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LIFE SCIENCE IN A SPACE AGE SETTING

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A REPORT submitted to the
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
on materials developed at Wayne State University

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sponsored by

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Wayne State University

SUBJECT: Letter of Transmittal, Manuscript, "Life Sciences in a Space Age Setting"

FROM: Louis Alcorta
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TO: DR. T.L.K. SMULL
Office of Grants and Research Contracts
National Aeronautics and Space Administration
Washington, D. C.

Herewith submitted is the final draft of the manuscript, "Life Science in a Space Age Setting", prepared as a by-product of a workshop conducted with the support and encouragement of the National Aeronautics and Space Administration and its staff.

The material included has been structured to serve as a guide for teachers at the upper elementary through the junior high school level in their individualized curriculum development efforts. It is anticipated that the material will serve as a curriculum reference as it was not structured for use as a textbook.

Included in the manuscript is:

(1) an introductory statement outlining the conceptual scheme utilized in the selection and placement of the various "inquiries";

(2) a series of problem areas which are intended for use by the teacher in presenting each "inquiry";

(3) a series of short supplementary readings for student use as a "primer";

(4) selected materials in the appendices for supplementing the inquiries; and,

(5) a short glossary of terms which may be encountered in the study of life science in a space age setting.

Two short explanatory films based on this manuscript are in the final stages of preparation. Each film is based on the classroom experience of the workshop participants and is intended to illustrate the various procedures and grade levels for which the manuscript materials are applicable.

The writers and workshop participants wish to acknowledge the sustained support and encouragement received from Mr. Everett E. Collin, Educational Programs Division, Office of Public Affairs, and his co-workers. In the revised copy, March, 1967, the physics content was reviewed by Dr. Henry Hooper, Department of Physics, Wayne State University.

LIFE SCIENCE IN A SPACE AGE SETTING

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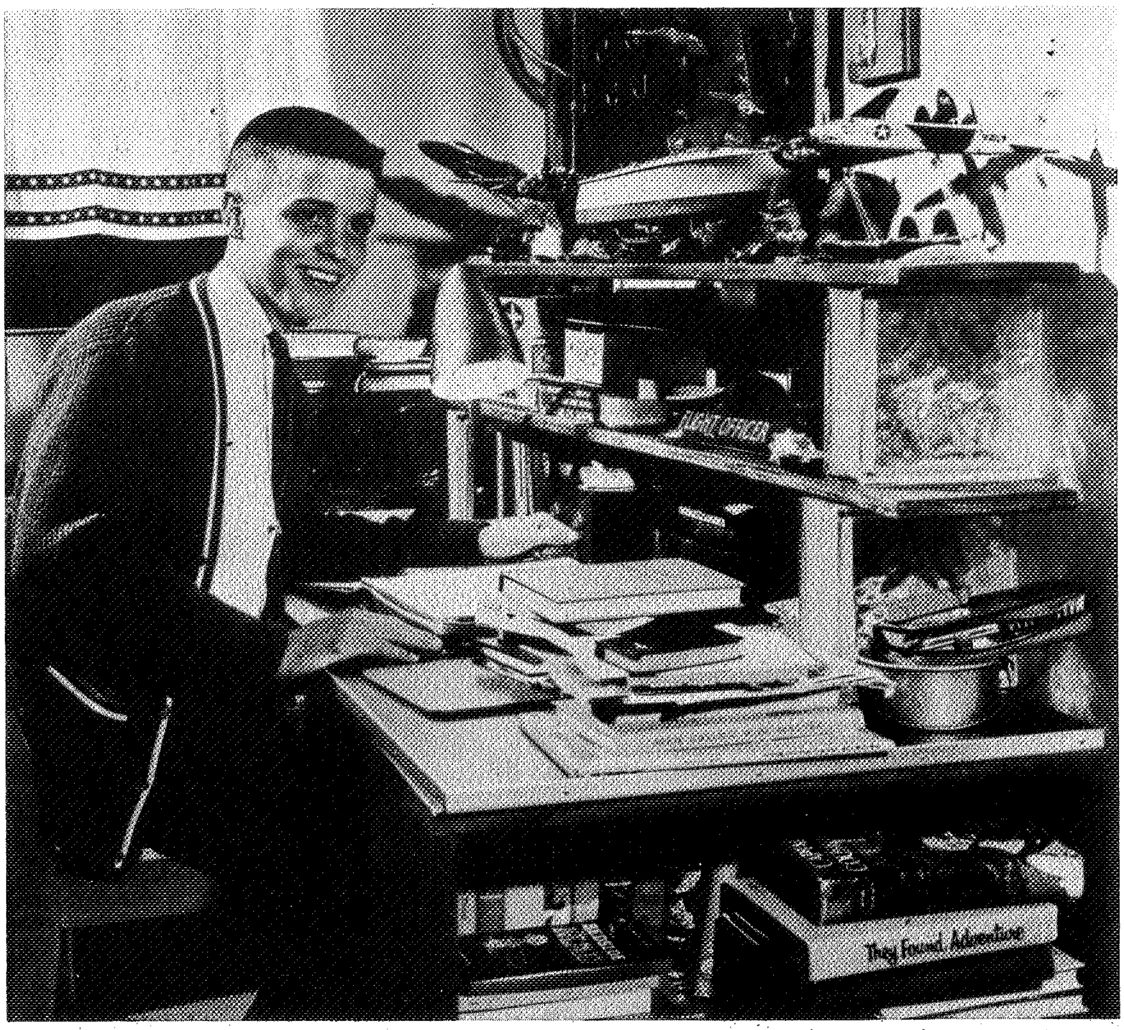

Dedicated

. . . to the continued development of

competent

and

compassionate

youth

PREFACE

The major problem facing the classroom teacher in this space age is a difficult and personal concern. It may best be identified by the view expressed by an elementary teacher, who, after having participated for two weeks in an aerospace workshop, stated: "Until I visited the NASA Lewis Research Center in Cleveland and I listened to one of the speakers talk about the ion propulsion engine with such sincerity, I thought all this interest and effort to travel in space to other planets was just a dream. They're serious!" The problem is a psychological one. For the most part, a teacher's view of the universe beyond our earth's atmosphere consists of the moon, stars, planets, and somewhere up there, other galaxies. To our students, that same view is filled with orbiting satellites, astronauts, future space platforms and space stations. Anthropologists have commented on this phenomenon pointing out that, as young adults in our society, we tend to migrate to a new location and raise our children in the new environment. Similarly, we have, as a society, entered a new age in which our students are the "natives" and the teachers are the "migrants".

Some reorientation is needed so that the students may gain the benefits of a mature perspective while retaining their natural curiosity and enthusiasm to be active participants in the exciting days before them.

As you review these materials, seek out the structure of ideas upon which each day's new developments can be founded. Conveyance to students of such a framework will enable them to understand the basis for man's groping efforts in that essentially hostile setting, outer space and will stimulate some to devote their lives to opening a bit wider that ever-expanding fund of knowledge from which man has fashioned his life patterns and aspirations. For some the joy will be in the becoming rather than in the being.

TABLE OF CONTENTS

CHAPTER I

INTRODUCTION

> Science like art should not be something extraneous added as a decoration to the other activities of existence; it should be a part of them, inspiring our trivial actions as well as our noblest thoughts.[1]

At Rice University on September 12, 1962, the late President John F. Kennedy, in reviewing the basis for our nation's efforts in the coming age of space stated,

> "We set sail on this new sea because there is new knowledge to be gained, and new rights to be won, and they must be won and used for the progress of all people."

To many of our citizens, this date marks the beginning of their awareness that the subject of space travel was no longer a science fictionist's dream. Yet, in 1952, at a time when most of the students who will use this material were just seeing the light of day for the first time, a four day meeting was being held near Rice University at which forty specialists in the problems of space travel were exploring the problems which they must

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[1]Campbell, Norman, What Is Science?, Dover Publications, 1952.

resolve to bring this dream to fruition. The reactions of two writers in attendance for the meetings were published in Harpers[1] and should be read by all teachers. The accounts, seemingly woven of gossamer and frivolity, forecast the pattern for the major steps which, in the intervening years, have been initiated and executed in full view of all nations.

Perhaps you have read Jules Verne's "From the Earth to the Moon and Back"[2] or viewed the film based on the novel. If it has been sometime since you've read the novel, try it again. The similarity in the steps outlined in his book and those of our "modern" efforts have startling parallels. Once grasped, the key ideas, which served as the framework for Verne's artilleryman's dream, can be related to the space program. Such an understanding is independent of the varied hardware (Rocket X, Capsule Y, Landing Craft Z) which may serve to accomplish the goal. While the specific techniques for the solution of the biological problems to be encountered in space had not been refined, the awareness of what such problems would be existed. Let us consider the conditions needed for existence whether on earth, in space or on a planetary satellite. The conditions can be broken down

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[1]Harpers, May 1952, Vol. 204, No. 1224, pp. 62-69.

[2]Verne, Jules, <u>From the Earth to the Moon and Back</u>,

in those which are <u>essential</u> and those which are <u>desirable</u>. Some of the essential conditions are:

Suitable air pressure for the respiratory process,
Suitable temperature range,
Oxygen (or carbon dioxide) for metabolic processes,
Food, and
Water.

Some of the desirable conditions are:

Suitable humidity,
Suitable gravity or acceleration,
Personal comfort, and
Peace of mind.

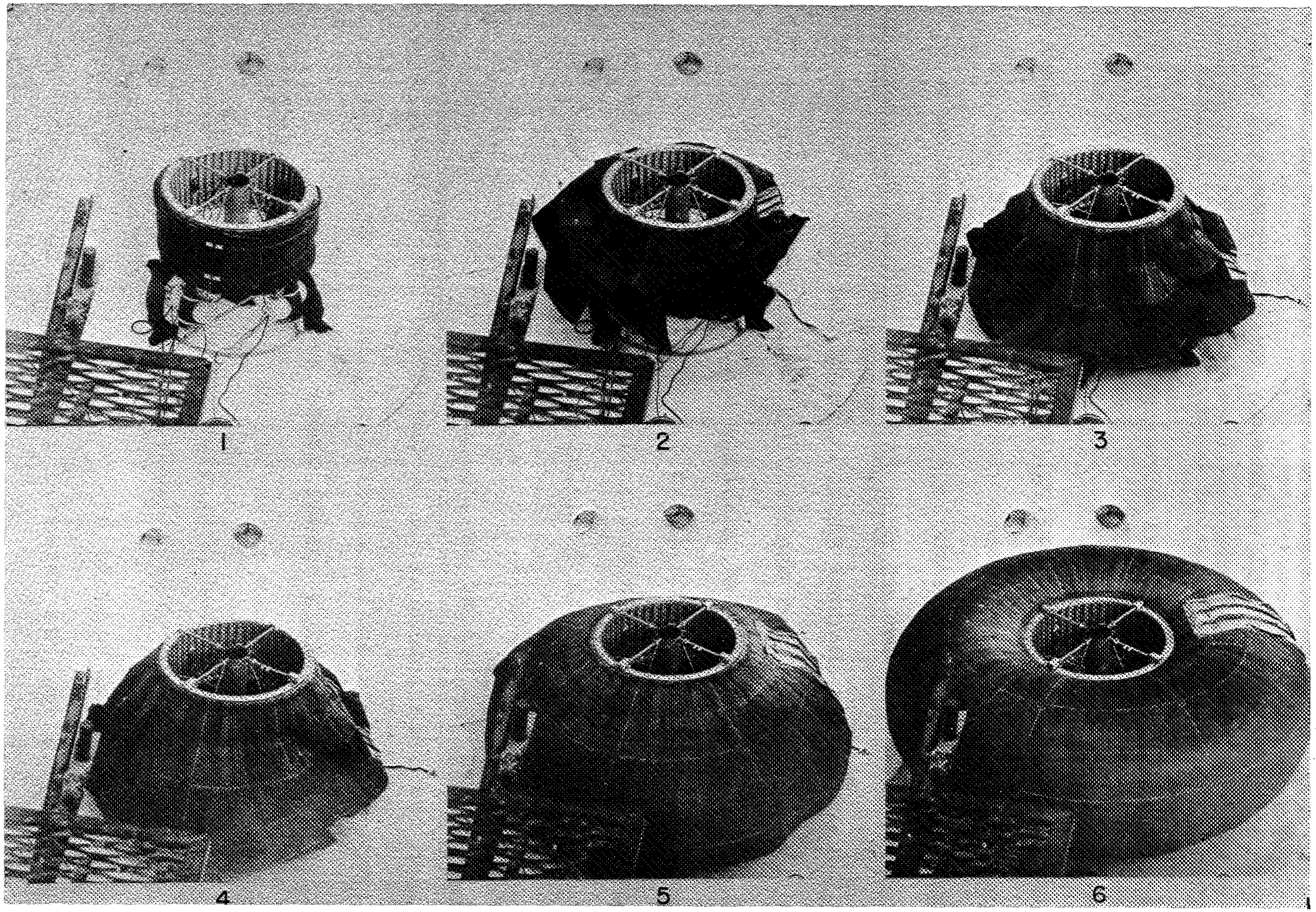
Many of these conditions are interrelated. Certainly, one's sense of personal comfort would influence one's peace of mind. In a similar manner, other conditions can be combined or additional conditions suggested. However, within the limits of any given environment, man has to maintain a dynamic balance between the essential conditions of air pressure, temperature range, oxygen, food and water. In this regard, the earth may be considered as a "super" capsule, on whose surface are to be found the resources from which man can provide for his needs for the foreseeable future. However, as one of the life forms on earth, man has always sought to know and to extend his knowledge of his surroundings. As his knowledge has increased, his ability to contend successfully with increasingly less suitable environments has increased. This process, progress, and interest can be projected into the future, a future in which the youth of today will find their challenge.

One key to man's extension of his knowledge of his surroundings has been his increasing awareness of the role of energy in life processes. Energy changes are basic to living systems. Energy has many forms: muscular, mechanical, heat, electrical, radiant, chemical, atomic, sound, etc. Energy changes have a cyclic nature which can be observed in the various biological and atmospheric patterns which occur about us; examples include, food cycles, the water cycle, the nitrogen cycle, the oxygen and carbon dioxide cycles, and many others. The dynamic nature of these energy changes and of the biological and atmospheric patterns in which they are found provide a rich and varied resource for instructional materials.

Another key to man's extension of his knowledge of his surroundings can be found in the nature of the scientific enterprise which has lead to our current interest in space exploration and the problems attendant to it. The significant factor upon which the scientific enterprise thrives is curiosity coupled with a high level of interest and effective inquiry techniques. The teacher can bring this curiosity and interest to focus on the underlying principles upon which man's efforts are founded. When student and teacher alike are encouraged to exercise their curiosity and make inquiry into the biological phenomena which are a part of space exploration, learning takes place. Such is the goal in the creation and development of the conceptual scheme and inquiries which make up the balance of this manual.

What is the structure upon which the material in this manual is founded? A series of "universes" are identified, taking the learner from an examination of the earth as a universe to the community as a universe, and in similarly graded steps, to the home as a universe and to a self-contained unit as a universe. Once having gained this terrestrially-based "universe" perspective, the various extensions of the biological problems associated with the "universes" are projected to the exosphere (environments outside of the earth's stratosphere including satellites and planetary stations). The exosphere as a universe is then examined in relation to the special problems which extend beyond the terrestrially-bound situation including greater divergences in pressure changes, heat problems, radiation and weightlessness.

What is the instructional goal? For the teacher who plans to incorporate some or all of this material into her classroom, the instructional goal recommended



A twenty-four foot diameter model placed inside a high altitude pressure chamber is inflating as the atmospheric pressure is reduced around it. This "exosheric unit" is planned for use as a space station. What features will be needed within the inflated cylinder? How could an artificial gravitational field be introduced?

is to acquaint the students with the framework of ideas upon which the material is based. Such a framework will enable the student to build future understandings even as changing technological advances in the capsules, rockets, sub-stages and the like appear. It should be recognized that technological advances tend to obscure the basic underlying ideas with which man must come to grips. Therefore, technological detail will not be a significant portion of this material; rather, the problems of how man has learned about himself and his environment will be stressed and wherever possible, the nature of some of the unresolved problems will be identified. Because quantification is an essential to scientific progress, experiments are included which provide opportunities for students to relate observations through mathematical treatment.

It is the belief of the authors and contributors that the relationships to be developed are within the scope of understanding of students in the upper elementary and junior high school grade levels.

As a consequence of their utilization of this material, it is anticipated that students may view science as a human activity, predominantly mental in character, in which they will wish to actively participate. To further this objective, the material is designed to:

1. extend the range of students' perceptions,

2. encourage a cooperative "think along with me" frame of teacher-student relationship,

3. identify problem situations with multi-directional possibilities,

4. provide a progression of ideas upon which the student can build his own conceptual understandings,

5. portray science as an endless adventure, and

6. be but a part of the total general education program for all students.

Thus a structure of ideas has been created upon which the student can build his own conception of the interrelatedness of the various "universes" which exist about him. The structure of ideas or conceptual scheme as it will be referred to in this guide should have its instructional origins in the experiences a child has had with his immediate environment. If successful, the conceptual scheme should provide each child with an awareness, and hopefully an understanding of the interrelationships between the problems man faces in his day-to-day survival on earth and those facing the explorers of our universe and universes yet unknown.

CHAPTER II

CONCEPTUAL SCHEME

The framework of ideas to be developed are structured from the interaction of two lines of thought. The first line of thought is that of the various universes which can be identified, progressing from the all-encompassing earth (terrestrially, that is) to the increasingly smaller units of space (Community, Home, Self-Contained Unit). The second line of thought is the identification of the biologically related problems which exist for all life forms, regardless of their location in time or space. When these two lines of thought interact, a structure, not unlike a cube can be visualized with the various universes along one axis and the problems along the second axis. (See Illustration No. 1) In this way, the commonality of the problems with the universes is more evident.

In the case of the "Exosphere As A Universe", a separate cube-like structure can be visualized in which the Universe and Problem axes are retained and a third "frame of reference", consisting of selected factors which are peculiar to the exosphere, is added. (See Illustration No. 2) In this way, the results of the

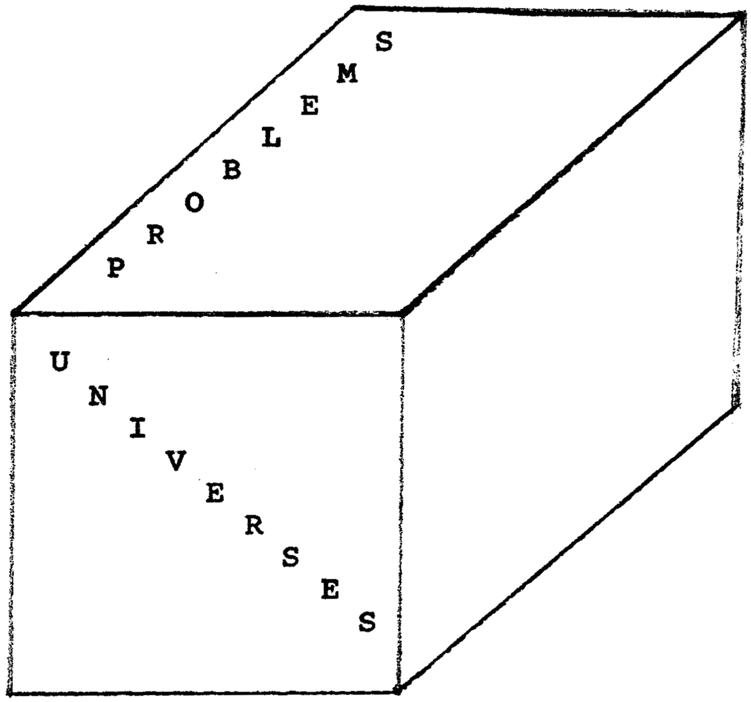


Illustration No. 1 Interaction of Universes With Biologically-Related Problems

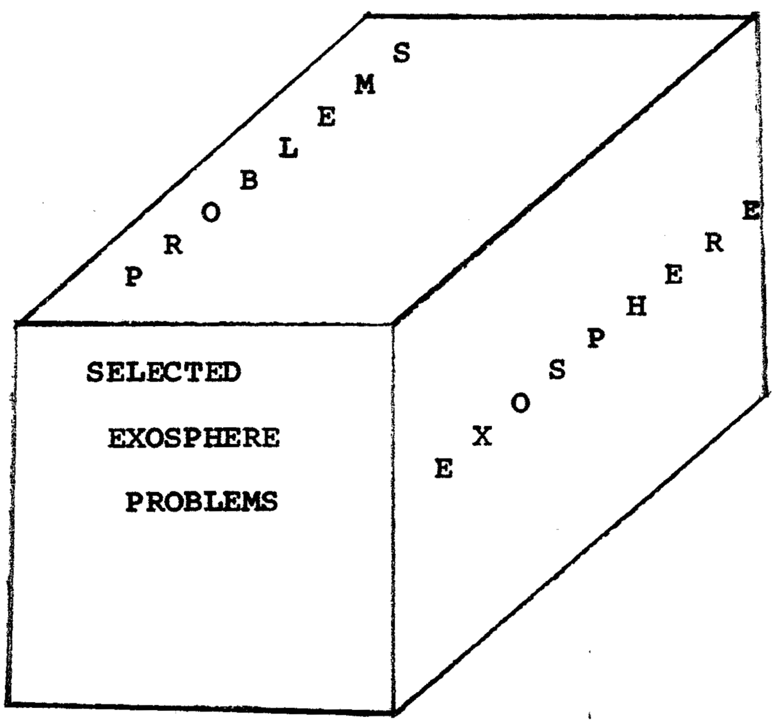
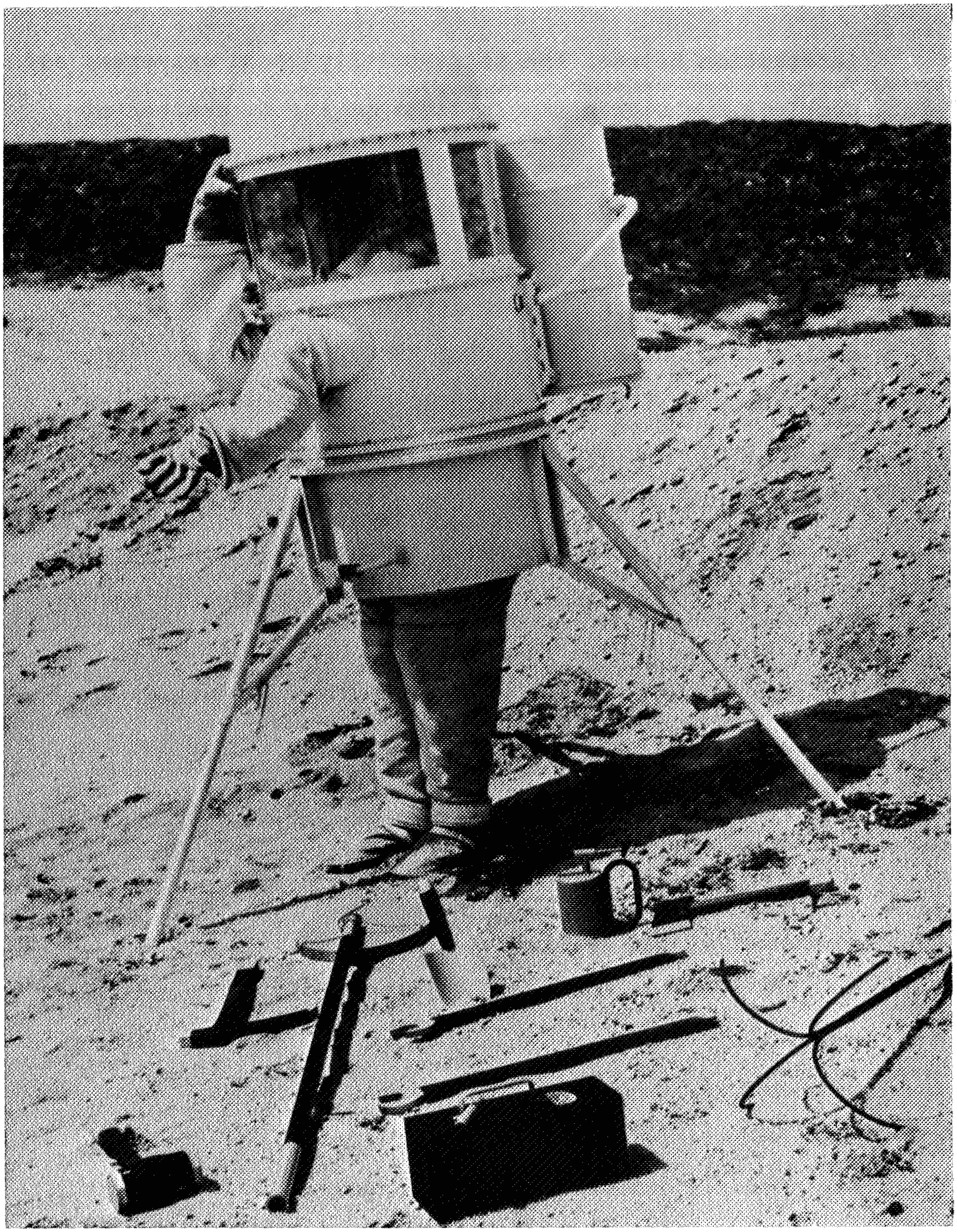


Illustration No. 2 Interaction of Exosphere As A Universe, Biologically-Related Problems, and Selected Exosphere Problems



One man's conception of a lunar surface exploration suit is pictured above. Encourage students to design "suits" which will satisfy the known lunar conditions. Encourage them to analyze the features included in this model.

interaction between the terrestrially-bound universes and problems are reexamined in light of the extensions of problems (pressure changes, heat problems, radiation and weightlessness) which the exosphere will entail.

For each of the interactions in Illustration Nos. 1 and 2, inquiries have been developed. Each inquiry is designed to bring the student into a direct experience relationship with the interaction of a universe and a problem. To achieve this goal, the inquiry is composed of a short student "primer", a statement of the basic concepts of science involved, a suggested sequence of ideas which lead to the development of the basic concepts, and finally, a suggested series of activities which embody the concepts and grow out of the suggested sequence of ideas. The mode of use of this material is left to the ingenuity and particular needs of the teacher. The inquiries are sequential in nature within each major problem area to encourage the development, by teacher and students, of the overall conceptual scheme.

In summary, the <u>student primer</u> is a short discourse on the main points which are to be developed by participation in the "inquiry". It is intended as supplementary reading material upon which both student and teacher may draw for guidance in the approach to the material.

The <u>basic concepts of science</u> column is to provide the teacher with a referrant as to the "big" idea which underlies this "inquiry". It may never be verbalized in the classroom setting but may rather find expression in the way students, in their own vernacular and level of understanding, convey their findings about the inquiry to one another.

The sequence summary represents some of the topical aspects of the inquiry. It may serve to provide a structure for the exploration of the inquiry in relation to the overall conceptual scheme. Motivating activities which relate to the topic are included in the activities and illustrations section.

The activities and illustrations are suggestions for the teacher's use in pursuing the inquiry. Both qualitative and quantitative activities are suggested, many in skeletal form. Innovation by the teacher is encouraged as this phase can best be implemented by a direct knowledge of the prior learning experiences to which the students have had exposure. Included in this section are activities which may serve as stimulus for follow-up participation. Such a stimulus would be a suggestion for introducing the inquiry. The stimulus may have been singled out for its open-ended quality and question-provoking nature. The unpredictable nature of student's response to such stimuli may elicit some concern by some teachers. However, it is intended, in the development of this material, that a free play of ideas be

This is an airborne command post built inside a KC-135-B jet stratotanker. What survival devices can you detect in the photograph?

encouraged, with the teacher serving to channel the fruitful ideas into activities such as those suggested in the <u>activities and illustrations</u> section or such as the teacher, from her own experience, can relate to the inquiry. Many of the suggestions in this section are purposefully unrefined problem situations to encourage students to make suggestions and, in so doing, to give them a sense of involvement which may generate a desire to pursue the topic further.

