURAL STATE.

PROPERTIES

COLOR

THE COLOR OF A MINERAL IS USUALLY NOTICED FIRST. THOUGH IMPORTANT IT IS SELDOM DIAGNOSTIC BY ITSELF, AS MANY MINERALS VARY WIDELY IN COLOR.

STREAK

THE COLOR OF THE POWDER FROM A MINERAL IS CALLED THE STREAK. TO OBTAIN THE STREAK, RUB THE MINERAL ON A PIECE OF UNGLAZED PORCELAIN OR MAKE A SMALL AMOUNT OF POWDER BY SCRATCHING THE SURFACE OF THE MINERAL WITH A KNIFE BLADE. MINERALS HARDER THAN THE PORCELAIN OR KNIFE WILL LEAVE NO STREAK, AND THE STREAK IN SUCH CASES IS USUALLY SAID TO BE WHITE.

HARDNESS

THE HARDNESS IS DETERMINED BY SCRATCH TESTS. ON THE BASIS OF THESE THE HARDNESS SCALE HAS BEEN SET UP.

TALC (SOFTEST OF ALL ROCKS)------1
GYPSUM --------------------------2
CALCITE -------------------------3
FLUORITE ------------------------4
APATITE -------------------------5
FELDSPAR ------------------------6
QUARTZ --------------------------7
TOPAZ ---------------------------8
SAPPHIRE ------------------------9
DIAMOND -------------------------10

TO ROUGHLY ESTIMATE THE HARDNESS OF MINERALS, THE FOLLOWING VALUES ARE USEFUL.

FINGER NAILS------2.5
COPPER PENNY------3.0

KNIFE BLADE------5.5
GLASS-----------5.5
QUARTZ----------7.0

SPECIFIC GRAVITY

Minerals vary in weight per unit volume. Quartz and calcite are light and gold and galena are heavy. An exact measure of this property is called specific gravity, and is determined by dividing the weight of the mineral by the weight of an equal volume of water. Thus, when we say that gold has a specific gravity of 19, we mean that a cubic inch of gold weighs 19 times as much as a cubic inch of water.

CLEAVAGE AND FRACTURE

Certain minerals have a tendency to cleave, producing a series of smooth flat surfaces. A good example of a single cleavage would be mica. A cleavage is the result of a crystal structure.

If the crystal does not break along a cleavage surface, it may fracture. Quartz shows no cleavage but does have a distinctive shellshaped fracture called a conchoidal fracture.

MINERAL DESCRIPTION FORM

Color	Color of streak	Cleavage or Fracture	Hardness	Other Characteristics	Name and Chemical Comp.	Uses

CHANGES IN EARTH SURFACE

EARTH SCIENCE- CHANGES ON EARTH SURFACE

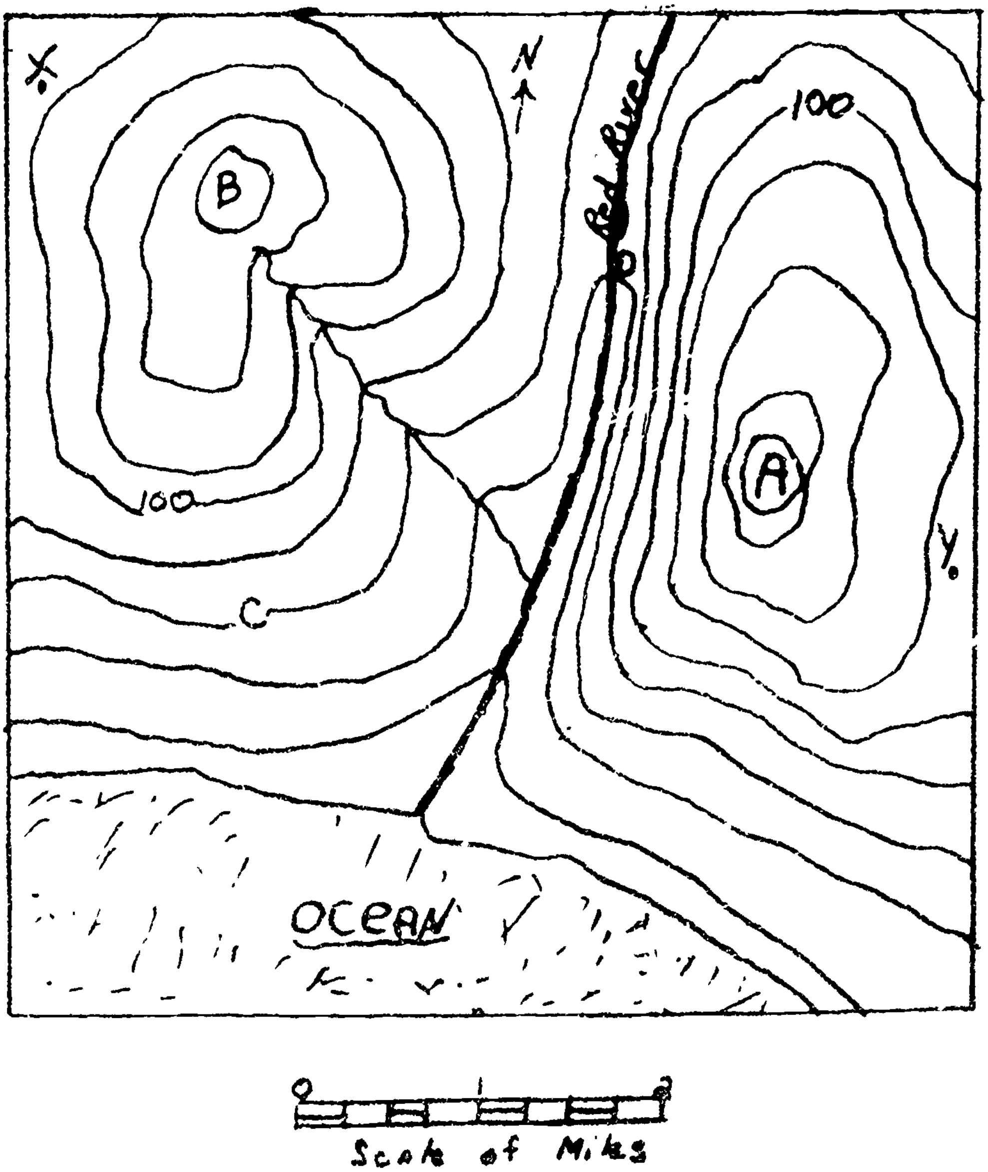
PETROLEUM ENGINEER
GEOPHYSICS
OCEANOGRAPHER
ELEMENTARY TEACHER
TECHNICAL WRITER
AGRICULTURAL EXTENSION WORKER
FARM CROP PRODUCTION TECHNICIAN
FISH & WILDLIFE TECHNICIAN
ORCHARD TECHNICIAN
PARKS LAND MANAGEMENT TECHNICIAN
SOIL CONSERVATIONIST
STRUCTURAL STEEL WORKER
GEOLOGIST
METEOROLOGIST
SURVEYOR
TEACHER SECONDARY-COLLEGE
URBAN PLANNER
DAIRY PRODUCTION TECHNICIAN
FARMING
FORESTER
HORTICULTURIST
RANGE MANAGEMENT
SOIL SCIENTIST

CHANGES ON EARTH SURFACE
LEVEL: JUNIOR HIGH

ACTIVITY: INTRODUCTION TO CONTOUR MAPS

MATERIALS: CONTOUR MAP PRINT OUT
LAB ACTIVITY WORK SHEET

PROCEDURE:



1. DEFINE CONTOUR LINE.

2. DEFINE CONTOUR INTERVAL.

3. WHAT IS THE CONTOUR INTERVAL OF THIS MAP?

4. NUMBER ALL THE CONTOUR LINES

5. WHAT IS THE SCALE OF MILES OF THIS MAP?

6. BY MEANS OF THE SCALE, MEASURE THE DISTANCE FROM THE TOP OF HILL "B" TO THE TOP OF HILL "A".

7. WHICH SIDE OF THE HILL "A" HAS THE STEEPEST SLOPE?

8. HOW CAN YOU TELL WHETHER A LAND FORM HAS STEEP OR GENTLE SLOPES?

9. IN WHAT DIRECTION FROM HILL "A" IS HILL "B"?_______________

10. WHAT IS THE ELEVATION ABOVE SEA LEVEL OF HILL "A"?____________

11.A WHICH OF THE TWO HILLS IS HIGHER?______ B HOW MUCH HIGHER?_______

12. IF YOU CLIMBED TO THE TOP OF HILL "B" FROM C, HOW MANY FEET WOULD YOU CLIMB?

13. IN WHAT DIRECTION IS THE RED RIVER FLOWING?______________

14. HOW DOES A CONTOUR MAP SHOW THE DIRECTION IN WHICH A RIVER IS FLOWING?

15. SHADE THE AREA ON THE MAP WHICH WOULD BE UNDER WATER IF THE SEA LEVEL ROSE 40 FEET.

16. FIND THE GRADIENT OF THE RED RIVER FROM POINT D TO THE OCEAN.

17. CONSTRUCT A PROFILE FROM X TO Y AS FOLLOWS: DRAW A LINE ON THE MAP FROM X TO Y. LAY A STRAIGHT EDGE OF A SHEET OF PAPER JUST UNDER THIS LINE XY. MARK ON THE PAPER WHERE EACH CONTOUR LINE AND THE RED RIVER BANKS INTERSECT THE EDGE. MARK THE ELEVATION OF EACH POINT ON THE PAPER. ASSUME THE SURFACE ELEVATION OF THE RIVER IS 30 FEET. TRANSFER THE MARKS AND FIGURES TO THE BASE LINE XY BELOW. PLOT THE ELEVATION OF EACH OF THESE POINTS USING THE VERTICAL SCALE GIVEN BELOW. LABEL THE TWO HILLS AND THE VALLEY.

200 FT.

160

120

80

40

0

X Y

CHANGES ON EARTH SURFACE

LEVEL: JUNIOR HIGH .

ACTIVITY: LANDSCAPE EVOLUTION & DRAINAGE SYSTEMS

MATERIALS: DIE (DICE)
QUADRILLE PAPER
A MAP OF A DENDRITIC DRAINAGE PATTERN

IMAGINE RAIN FALLING ON A SMOOTH, SLOPING AREA OF THE EARTH'S SURFACE. SOME OF THE DROPS SOAK INTO THE SURFACE, AND OTHERS EVAPORATE BACK INTO THE ATMOSPHERE. THE REST OF THE DROPS FLOW ALONG THE SURFACE. EACH MOVES DOWNSLOPE UNTIL IT COMES TO SOME SMALL OBSTACLE. WILL THE DROP THEN PASS TO THE LEFT OR TO THE RIGHT OF THE OBSTACLE? IT IS NOT POSSIBLE TO PREDICT THIS. SUCH AN UNPREDICTABLE EVENT IS SAID TO BE RANDOM. IN THIS INVESTIGATION YOU WILL PRODUCE SOME RANDOM PATHS.

PROCEDURES:

A. SELECT ONE OF THE LONG SIDES OF THE PAPER TO REPRESENT DOWNSLOPE. REPRESENT THE DOWNSLOPE BY A SHORT ARROW DRAWN PARALLEL TO AND NEAR EITHER OF THE SHORTER SIDES OF THE PAPER.

B. PLACE ABOUT FORTY DOTS ON THE SHEET OF PAPER AS FOLLOWS: EACH DOT SHOULD BE LOCATED AT A CORNER OF ONE OF THE SMALL SQUARES RULED ON THE PAPER; THE DOTS SHOULD BE SPACED FAIRLY UNIFORMLY, BUT THERE SHOULD BE NO ORDER OR PATTERN TO THEM. THE DOTS WILL REPRESENT DROPS WHICH WILL MOVE DOWN THE SURFACE ACCORDING TO THE FOLLOWING RULES:

   1. IN ITS TURN EACH DROP IS MOVED ONE SPACE, AND ITS PATH IS MARKED BY A PENCIL LINE ON THE PAPER.
   2. BEFORE IT IS MOVED, THE DROP'S PATH IS DETERMINED BY ROLLING THE DIE. A ROLL OF 1 OR 2 ON THE DIE DETERMINES THAT THE PATH WILL BE DIAGONALLY DOWNSLOPE TO THE LEFT, A 3 OR 4, THAT IT WILL BE DIRECTLY DOWNSLOPE, AND A 5 OR 6, THAT IT WILL BE DIAGONALLY DOWNSLOPE TO THE RIGHT. (NOTE THAT THE NUMBER ON THE DIE INDICATE DIRECTION ONLY, AND NOT DISTANCE.)
   3. IN GENERAL, UPSLOPE DOTS SHOULD BE ROLLED FOR AND MOVED BEFORE LOWER DOTS ARE MOVED. DO NOT MOVE DOTS DOWNSLOPE UNTIL ALL UPPER DOTS HAVE PROGRESSED DOWN TO THEIR LEVEL.
   4. ONCE A DROP INTERSECTS THE PATH OR LOCATION OF ANOTHER DROP, THE TWO MOVE TOGETHER, AND THEIR PATH IS REPRESENTED BY TWO PENCIL LINES SIDE-BY-SIDE. A SINGLE ROLL OF THE DIE WILL DETERMINE THE DIRECTION OF THEIR JOINT MOVE. IF A THIRD DROP JOINS IN, THE THREE WILL THEREAFTER MOVE TOGETHER, AND THEIR PATH IS MARKED BY THREE PARALLEL LINES, AND SO ON.
   5. OTHER THINGS BEING EQUAL, LARGER AMOUNTS OF WATER MOVE MORE READILY DOWN A SLOPE THAN DO SMALLER AMOUNTS. IN ORDER TO ACCOUNT FOR THIS, THE LENGTH OF A MOVE IS DETERMINED BY THE NUMBER OF DOTS REPRESENTED IN THAT MOVE: SINGLE DROPS MOVE ONE SPACE EACH ROLL; TWO TOGETHER MOVE TWO SPACES IN THE DIRECTION DETERMINED BY A SINGLE ROLL.

PROCEDURES:

C. ROLL THE DIE AND DRAW THE PATHS FOR THE DOTS UNTIL ALL HAVE MOVED OFF THE SHEET. COMPARE YOUR RESULTS TO A MAP OF AN ACTUAL DRAINAGE PATTERN OF DENDRITIC OR TRELLIS.

INTERPRETATIONS

1. IN WHAT WAYS DOES THE PATTERN PRODUCED BY MOVING THE DOTS RESEMBLE THE DRAINAGE PATTERN OF A DENDRITIC SYSTEM?
2. IN WHAT WAYS DOES THE PATTERN YOU PRODUCED DIFFER FROM THE DRAINAGE PATTERN OF A DENDRITIC SYSTEM?
3. HOW MIGHT THE RULES BE CHANGED TO PRODUCE A PATTERN THAT CORRESPONDS MORE CLOSELY TO THE DRAINAGE PATTERN?

CHANGES IN EARTH SURFACE
LEVEL: 7TH-10TH

ACTIVITY: GROWTH OF PLANTS IN DIFFERENT SOILS

PROBLEM:

YOU KNOW THAT THE GROWTH OF MOST PLANTS USUALLY DEPENDS ON THE TYPE OF SOIL IN WHICH THEY ARE GROWN. THUS, SOME SOILS ARE MORE FERTILE THAN OTHERS. WHAT ARE THE RESULTS OF GROWING THE SAME KINDS OF PLANTS IN TOPSOIL AND IN SUBSOIL?

MATERIALS:

TWO LARGE FLOWERPOTS
SAMPLES OF TOPSOIL AND SUBSOIL
RADISH SEEDS

PROCEDURE:

LOCATE AN OPEN FIELD OR VACANT LOT WHERE THE GROUND HAS NOT BEEN CULTIVATED, AND DIG DOWN TO OBTAIN SAMPLES OF THE SOIL. FILL ONE FLOWERPOT WITH THE DARKER TOPSOIL FOUND A FEW INCHES BELOW THE SURFACE OF THE GROUND. DIG DOWN DEEPER AND FILL THE SECOND FLOWERPOT WITH SUBSOIL FOUND 12 INCHES OR MORE BELOW THE SURFACE.

PLANT ABOUT 15 RADISH SEEDS WHICH HAVE BEEN SOAKED IN WATER OVERNIGHT IN EACH FLOWERPOT. WATER BOTH POTS REGULARLY AND KEEP THEM IN A WARM, LIGHTED CONDITION, BUT NOT IN DIRECT SUNLIGHT. OBSERVE ANY DIFFERENCES IN THE GROWTH OF THE RADISH PLANTS.

OBSERVATIONS:

FILL IN THE FOLLOWING TABLE AND DRAW CONSLUSIONS.

LENGTH OF GROWING PERIOD	PLANTS GROWN IN TOPSOIL				PLANTS GROWN IN SUBSOILS			
	NO. OF PLANTS GROWING	AVERAGE HEIGHT OF PLANTS	AVERAGE NO. OF LEAVES	AVERAGE DIAMETER OF ROOTS	NO. OF PLANTS GROWING	AVERAGE HEIGHT OF PLANTS	AVERAGE NO. OF LEAVES	AVERAGE DIAMETER OF ROOTS
4 DAYS								
6 DAYS								
8 DAYS								
10 DAYS								
12 DAYS								
14 DAYS								

WHY ARE MEASURES TAKEN TO PREVENT EROSION OF FARM LANDS IMPORTANT AS A MEANS OF PREVENTING THE LOSS OF SOIL FERTILITY?

Changes in Earth Surface
Level: Jr. High or High School

ACTIVITY: Measure Amount of Soil Loss

You can measure how much soil has been eroded away in several ways. You may want to try one of the following in your neighborhood:

1. Find a cultivated field where the slope has at least a 5-foot fall in 100 feet of horizontal distance. Try to find a field that has been in cultivation for some time. You can check this information about the farm with the owner or the neighbors.

   Dig a small hole deep enough to get below the topsoil layer. Then cut off a slice an inch or more thick along the vertical side of the hole. Lay this slice on the ground and study it. Note the depth of the topsoil layer. Study the structure--how the particles are held together. Are they tight and does the soil hold together in large lumps (clods)? Or is it crumbly like cake?

   Dig another hole in the fence row at the edge of the field or just across the fence in a pasture that has not been plowed. Try to dig the second hole at about the same point on the slope and as close to the first one as possible. Study the soil layers as you did with the first sample. Lay the two samples side by side and compare them. Compare the depth of the topsoil layer and the structure of the soil.

2. Find a field where there is a fence built across the slope. Compare the height of the land at the fence row with that in the field down the slope. To do this attach a string to a stake driven in the ground above the fence row. From a spot down the slope, pull the string parallel to the ground line above the fence and measure from it to the ground.

3. Measure the growth of a gully. Find one that is cutting deeper and farther into the field with each rain. Drive wooden pegs 10 to 15 feet above the gully head and on each side of the gully. After each rain, measure from each stake to the nearest edge of the gully to see how much the gully has grown. Do this after several rains and compare your measurements to see how much the gully has grown since you first set the stakes. By measuring the width, depth, and length of the gully, figure out how many cubic feet of soil have been lost.

Interpretation:

Soil washed from a field is not necessarily lost forever. But for all practical purposes it may be lost for a very long time. The soil fills the bottom of a lake, for example, is still soil, but it is useless for agriculture. Soil that is piled deeply at the lower edge of a field covers other soil, making it useless. And soil that is carried to the sea may lie there, turn to rock, and later be raised from the ocean floor [illegible]logic action to be broken down again into soil.

THE FIRST PERSON TO SUFFER FROM LOSS OF SOIL USUALLY, THOUGH NOT ALWAYS, IS THE FARMER. MANY EXPERIMENTS HAVE SHOWN THAT IN GENERAL THE DEEPER THE ORIGINAL TOPSOIL THE HIGHER THE YIELD OF CROPS. IN MISSOURI TOPSOIL 12 INCHES THICK PRODUCED 64 BUSHELS OF CORN PER ACRE WHILE TOPSOIL 4 INCHES DEEP PRODUCED 38 BUSHELS. THE SOILS WERE SIDE BY SIDE AND RECEIVED THE SAME TREATMENT.

IN WASHINGTON, WHEAT YIELDED 35 BUSHELS PER ACRE ON TOPSOIL 11 INCHES DEEP, BUT ONLY 23 BUSHELS ON TOPSOIL 5 INCHES DEEP.

SO THE FARMER LOSES WHEN HE LOSES TOPSOIL. HIS CROP YIELDS GO DOWN. THE COST OF PRODUCING EACH BUSHEL OF GRAIN OR POUND OF MEAT GOES UP. AND, HE MAKES LESS MONEY OR EVEN LOSES MONEY.

PEOPLE WHO DO NOT LIVE ON THE LAND DEPEND ON THE FARMER TO GROW THEIR FOOD. THE SURPLUS THAT HE GROWS BECOMES THEIR THREE MEALS A DAY. ACTUALLY, WHOLE CIVILIZATIONS DEPEND ON THIS SURPLUS. THE PRIMARY PRODUCERS--THE FARMERS--MUST SUPPLY A SURPLUS OF FOOD, CLOTHING, SHELTER, AND OTHER NECESSITIES BEFORE THE ARTISANS, ENGINEERS, SCIENTISTS, PHILOSOPHERS, WRITERS, AND OTHERS CAN LIVE. FEW NATIONS EVER ADVANCED THEIR CIVILIZATION WHILE ALL THEIR PEOPLE PRODUCED THEIR OWN FOOD, CLOTHING, AND SHELTER DIRECTLY FROM THE SOIL.

WE CAN FIND PLENTY OF EVIDENCE THAT COUNTRIES THAT LOST THEIR ABILITY TO PRODUCE A SURPLUS ACTUALLY LOST THEIR CIVILIZATIONS TOO. ALL ACROSS THE CONTINENT OF ASIA AND INTO EUROPE AND NORTH AFRICA, FOR EXAMPLE, YOU CAN FIND CENTERS OF FORMER CIVILIZATIONS THAT ARE NOW AMONG THE BACKWARD AREAS OF THE WORLD. IT IS TRUE THAT CONQUERING HORDES THAT REPEATEDLY OVERRAN THESE COUNTRIES SACKED AND RAZED THE CITIES. BUT WHERE SOIL AND OTHER RESOURCES REMAINED THE CITIES WERE USUALLY REBUILT. IT WAS ONLY AFTER THE LAND WAS DEPLETED OR EXHAUSTED THAT THE FIELDS BECAME BARREN AND THE CITIES WERE NOT REBUILT.

HOW BADLY HAS EROSION HURT AMERICA? ACCORDING TO THE BEST INFORMATION WE NOW HAVE, 25 MILLION ACRES OF LAND ONCE SUITABLE FOR CULTIVATION HAS NOW BEEN LOST. EVERY YEAR WE ARE LOSING ANOTHER 400,000 ACRES TO EROSION AND 100,000 ACRES TO WATERLOGGING, SALTING, AND SEDIMENT DEPOSITION. IN ADDITION TO THESE LOSSES, EVERY YEAR MORE THAN A MILLION ACRES ARE BEING TAKEN OUT OF AGRICULTURAL USE AND PUT INTO HIGHWAYS, URBAN DEVELOPMENT, AIRPORTS, AND OTHER NON-AGRICULTURAL USES.