What are the problems common to all universes, even the exosphere? Man has had to contend with many problems over his period of tenure on earth. These can be biologically identified as:

A. Biologistics,

B. Toxicology,

C. Radiation,

D. Physiological Stress, and

E. Psychological Stress.

Let us examine each in more detail.

A. <u>Biologistics</u> is the maintenance of an adequate supply of food, oxygen and water for his use. The three essential conditions included in this category are self-explanatory. However, the ramifications of each, when considered in relation to the "universes" gives this area an open-ended quality.

B. Toxicology is the reduction of the hazards associated with carbon dioxide, carbon monoxide and other toxic gases, and the control of sanitary waste materials. Diffusion of gases within our atmosphere plus adequate ventilation in semi-confined spaces have, for the most part, been sufficient to avoid the generation of problems from carbon dioxide gas. It should be noted, however, that when you are in a crowded "stuffy" room, the physiological stresses which you experience are due to the increase in CO_2 concentration rather than any marked reduction in the amount of O_2 in the air. Carbon monoxide gas, as a problem, still comes to our attention during winter months for we read of the fatal consequences of poorly ventilated heaters and leaky car mufflers. Toxicological problems associated with sanitary wastes (urine, feces, etc.) have been reduced by improvement in the control of sanitary waste disposal facilities although this still represents an important problem in the pollution of our lakes, rivers and streams. However, despite the increasingly rare instances of water-borne disease epidemics, students should be reminded that wherever raw untreated sewage is allowed to enter bodies of water, the epidemic disease potential still exists.

C. Radiation, is the influence on living organisms of charged particles of either an electromagnetic, cosmic, or man-made nuclear origin. Man has adapted to natural radiation and many scientists believe that cosmic radiation may have had an important role in the wide range of mutations which resulted in our various forms of life. The Uffen Hypothesis[1] of the earth's origin and development includes the role of radiation as an important part of the pattern which produced the multiplicity of forms.

D. Physiological Stresses include temperature fluctuations and acceleration, daily events in our lives, which we may not always recognize as stress. The body's response to cold, to extreme heat or to marked changes in temperature is recognized when one hears people say, "Brr, the water in the pool was sure cold!", or, "I'm so hot my blood must be boiling." Man's knowledge and growing ability to predict and thus anticipate temperature variation have perhaps masked the fact that we are subject, as a constant temperature organism, to external conditions which place a heavy physiological burden on our bodies.

Yet again, acceleration is a sensation which we actively seek for pleasure and enjoyment. At a carnival, the rides available capitalize on our desire to experience the effects of rapid motion, whether on a roller coaster or rolling barrel. Each of us has experienced the reverse

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[1]Lear, John, Is Magnetism the Key to Life's Origin on Earth?, Saturday Review, July 6, 1963, pp. 35-38.

Discuss the life-maintaining features which have been built into each of the self-contained units pictured above.

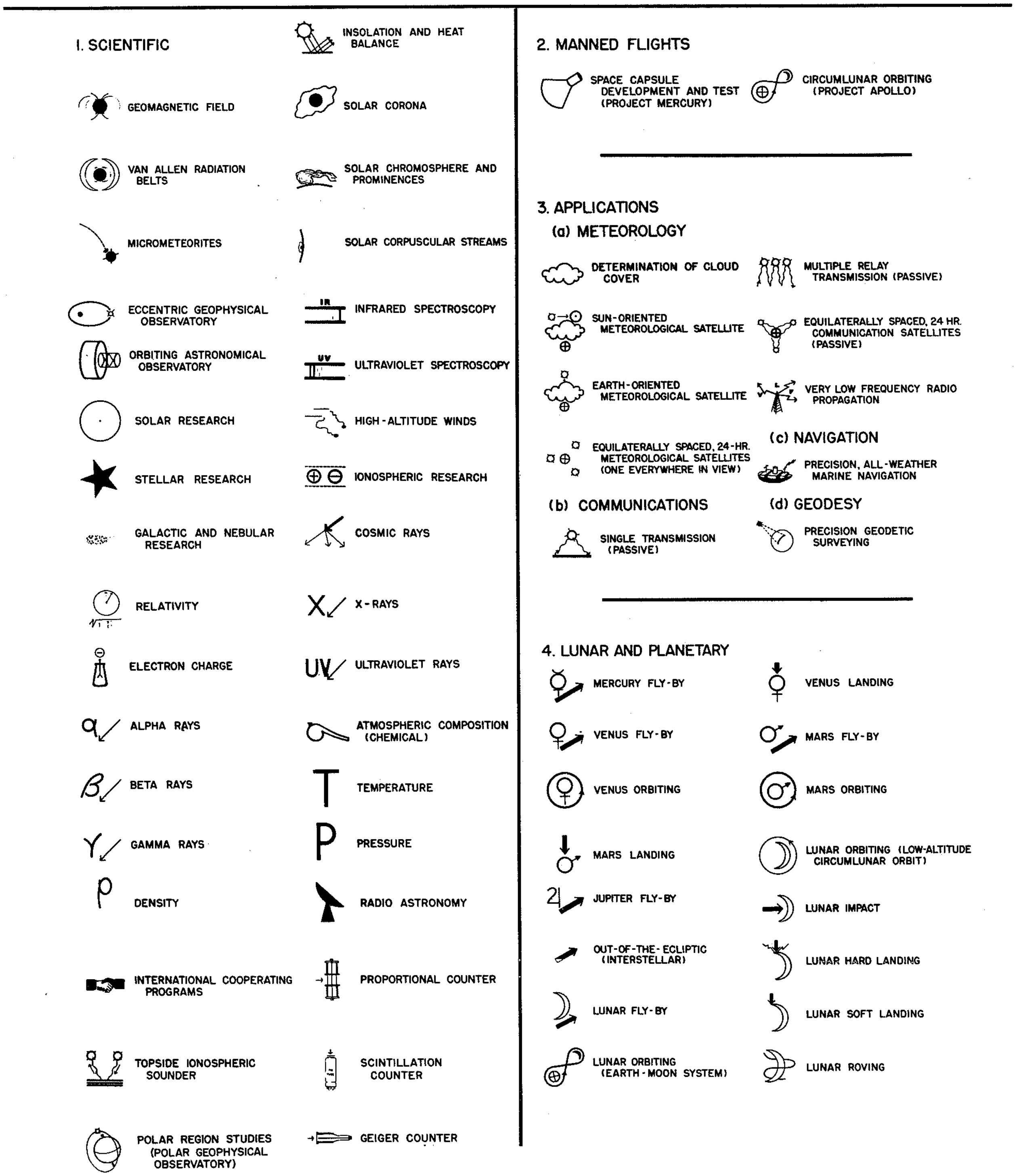
of acceleration when we have fallen and received a hard jolt. Such deceleration may have been only temporarily unpleasant. If the part of your body which struck the surface were bony and the surface were hard, you may have experienced a deceleration of 5-10 g's for a fraction of a second. When a jet takes off or when you step on the accelerator, you may also have experienced the "g" force as you are pushed back into your chair. As you ride along in the car, you may not realize that you are traveling at the same speed as the car and that, unless you have braced yourself or have a seat belt on, when you step on the brakes, you will continue at the same speed leaving the car or possibly decelerating against the dashboard or other surface in the car. This type of trauma is an indirect result of the acceleration-deceleration stress. Fortunately, within the limits of private cars and some forms of commercial transportation, our bodies can adapt to the acceleration-deceleration stresses associated with their safe operation.

E. Psychological Stresses such as anxiety, disorientation and isolation. These stresses are also part of our surroundings. However, we seldom experience them for extended periods of time. You may be anxious about the outcome of a baseball game, a drive downfield by your favorite football team or whether you will receive a desired gift for Christmas or your birthday; however, one learns to control such anxiety, so that it does not interfere with one's work and play activities. In a similar way, you may find that, momentarily, you can't remember your phone number, home address or the last name of your best friend. You cannot "orient" yourself. A common way you hear this expressed is, "Gee I'm all mixed up. Let me think for a minute." Here again, one learns how to handle such stress. Have you ever thought it would be fun to be completely alone? At first, it would be a new and interesting experience, but you may soon find that you would like to talk with someone. Each of us learns how to adjust to such isolation; however, as noted before, we seldom do this for long periods of time so that it is not a serious stress for us.

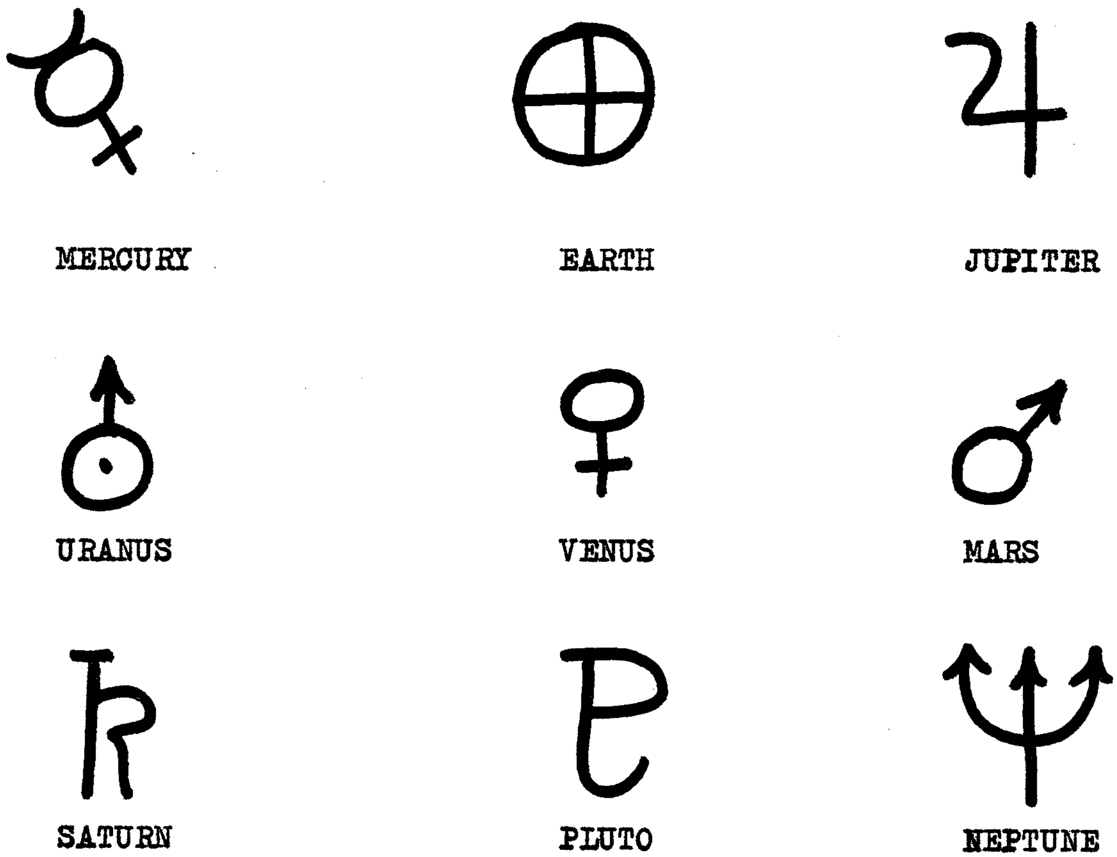
In the next chapter, the problems identified above are treated in an integrated series of inquiries. Each inquiry represents an interaction between one of the "universes" and one of the biologically related problems.

SATELLITE PROJECT SYMBOLS

MAJOR AREAS OF STUDY



These symbols will appear throughout the manual as they may apply to the topic under discussion.



Planetary symbols from antiquity.

CHAPTER III

INQUIRIES

An attempt has been made to incorporate the conceptual framework into the organizational layout of this section. The inquiries related to the descending level of consideration (Earth to Community to Home to Self-Contained Unit to Exosphere) are listed under the facets of each major problem area (Biologistics, Toxicity, Radiation, Physiological Stress, Psychological Stress). Thus, for the major problem area of Biologistics, the facet of Food is sub-divided with a primer and inquiry (in this instance, a primer for each of two inquiries) for the examination of the Earth As A Universe; a similar arrangement for the Community As A Universe; Home As A Universe, and for the Self-Contained Unit As A Universe.* As each aspect of the conceptual framework is developed by these descending levels of concern, the commonality of the problems to be solved, the variation in problem solution which is dependent upon the nature of the universe, and the nature of the yet unresolved problems emerge. By following this pattern, class activities,

*For this facet, the Self-Contained Unit and the Exosphere were combined.

discussion, and independent readings can be given a direction and point of focus; further, as new developments occur, referral to portions of the conceptual framework will help reinforce prior learning and help point the student's thinking toward possible next steps in man's efforts to understand and utilize his environment for mankind's benefit.

An exploded diagram for the terrestrially-bound categories in the conceptual framework is reproduced in Illustration No. 3.

Each aspect of the biological problems is associated with each level of "universe". The essential unity of the concerns is thus emphasized while the recurrence of the problem at each level contributes to the reinforcement of the understanding of the basic concept to be examined.

For the Exosphere As A Universe, an exploded diagram is included as Illustration No. 4. The addition of Pressure, Heat-Cold, Radiation and Weightlessness as the third dimension represents one method of identifying the essentially hostile nature of the environment found in the exosphere. Each factor must be examined as it may influence the already existing biological problems. Thus, man's need for a suitable food supply must be examined in an environment wherein pressure variations, temperature conditions, radiation concentrations and the absence of a suitable gravitational force, may render useless, procedures which have been

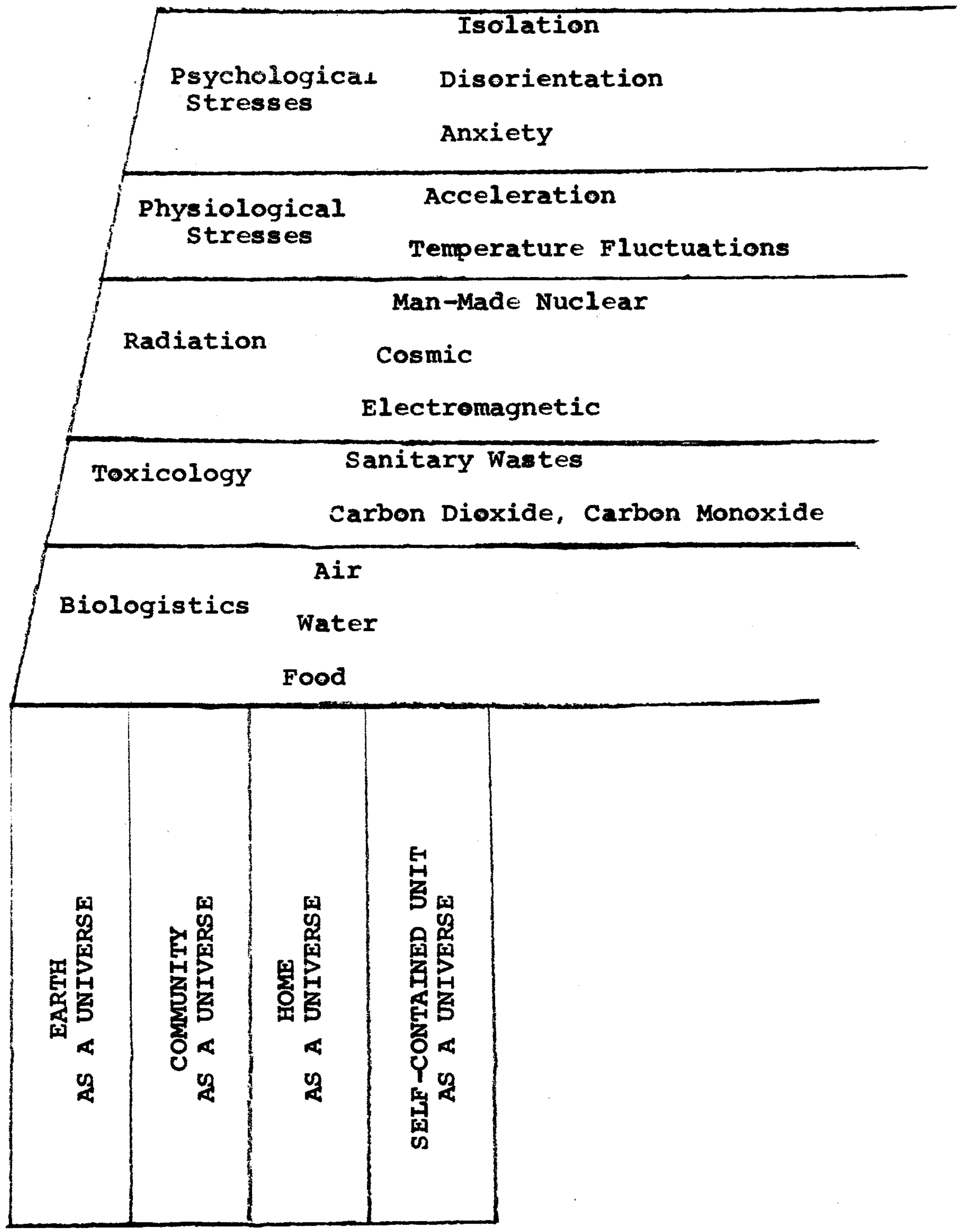


Illustration No. 3 Exploded Diagram of the Interaction of Terrestrially-Bound Universes and Biologically-Related Problems

What problems would you expect these two members of a combat crew in an underground command post for the operation of ten intercontinental range silo-stored missiles would face if they were unable to leave their "self-contained unit" for several months?

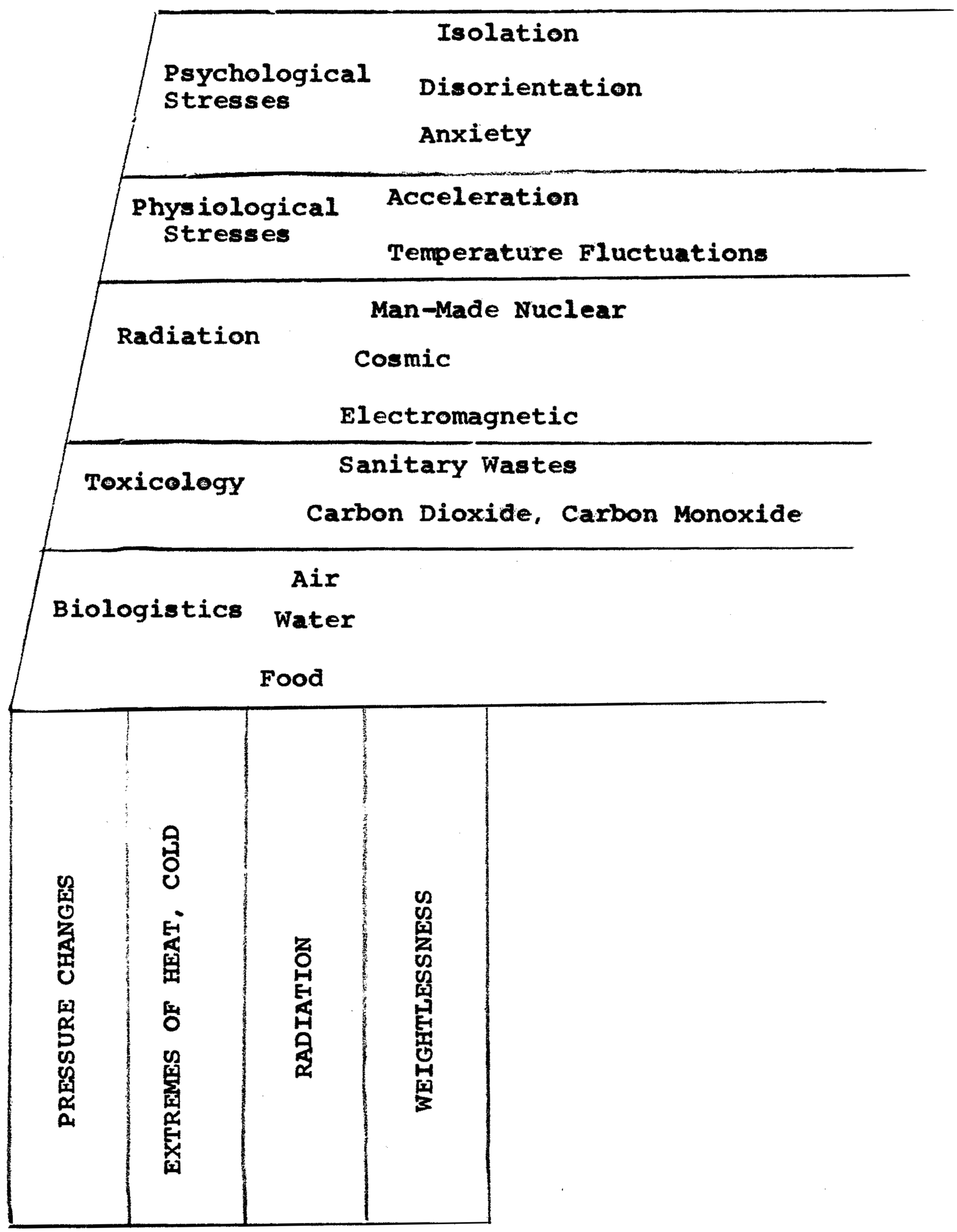


Illustration No. 4 Exploded Diagram of Interaction of Exosphere As A Universe, Biologically-Related Problems and Selected Exosphere Problems utilized effectively in the other Universes (Earth, Community, etc.) already studied.

A composite summary of the conceptual framework is represented in Illustration No. 5.

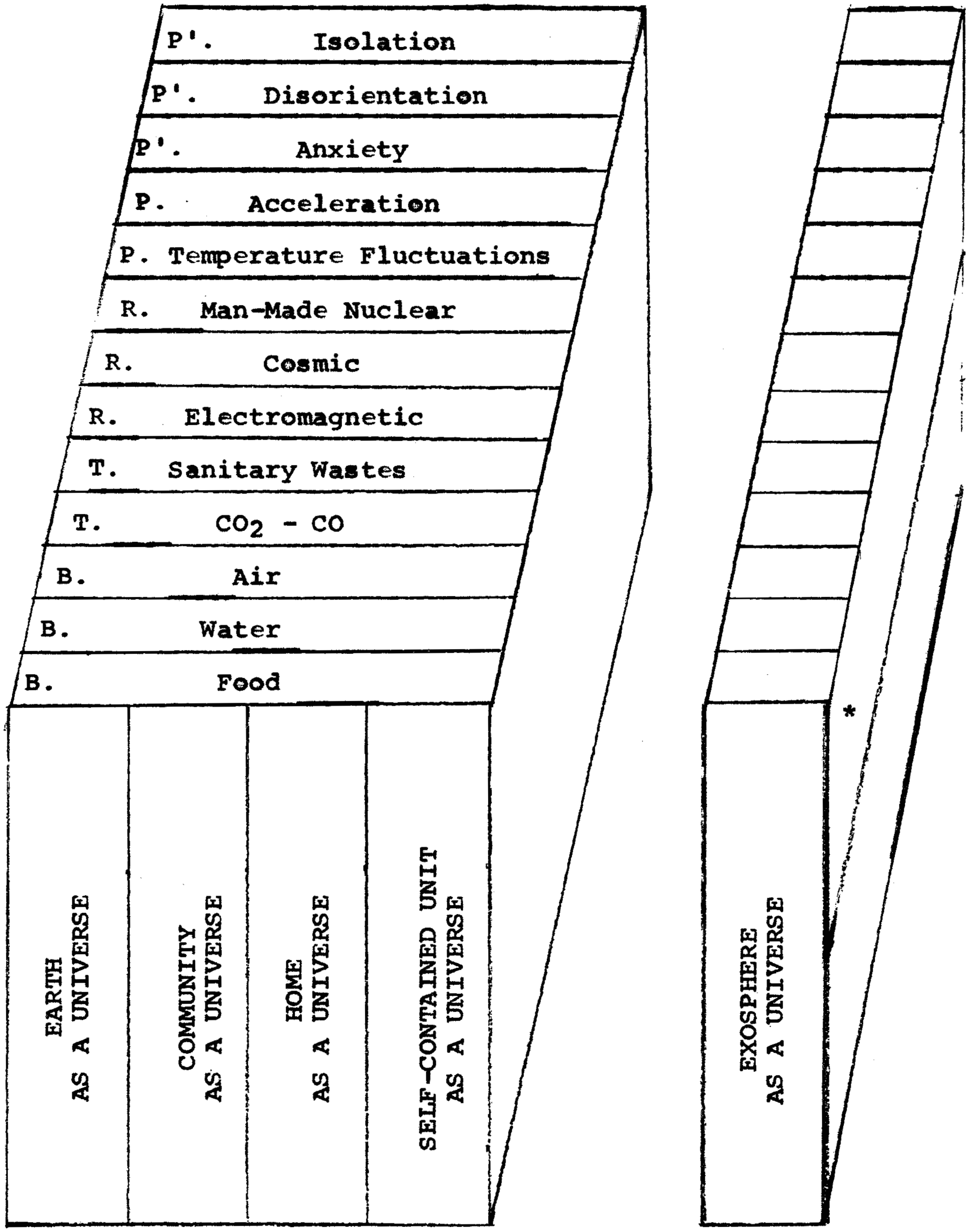


Illustration No. 5 A Composite Summary of the Conceptual Scheme for Life Science In A Space Age Setting

*Exospheric Problem - See Illustration No. 4, p. 20

LIFE SCIENCE IN A SPACE AGE SETTING

A. BIOLOGISTICS

Problems related to the securing of an adequate food, air and water supply are grouped in this block of inquiries. Food, air and water will be treated separately as they interact with the various universes. An outline of the problems, universes and inquiries is included below:

1. Food

    a. Earth As A Universe

        1) No. 1: A World of Your Own
        2) No. 2: Jack, You've Grown A Soil-less Garden

    b. Community As A Universe

        1) No. 3: Food for Thought

    c. Home As A Universe

        1) No. 4: This Little Piggie Went to Market

    d. Self-Contained Unit and Exosphere As A Universe

        1) No. 5: Ma, Please Pack Me a Lunch - I'm Off to the Moon

2. Air

    a. Earth As A Universe

        1) No. 6: The Atmosphere and You

b. Community As A Universe

1) No. 7: The Best Things In Life Are . . .

c. Home As A Universe

1) No. 8: Molecules of Life

d. Self-Contained Unit As A Universe

1) No. 9: There She Blows!

e. Exosphere As A Universe

1) No. 10: O_2, You Beautiful Gas

3. Water

a. Earth As A Universe

1) No. 11: Living Buttons
2) No. 12: Water: Friend or Foe? It Is Up To Us

b. Community As A Universe

1) No. 13: Water Drop - What Is Your History?

c. Home As A Universe

1) No. 14: Liquid Nectar Everywhere

d. Self-Contained Unit As A Universe

1) No. 15: A Drop In Time . . .

e. Exosphere As A Universe

1) No. 16: Spilt Milk - On The Ceiling

The student primer is introduced at the beginning of each inquiry and can be identified by the term, "primer" which is included below the heading of the inquiry.

INQUIRY NO. 1

A WORLD OF YOUR OWN
(Primer)

What would you do if you had a chance to design a world of your own? What would you put in it? A group of students came up with this list. Compare it with your own: air, people, plants, insects, music, rocks, water, animals, peace, sun. When we look over the list, we can see that it is rather general and includes several things, such as people, peace and sun, which would be difficult for any one person to control. Let us then ask the question in a more specific way. What would you put in a world of your own if the things chosen would have to be available to you and could be controlled by you? The list takes a more specific form: air, water, earthworms, soil, small plants, snakes, ants, beetles, snails, and goldfish. You may compare this list with the first one and find that certain factors are no longer present. People, music, peace and the sun - where have these gone? To be sure, without the sun or at least some form of energy, no world of which man can conceive at the present time, could exist. Therefore the sun is one exception that we will have to make in our problem. We have no way of creating a substitute for the sun so we will have the sun come into our world from the outside. Since this is what happens in the case of our own earth, it is not a bad example to follow.

Let us look at the list that we have made and ask a further question. Let us assume that you are provided with the items on the list. How can you in some way isolate these items from the world of which you are currently a part? Unless you do so, you cannot claim that you are controlling this world and it would, therefore, not satisfy the conditions in our question. What do you suggest? We know that to isolate the items a "container" is needed which would meet certain qualifications. First, because we agreed that the sun was not a controllable factor, it would be necessary that the sun's rays be able to penetrate the "container's" surface. We know that certain rays of the sun are stopped by glass; however, if we can have most of them come through, we will accept that for the moment. The second thing, and perhaps the most important, is that once we design this world we will have to enclose it in such a way that our external world will not affect it. In other words, when we design this world, we must seal it tightly so that our outside world and this inside world will not in any way come in contact with each other. Does that raise some questions in your mind? Can you see such a world?

The first inquiry that we will pursue requires that we create our own "world". Once we have assembled it, we must then think in terms of what is occurring within it. This means that each person who has made a world will need to keep a record of what was put in his "world" and then to observe what is happening in the "world" itself. This record keeping and observation recording is one of the important bits of behavior which the scientist follows as he plans a particular experiment. At the same time he tries to predict or make guesses as to the outcome. This guessing or predicting is very helpful when it is done before or during the experiment. Very often such predicting may point up problems which would otherwise be overlooked and which could then be eliminated. Try to follow the record keeping, observation recording and predicting process as you examine your "world"

Now let's examine some of the predictions that other students have made about their world. One of the first predictions is that "the air will all be used up". Another prediction, based on the first is that, "once the air is used up, any plant life that is in this world will die, and because the plants die, the animals will die. In a short time there will be nothing left in the world". What do you think will happen?

Another prediction that has been made is that, "if seeds were planted in the soil of your "world", the seeds will not grow". In the study of your own "world", you will have an opportunity to decide which of these predictions are confirmed by your observations. This type of "Yes, there is!", "No, there isn't!", controversy is what is going on at the present time as our scientists consider the possibility of life on other planets and galaxies. No one can yet predict with certainty what will be found on other planets. Attempts are being made to duplicate the known conditions on these planets to see if life, as we know it on our earth can exist under such conditions. You may wish to create a "world" which is like that of some planet you have read about. To do so, you will have to exercise your ingenuity and devise special chambers. The problems which you face in duplicating the world on which you live by making a "world" may help you understand the problems the scientists are having in their efforts to duplicate the known conditions on other planets.

Consider for a moment how the world about us handles some of the questions that we raised or made predictions about in our own "world" in glass. The air that flows over the surface of the earth is in constant motion. We know this for we need but stand out on the street to feel the air as it rushes past us.

During a storm we are impressed by the wind, especially when it reaches a velocity of fifty, sixty or even a hundred miles per hour. This movement of air has an effect on the plant and animal forms around us. We know that air contains approximately 20 per cent oxygen and over 78 per cent nitrogen with the remainder a mixture of some of the rare gases, water, carbon dioxide and waste gases. This air is constantly mixed and, in the mixing process, the plants and animals remove what they need from the air for their own use. Does this process occur in our "world"? Is it possible that all of the air is being "used up"?

Consider another problem. What is happening to the seeds that are in the ground? The seed is a storehouse of food materials for the young growing plant and until that food material is used up, the plant does not need to manufacture its own food. Therefore, during the time it is in the ground, the seed's needs are similar to our own. It takes from the air the necessary gases, in this case, oxygen, to help it use up the fuel that it contains, and, in this way, gets the energy it needs to start to grow (germinate). Once the plant's stem is above ground, it can capture the sunlight in the chloroplasts of its leaves, and, in this way, begin the process whereby it makes the necessary food materials for the plant to continue its growth. In our "world" how will this process take place? Will there be enough oxygen in the air within our "world" for seeds to use for their growth purposes? If all the oxygen is "used up", then what will happen to the seeds? You can see that it will be necessary that you observe and record carefully all that you see. In this way you may answer these questions and many that will also arise as you wonder and ponder over your "world".

<u>Class Discussion - Questions</u>

1. If you were to place a candle in your world, and just before you sealed up your "world", you were to light the candle, what do you think would happen? Try to describe the various steps that you think will occur. What in your "world" serves the same purpose as the candle?
2. What patterns that exist in the world around you do you see occurring in your own "world"?
3. What changes would you make in your "world" if you were to start over again? Try it.
4. What predictions did you make which did not come out as you expected. How did you explain the unexpected? What new predictions have you made?

A. Biologistics
   1. Food
      a. Earth As A Universe

INQUIRY NO. 1 A WORLD OF YOUR OWN

<u>Basic Concepts</u>:

Life is a continuous process requiring material and energy changes.
A study of life processes can help man learn how to control and utilize his surroundings.

<u>Sequence - Summary</u>	<u>Activities - Illustrations</u>
Plants need certain essentials for growth and production of food. These include: 1. Sun's energy 2. Water 3. Oxygen and Carbon dioxide 4. Certain water soluble minerals.	Place, within a gallon jug, the various materials which students believe are conducive to life as we know it. Encourage variety but have the students take careful note of what they include in their "world". After materials are in "world", seal the gallon jug and place it where it will receive some sunlight. Encourage students to make predictions as to what will occur within their "world". Place a snail, water plant such as <u>Elodea</u>, and some pond water in a large test tube. Seal the

tube, leaving an air space equal to at least 1/3 of the space within the test tube. Place in a location similar to that for the gallon jug.

Encourage students to observe and record information about plant germination, plant development and atmospheric changes within their "world". Help student identify the conditions needed for life, the relationships between water and plants, air and plant development, and the role of decay organisms in stimulating plant growth by providing necessary nutrients.

A. Biologistics
1. Food
a. Earth As A Universe

INQUIRY NO. 2

JACK, YOU'VE GROWN A SOILLESS BEANSTALK
(Primer)

One of the most essential needs of a plant is its need for sunlight. Such a need can be demonstrated using two seedlings that are approximately of the same size and age. One plant (the control) is exposed to sunlight while the second plant is placed in a drawer where it is not exposed to sunlight. You may be surprised to see some growth for a short period of time after the second plant is placed in the dark (to what do you attribute the continued growth? Try the experiment with bean seeds.).

In a similar way, you are able to set up an experiment to test the plant's need for water and for atmospheric gases (both carbon dioxide and oxygen). But what of the plant's need for soil? Have you ever seen plants growing without having their roots buried in soil? What does the soil contribute to a plant? Many years ago, a curious person tried this. He took a young tree growing in a tub of soil. He weighed the tub, the soil and the tree and then, after the tree had grown to over double its original size, he repeated the weighing, having been quite careful in the time interval not to add anything to the tub other than water (he even kept a record of the amount of water!). What predictions would you make as to the weight of the soil and that of the tree? He found that the amount of soil was almost the same as before while the tree weighed many pounds more than before. Even when he took the weight of the water into account, the gain in weight by the tree could not be credited to the soil or to the water, either taken separately or combined. As you have probably guessed, this finding led to more questions and experiments to determine whether soil was really needed for plant growth. Other men found that while the soil is the chief source of water-soluble minerals (why water-soluble? for what use by the plant?), it could be replaced by solutions of these water-soluble minerals in the form of salts for the growth and production of food by plants.

Why should we be interested in the role of soil in plant growth? Our source of food, either directly as plants which we eat or indirectly as the animal flesh we eat which comes from the animal's digestion and assimilation of the plants it has eaten, is dependent upon plants. As man has explored our earth's surface and the seas, he has had to bring the seeds or products of plants with him. In many cases, he has discovered new and often exotic plants which have added to his store of foodstuffs. In these activities, man was always able to rely on having soil available; even when on the high seas, he was usually able to locate some island upon which plant life was growing. As we point our sights to the stratosphere and beyond, the problem of soilless lands emerges. What knowledge can we gain about plant growth without soil which may help us provide food for those who will be on space platforms or on extended trips to other planets. What of their needs once stations are established on other planets? These are some of the questions which we must begin to seek answers for now. As you explore in this inquiry as to how men have learned how to raise plants without soil, see what questions and ideas occur to you which may point the way toward the solution of some of the questions in this primer.

A. Biologistics

1. Food

a. Earth As A Universe

INQUIRY NO. 2 JACK, YOU'VE GROWN A SOILLESS BEANSTALK

<u>Basic Concepts</u>:

Plants may be grown in a solution of nutrient salts with the complete absence of soil.

<u>Sequence - Summary</u>

Plants need certain essentials for growth and the production of food.

Plant needs include energy (usually solar although some plants use other plants for this purpose), water, oxygen (particularly when germinating), carbon dioxide, and certain essential water-soluble minerals.

The absence of water-soluble minerals such as calcium, iron, potassium, magnesium, nitrogen, phosphorus and sulfur will retard and in some cases, result in the death of plants.

<u>Activities - Illustrations</u>

Attempt to grow lima beans in vermiculite or sphagnum. Provide water (distilled) but do not add any soil. Try the same thinq with tomato plants, potatoes, radishes, or other plants which the students suggest.

Secure a set of water-soluble minerals from a biological supply house and repeat the first experiment.

Various deficient nutrient solutions are also available from the biological supply houses. Try several with controls in the form of plants in

Plants vary in their requirements of the various water-soluble minerals.

soil, and plants in basic water-soluble minerals.

Repeat the experiments using excess amounts of some of the water-soluble minerals. One way to do this is to provide half or some smaller fraction of the water suggested when mixing the various nutrient solutions.

Attempt to grow plants from cuttings in the water-soluble mineral solutions and the deficient nutrient solutions.

References:

Hydroponics: Growing Plants in Nutrient and in Deficient Nutrient Solutions without Soil, Turtox Service Leaflet No. 51, General Biological Supply House, 8200 South Hoyne Avenue, Chicago, Illinois

Sourcebook for Biological Sciences, Morehold, Brandwein and Joseph, Harcourt, Brace and Company, pp. 112-113

Soilless Growth of Plants, Ellis and Swaney, Reinhold Publishing Company,

INQUIRY NO. 3

FOOD FOR THOUGHT
(Primer)

A teacher raised the following question during a class discussion on the importance of knowing the nutritive value of various foods:

> If the class were to represent a community, and that community were to be sealed off from all sources of communication or contact with the rest of the world, how would you, as a class member, be able to provide yourself with an adequate supply of nutrients for continued survival?
>
> If you were given 48 hours prior notice of the problem, how could you then best prepare yourself?

Some of the points which the students raised in their discussion were:

1. We would have to know what comprises the basic nutrients for minimal healthful survival.
2. We would have to know what types of foods would furnish us with these basic nutrients.
3. We would need to set up tests to determine what kinds of nutrients are found in the foods which can be grown in our community.

4. We would need to know how to recognize cases of malnutrition, and the corrective or preventive steps which should be taken.
5. We would need to know if food can be grown even if the soil were found to be insufficient to support plant growth. (Use of hydroponics - See Inquiry No. 2)
6. We would want to know many methods for storing and preserving foods.

How many of these points occurred to you? In this inquiry, you will explore these problems. Your approach and results may take many forms. This same class did these things:

1. Set up a bulletin board display showing the new and old methods of preserving foods.
2. Carried out a project to show how foods can be grown hydroponically. (See Inquiry No. 2)
3. Carried out a project showing how foods are tested for sugar, starch, fat, protein, minerals and vitamins.
4. Carried out a project showing what happens to food if not properly preserved.
5. Students brought in recipes and prepared foods which can be used but are not part of the community's normal diet. Their list included grasshoppers, snails, worms and small mammals.

What additions would you make to this list? Try it first.

A. Biologistics
   1. Food
      b. Community As A Universe

INQUIRY NO. 3 FOOD FOR THOUGHT

Basic Concepts:

An adequate supply of proper nutrients is necessary to maintain a healthy community.

The food requirements of a community must be satisfied by agencies both within and without its boundaries. Special problems arise as the degree of outside support increases.

Sequence - Summary	Activities - Illustrations
A sufficient supply and a suitable variety of foods should be produced in or for a community.	Discuss the storage and transportation of foods as related to the method of preservation.
An adequate diet includes starch, sugar, proteins, minerals, and vitamins.	Show films demonstrating various methods of food processing.
Some foods must be preserved in order to maintain an adequate supply over an extended period of time.	Visit a cannery, freezer plant or meat processing unit.
	Check on local regulations dealing with food handling, storage and purity of products.

Preservative techniques include: drying, salting, canning, refrigerating, using dry ice or ultraviolet light, radiation treatment and pickling.

With the advent of food processing for mass consumption, we must guard against the possibility of large scale food poisoning.

Regulatory agencies, such as the Public Health Department, and Food and Drug Administration act, on behalf of the public, to reduce food contamination and the incidence of disease from food or water sources.

Discuss the origin and function of the Food and Drug Administration. Visit their local office.

Test foods for starch, sugar, protein, fats, minerals and vitamins.

Discuss the "best" ways to preserve specific foods. Try it.

Make a list of the essential foods which your community must obtain from other areas or communities.

Make a collection of pictures showing the variety of foods used in various cultures.

Invite a dietician to speak on problems of malnutrition and the corrective or preventive steps which should be taken.

Invite a representative from the Public Health Department to visit class and explain his department's responsibilities in food handling for public consumption.

INQUIRY NO. 4
(Primer)

THIS LITTLE PIGGIE WENT TO MARKET

The fact that food is essential for life has affected many areas of man's activities. What he eats, how he eats, and when he eats, are all an integral part of his physical, social and spiritual world. In his religious life man may pray for his daily bread and return thanks for having received it. Also a vast array of social customs bind food with hospitality. One may give salt and flour to his host as a token of friendship; similarly, we offer our guest food as an act of friendship. In many areas of the world today, most of man's waking hours are devoted to the search for food. Indeed, the entire history of man's advancement over the face of the globe has been dependent on the ease with which he could procure daily nourishment. Man's movements are often restricted until he has solved the basic problem of what food could be taken with him and what he would have to eat when he arrived at his destination. Thorstein Veblen[1] has stated that

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[1]Veblen, Thorstein, The Theory of the Leisure Class,

the advancement of man could not have taken place until a portion of a society was able to provide enough food for the entire community, thus freeing others for tasks such as protection, tool making, experimentation and exploration. In his view, the entire development of any given society is directly connected with its food supply. In this way, food and culture can be seen as being closely related.

One can pinpoint with considerable certainty the area of the world in which a person lives by knowing the types of food he eats. Some scientists have raised the question as to whether the tremendous variety of food preferences exhibited by people in various parts of the world is due to conditioned social practices alone, or whether there may be some biological difference in the people. It is interesting to puzzle as to whether the long centuries of inbreeding within isolated geographical communities may have affected the people's food requirements. Can all people taste things exactly alike? If people do not taste things alike, why? Such unresolved questions will be your generation's concern, for as our capacity for solving problems increases, so also do the number and complexity of new questions.

A very young child is taught that too many sweets are "bad for you" and that milk is needed for "strong bones and teeth". In such ways we have been made aware of the need for an adequate diet to maintain good health. Yet it was not so many years ago that, here in America, many people were dying or were deformed because of nutritional deficiences, even though they were not going hungry and seemingly had enough to eat. Because of this, it is not enough to say that food is essential for life. A _Hydra_, taking a bit of lettuce into its gullet, will starve to death while waiting for its digestive enzymes to dissolve the cell walls in order to extract the nutritive value from the lettuce. A human being can also starve in the midst of plenty, if that plenty does not contain the essential elements needed for cell growth, repair and replacement.

Some of the more interesting problems which scientists have explored are those concerned with our appetites and the reactions we get which some people call cravings. An experiment was conducted among a group of babies in which small dishes of food were placed before them, each containing a different food, such as meats, various vegetables, sweets, fruits, etc. No direction was given to the children. They were allowed to dip their fingers in and sample the foods at will. They were allowed to eat anything without fear of scolding, nor were they encouraged in any way to try another food if all they preferred on a particular day was sweets. Careful records were kept though, of what they did consume, and it was found that over a period of any given week, they had eaten what nutritionists would term a very adequate diet. Apparently, when left to make his own selection, without any social conditioning, the human being is able to select those foods which satisfy his biological needs. Why this is so still puzzles the scientist and is the starting point for many experiments and careful studies.

Most of us tend to take our daily food supply for granted as we seldom experience the pangs of hunger for any longer than it takes us to reach into the refrigerator. However we should be aware of the vast advancements that have been made in agricultural production, food preservation and distribution. These advances have enabled farmers to provide us with food at a lower cost and also made the food more readily available to a rapidly increasing population. We hear much talk of the population explosion and that the population will soon increase to the point where we will exceed our food supply. However, our advances in technological processes have continued to keep pace with our needs, and there is much evidence that this will continue to be true for the foreseeable future.

A. Biologistics
  1. Food
    c. Home As A Universe

INQUIRY NO. 4 THIS LITTLE PIGGIE WENT TO MARKET

<u>Basic Concepts</u>:

Provisions for procuring and storing foods within the home have changed over time.

Within certain limits, heat increases the growth rate of living organisms.

Lack of heat slows or may arrest the growth of living organisms.

<u>Sequence - Summary</u>

Game hunting and fishing are carry-overs from the days when man was wholly dependent upon his own powers to provide for his family.

The pioneer's home included provision for raising crops and livestock.

<u>Activities - Illustrations</u>

Discuss these questions with your students:

1. How did pioneers procure and store foods while travelling (Conestoga wagons could be considered as home while on the move)?
2. How is the food storage problem handled in various parts of the world? At various times of the year?

Those whose home bordered on the sea would secure a significant portion of their food from it.

As communities have grown, the need for specialization has resulted in the reduction of each family's efforts to provide its own food supply by growing it.

Food storage devices have made it possible for man to have available "out of season" foods.

Dehydration, irradiation, canning, smoking or salting prevent bacterial growth.

3. How were sod houses used for food storage?
4. Campers have to contend with food storage problems when out for long periods of time. What suggestions do you have to meet this problem?
5. Why was food salted, dried, pickled, canned or highly seasoned?
6. What are some edible forms of sea life?
7. What food materials did the "general store" provide the cattle rancher? the bank clerk? the farmer?
8. What are game laws? What procedures should be followed to assure proper utilization of game after its capture?

Visit the local supermarket and identify the various storage methods which make it possible for us to eat a particular "seasonal" food the year-round.

Experiment with bread mold, agar plates of bacteria, at different temperatures.

Experiment with preserved and non-preserved foods to determine rate of bacterial growth. Compare fresh and powdered milk.

Experiment using intact and damaged packaging of various types. Determine rate of bacterial growth.

Investigate the problem of botulism.

Determine what nutritious foods require no preservatives (nuts?, fruitcake?, other?)

Raise the question: Could one survive for twenty five years without ever eating a cooked meal?

Determine whether there are micro-organisms which are helpful in food preservation.

INQUIRY NO. 5

MA, PLEASE PACK ME A LUNCH - I'M OFF TO THE MOON

With the coming of the space age, mankind has been faced with new problems in food storage. Extended periods of time will pass as man travels the great distances between planets. Food storage will be a factor which will need to be considered and may limit the extent to which man will be able to wander among the stars. The requirements for food and its storage can be determined with some precision. The food must contain food nutrients in highly concentrated form per gram of weight as room is limited. The stored food must look tasty, and must be able to withstand radiation and extremes of heat and cold. In trying to solve these space problems, scientists look to the way we store food in our everyday life. Some foods are frozen and then stored. They are eaten after they thaw out. Other foods are put in sealed cans and are exposed to great heat. They are then cooled and stored. In any grocery store, one can see vegetables and many other types of food stored in both ways. Also, many materials are used to keep the heat out and the cold in - ice cream sacks and tin foil are two examples.

Many of the ways we keep foods from spoiling in our everyday lives cannot be used in space travel. Some of the materials we use cannot stop radiation, or else, they cannot stand changes in temperature which may exceed hundreds of degrees. Radiation may affect the food, changing its chemical composition so that some food essentials, such as amino acids, may be converted into nonusable form for cell growth and development. A further complication is the food's consistency. Visualize a broken cracker eaten during a weightless state. The cracker crumbs would float about creating a fascinating but potentially dangerous "fog" until a gravitational field removed them from the atmosphere.

In this inquiry your capacity for original thinking will be tested. Can you devise a method for food processing and packaging which provides for maximum food value for the least weight and <u>bulk</u>, with packaging to protect against radiation, temperature extremes and yet, when the food is eaten, the packaging can be readily disposed? As an after-thought and yet of major importance, can you provide food which is tasty and appealing?

Mid-Air Meals: This jet-to-jet refueling represents one way whereby these "self-contained units" are maintained for extended periods of time. The refueling, being completed by a KC-135 (plane on the left) at approximately 350 miles per hour (B-52, plane on the right, is a 650 mile per hour heavy bomber) presents an interesting problem. As the KC-135 passes fuel to the B-52, it becomes lighter while the B-52, with extra fuel, becomes heavier. What do you predict will happen? How do pilots adjust to achieve a steady position in relation to each other?

A. Biologistics
   1. Food
      d. Self-Contained Unit and Exosphere As A Universe

INQUIRY NO. 5 MA, PLEASE PACK ME A LUNCH - I'M OFF TO THE MOON

Basic Concepts:

Types of food, packaging and palatability are major problems in providing food for any self-contained unit and in the exosphere.

The goals of food provision include maximum food value for minimum weight and bulk, packaging for protection, multiple utility and ready disposability.

Sequence - Summary

Food, if preserved and packaged properly, can withstand wide variations in temperature.

Extended periods of food storage may adversely affect the taste and nutritional value of foods.

The use of dehydrated foods has the advantage of low weight and

Activities - Illustrations

Discuss with students how food packaging can insulate food against heat and cold; how packaging can be durable yet light in weight; how packaging can have some further use after the removal of the food; how packaging can be designed to withstand low levels of radiation.

bulk, rapid reconstitution, long storage period potential, and it may be pre-cooked.

Freeze-drying (sometimes called freeze dehydration) is superior to canning in that the food retains its size and shape but is less in weight due to water loss.

Recycling systems, whereby algae, and sanitary wastes are used to provide protein for use by man, are being developed for use on extended trips or on planetary stations.
(See B. Toxicology, 2. Sanitary Wastes)

Expose many kinds of food to extremes of heat and cold.

Find out which types of foods last longest without preservation under varying conditions of heat and cold.

Try available packaging materials under varying temperature conditions.

Raise the question: What would happen to egg white in the presence of dry ice?

Finely divided food particles can be a problem in a space craft in which the oxygen content is higher than our own atmosphere.
Demonstrate the effect of dust in the air by blowing finely divided flour past a flame. Discuss coal mine dust explosions, grain mill explosions.

Secure samples of the following types of food preservation:

a. dehydration
b. freeze dehydration
c. vacuum packing
d. radiation
e. salting
f. smoking
g. others suggested by students.

INQUIRY NO. 6

THE ATMOSPHERE AND YOU
(Primer)

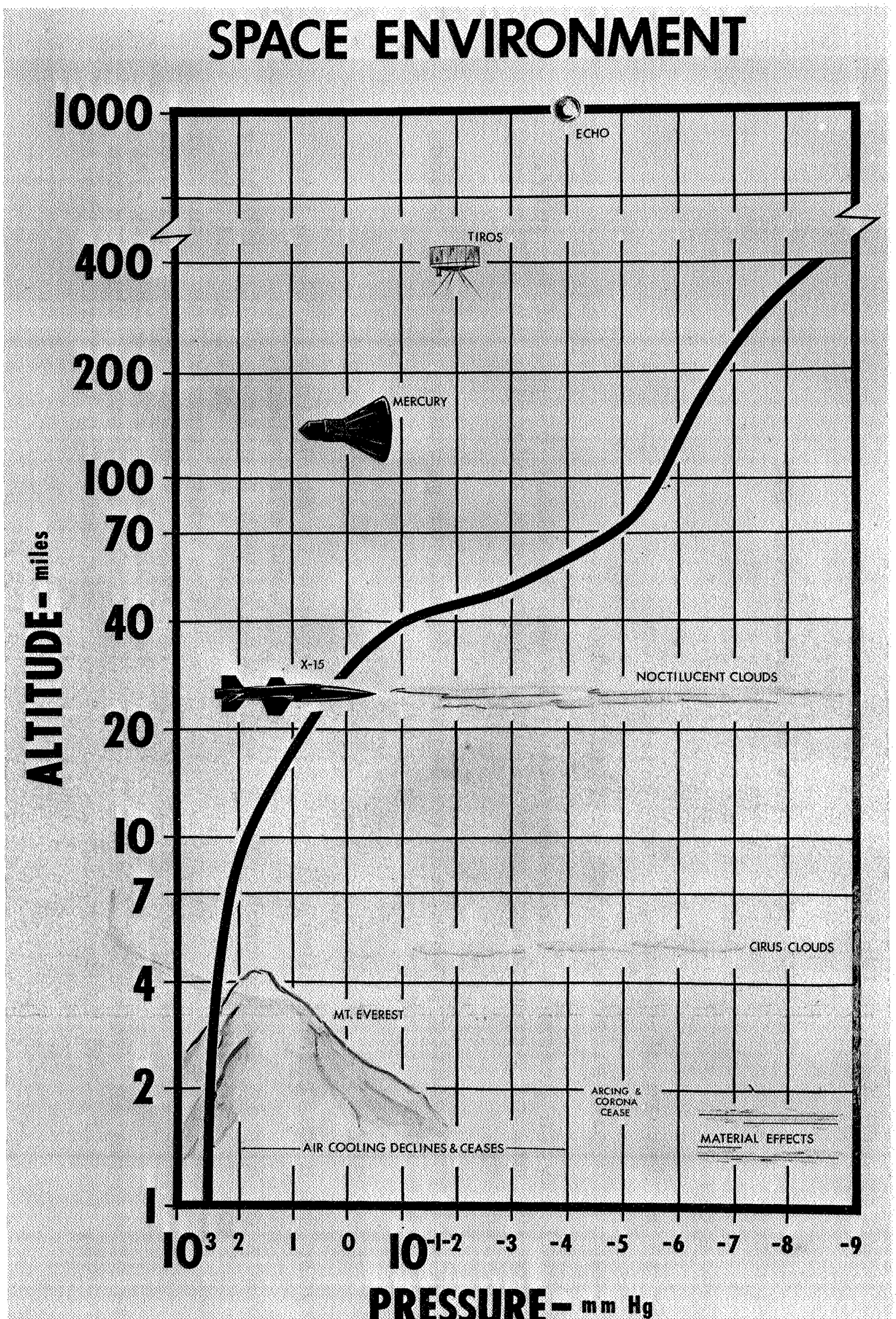
The sea of air around us is often taken for granted. In this inquiry we will establish the groundwork upon which you can increase your understanding of the significance of air and all of its components for all forms of life.