WHAT ABOUT THE LAND WE NOW HAVE? OF OUR TOTAL OF 478 MILLION ACRES NOW IN CULTIVATION, 121 MILLION IS SUBJECT TO A CRITICAL RATE OF DAMAGE. ANOTHER 128 MILLION IS SUBJECT TO SERIOUS DAMAGE.

CHANGES IN EARTH SURFACE
LEVEL: JR. HIGH OR HIGH SCHOOL

ACTIVITY: THE FIELD TRIP TO STUDY THE CHANGES IN THE EARTH'S SURFACE

ALTHOUGH CERTAIN ASPECTS OF GEOLOGY CAN BEST BE TREATED IN THE LABORATORY, IT IS STILL AS TRUE AS EVER THAT THIS IS A FIELD SCIENCE. TO THE BEGINNER IN GEOLOGY, THE FIELD TRIP IS SUPERIOR TO THE VARIOUS VISUAL AIDS USED IN THE CLASSROOM.

IT IS IMPORTANT THAT EACH MEMBER OF THE CLASS DISCOVER THE REQUIRED INFORMATION FOR HIMSELF. SYSTEMATIC NOTE TAKING IS ESSENTIAL AS IS THE COLLECTION OF ROCKS, MINERALS, AND FOSSILS, WHICH SHOULD BE LABELED. GO AS A DISCOVERER, NOT AS ONE TO BE SHOWN. RECORD IN YOUR MIND AND IN YOUR FIELD NOTEBOOK WHAT YOU YOURSELF SEE, NOT WHAT SOMEBODY ELSE TELLS YOU HE SEES, NOR WHAT ANOTHER SUGGESTS YOU OUGHT TO SEE. ASK FOR THE INSTRUCTOR'S HELP IF YOU FAIL TO SEE WHAT OTHERS SEE.

IT IS OBVIOUSLY IMPOSSIBLE TO OBSERVE GEOLOGICAL PHENOMENA IN THE SAME ORDER AS THAT IN WHICH THEY ARE TREATED IN THE CLASSROOM AND LABORATORY. FACTS WHICH MAY NOT AT THE TIME BE UNDERSTOOD MUST THEREFORE BE KEPT IN MIND UNTIL THE APPROPRIATE POINT IS LATER REACHED WHEN THEY MAY SERVE AS ILLUSTRATIVE MATERIAL OR AS THE BASIS FOR CONCLUSIONS. FOR THESE REASONS CAREFUL FIELD NOTES SHOULD BE TAKEN AND SHOULD BE CONFINED, IN GENERAL, TO STATEMENTS OF OBJECTS AND RELATIONSHIPS ACTUALLY OBSERVED. YOUR NOTES SHOULD BECOME A PART OF THE CLASS NOTEBOOK.

THE FOLLOWING GENERAL QUESTIONS ARE TO BE ANSWERED FOR EACH TRIP:

1. PURPOSE

2. WHAT IS THE GEOGRAPHIC LOCATION OF THE AREA?

3. DESCRIBE THE TOPOGRAPHY OF THE AREA, I.E., FLAT, UNDULATING, PLATEAU, MOUNTAINOUS, HILLY, AND ITS DRAINAGE.

4. WHAT IS THE PHYSIOGRAPHIC AGE OF THE REGION?

5. WHAT PHYSIOGRAPHIC DEVELOPMENTS MAY OCCUR IN THIS REGION? GIVE REASONS.

6. WHAT IS THE GEOLOGIC HISTORY OF THE AREA?

7. DOES THE AREA HAVE ANY ECONOMIC IMPORTANCE? WHAT IS IT?

CHANGES IN EARTH SURFACE
LEVEL: JR. HIGH OR HIGH SCHOOL

ACTIVITY: INVESTIGATING CHANGE

MATERIALS: PIECE OF HALITE, LARGER THAN 1 CM.

THIS ENABLES THE STUDENT TO INVESTIGATE THE VARIETY OF CHANGES A SINGLE SUBSTANCE CAN UNDERGO AND TO RELATE SOME OF THE PROCESSES PRODUCING THESE CHANGES TO NATURAL EARTH CHANGES.

CAUTION

1. DO NOT TELL STUDENT WHAT THE MATERIAL IS:
2. CAUTION STUDENTS TO PRACTICE COMMON SAFETY PROCEDURES WHEN HE CHANGES HIS EARTH MATERIAL.

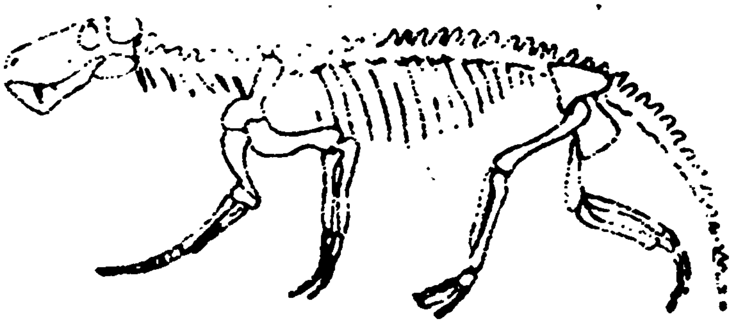
PROCEDURE:

TELL THE STUDENT THAT HE IS TO TRY TO CHANGE THE EARTH MATERIAL IN AT LEAST THREE WAYS. LEAVE THE METHODS UP TO HIM. (YOU MAY WISH THE STUDENT TO TAKE THE MATERIAL HOME.) HAVE EACH STUDENT SUBMIT A REPORT FOR CLASS DISCUSSION.

THE STUDENT'S RESULTS MAY INCLUDE DISSOLVING IN WATER, FREEZING, CRUSHING, HEATING ETC.

WHY WOULD THE PEOPLE IN AGRICULTURE, GEOLOGY, GEOPHYSICS AND RELATED FIELDS BE INTERESTED IN UNDERSTANDING HOW EARTH MATERIALS CHANGE?

ANCIENT EARTH HISTORY



EARTH SCIENCE - ANCIENT EARTH HISTORY

ANTHROPOLOGY
GEOPHYSICS
ELEMENTARY TEACHER
TECHNICAL WRITER

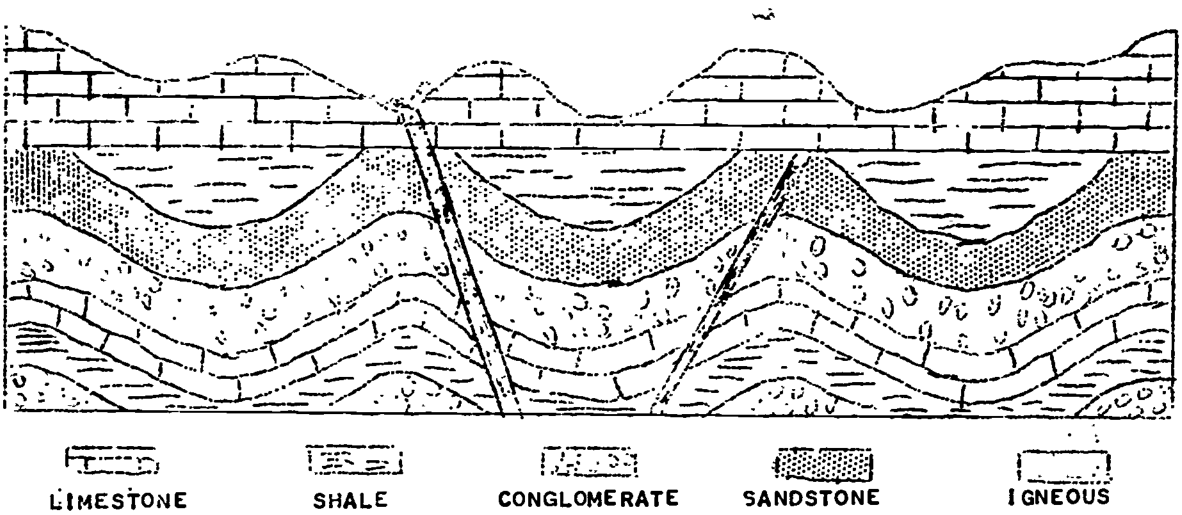
GEOLOGIST
OCEANOGRAPHER
TEACHER SECONDARY-COLLEGE

ANCIENT EARTH HISTORY
LEVEL: JUNIOR HIGH

ACTIVITY: INTERPRETATION OF ROCK LAYERS

MATERIAL: LAB ACTIVITY SHEET WITH DIAGRAM

PROCEDURE: STUDY THE DIAGRAM. NUMBER THE SEDIMENTARY ROCK LAYERS ACCORDING TO AGE, STARTING WITH THE OLDEST AS #1. THEN ANSWER THE QUESTIONS.



1. WHICH OF THE TWO DIKES IS THE OLDEST?________________ HOW CAN YOU DETERMINE THIS FACT FROM THE DIAGRAM?________________

____

2. EXPLAIN THE GEOLOGIC HISTORY OF THIS REGION. INCLUDE AS MUCH DESCRIPTIVE DETAIL AS POSSIBLE. ________________

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3. WHICH OF THE LAYERS REPRESENT SHALLOW WATER DEPOSITS?________ ________________ WHICH OF LAYERS REPRESENT DEEP WATER DEPOSITS?________________

4. WHAT OCCUPATIONS CAN YOU NAME WHERE A PERSON MIGHT DO THIS TYPE OF ACTIVITY?________________

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ANCIENT EARTH HISTORY
LEVEL: JUNIOR HIGH

ACTIVITY: INTERPRETING EVIDENCE

MATERIALS: FIRECLAY OR PATCHING PLASTER
PAPER DISHES
ASSORTED OBJECTS

STUDENTS ARE SOMETIMES SKEPTICAL OF RECONSTRUCTIONS MADE FROM FOSSIL EVIDENCE. DEVELOPMENT OF SUCH RECONSTRUCTIONS DEPENDS MORE UPON DEDUCTION AND PAST SCIENTIFIC WORK THAN UPON PURE GUESSWORK, AND STUDENTS MAY BE MADE AWARE OF THIS THROUGH ATTEMPTING SOME RECONSTRUCTIONS OF THEIR OWN. THROUGHOUT THE RECONSTRUCTION PROCESS, STUDENTS SHOULD BE ASKED TO DISTINGUISH BETWEEN THEIR OBSERVATIONS AND THEIR DEDUCTIONS DRAWN FROM THE OBSERVATIONS. THEY MAY, THUS, BECOME MORE AWARE OF THE AMOUNT OF DEDUCTION WHICH IS INVOLVED IN EVERYDAY OPEN-AND-SHUT CONSLUSIONS THEY MAKE. AND THEY MAY ALSO BETTER APPRECIATE THE PROCESSES BY WHICH PALEONTOLOGISTS, ARTISTS, AND OTHERS WORKING WITH FOSSILS PRODUCE THE SKETCHES AND DESCRIPTIONS OF ORGANISMS WHICH LIVED IN THE PAST.

PROCEDURES:

A. PREPARE A SET OF IMPRINTS OF A TIRE PRINT, TOP OF A FULL POP CAN, SCREWS & BOLTS, & A TWISTED ROPE. PLACE AN IDENTIFYING NUMBER ON EACH IMPRINTED PLATE.
B. SHOW ONE OF THE OBJECTS, SAY A TIRE PRINT, TO THE CLASS AND INVITE DISCUSSION ABOUT IT. THIS WILL ALLOW THE STUDENTS TO RECOGNIZE THE TYPES OF OBSERVATIONS, INTERPRETATIONS, AND CONCLUSIONS WHICH MIGHT BE MADE CONCERNING EACH SPECIMEN.
C. IN THEIR NOTEBOOKS STUDENTS SHOULD WRITE THE NUMBER OF THE IMPRINT AND NOTES CONCERNING IT FOR REFERENCE IN DISCUSSION. SUGGESTED DISCUSSION POINTS FOR FOUR IMPRINTS ARE AS FOLLOWS:

SAMPLE DISCUSSION POINTS:

1. A GEOMETRIC DESIGN, PROBABLY A TIRE PRINT: IT MAY HAVE BEEN MADE BY A WHEELED VEHICLE OR SIMPLY BY A TIRE. IN MANY PARTS OF THE WORLD, OLD TIRE SECTIONS ARE MADE INTO SANDALS, SO THE PRINT MAY HAVE BEEN MADE BY A PERSON WALKING. THE NATURE OF THE "VEHICLE" (AUTOMOBILE, BICYCLE, MOTORCYCLE, AIRPLANE) MIGHT BE DEDUCED BY SOMEONE FAMILIAR WITH TREAD DESIGNS. THE PATTERN OF WEAR ON THE TREAD MIGHT GIVE SOME INDICATION OF THE PARTICULAR VEHICLE INVOLVED, JUST AS A TRACKER MAY BE ABLE TO RECOGNIZE AN ANIMAL WITH A LIMP. THE SPACING OF THE PRINTS, IF KNOWN, MIGHT GIVE INSIGHT INTO THE NATURE OF THE VEHICLE (OR THE PEDESTRIAN WEARING SANDALS), JUST AS GROUPS OF FOSSIL FOOTPRINTS TELL MORE ABOUT THE SIZE AND GAIT OF THE ANIMAL INVOLVED THAN DOES A SINGLE PRINT.
2. A CIRCLE WITH DESIGN WITHIN: STUDENTS MAY KNOW, FROM THEIR EXPERIENCE WITH SOFT-DRINK CANS, THAT THIS IMPRINT COULD HAVE BEEN MADE BY SUCH A CAN. THEY SHOULD NOTE THAT ONLY THEIR EXPERIENCE WITH REAL CANS ALLOWS THEM TO INTERPRET THE PRINT. IN THEORY THE PRINT COULD HAVE BEEN MADE BY A DISK ONLY A FEW CENTIMETERS THICK OR BY THE END OF A CYLINDER MANY METERS

LONG. IT IS FAMILIARITY WITH SOFT-DRINK CONTAINERS WHICH WILL SUGGEST TO MOST OBSERVERS THAT A CAN WAS INVOLVED.

THE EXISTENCE OF THE PULL TOP, INTACT, SUGGESTS THAT THE CONTAINER WAS FULL, BUT IT IS POSSIBLE THAT IT WAS OPENED WITH A CAN OPENER AT THE OTHER END. PRESENCE OR ABSENCE OF A SEAM MIGHT INDICATE WHETHER THE CAN WAS MADE OF ALUMINUM OR STEEL. SINCE ALUMINUM CANS HAVE BEEN INTRODUCED RELATIVELY RECENTLY, THE LACK OF A SEAM MIGHT SUGGEST A DATE PRIOR TO WHICH THE IMPRINT COULD NOT HAVE BEEN MADE.

A GROCERY CLERK, FAMILIAR WITH VARIOUS CANNED BEVERAGES, MIGHT BE ABLE TO TELL WHAT BRAND IT WAS OR ELIMINATE BRANDS IT COULD NOT HAVE BEEN. A STUDENT LACKING SUCH KNOWLEDGE OFFHAND, MIGHT BE ABLE TO IDENTIFY THE PRINT BY COMPARING IT TO CANS IN A MARKET. PALEONTOLOGISTS KEEP COLLECTIONS OF FOSSILS IN MUSEUMS FOR MUCH THE SAME REASON.

3. A REGULAR PATTERN, PROBABLY THE IMPRINT OF A BOLT: EVEN THOUGH THE OBJECT ITSELF IS NOT PRESENT, STUDENTS MAY SUGGEST THAT IT WAS PROBABLY MADE OF METAL. THE METAL MIGHT HAVE BEEN BRONZE OR STEEL, SINCE SOFTER METALS (SUCH AS LEAD AND COPPER) ARE NOT OFTEN USED IN THE MANUFACTURE OF BOLTS.

CLOSE INSPECTION OF A HIGH QUALITY IMPRINT MIGHT SHOW THREAD WEAR, CROSS THREADING, STRIPPING, OR OTHER EVIDENCE OF USE.

BOLTS OF VARIOUS DESIGNS ARE COMMONLY USED FOR DIFFERENT PURPOSES. A WOOD SCREW IS OF DIFFERENT SHAPE THAT A MACHINE SCREW OR A METAL SCREW. CARRIAGE BOLTS, WITH SQUARE SHANKS, ARE OFTEN EMPLOYED FOR JOINING WOOD TO METAL.

DIMENSIONS OF THE BOLT MIGHT TELL WHETHER IT WAS OF AMERICAN OR EUROPEAN MANUFACTURE. THE RELATIONSHIPS BETWEEN HEAD AND BODY SIZES OF BOLTS HAVE CHANGED PERIODICALLY. KNOWING THIS AND GIVEN ACCESS TO NEW AND OLD CATALOGS, A STUDENT MIGHT BE ABLE TO DATE THE BOLT WITHIN, PERHAPS, TWENTY YEARS.

THE SIZE OF THE BOLT SUGGESTS THAT IT WAS INTENDED TO JOIN PIECES OF MATERIAL A FEW CENTIMETERS THICK AND NOT LARGE GIRDERS OR THIN SHEETS OF METAL.

4. A REGULAR, REPEATED PATTERN, PROBABLY A TWISTED ROPE: A MICROSCOPIC EXAMINATION OF THE CAST MIGHT GIVE EVIDENCE AS TO WHETHER THE ROPE WAS OF SMOOTH, SYNTHETIC FIBER, OR ROUGHER, NATURAL FIBER. THE NATURE OF THE FIBER WOULD GIVE A ROUGH INDICATION OF THE ROPE'S WORKING STRENGTH AND POSSIBLE APPLICATION. IT WOULD ALSO GIVE, IN SOME CASES, A CLUE TO THE AGE OF THE ROPE. ROPES OF NATURAL FIBER (HEMP AND MANILA) HAVE BEEN USED FOR MANY YEARS AND ARE STILL BEING PRODUCED, WHEREAS SYNTHETIC ROPES WERE NOT COMMON UNTIL TWENTY-FIVE YEARS AGO. WORKING WITH FOSSILS, PALEONTOLOGISTS ARE STILL MORE LIKELY TO SOLVE PROBLEMS IN DATING IN THE OPPOSITE SENSE: THE APPEARANCE OF A NEW TYPE (E.G., SYNTHETIC ROPE) IS USED AS A RELATIVE DATE (TWENTY-FIVE YEARS AGO, OR LATER THAN NATURAL FIBERS).

STUDENTS MAY SEE THAT COLLECTIONS OF IMPRINTS, OF THE SAME OR OF VARIOUS TYPES OF ITEMS, SUPPLY MORE EVIDENCE FOR DATES THAN SINGLE, ISOLATED FINDS DO.

KNOWLEDGE OF THE LOCALE IN WHICH THE SPECIMEN WAS COLLECTED IS USEFUL. AN IMPRINT FOUND NEAR A SHORELINE MIGHT REPRESENT A PIECE OF LINE USED TO TIE UP A BOAT, WHEREAS AN IMPRINT FROM NEAR A DEEPLY RUTTED MUDHOLE ON A BACK ROAD WOULD SUGGEST A TOWROPE.

DIFFERENT ROPES ARE MADE FOR DIFFERENT USES; THEY MAY HAVE THREE OR FOUR LAID (TWISTED) STRANDS; THEY MAY BE OF BRAIDED OR WOVEN MATERIALS OR OF CONTINUOUS FIBERS ENCLOSED IN SHEATHS.

KNOTS IN THE ROPE WOULD GIVE FURTHER CLUES AS TO THE USE OF THE ROPE, AND FRAYED OR BROKEN STRANDS WOULD SUGGEST THE AMOUNT OF USE BEFORE THE IMPRINT WAS MADE.

FROM THESE AND OTHER EXAMPLES STUDENTS MAY, QUITE CORRECTLY, REACH THE CONSLUSION THAT THERE IS A GREAT DEAL OF "DETECTIVE WORK" INVOLVED IN INTERPRETING IMPRINTS, BUT THAT IT CAN BE LOGICALLY AND INTELLIGENTLY DONE. PERHAPS THE POINT TO BE MADE IS THAT THERE IS A LOT OF DEDUCTION INVOLVED IN EVERYDAY, NONSCIENTIFIC LIFE. THE DIFFERENCE BETWEEN THE SCIENTIST AND THE NONSCIENTIST IS NOT THAT ONE GUESSES AND THE OTHER DOES NOT. IT IS MORE THAT THE SCIENTIST IS AWARE OF THE FACT THAT HE IS MAKING DEDUCTIONS, WHEREAS THE NONSCIENTIST MAY FALL INTO THE TRAP OF CONSIDERING COMMONLY MADE DEDUCTION TO BE FACTS OR OBSERVATIONS.

AN INTERESTING DISCUSSION CAN BE BUILT AROUND THE QUESTION, WHAT THINGS IN YOUR DAILY LIFE DO YOU KNOW AS FACTS WITH ABSOLUTELY NO GUESSWORK OR DEDUCTION INVOLVED? YOU MAY WISH TO RECALL CLASS DISCUSSION IN SECTION ONE OF STATEMENTS THAT ARE BASED ON FACT OR BASED ON MODELS.

RANGE OF RESULTS

AN IMAGINATIVE STUDENT SHOULD DEVELOP SEVERAL DEFENSIBLE HYPOTHESES. ONE OF THE MOST COMMON IS THAT TWO ANIMALS MET AND FOUGHT. THERE IS NO REAL REASON TO ASSUME THAT ONE ANIMAL ATTACKED AND ATE THE OTHER. CERTAIN LINES OF EVIDENCE--THE QUICKENED GAITS, CIRCULAR PATTERN, AND DISAPPEARANCE OF ONE SET OF TRACKS--DO SEEM TO BEAR THIS OUT. IT MIGHT, HOWEVER, HAVE BEEN A MOTHER PICKING UP HER BABY. MANY EXPLANATIONS ARE POSSIBLE. THE DESCRIPTION AND TEMPERAMENT OF THE ANIMALS INVOLVED ARE OPEN TO QUESTION. INDEED, WE LACK THE EVIDENCE TO SAY THAT THE TRACKS WERE MADE AT THE SAME TIME. THE INTERMINGLING MAY BE EVIDENCE THAT BOTH TRACKS WERE MADE AT ONE TIME, BUT IT COULD BE ONLY A COINCIDENCE. PERHAPS ONE ANIMAL PASSED BY AND FLEW OFF, AND THEN THE OTHER CAME ALONG. WE STILL CANNOT SAY.

SUGGESTED ADDITIONAL INVESTIGATIONS

YOU CAN HAVE MORE DISCUSSIONS ON INTERPRETING SERIES OF EVENTS USING ANIMAL PRINTS STUDENTS FIND OUT-OF-DOORS AND REPRODUCE FOR THE CLASS. DON'T FORGET TO LOOK FOR HUMAN FOOTPRINTS.