The atmosphere is a complex system, composed, neither of a simple chemical element, nor even of a single compound, but rather of a relatively stable mixture of a number of gases. First, there are several chemical elements which remain permanently in gaseous form under all natural conditions. Second, gaseous water, known as water vapor, is a variable part of this mixture. Finally, the air contains, although not as essential ingredients, a great number of solid particles of varied nature, known collectively as dust. The two permanent gases that make up 99 percent of the volume of the atmosphere, after the water vapor and the dust particles have been removed, are the chemical elements, nitrogen and oxygen. Nitrogen forms about 78 percent of the total volume of dry air, and oxygen about 21 percent. Of the remaining one percent, the greater part is argon, and of the 0.04 percent which remains, approximately 0.03 percent is carbon dioxide. The remainder is composed of minute quantities of neon, helium, krypton, hydrogen, xenon, ozone, radon, and other gases.

Although its composition may remain fairly constant throughout its depth, the density of the atmosphere drops rapidly as higher altitudes are reached. At three and one-half miles above sea level, the air pressure as measured on a barometer is half that on the earth's surface. With another rise of three and one-half miles to seven miles, the atmospheric pressure is half that at three and one-half miles, or to put it another way, it is one quarter the air pressure on the earth's surface. Thus, at a height of seven miles, the oxygen pressure which is about 152 mm. of mercury (about 6 inches) at sea level, drops to less than 40 mm. of mercury (a little over 1.5 inches).

Ten miles above the earth's surface, there is not enough oxygen to support burning such as you might try with a match or a candle. Six miles above the earth's surface respiration or breathing is practically impossible. Indeed, the Mt. Everest expedition members who finally conquered the 29,000 foot peak (how many miles?), carried their own oxygen supply with them. Although some South American Indians live at an elevation of 13,000 feet, permanent human activity, including farming and living ceases at about two and one-half miles (how many feet?) above sea level. The reason for this can be better understood when the process of oxygen-carbon dioxide gas exchange (respiration) is considered. The process of oxygen intake by the human organism is one of diffusion of gas from a region of higher concentration of that particular gas to a region of lower concentration of the same gas. The alveolar air, which is the air remaining in the lungs at the end of each breath, normally has an oxygen pressure of about 105 mm. of mercury. As long as the external air has a higher oxygen pressure, the process of diffusion will continue. However, if the external oxygen pressure drops much below 105 mm. of mercury, there will be little if any diffusion of oxygen into the lungs and symptoms of anoxemia or oxygen starvation will appear. Compare the value of 105 mm. of mercury with those given above for oxygen pressure at sea level, 3½ and 7 miles above the earth's surface! In the case of the South American Indians who live at elevations of 13,000 feet, their markedly greater than normal lung capacity enables them to get the oxygen they need by taking in a larger amount of air but extracting very small amounts of oxygen from it.

The active element in air which is essential for animal life is oxygen. The carbon dioxide which is exhaled by animals and which is found in our atmosphere is taken in by plants, and oxygen, a by-product of plant cell growth and development, is released into the air. This exchange of atmospheric gases by plants and animals is, in large part, responsible for the existence of a relatively constant ratio of these two gases over the earth's surface. Oxygen is used by animal cells to oxidize (decompose) foods. This chemical decomposition of food releases energy which is used by the cell in carrying out its growth, repair and replacement. The other permanent gases appear to have no special biological role except as they contribute to the increase in density of the atmosphere.



The decline in atmospheric pressure with increased distance from the earth's surface is graphically portrayed. Is the pattern of pressure to altitude an inverse square (twice the distance, one-fourth the pressure; three-fold distance, one-ninth the pressure, etc.)? a direct relationship? Demonstrate by comparing values at various altitude multiples (10 miles vs 20 miles; 20 miles vs. 40 miles, etc.).

A. Biologistics
    2. Air
        a. Earth As A Universe

INQUIRY NO. 6 THE ATMOSPHERE AND YOU

Basic Concepts:

Air is a mixture of gases.

Atmospheric pressure decreases with altitude.

Minimal oxygen pressure for respiration in man is about 65 mm. of mercury. Below 100 mm. of mercury oxygen pressure, there is a reduction in efficiency and vitality.

Standard atmospheric pressure (sea level, 760 mm. of mercury) is 14.7 pounds per square inch.

Sequence - Summary

Oxygen is a fuel for animal life.

Levels of air in the atmosphere:
- Troposphere
- Stratosphere
- Ionosphere

Use of oxygen in the cells for growth, repair, and reproduction.

Activities - Illustrations

Oxygen is found in air which may be found everywhere.

1. Plunge a narrow mouthed bottle into a tank of water and tip the mouth toward the water surface. Observe the air bubbles.
2. Pour water into a battery jar containing soil. Observe the air bubbling up through the soil.

2. Continued. (Even students in the upper grades are not sure that soil contains air nor are they sure that animals found in the soil need air.)
3. Fill a glass with water and observe it closely. Let it stand in a warm place for several hours. Observe again. (The collection of air bubbles indicates that water contains air. Here is an opportunity to do research on the amount of gas that a liquid can contain at different temperatures. Students know that soda pop tastes better cold. Help them discover that it is because cold liquids can contain more gas than warm liquids.)

Air takes up space.
1. With a bottle and a funnel, place the funnel in the back of the bottle and fill the space around the funnel with modeling clay. Pour water slowly into the funnel. Only a small amount of water gets into the bottle. Why? (Help the students arrive at the conclusion that air takes up space.)
2. With a beaker and balloon fitted around the neck of the beaker, observe and measure the effects of heating the beaker and of cooling it under water or surrounded by ice.

Air has weight.
1. Balance a meter stick or rod by driving a nail through its center (the geometrical center is not always the center of gravity of an object) and balancing it on the nail between the rims of two drinking glasses. Hang a large plastic bag by means of a thin wire on one end of the rod and counterbalance the bag with some weight at the opposite end. Now fill the bag with air and put it back on meter stick at the same point as before. Have the class observe and help them find the explanation(s) for this.

Air exerts pressure.
1. Place a small amount of water in a tin can with a screw top.

Activities - Illustrations (con't)

1. Continued. Place the open can over a burner and heat. Remove the can from the heat and screw the lid on very tightly. Allow the can to stand and observe the results. Why does this happen?
2. Partially inflate a small rubber balloon and tie the end in a knot. Place the balloon in a receiver jar (made from a large jar with a screw-top and a metal tube soldered into the cap with a tire valve soldered into the lower end of the tube) and remove some of the air with a bicycle pump that has the washers reversed. What will happen (let the students speculate and then observe)? Why?

   This topic could lead into studies of effects of atmospheric pressure on space travelers. What are some of the dangers? Could spacemen explode outward (as the balloon expanded) in an atmosphere of lower pressure than that of the earth? Could spacemen be crushed inward as the tin can in an atmosphere of greater pressure than that of the earth? Why are we not crushed inward on the earth since air exerts 14.7 pounds per square inch pressure for each square inch on the human body? Students might be interested in calculating how much pressure is exerted on their bodies.

An equal volume of cold air weighs more than the same volume of warm air.

1. Use a balance stick and suspend two large paper bags at each end (make sure the stick is in perfect balance). Next place a light bulb in one of the large bags. The balance will be upset. Have the class answer "How?" and "Why?"

   This experiment can be used to lead the class into discussion of air currents on land and water, in ventilated rooms.

Activities - Illustrations (con't)

Being more dense, cold air "sinks" and warm air is "pushed" upward.

1. With the use of a convection box and a smoke source show that the warm air above the candle is forced to rise as the cold air comes in through the other chimney. (A convection box is a box with a window in front and two chimneys on the top. A place for a candle should be provided under one of the chimneys.)

Air contains moisture

1. This can be shown by putting ice and water in a beaker and letting the water vapor condense on the sides of the beaker.

   Raise the question: "How much moisture can the air contain?" The class can find answers to this question by constructing a hygrometer and measuring the relative humidity. They can compare the relative humidity inside their classroom and out-of-doors; different days, different seasons of the year.

   Warm air can contain more moisture than cold air.

   This should be incorporated into the study above.

Air is a mixture of gases.

1. Place a candle into each of two cake pans and fill each with water. Next light the candles and then place bottles inverted over the burning candles. The candles stop burning and water rises into the bottles. Why? What do candles need in order to burn? Is all the air oxygen?
2. Prepare clear lime water ($Ca(OH)_2$) by stirring some lime (CaO) with water. Let the mixture stand for a day and then pour the clear liquid into a bottle. This is lime water. When the mixture gets cloudy, a white precipitate will settle out (calcium carbonate).

2. Continued. The white precipitate indicates the presence of carbon dioxide in the water.

Air promotes some chemical reactions.

1. The class has already observed the burning of a candle in air and the formation of calcium carbonate - these are chemical reactions which were promoted by the presence of air.
2. Wash a small wad of steel wool in carbon tetrachloride to remove any grease. Squeeze it out and then fluff it. As soon as it is dry, place the steel wool in a flask fitted with a one-hole stopper carrying a length of glass tube at least 12 inches long. Stand the flask and tube in a jar of water with the end of the tube under water. Observe for a few hours. What happens? Help the students explain.
3. Balance a steel rule on a knife edge. Leave it in moist air or on a window sill for a few days and notice the effect of the air on the steel.

Air in the body.

1. In order that you may show how the lungs act, cut the bottom off a large bottle and fit a Y tube in the cork. To each of the branches of the Y tube tie a rubber balloon or some small bladder.

   Tie a sheet of brown paper or if handy, a piece of sheet rubber around the bottom of the jar. Pass a string through the middle of the brown paper. Knot the string and seal it in place with wax. Pulling this string lowers the diaphragm and air enters the neck of the Y piece. Help students discover why the balloons inflate.

   Pressing the diaphragm upwards has the opposite effect. Help them explain this.

2. To measure the volume of air in the lungs, invert a bottle full of water so that its neck is under the surface of water in a jar. Introduce a glass or rubber tube into the neck and blow one full breath of your lungs into the bottle.

   Adjust the level of the water in the bowl so that the pressure of the air in the bottle is the same as that of the atmosphere, and stick a piece of gummed paper on the side of the bottle. Remove the bottle and measure the volume of water required to fill it to this mark.
3. To show that expired air contains carbon dioxide use two large flasks connected by a T tube.

   The two flasks are connected so that when you breathe through the T tube, all the air bubbles pass through the lime water in the flasks. One tube is closed with the finger while the air is drawn in; the other tube is closed when air is exhaled.

   Ask the class to predict the outcome of this experiment. Will a white precipitate form in both flasks? If so, why? If not, why?

Additional Materials:
1. Using a bell jar, fill with a gas which is naturally colored. Concentrate the gas as much as possible. Reduce the pressure and observe. Is the color becoming less intense as molecules become less dense?
2. Place a flask, after water has stopped boiling under stream of cold water. Repeat except this time put a stopper on the flask. (Reduced air pressure over liquid, due to cooling by stream of water will result in boiling of the water in the flask.)
3. After collapsing a tin can (see earlier experiments) place under bell jar and see if it recovers when air pressure is reduced. (Be sure the tin can's cap is on!)

<u>Activities - Illustrations</u> (con't)

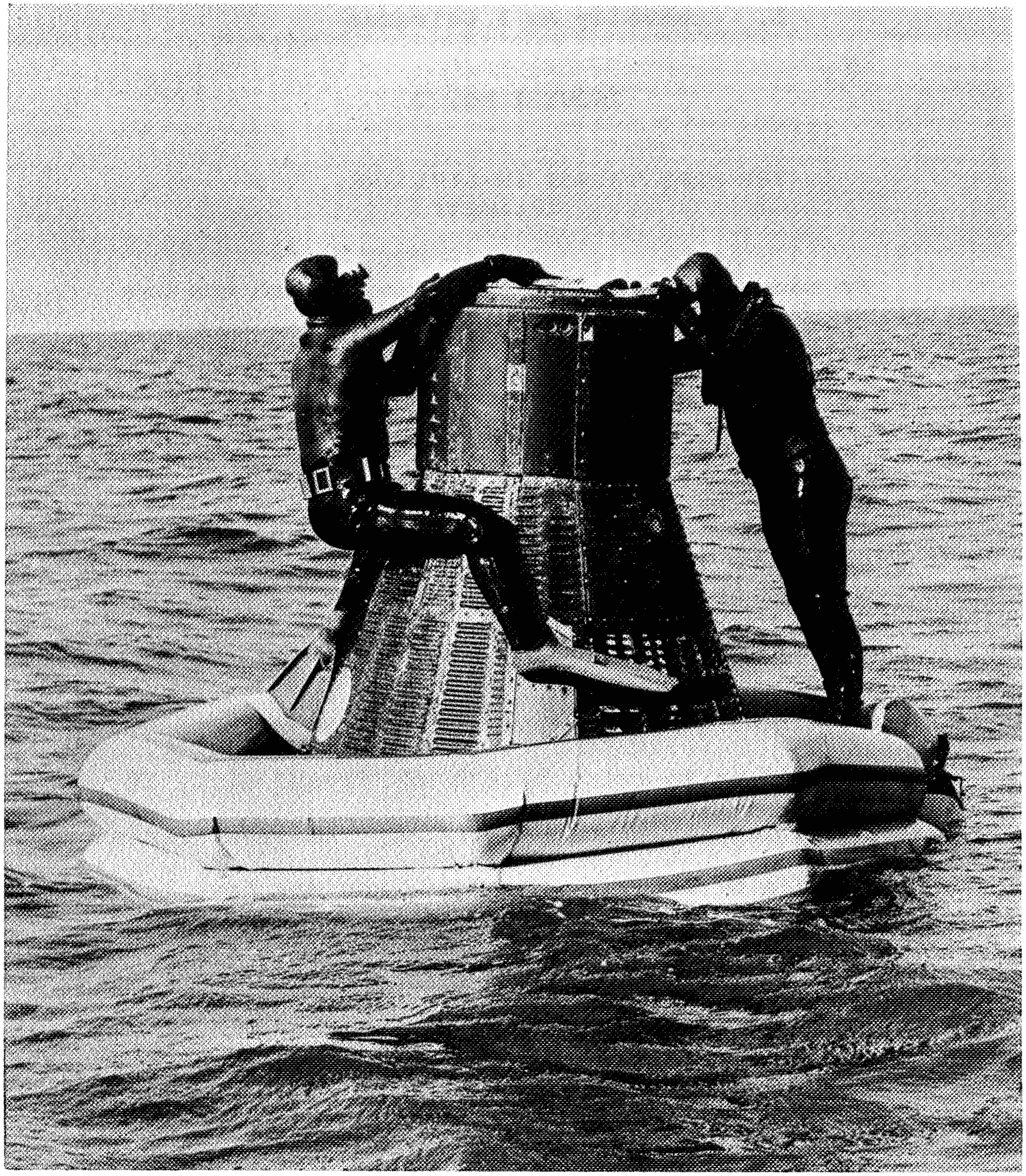
4. On tin can experiment, work out the total number of pounds pressure on surface of can. Recalculate in 5 lbs./in.^{2} (this is capsule pressure when pure oxygen is used). Get across idea that there is also force <u>pushing out</u> inside can. Relate to capsule in space (no outside pressure to push back).
5. Locate a sump pump for use as a vacuum pump. How can it serve for this purpose?
6. Open cold, warm soda pop to illustrate gases dissolved in a liquid under pressure. Relate findings to our circulatory system.
7. Test atmosphere for oxygen (qualitative)
   a. Burning candle
   b. Rusting steel wool
   c. Oxidation in the presence and absence of water.
   d. Extend to quantitative (i.e., how much volume was used?) study.
8. Observe reaction of insects in an environment of pure O_2, CO_2, and a mixture of both (plain air).
9. Encourage students to read about divers and the "rapture of the deep"; decompression chambers; the "bends"; sandhogs.
10. Mouse and barometer are placed in bell jar. Connect to vacuum pump and reduce pressure in stages. What elevations can be duplicated? What observations do the students make as to the mouse's breathing rate? activity?
11. Boil water at different levels within the same building. Establish difference in elevation. Take temperature reading in steam above water, <u>not</u> in water. (Use anaeroid barometer to establish differences in pressure between two locations. Do this on different days; different time of day.
12. Train fish to come for food with small changes in atmospheric pressure.

13. Place balloons in refrigerator, on top of a bottle which is heated. What is relation of temperature and volume? Do the same under a bell jar with pressure reduced.
14. Discuss these questions with the students:
    What is human response to pressure fluctuations? (arthritic patients are sensitive to pressure fluctuations; many people are depressed by reduction in atmospheric pressure (mountain climbing); there may be increased heart output due to reduced atmospheric conditions. Important to get across notion that fewer molecules of oxygen are available under reduced pressure conditions.)

    What is the atmospheric pressure range within which an organism similar to man (mouse or rat) is able to survive?

    Can organisms adapt to pressures close to their limits?

    Why doesn't a scuba diver need to wear a rigid suit while diving?



How do these frogmen maintain an adequate air supply for extended submerged periods?
How do these frogmen contribute to the psychological "peace of mind"of the astronauts?

INQUIRY NO. 7

THE BEST THINGS IN LIFE ARE . . .
(Primer)

We can all finish the title above with the one word, "free". The choice of this familiar saying as the title of this inquiry was based on the notion that we all accept the idea that the air around is available without any cost to us. And yet, is this really true? If you live on a farm, you may have little occasion to complain about the quality of the air you breathe. Perhaps you have been in the area where a large fire has been burning out of control and have noticed how difficult it is to get a breath of "fresh" air. If you live in an industrial city like Gary, Indiana, Pittsburgh, Pennsylvania or Detroit, Michigan, you may have had to contend with industrial wastes and automobile exhaust fumes in your efforts to get that elusive "fresh" air. Most of us are aware of the problems that communities such as Los Angeles and San Francisco have with "smog", a combination of industrial wastes, automobile exhaust fumes and a meteorological condition called the inversion layer. In the case of the California smog problem, the state legislature has passed a law requiring that all automobiles, after a certain date, be equipped with a device to reduce the contribution of automobile exhaust fumes to the smog conditions in the state. Thus, we can see that a price is being paid for what we take for granted.

In this inquiry, we shall need to explore the problem of air pollution and to examine how steps are being taken to reduce the undesirable effects of air pollution on our health and national economy.

A. Biologistics
2. Air
c. Community As A Universe

INQUIRY NO. 7 THE BEST THINGS IN LIFE ARE . . .

__Basic Concepts:__

Air is utilized in a wide variety of ways within the community.

A supply of relatively pure air is needed for continued community activity and growth.

Air can be analyzed and its components utilized in industries to the benefit of the community.

__Sequence - Summary__

Air can be used in the community for:

a. burning
b. heat production
c. electricity (production)
d. medical applications

Oxygen, removed from the atmosphere is used for chemical production, oxidation of materials and medical applications.

__Activities - Illustrations__

Find pictures illustrating the use of air in:

a. medicine
b. industry
c. transporation
d. power production
e. production of electricity

Have as guest speaker, a representative of the Air Pollution Control Board (if community has a smog problem). If not, write to nearby large city for information on the problem and ways whereby problem is being controlled. (Tie this in with B. Toxicology, b. Community As A Universe, Inquiry No. 19, Wastebasket in The Sky.)

INQUIRY NO. 8

MOLECULES OF LIFE
(Primer)

Perhaps the most treated substance to enter your home is air. Why can one make such a statement? Let us consider what happens to the air in our homes before it reaches us. First, how does it get into the house? If it's winter, you have probably sealed every possible avenue for air to come in unwanted. What does come in is heated by the furnace, possibly some moisture is added to it, and in many cases, even before it was heated, it was passed through a filter to remove dirt, dust and any other undesirable solids. During the summer, the process may not be as elaborate but you still may have screens on the doors and windows, an air conditioner to cool it off or fans to push it around within the house. What other "Treatments" can you suggest from your own experience? One more example would be the use of deodorizers or perfumes to remove or mask odors.

In this inquiry you will have an opportunity to explore some of the problems which must be solved as the size of the "universe" we are studying gets smaller.

Unless the molecules of life can be provided in an acceptable way, the home will not continue as a universe for any extended length of time.

A. Biologistics
2. Air
c. Home As A Universe

INQUIRY NO. 8 MOLECULES OF LIFE

Basic Concepts:

The air conditions surrounding our homes are a product of the community within which we reside plus our own contribution to it.

Sequence - Summary:

Air within the home can be controlled with regard to its:

a. temperature
b. moisture
c. particle content
d. circulation
e. odor content

Activities - Illustrations

Use calcium chloride ($CaCl_2$) to show removal of water from air. Pass air through a moistened cloth to show increase in moisture content.

Examine furnace filter to see what particles have been removed.

What is size of openings in window screens.

Watch smoke from a burnt match and see if you can determine the way air circulates in a room. What can be done to control this?

What odors are common in the home? At what time of day? How are these controllable?

Air Conditioning:

a. How do we filter and screen air before it enters our homes?
b. What controls do we have on air temperature?
c. How do we adjust the moisture content of air within our homes?
d. What type of air circulation occurs within our homes?

INQUIRY NO. 9

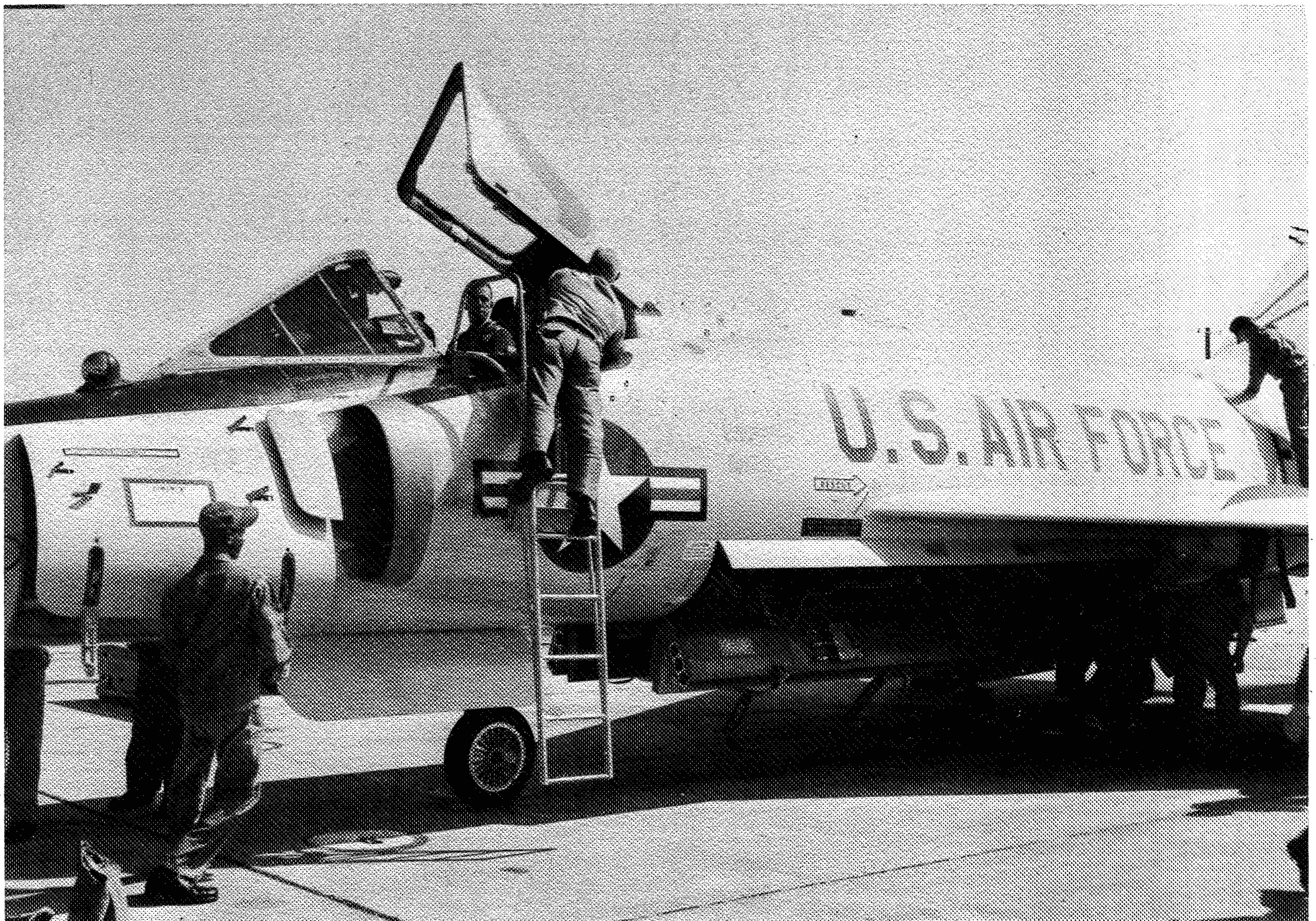
THERE SHE BLOWS!
(Primer)

"There she blows!" is a familiar expression used by whalers when a whale's warm exhaled breath becomes a spout of condensed water vapor. Shortly thereafter the whale will refill his large lungs and disappear below the water's surface into the depths of the ocean. Have you ever wondered how a whale can withstand the tremendous pressures which the water, pressing on him from all sides, exerts on his body? Similarly, what is the effect of the water on the hull of a submarine? Perhaps you have been fishing in a deep lake and have seen someone bring up a fish from a depth of 150 or 200 feet. How does a fish manage to move up and down in the water? Have you ever heard of sandhogs? That is the name given to men who work on the building of tunnels under rivers. They are required to work in an atomosphere in which the air pressure may be four or five times greater than our atmospheric pressure of 14.7 pounds per square inch. In the mining industry, such men are called groundhogs. What is common to all the examples and questions which have been raised?

You've guessed it, it is pressure. How each organism is able to adjust to changes in pressure is of vital importance if it is to survive in the environment. We have learned how to protect the human from too much pressure, as in the case of submarine construction. What other examples can you suggest in which man has had to develop ways to protect himself from either too much or too little air pressure in his environment?

Another area in which pressure is important to us can be found in our daily lives. People living at elevations of four or five thousand feet find that it takes a longer time to cook foods such as potatoes than when they try the same thing at sea level. If you are driving over a high mountain pass, you may find that the air pressure in your family car's tires is much higher at the top of the pass as compared with your home or at sea level. If you keep a record of the readings on a mercury or anaeroid barometer over several weeks, you will find that the readings go up and down. As in our first paragraph, the question is: What do these events have in common?

In this inquiry you will be encouraged to find examples of what you have read about and to suggest ways whereby man has learned to live with the problem of an adequate air supply in limited spaces such as self-contained units represent. In your findings you will have identified some of the problems and directions for solutions which face the scientists and engineers as they look to the stars and plot our future explorations into space.



The arrow by the wing on this F-102 "Delta Dagger", is marked "Rescue". The instructions printed below it indicate that, upon pushing button (red circle), a door opens. Inside the door, pulling a lever jettisons the canopy over the pilot's seat. Of what value is this procedure? Why couldn't you just lift off the canopy? In flight, why is an airtight canopy desirable?

A. Biologistics
   2. Air
      d. Self-Contained Unit As A Universe

INQUIRY NO. 9 THERE SHE BLOWS!

Basic Concepts:

Pressure is the force per unit area acting on a surface.

Atmospheric pressure fluctuates.

Air pressure can be measured with a number of instruments.

When the pressure is decreased on a gas, the volume increases (temperature is assumed to remain constant) and the density of the gas decreases uniformly.

Sequence - Summary

Air pressure has an effect on:
- a. food
- b. water
- c. air (O_2, N_2, CO_2)
- d. temperature
- e. psychological reactions

Air pressure varies from the surface of the earth upwards (also downwards)

Activities - Illustrations

Place a balloon in a bell jar on a vacuum pump plate and observe it as the amount of air in the bell jar is reduced. Try this with the balloon inflated to various degrees.

Repeat the balloon experiment using a pan of water which has been slightly warmed.

Encourage the students to try to train fish in the aquarium to come to a particular spot in the fish tank for food when a small change is made in the atmospheric pressure above the tank.