ANCIENT EARTH HISTORY
Level: 8th–9th

ACTIVITY: Investigating a footprint puzzle

Advance Preparation:

Make an overhead transparency of the footprint puzzle. Have a blank piece of paper on hand to mask the puzzle when it's on the projector.

Time requirements:

Pre-lab	5 minutes
Lab	30 minutes
Post-lab	10 minutes

Pre-Lab Discussion:

Simply point out to the students that they will be attempting to reconstruct happenings from the geologic past. In this investigation students will form several defensible hypotheses. As more evidence becomes available the hypotheses must be modified or abandoned.

Notes on Procedure:

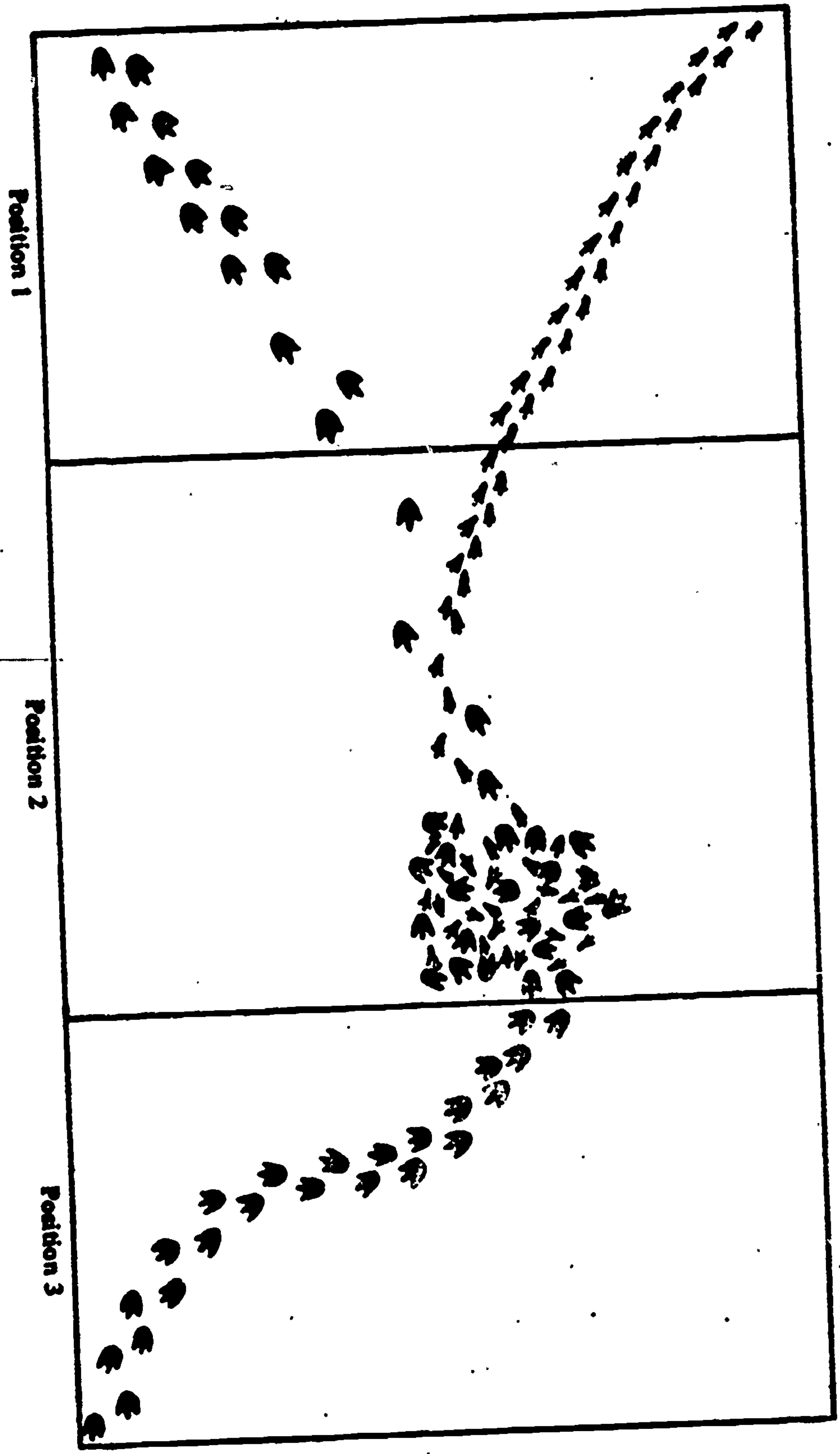
Use a blank piece of paper to slide across the transparency and reveal additional puzzle sections. Begin by projecting the first part of Guide. Be receptive to any reasonable hypotheses students offer to explain the footprints. As you show the next section of the transparency students will see that the first hypotheses need to be modified and new ones probably can be added.

Next project the complete puzzle and ask students to interpret what happened. A key point for students to recognize is that the conclusion must be based only on those tentative hypotheses that still apply when all of the puzzle is projected. Any interpretation that is consistent with all the evidence is acceptable.

Should it become necessary to prod the students' thinking and stimulate the discussion, the questions below may help. Students should give evidence for their answers.

1. In what directions did the animals move?
2. Did they change their speed and direction?
3. What might have changed the footprint pattern?
4. Was the land level or irregular?
5. Was the soil moist or dry on the day these tracks were made?
6. In what kind of rock were the prints made?
7. Were the sediments coarse or fine where the tracks were made?

The environment of the track area should also be discussed. If dinosaurs made the tracks, the climate probably was warm and humid. If students propose that some sort of obstruction prevented the animals from seeing each other, this might suggest vegetation. Or, perhaps the widened place might suggest a slope. Speculate on the condition of the surface at the time the prints were made. What conditions were necessary for their preservation?


Position 1
Position 2
Position 3

ANCIENT EARTH HISTORY
LEVEL: JR. HIGH OR HIGH SCHOOL

ACTIVITY: MAKING ARTIFICIAL SEDIMENTARY ROCK

FOSSILS ARE MOST FREQUENTLY FOUND IN SEDIMENTARY ROCKS. SUCH ROCKS WERE FORMED BY LAYERS OF SEDIMENT LAID DOWN MILLIONS OF YEARS AGO. THE FOLLOWING ACTIVITY WILL HELP YOU UNDERSTAND HOW SEDIMENTS SETTLE IN WATER TO FORM LAYERS.

PROCEDURE:

OBTAIN A LARGE, TALL JAR. MIX SOME COARSE SOIL, SAND, OR GRAVEL WITH SOME FINER SAND AND SOIL. FILL THE JAR WITH WATER AND THEN POUR THE MIXTURE INTO IT. ALLOW THE JAR TO STAND FOR SEVERAL DAYS OR UNTIL THE WATER ABOVE THE SETTLED PARTICLES IS COMPLETELY CLEAR. NOTE THAT THE COARSE, HEAVY PARTICLES SETTLED TO THE BOTTOM FIRST.

ADD MORE OF THE SAND, SOIL, GRAVEL AND WATER MIXTURE. ADD ADDITIONAL LAYERS UNTIL THE JAR IS NEARLY FILLED. THE LAYER STRUCTURE IS EASILY OBSERVED THROUGH THE GLASS.

AN ARTIFICIAL SEDIMENTARY ROCK CAN BE MADE BY REPEATING THE PROCEDURE DESCRIBED ABOVE AND ADDING A LITTLE CEMENT TO EACH MIXTURE OF SAND, SOIL, GRAVEL, AND WATER. UNDER NATURAL CONDITIONS CERTAIN MATERIALS ARE PRESENT THAT ACT AS THE CEMENT.

WHEN A JAR WITH CEMENT ADDED TO THE LAYERS IS FULL, INVERT IT AND ALLOW IT TO DRY THOROUGHLY. NOW BREAK THE JAR AND REMOVE THE ARTIFICIAL SEDIMENTARY ROCK. BRING THE ROCK TO CLASS AND COMPARE IT WITH OTHERS MADE BY YOUR CLASSMATES.

ANCIENT EARTH HISTORY

LEVEL: JR. HIGH OR HIGH SCHOOL

ACTIVITY: YOU CAN'T SEE THE FOREST FOR THE ROCKS (MAKING A FOSSIL IMPRESSION)

WE LIVE IN A WORLD THAT IS FULL OF MANY, MANY DIFFERENT KINDS OF LIVING THINGS. THERE ARE PEOPLE--AND PENGUINS--AND PORCUPINES--AND PINE TREES--AND PARAMECIA.

WE FIND ORGANISMS LIVING IN A DROP OF WATER--IN AN INCH OF SOIL--AND ON MOUNTAIN TOPS.

EVEN THOUGH THERE ARE MANY DIFFERENT KINDS OF LIVING THINGS, YOU HAVE PROBABLY DISCOVERED THAT: ALL LIVING THINGS ARE COMPOSED OF CELLS. AND ALL LIVING THINGS CAN BE CLASSIFIED INTO RELATED GROUPS.

THESE STATEMENTS LEAD US TO SOME VERY IMPORTANT QUESTIONS. HOW DID THE DIFFERENT KINDS OF LIVING THINGS COME TO BE? HOW DID THE DIFFERENT KINDS OF LIVING THINGS COME TO BE SEPARATED INTO RELATED GROUPS?

A. A DINOSAUR IN MY TANK?

MILLIONS OF YEARS AGO, THERE WERE ANIMALS CALLED DINOSAURS THAT ROAMED THE EARTH. YET THESE DINOSAURS ARE NOT KNOWN TO BE ALIVE TODAY. WHAT PROOF DO WE HAVE THAT DINOSAURS EXISTED?

LET'S TAKE ANOTHER EXAMPLE. THE GIRAFFE DID NOT ALWAYS HAVE A LONG NECK AND LONG LEGS. IN FACT, AT ONE TIME THE GIRAFFE LOOKED LIKE TODAY'S HORSE. BUT WHAT EVIDENCE DO WE HAVE TO PROVE IT?

YOU NOW HAVE SOME BACKGROUND FOR OUR PROBLEM. AS YOU HAVE LEARNED, A SCIENTIST OFTEN MAKES A PREDICTION TO HELP FIND THE POSSIBLE ANSWER OF A PROBLEM. THIS IS WHAT YOU ARE TO DO.

1. WHAT DO YOU THINK HAS BEEN HAPPENING TO LIVING THINGS OVER MILLIONS AND MILLIONS OF YEARS?

YOU HAVE JUST MADE YOUR PREDICTION. BUT IT IS JUST AN EDUCATED GUESS. YOUR GUESS MUST NOW BE TESTED. A SCIENTIST MUST PRODUCE DATA OR EVIDENCE THAT WILL EITHER SUPPORT OR REJECT THE PREDICTION.

2. WHAT EVIDENCE DO YOU THINK SCIENTISTS HAVE THAT WILL SUPPORT THE PREDICTION YOU MADE IN "1"?

B. IT'S PRESERVED IN ROCK

OBTAIN TWO BLOCKS OF MODELING CLAY. TAKE ONE BLOCK OF CLAY AND DIP ONE OF ITS LARGE SURFACES IN A SOAP SOLUTION. LAY THIS BLOCK ON THE TABLE WITH THE SOAPY SURFACE FACING UP.

OBTAIN A PLASTIC MODEL OF AN ANIMAL FROM THE TEACHER AND DIP IT INTO THE SOAP SOLUTION. THEN PRESS THE MODEL HALFWAY DOWN INTO THE CLAY BLOCK. IMAGINE THAT YOU ARE LOOKING AT AN ANIMAL THAT DIED MANY MILLIONS OF YEARS AGO. NOW DIP THE END OF A PENCIL INTO THE SOAP SOLUTION AND PRESS IT INTO THE CLAY BLOCK SO THAT AN OPENING WILL BE FORMED FROM THE PLASTIC MODEL TO THE EDGE.

DIP ONE OF THE LARGE SURFACES ON THE OTHER BLOCK OF CLAY INTO THE SOAP SOLUTION. THEN PRESS THIS BLOCK ONTO THE FIRST BLOCK FIRMLY. THIS SECOND BLOCK REPRESENTS SEDIMENT THAT BURIED THE DEAD ANIMAL.

USUALLY, MOST ORGANISMS THAT DIE ARE EITHER EATEN OR DESTROYED BY DECAY. BUT SOMETIMES BURIAL IN SEDIMENT PRESERVES THE ANIMAL FOR MILLIONS OF YEARS FROM DECAY AND THE ATTACK OF SCAVENGERS. THERE ARE SCIENTISTS WHO LOOK FOR AND STUDY THESE PRESERVED ANIMALS.

CAREFULLY SEPARATE THE TWO HALVES. THIS ACTION WOULD NEVER HAPPEN SO FAST IN NATURE. NORMALLY, THE EARTH WOULD SLOWLY WEAR AWAY OR THE SCIENTIST WOULD CAREFULLY PICK AWAY AT THE SEDIMENT TO FIND THIS HIDDEN TREASURE. WHAT YOU SEE INSIDE YOUR CLAY BLOCKS REPRESENTS AN ANIMAL THAT HAS BEEN PRESERVED FOR MILLIONS OF YEARS.

3. WHAT DO YOU CALL AN ORGANISM OR A PART OF AN ORGANISM THAT HAS BEEN PRESERVED FOR MILLIONS OF YEARS?

NOT ALL ORGANISMS ARE PRESERVED IN THIS WAY, HOWEVER.

REMOVE THE PLASTIC MODEL AND THE PENCIL. DIP THE SAME TWO SURFACES IN THE SOAP AGAIN. NOW PLACE THE TWO BLOCKS OF CLAY TOGETHER IN ITS ORIGINAL POSITION.

USING THE MELTED WAX WHICH HAS BEEN PREPARED, POUR THE WAX INTO THE HOLE AT ONE END OF THE BLOCKS. SET IT ASIDE TO DRY.

IN POURING WAX INTO THE CLAY, YOU ARE REPLACING THE ORIGINAL MOLD OF THE ORGANISM WITH ANOTHER MATERIAL. IN NATURE, THIS SUBSTITUTION TAKES PLACE AS WATER AND CHEMICALS DRIP THROUGH TINY HOLES IN THE SEDIMENT.

AFTER TWENTY MINUTES, CAREFULLY PRY APART THE TWO CLAY BLOCKS TO REVEAL THE WAX CAST OR MODEL.

4. WHAT DOES THE CAST REPRESENT?

THIS IS ONLY ONE WAY IN WHICH PREHISTORIC ORGANISMS CAN BE PRESERVED.

C. THE RECORD OF LIFE

5. WHAT DO YOU CALL AN ORGANISM, OR A PART OF AN ORGANISM, THAT HAS BEEN PRESERVED THROUGH TIME?

6. HOW DOES EXAMINING PREHISTORIC REMAINS HELP US TO UNDERSTAND ABOUT THE PAST?

7. WHAT IS ONE FORM OF EVIDENCE THAT SCIENTISTS HAVE BEEN ABLE TO "DIG UP" TO SUPPORT THE PREDICTION YOU MADE IN QUESTION 1?

ANCIENT EARTH HISTORY
LEVEL: HIGH SCHOOL

ACTIVITY:

DEMONSTRATION

A COMMON TYPE OF FOSSILIZATION RESULTS WHEN THE HARD PARTS OF AN ORGANISM HAVE ADDITIONAL MINERALS DEPOSITED IN THEIR PORE SPACES. THIS PROCESS IS KNOWN AS PERMINERALIZATION. PERMINERALIZATION CAN BE DEMONSTRATED WITH A COMMON CELLULOSE SPONGE (A BRIGHTLY COLORED ONE IS BEST) AND SOME PARAFFIN. MELT THE PARAFFIN AND SATURATE THE SPONGE WITH IT. ALLOW THE PARAFFIN TO HARDEN AND EXAMINE THE SPONGE. CUT IT INTO PIECES TO SEE INSIDE.

THE FARAFFIN IN THE VOIDS IN THE SPONGE HAS MADE IT MORE RESISTANT TO PHYSICAL AND CHEMICAL CHANGE. THE PARAFFIN IS ANALOGOUS TO THE MINERALS DEPOSITED BY GROUND WATER WHEN PERMINERALIZATION OCCURS.

DEMONSTRATION

CARBONIZATION IS ANOTHER COMMON TYPE OF FOSSILIZATION, ESPECIALLY FOR PLANT REMAINS. EVEN THE MOST DELICATE STRUCTURES ARE RECORDED IN CONSIDERABLE DETAIL BY THE THIN FILMS OF CARBON. ARTIFICIAL CARBON IMPRINTS OF LEAVES CAN BE PREPARED AS FOLLOWS: EMBED A LARGE LEAF IN ABOUT AN INCH OF CEMENT IN A DISPOSABLE PLATE. LET THE CEMENT DRY. BAKE IT IN A HOT OVEN FOR TWO HOURS. BREAK IT OPEN WITH A SHARP BLOW ON THE THIN EDGE OF THE CEMENT. A CARBONIZED IMPRESSION WILL BE VISIBLE. IF YOU HAVE A DEMONSTRATION COLLECTION OF FOSSILS, COMPARE THE ARTIFICIAL CARBON IMPRINT WITH A NATURAL CARBON IMPRESSION. HOW DO THESE DIFFER FROM OR RESEMBLE EACH OTHER? WHICH OF THEM MORE CLOSELY RESEMBLES A LEAF?

ANCIENT EARTH HISTORY
LEVEL: 9TH

ACTIVITY: COMPARISON OF TEETH IN FOSSILS

PROBLEM:

YOU HAVE LEARNED THAT CLASSIFICATION AND RELATIONSHIPS OF VARIOUS FORMS OF PLANT AND ANIMAL LIFE ARE BASED ON STRUCTURAL SIMILARITIES. THE SKELETONS OF MODERN AND THE FOSSILIZED REMAINS OF HORSE-LIKE ANIMALS HAVE BEEN STUDIED TO FIND SIMILARITIES. FOR EXAMPLE, HOW DOES THE TEETH STRUCTURE IN THESE SKELETONS COMPARE?

INVESTIGATION:

ACCORDING TO SCIENTIFIC EVIDENCE, MODERN HORSE (GENUS EQUUS) DEVELOPED THROUGH A SERIES OF HORSELIKE ANIMALS FROM A PRIMITIVE FORM (GENUS OROHIPPUS) THAT EXISTED ON EARTH MANY MILLIONS OF YEARS AGO. THE VARIOUS ANIMALS OF THIS SERIES ARE CLASSIFIED IN DIFFERENT GENERA, AS SHOWN IN THE CHART ON THE NEXT PAGE, BUT ALL OF THEM ARE MEMBERS OF THE HORSE FAMILY (EQUIDAE). THE SPAN, OR DISTANCE, FROM THE SECOND PREMOLAR TOOTH TO AND INCLUDING THE THIRD MOLAR TOOTH, HAS BEEN MEASURED IN MANY SKULLS OF THESE VARIOUS HORSELIKE ANIMALS. THE AVERAGE RESULTS ARE SHOWN IN THE CHART ON THE NEXT PAGE. (IT IS NOT NECESSARY TO LEARN THE SCIENTIFIC NAMES OF THE VARIOUS ANIMALS.)

INTERPRETATIONS:

IN THE FOLLOWING GROUPS OF STATEMENTS, PLACE THE LETTER OF THE TERM WHICH CORRECTLY COMPLETES EACH STATEMENT IN THE SPACE PROVIDED.

1. THE EARLIEST FOSSILIZED REMAINS OF HORSELIKE ANIMALS SHOWN IN THE CHART ARE THOSE OF (A) EPIHIPPUS, (B) PLIOHIPPUS, (C) OROHIPPUS, (D) MESOHIPPUS. ____

2. THE FORM OF HORSELIKE ANIMAL THAT EXISTED ABOUT 30 MILLION YEARS AGO IS CALLED (A) EPIHIPPUS, (B) PARAHIPPUS, (C) MESOHIPPUS, (D) PLIOHIPPUS. ____

3. THE TOTAL INCREASE IN THE SPAN OF THE CHEEK TEETH OF HORSELIKE ANIMALS SHOWN IN THE CHART IS ABOUT (A) 15 CM, (B) 13 CM, (C) 11 CM, (D) 9 CM. ____

4. THE MOST RAPID CHANGE IN THE SPAN OF THE CHEEK TEETH OF HORSELIKE ANIMALS TOOK PLACE ABOUT (A) 5-10 MILLION YEARS AGO, (B) 10-15 MILLION YEARS AGO, (C) 15-20 MILLION YEARS AGO, (D) 20-25 MILLION YEARS AGO. ____

5. THE SPAN OF THE CHEEK TEETH IN THE MODERN HORSE COMPARED TO THE EARLIEST HORSELIKE ANIMALS SHOWN IN THE CHART IS ABOUT (A) 8 TIMES AS GREAT, (B) 6 TIMES AS GREAT, (C) 4 TIMES AS GREAT, (D) 2 TIMES AS GREAT. ____

6. IN THE LAST 20 MILLION YEARS, THE SPAN OF THE CHEEK TEETH IN HORSELIKE ANIMALS INCREASED ON AN AVERAGE OF ABOUT (A) 5 CM, (B) 4 CM, (C) 3 CM, (D) 2 CM. ____

7. THE LEAST CHANGE IN THE TEETH OF HORSELIKE ANIMALS TOOK PLACE BETWEEN THE (A) EPIHIPPUS AND MESOHIPPUS, (B) PARAHIPPUS AND MERYCHIPPUS, (C) MERYCHIPPUS AND PLIOHIPPUS, (D) PLIOHIPPUS AND EQUUS.

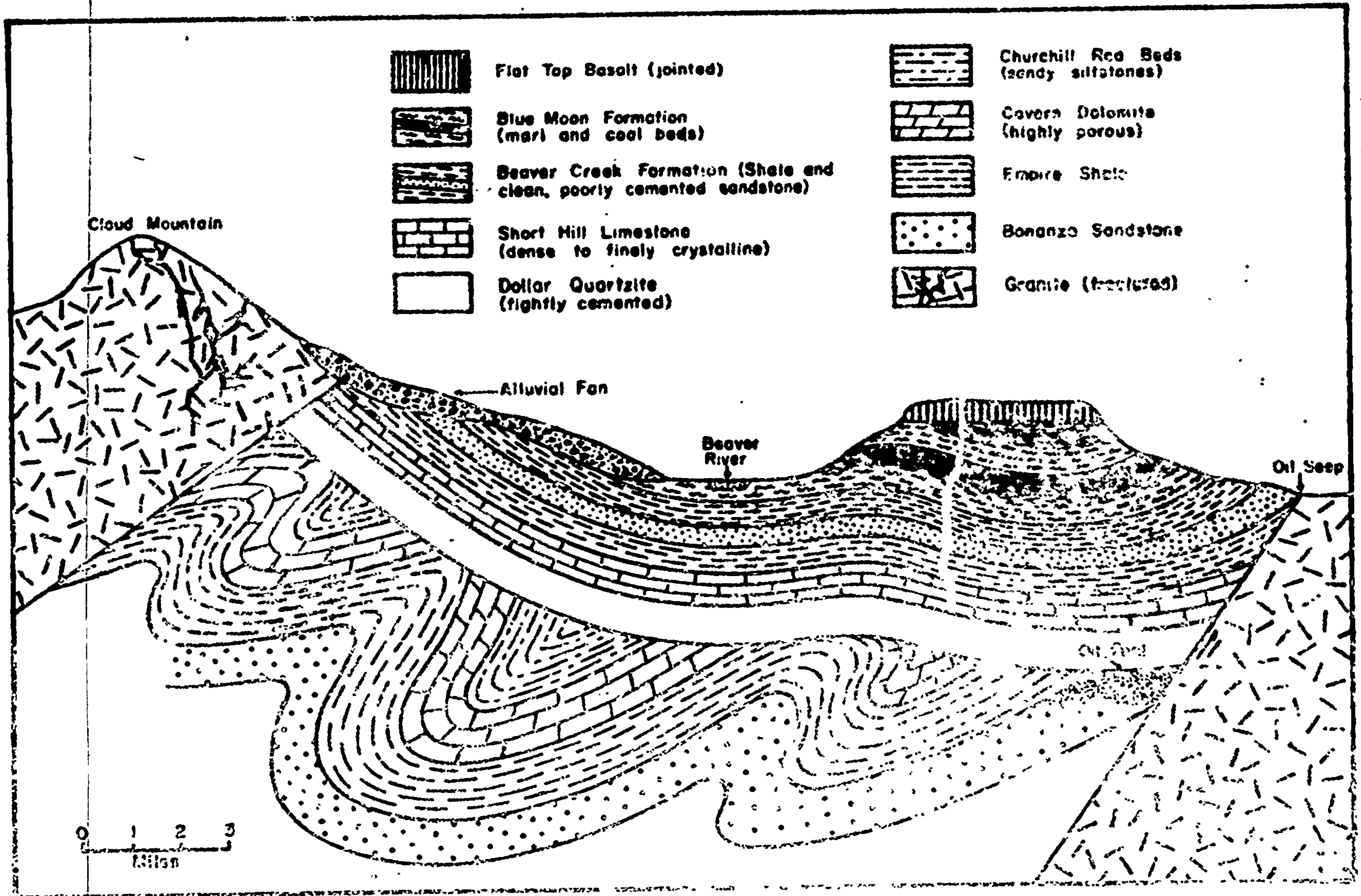
8. THE SPAN OF THE CHEEK TEETH IN HORSELIKE ANIMALS DOUBLED IN THE PAST (A) 25 MILLION YEARS, (B) 20 MILLION YEARS, (C) 15 MILLION YEARS, (D) 10 MILLION YEARS. ____

9. IN THE EARLY DEVELOPMENT OF HORSELIKE ANIMALS, THE SPAN OF THE CHEEK TEETH INCREASED ABOUT 3 CENTIMETERS BETWEEN THE (A) MERYCHIPPUS AND EQUUS, (B) PARAHIPPUS AND MERYCHIPPUS, (C) MESOHIPPUS AND PARAHIPPUS, (D) OROHIPPUS AND MESOHIPPUS. ____

10. IN COMPARING THE TIME IT TOOK FOR THE CHANGES IN THE SPAN OF THE CHEEK TEETH IN HORSELIKE ANIMALS, THE INCREASE FROM 4.3 CM TO 8.3 CM, WHEN COMPARED TO THE INCREASE FROM 8.3 CM TO 12.3 CM, TOOK ABOUT (A) 2 TIMES AS LONG, (B) 4 TIMES AS LONG, (C) 6 TIMES AS LONG, (D) 8 TIMES AS LONG. ____

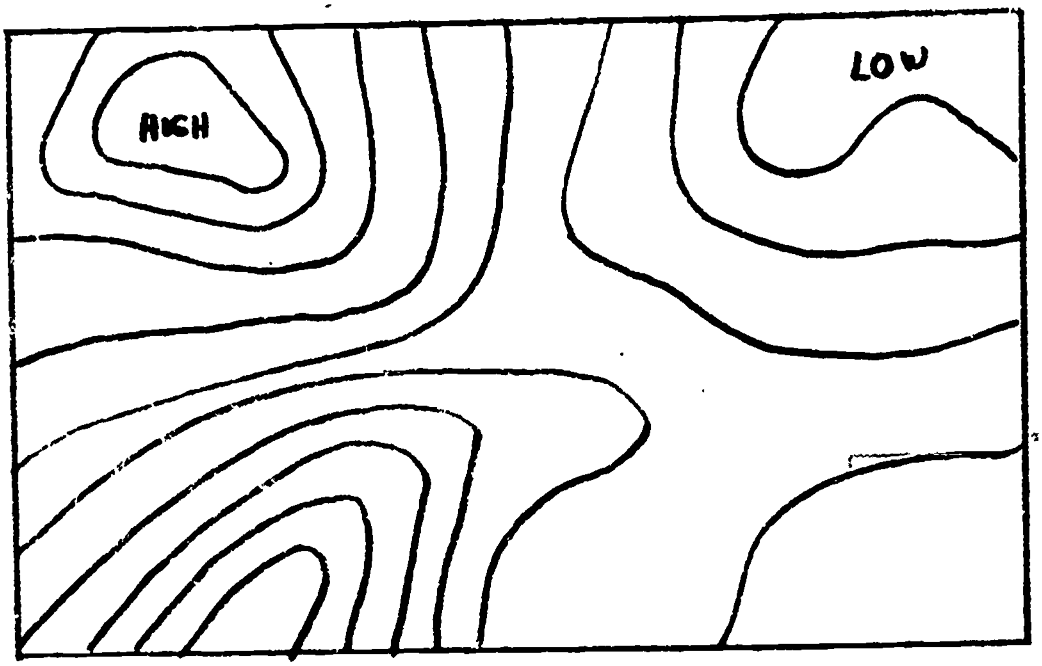
APPLICATION:

SKELETONS OF ANCIENT MANLIKE ANIMALS HAVE BEEN FOUND AND STUDIED BY SCIENTISTS. DESCRIBE HOW THE LENGTH OF THE JAW IN THESE PRIMITIVE SKELETONS COMPARES WITH THE LENGTH OF THE JAW IN MODERN MAN.



[illegible] 2. Cross section for Exercise 1a.

ATMOSPHERE-WEATHER



EARTH SCIENCE - ATMOSPHERE-WEATHER

AIR TRAFFIC CONTROLLER	ASTRONAUTS
GEOGRAPHER	GEOLOGIST
GEOPHYSICIST	GROUND RADIO OPERATOR
MERCHANT MARINE	METEOROLOGIST
OCEANOGRAPHER	PHOTOGRAPHER
PILOTS	ELEMENTARY TEACHER
TEACHER SECONDARY-COLLEGE	TECHNICAL WRITER
COMPUTER OPERATORS	AGRICULTURAL EXTENSION WORKER
DAIRY PRODUCTION TECHNICIAN	FARM CROP PRODUCTION TECHNICIAN
FARMING	FISH & WILDLIFE TECHNICIAN
FISH CULTURE TECHNICIAN	FORESTER
FORESTERY PRODUCTION TECHNICIAN	LIVESTOCK PRODUCTION TECHNICIAN
ORCHARD TECHNICIAN	HORTICULTURIST
PARKS LAND MANAGEMENT TECHNICIAN	RANGE MANAGEMENT
SOIL CONSERVATIONIST	SOIL SCIENTIST
FLIGHT ENGINEER	BRICK LAYER
CEMENT MASON	TELEPHONE INSTALLER
ELECTRICAL REPAIRMAN	GLAZIER
LINEMAN	PLASTERER
PLUMBER & PIPE FITTER	ROOFER
SHEET METAL WORKER	STONE MASON
STRUCTURAL STEEL WORKER	TELEPHONE REPAIRMAN
AIRPLANE DISPATCHER	TAXI DRIVER
POWER DISPATCHER	TRUCK DRIVER

ATMOSPHERE & WEATHER
LEVEL: JUNIOR HIGH

ACTIVITY: WHAT CONDITIONS AFFECT HEAT ABSORPTION BY SOIL?

MATERIALS: (PER TEAM)

THREE 500 ML BEAKERS
THREE THERMOMETERS
THREE CARDBOARD COVERS FOR BEAKERS
AT LEAST A 150 WATT LIGHT BULB WITH SOCKET AND CORD
TWO PINTS OF DARK SOIL
ONE PINT OF LIGHT-COLORED SOIL
WATER
KNIFE

PROCEDURE:

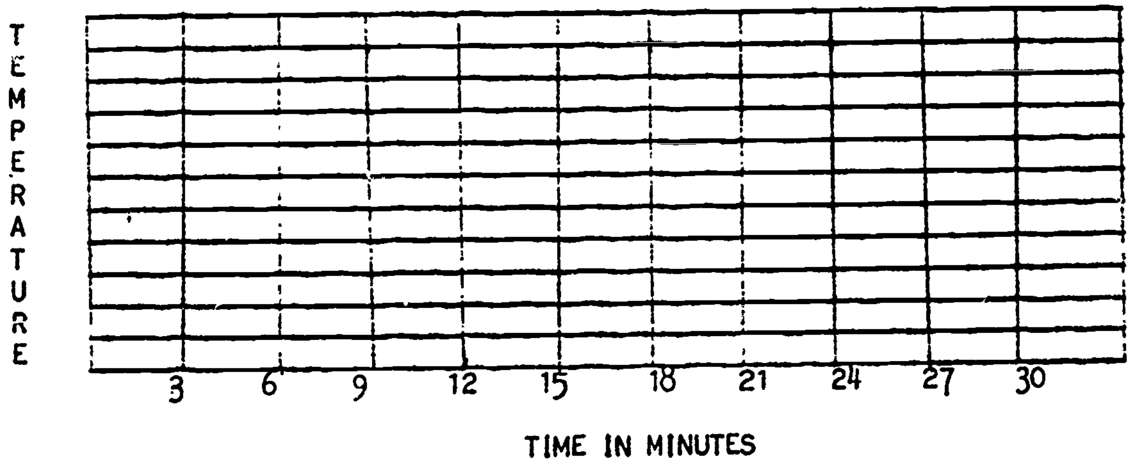
A. FILL ONE BEAKER WITH LIGHT-COLORED, DRY SOIL AND THE OTHER TWO WITH DRY, DARK SOIL. LABEL THE BEAKERS A, B, AND C.
B. POUR ENOUGH WATER IN ONE OF THE DARK SOIL SAMPLES TO MAKE IT MUDDY. STIR THE MIXTURE CONSTANTLY.
C. CUT A HOLE IN THE MIDDLE OF EACH CARDBOARD COVER LARGE ENOUGH TO PUSH A THERMOMETER THROUGH. PLACE A COVER OVER EACH BEAKER AND PUSH THE THERMOMETER ABOUT HALFWAY INTO THE SOIL.
D. PLACE THE BEAKERS AROUND A 150-WATT LIGHT BULB, ABOUT 3 INCHES FROM THE BULB. BE SURE ALL THE BEAKERS ARE EQUALLY DISTANT FROM THE BULB.

E. TAKE A READING, EVERY THREE MINUTES, OF EACH THERMOMETER AND RECORD THE TEMPERATURE BELOW. REPEAT 10 TIMES.

WHAT DO WE SEE?

1. WITH THE INFORMATION YOU HAVE GOTTEN TOGETHER, MAKE A GRAPH USING THE FOLLOWING SYMBOLS:

LIGHT-COLORED DRY SOIL ______________
DARK-COLORED DRY SOIL ___0 ___0 ___0
DARK-COLORED WET SOIL ___+ ___+ ___+



WHAT DO WE LEARN?

1. EXPLAIN THE PATTERN OF YOUR GRAPH.

2. IN WHICH BEAKER DID THE TEMPERATURE RISE THE MOST? EXPLAIN WHY THIS WAS THE CASE.

3. IN WHICH SOIL SAMPLE DID THE TEMPERATURE RISE THE LEAST? EXPLAIN WHY YOU THINK THIS WAS THE CASE.

4. IF YOU GOT WET IN THE RAIN, WOULD YOU FEEL COLD? WHY?

5. WOULD THE SAME KIND OF CHANGE HAPPEN TO THE SOIL SAMPLE THAT WAS WET?

6. IN THE SUMMER IS IT BETTER TO WEAR LIGHT OR DARK CLOTHING? WHY?

7. DOES THE COLOR OF CLOTHING WORN AFFECT BODY TEMPERATURE?

8. DOES THE COLOR OF SOIL AFFECT ITS TEMPERATURE? WHY?

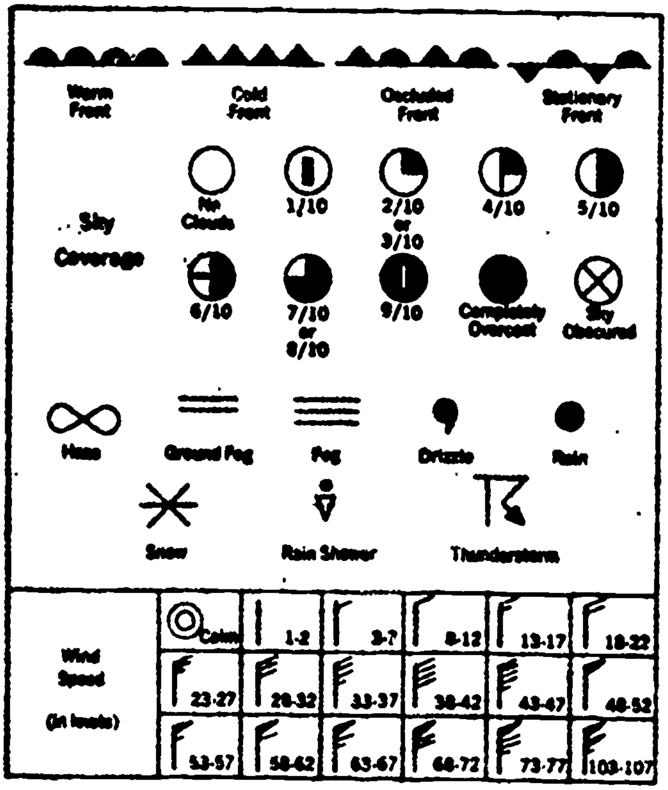
A B C

D E F

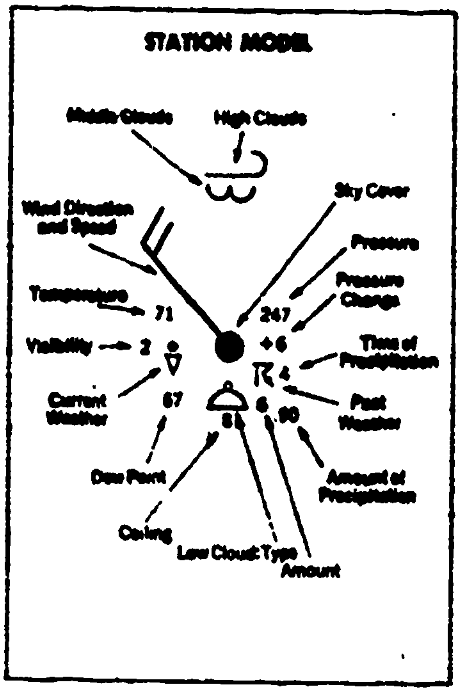
Station	A	B	C	D	E	F
Wind direction	SE	N	W	-	S	NW
Wind Speed (knots)	3-7	13-15	23-27	Calm	29-31	1-2
Cloud coverage	Clear	Overcast	Overcast	Clear	Scattered	Obscured
Temperature	77	26	78	60	80	50
Visibility	20 Miles	1 Mile	6 Miles	30 Miles	8 Miles	0
Current Weather	-	Snow	Drizzle	-	-	Fog
Dew point	67	18	62	55	63	49
Pressure	1034.5	998.6	1021.5	1005.6	1033.3	995.8
Pressure Change	Steady	-5	-3	+6	+8	Steady
Past weather	-	Snow	Rain	Thunder-storm	-	Rain Shower
Amount of precipitation	None	.05	9	.8	None	.6

PROCEDURE:

CONSTRUCT STATION MODELS IN THE SPACES PROVIDED. REFER TO THE WEATHER SYMBOL KEY AND SAMPLE STATION MODEL.



WEATHER SYMBOL KEY AND SAMPLE STATION MODEL



ATMOSPHERE - WEATHER
LEVEL: HIGH SCHOOL

ACTIVITY: ABSORPTION AND RADIATION OF ENERGY: LAND AND WATER

PURPOSE: TO SEE WHETHER LAND AND WATER DIFFER IN THE ABSORPTION AND RADIATION OF HEAT ENERGY.

BACKGROUND:

THE CONTINENTS AND ISLANDS OF THE EARTH COMPRISE ONLY ABOUT ONE-FOURTH OF ITS SURFACE. THE REMAINING THREE-FOURTHS IS WATER. IF THESE TWO MATERIALS--LAND AND WATER--DIFFER IN THEIR ABILITY TO ABSORB AND RETAIN THE HEAT ENERGY TRANSMITTED TO THEM BY THE SUN, THIS WOULD EXPLAIN IN LARGE MEASURE THE GREAT DIFFERENCES IN THE WEATHER AND CLIMATE OF COASTAL REGIONS AS AGAINST REGIONS IN CONTINENTAL INTERIORS.

IN THIS INVESTIGATION, WE SHALL COMPARE THE TEMPERATURE CHANGES THAT OCCUR ON A SMALL "LAND" SURFACE AND A SMALL WATER SURFACE, FIRST AS THEY ARE WARMED BY THE RADIATION FROM AN INCANDESCENT BULB SERVING AS THE "SUN", AND THEN AS THEY COOL OFF AFTER THE SUN "SETS".

MATERIALS:
SMALL BEAKERS (ABOUT 250 C.C.) OR DEEP DISHES OR BOWLS; DESK LAMP OR CLIP-ON LAMP; INCANDESCENT BULB (AT LEAST 100 WATTS); THERMOMETERS (RANGE AT LEAST 0°C TO 50°C, OR 32°F TO 122°F); RING STANDS AND CLAMPS; SAND OR SOIL; WATER.

PROCEDURE:

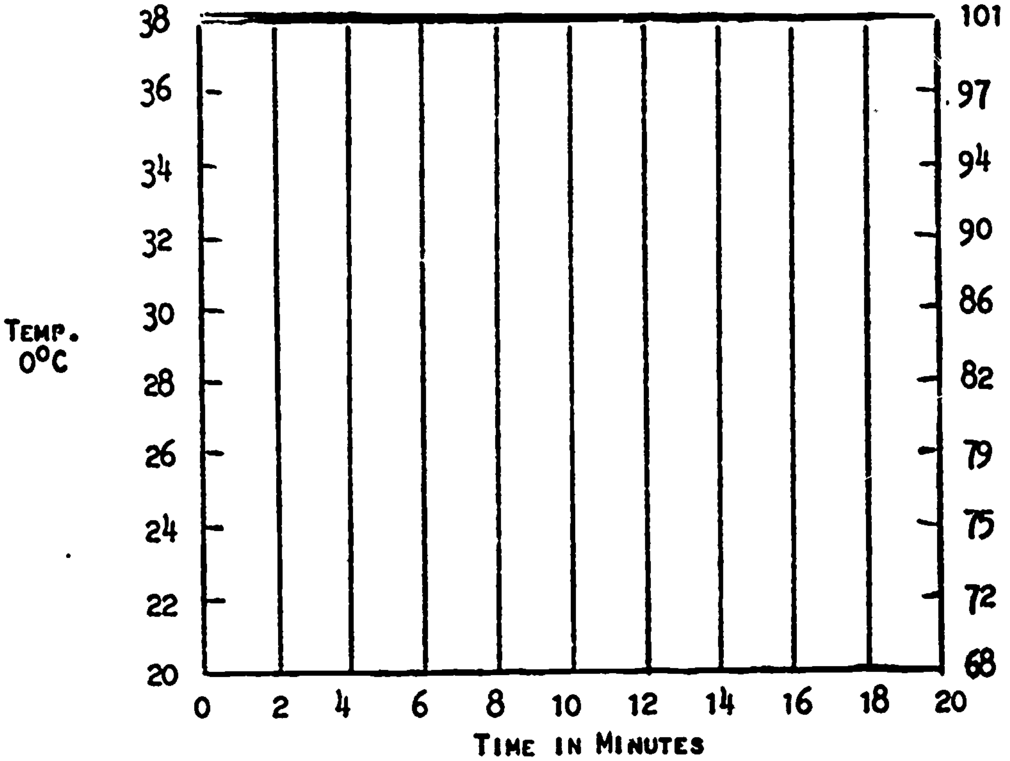
TAKE TWO SMALL BEAKERS (OR DEEP DISHES OR BOWLS). HALF FILL ONE BEAKER WITH WATER AT ROOM TEMPERATURE. FILL THE SECOND BEAKER WITH SAND OR SOIL TO THE SAME LEVEL. PUT THE TWO BEAKERS CLOSE TOGETHER, BUT NOT TOUCHING. PLACE THE ELECTRIC LIGHT (SWITCH OFF) DIRECTLY OVER THE CENTER POINT BETWEEN THE TWO BEAKERS, ABOUT ONE FOOT ABOVE THE WATER AND SOIL SURFACES.

PLACE ONE THERMOMETER IN THE SOIL WITH ITS BULB JUST BELOW THE SURFACE. PLACE THE SECOND THERMOMETER AT EXACTLY THE SAME LEVEL IN THE WATER. WHEN BOTH THERMOMETERS SHOW THE SAME READING--WHICH SHOULD BE JUST ABOUT ROOM TEMPERATURE--RECORD THE READING IN THE TABLE BELOW, SWITCH ON THE BULB, AND THEN RECORD THE READINGS OF BOTH THERMOMETERS EVERY TWO MINUTES FOR TEN MINUTES.

AT THE END OF 10 MINUTES SWITCH OFF THE LIGHT. CONTINUE TO RECORD THE THERMOMETER READINGS FOR 10 MORE MINUTES.

PLOT THE READINGS ON GRAPH PAPER, USING TWO DIFFERENT KINDS OF LINE TO REPRESENT THE TWO DIFFERENT MATERIALS.

			LIGHT ON						LIGHT OFF		
TIME (MINS.)	0	2	4	6	8	10	12	14	16	18	20
WATER											
LAND											



ANALYSIS OF OBSERVATIONS:

1. ABSORPTION OF HEAT ENERGY

DID THE TWO MATERIALS WARM UP AT THE SAME RATE?__________ IF NOT, WHICH WARMED UP FASTER?___________ HOW MANY OF YOUR CLASSMATES (TEAMS) HAVE RESULTS THAT AGREE WITH YOURS?____________ HOW MANY DIFFER?_____ _____ ON THE BASIS OF THESE RESULTS, WHAT MAY YOU SAY REGARDING THE RELATIVE ABILITY OF LAND AND WATER TO ABSORB RADIANT ENERGY?_________

2. RADIATION OF HEAT ENERGY

DID THE LAND AND WATER COOL OFF AT THE SAME RATE?___________ IF NOT, WHICH COOLED OFF FASTER?_________HOW DID YOUR CLASSMATES RESULTS AGREE WITH YOURS?_________ON THE BASIS OF THESE RESULTS WHAT CAN YOU SAY REGARDING THE RATE AT WHICH LAND AND WATER LOSE HEAT?__________

WHAT REASONS CAN YOU GIVE FOR THE DIFFERENT RATES AT WHICH LAND AND WATER ABSORB AND LOSE HEAT?