Place balloons in the refrigerator in various stages of inflation. Affix a balloon to the top of a bottle which has been previously heated. Place it in the refrigerator. What is the relationship observed between volume and temperature?

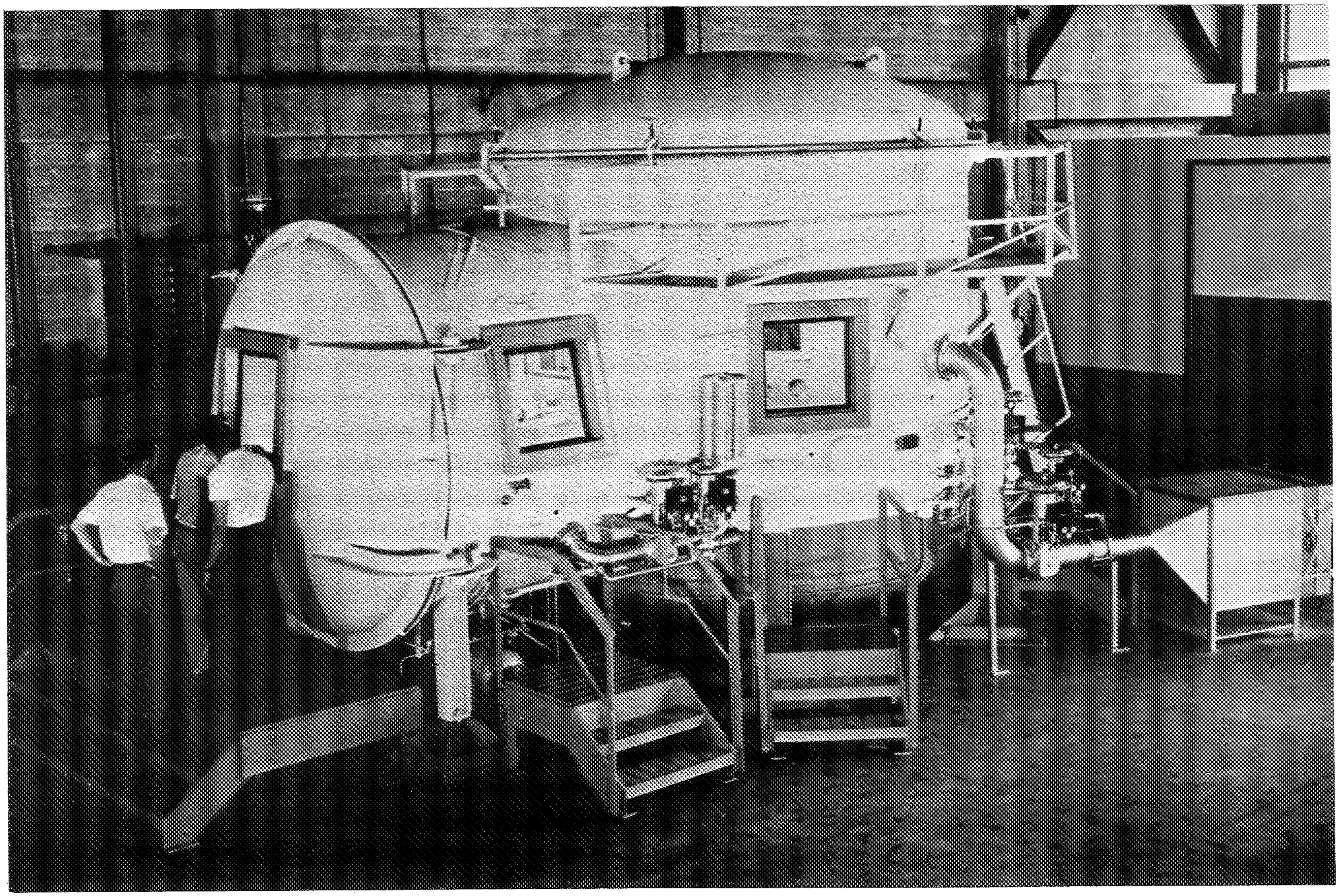
Boil water at different levels within the same building. Determine the differences in elevation. Be sure to take the temperature reading for each sample in the steam above the water, not in the water itself. (Why?) Use an anaeroid barometer to establish the differences in air pressures between the two locations.

Try the boiling water experiment on different days; at different times of the day.

Encourage the students to find information on the air pressure conditions on the moon, other planets, inside various self-contained units such as submarines, high altitude aircraft, and others the students may suggest.

Place a cork on a gallon jug filled with water. Strike the cork a sharp blow with a hammer. Help students interpret the results. (CAUTION: Place the gallon jug inside a waterproof container to avoid a deluge or injury.) Discuss Pascal's Law and its applications with the class.

Explore with students the reasons for, and examples of pressurized foods. (Tie this in with A. Biologistics, 1. Food, d. Self-Contained Unit and Exosphere As A Universe, Inquiry No. 5 Ma, Please Pack Me A Lunch - I'm Off to The Moon.)



The high altitude pressure chamber can be used to simulate conditions outside our earth's atmosphere. Would you expect to find the air pressure inside the chamber (when it is in operation) higher or lower than that on the outside? Explain. Encourage students to design their own "self-contained" pressure chamber.

A. Biologistics
  2. Air
    e. Exosphere As A Universe

INQUIRY NO. 10

O_2, YOU BEAUTIFUL GAS
(Primer)

Have you a quart bottle handy? If not, close your eyes and visualize one in your mind. How many quarts of oxygen do you think you use each day? 5, 100, 300, 1000? If you are a reasonably active person, take your weight and multiply it by 3. This will give you an idea of the magnitude of the problem which scientists and engineers have in providing a continuous oxygen supply to those who will be orbiting our planet and colonizing our satellites and other planets. An average man who needs 3,000 Calories (also referred to as kilogram-calories) per day will use over 530 quarts of oxygen, or approximately two pounds of oxygen per day. Our astronauts are assumed to be somewhat less active during their flights (particularly during the weightlessness periods) so that a somewhat smaller value can be used for flight planning purposes. Is this a good assumption in light of the space walk experiences?

What will be the source of oxygen for our exospheric explorers? Stored tanks of oxygen are sufficient for short trips up to several months. Beyond such time periods, some other sources will be needed. What suggestions would you make? Chemicals? If so, which? Some type of recycling system? If so, what organisms will be able to take the carbon dioxide, water vapor and other waste products and convert them into oxygen and other useful products? Keep in mind that whatever system you propose must be reasonably lightweight; must be effective under conditions of radiation exposure, weightlessness, and possibly, extremes of temperature; and, must be highly efficient and trustworthy. Some of the chemicals which are being considered include hydrogen peroxide (90% H_2O_2), sodium chlorate ($NaClO_3$), potassium superoxide (K_2O_4, KO_2), sodium superoxide (NaO_2, Na_2O_4), sodium peroxide (Na_2O_2), potassium peroxide (K_2O_2) or the electrolysis of water (H_2O). What is common to all of these chemicals? What problems do you see in the use of a chemical source for the oxygen supply? A word of caution should be added. Do not try to experiment with these chemicals without expert supervision. Chemicals with high oxygen content can be very unstable and, since they release a large amount of oxygen when they are heated, any burning which may take place will be very hot and potentially explosive. Recycling systems include the use of algae, corn, and a variety of other high oxygen-producing plants. How would you go about determining which plants are high oxygen-producers? How would you compare the amount of carbon dioxide needed by the plant to the amount of oxygen it releases?

Other aspects of providing a continuous supply of oxygen for our space explorers include the problem of removing the water vapor from the air; the adsorption of the carbon dioxide gas; removal of trace amounts of toxins; and the removal of objectionable odors. You will want to consider each of these problems separately and then, use your ingenuity to suggest ways whereby a system can be designed which will provide a continuous supply of usable air over an extended period of time.

A. Biologistics
  2. Air
    e. Exosphere As A Universe

INQUIRY NO. 10 O_2, YOU BEAUTIFUL GAS

Basic Concepts:

Air must be properly controlled for adequate body functions within narrow ranges of temperature, moisture, carbon dioxide content, and for the presence of trace toxins.

Sequence - Summary

An adequate supply of oxygen can be provided by:

1. storage
2. chemical production
3. recycling systems
4. other means (See Bioastronautics*, p.282)

Techniques for the purification of air include:

1. carbon dioxide removal by chemical adsorption or the use of biological processes
2. water removal by use of desiccants (lithium or calcium chloride, calcium hydroxide) or by

Activities - Illustrations

If there is a source for liquid oxygen in your community, procure some and demonstrate its properties.

Discuss the role of pure oxygen in medicine, oxyacetylene torches, and space capsules.

Bring some dry ice to class to demonstrate some properties of this gas.

Invite a representative from an airlines to talk to class about the pressurizing system used in airplanes.

2. Continued.
   condensation. Magnesium perchlorate (anhydrone) is one of the best desiccants.
3. removal of trace toxins by subjecting them to high temperature burner (650° F)
4. odor control by use of activated charcoal.
5. other means (See Bioastronautics*, p. 282)

Encourage students to develop projects which test their ideas on removal of various materials from air, or on various recycling systems.

Useful Resources:

Principles of Bioastronautics, Gerathewohl, Prentice-Hall Space Technology Series, 1963, pp. 412-425

Space Biology: Part II, The American Biology Teacher, Vol. 25, No. 7, November 1963, pp. 502-535

*Bioastronautics, Schaefer, ed., The Macmillan Company, 1964, pp. 245-251; pp. 281-285

INQUIRY NO. 11

LIVING BUTTONS
(Primer)

In Inquiry No. 1, you were invited to create a world of your own. It is most likely you included water in the list of materials which went into that world before you sealed it up. If so, then you are already aware of the importance of water for the maintenance of life. In this inquiry, you will have an opportunity to explore the role of water, as it is present, and, as it acts, over the surface of the earth.

Over the United States, a fresh supply of water is provided by the clouds at an average rate of 1,100 billion gallons a day. That seems like a remarkably large amount and represents over five thousand gallons per person per day for the entire population of our country. Do you use that much water each day? It has been estimated that we each use almost 50 gallons of water per day in our various eating, washing and hygienic activities! Of the billions of gallons of water that pour down on us, only 366 billion, or about one third of the total amount remains on the earth's surface for our use. What happens to the other two-thirds? It goes back into the atmosphere by evaporation, or it is taken up by plants, which by the process of transpiration, discharges the moisture back into the atmosphere. Have you noticed that it is cooler in the summertime under a tree than out in the direct sunlight? The moisture taken up by the tree's roots passes out of the stomata on the underside of the leaves. Some of the sun's energy is used up in this process resulting in a lowering of the temperature in the immediate vicinity of the tree's leaves.

How do we use our share of the daily water supply? Over two-fifths is used for the irrigation of crops; of that two-fifths, almost two-thirds is used just once for the irrigation of lands which would otherwise yield less than one-third of their potential in marketable crops. Industries use an amount equal to that of the farmers. However, in their activities, slightly less than one tenth of the water is lost. Thus, this water is available for reuse. Alas, while the amount of water returned is high, the quality of the water may not be. Industrial processes may add chemicals to the water or the water may contain solids, which, when they settle to the bottoms of rivers, lakes or streams, may kill the biological life present. Before the next user (it may be you) can safely use the water, careful and often costly processes may be needed to protect your health. How much of the total available water do we use for our home and personal needs? It is estimated that slightly less than ten per cent goes for our eating, drinking, washing and lawn watering and similar household uses. This figure will tend to climb as more and more devices requiring water for their operation become commonplace in our homes. What devices can you suggest?

If we use only one-tenth of the available water supply, then there should be little concern for the conservation of our water supply. Such a view is premature. Water is not evenly distributed over the earth's surface. Mountains tend to collect excessive amounts of water while the areas beyond them may only receive scattered and unpredictable amounts of rainfall. Therefore, the exploration of techniques whereby the two-thirds of our water supply presently being lost through evaporation and plant transpiration can be conserved is essential to our continued growth and development as a nation. Chemical films on the surface of lakes or along the bottom of irrigation ditches have proven useful in reducing water loss, by evaporation in the former case, and by absorption into the surrounding lands, in the latter. As you scan newspapers and read current periodicals, you may find additional examples of new and ingenious ways that are being proposed and tested.

Have you ever filled a pan with water and kept some record of the time required, under various conditions of sunlight and wind, for it to evaporate? What factors can you suggest which tend to increase the rate of water evaporation? To slow down the rate of evaporation? Try your suggestions on a substance other than water. Do they still check out?

A. Biologistics
   3. Water
      a. Earth As A Universe

INQUIRY NO. 11 LIVING BUTTONS

<u>Basic Concepts</u>:

Living organisms are capable of living under varying environmental conditions.

The degree to which an organism can adapt controls its survival when placed in a changing environment.

<u>Sequence - Summary</u>

The atmosphere contains:
1. water
2. minerals
3. various gases

Plants cut off from their normal sources of water vary in their tolerance to the new condition.

<u>Activities - Illustrations</u>

Provide students with pieces of driftwood and succulents (plants having juicy or watery tissues such as cacti, iceplant, century plant, etc.). Have them remove portions of the plant tips, and after applying some of the airplane model building glue to the cut end, attach it to the driftwood in some aesthetically pleasing pattern. Encourage them to observe their "driftwood gardens".

Activities - Illustrations (con't)

Provide students with large coat buttons. Cover base of button with airplane model glue, sprinkle sand over surface and provide a variety of small pebbles to simulate a desert scene. Attach succulents as suggested for driftwood garden above. Encourage students to observe their "button gardens".

Compare the conditions for plant life on a desert and on a beach. How do both situations parallel each other? (porous sands; shortage of water for by sea side, the salt spray will tend to remove water from plant cells; extended periods of intense sunlight; absence of tall protective trees)

Compare the "button" and "driftwood" worlds with the "world" students made in Inquiry No. 1. What other "worlds" can the students suggest? Try to create them.

INQUIRY NO. 12

WATER: FRIEND OR FOE? IT IS UP TO US
(Primer)

When we want water to drink, to use for preparing food, for washing, for watering our lawn, or for any other reason, we need merely turn the faucet on and - Presto! - we have a supply of pure, clean water. Few of us pause to consider the existence of the piping system, the lake or reservoir, the stream, the land itself, and ultimately the rain, snow, or hail, which contributed to the flow from that faucet. Next to air, water is our most important basic resource. You can live longer without food than you can without water. Without water there would be no life of any kind on our earth. These simply stated but most important facts are the underpinnings upon which this inquiry is built.

In our communities, water is needed for fire protection. Falling water is one of the sources of power for the generation of electricity for our cities. Running water is used to carry away the wastes from our homes and cities. Since water can absorb more heat at ordinary temperatures than any other common liquid, we can use it for controlling the temperature of our homes. Without an adequate water supply, any city would be a deserted "ghost town".

Water is extremely important in agriculture. Farmers need water to grow crops and rear animals. The irrigation of farmland is critical in some areas, for without this artifical water supply, the production of farm products would not be possible. Because fresh water is not available in many parts of the world, many thousands of miles of land are useless for agricultural purposes.

Two other areas in which water plays an important role are in transportation and recreation. In your study of our country's history, or even more broadly, the world's history, ships, barges, canoes, and submarines played important roles. At times, the presence of bodies of water provided modes of natural defense, a feature which the advent of the airplane and the guided missile has eliminated. In the field of recreation, one need only mention swimming, sailing, and fishing to illustrate ways whereby we take advantage of the presence of water in our world for our relaxation and personal pleasure. You may be able to add many more suggestions to this list.

Up to this point, we have seen that water is our oldest friend and our most valuable servant.

What is the source of water this astronaut is tapping? What problems can you foresee when such resources are being sought?

Unfortunately, it can also be a tyrant. The uncontrolled flow of water in the form of floods can be disastrous, resulting in the loss of life and much property damage. Streams, contaminated by human and industrial wastes, may have a greasy look and a foul odor, and perhaps may be filled with the bodies of dead fish and potential health problems for the next water user. Our abuse of water and also of the land areas from which a stream gets its supply of water (its "watershed") is a common public concern since all of us must depend upon water for our very existence. You will want to explore the ways floods are controlled, and the ways each of us can contribute to their prevention. You may wish to visit your community's water treatment and sewage disposal plants to see first-hand how these vital problems are being resolved for the protection of your health and future well-being. Polluted water is a product of disposal of sanitary sewage and industrial wastes, without proper treatment, into our streams. These wastes must be treated so that they do not impair the quality of our water. Furthermore, treatment should be such that it does not reduce the effectiveness of the treatment which is given the water in the water treatment plant, prior to its outflow in your faucet.

As you begin this inquiry, keep this question in mind: "Will water remain our friend or will it become our foe?" The choice is ours. What can and should be done?

A. Biologistics
   3. Water
      a. Earth As A Universe

INQUIRY NO. 12 WATER: FRIEND OR FOE? IT IS UP TO US

<u>Basic Concepts:</u>

Most water sources contain accumulating contaminants.

Humans need a supply of water "free" from contamination by pathogenic (disease-producing) bacteria, chemical and metabolic wastes.

<u>Sequence - Summary</u>

Practically all the water that appears in public or private supplies has been exposed to pollution while running over the ground surface, or in streams, or while passing through the soil.

Pure water is not found on the earth's surface. Rain collects various gases (CO_2, O_2) and dust as it falls to earth.

<u>Activities - Illustrations</u>

Encourage students to compare water samples of:
1. distilled water
2. community drinking water
3. aquarium or pond water
4. boiled water from these various sources
5. sea water

Some ways for comparison:
1. boil it away completely and compare solid residue as to amount and texture.

The most important water-borne diseases are typhoid fever, paratyphoid, dysentery and cholera.

High organic content in water may produce digestive disturbances and diarrhea.

The presence of various chemicals may lead to metallic poisoning (lead, arsenic, others). There is no evidence that water containing inorganic impurities such as calcium and magnesium combined with carbonates, sulphates, chlorides or silicates have any undesirable effects on the kidneys of humans.

Water treatment processes have been developed to reduce or eliminate the undesirable factors from water prior to public use.

2. apply taste test to boiled, distilled and regular drinking water (Why not aquarium or pond water?).
3. compare odor of each sample.
4. compare color or degree of translucency. If a light meter is available (any camera hounds in class?), place it behind container with various water samples, keep light source distance constant and compare readings.
5. examine each sample under high power magnification of a microscope. Can you devise some quantitative basis for comparison?
6. Place some goldfish of about same size and weight in equal volumes of water samples. Be sure the amount of surface area is the same also.

Use water samples of contaminated water (introduce various chemicals to produce own source of contamination or secure samples) and use it to water plants. Observe and help students compare results with controls maintained with distilled and community drinking water.

INQUIRY NO. 13

WATERDROP - WHAT IS YOUR HISTORY?
(Primer)

Let's play the game, "waterdrop". Suppose your life started as a waterdrop from freshly melted ice at the base of the Worthington Glacier, near the seaport community of Valdez, Alaska. It is late summer and, before the glacial stream which you have helped create has traveled very many miles, you are warmed, begin to bounce back and forth near the air-water surface, and, after further warming, leave the water's surface and travel over the ground as water vapor. Soon you are soaring upwards, a most pleasant sensation, except that you find it is getting colder. Soon you are part of a moving air mass loaded with other rather chilly water vapor particles. To the salmon fisherman off the coastal community of Ketchikan, Alaska, now nearly 650 miles from your home base glacier, you appear as part of a large cloud moving in a southeasterly direction. What will be your ultimate destination? You can pick up the story at this point and fill in many of the details as you explore in this inquiry.

Your community must consider the history of the waterdrops that come to it, for those waterdrops may be the very ones which you flick off your arm as you step out of the shower or tub, confident that they are safe for your use. The community's concern for water is increasing each year as our population increases and the use and reuse of the same water increases. How many ways might that last sip of water you took at the drinking fountain have been used before? How many water molecules are being chemically produced, decomposed, and then re-produced each minute of the day? As you compose the ending to the game of "waterdrop", some ways whereby you may find answers to these questions may occur to you. Try them.

A. Biologistics
  3. Water
    b. Community As A Universe

INQUIRY NO. 13 WATERDROP - WHAT IS YOUR HISTORY?

Basic Concepts:

A community needs an adequate and safe supply of water.

Communities are dependent upon each other for the control of chemical, disease and organic contaminants in streams, lakes and other common-use water resources.

Changes in the watershed, from which waters for community use are secured, are of vital community concern.

Sequence - Summary

Community water needs include:
1. agriculture
2. industry
3. human

Community water treatment procedures include:
1. aeration
2. settling basins
3. filters
4. chlorination
5. fluoridation
6. other

Activities - Illustrations

Show how a faucet works.
1. Demonstrate methods of irrigation.
2. Industrially show how water is used as a solvent and a coolant.

Visit the water department of the city.
1. Demonstrate how water is collected.

Demonstrate water distillation by heat and cold.

Community water resources include:
1. above ground
2. below ground

Community water storage include:
1. storage tanks
2. wells
3. reservoirs

Community storage area protection include:
1. reforestation
2. controlled public access
3. laboratory sample testing
4. evaporation control by use of chemicals

Promising avenues for water resources in the future:
1. desalination of sea water
2. use of the solar still

Demonstrate the solar still.

Experiment to show effects of contour plowing.

Correlate the placement of industry and accessibility of water.

Observe the various sources of water in the community.
1. Observe how water rises in dug wells and artesian wells.
2. Make a clay or papier-mache model of the city's watershed.
3. Construct model pumps.

Examine water mixtures under the microscope.
1. Have water samples tested for impurities.
2. Experiment with various chemicals to purify water.
3. Construct a water filter system.

Experiment to prove the types of reservoirs that will best prevent evaporation of water.
1. Investigate present methods of sewage disposal.
2. Experiment to test the effectiveness of ground cover on soil.

A. Biologistics
3. Water
c. Home As A Universe

INQUIRY NO. 14

LIQUID NECTAR EVERYWHERE
(Primer)

Have you ever watched while a house was being built? It is interesting to see the gaping hole in the ground become a basement, or, if no basement is planned, to see the foundations being poured and the walls of the house seemingly spring up overnight. Very often we are now aware of many of the steps in the building process which occurred long before the shape and general pattern of the house came into being. Have you ever tried to trace the plumbing in your home? Where do all those pipes go? If you live in an apartment, you may not have much occasion to be concerned about the pipes, unless they get clogged or the water is turned off. However, if the opportunity arises, try to determine where the water enters your home, or apartment house, how it is distributed throughout the house (CAUTION: If you have a hot water heater, be careful that you don't burn yourself by handling the pipes that deliver the hot water to the various parts of your home!), and where the waste water from the various sinks, bathroom fixtures and floor drains leaves your home. Did you find any places along the way where the two systems, the one bringing water in and the other taking water and waste materials out, were connected together? Why?

The quality of the water that enters our home is not under our direct control. Someone else, somewhere else has had the responsibility for checking on the water quality and treating it as may have been required for safe use. Thus we are dependent upon others for our well-being. Occasionally, some type of natural disaster, such as flood, large scale fire, or severe storm, may damage or destroy the normal sources for a safe water supply. Under such conditions, it is important to purify your own water supply or to limit your consumption to the reservoirs of water within your home. Can you think of several reservoirs of water within your home, should the existing supply from outside your home be cut off? Liquids in your refrigerator may be your first suggestion. Canned goods with high liquid content may be a second. But, what of purified water sources? The hot water heater tank! Any others? Many families have set aside an emergency food and water supply for use in the case of natural or national emergencies. What would you suggest be included in such a food and water supply? Many of these emergency kits contain a bottle of common household bleach. Check the label on a bottle and see if you can find a reason for its inclusion in the kit.

While we have little direct control over the quality of water entering our homes, its uses within the home are our responsibility. If we practice good health habits and in particular, if we don't allow water we use for our personal cleanliness to get mixed in with water used for food cleaning and cooking, we can virtually eliminate the transmission of water-borne diseases to other members of our family.

A certain amount of water vapor in the air is important for our breathing. The amount of water vapor in the air as compared with what the air can hold, at a given temperature, is a ratio which can be expressed as a percent. The ratio is called the relative humidity and when expressed as a percentage such as 60% relative humidity, means that, for a particular temperature, the air contains six-tenths (.6) of what it could hold in the way of water vapor. If it were 100% relative humidity, we might expect it to be raining. Indeed, a heavy fog is sometimes very near 100% relative humidity. On the desert, during the hot summer days, this value may be as low as 2-5%. On hot muggy days, when your clothes seem to stick to your back, it may be 70-80%. In the case of the desert situation, your perspiration would quickly evaporate, cooling your body while, on hot muggy days, this process of evaporative cooling is blocked as the air can take up relatively small amounts of additional water vapor. As a result, you may feel hot and uncomfortable. Many homes are equipped with devices to add water vapor to the air blown in by the furnace during the wintertime. The reason for this can be seen if you consider what happens to an inflated balloon when you place it in the refrigerator. Your prediction? Right, it tends to shrink in size. The air molecules are not moving around with as much energy and the entire group of molecules occupies less space (volume). The water vapor inside that balloon also is more concentrated so that the ratio (relative humidity) goes up. Now reverse the process. We take in cold air, warm it up and then distribute it throughout the house. Per volume of air, the amount of water vapor goes down. For your comfort, particularly to the moist linings of your nostrils and throat, the additional water vapor is helpful. During the summer, air conditioners are used. What is their purpose?

A. Biologistics
   3. Water
      c. Home As A Universe

INQUIRY NO. 14 LIQUID NECTAR EVERYWHERE

Basic Concepts:

Water quality is controlled by forces outside the direct control of the home.

When in doubt as to the water quality, purification practices should be used.

Water vapor in the air within the home is necessary for personal comfort, particularly for the proper function of nasal membranes.

Sequence - Summary

Community control on the quality of water distributed to each home is maintained by:
1. testing of water
2. licensing of plumbers
3. plumbing ordinances
4. building inspection
5. investigation of water-borne diseases

Activities - Illustrations

Raise these questions:

1. What materials are added to our water supply? For what purpose? When? Was this water used before?

2. What measures should we take to be sure our water is safe to drink?

3. What water storage facilities do you have within your home?

4. How many different uses do you make of water in (and about) your home in a week? Do you need "safe" water for all of these uses?

Encourage students to suggest experiments which will show the effects of the various materials on the organic material in water. Try them.

INQUIRY NO. 15

A DROP IN TIME . . .
(Primer)

Not too long ago, a small private plane with a man and woman aboard crashed in Northern Canada. They both survived the accident with the only injury being a sprained ankle by the woman. It was winter and the area was isolated and uninhabited. They were stranded for forty-one days before an aircraft spotted them and a rescue crew reached them. In that time period, they had eaten a couple of candy bars, several bottles of vitamin pills and water secured by melting snow over a continuous fire. Doctors reported that, because both were overweight, because they did very little strenuous activity, and because they were able to supplement their enforced "dieting" with vitamin pills and ample water, they were in good physical condition upon their rescue! In many ways, their's was a self-contained universe, even though not one of their own choosing. The combination of factors which enabled them to survive is worth examining as we consider, in this inquiry, how isolated units, such as a dirigible, submarine, or underwater home, can be supplied with an adequate supply of water, one of the necessary elements for survival.