3. APPLICATION TO THE EARTH

WHAT EFFECT WILL THE DIFFERENT RATES OF HEATING AND COOLING OF LAND AND WATER HAVE ON THE SUMMER WEATHER OF INLAND PLACES AS COMPARED WITH COASTAL PLACES?

WHAT EFFECT WILL THERE BE ON THEIR WINTER WEATHER?

4. WHAT CAREERS DO YOU THINK WOULD NEED TO BE FAMILIAR WITH THE CONCEPT OF THIS ACTIVITY? LIST.

ATMOSPHERE - WEATHER
LEVEL: HIGH SCHOOL

ACTIVITY: WEATHER FORECASTING

PROBLEM:

FAIRLY RELIABLE WEATHER FORECASTS MAY BE MADE FROM YOUR UNDERSTANDINGS OF THE PRINCIPLES OF WEATHER FORMATION AND YOUR KNOWLEDGE OF MEASURING TECHNIQUES. THESE PREDICTIONS SHOULD NOT BE CONSIDERED VALID FOR MORE THAN 12 TO 24 HOURS. HOW MAY AMATEUR WEATHER FORECASTS BE MADE?

MATERIALS:

EITHER AN ANEROID OR MERCURIAL BAROMETER CORRECTED FOR THE ALTITUDE WHERE THE READING IS MADE	THERMOMETER WIND VANE HYGROMETER

PROCEDURE:

MAKE A TABLE ON SEPARATE SHEETS OF PAPER ON WHICH TO RECORD THE FOLLOWING DATA AT LEAST ONCE EACH DAY FOR SEVERAL WEEKS:

(A) BAROMETER READING
(B) DIRECTION OF MOVEMENT OF THE BAROMETER
(C) WIND DIRECTION
(D) TYPE OF CLOUD FORMATION
(E) RELATIVE HUMIDITY (OUTDOOR)
(F) TEMPERATURE

PROVIDE A COLUMN ON YOUR DATA TABLE FOR YOUR PREDICTION FOR EACH DAY. IN THE NEXT COLUMN, RECORD WHAT THE ACTUAL WEATHER WAS FOR THAT DAY AND COMPARE THE TWO TO DETERMINE THE ACCURACY OF YOUR PREDICTION. USING THE DATA GIVEN IN THE KEY BELOW, THE PREDICTION MAY EASILY BE MADE.

INTERPRETATION:

A.

CLOUD FORMATION	WEATHER INDICATION
CUMULUS OR ALTOCUMULUS	FAIR
CUMULONIMBUS	RAIN OR THUNDERSTORM
DENSE CIRRUS WITH HOOKED ENDS	RAIN
ALTOSTRATUS FOLLOWING CIRROSTRATUS	RAIN

B.

BAROMETER TENDENCY	WEATHER INDICATION
FALLING RAPIDLY	APPROACHING COLD FRONT
FALLING SLOWLY	APPROACHING WARM FRONT
RISING RAPIDLY	PASSING COLD FRONT
RISING SLOWLY	COLD AIR MASS IN AREA

C.

WIND	BAROMETER READING	WEATHER INDICATION
SW TO NW	STEADY AT 30.1	FAIR
SW TO NW	RISING ABOVE 30.1	FAIR FOLLOWED BY CHANGE
SW TO NW	STATIONARY ABOVE 30.2	FAIR
SW TO NW	FALLING FROM 30.2	FAIR WITH RISING TEMPERATURE
S TO SE	FALLING SLOWLY FROM 30.2	RAIN
S TO SE	FALLING RAPIDLY FROM 30.2	RAIN, WINDS
SE TO NE	FALLING SLOWLY [redacted].2	RAIN
SE TO NE	FALLING RAPIDLY FROM 30.2	RAIN, WINDS

E TO NE	FALLING SLOWLY BUT ABOVE 30	WINDY, OVERCAST
E TO NE	FALLING RAPIDLY BELOW 30	RAIN
SE TO NE	FALLING SLOWLY BELOW 30	CONTINUED RAIN
SE TO NE	FALLING RAPIDLY BELOW 30	RAIN, WIND
S TO SW	RISING SLOWLY	FAIR
S TO E	FALLING RAPIDLY	STORM
E TO N	FALLING RAPIDLY	SEVERE STORM
MOVING TO WEST AFTER STORM	RISING	CLEARING, FAIR, COOLER

ATMOSPHERE - WEATHER
Level: High School

ACTIVITY: It's Not the Heat; It's the Humidity

Procedures:

A. Clean Hands for Science

We know there is water in the air; every rainstorm tells us that. We have some ideas about how it gets there. The hint comes from every clothesline. The clothes do get dry. Maybe drying can tell us something about water entering the air.

Make your hands equally wet. They should not be dripping. Keep your left hand still at your side. Swing your right arm around in a circle. Keep it up for at least thirty seconds.

1. Now look at your two hands. Which is drier?

2. Which hand is colder?

There are more ways of getting rid of water than by just waving it away. Add about 20 ml of water to a flameproof dish or beaker. Place it over a burner and heat it.

3. After a short time, what has happened to the water?

B. Wet Wind, Dry Wind

When we waved wet hands around, the water went into the air. When we heated water, it went into the air. How can we get some of this water back?

Take a shiny metal cup. Fill it half full of water. Add pieces of ice until it is almost full. Now keep looking at the outside surface of the cup.

4. What happens after a while?

   A car is sometimes wet early in the morning even though it didn't rain.

5. What do you think happened to the car's temperature during the night?

So drops of water form on cold surfaces. It happens on cars and cold cans from the refrigerator. It even happens on eyeglass lenses. But what happens when it rains? There are no cold metal cups up in the air. We see clouds and know they bring rain, snow, and hail. Clouds form in air. Air may be warm or cold. Let's cool some air and see what happens.

Fill a jar about one-quarter full of warm water. Tie some pieces of ice in a piece of cheesecloth. Make the bundle larger than the mouth of the jar. Place the bundle of ice on the mouth of the jar and observe the jar for a few minutes.

6. WHAT IS HAPPENING INSIDE?

7. WHAT IS FLOATING AROUND IN THE AIR THAT MIGHT BE MISSING IN THE JAR?

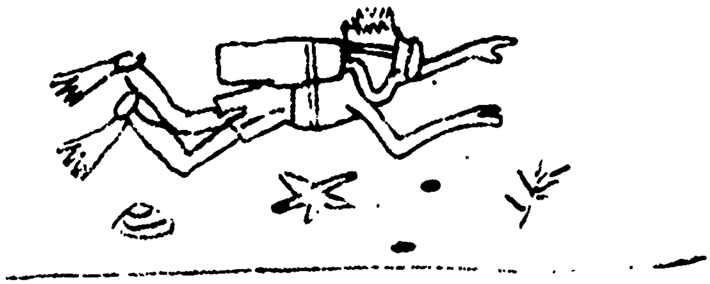
LIGHT A SPLINT AND LET IT BURN FOR A MOMENT. BLOW OUT THE FLAME SO THE SPLINT GLOWS. LOWER THE GLOWING SPLINT INTO THE JAR FOR 1 OR 2 SECONDS, THEN REMOVE IT. PLACE THE BUNDLE OF ICE ON THE MOUTH OF THE JAR.

8. OBSERVE THE JAR FOR A FEW MINUTES. WHAT IS HAPPENING INSIDE?

9. WHAT DID WE DO TO THE AIR IN THE JAR TO GET THIS RESULT?

10. WHAT DID THE GLOWING SPLINT ADD FOR THE FOG TO FORM AROUND?

WATER AND SUPPLY



EARTH SCIENCE - WATER & SUPPLY

Architects
Petroleum Engineer
Geophysicist
Merchant Marine
Elementary Teacher
Technical Writer
Fireman
Dairy Production Technician
Farming
Fish Culture Technician
Forestery Production Technician
Orchard Technician
Parks Land Management Technician
Soil Conservationist
Power Plant Operator
Boiler Fireman

Astronauts
Geologist
Landscape Architect
Oceanographer
Teacher secondary-college
Urban Planner
Agricultural Extension Worker
Farm Crop Production Technician
Fish & Wildlife Technician
Forester
Livestock Production Technician
Horticulturist
Range Management
Soil Scientist
Stationary Engineer
Power Dispatcher

WATER SUPPLY (Underground)
Level: Junior High & Above

ACTIVITY: How large a watershed would be required for your town?

Materials: Geological survey map with location of gaging stations in your area
Summary of statistics pertinent to the gaging stations you want to use

Introduction to Teacher: This activity could be a part of a community unit on water or could be a separate activity. A teacher would need to relate this activity to their own local situation.

Procedure:

All fresh water on the surface of the earth once fell as precipitation--rain, snow, or in other forms. Part of the precipitation evaporated and returned to the atmosphere as water vapor; part of it was consumed by plants and vegetation and through the process of transpiration returned to the atmosphere as water vapor. Water thus returned to the atmosphere is commonly referred to as "natural water loss". It is the remainder of the precipitation after this natural water loss has been subtracted, that feeds our streams and supplies man with water for his many needs.

Has it ever occurred to you that water is a form of crop, like corn? You have seen statistics on the number of acres of productive land required to supply each person with his necessary requirements of food. Likewise, a certain number of acres of land is required per person to supply the water needs of that person. An interesting activity might be to determine how large an area in your general vicinity would be required to supply your town or community with water. Suppose you live in a town of 10,000 population, and we assume that the use of water is 100 gallons per day per capita. Your town would use 1,000,000 gallons per day, or 365,000,000 gallons per year.

Your problem is to determine the water-productivity of the land in your general vicinity. The Geological Survey can supply you with a small map of your State, showing the location of gaging stations on some of the principal streams. A gaging station is a point where the flow of a stream is actually measured with special kinds of equipment. A continuous record of the flow is kept, so that it is possible to compute the volume of water that has passed the gaging station in any one day, month, year, or whatever period of time is desired.

In addition to the map, the Geological Survey can furnish you a sheet showing the names of the gaging stations whose locations are plotted on the map, and a summary of the statistics pertinent to these stations. The statistics you will want to use are drainage area and average discharge in acre-feet.

BEFORE WE GO FURTHER, THESE TERMS SHOULD BE DEFINED. THE TERM "DRAINAGE AREA" AS USED HERE MEANS THE AREA, EXPRESSED IN SQUARE MILES, OF THE DRAINAGE BASIN ABOVE THE GAGING STATION. A DRAINAGE BASIN CAN BE COMPARED TO AN IRREGULAR SHAPED BOWL THAT IS OPEN ON ONE SIDE. THE MAIN STREAM OCCUPIES ROUGHLY THE MIDDLE OF THE BOWL AND FLOWS OUT THROUGH THE OPEN SIDE. TRIBUTARY STREAMS FLOW DOWN THE SIDES OF THE BOWL IN THE GENERAL DIRECTION OF THE MAIN STREAM, INTO WHICH THEY EVENTUALLY EMPTY. "AVERAGE DISCHARGE" IS THE AVERAGE VOLUME OF FLOW, OVER A PERIOD OF YEARS--EITHER SOME SPECIFIED PERIOD, OR THE ENTIRE PERIOD DURING WHICH RECORDS HAVE BEEN COLLECTED AT A GIVEN GAGING STATION. AVERAGE DISCHARGE MAY BE EXPRESSED IN TERMS OF FLOW STATED IN CUBIC FEET PER SECOND (CFS) OR IN ACRE-FEET PER YEAR. AN "ACRE-FOOT" OF WATER IS THE AMOUNT OF WATER REQUIRED TO COVER AN ACRE OF FLAT SURFACE TO A DEPTH OF ONE FOOT. HENCE AN ACRE-FOOT OF WATER IS EQUIVALENT TO 325,821 GALLONS.

TO DEMONSTRATE HOW THESE FIGURES CAN BE USED, SUPPOSE YOU LIVE IN NORTH-CENTRAL OHIO, AND UPON EXAMINING THE MAP YOU FIND THAT GAGING STATION 30, ON THE SANDUSKY RIVER NEAR FREMONT, IS THE NEAREST STATION. YOU WOULD FIND THAT ITS DRAINAGE AREA IS 1,248 SQUARE MILES AND ITS AVERAGE DISCHARGE IS 661,000 ACRE-FEET PER YEAR. DIVIDE 661,000 BY 1,248 AND YOU GET 530 ACRE-FEET PER SQUARE MILE PER YEAR AS THE AVERAGE DISCHARGE OF SANDUSKY RIVER. HOWEVER, THESE COMPUTATIONS ASSUME THAT ALL THE FLOW OF THE STREAM, EVEN DURING FLOODS, CAN BE STORED FOR LATER USE. IT IS NOT PRACTICABLE TO STORE ALL THE FLOW, FOR MANY REASONS. HENCE, IN ORDER TO MAKE THE RESULTS MORE REALISTIC, ASSUME THAT ONLY ONE-HALF THE COMPUTED YIELD CAN BE STORED. IN THIS EXAMPLE, THEN, YOU WOULD ASSUME THAT 265 ACRE-FEET PER YEAR IS AVAILABLE FOR STORAGE FOR YOUR MUNICIPAL NEEDS.

TO COMPUTE THE SIZE OF DRAINAGE BASIN NEEDED TO SUPPLY YOUR HYPOTHETICAL TOWN WITH WATER, YOU NEED TO CONVERT THE 365,000,000 GALLONS PER YEAR USED BY YOUR TOWN TO ACRE-FEET PER YEAR, AND THEN COMPARE THE RESULT WITH THE YIELD OF THE SANDUSKY RIVER. DIVIDING 365,000,000 GALLONS PER YEAR BY 325,821 GALLONS PER ACRE-FOOT, YOU WOULD GET 1,120 ACRE-FEET PER YEAR AS THE AMOUNT USED. THEN BY ASSUMING THAT A STREAM IN YOUR GENERAL VICINITY YIELDS THE SAME AS THE SANDUSKY RIVER, YOU CAN DIVIDE 1,120 ACRE-FEET PER YEAR BY 265 ACRE-FEET PER YEAR PER SQUARE MILE AND OBTAIN 4.2 SQUARE MILES AS THE SIZE OF "WATERSHED" NEEDED TO SUPPLY YOUR TOWN.

AS YOU MAY SUSPECT, THE EXAMPLE PRESENTED IN THIS OUTLINE IS SIMPLIFIED. IN ACTUAL PRACTICE, MANY VARIABLE PHYSICAL FACTORS MUST BE ACCOUNTED FOR IN DESIGNING A PROJECT THAT UTILIZES THE FLOW OF A STREAM. FINALLY, WE CALL ATTENTION TO THE FACT THAT THIS EXAMPLE PERTAINS TO STREAMFLOW ONLY. MANY MUNICIPALITIES OBTAIN PART OR ALL OF THEIR WATER FROM WELLS, WHICH PRESENTS AN ENTIRELY DIFFERENT PROBLEM.

WATER AND SUPPLY
LEVEL: JR. HIGH OR HIGH SCHOOL

ACTIVITY: MEASURE THE SLOPE OF A FIELD

SLOPE IS EXPRESSED IN PERCENT, MEANING THE NUMBER OF UNITS THE LAND FALLS (OR RISES) IN 100 UNITS OF HORIZONTAL DISTANCE. YOU CAN MEASURE HOW STEEP A SLOPE IS WITH SOME SIMPLE MATERIALS.

YOU WILL NEED A YARDSTICK, A STRAIGHT STICK EXACTLY 50 INCHES LONG, AND A CARPENTER'S LEVEL OR A FLAT BOTTLE HALF FULL OF A COLORED LIQUID. GO OUT ON A PLAYGROUND OR TO ANY PLACE YOU WOULD LIKE TO KNOW HOW STEEP THE SLOPE IS. PLACE THE 50-INCH STICK HORIZONTALLY ON THE GROUND (ONE END WILL BE HIGHER THAN THE OTHER BECAUSE OF THE SLOPE). PUT THE LEVEL (OR THE BOTTLE) ON THE 50-INCH STICK, AND MOVE THE FREE END OF THE STICK UP OR DOWN UNTIL THE BUBBLE (OR THE WATER) SHOWS THAT THE STICK IS LEVEL.

READ ON THE YEARDSTICK THE DISTANCE FROM THE GROUND TO THE BOTTOM EDGE OF THE HORIZONTAL STICK. THIS READING IN INCHES, MULTIPLIED BY 2, GIVES THE PERCENT OF SLOPE.

IF YOU USE A STICK 100 INCHES LONG, THEN THE READING ON THE YARDSTICK WOULD GIVE THE PERCENT OF SLOPE AND YOU WOULD NOT NEED TO MULTIPLY BY 2.

INTERPRETATION:

SLOPE IS A VERY IMPORTANT LAND FEATURE. IT OFTEN DETERMINES WHETHER A PIECE OF LAND SHOULD BE USED FOR GRASS, TREES, OR CULTIVATED CROPS.

THE SIZE OF PARTICLES MOVED BY WATER RANGES FROM THE SMALLEST CLAY PARTICLES, CARRIED IN SUSPENSION, TO LARGE STONES AND BOULDERS THAT SLIDE OR ROLL ALONG ON STEEPLY SLOPING STREAM BEDS.

WATER FLOWS SLOWLY OVER A GENTLE SLOPE AND RAPIDLY OVER A STEEP ONE. SINCE THE SLOPE OF A FIELD ITSELF CANNOT BE CHANGED, A FARMER NEEDS TO DO WHAT HE CAN TO SLOW THE MOVEMENT OF WATER DOWN HIS SLOPES. GROWING GRASS OR TREES, OR USING CONSERVATION MEASURES LIKE CONTOUR FARMING AND STRIP-CROPPING WILL HELP. OR HE MAY SHORTEN THE LENGTH OF SLOPE BY BUILDING TERRACES AND DIVERSIONS.

BUT REDUCING THE SPEED OF THE WATER IS ESSENTIAL.

INCREASING THE VELOCITY OF A STREAM INCREASES ITS CUTTING OR ERODING POWER. THE GREATLY MAGNIFIED POWER OF SWIFT CURRENTS AS COMPARED WITH THAT OF SLOW ONES EXPLAINS THE WORK OF STREAMS AT FLOOD STAGE ON STEEP SLOPES.

WATER AND SUPPLY
Level: Jr. High or High School

ACTIVITY: See How Capillary Water Moves Through Soil

Materials:
3 old-fashioned lamp chimneys or glass or plastic cylinders plus 3 small pans or low wide-mouthed glass jars, some thin cloth, and some string or rubber bands.

Procedures:

Fasten the cloth over the top of the lamp chimneys or the cylinders. Turn them upside down and fill each three-fourths full with one of the following dry soils:

1. Sand
2. Clay soil. This kind of soil is sticky when wet and dries in hard clods. Grind up the clods and put the dry clay in the chimney.
3. Dark, crumbly soil like that found under good grass sod. Or get topsoil from a garden or commercial nursery.

Jar the cylinders slightly by bumping on a table to settle the soil. Be sure the soils are dry.

Set the cylinders in the jars and pour water in the jars--do not pour water in the cylinders.

Keep a record of how long it takes the water to move up 1 inch, 2 inches, and 3 inches in each cylinder. Note how long it takes for the water to reach the top or whether it ever reaches the top.

The idea is to compare the capillary movement of water in coarse, medium, and fine soil particles.

Interpretations:

Moisture moves through soil in all directions, even against gravity, by capillary movement. This movement is caused by the attraction water molecules have for each other as well as the attraction between water molecules and soil particles. Water molecules cling together and form droplets in the air or on a greasy surface where there is nothing to interfere. But when a drop of water falls on soil particles, it spreads out as a thin film over the soil particles--because the attraction between the soil particles and the water molecules is greater than the attraction between the water molecules themselves. Water that moves through soil this way is known as capillary water.

How far and how fast capillary water will move in a soil depends on the size of the soil particles and the condition of the soil. If the spaces around the soil particles are large, the attraction between the water molecules and the soil particles will not be enough to overcome the weight of the water and it will not rise appreciably; however, what movement it makes will be rapid because there will be little friction. This is true in sandy soils.

On the other hand, in fine-textured soils the particles are closer together and the attraction between soil and water is greater. Water may then be expected to rise more slowly but higher in soils of fine texture.

UNDER FIELD CONDITIONS MOISTURE MOVES FROM WETTER SOIL TO DRIER SOIL. THE DIFFERENCE IS NOT ALWAYS GREAT, THEREFORE CAPILLARY WATER MOVES SLOWLY AND NOT FAR. EVEN SO, ENOUGH MOISTURE MOVES A SHORT DISTANCE TO THE ROOTS OF GROWING PLANTS TO MAKE IT AN IMPORTANT PLANT-SOIL RELATIONSHIP.

MUCH SOIL MOISTURE CAN BE LOST WHEN CAPILLARY WATER MOVES TO THE SURFACE AND EVAPORATES. USING MULCHES CAN REDUCE THIS.

WATER AND SUPPLY
Level: Jr. High or High School

ACTIVITY: Compare How Much Water Different Soils Hold

Materials:

- 2 cans of equal size (coffee cans will do)
- Two 18-inch squares of cloth
- A package or similar scale that weighs up to 64 ounces or 2,000 grams
- Some heavy string
- Container of water such as a 2- or 3-gallon bucket or a 5-quart oil can with the top cut out.

Procedures:

Put equal volumes of soil in the two cans. Take the soil for one from a field or garden that has been cultivated for several years and that shows lack of organic matter. This sample should be hard and cloddy. Get the other from a well-managed field where grasses and legumes have been grown, or from a good pasture or similar location. This sample should be crumbly and free from clods.

First allow the soils to dry.

Empty the two soil samples on the cloth squares, pull the corners together, and tie with a heavy string. Weigh each sample and record the weight.

Saturate each bag of soil by holding it in the water long enough to soak thoroughly. Remove the soil samples from the water and allow them to drain off the free water for a few minutes. Then weigh again and record the weights.

Calculate the difference in weight.

Another way to measure the water-holding capacity of soils is to use two old-fashioned lamp chimneys or cylinders. Tie a cloth over the top, turn them upside down, and fill them about two-thirds full with the same two soils.

Be sure the soils are equally dry.

Place the chimneys in small-mouth fruit jars.

Pour a pint of water into each chimney. Then note how long it takes the water to begin to drip into the jars, how much water comes from each soil, and how long the water continues to drip.

Interpretations:

When organic matter is used up, soil packs together. Thus, a cloddy soil has fewer air spaces, its particles do not cling together in granules, and the lack of organic matter means that it weighs more than an equal volume of crumbly soil from a well-managed plot.

Not only does a crumbly soil take in water faster than a cloddy one, it holds more. The thoroughly decomposed organic matter (humus) in a crumbly soil can absorb lots of water. On a dry-weight basis, this humus has a water-holding capacity of several hundred percent and may act like a sponge. In addition to the water held by the organic matter itself is the water held in the pores between the soil particles and between the soil granules. Hundreds of very fine soil particles are [illegible]ogether by the organic matter into soil granules.

THIS INCREASED WATER-HOLDING CAPACITY OF SOILS HIGH IN ORGANIC MATTER UNDER NATURAL CONDITIONS MAKES A BIG DIFFERENCE IN THE INTAKE OF WATER. THESE WELL-MANAGED SOILS CAN ABSORB MOST OF THE RAIN AND SNOWMELT (IF THE SOIL IS NOT FROZEN). THIS MEANS THERE WILL BE LESS EROSION. STREAMS WILL RUN CLEAR. OF COURSE, WHEN THE SOIL IS SATURATED BY A LONG PERIOD OF RAINFALL, ANY ADDITIONAL WATER THEN RUNS OFF.

WATER AND SUPPLY
Level: High School

ACTIVITY: Investigating the Movement of Water in the Earth

MATERIALS: ESCP kit for investigation 9-3
Plastic column 80 cm x 35 mm inside diameter

- Cap with drain hose
- Screen to prevent beads from drowning
- Ring stand and clamp
- 2 500 ml beakers
- 1 100 ml graduated cylinder
- 200 ml of coarse sand
- Hose clamp
- Beads, approximately 4mm, 6mm, and 8mm (500 ml of each per class.)
- 200 ml of fine sand
- Graph paper

INTRODUCTION:

Have you ever seen water seeping or flowing from a hillside? How fast does ground water move through the pore spaces in earth materials? Can water move upward through soil? In this investigation you will find evidence to answer some of these questions by examining three properties of earth materials that affect the flow of water underground.

PROCEDURE:

Clamp 80 cm to the ring stand and put cap with drain hose on lower end.

Place 100 ml of uniform beads in the column, making sure the wire screen is in position to prevent the particles from running out.

A. Record the amount of water necessary to just cover the upper surface of the particles.
B. Open the clamp and allow the water to run out into a beaker. Record the amount of water retained by the particles.
C. Add 300 ml of water to the cylinder holding the beads. Record the time required for the water to drain through the particles. Repeat using other size particles.

INTERPRETATION: Answer the following questions.

1. What is the relationship between the water you add and porosity, the percentage of space between the grains? Make a graph showing the relationship between porosity and the diameter of the particles. Explain your results.
2. Make a graph showing the relationship between grain size and the amount of water retained in the column after draining. What conclusions can you draw from the graph?
3. Construct a graph showing the relationship between each of the grain sizes and the time required for 300 ml of water to run through them. Explain your results.
4. Permeability is the rate at which water can pass through a porous material. What is the relationship between permeability and size.

Set up the apparatus for investigating capillarity. Use 200 ml of fine dry sand in the tube. When your partner is ready to time, lower the tube into the water so that the base is just beneath the water surface. Time and record the changes in w[illegible]vel in the tube at 30-second intervals. Repeat this procedure with 200ml of course sand in the tube.

5. On the basis of your observations, what is capillarity?

WATER SUPPLY
LEVEL: JUNIOR HIGH & ABOVE

ACTIVITY: GROUND WATER: NATURE & DISTRIBUTION OF AQUIFERS

MATERIALS: CROSS SECTION CHART OF FORMATIONS
QUESTION SHEET

BACKGROUND: A BODY OF ROCK OR UNCONSOLIDATED SEDIMENT THAT IS PERMEABLE AND CAN YIELD WATER IS CALLED AN AQUIFER. THE MOST COMMON AQUIFERS ARE LAYERS OF SAND OR GRAVEL, OR BEDS OF SANDSTONE, LIMESTONE, AND DOLOMITE. AN INCLINED AQUIFER, THAT IS EXPOSED AT THE SURFACE AND OVERLAIN DOWN DIP BY AN IMPERMEABLE LAYER IS A CONFINED OR ARTESIAN AQUIFER. WHEN AN ARTESIAN AQUIFER IS PENETRATED BY A WELL, WATER WILL RISE IN THE WELL UNDER PRESSURE FROM THE WATER COLUMN IN THE AQUIFER. IF THE GROUND SURFACE AT THE SITE OF THE WELL IS APPRECIABLY LOWER THAN THE INTAKE AREA OF THE AQUIFER, THE WATER WILL RISE TO SURFACE, MAKING THIS A FLOWING ARTESIAN WELL.

PROCEDURE: USING THE CROSS SECTION CHART DETERMINE AND DO THE FOLLOWING:

1. LIST THE ROCK UNITS THAT YOU WOULD EXPECT TO CONTAIN FRESH GROUND WATER. ______________________________

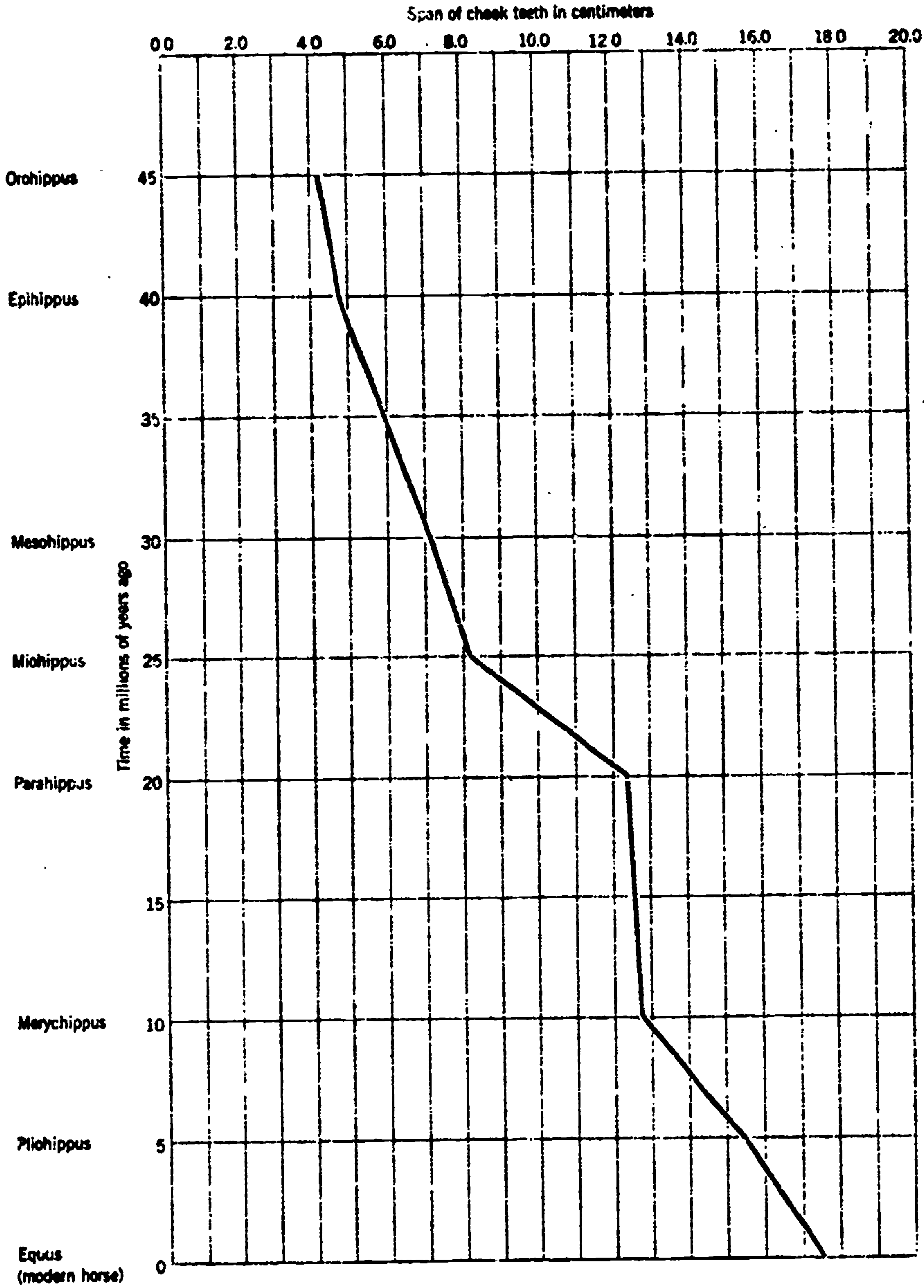
   ____

2. WHICH OF THESE UNITS IS AN ARTESIAN AQUIFER?________
   DRAW A COLORED ARROW TO INDICATE THE DIRECTION OF GROUND WATER MOVEMENT THROUGH THE AQUIFER.

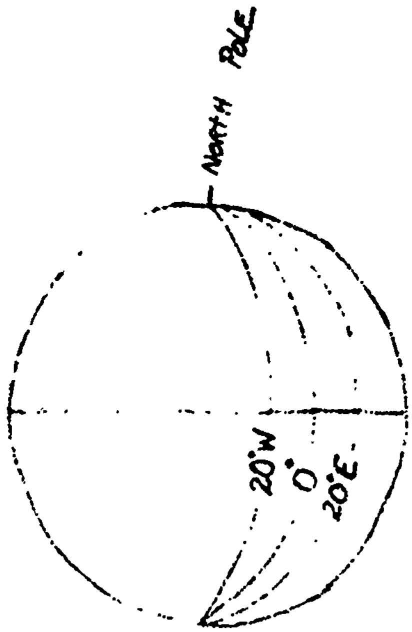
3. SUPPOSE YOU WERE RETAINED AS A CONSULTANT TO LOCATE WATER WELLS OF THE SEVERAL TYPES LISTED BELOW. ON THE CROSS SECTION, SHOW BY MEANS OF COLORED LINES LABELED A, B, C, & D THE WELLS OF THE VARIOUS TYPES THAT YOU COULD DRILL.
   A. FRESH WATER, NONARTESIAN WELL
   B. FRESH WATER, FLOWING ARTESIAN WELL
   C. FRESH WATER, NONFLOWING (PUMPING) ARTESIAN WELL
   D. SALT-WATER, PUMPING WELL
   ALSO INDICATE ONE LOCATION AT WHICH YOU WOULD EXPECT TO FIND A FRESH WATER SPRING (LABEL E).

4. SUPPOSE THAT YOU WANTED TO PUMP SALT WATER FOR USE AS A COMMERCIAL SOURCE OF IODINE. HOW COULD YOU PREVENT THE SALT WATER FROM BEING DILUTED BY FRESH WATER IN THE WELL?

5. IN WHAT OCCUPATIONS CAN YOU THINK OF WOULD THIS TYPE OF ACTIVITY BE HELPFUL.


Span of cheek teeth in centimeters
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
Time in millions of years ago
45
40
35
30
25
20
15
10
5
0
Orohippus
Epihippus
Mesohippus
Miohippus
Parahippus
Merychippus
Pliohippus
Equus
(modern horse)

LOCATING PLACES AND KEEPING TIME



EARTH SCIENCE - LOCATING PLACES & KEEPING TIME

Air Traffic Controller
Astronomer
Cartography
Geophysics
Merchant Marine
Pilots
Elementary Teacher
Technical Writer
Travel Agents
Agricultural Extension Worker
Fish & Wildlife Technician
Forestery Products Technician
Flight Engineer
Watch Repairman
Airplane Dispatcher
Broadcast Technician
Locomotive Engineer
Stevedore
Power Dispatcher

Astronauts
Geography
Geologist
Ground Radio Operator
Meteorologist
Surveyor
Teacher secondary-college
Telegrapher
FBI Agents
Farming
Forester
Soil Scientist
Instrument Maker
Signal Maintainer
Brakeman (train)
Bus Driver
Apprentice Engineer
Taxi Driver
Truck Driver

LOCATING PLACES & KEEPING TIME
LEVEL: JUNIOR HIGH

ACTIVITY: THE LENGTH OF DAYS

MATERIALS: (PER TEAM)

GLOBE WITH AXIS AND BASE
LIGHT SOURCE
PROTRACTOR
STRAIGHT PINS
MARKING PEN
(WATER SOLUBLE INK)

INTRODUCTION:
AT ANY TIME OF THE YEAR, A DAY--FROM NOON TILL NOON--LASTS ABOUT TWENTY-FOUR HOURS. BUT EXPERIENCE HAS SHOWN YOU THAT DURING SUMMER THERE ARE MORE HOURS OF DAYLIGHT THAN OF DARKNESS IN EACH DAY. IN WINTER THERE IS LESS DAYLIGHT IN EACH TWENTY-FOUR HOUR DAY. WHAT COULD CAUSE THIS? WHAT CHANGES WOULD HAVE TO BE MADE IN THE ROTATING-GLOBE MODEL OF THE EARTH TO ACCOUNT FOR CHANGES IN THE LENGTH OF DAYS? IN THIS INVESTIGATION YOU WILL CONSIDER ONE POSSIBILITY.

PROCEDURES:

A. COPY THIS CHART IN YOUR NOTEBOOK.

TILT				
LOCATION	VERTICAL-NO TILT	TILT TOWARD LIGHT SOURCE	TILT AWAY FROM LIGHT SOURCE	TILT TO ONE SIDE OF LIGHT SOURCE
EQUATOR PIN				
NORTHERN-HEMISPHERE PIN				

B. CAREFULLY DRAW LINES AROUND THE GLOBE, FROM TOP TO BOTTOM, TO DIVIDE THE GLOBE INTO EIGHT EQUAL SECTIONS.

C. STICK A STRAIGHT PIN ABOUT 9/10 OF THE WAY INTO THE GLOBE NEAR THE "EQUATOR" AND ALONG ONE OF THE "NORTH-SOUTH" LINES. STICK A SECOND PIN INTO THE GLOBE AT A POINT ABOUT HALF-WAY FROM THE "EQUATOR" TO THE "NORTH POLE." THE SECOND PIN SHOULD BE ON THE SAME "NORTH-SOUTH" LINE AS THE FIRST PIN.

D. PLACE THE GLOBE ABOUT 3 FEET FROM THE LIGHT SOURCE. BE SURE THAT THE CENTER OF THE GLOBE IS LEVEL WITH THE LIGHT SOURCE AND THAT THE AXIS IS VERTICAL (STRAIGHT UP AND DOWN).

THE EARTH ROTATES ONCE ON ITS AXIS IN EACH TWENTY-FOUR HOURS. IMAGINE THAT YOUR GLOBE ROTATES AT THE SAME SPEED. SINCE THE LINES DIVIDE IT INTO EIGHT EQUAL PARTS, IT WOULD TAKE 24÷8, OR 3 HOURS, TO TURN FROM ONE LINE TO THE NEXT.

E. ONE TEAM MEMBER SHOULD BE POSITIONED SO THAT HE CAN SEE THE "MORNING" SIDE OF THE GLOBE. A SECOND MEMBER SHOULD BE POSITIONED OPPOSITE THE FIRST, LOOKING AT THE "EVENING"

SIDE OF THE GLOBE. ROTATE THE GLOBE UNTIL THE "EQUATOR" PIN IS JUST COMING FROM DARK INTO DAYLIGHT ("MORNING" FOR THE PIN). THE EVENING OBSERVER SHOULD ROTATE THE GLOBE SLOWLY UNTIL THE PIN REACHES THE DARK-LIGHT LINE (EVENING). AS THE GLOBE IS BEING TURNED, THE MORNING OBSERVER SHOULD COUNT THE "THREE HOUR" SECTORS THAT PASS FROM DARKNESS INTO LIGHT.

FOR HOW MANY "HOURS" WAS THE PIN IN THE LIGHT? (IF YOU CANNOT TELL EXACTLY, ESTIMATE THE NUMBER AS CLOSELY AS YOU CAN.) ENTER THE NUMBER OF "HOURS" IN THE TABLE IN YOUR NOTEBOOK IN THE SPACE OPPOSITE "EQUATOR PIN" AND BELOW "VERTICAL-NO TILT."

F. REPEAT PROCEDURE E, BUT THIS TIME OBSERVE THE PIN IN THE "NORTHERN HEMISPHERE." ESTIMATE THE NUMBER OF "HOURS" IT SPENDS IN LIGHT AND ENTER THE NUMBER IN THE TABLE.

G. NOW TILT THE AXIS OF THE GLOBE ABOUT 30° FROM VERTICAL TOWARD THE LIGHT SOURCE (THE "NORTH POLE" TOWARD THE LIGHT; THE "SOUTH POLE" AWAY FROM IT). CHECK TO BE SURE THAT THE CENTER OF THE GLOBE IS STILL LEVEL WITH THE LIGHT SOURCE. TURN THE GLOBE TO SEE HOW MANY "HOURS" EACH PIN SPENDS IN LIGHT. BE CAREFUL NOT TO CHANGE THE TILT AS YOU TURN THE GLOBE. ENTER YOUR OBSERVATIONS IN THE TABLE.

H. TURN THE BASE OF THE GLOBE UNTIL THE AXIS OF THE GLOBE IS TILTED AWAY FROM THE LIGHT SOURCE. TEST EACH PIN IN TURN TO SEE HOW MANY "HOURS" IT SPENDS IN LIGHT. ENTER YOUR OBSERVATIONS IN THE TABLE.

I. FINALLY, TURN THE BASE OF THE GLOBE UNTIL THE AXIS IS TILTED NEITHER TOWARD NOR AWAY FROM THE LIGHT SOURCE, BUT TO ONE SIDE. ESTIMATE THE NUMBER OF "HOURS" SPENT IN THE LIGHT BY EACH PIN AND ENTER THESE IN THE TABLE.

J. WHEN FINISHED, WASH THE LINES OFF THE GLOBE WITH SOAP AND WATER, RINSE, SQUEEZE, AND SET OUT TO DRY.

INTERPRETATIONS:

1. COULD CHANGES IN LENGTHS OF DAYS ON EARTH BE ACCOUNTED FOR BY THINKING OF THE EARTH AS HAVING A TILTED AXIS?
2. IF SO, WHICH SEASON WOULD CORRESPOND TO WHICH DIRECTION OF TILT?
3. WHAT CAN YOU SAY ABOUT THE LENGTHS OF DAYLIGHT FOR POINTS ON THE EQUATOR IF THE TILT OF THE AXIS CHANGES?

PROBLEMS:

1. HOW DO YOU THINK THE LENGTHS OF DAYLIGHT FOR A POINT NEAR THE NORTH POLE WOULD BE AFFECTED IF THE TILT OF THE AXIS CHANGES? DOES THIS AGREE WITH REPORTS YOU MAY HAVE HEARD ABOUT CONDITIONS NEAR THE POLE?

LOCATING PLACES & KEEPING TIME
LEVEL: JUNIOR HIGH

ACTIVITY: DETERMINING YOUR LATITUDE

MATERIALS: CARDBOARD 20 CM X 30 CM
STRING
PROTRACTOR
WEIGHT
SCISSORS
STAPLER
METRIC RULER

TO THE TEACHER: STUDENTS NEED TO BE TOLD THAT THE ALTITUDE OF POLARIS AND LATITUDE ARE THE SAME OR THIS CAN BE DEVELOPED BY AN ACTIVITY WHERE THEY CAN DISCOVER THIS FOR THEMSELVES. AFTER THEY KNOW THIS INFORMATION THEY CAN DO THE FOLLOWING ACTIVITY.

PROCEDURES:

A. IN THIS PROCEDURE YOU WILL CONSTRUCT AN INSTRUMENT CALLED AN ASTROLABE (AS-TROH-LAYB). INVENTED BY THE GREEKS IN THE SECOND OR THIRD CENTURY B.C., THE ASTROLABE IS ONE OF THE MOST ANCIENT SCIENTIFIC INSTRUMENTS. IT WAS AN IMPORTANT NAVIGATIONAL TOOL FOR EARLY SAILORS. IT IS USED TO MEASURE VERTICAL ANGLES.

WITH A STRAIGHTEDGE, DRAW A LINE ACROSS THE CARDBOARD. NEAR THE MIDDLE OF THE LINE MAKE AN INDEX MARK WITH A PENCIL.

USE SCISSORS TO CUT A TRIANGULAR NOTCH AT EACH END OF THE LINE. THE NOTCHES SHOULD BE ABOUT 1 CM DEEP.

AT 10 CM FROM EACH OF THE UPPER CORNERS OF THE CARDBOARD, MAKE A CUT 2 CM LONG. FOLD THE CARDBOARD.

PLACE A PROTRACTOR ON THE CARDBOARD AND CAREFULLY MARK OFF DEGREES. MAKE EACH 5° AND 10° MARK LARGER THAN THE OTHERS. (DO NOT COPY THE NUMBERED DEGREES SHOWN ON THE ORIGINAL PROTRACTOR.) MARK THE DEGREE NUMBERS AS FOLLOWS:

PLACE THE STRING OVER THE INDEX MARK. FASTEN THE STRING AT THE INDEX MARK WITH A STAPLE OR TWO. TIE THE WEIGHT SO THAT IT SWINGS FREE OF THE INSTRUMENT.

THE ASTROLABE IS COMPLETE AND CAN BE USED TO MEASURE THE ALTITUDES OF STARS, WITH REFERENCE TO THE EARTH'S HORIZON.

NOTE: THE FOLLOWING PROCEDURES HAVE TO BE DONE AT HOME IN THE EVENING.

B. In the evening, face Polaris and raise the far end of the astrolabe until you sight Polaris through the notches. The weighted string must hang freely. When you have sighted Polaris, press the string against the cardboard, and read the angle at which it crosses the scale. This angle is the altitude of Polaris.

C. Take your astrolabe home tonight and measure your latitude.

Interpretations:

1. What is your measurement for the latitude of your home?
2. What is the average of the values obtained by your class?
3. What latitude is given on maps for your location?

LOCATING PLACES AND KEEPING TIME
LEVEL: 9TH

ACTIVITY: TOPOGRAPHY

THE TOPOGRAPHIC OR CONTOUR MAP IS AN ACCURATE MEANS OF REPRESENTING THE RELIEF OF THE EARTH'S SURFACE.