In a confined area, man will require water for drinking, washing and food preparation. What would be your prediction for each need? Express your guess in pounds per man per day. To do so, use the rough value of nine pounds as equal to a gallon of water. An estimate of these requirements includes two and one-half pounds per man per day for drinking water, four pounds per man per day for washing, and two pounds per man per day for food preparation (regular food weighing one and one-half pounds). This totals nine pounds or roughly one and one-third gallons (5-1/2 quarts) of water. With such values to work from, it would seem a reasonably simple task to work out some type of storage facility for water and then move on to some other more complex problem. However, it is not all of the story. Everytime you exhale, one of the waste products you are discharging is water. For the same person that we provide eleven pounds of water per day, he releases two and one-fifth pounds of water vapor per day! This figure also includes the water loss from the body due to perspiration. An additional three pounds per man per day can be accounted for from the urine and the water in the feces, both sanitary wastes which, on short trips in self-contained units, can be stored. Let us illustrate these values in tabular form:

Illustration No. 6 Comparison of Water Intake and Water Output for A Man

	Water Intake (lbs./man/day)	Water Output (lbs./man/day)
1. Drinking	2.5	-
2. Washing	4.0	4.0
3. Food Use	2.5	-
4. Exhalation and Perspiration	-	2.2
5. Urine, Feces	-	3.0
Total	8.5	9.2

Are you surprised that the water intake and water output are not equal? In the process of converting food to usable substances such as glucose, fatty acids and amino acids, water is a by-product. It accounts for about a half pound of water per man per day. The remainder represents water in the food which was not measured in the water input column. You can explore similar input-output problems using a mouse, rat, guinea pig or hamster. It would be interesting to design a cage so that the waste materials would be collected, weighed, and compared with the water and food intake of the animal. Various diets can be tested. If you use a young animal, which is still growing, what predictions would you make as to the kinds of results you are likely to get? Will the water and food input equal the output? Why?

A. Biologistics
   3. Water
      d. Self-Contained Unit As A Universe

INQUIRY NO. 15 A DROP IN TIME . . .

Basic Concepts:

Under all conditions, water must be provided for human use.

Water is both a necessary essential for life and a waste product of metabolic activity.

Sequence - Summary

Sources for water for self-contained units:

1. storage tanks
2. desalination
3. distillation

Methods of storage needed to satisfy these requirements:

1. materials must be light in weight
2. size and shape must be considered
3. material must be evaporation and expansion proof

Activities - Illustrations

If accessible to your school, plan a visit to a self-contained unit such as a submarine, dirigible, or large airplane.

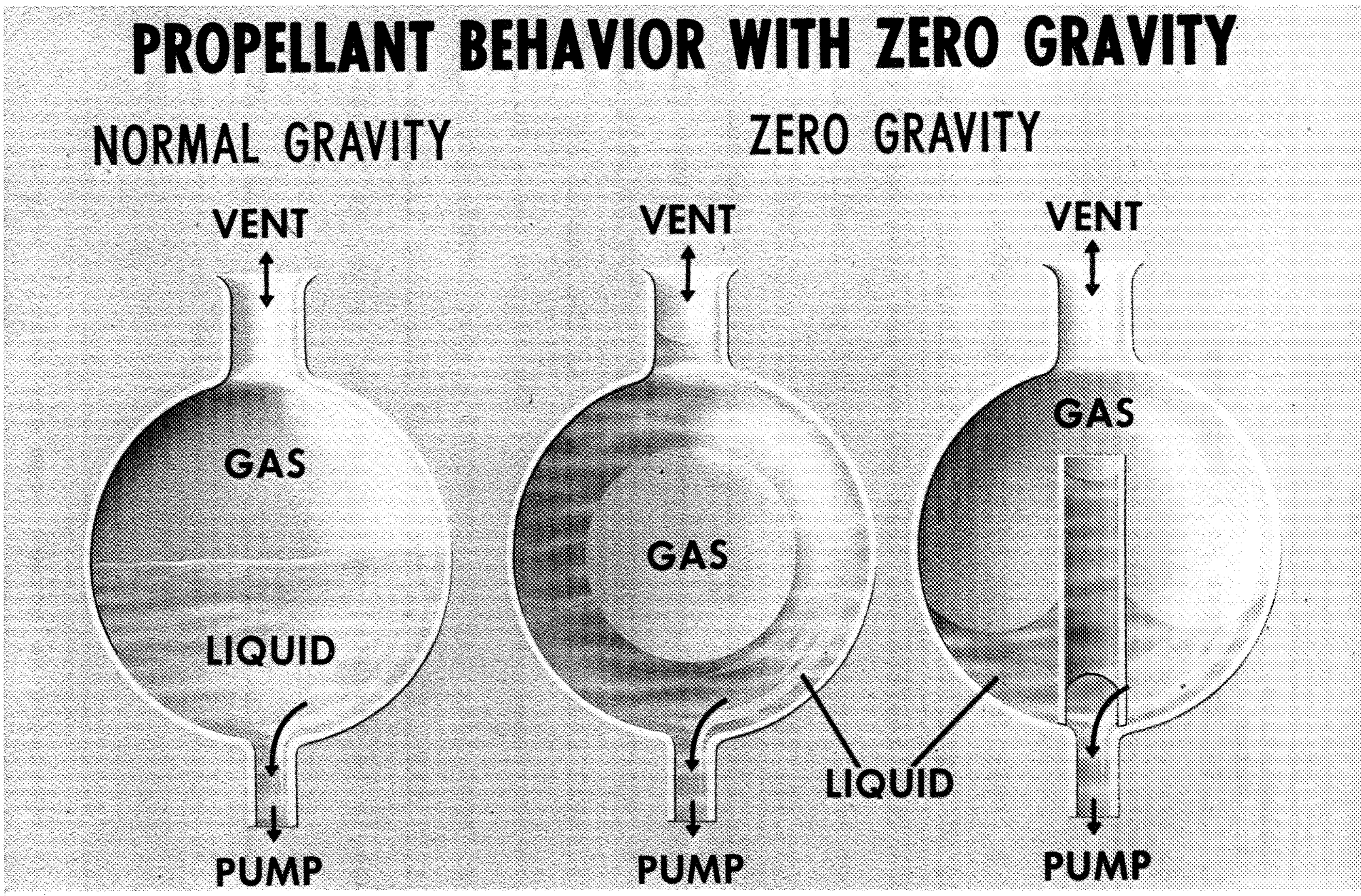
Encourage students to design and build a self-contained unit from cardboard. Have a student spend some time in it and then report on his reactions (increase moisture in air, "stuffiness", etc.)

Fill a gallon jug with tap water and let it stand for several weeks. Observe, taste, and

4. design of container must provide for flow while in weightless state. (in the absence of a gravitational field, water assumes a spherical shape unless a standing tube is placed in container. This spherical shape is due to the surface tension between the water molecules.

discuss the problems associated with storage of water for extended periods of time.

Encourage students to bring in dehydrated foods, explore amount of water needed to reconstitute them.



The major objective of this zero gravity experiment was to analyze liquid behavior in a zero-gravity (zero-g) state for an extended duration. The standpipe, inside the sphere on the right, has three holes equally spaced around its base to allow passage of fluid. It was theorized and shown that, in a zero-gravity ("zero-g") state, the liquid within the sphere would rise in the standpipe because of surface tension, rather than float around in globules.

A. Biologistics
3. Water
e. Exosphere As A Universe

INQUIRY NO. 16

SPILT MILK - ON THE CEILING
(Primer)

A leaky faucet can be quite an annoyance, particularly when you are trying to get to sleep and the drip - drip - drip reminds you that you may not have turned the faucet handle quite tight enough. If you finally give up, get up, and decide to stop it, you may pause and watch to see how the waterdrops are being formed and released. It is quite fascinating. Depending upon the rate at which the drops are falling, you may be able to see several steps in the process. As the amount of liquid increases, the surface of the liquid tends to bulge, much like the beginning of a good bubble-gum bubble. Then, as the "drop-to-be" increases in size, it may begin to vibrate, moving back and forth, as though it were undecided as to whether to leave the shelter of the faucet or not. Finally, it stretches, seems to slide off the edges of the faucet, and begins its travel to become the "drip" that originally annoyed you. Enroute to that destination, it assumes a spherical shape as though expecting an attack from any point. Why a spherical shape? During its descent from faucet to drain, it appears as though it were "weightless".* That is, for this period, called "free fall", the force of gravity is being balanced at every point in the fall by the resistance to change of the water molecules (inertia) so that gravity as a factor is eliminated. True, it is falling toward the earth, but, within itself, the force, due to the gravitational attraction of a large object for a much smaller object (earth to water drop), is not effective in effecting a change in the shape of the drop. Therefore, the attraction of water molecule to water molecule in the water drop (cohesive force referred to as surface tension) is strong enough to pull all the water molecules close together, and, since this pulling is equal in all directions, the shape assumed is that of a circle. (Draw a circle and satisfy yourself that this is the shape which provides for equal forces at every point on its surface.) This same phenomenon occurs in space travel when the gravitational force of the earth is balanced in the free fall of the space craft as it continually "falls" toward the earth in its orbital path. Technically, this balance is referred to as "zero-g" or "null-g" rather than weightlessness. However, for our purposes, we shall adopt the term, "weightlessness".

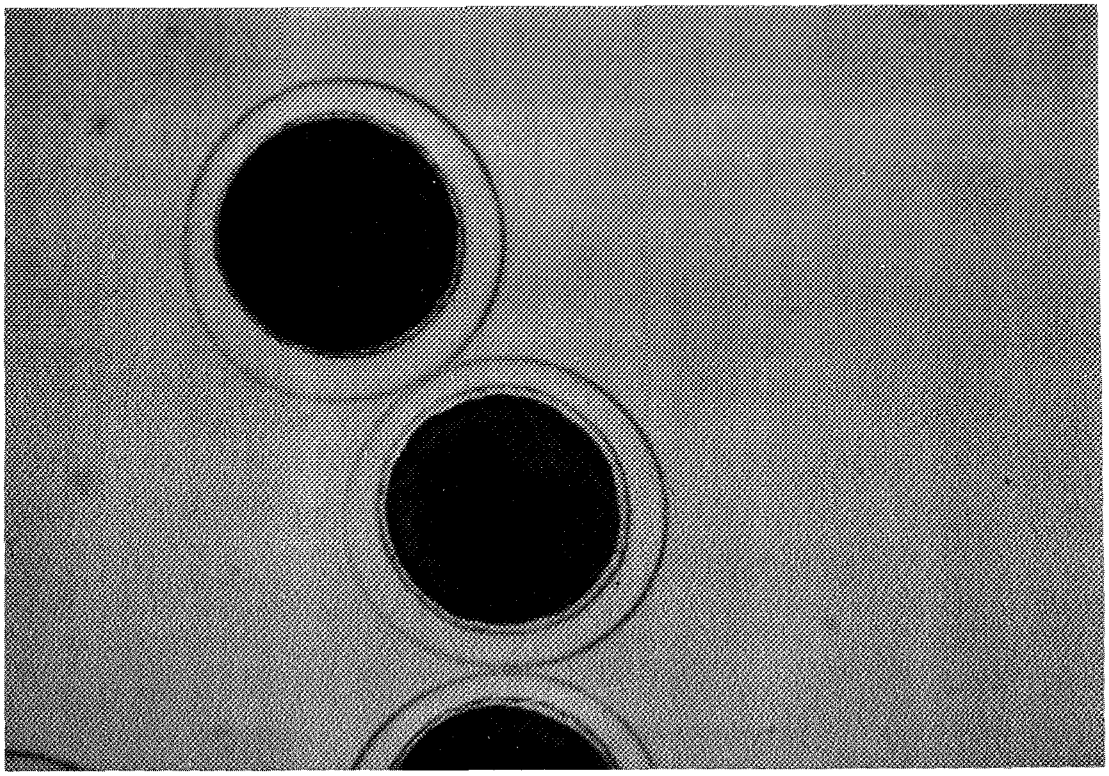
Fluids in a weightless state are affected by the adhesive and cohesive forces present. Adhesive refers

*See footnote, p. 115

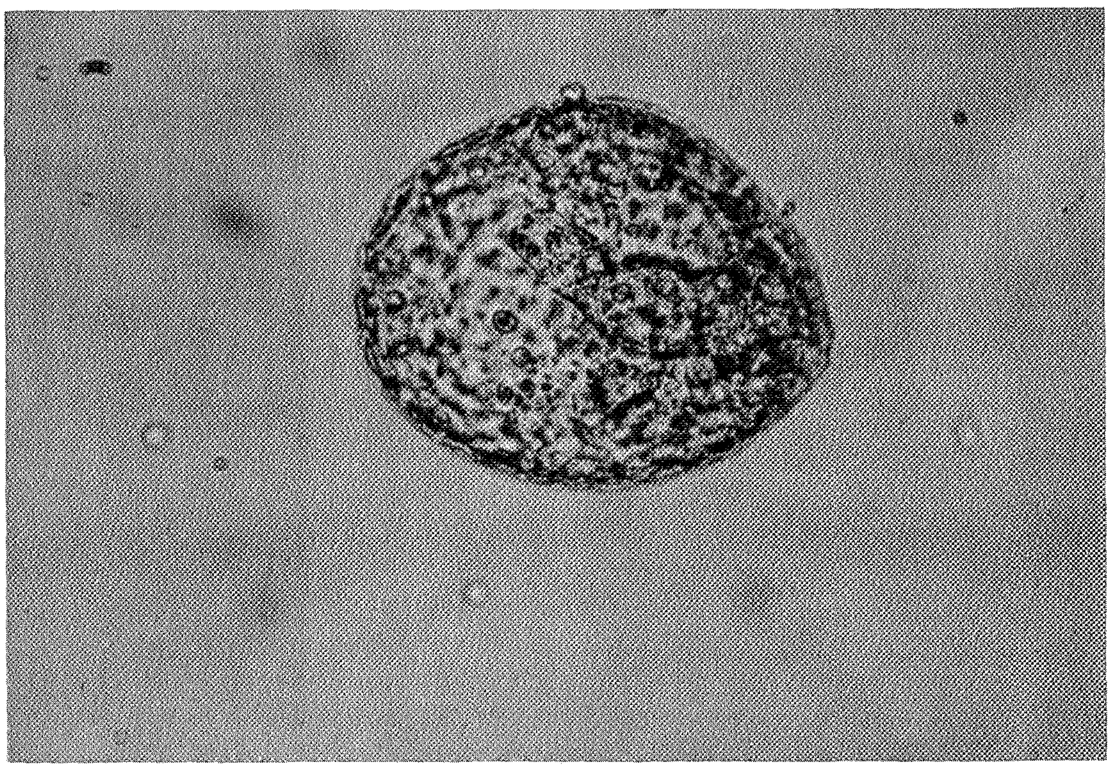
Weightlessness: For short periods of time, while riding in an aircraft flying the Keplerian parabolic arc, the Mercury astronauts experienced weightlessness, a condition resulting from the balance of two opposing forces - inertial velocity and the earth's gravitational pull.

to the attraction of materials which are different (hence, the term adhesive tape), while cohesive refers to the attraction of molecules of the same material to each other. Stick your finger in a dish of mercury. Can you break through its surface? What you are observing is a substance with high cohesive force. Now, take a piece of scotch tape and apply it to various materials. This is an example of relatively high adhesive force. Are there materials for which scotch tape is not a good "adhesive"? Can you suggest reasons for this?

A second problem which arises when fluids are placed in space, in a weightless setting, is that of heat transfer. Have you ever watched water when it is being heated? Currents can be seen as the warmer water rises and the colder water settles to the bottom. But, what will happen when the force of gravity, which makes this movement operate, is neutralized? The answer to this question has many applications. For instance, what happens to a plant in which some of the materials produced by the plant settle to the bottom of its plant cells? Without gravity, will the absence of this settling process (sedimentation) result in changes in plant growth, both in amount and direction? The same question can be raised in the case of a hen's fertilized egg. The egg may require, for proper development of the chick-to-be, the settling of various compounds to the



A key experiment in the study of the effects of zero gravity, "zero-g", involves the use of eggs and sperm from small marine animal, the sea urchin. In upper panel are sea urchin eggs magnified 400 times



as they appear five minutes after fertilization. The lower panel shows egg development two and one half days after fertilization, magnified 400 times. What suggestions would you offer as to types of experiments which can be performed with these eggs?

lower portions of the egg. A similar question arises in the case of the various gaseous waste products which may be produced by the egg cells. In a gravity-present situation, these gases are, in effect, "driven" away by the heavier or lighter gases around them. Without this "driving" force, what happens?

In this inquiry, you will have a wide field in which to explore. Keep in mind the fact that the problems you will be considering are extensions of those previously discussed, and that, solutions, as they appear, may have profound influence on the earlier topics. Those concerned with advancing our fund of knowledge see, in these questions, an opportunity to explore the fundamental nature of the life processes. You are invited to join them in the exploration.

Footnote: The falling drop situation is not "weightless". The drop falls with a constant velocity usually termed the terminal velocity. Under such conditions the gravitational force is "balanced" by the frictional force of air on the water drops. In general $mg - (\text{const})xv = ma$ for drop falling through a fluid (air). The $(\text{const})xv$ term is a resistive force and as v increases this term just becomes equal to mg, and then there will be no acceleration. Near the bottom of this page the sentence beginning "This same phenomenon ...." is a statement concerning a completely different situation. The situation here is commonly expressed as a "balance" of centrifugal force by the gravitational force. In any case, this situation is quite different from the falling drop in air.

A. Biologistics
   3. Water
      e. Exosphere As A Universe

INQUIRY NO. 16 SPILT MILK - ON THE CEILING

Basic Concepts:

The configuration of a liquid volume under "zero-g" in a vacuum, or within an equally weightless gas volume, is a spheroid.

The absence of the force of gravity may have disrupting effects on plant and animal cell growth, repair and reproduction.

Sequence - Summary

Sources of water in the exosphere situation:
1. provided by storage
2. recycling system
3. removed from resources of new situation
4. electrolysis

Problems associated with water provision:
1. weightlessness
2. pressure variations
3. radiation effects
4. temperature variations

Activities - Illustrations

Bake a rock. Weigh it before and after. Raise the question: Can water be recovered from rock on other planets? Encourage students to devise ways to reclaim water from rocks. Try it.

Encourage students to build recycling systems for water.

Demonstrate electrolysis. Discuss problems which arise in a weightless state (bubbles remain by electrodes).

Design a "dripless" drinking container.

Observe the shape of liquids under weightlessness. (film)

Observe "behavior" of mercury droplets in a shallow dish as the mercury is manipulated by touching with a straw or toothpick or dropped from an eyedropper.

Drop molten lead or solder on news-paper and examine small particles that solidify in air as the lead spatters. Microscope examination of the small particles shows near-spherical shape achieved by cooling and solidification during ballistic flight as the spattering occurs.

Use high-speed photography or strobe-light effect to "stop" a stream of liquid droplets in a free fall. A television tube or movie projector may be good stroboscopic light improvisations. (Milk is better liquid than water for observation.)

Observe a drop of water as it falls through oil in a test tube.

LIFE SCIENCE IN A SPACE AGE SETTING

B. TOXICOLOGY

Problems related to the reduction of the hazards associated with carbon dioxide, carbon monoxide, other toxic gases, and sanitary waste materials are grouped in this block of inquiries. Carbon dioxide, carbon monoxide, and other toxic gases will be treated as one area, and sanitary waste materials as another. The interaction of these problems with the various universes can be shown in the outline below:

1. Carbon Dioxide, Carbon Monoxide and Other Toxic Gases
   a. Earth As A Universe
      1) No. 17: Take A Deep Breath - Now, Hold It
   b. Community As A Universe
      1) No. 18: Wastebasket in The Sky
   c. Home As A Universe
      1) No. 19: Troubles - Stay Away from My Door
   d. Self-Contained Unit As A Universe
      1) No. 20: First You Push The Damper In . .
   e. Exosphere As A Universe
      1) No. 21: How Motionless Are My Molecules

2. Sanitary Wastes

a. All Universes

1) No. 22: Human Flotsam, Jetsam and Lagend

B. Toxicology
1. Carbon Dioxide, Carbon Monoxide and Other Toxic Gases
a. Earth As A Universe

INQUIRY NO. 17

TAKE A DEEP BREATH - NOW, HOLD IT
(Primer)

The movement of large air masses over the surface of the earth has, for the most part, been sufficient to eliminate problems associated with the toxic effects of excessive amounts of carbon dioxide, carbon monoxide and other gases, toxic to man. Rodents, trapped underground during a fire, or mammals enveloped in a thick blanket of smoke from such a blaze, may be killed by inhaling the carbon monoxide which is produced by the incomplete burning of damp or green foliage. A somewhat similar problem arises in areas with volcanic activity, in which the gases are predominantly sulfurous in nature. It is interesting to note that, at one time, odorous gases produced by perspiration mixed with organic compounds from the skin and breath, were thought to be disease-producing. The term, "crowd poison", was used in referring to odors produced when large groups of people gathered in relatively confined areas, and it was many years before this mistaken notion was dispelled. What other examples of toxic gases which fit into the earth as a universe category can you suggest?

B. Toxicology

1. Carbon Dioxide, Carbon Monoxide and Other Toxic Gases

a. Earth As A Universe

INQUIRY NO. 17 TAKE A DEEP BREATH - NOW, HOLD IT

<u>Basic Concepts:</u>

There are various gases in the air which are not directly useful for human respiration, and some gases which are toxic to human respiration.

Carbon dioxide is a by-product of organic metabolism.

<u>Sequence - Summary</u>

Review use of oxygen in body for combustion and energy.

Review respiration, percentage of oxygen in air, amounts exhaled. Lime water test would be qualitative only.

Determine amounts of oxygen in the air where pressure varies.

Locate places on earth which represent extremes of human habitation and estimate amount of oxygen. Discuss adaptations of nature.

<u>Activities - Illustrations</u>

Light a candle. Invert a small beaker or water glass and lower it over the candle flame, holding it in this position for a few seconds. Discuss: Why was the flame extinguished? Let the students write out answers to this, stating reasons for hypotheses. Present to class and permit class to question reasoning processes and thinking. Try out some of the suggestions offered. Some student is certain to say the flame was extinguished by the carbon dioxide of the flame, and it is hoped someone else will

Study conditions of smog and communities where this is a problem. (CO, other pollutants.)

note that carbon dioxide is heavier than air. Encourage the students in their observations of the flame. Is the flame extinguished from bottom to top, or the reverse? Does it make a difference if the candle is short or tall; if the bottle is small in diameter and tall or large in diameter and short? What container design (volume of container remaining the same) provides longest length of burning?

This discussion should stimulate questions about percentage of gases in air. Study the characteristics of various gases; secure bottles of as many gases as possible particularly oxygen and carbon dioxide. They can be made. Try various experiments as suggested by the class to see what they will do.

Check reference sources for toxic concentration tables.

Useful References: Bioastronautics, Schaefer, (ed.), The Macmillan Company, 1964, pp. 93-102.

Principles of Astronautics, Gerathewohl, S.J., Prentice-Hall Space Technology Series, 1963. pp. 412-425.

B. Toxicology
1. Carbon Dioxide, Carbon Monoxide and other Toxic Gases
b. Community As A Universe

INQUIRY NO. 18

WASTEBASKET IN THE SKY
(Primer)

We look up into the sky and the air above seems infinite. What's in the air? The atmosphere consists of a mixture of gases, primarily nitrogen and oxygen, with varying amounts of water vapor, and a small amount of carbon dioxide. But, if we live in or near a city, what's actually in the air we breathe? The air is packed with visible and invisible industrial gases, smoke and countless dust particles. A good way to discover what is in the air in your community is to take strips of scotch tape and lay them on a sheet of paper with the sticky side showing. Place this "sample-taker" in your schoolyard or backyard, high enough so that it won't be stepped upon or pick up the dirt and dust you kick up as you walk in the area. Leave it out for 24 hours and then examine the surface with a hand lens or under a dissecting microscope. You can even get some quantitative results by burning the scotch tape in a crucible with cover. By weighing before and after and knowing how much of the weight was due to the crucible, cover and piece of scotch tape, you can determine the amount of solids picked up. From such a procedure you may wish to estimate the amount of solids which are being carried by your "wastebasket in the sky".

What is the source of these pollutants? It is generally agreed that one of the most important sources of these impurities is the burning or incomplete combustion of carbon compounds. Although in theory it is possible to burn something completely, in practice this doesn't happen. Combustion wastes come from automobile engines, incinerators, municipal dumps, factories and refineries.

Some of the harmful effects of air pollution are known. Air pollutants are responsible for such things as injury to agricultural crops and livestock, damage to buildings, eye irritation, creation of hazardous driving conditions, and even for dissolving nylon stockings. Furthermore, there is the strong possibility that our pollutants are a real menace to health, possibly resulting in lung cancer, chronic diseases such as bronchitis, and other respiratory disorders. Sulfur dioxide gas, formed by the burning of fuels containing small amounts of sulfur, has been found to play a significant role in breathing difficulties. Another poisonous substance, carbon monoxide gas, may appear as a pollutant when carbon compounds are burned with an insufficient supply of oxygen. There have been times and places in the past when many people have died because of polluted air!

Attempts are being made to reduce impurities at their source through the use of automobile exhaust catalysts, new engine mufflers, and industrial electric soot precipitators. But it is very difficult to sample pollutants in the air, especially the pollutant gases. There exists a great need for more smog experiments to discover the effects of toxic substances in the air.

In an earlier inquiry, we explored soilless gardens (hydroponics). In the study of pollutants, hydroponics can be extremely useful. One can determine the effects of certain chemicals on living plants by growing soilless cultures in an atmosphere containing the particular chemical. In this inquiry, you will have an opportunity to explore the effects of various chemicals associated with various industries and activities carried on in a community setting on animals, plants and humans.

B. Toxicology

2. Carbon Dioxide, Carbon Monoxide and Other Toxic Gases

b. Community As A Universe

INQUIRY NO. 18 WASTEBASKET IN THE SKY

Basic Concepts:

The amount of carbon dioxide, carbon monoxide and other toxic gases in the atmosphere has important effects on the health and well-being of community members.

Industrial or other human activities, and normal animal and plant activity cause variations in the amounts of various impurities in the air.

Sequence - Summary

Community concern for maintaining a suitable air supply, free from toxic gases is expressed through:

1. pollution control boards
2. public health department activities
3. local ordinances covering industrial air pollution

Activities - Illustrations

In season, use heavy pollen-dispersing flowers to illustrate how their particles become air-borne. Do the same thing with spore-releasing fungus such as dry puff-ball.

Arrange an electric fan with a cheesecloth or other filter to trap dust particles at the in-take and observe amount of particles collected over a period of time in various locations.

Observe dust particles in the air in the light beam from a projector in a darkened room.

Release perfume spray in one corner of room and note time it takes for observers in different parts of the room to detect the odor, to illustrate dispersal of airborne particles.

Encourage students to study the effects of smog on living organisms. Help them create a contaminated atmosphere and observe its effect on selected animals and/or plants.

Useful Reference: *Experiments for the Science Classroom Based on Air Pollution Problems*, State of California, Department of Public Health, Berkeley, California.

B. Toxicology

1. Carbon Dioxide, Carbon Monoxide and Other Toxic Gases

c. Home As A Universe

INQUIRY NO. 19

TROUBLES - STAY AWAY FROM MY DOOR
(Primer)

Air, like water, contains impurities. These impurities can cause beautiful sunsets or disease. The control of harmful impurities in both air and water are vital to our health and may be increasingly difficult to achieve as our cities and industries grow. Large cities have established Air Pollution Control programs to reduce the discharge of harmful substances into the atmosphere. Special filters and other devices are used by industrial plants to trap some of the materials. In some cases, important uses have been found for such trapped materials. If you live in a city where "smog" is a problem, or have friends who do, you may be aware of the irritating influence of "smog" on eyes and throat membranes. Some people have reported that, as you fly into a smog area, the change in the air purity is immediately noticeable. Smog experts can even tell how severe the air pollution problem is by looking for various kinds of lichen (a plant form combining an algae and a fungus) which are sensitive to the pollutants in the air.

Various commerical crops are similarly affected by materials in the air, making the problem of maintaining "clean" air, both a farm and city problem.