MAP PROJECTIONS:

1. WHAT IS A MAP?

2. WHAT IS A MAP PROJECTION?

3. NAME AT LEAST FOUR COMMON MAP PROJECTIONS AND STATE ONE ADVANTAGE OR DISADVANTAGE OF EACH.

TOPOGRAPHIC MAPS:

1. WHAT IS A TOPOGRAPHIC OR CONTOUR MAP?

2. NAME SEVERAL PHYSICAL FEATURES WHICH APPEAR ON TOPOGRAPHIC MAPS.

3. NAME THE FEATURES INDICATED ON CONTOUR MAPS BY EACH OF THE FOLLOWING COLORS:
(A) BLUE: ____________________
(B) BROWN: ____________________
(C) BLACK: ____________________
(D) RED: ____________________
(E) GREEN: ____________________

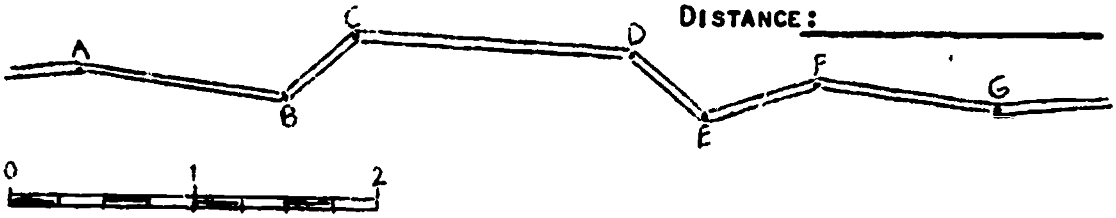
4. WHAT IS A RELIEF MAP?

5. WHAT IS MEANT BY THE SCALE OF A MAP?

6. IN THE SPACE BELOW SHOW THREE WAYS OF INDICATING THE SCALE OF A MAP.

7. MEASURE THE DISTANCE ALONG THE MIDDLE OF THE ROAD FROM POINT A TO POINT G SHOWN BELOW. USE THE STRAIGHT EDGE OF A SHEET OF PAPER TO MARK OFF IN SUCCESSION EACH SEGMENT OF THE ROAD. COMPARE THE TOTAL DISTANCE WITH THE GRAPHIC SCALE SHOWN TO DETERMINE THE DISTANCE ALONG THE ROAD FROM A TO G.

DISTANCE: ____________



8. WHAT IS A CONTOUR LINE?

9. WHAT IS MEANT BY A CONTOUR INTERVAL?

10. IN WHAT TYPE OF AREA IS IT BEST TO USE;
(A) A SMALL CONTOUR INTERVAL?

(B) A LARGE CONTOUR INTERVAL?

11. IN THE SPACE PROVIDED ILLUSTRATE BY CONTOUR LINES EACH OF THE FOLLOWING:
(A) A HILL FOUR CONTOUR LINES HIGH:

(B) A DEPRESSION THREE CONTOUR LINES DEEP:

(C) A VALLEY CONTAINING A STREAM (USE FOUR CONTOUR LINES):

(D) A RIDGE CONSISTING OF AT LEAST THREE PEAKS:

12. EXACT LATITUDE AND LONGITUDE IN DEGREES AND MINUTES CAN BE DETERMINED ON THE TOPOGRAPHIC MAP. (SEE NEXT PAGE)

(A) THE LATITUDE OF POINT X IS ____________

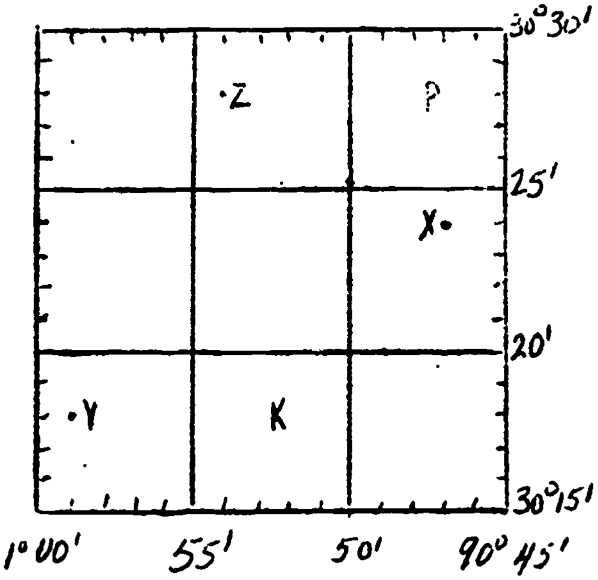
(B) THE LONGITUDE OF POINT Y IS ____________

(C) LOCATE POINT Z ____________

(D) IN WHICH SECTION IS P LOCATED? ____________

(E) IN WHICH SECTION IS K LOCATED? ____________________

(F) WHICH MAP SERIES IS INDICATED HERE? ____________________



LOCATING PLACES AND KEEPING TIME
LEVEL: 9TH

ACTIVITY: LATITUDE, LONGITUDE, AND TIME

ROTATION AND REVOLUTION OF THE EARTH ARE BASES FOR THE MEASUREMENT OF TIME.

LATITUDE:

1. LATITUDE IS THE DISTANCE __________ OR __________ OF THE __________ MEASURED IN __________ ON LINES CALLED __________.

2. THE DISTANCE FROM THE EQUATOR TO THE POLES IS _____ DEGREES. THE LATITUDE OF THE EQUATOR IS _____ DEGREES. THE TROPICS ARE LOCATED _____ DEGREES __________ AND __________ OF THE __________, AND THE ARCTIC AND ANTARCTIC CIRCLES ARE _____ DEGREES FROM THE __________. YOUR HOME IS LOCATED ABOUT _____ DEGREES __________ LATITUDE.

3. ON A CLEAR NIGHT, LATITUDE MAY BE DETERMINED BY FINDING THE __________ OF THE NORTH STAR. IN THE NORTHERN HEMISPHERE, THE NUMBER OF DEGREES THAT THE NORTH STAR IS ABOVE THE HORIZON IS THE OBSERVER'S __________.

4. DURING THE DAY, LATITUDE CAN BE DETERMINED FROM THE __________ BY USE OF AN INSTRUMENT CALLED THE __________.

LONGITUDE:

1. LONGITUDE IS THE DISTANCE __________ OR __________ OF THE __________ MERIDIAN MEASURED IN __________ ON CIRCLES CALLED __________. THESE CIRCLES MEET AT THE __________ AND ARE FARTHEST APART AT THE __________. AT THE EQUATOR, A DEGREE OF LONGITUDE (1/360TH OF THE EARTH'S CIRCUMFERENCE) IS EQUAL TO ABOUT _____ MILES, WHILE AT THE POLES, A DEGREE OF LONGITUDE IS EQUAL TO _____ MILES.

2. STARTING FROM THE PRIME MERIDIAN, THE MERIDIANS ARE NUMBERED UP TO __________ DEGREES __________ AND __________. YOUR HOME IS LOCATED ABOUT __________ DEGREES __________ LONGITUDE.

TIME:

1. THE LENGTH OF DAY IS DETERMIND BY __________. THE LENGTH OF YEAR IS DETERMINED BY __________.
THE LENGTH OF LUNAR MONTH IS DETERMINED BY __________.

2. IN ONE ROTATION ON ITS AXIS, THE EARTH TURNS________ DEGREES IN __________ HOURS. THIS IS A RATE OF_____ DEGREES PER HOUR. PLACES ON THE EARTH THAT ARE FIFTEEN DEGREES OF LONGITUDE APART WILL DIFFER' _______________ IN TIME.

3. WHEN THE SUN IS OVER ANY GIVEN MERIDIAN, THE TIME ON THAT MERIDIAN IS_____________. THE TIME AT A PLACE FIFTEEN DEGREES TO THE EAST OF THIS MERIDIAN WILL BE ___________ O'CLOCK, WHILE AT A PLACE FIFTEEN DEGREES TO THE WEST IT WILL BE ______ O'CLOCK.

4. DUE TO THE FACT THAT THE EARTH MOVES_____________WHEN NEARER THE SUN AND_____________WHEN FARTHER AWAY, THE SOLAR DAYS ARE NOT ALL OF THE SAME LENGTH. THE AVERAGE OF ALL THE SOLAR DAYS OF THE YEAR IS KNOWN AS THE_______________DAY. OUR CLOCKS KEEP ________________TIME. A SUNDIAL KEEPS __________TIME.

5. STANDARD TIME IS____

____

6. THE STANDARD TIME BELTS OF THE UNITED STATES AND CANADA FROM EAST TO WEST ARE____

____

____

RELATED QUESTIONS:

1. STATE TWO OR THREE WAYS BY WHICH TRUE NORTH MAY BE DETERMINED.

2. (A) WHAT IS MEANT BY A GREAT CIRCLE?

   (B) WHAT IS A GREAT CIRCLE ROUTE?

3. DISTINGUISH BETWEEN:
   (A) A SEXTANT AND A CHRONOMETER

   (B) CELESTIAL NAVIGATION AND DEAD RECKONING

4. WHAT CAREERS DO YOU THINK WOULD NEED BACKGROUND IN THIS ACTIVITY? LIST.

[redacted]

LOCATING PLACES AND KEEPING TIME
LEVEL: 9TH

ACTIVITY: STANDARD TIME

INTRODUCTION: IN THIS ACTIVITY YOU WILL STUDY THE STANDARD TIME ZONES OF THE UNITED STATES.

MATERIAL: MAP OF THE UNITED STATES

DIRECTIONS:
1. ON A MAP, DRAW AND LABEL THE MERIDIANS UPON WHICH EACH OF THE STANDARD TIME BELTS OF THE UNITED STATES AND CANADA ARE BASED.
2. DRAW THE BOUNDARIES FOR EACH TIME BELT, AND LABEL EACH OF THE BELTS.

ACTIVITY QUESTIONS:

1. WHAT IS MEANT BY STANDARD TIME?

2. WHY ARE THE BOUNDARIES OF THE TIME ZONES ZIGZAG LINES?

3. HOW WOULD A PERSON CHANGE HIS WATCH AS HE CAME TO EACH NEW TIME ZONE:
   (A) WHEN TRAVELING EAST TO WEST?

   (B) WHEN TRAVELING WEST TO EAST?

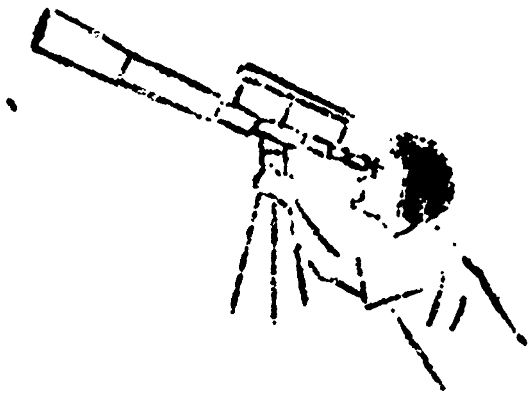
4. IN WHICH STANDARD TIME BELT IS EACH OF THE FOLLOWING:
   (A) SALT LAKE CITY?
   (B) LOS ANGELES?
   (C) ATLANTA?
   (D) EL PASO?

5. WHEN IT IS 4 P.M. IN LONDON, ENGLAND, WHAT TIME IS IT IN:
   (A) RICHMOND?
   (B) PHOENIX?
   (C) DES MOINES?
   (D) ALBANY?

6. AT WHAT TIME WOULD THE STROKES OF MIDNIGHT ON NEW YEAR'S EVE IN LONDON, ENGLAND, BE HEARD OVER THE RADIO IN:
   (A) TOPEKA?
   (B) LOS ANGELES?
   (C) DENVER?
   (D) ALBANY?

7. IN ORDER TO LISTEN TO A CALIFORNIA FOOTBALL GAME WHICH STARTS AT 1 P.M., WHAT TIME WOULD A PERSON NEED TO TURN ON HIS RADIO OR TV IN:
   (A) NEW YORK CITY?
   (B) HELENA?
   (C) AUSTIN?
   (D) NEVADA?

ASTRONOMY



EARTH SCIENCE - ASTRONOMY

AIR TRAFFIC CONTROLLER
ASTRONOMER
GEOPHYSICIST
MERCHANT MARINE
ELEMENTARY TEACHER
TECHNICAL WRITER
INSTRUMENT MAKER

ASTRONAUTS
GEOLOGIST
MATHEMATICIANS
PILOTS
TEACHER SECONDARY-COLLEGE
FLIGHT ENGINEER
AIRPLANE DISPATCHER

ASTRONOMY
LEVEL: JUNIOR HIGH

ACTIVITY: CONSTRUCTING A TELESCOPE

MATERIALS: (PER TEAM)
LENSES, 2
MASKING TAPE
METER STICK
CONSTRUCTION PAPER, 2 SHEETS
SCISSORS

PROCEDURES:

A. THE LENS WITH THE GREATER MAGNIFICATION WILL BE THE EYE-PIECE OF YOUR TELESCOPE. HOLD THIS LENS NEAR YOUR EYE. THE SECOND LENS AT ARM'S LENGTH. BRING IT NEARER TO YOUR EYE WHILE LOOKING AT A DISTANT OBJECT THROUGH BOTH LENSES. WHEN THE OBJECT IS IN SHARP FOCUS, HOLD THE LENSES STEADY. IMMEDIATELY HAVE ONE OF YOUR TEAM MEMBERS MEASURE AND RECORD THE DISTANCE BETWEEN THE TWO LENSES.

B. ROLL AND TAPE TWO SHEETS OF CONSTRUCTION PAPER TO FORM TWO TUBES WITH SLIGHTLY DIFFERENT DIAMETERS. THE TUBES SHOULD BE MADE JUST LARGE ENOUGH IN DIAMETER TO HOLD THE LENSES. ONE TUBE SHOULD SLIDE INSIDE THE OTHER. WHEN EXTENDED, THE COMBINED LENGTH OF THE TUBES SHOULD BE GREATER THAN THE DISTANCE FOUND BETWEEN THE LENSES IN PROCEDURE A.

C. USE MASKING TAPE TO ATTACH THE LENSES TO THE FREE END OF EACH TUBE.

D. LOOK AT A DISTANT OBJECT THROUGH YOUR TELESCOPE, AND SLIDE THE TUBES IN OR OUT UNTIL THE OBJECT COMES INTO FOCUS.

INTERPRETATION:

1. IS THE IMAGE YOU SEE UPRIGHT OR INVERTED?

FOR FURTHER ACTIVITY:

1. TRY TO CONSTRUCT A TELESCOPE USING ONE CONVEX LENS AND ONE CONCAVE LENS. DESCRIBE THE RESULTS.
2. USE A TELESCOPE TO VIEW SEVERAL OF THE OBJECTS THAT GALILEO OBSERVED IN THE SKY.

CAUTION: NEVER LOOK AT THE SUN THROUGH ANY TELESCOPE. YOU CAN PERMANENTLY DAMAGE YOUR EYES BY VIEWING THE SUN, EVEN THROUGH DARK GLASSES.

PROBLEM:
MOST STARS ARE SO FAR FROM THE EARTH THAT THEY DO NOT APPEAR TO MOVE. ONLY THE CLOSER STARS CAN BE SEEN TO CHANGE POSITION SLIGHTLY FROM YEAR TO YEAR. ONE OF THE CLOSEST, BARNARD'S STAR, HAS BEEN OBSERVED TO WOBBLE BACK AND FORTH SLIGHTLY IN ITS PATH. WHAT DO YOU THINK MIGHT BE THE CAUSE OF THE WOBBLE?

ASTRONOMY

LEVEL: JUNIOR HIGH

ACTIVITY: GLOBE SHADOWS

MATERIALS: CLAY	NAILS
COFFEE CAN	GLOBE

INTRODUCTION:

SUNLIGHT STRIKES THE GLOBE IN THE SAME WAY THAT IT STRIKES THE EARTH. AT ANY ONE TIME HALF OF THE EARTH (AND OF THE GLOBE) RECEIVES DIRECT SUNLIGHT AND THE OTHER HALF OF THE EARTH (AND OF THE GLOBE) RECEIVES NO SUNLIGHT. THERE ARE AREAS OF DAYLIGHT AND AREAS OF DARKNESS, AND THE BOUNDARIES BETWEEN THEM ARE THE LINES OF SUNRISE AND SUNSET. WHEN YOUR TOWN IS ON TOP AND THE GLOBE IS TURNED SO THAT NORTH ON THE GLOBE POINTS TO NORTH ON THE EARTH, THE GLOBE IS FACING EXACTLY THE SAME WAY THE EARTH IS. HERE IS A WAY CHILDREN HAVE ORIENTED GLOBES OUT-OF-DOORS.

PROCEDURES:

1. USING CLAY, FIX A NAIL AT YOUR HOME SPOT. (THAT NAIL IS POINTING STRAIGHT UP, JUST LIKE THE SHADOW STICK ON YOUR CHART.) THEN STAND THE GLOBE IN A COFFEE CAN OR OTHER SUPPORT SO THAT THE NAIL IS AT THE VERY TOP. TO CHECK TO SEE IF YOU REALLY HAVE YOUR TOWN ON TOP, SIGHT ACROSS THE GLOBE FROM SEVERAL PLACES.
2. KEEPING THE NAIL ON THE TOP, TURN THE GLOBE SO THAT IT IS IN THE SAME POSITION AS THE EARTH BENEATH YOUR FEET.

THE MIDDAY SHADOW LINE POINTS NORTH. THE NORTH POLE ON YOUR GLOBE SHOULD POINT IN THE SAME DIRECTION AS THE MIDDAY SHADOW. TO DO THIS, GO OUTSIDE AT MIDDAY AND TURN THE GLOBE UNTIL THE SHADOW OF THE NAIL POINTS TO THE NORTH POLE ON THE GLOBE.

CHILDREN CHECK THEIR ORIENTATION OF THE GLOBE BY REFERRING TO LANDMARKS OR TO FACTS THEY KNOW ABOUT LOCAL TIME IN DIFFERENT PARTS OF THE COUNTRY: "I THINK MINE'S RIGHT. I KNOW THAT THE TURNPIKE RUNS EAST AND WEST, AND WEST ON THE GLOBE IS IN THE SAME DIRECTION AS WEST ON THE TURNPIKE." "THE SUNRISE LINE IS JUST AT CALIFORNIA. MY GRANDMOTHER LIVES THERE, AND WHEN WE PHONE HER, IT'S ALWAYS THREE HOURS EARLIER THAN IT IS HERE. SO IF IT'S 9 O'CLOCK HERE, IT'S ABOUT 6 O'CLOCK THERE--AND THAT SHOULD BE ABOUT SUNRISE TIME."

LEAVE THE GLOBE IN ONE POSITION--AT LEAST AT FIRST. CHILDREN ARE LESS CONFUSED WHEN THEY PLACE THE GLOBE OUTSIDE AND LEAVE IT IN ONE POSITION AND THEN WAIT FOR THE SUN TO "MOVE" RATHER THAN TRYING TO ROTATE THE EARTH--AT LEAST DURING THE EARLY WORK WITH GLOBES. WITH THE GLOBE SERVING AS A SMALL MODEL OF THE EARTH, CHILDREN CAN SEE HOW THE AREAS OF LIGHT AND SHADOW CHANGE OVER THE COURSE OF THE DAY.

ONCE THE CHILDREN HAVE THEIR GLOBES PROPERLY ORIENTED IN THE SUNLIGHT (WITH A NAIL AT THEIR HOME TOWN, AND THEIR HOME TOWN ON TOP), THEY MAY WISH TO TRY TO ANSWER SOME OF THESE QUESTIONS.

Globe Questions:

1. Where on the globe is the sun directly overhead now? Take another nail, and move it around until you find such a place. Then stick the nail there with some clay.
   "I moved the nail around on the globe until there wasn't any shadow. There wasn't a shadow near the Panama Canal."

2. Are there other places where there is no shadow now? Children try to answer this by putting nails in several locations. For only one place do they get a "no shadow." It takes time before they are satisfied that there can be only one no-shadow place, and that this place must be directly under the light (whether the sun or a light bulb).

3. Find places where it is midday now. Are the places where it is midday to the east or to the west of you? By trying nails in different places, children discover that when it is midday where you are, it is midday at every place directly north and directly south of you. It may take time for them to realize that when it is midday where you live, the sun is directly overhead at some point south of you along the same longitude and that is the no-shadow place.

4. Where will it be midday in an hour? Where was it midday an hour ago? These are good questions to ask outdoors. The children have some knowledge of time zones, and they may tell you that it is an hour earlier where a friend lives in Chicago, three hours earlier in California. Can they tell how many hours earlier it is in Nome, Alaska?

5. Where do you think there will be no shadow an hour from now? This is a game that children have enjoyed. They put labelled nails on their prediction points. When they go out after the hour is up, the children whose nails are closest to the no-shadow position and the north-south shadow position are the best predictors.

ASTRONOMY
Level: High School

ACTIVITY: Tools of the Astronomer

1. Why do astronomers usually take pictures of the sky rather than just study it through the telescope?

2. How are exposures of stars made possible when such a small amount of light is available from them?

3. If a camera is pointed toward the North Star and the shutter left open for a period of time, the film will show many tracks or streaks caused by the light from the stars. What do these streaks indicate?

4. Why should the photographic film used in astrophotography be the same shape as the mirror?

5. What is a blink comparator?

6. Which planet was located through the use of a blink comparator?

7. What is a spectroscope?

8. Discuss several uses of the spectroscope.

9. Describe three types of spectra.
   1.

   2.

   3.

10. What do the dark lines of the absorption spectrum represent?

11. What color is present on the spectroscope if a star's temperature is high? Low?

ASTRONOMY

Level: High School

ACTIVITY: The Spectroscope (How can we identify elements by the light they emit?)

When properly stimulated, each element emits light of a characteristic color or colors. The spectroscope is a device for separating light of different colors. We shall learn more about the way in which it works when we study light. In this experiment, we shall use it much as you can use a camera without knowing exactly how it produces a picture.

MATERIALS:

- Hand spectroscope
- Nichrome wires with glass or wood handles
- Calcium chloride
- Cupric chloride
- Sodium nitrate
- Bunsen burner
- Solutions of lithium chloride
- Potassium chloride
- Strontium chloride
- Sodium chloride
- Concentrated nitric acid (optional)

PROCEDURES:

The spectroscope consists of a lightproof box with a slit at one end near an edge. At the other end of the box is an opening for the eye, and just in front of this opening is a diffraction grating, a device for splitting light into its various colors much as a prism does. Each color is deviated by a different amount as shown. The observer sees them against a translucent scale which may be calibrated in angstroms (1 A = 10^{-10} m).

Look through the spectroscope at the light from a window or an incandescent lamp. The limits of the visible spectrum should be about 4000 to 7000 A. (7000 A is the red end of the spectrum.) If your spectroscope has a scale, check it for accuracy. If the scale is calibrated in arbitrary units (0 to 100), note the position of the two ends of the spectrum. Red____________ Violet____________.

1. How many divisions are there between the red and the violet ends of the spectrum?____________________

You can assume without too much error that the scale between the two ends of the spectrum is linear.

2. How many angstroms does each division on the scale represent?

____

Your instructor will give you a piece of platinum or nichrome wire attached to a glass handle. Form a small loop in the end of the wire. Dip it into clean water and then hold it in the Bunsen Burner flame. Now dip it into a solution of sodium chloride and water. Again hold it in the flame.

3. What do you observe?______________________________

____

The line that you see can be resolved by better instruments into two lines at 5890 A and 5896 A.

Repeat the experiment with solutions of lithium chloride, potassium chloride, calcium chloride, strontium chloride, cupric chloride, and sodium nitrate.

If possible, use a separate wire loop for each solution and be very careful not to contaminate one solution with another. If you must use the same loop, rinse it in clean water and then in concentrated nitric acid and heat it in the Bunsen flame until any color in the flame disappears before using it each time.

Draw in lines in the data table for each different element.

The instructor will give you a solution which may contain one or more of the elements that you have studied. Test it with the spectroscope.

4. What elements does it contain?________________________________

____

Observe a fluorescent lamp through the spectroscope. Look directly at the bulb, holding the slit parallel to the length of the bulb.

5. Do you observe any bright lines?________________________
Make a sketch of your observations.

6. What is the element in the fluorescent lamp which is causing the lines. (Use a reference book.)

DATA

Sodium chloride	
Lithium chloride	
Potassium chloride	
Calcium chloride	
Strontium chloride	
Cupric chloride	
Sodium nitrate	

Discussion:

1. Name two practical uses for the spectroscope as a means of identifying the presence of elements.

2. Do you think that any of the lines which you saw could have been caused by the chloride ion? Why or why not?

3. What two methods can be used to excite atoms, causing them to emit light?

4. There are additional lines of the elements which are too faint to be seen with the naked eye. How can we detect them?

5. What occupations would need to know how to use some method of identifying various elements?

ASTRONOMY

Level: High School

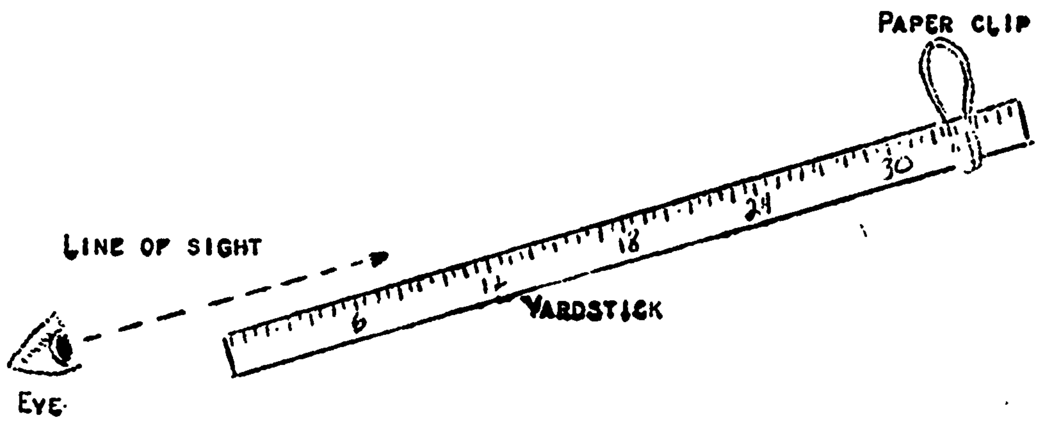
Activity: Apparent Size of the Moon

Problem:
You have seen a full moon rising above the horizon on a clear evening. As it comes into full view, it seems to be much larger than when it is seen overhead in the sky. Does the size of the moon actually change?

Materials:
Yardstick
paper clips

Procedure:

Bend a paper clip in a Y-shape so that it fits tightly around the yardstick, as shown in the figure below. Sight along the yardstick at the moon as it appears over the horizon and bend the open ends of the paper clip so that they are the same width apart as the moon appears to the eye. Without moving the paper clip or changing the distance between the open ends, sight along the yardstick at the moon at intervals of one hour as it rises in the sky.



Observations:

1. Does the moon appear larger when seen over the horizon or when it is high in the sky?

2. Does the apparent size of the moon fill the same space between the ends of the paper clip at different sightings during the evening?

3. Does the moon seem to get smaller, as far as the naked-eye observation is concerned, when it rises in the sky?

4. According to your paper-clip measurement, has the size of the moon actually changed?

Application:
Do some library research and compare the two moons revolving around Mars with our own natural moon.

ASTRONOMY
LEVEL: HIGH SCHOOL

ACTIVITY: MOTIONS AND PHASES OF PLANET X

TIME REQUIREMENTS

PRE-LAB	5 MINUTES
LAB	10-15 MINUTES
POST-LAB	15 -20 MINUTES

MATERIALS: (PER GROUP OF FOUR STUDENTS)
STYROFOAM SPHERE, 3 TO 10 CENTIMETERS IN DIAMETER, STUCK ON A PENCIL OR A PIPE CLEANER; LIGHT SOURCE WITH A 15- OR 25-WATT BULB.

SPECIAL NOTES:

KEEP THE ROOM AS DARK AS POSSIBLE. YOU WILL HAVE TO ARRANGE THE LIGHT SOURCES CAREFULLY. IF GROUPS ARE TOO CLOSE TOGETHER IT WILL BE IMPOSSIBLE TO SEE THE PHASES OF THE STYROFOAM SRHERE.

THERE SHOULD BE NO BARE WIRES OR TERMINALS EXPOSED ON THE LIGHT SOURCES.

PRE-LAB DISCUSSION:

BEGIN THE INVESTIGATION BY EXPLAINING TO STUDENTS THAT THEIR PROBLEM IS TO PRODUCE THE PHASES OF PLANET X. SHOULD THEY USE A SYSTEM CENTERED ON THE EARTH, THE SUN, OR ONE CENTERED ON PLANET X? DO NOT SUGGEST WHICH ARRANGEMENT TO USE. LET STUDENTS INVESTIGATE ALL POSSIBLE WAYS TO REPRODUCE THE GIVEN PHASES.

NOTES ON PROCEDURE:

STUDENTS SHOULD HOLD THE STYROFOAM SPHERE IN DIFFERENT POSITIONS RELATIVE TO THE LIGHT. MOVE ABOUT THE ROOM, REMINDING STUDENTS WHO ARE HAVING DIFFICULTY THAT THEY ARE TRYING TO FIND WHERE THIS PLANET IS RELATIVE TO THE SUN AND THE EARTH.

IF THE LIGHT SOURCE IS TOO DIFFUSE, YOU WILL NOT BE ABLE TO SEE THE PHASES.

YOU GET THE BEST RESULTS WHEN YOU CLOSE ONE EYE TO LOOK AT THE SPHERE. YOU MIGHT ASK STUDENTS WHY THEY DON'T SEE STARS AND PLANETS IN THREE DIMENSIONS.

RANGE OF RESULTS:

TO SHOW ALL THE PHASES OF THE MOON STUDENTS SHOULD POSITION THE SUN IN THE CENTER, WITH PLANET X'S ORBIT BETWEEN THE SUN AND EARTH'S ORBIT.

POST-LAB DISCUSSION:

YOU MIGHT HAVE ONE GROUP PRESENT ITS VIEWS AND THEN HAVE A DEBATE. STATEMENTS CAN BE MADE ONLY ABOUT INFORMATION AVAILABLE FROM THE INVESTIGATION. FOR EXAMPLE, DO NOT ALLOW A STATEMENT SUCH AS "BUT I KNOW THAT THE MORNING AND EVENING STAR IS REALLY VENUS."

NOW WE CAN UNDERSTAND WHAT GALILEO WROTE. CYNTHIA IS ONE NAME FOR THE MOON AND "MOTHER OF LOVE" REFERS TO VENUS, THE MYTHICAL GODDESS OF LOVE. GALILEO SECRETLY ANNOUNCED THAT VENUS SHOWED ALL THE PHASES OF THE MOON. THEREFORE, PTOLEMY WAS WRONG.

ANSWERS TO QUESTIONS:

1. WHAT PLANET DO YOU BELIEVE PLANET X REPRESENTS? ANSWER: EITHER MERCURY OR VENUS IS AN ACCEPTABLE ANSWER. SINCE STUDENTS SHOULD HAVE CONCLUDED THAT THIS IS A PLANET WITHIN THE ORBIT OF THE EARTH THESE ARE THE ONLY CHOICES. THEY HAVE NO EVIDENCE TO PREFER ONE OVER THE OTHER.

2. IS THE ORBIT OF PLANET X IN THE SAME PLANE AS THE EARTH'S ORBIT? HOW DO YOU KNOW? ANSWER: FROM THE INFORMATION GIVEN, STUDENTS WOULD HAVE TO CONCLUDE THAT IT IS NOT. IF IT WERE IN THE SAME PLANE WE WOULD NEVER SEE A FULL OR NEW PHASE. INFREQUENTLY,
P PLANET X DOES CROSS THE PLANE OF THE EARTH'S ORBIT. HOWEVER, REASONING EXCLUSIVELY FROM THE MODEL, STUDENTS WOULD NOT SAY SO.

3. ARE THE PHASES OF THE MOON AND OF PLANET X CAUSED IN THE SAME MANNER? ANSWER: NO. THE MAIN DIFFERENCE IN PHASES SHOWN IN FIGURE 20-6 IS THE SMALL SIZE OF PLANET X WHEN IT'S FULL AND ITS LARGE SIZE WHEN AT CRESCENT. THE SIZE OF THE MOON IN THESE PHASES ALSO VARIES, BUT NOT NEARLY SO MUCH AS PLANET X. THIS IS BECAUSE PLANET X REVOLVES AROUND THE SUN IN AN ORBIT FAR FROM OURS. THE MOON IS VERY CLOSE TO THE EARTH, SO ITS VARIATION IN SIZE IS SMALL.

4. IF PTOLEMY'S SCHEME WERE CORRECT, COULD PLANET X SHOW ALL OF THE PHASES OF THE MOON? ANSWER: YES. HOWEVER, THE BACKGROUND OF STARS THROUGH WHICH PLANET X PASSED WOULD BE DIFFERENT.

ASTRONOMY
LEVEL: HIGH SCHOOL

ACTIVITY: INVESTIGATING INTERPLANETARY DISTANCES

CALCULATE THE SCALE DISTANCES SO YOU CAN HELP STUDENTS WHO HAVE TROUBLE WITH CALCULATIONS.

TIME REQUIREMENTS:

PRE-LAB	5 MINUTES
LAB	20-25 MINUTES
POST-LAB	15 MINUTES

MATERIALS: (PER GROUP OF TWO STUDENTS)
PAPER TAPE AT LEAST 40 M LONG   METER STICK

SPECIAL NOTES:

SPACE WILL BE A PROBLEM SINCE EACH GROUP IS WORKING WITH 40 METERS OF TAPE. THE INVESTIGATION CAN BE DONE BEST IN A LONG HALL, A GYMNASIUM, OR OUTSIDE THE BUILDING. A GOOD WAY TO BEGIN THIS INVESTIGATION IS TO HAVE THE STUDENTS GIVE THEIR IDEAS OF DISTANCES IN SPACE. MANY STUDENTS WILL BE ABLE TO RECITE THE ORDER OF THE PLANETS. SOME MAY BE ABLE TO GIVE THEIR DISTANCES FROM THE SUN. THIS DOES NOT NECESSARILY MEAN THAT THEY CAN VISUALIZE THE DISTANCES BETWEEN PLANETS.

ANOTHER QUESTION YOU MIGHT ASK IS: WHAT DOES THE SOLAR SYSTEM LOOK LIKE FROM A POINT IN SPACE? HAVE STUDENTS DISCUSS THEIR IDEAS BRIEFLY.

NOTES ON PROCEDURE:

ONCE STUDENTS HAVE STUDIED FIGURE 1 THEY SHOULD SELECT A SCALE TO USE FOR THE MODEL. GUIDE FIGURE 1 SHOWS THE MEASUREMENTS STUDENTS WILL USE IF THEY PICK ONE METER TO REPRESENT ONE ASTRONOMICAL UNIT.

SINCE THE SCALE DIAMETERS OF THE PLANETS ARE FRACTIONS OF A MILLIMETER THEY WILL BE IMPOSSIBLE TO PLOT ACCURATELY.

AMONG THE MANY WAYS STUDENTS HAVE USED TO MARK THE DISTANCES BETWEEN THE PLANETS AND THE SUN ARE:

1. MARK OFF THE DISTANCE WITH METRIC SURVEYOR'S TAPE.
2. MEASURE OFF THE DISTANCE USING METER STICKS.
3. STUDENTS MAY DEVELOP SOME CONVENIENT AND SIMPLE MECHANISMS TO MAKE THE MEASURING EASIER. ONE ARRANGEMENT IS SHOWN IN GUIDE FIGURE 2.

RANGE OF RESULTS

AS LONG AS THE RELATIVE DISTANCES ON THE PAPER TAPES ARE REASONABLY ACCURATE, DO NOT BE TOO CONCERNED ABOUT EXACT MEASUREMENTS. THE SMALLNESS OF THE PLANETS IN COMPARISON TO THE DISTANCE BETWEEN THEM WILL BE OBVIOUS WHEN STUDENTS TRY TO DRAW A 0.1 MILLIMETER DOT ON A 40 METER TAPE. NOW THAT THE SCALE OF THE SOLAR SYSTEM CAN BE SEEN BY THE CLASS, YOU MIGHT DISCUSS HOW LONG IT WOULD TAKE TO TRAVEL FROM ONE POINT TO ANOTHER. THIS DISCUSSION SHOULD CLEAR UP ANY CONFUSION LEFT ABOUT THE ASTRONOMICAL UNIT. STUDENTS SHOULD REALIZE THAT DISTANCES IN INTERPLANETARY SPACE ARE UNWIELDY WHEN YOU USE MILLIONS OF KILOMETERS.

A sample question you might ask is: How long would it take to travel from Earth to Mars at 100,000 kilometers per hour assuming these planets are approximately 0.5 A.U. apart? One half of 150×10^6 is 75×10^6 kilometers. At 100,000 kilometers per hour (a velocity no present spacecraft can reach) it would take 750 hours- about one month.

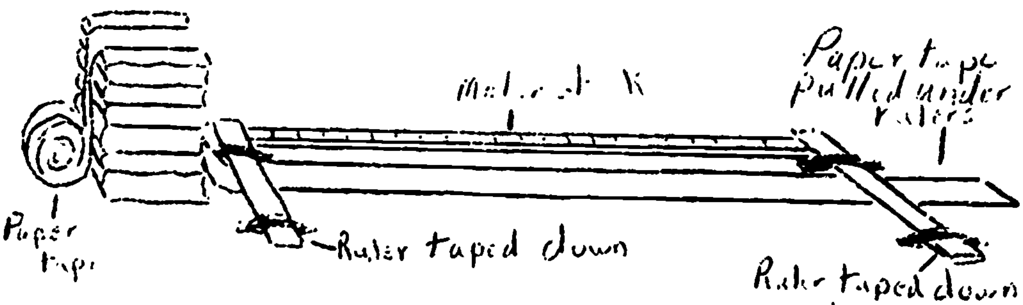
It would be a rare occurrence to have all the planets line up as shown on the tape. Instead of a tape, a great sheet of paper 80 meters in diameter could be used. Looking at such a large sheet, do you think you could see the planetary dots easily? The solar system seems to be mostly space.

NASA's accomplishment of putting two astronauts on the moon meant going only 2½ millimeters on the scale!

Guide Figure 1
Solar System to Scale
1 A.U. (astronomical unit) = 1 Meter

Object	Distance From sun, meters	Diameter, Millimeters
Sun		11.00
Mercury	0.4	0.04
Venus	0.7	0.10
Earth	1.0	0.10
Mars	1.5	0.05
Jupiter	5.2	1.12
Saturn	9.5	0.95
Uranus	19.2	0.37
Neptune	30.1	0.35
Pluto	39.5	0.05

Guide Figure 2



ASTRONOMY
Level: High School

ACTIVITY: Convex lens; image formation

Why does our camera have to be adjusted for the distance of the object?

When the pictures of near objects are to be taken, the bellows of the camera is greatly extended. The location of what part of the camera has been changed by this adjustment?

Mount the lens and holder on the meter stick and point the stick at some distant object outside the window. Stand back of the window in a darker portion of the room. Place the cardboard screen on the opposite side of the lens. Move the lens until you see a clear image of the object on the screen.

1. Is the image a real image?

2. Is it smaller or larger than the object?

3. Inverted or erect?

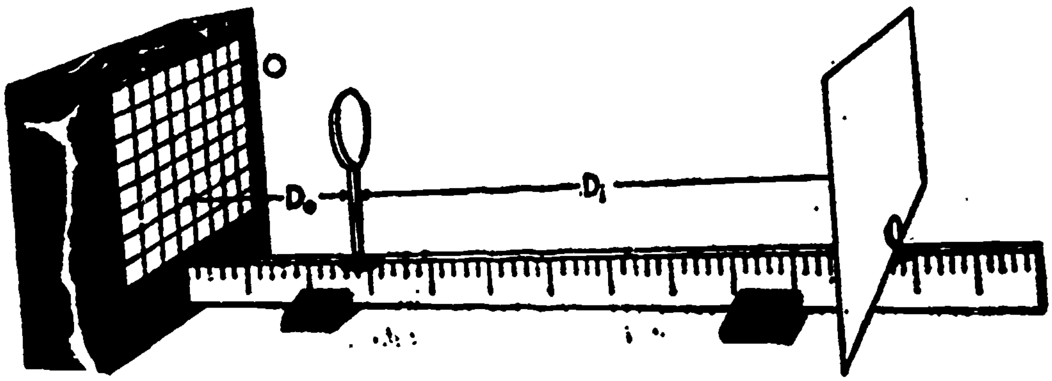
The distance from the lens to the cardboard is the focal length. Record this distance.

Procedure: A. Object Beyond Twice the Focal Length

Place the light box and wire mesh O at the zero end of the meter stick and the cardboard screen near the opposite end (see diagram). Set the lens at a distance from O greater than 2 times the focal length (for example, 3 times).

Move the cardboard until a distinct image of the wire mesh is formed. Record the distance of the object from the lens D_O and the distance D_I of the image from the lens.

Measure with a metric rule (or vernier caliper) the size of five squares on the image. Record as S_I. Measure five squares on the wire mesh and record as S_O.



B. Object at Exactly Twice the Focal Length

Move the lens so that it is exactly twice the focal length distant from O. Locate the image. Record the distances. Again measure five squares on the image.

4. How does this image compare in size with the image formed at the first position?

C. Object Between the Focal Point and Twice the Focal Length

Repeat the procedure with the lens at a distance from O equal to $1\frac{1}{2}$ times the focal length.

5. How does the size of the image compare with the object?

D. Conjugate Foci

Leave the cardboard screen at the position found in the last trial. Move the lens until you find another location for which an image is formed on the cardboard screen.

6. How does the size of this image compare with the other one found at this same point?

Record the distances of the object and the image from the lens.

7. How do these distances compare with those of trial C?

Two such points are called conjugate foci.

To find the numerical relation between the distances of the image and the object and the focal length, it is necessary to calculate the expression $\frac{1}{D_O} + \frac{1}{D_I}$. It will be simpler if each fraction is reduced to a decimal and the two results are added. Calculate this expression and carry out the result to three decimal places.

Since the focal length of the lens was constant throughout the experiment, the fraction $\frac{1}{F}$ will be the same for all trials. Express as a decimal.

8. Do you see any similarity between the results?

To find the relation that exists between the distances of the image and the object and their respective sizes, reduce the fractions, $\frac{D_O}{D_I}$ and $\frac{S_O}{S_I}$, to decimals.

9. What do your results indicate?

DATA

Focal Length ________ CM

Trial	D_O (CM)	D_I (CM)	$\frac{1}{D_O} + \frac{1}{D_I}$	$\frac{1}{F}$	S_O (CM)	S_I (CM)	$\frac{D_O}{D_I}$	$\frac{S_O}{S_I}$
A								
B								
C								
D								

Discussion:

1. Write the relation which you found to exist for the distance of the object, the image, and the focal length.

2. A clear image is formed at a distance of 30 in. from a lens when the object is placed 15 in. from the lens. What is the focal length of the lens?

3. Have you ever noticed that a much greater adjustment of the camera lens postion is needed to change the focus from 3 feet to 4 feet, than to change from 25 feet to 50 feet? Can you explain why?

ASTRONOMY
LEVEL: HIGH SCHOOL

ACTIVITY: HOBBIES IN SCIENCE AND TECHNOLOGY

PROCEDURES:

A. WITNESSING THE ROLE OF THE FILM

FIND A CAMERA WITH A REMOVABLE BACK. FASTEN A PIECE OF TRANSLUCENT PAPER TO THE BACK OF THE CAMERA WITH SOME TAPE. YOU MAY USE WAXED PAPER OR SOME TRACING PAPER. FIX THE SHUTTER MECHANISM SO THAT IT REMAINS OPEN AND THEN POINT THE CAMERA AT SOME DISTANT OBJECT. BY MOVING THE FOCUSING CONTROLS, BRING THE OBJECT INTO FOCUS ON THE PAPER. NOW, FOCUS ON AN OBJECT NEARER THAN THE PREVIOUS ONE.

DID YOU HAVE TO MOVE THE LENS FORWARD OR BACKWARD TO FOCUS?

B. AN IMPORTANT PRINCIPLE USED IN PHOTOGRAPHY MAY BE DEMONSTRATED AS FOLLOWS:

DISSOLVE A FEW CRYSTALS OF SILVER NITRATE IN A HALF A TEST TUBE OF DISTILLED WATER. ADD A LITTLE TABLE SALT SOLUTION. SHAKE THE TEST TUBE WELL AND POUR HALF OF THE RESULTNNG SUSPENSION INTO ANOTHER TEST TUBE. PLACE ONE TEST TUBE IN BRIGHT SUNLIGHT. KEEP THE OTHER TEST TUBE IN THE DARK AS A CONTROL.

DESCRIBE YOUR OBSERVATIONS HERE.

C. PHOTOCHEMICAL DEMONSTRATION

FROM YOUR TEACHER OR FROM THE CHEMISTRY DEPARTMENT, OBTAIN A SOLUTION OF SILVER NITRATE IN WATER AND THEN MAKE SOME SALT WATER BY DISSOLVING AS MUCH SALT AS WILL DISSOLVE IN WATER AT ROOM TEMPERATURE. MIX THESE TWO CHEMICALS TOGETHER: ($AgNO_3$ + $NaCl$ -- $AgCl$ + $NaNO_3$). THE AGCL, OR SILVER CHLORIDE, WILL PRECIPITATE AND WILL COAGULATE IF YOU HEAT IT SLOWLY WITH A BURNER.

FILTER THIS ENTIRE SOLUTION AND THE SILVER CHLORIDE WILL REMAIN ON THE FILTER PAPER. DRY THIS PRECIPITATE THOROUGHLY WITH BLOTTING PAPER.

IN THE MIDDLE OF THIS BLOTTING PAPER, PLACE A LARGE COIN OR OTHER OPAQUE OBJECT TO COVER A PART OF THE CHEMICAL. NOW, EXPOSE THE PAPER TO A VERY BRIGHT LIGHT SUCH AS BURNING MAGNESIUM RIBBON.

WHAT DO YOU OBSERVE WHEN YOU REMOVE THE COIN?

WHAT DOES THIS DEMONSTRATION SHOW?

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