With every breath we take, each of us discharges waste products into the atmosphere. The carbon dioxide and water vapor we release is rapidly mixed with the oxygen, nitrogen and water vapor in the air around us. If there is enough air movement, no particular problem will arise. However, if we are in a small room, with many other people, and there is not enough ventilation, the effects will be easily observable. As the amount of carbon dioxide in the air increases, we will find it more difficult to breathe; our rate of breathing will increase. As the amount of water vapor in the air increases, we will begin to feel uncomfortable. Our natural "cooling" system, perspiration, will be blocked. Our every breath adds to the rise in temperature in the room as we discharge warm gases from our lungs. Thus, our home as a universe must be provided with adequate ventilation to eliminate the build-up of carbon dioxide gas.

A more serious threat to our air supply is the build-up of carbon monoxide gas within the home. The practice of warming up the family car in wintertime in a closed garage, the use of faulty furnace burners, leaky auto mufflers, and many other devices which burn natural gas, oil or gasoline contribute to a loss of life annually throughout our country. The presence of carbon monoxide in amounts of one part per ten thousand parts of air is enough to be fatal for adults.

Other toxic gases in the home include the natural gas used for furnace, stove or water heater; paint fumes if proper ventilation is not provided; and the variety of household chemicals whose vapors may be inhaled. An awareness of these potential hazards and the ways whereby man has learned to live with them are important goals in this inquiry. In this way you <u>can</u> keep troubles away from your door.

B. Toxicology
1. Carbon Dioxide, Carbon Monoxide and Other Toxic Gases
c. Home As A Universe

INQUIRY NO. 19 TROUBLES - STAY AWAY FROM MY DOOR

Basic Concepts:

The home environment must be kept free from toxic levels of gases such as carbon dioxide, carbon monoxide and others found in use within the home.

Sequence - Summary

Sources of various gases found in the home:
1. fuel sources
2. by-products of burning (carbon dioxide, carbon monoxide)
3. industrial contaminants
4. household chemicals

Physiological effects of various gases:
1. respiratory enzyme-bonding action of carbon monoxide
2. suffocation (asphyxiation)
3. kidney, liver damage

Activities - Illustrations

Experiment with animals or plants in different types of closed systems containing various amounts of methane, ammonia, carbon dioxide, sulfur dioxide and carbon monoxide. (CAUTION: As these materials have a potential toxic effect, any experiments should be done with adult supervision.)

Remove toxic gases by filtering through various filters (activated charcoal, alumina, etc.)

Help students develop a list of household chemicals which have a toxic gas by-product. Discuss precautionary measures which should be followed.

INQUIRY NO. 20

FIRST, YOU PUSH THE DAMPER IN . . .
(Primer)

The blood of city dwellers regularly contains over one per cent of the total hemoglobin as carbon monoxide hemoglobin; tobacco-smoking may increase this to five per cent. What does this mean for you? The presence of carbon monoxide in the atmosphere of a community with heavy industrial operations may well account for part of that one per cent. But, you will notice that the statement is not limited to city dwellers <u>in heavily industrialized</u> areas. Therefore, we shall have to seek elsewhere to find a way to account for the carbon monoxide which, once it enters our blood stream through our lungs, has a two hundred-fold attractiveness over oxygen for the hemoglobin. What other sources for carbon monoxide can you identify? A list of causes for accidental asphyxiations covering one year for the state of Ohio included as sources, from the most frequent to the least frequent: gas water heaters, automobile motor exhausts, room heaters, kitchen stoves, bathroom heaters, and bedroom heaters. In that one state for one year there were seventy two deaths and two hundred and thirty seven partial asphyxiations due to carbon monoxide poisoning by accidental causes!

If you were to design a self-contained unit in which a number of people were to stay for an extended period of time, some system for venting gases of the unit would be needed. If the surrounding atmosphere were at the same pressure as the self-contained unit, some type of fan or blower system could be improvised. However, when you have a variation in pressure, such as could be the case for a submarine or high altitude airplane, the problem becomes more complex. Have you read stories of submariners and of their problems during wartime when under attack? The crew of a submarine, resting at the bottom of some bay, engines shut off to prevent detection by sonar, is in a rather touchy situation. Without engines to generate electrical current, the operation of the ship is dependent upon the current from the electrochemical action of the batteries. This energy source will provide the needed current but also releases hydrogen gas, a by-product of the electrochemical process. If you have had some chemistry, you will recognize the problem: free hydrogen gas, oxygen gas and a match - BOOM!! - and you have water. The final product is not the concern of the submariner, it is that BOOM!! which can be quite destructive. A second problem is the possible release of chlorine gas from the batteries. This problem depends upon the acid being used, and whether any type of gas absorber is in use. Fortunately, with the advent of the nuclear submarine, this type of problem may be out-of-date.

In this inquiry, you will want to explore the techniques which have been developed for the safe operation of self-contained units. Perhaps you will be able to suggest some improvements.

B. Toxicology

1. Carbon Dioxide, Carbon Monoxide and Other Toxic Gases

d. Self-Contained Unit As A Universe

INQUIRY NO. 20 FIRST, YOU PUSH THE DAMPER IN . . .

Basic Concepts:

A system of venting and filtering air for reuse in a self-contained unit is required. Such a system must be able to remove the carbon dioxide, carbon monoxide and build-up of other toxic gases.

Toxicological products must be protected against temperature extremes.

Sequence - Summary

For conditions of continuous exposure (90 days), the maximum allowable concentration (MAC) of carbon monoxide is fifty parts per million.

The body's metabolism, through the breakdown of hemoglobin, is continuously producing and exhaling small amounts of carbon monoxide. The rate of release is such that, unless removed, it will build up to fifty parts per million in five days.

Activities - Illustrations

Place ammonia in a beaker. Observe the diffusion of the gas at different temperatures.

Place carbon dioxide in lime water. Place filters (absorbents) to slow down CO_2 diffusion and observe at different temperatures.

Chart observations as to speed of gas diffusion at the different temperatures.
Plan a trip to a plant to observe manufacture of CO_2.

If the amount of carbon dioxide gas in the air is not controlled, its increase will stimulate an increase in the production of carbon monoxide by the body's metabolism.

When subjected to carbon dioxide gas concentrations as high as 1.5%, for a six to twelve week period, adult males showed no changes in general levels of work performance. However, evidence was found of marked adaptive changes in their respiration, acid-base balance and calcium phosphorus metabolism.

Organic vapor-producing compounds can be serious toxic gas sources in self-contained units.

Read account, "The Fog" to class. Story is taken from, Eleven Blue Men, B. Rouche, Berkley Medallion Books, New York, 1953, pp. 171-189.

Useful Reference: Bioastronautics, Shaefer, (ed.), The Macmillan Company, New York, 1964. pp. 88-110.

INQUIRY NO. 21

HOW MOTIONLESS ARE MY MOLECULES
(Primer)

Take a gas. Bombard it with high energy particles. Reduce the pressure around it to 7 lbs. instead of 14.7 lbs. per square inch. Neutralize the field of gravity so that the forces acting on the gas molecules are equal in all directions. Circulate the gas through a closed system at a temperature of 90° F. (33° C.). Now introduce an adult male into the system. What happens?

The description above could well serve as an introduction to a life-long study for you and all of your classmates. It represents the outline of a problem with many sub-problems, each of which requires careful examination and further sub-division. The aspect of this problem which concerns us here is the removal of the various potentially toxic gases which may enter the system. The toxic gases are either by-products of the human's metabolic processes or are those which may be present in the environment from other systems. The latter concern will become increasingly important as space stations, lunar bases and planetary bases with their many sub-systems come into existence.

How many of the conditions mentioned in the first paragraph can you simulate in a laboratory setting? For practical reasons, it would be most desirable to find another form of life for the role of "adult male." What do you suggest? Have you worked with other organisms in earlier inquiries?

In line with our concern in this grouping of inquiries about the various toxic gases, it may be well to insert a reminder here that the main source and form of toxic gas with which we are concerned as we explore the exosphere is the carbon dioxide gas produced by man. The amount involved exceeds 2.25 lbs./man/day. Since the rate of oxygen consumption is approximately 2.0 lbs./man/day, how do you account for such a large amount of carbon dioxide? Your supposition is correct. The two pounds of oxygen, combines with the 1.32 lbs. of dry food and results in approximately .6 lbs. of carbon in the food being converted by the body's metabolic processes into carbon dioxide. That .6 lbs. of carbon combines with 1.6 lbs. of oxygen to form the 2.2 lbs. of carbon dioxide which is exhaled daily. In addition, .75 lbs. of oxygen combine with the hydrogen molecules present in the dry food to form water. The total for all the oxygen consumed is now over the original amount (1.6 + .75 = 2.35 lbs.) and can be accounted for by its presence in the dry food in the form of carbohydrates (carbon, hydrogen, oxygen), fats (carbon, hydrogen, oxygen) and proteins (carbon, hydrogen, oxygen, nitrogen).

In this inquiry, you will be able to try out various "systems" for the removal of toxic gases. Your awareness of the value of a knowledge of chemicals, their reactions and relationships will increase as you study the various proposals for the solutions of this problem.

B. Toxicology
   1. Carbon Dioxide, Carbon Monoxide, and Other Toxic Gases
      e. Exosphere As A Universe

INQUIRY NO. 21 HOW MOTIONLESS ARE MY MOLECULES

Basic Concepts:

Toxic gases can be removed from recycling systems by the use of chemical filters, molecular sieves, or high temperature burners (650° F.).

Moisture carried in the air in the form of small liquid droplets results in the formation of aerosols. Such aerosols must be considered as toxic as, in the weightless state, they tend to clump into larger droplets, affecting human respiration and the performance of filters. Smoking tends to increase the aerosol content in confined areas.

Organic vapor-producing chemicals must be carefully controlled as, at reduced pressures, the rate and amount of evaporation is increased.

The interaction of sub-toxic amounts of various chemicals in a gaseous state may produce new potentially toxic substances, or, acting together, may have a greater effect than when present separately.

Aside from man's contribution to toxic gases in a confined environment, radio and electronic equipment are major sources for toxic materials.

Uncharged aerosol particles (condensation nuclei) may tend to concentrate toxic trace substances in the respiratory tract so that they may exceed maximum allowable concentration (MAC).

Sequence - Summary

Chemical composition of various foods:

1. sugar
2. starch
3. fats
4. protein

Role of oxygen in the oxidation of foods.

Removal of carbon dioxide gas by absorbents such as:

1. sodium hydroxide ($NaOH$)
2. potassium hydroxide (KOH)
3. soda lime [$Ca(OH)_2$+$NaOH$]
4. lithium hydroxide ($LiOH$)
5. baralyme [$Ca(OH)_2$+$Ba(OH)_2$]

Potential uses of carbon dioxide gas:

1. recycling system with plants for the production of food and oxygen.
2. collection, concentration and reuse in attitude control system.
3. combine with hydrogen gas to form water which in turn is electrolyzed to produce oxygen.

Activities - Illustrations

Discuss and demonstrate the basal metabolism test. Attempt to determine the amount of carbon dioxide a student produces each day. (Carbon dioxide gas weighs 1.98 grams/liter or about 228 liters/lb.. Another way to put it is, approximately 242 quarts/lb.)

Try various chemicals as absorbents for carbon dioxide gas. Set up a closed system so that, based on the amount of carbonate formed in the reaction of carbon dioxide with the various hydroxides, you can determine the carbon dioxide output.

INQUIRY NO. 22

HUMAN FLOTSAM, JETSAM AND LAGEND
(Primer)

Lawyers have rather clear definitions to separate the three terms, "flotsam", "jetsam" and "lagend". Each represents a way of describing materials, once in human possession, and now, floating in the sea or washed ashore. Rights of ownership, responsibility for damages it might have caused, and similar legal concerns are dependent upon which of these terms is used to describe the material. Sanitary wastes, such as urine, feces and wash-water, may be considered as our human flotsam, jetsam and lagend. We may not tie a buoy to it in order that it may be found again, as is the case in the legal description of "lagend"; however, should such a practice be started, we would be amazed and distressed by the degree of contamination which would become apparent. Rights and responsibilities would them be readily recognized, and concrete and effective steps would follow to eliminate the problem. Historically, man has used the diluting and distributing capacity of water to remove undesirable sanitary wastes from his environment. With the growth of communities and an increasing awareness of the disease-related nature of sanitary wastes, steps have been taken to isolate and treat these materials. At one time, man believed that infectious materials were released from sanitary wastes and were carried about in the night air, causing a wide variety of diseases. This idea is false; however, the use of untreated sanitary wastes (referred to as "night soil" in Asian countries) as fertilizer for vegetables can result in the transmission of typhoid and paratyphoid fever, and dysentery of various kinds. Hookworm, carried in the feces, can be transmitted if contact is made with the larva. Such contact is most commonly made by walking about barefooted.

From early childhood, we are trained in the use of good health habits. We wash our hands and face, avoid putting dirty pencils, fingers or other objects in our mouths, avoid chewing our nails as well as a large number of similar activities. We do these things to reduce the chances of our picking up disease-causing bacteria or of passing on such bacteria to others. In the early days of man's history on earth, knowledge of the existence of bacteria and an awareness of their role in disease production were unknown. Where disease epidemics would break out in the centers of population, the people in that community would flee from it, unknowingly taking the disease organisms with them. In this way, the disease organism was distributed to others. Over a century ago, the role of water in carrying disease organisms from one community to another was dramatically illustrated in a community in Germany. On a single street, people on one side of the street were stricken by typhoid, while those on the opposite side of that same street were not. The important difference between the two groups was that those who contracted typhoid received river water which had not been processed in any way, while those who did not contract typhoid had their water supply passed through a sand filter before it was distributed for their use. Today we have a number of ways to guard our water supply against contaminants; however, our own personal health habits are still the first and most important line of defense in this unending battle.

As man points his dreams to the conquest of space, his attitude toward the role of sanitary wastes as part of his environment has changed. Because it is anticipated that space will be a hostile environment, contributing little toward his well-being, he must utilize all of his resources, including sanitary wastes. Such waste materials include fecal and urinary wastes of both man and animal, respiratory organic gases found in trace quantities, skin debris such as dead cells and salt, hair from shaving and haircuts, skin microorganisms, food scraps left over from cooking and eating, and the inedible parts of animal and plant foods. He must plan to convert these waste products into useful forms which will enable him to carry out his activities in space. Nutrients, which may contribute to plant growth, gases, which may be used as fuel or converted into forms, for the creation of an artificial atmosphere, may be the end-products of this venture. Methods for incorporating them into recycling systems with algae, use of urine for water recovery and reuse, (electrolysis of water would be an oxygen-producing source), and after treatment, use as a fertilizer for plant growth on planetary bases, are being given careful consideration. If you should visit a sewage treatment plant, you may find that some of these methods are currently being used for your community's benefit. The human flotsam, jetsam and lagend of yesterday are becoming biological allies, dangerous if left untreated, but when incorporated into a treatment system, an important source for water, plant nutrients and oxygen.

B. Toxicology
   2. Sanitary Wastes
      a. All Universes

INQUIRY NO. 22 HUMAN FLOTSAM, JETSAM AND LAGEND

Basic Concepts:

Control of the disposal of sanitary wastes is necessary for the protection of the public's health.

Sanitary wastes, as part of a recycling system, may become an important source for water, plant nutrients, and oxygen in the hostile environment of space.

Sequence - Summary

Sources of sanitary wastes

Diseases associated with sanitary wastes

Treatment procedures developed for sewage:

1. screening
2. sedimentation
3. filter beds
4. chlorination

Recycling systems

Activities - Illustrations

Experiment with various kinds of animals feeding on foods contaminated in various ways.

Check spoilage level at which animals will not eat food.

Compare bacterial concentration to unspoiled sample.

Dirty hands or implements and "cleaned" compared for bacterial content through use of agar dishes.

Observe effects of oil on mosquito larvae

Observe effects of latent dissolved detergents in water that is re-agitated, compared to relatively pure water agitated in some way.

Mix oil, water and soil in a jar and allow to stand, to illustrate use of settling ponds in sewage disposal.

Use litmus paper test on water from various sources to indicate acidity or alkalinity variance.

Experiment by touching agar plates to accumulated refuse or garbage; compare with sterile, control sample.

Allow flies to contact refuse put in cage with agar plates. Keep control sample in fly free conditions and check bacterial growth in each.

<u>Useful References</u>: <u>Municipal and Rural Sanitation</u>, Ehlers and Steel, McGraw-Hill Book Company, 1950, Chapters I, II

<u>The American Biology Teacher</u>, Vol. 25, No. 7, November 1963 (Special Space Biology Issue), Pages 512-521; 529-535

<u>Bioastronautics</u>, Schaefer (ed.) The Macmillan Company, 1964, Pages 274-304

<u>Principles of Bioastronautics</u>, Gerathewohl, S., Prentice-Hall Space Technology Series 1963, Pages 414-441. Account of experiments by Danileyko (USSR) on closed ecological system is included.

C. RADIATION

The range of radiation sources to be considered in this grouping of inquiries includes those from electromagnetic rays or photons, cosmic discharges and man-made nuclear sources. The intent is to help students understand the similarities and the differences among the various types of radiation. A summary of the universes and inquiries is included below:

1. Electromagnetic, Cosmic and Man-Made Radiation
    a. Earth As A Universe
        1) No. 23 Glow Away
    b. Community As A Universe
        1) No. 24 Unseen Energy
    c. Home As A Universe
        1) No. 25 Watch the Birdie
    d. Self-Contained Unit and Exosphere As A Universe
        1) No. 26 Gopher Holes on The Moon

C. Radiation

1. Electromagnetic, Cosmic and Man-Made Radiation

a. Earth As A Universe

INQUIRY NO. 23

GLOW AWAY
(Primer)

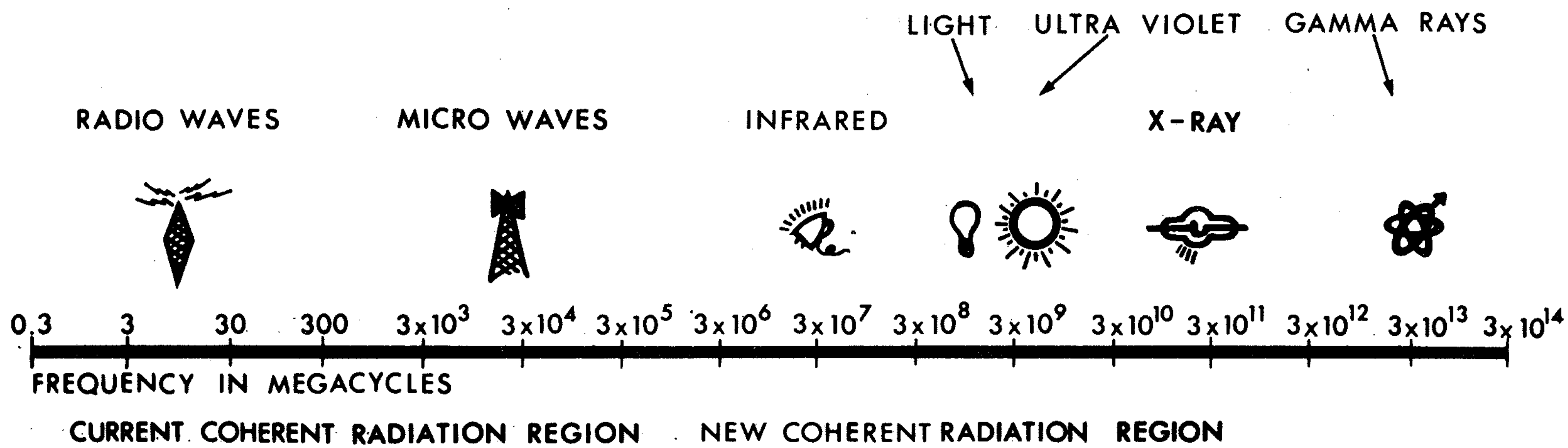
If you stand before a fireplace, the heat that reaches you from the burning coal is said to travel through the intervening space as radiant energy. It would reach you in the same way even if there were no air in the space between you and the burning coal. The fuel releases the energy which is sent out through space in a form having many of the characteristics of transverse waves. These are known as electromagnetic waves, and the energy thus transferred is called radiant energy or radiation.

Not only does radiant energy travel through space without the presence of any material substance, but portions of it also pass through certain kinds of matter. Light rays, for example, travel through air, water, and glass; X-rays and other short waves travel through denser substances opaque to visible light. In these cases the radiation is said to be transmitted; that is, it is not itself affected, and has no effect on the matter through which it passes. Most substances show a selective transmission; that is, some of the wave lengths get through, but others do not. That portion of the radiant energy which enters a substance but is not transmitted is said to be absorbed. It is that absorption of radiant energy that warms that part of you that is facing the burning coal.

The heat of the atmosphere and of the surface of the earth is derived almost wholly from the radiant energy of the sun. The amounts received from the moon, planets, stars and the earth's interior are negligible in comparison. Evidence to support this can be secured when you consider how the temperature over the earth's surface ordinarily rises by day under the influence of sunshine and falls by night, whereas other factors are present both day and night.

The energy received from the sun includes the visible light rays, ultraviolet and infra-red radiation. Most of the ultraviolet rays are absorbed by a layer of atmosphere known as the ozone layer. This is a layer of gas between 20 and 37 miles above the earth. The amount of ultra-violet rays reaching the earth increases as you travel from the equator to either of the earth's magnetic poles. The amount of this type of radiation over the earth's surface is affected by seasonal changes, being greatest in the spring and least in the autumn. Can you suggest some reasons for this?

It is fortunate for us that the ozone layer of the atmosphere acts as a filter, absorbing ultraviolet radiation. If it were not there, the full complement of ultraviolet reaching us from the sun would burn our skins, blind our eyes, and, if human, animal and plant forms were unable to adapt to this increased amount of radiation, it could well result in the elimination of life as we know it.



FREQUENCY SPECTRUM

The wave length of radio waves is very large as compared with the wave length of x-ray and gamma rays. From your examination of the frequency spectrum, what is the relationship between wave length and frequency? Is it direct? inverse? inverse square?

C. Radiation
   1. Electromagnetic, Cosmic and Man-Made Radiation
      a. Earth As A Universe

INQUIRY NO. 23 GLOW AWAY

Basic Concepts:

The earth is constantly subjected to various forms of radiation.

Sequence - Summary

There are many kinds of radiation.

The earth's surface and atmosphere obtain almost all their heat by energy radiation from the sun.

Certain wavelengths affect plant growth.

Ultra-violet radiation, an important source of heat on the earth, can be harmful to human being. (CAUTION: Sunburn is a result of over-exposure to the relatively weaker radiations of energy from the sun that do penetrate the earth's protective layers. Eye damage easily may result from any prolonged gaze at the sun.)

Activities - Illustrations

Identify radiofrequency micro-wave, infra-red, visible (light), ultra-violet, X-rays and gamma rays as radiation. Discuss the discovery of the nature of radioactive elements, alpha and beta particles and gamma rays.

Introduce charts showing the breakdown of the electro-magnetic waves, and formulas illustrating minimum and maximum ranges for sustaining life.

Encourage students to list and locate over the earth's surface where the naturally radio-active elements are found.

Use a prism to show students the composition of white light.

Grow a given type of plant under different colored gelatin filters - red, blue, yellow, green, etc. - all other factors equal. Note results.

"Seed in a box" experiment: sprouted lima bean placed in light-tight box with baffles and a hole in top.

Discuss and if possible, demonstrate the saying, "Sunflowers follow the sun".

Show chart of electro-magnetic waves with location of ultra-violet waves.

Discuss sunlamp wave lengths. Do all lamps give off ultra-violet rays? Find characteristics of various lights from manufacturer's brochures.

Invite the nurse to discuss the physiology of sunburn, using information to show what acts as a shield.

Set up an experiment to determine which materials shield against ultra-violet radiation. Secure an ultra-violet light, fluorescent minerals or paint, and a dark room. Place the fluorescing materials as close as possible to the light to increase the intensity of the glow, allowing space in between to place various objects and media. This is best set up vertically since then liquids can be included. Try glass, plastics of various thicknesses, various liquids, water vapor, aluminum foil, smoke, etc.

The experiment can be set up as follows:

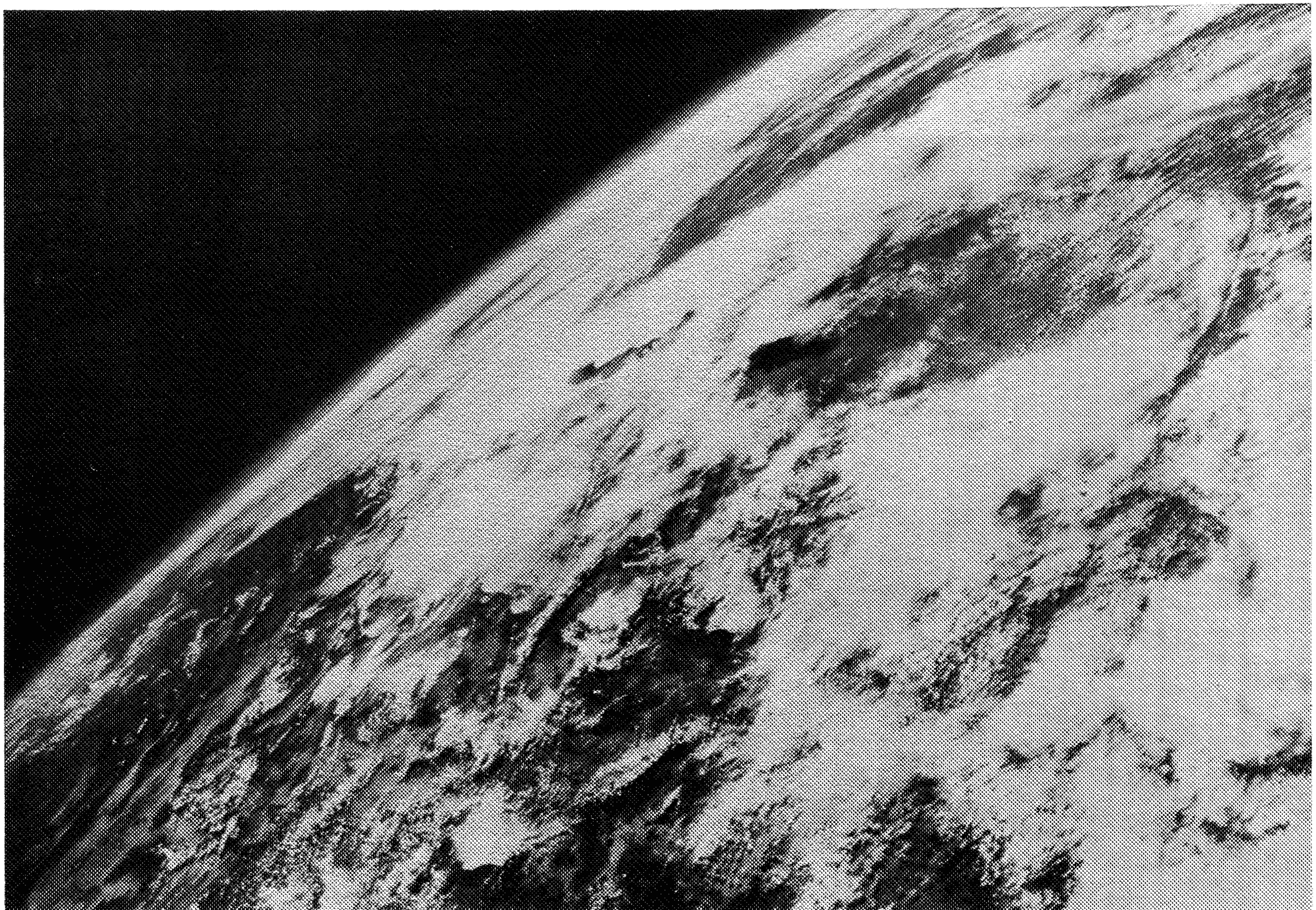
1. Materials needed:
   a. Ultra-violet light source
   b. Ring stand
   c. 3 Ring clamps
   d. Fluorescent minerals: The best of several tried was Colemanite. Others which fluoresce brilliantly may be used. Most soap flakes or powders work well.

<u>Activities - Illustrations</u>(con't)

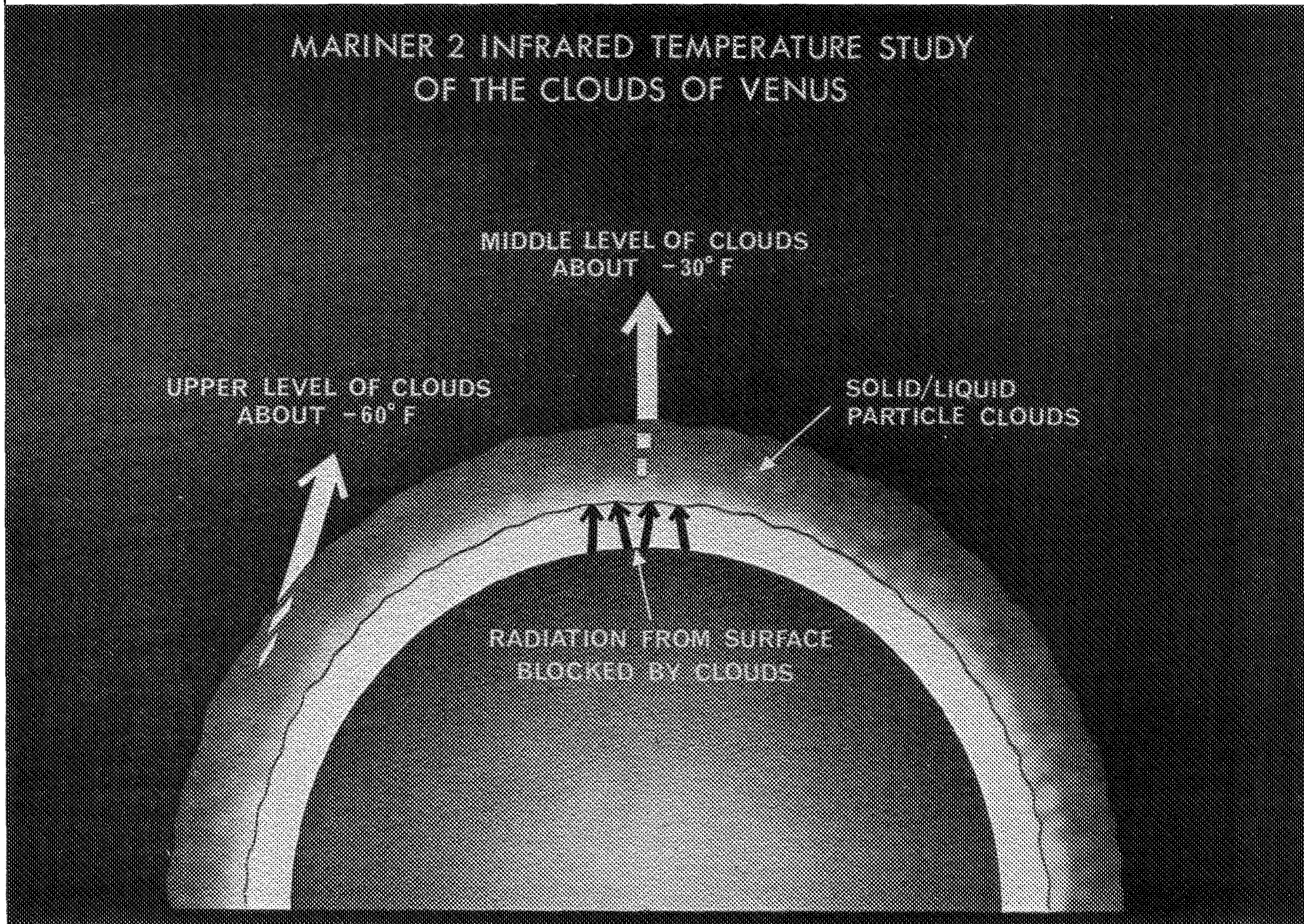
e. Materials to test:
   Aluminum foil, glass (bottom section of Petri dish and two microscope slides), plastic (plastic Petri dish section), plastic bag, water, smoke, (cigarette confined in area by plastic), steam (plastic sack enclosure), dialyzing paper.

2. Results (with Colemanite, a sample of which fluoresced bright green and red):
   a. Aluminim foil:
      complete shielding
   b. Plastic Petri section:
      red had faint pinkness
      green shielded completely
   c. Glass Petri dish:
      slight pink from red part
      green shielded completely
   d. Dialyzing paper (like parchment):
      Less intensity, but not much shielding
   e. Water added to dialyzing paper in puddle:
      Same as above - very little shielding
   f. Plastic cover of an instrument:
      No shielding
   g. Plastic wrapping around Petri dish:
      No shielding

3. Materials used, in order of their transmission of U.V. light:
   a. Saran wrap, 2 layers:
      Almost total transmission
   b. Saran wrap surrounding a cigarette carton, windowed on both sides and full of smoke (smog conditions?):
      Slight Obstruction
   c. Saran wrap bag full of water (2" thick): Transmission same as above or slightly better. Almost no loss of light
   d. Dialyzing paper (like parchment):
      About ½ + cut down
   e. Flat piece of cellophane:
      Cut down about ½
   f. Crumpled piece of cellophane: great deal of obstruction, almost all
   g. Filter paper: Transmission about ½
   h. Plastic cover to equipment: Almost complete transmission of light
   i. Aluminum foil: No transmission



Photographs such as this were made from an altitude of 154 miles above the Earth's surface by using film sensitive to infrared rays. Why was this portion of the electromagnetic spectrum selected? How do you account for the darkness of the ionsphere in the upper left-hand portion of the photograph?



What predictions would likely be made by ypur students as to the temperature on the surface of Venus? What parallels exist between Venus and Earth in the influence of their atmospheres on the penetration of infrared rays?

C. Radiation
1. Electromagnetic, Cosmic, and Man-Made Radiation
b. Community As A Universe

INQUIRY NO. 24

UNSEEN ENERGY
(Primer)

Radiation comes to us in an amazing way. Imagine a particle too small to be seen even with the most powerful electron microscope. Further imagine that this tiny particle moves in such a wave-like fashion that its rate of speed is such that it would circle the earth more than seven times in one second. (How many miles per second would that be? Is it the same as the speed of light?) Such high-speed particles actually exist. They are called photons. Light rays, heat radiation, radio waves, x-rays, cosmic rays, and the gamma rays produced by splitting the atom are all streams of photons which travel at the speed of light.* Thus the term radiation includes the description of any stream of photons.

When we go out in the sunlight, we may sunburn or tan. This condition results from the action of photons which have so high a frequency that they are invisible. These photons are ultraviolet rays. Other invisible photons, vibrating even more rapidly than ultraviolet rays, can pass through objects that visible light

*See footnote, p. 161

cannot penetrate. These are X-rays which we use in medicine and in industry. As atoms split or decay in natural radioactivity, they give off very fast photons vibrating at ultra-high frequencies.** These photons are called gamma rays. The highest frequency photons known are the cosmic rays that bombard the earth from outer space.

In 1900 the great German scientist Max Planck developed a theory to explain radiation. The theory was a product of his study of the problem of what causes heated objects to give off light. While earlier work on interference and diffraction of light had established light's wave properties, Planck's theory gave us a start in accounting for the particle or photon nature of light. He assumed that the motions of atoms and of the vibrating electrons within atoms caused tiny, vibrating particles to be shot out into space. We now know that these particles vibrate with a frequency that varies according to the energy of the atoms or of the electron vibrations which cause them to be shot out. Planck developed the quantum theory of energy transmission in which he suggested that any heated body gives off light in tiny, separate packages, or quanta, which we now call photons.

In this inquiry, you shall explore the many ways whereby radiation is used in your community. The range and variety may surprise you.

**See footnote, p. 161

C. Radiation
    1. Electromagnetic, Cosmic, and Man-Made Radiation
        b. Community As A Universe

INQUIRY NO. 24 UNSEEN ENERGY

<u>Basic Concepts</u>:

To the community, radiation is not a problem different from that of the world, except as the radiation changes in variety or intensity.

Actions which produce significant changes in the total irradiation exposure of a community are of concern, regardless of whether such changes exist in fact or are being projected.

Atomic power can serve the energy needs of the community.

<u>Sequence - Summary</u>

There is a "natural" level of radiation: Contributors:

1. Sun
2. Cosmic rays (and secondaries)
3. Naturally radioactive elements
    a. Uranium
    b. Radium
    c. Thorium
    d. Others

Man created atomic reactions:
    Bomb testing (fall-out)
    Reactors (waste material)

<u>Activities - Illustrations</u>

Photographic film or other radiation sensor can be used with low-intensity radio-active particle source to illustrate emission and simple shielding.

Use Geiger counter or film method to determine radioactivity of rocks in class geology collection.

Visit a nuclear reactor or industry where atomic energy is employed in their production activities.

Detectors of radiation:

1. Geiger counter (Geiger-Muller Tube)
2. Film
3. Cloud chamber
4. Electroscope

For electromagnetic radiation, the shorter the wavelength, the higher the energy (inverse relationship).

For electromagnetic radiation, the higher the vibration frequency, the higher the energies. (direct relationship)

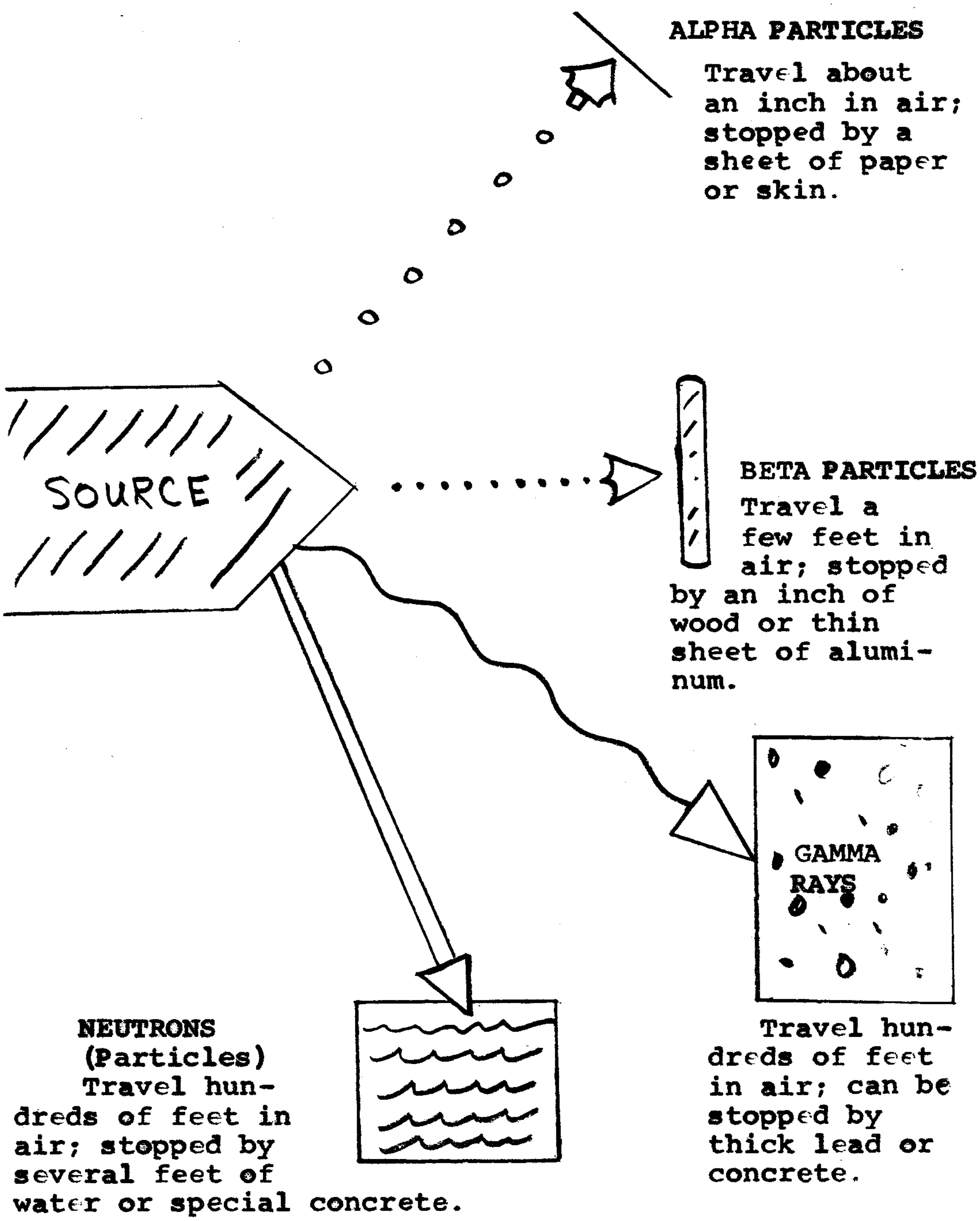
All electromagnetic radiations follow the inverse-squared law for intensity at extended distances. (Exception: a laser light does not fall off as one over the distance squared).
Biological damage is caused by ionizing types of radiation and is related to the energy of the photons.

The degree of biological damage is related to both the intensity and the duration of the ionizing radiation.

Shielding against radiation can be provided with the more dense elements tending to provide the greater degree of radiation absorption.

Radioactivity is independent of all physical conditions: heat, cold, pressure, and chemical state.

Illustration No. 7 Action of Nuclear Particles and Electromagnetic Waves In Air and Shielding Materials



Useful Definitions:

Roentgen (R)	Unit of X or gamma radiation exposure. Approximated, 100 ergs per gram of tissue.
Milliroentgen (mr)	Smaller exposure unit equal to one thousandth of a Roentgen.
Rad	Unit of exposure for any combination of radiation type and material. 100 ergs per gram.
Roentgen effective Man (rem)	Unit of exposure for any type of radiation producing the same biological effect as one Roentgen.
Dose Rate	R/hour, m/hr, rem/hr, mrem/hr.
Curie	Unit of disintegration rate, 3.7×10^{10} dps. (Disintegrations per second)
Half-life	Time for two-fold reduction of initial activity (seconds, minutes, days, years, etc)
Electron volt (ev)	Unit of energy for various radiation types. A larger unit - million electron volts (MeV) - is more commonly used.

Useful References:

1. The Biological Effects of Atomic Radiation--A Report to the Public. National Research Council. 1956. (A detailed summary.)

2. Radiation Hygiene Handbook--Blatz. McGraw-Hill Co., 1959. (Space radiation information.)

3. Radiation Belts--O'Brien. Scientific American, May 1963.

4. The Magnetopause: A New Frontier in Space--Hines. Science July 12, 1963.

5. The Ecological Effects of Radiation--Woodwell. Scientific American, June 1963. (Vegetation damage from radiation.)

6. The Voyage of Mariner II--James. Scientific American, July, 1963.

7. Radioisotopes in Biology and Agriculture--Comar. McGraw-Hill Co., 1955. (Use of radioisotopes as tracers in research.)

8. Radiation Environment in Space--Newell and Naugle. Science, November 18, 1960.

9. The Nature of Radioactive Fallout and Its Effects on Man. Hearings before the Joint Committee on Atomic Energy, Congress of the United States, held May and June, 1957 (In three parts), U.S. Government Printing Office.

* There are two facts to be considered here: First, all electromagnetic waves, whether they be light rays, x-rays, or gamma rays, travel at the same speed, the velocity of light, in a vacuum (same in air). These waves all obey the wave equation - the velocity = frequency times wavelength. These waves differ in that their "vibration" frequency differs. Also, their wavelength varies in such a manner that the product of frequency and wavelength = the velocity of light.

** This statement, in connection with previous statements, may be somewhat misleading since all photons travel at the same speed. The gamma rays given off in radioactive decay are to be sure of much higher frequencies than normal x-rays or light waves.

C. Radiation
1. Electromagnetic, Cosmic, and Man-Made Radiation
C. Home As A Universe

INQUIRY NO. 25

WATCH THE BIRDIE
(Primer)

Sunlight passing through a prism is spread into a band of rainbow colors called a spectrum. One color, green for instance, is to this band of many colors as the whole range of visible light is to the much wider wave spectrum that includes everything from gamma rays of tiny wave length to radio waves of long wave length. This broad arrangement of types of radiant energy is called the electromagnetic spectrum. The light we see is only a small portion of it.

Aside from light and radio waves little other radiant energy reaches the earth because of the blotting effect of our atmosphere. This is indeed fortunate for man's exposure to ultra-violet, x-ray radiation and gamma rays must be restricted or this high energy radiation can kill him. Once outside of our protective atmosphere this becomes a serious problem for space travelers. Yet without visible light radiation, man could not survive. The fact that radio waves penetrate our atmosphere has led to the development of radio telescopes and some astronomers now "listen" to the stars.

What marvelous instruments our eyes are even though they can perceive only a narrow band of the electromagnetic spectrum. We really don't "see" with our eyes at all, but with the optic center at the back of our brain. Our eyes admit light, the elastic lens focuses it upon the retina and impulses are sent through the optic nerve which are interpreted or "seen" in the brain. One practical application of this knowledge is the use of good light for all jobs to help our eyes send the best possible "picture" to our brain.

Another form of radiation which influence our home environment is due to conduction of heat and is related to the specific heat capacity of the object. You are aware of such radiation when you touch an object which to you is "cold". What you are saying is that the object is not radiating as much heat as your hand so that it is cooler by comparison. The same line of reasoning would apply for objects which to you feel "hot". An interesting extension of this process is to place one hand in warm water, the other in cold water, and after a minute or two, have both hands touch the same object. What predictions would you make? What would you do if you wished to photograph the heat which your body gives off? What part of the spectrum would you use? How would you prepare your subject before you ask him to, "Watch the Birdie"?

C. Radiation
1. Electromagnetic, Cosmic, and Man-Made Radiation
c. Home As A Universe

INQUIRY NO. 25 WATCH THE BIRDIE

Basic Concepts:

In the normal course of living within the home, radiation of the ionizing type would not pose a problem.

Light and normal body radiation are forms of radiation which must be considered within the home.

Sequence - Summary

Light is a form of radiation.
Light is necessary for vision.

Home ventilating systems are needed to eliminate or prevent a build up of heat from normal body radiation.

Activities - Illustrations

Discuss these topics:

1. Function of eye
2. Study of light meter
3. The camera and film operation
4. Refraction, reflection and absorption of light.

Display an eye chart, spectral chart of the various electromagnetic radiations. Use a model of the eye to explain its similarity to a camera.

Encourage students to build a pin hole camera.

Have children write in the dark and then have them write under normal conditions.

Have children take pictures with a polaroid camera with different amounts of light and the same lens opening and then with the same amount of light and different lens opening. (Cost of film may be a consideration - Under $2.00)

Hang a thermometer inside a bell jar. Evacuate the bell jar with a suction pump. Read the thermometer. Put the bell jar in sunshine or place a bright light next to the bell jar so that it illuminates the bulb of the thermometer. Read the thermometer again. The increase in temperature of the thermometer is chiefly due to radiation of heat from the light source through the reduced atmosphere in the bell jar. Convection and conduction as means of heat transfer are minor factors in reduced atmospheric situations.

C. Radiation
1. Electromagnetic, Cosmic, and Man-made Radiation
d. Self-Contained Unit and Exosphere As A Universe

INQUIRY NO. 26

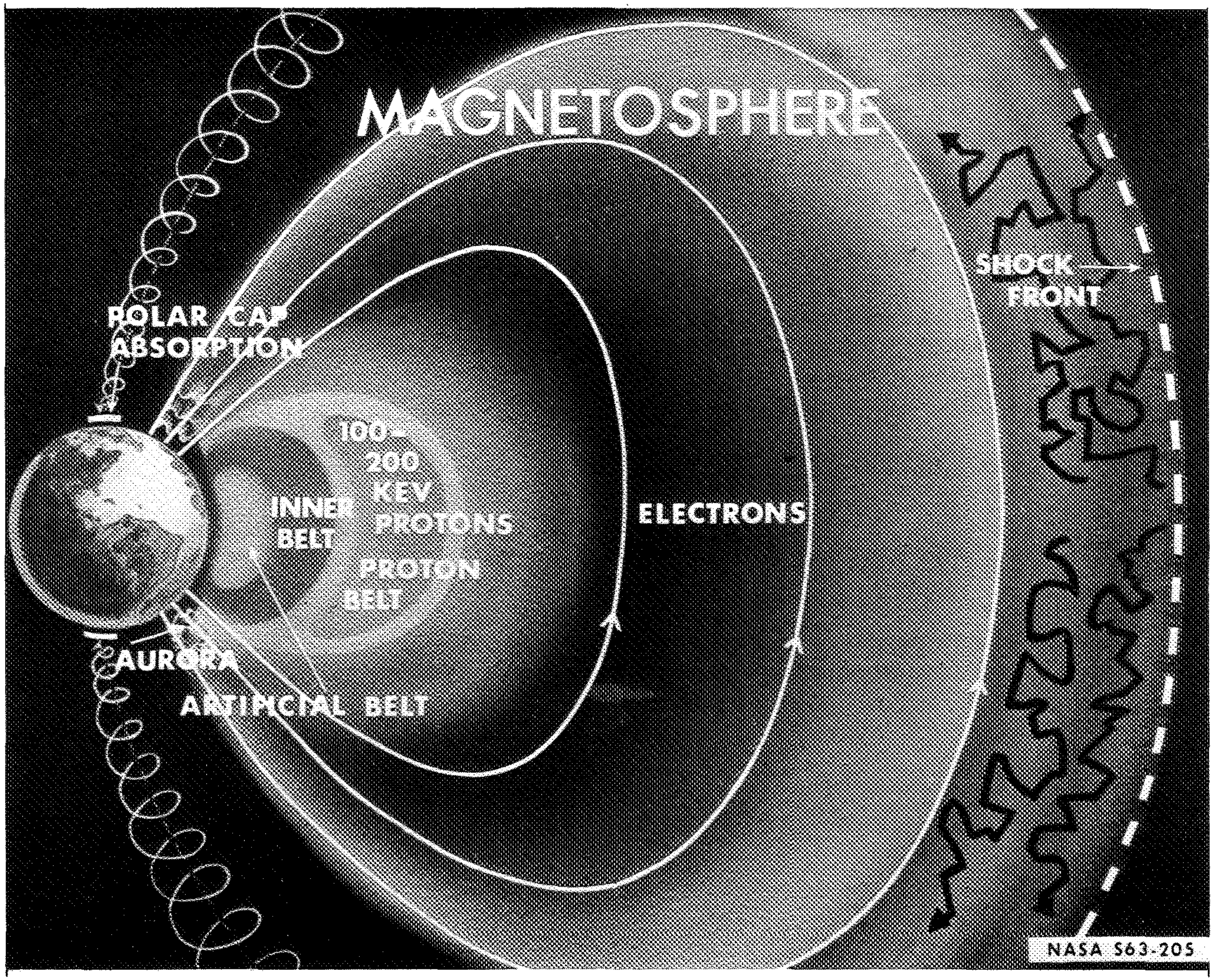
GOPHER HOLES ON THE MOON
(Primer)

Skiing has undergone an explosion of popularity in many of our northern states recently and many people now enjoy exciting week-ends on the sloping hillsides. Even though skiing does offer an excellent opportunity for exercise, it may lead to harmful or dangerous effects.

Most skiers will be quick to tell you that the dangers from falling are greatly minimized by learning how to fall, but falling is not the only danger involved. Occasionally skiers have gone blind, especially after a day of cross-country skiing on bright sunny days. The cornea of the eye actually turns cloudy or opaque, although this usually does not last more than a few days. We refer to this temporary clouding of the cornea as snow-blindness. A cause-effect pattern between bright sunshine and snow-blindness might easily be established, yet the cause of blindness is not the intensity or the brightness of the sunlight, but rather the reflection of radiation from snow which accompanies the sunny conditions. Ultra-violet light injures the delicate tissue of the cornea and the damaged cells cause the cornea to become cloudy. If they are injured extensively, scar tissue may be formed, resulting in permanently impaired vision.

Ultra-violet light is only one of many types of radiation. Radiation can be either natural or man-made, and both types will cause damage to living cells, as was illustrated by the example of snow-blindness. Much natural radiation is filtered by the atmosphere before it ever reaches the earth's surface; however, we are undergoing continuous bombardment by particles from outer space known as cosmic rays. Our satellites and other space explorations have shown that many regions of space contain a high intensity of charged particles. Three large radiation belts surrounding the earth, called Van Allen belts, once led some scientists to suggest that space-craft with living specimens could never pass through these radioactive belts and survive.

Our inquiry will lead us into discussing the basic principles of radiation, especially in space travel, and we will try to solve some of the problems radioactivity causes in space travel.



A diagrammatic representation ("model") of the interaction of the earth's magnetic field with cosmic particles has been prepared. For space exploration, minimizing exposure time rather than providing extensive shielding is the technique proposed. Rapid passage through belts of ionizing radiation can be compared to the rapid passage of a splinter through a flame. Encourage students to compare the relative effects of the 100-200 Kev protons, and the electrons as ionizing radiation sources.

C. Radiation
   1. Electromagnetic, Cosmic, and Man-made Radiation
      d. Self-Contained Unit and Exosphere As A Universe

INQUIRY NO. 26 GOPHER HOLES ON THE MOON

Basic Concepts:

Particle and electromagnetic radiation are present in space at far greater intensities than under the earth's protective shield of atmosphere and ionized layers.

Man in space must be shielded from high-intensity radiation, or, if not possible, the time of exposure must be kept at a minimal level.

Sequence - Summary

Human body must be insulated to protect from radiation. Temperature changes must be maintained within certain limits. (Ionizing types)

During solar flare periods, radiation greatly increases over normal levels. Within the Van Allen belts, radiation is constantly at a far higher level than elsewhere in space.

Activities - Illustrations

Experiment with any ionizing radiation on fruit flies in an enclosed, isolated box. Observe cumulative effects of radiation at different temperatures.
Determine lethal rate at different temperatures.
Note mutation incidence at various temperatures.
With prolonged exposure, note any differences in sterility at the different temperatures. Do the same with plant life.

Long-flight vehicles, space stations or moon colonies would need special shielding during solar flares.

The Van Allen belt is expected to be passed through rapidly enough so that extra shielding will not be necessary. (Time of exposure a factor)

Magnetic field around spacecraft may shield astronauts from high-intensity radiation.

The lunar surface has been acted upon by radiation from the sun, including ultra-violet light, x-rays and cosmic particles. All of these forms of radiation may have had an effect on the chemical composition of the surface.

Use:

1. Charts of solar flares (11 year cycles).
2. Charts of Van Allen Radiation Belts.
3. Charts on solar magnetic fields.

Encourage students to find and experiment with effective <u>shields</u> of ultra-violet, visible light, and infra-red rays.

To demonstrate time of exposure as a factor, a wood splint passed rapidly through candle flame does not ignite, although if left within the flame for a few seconds, it easily ignites and burns. Discuss.

Use "tuning eye" radio tube, or oscilloscope or T.V. tube, to illustrate how magnetic fields deflect charged-particle radiation.

<u>Useful References:</u>

1. <u>Biological,Medical and Environmental Research Program.</u> USAEC, Division of Technical Information, Pamphlet, 1962.

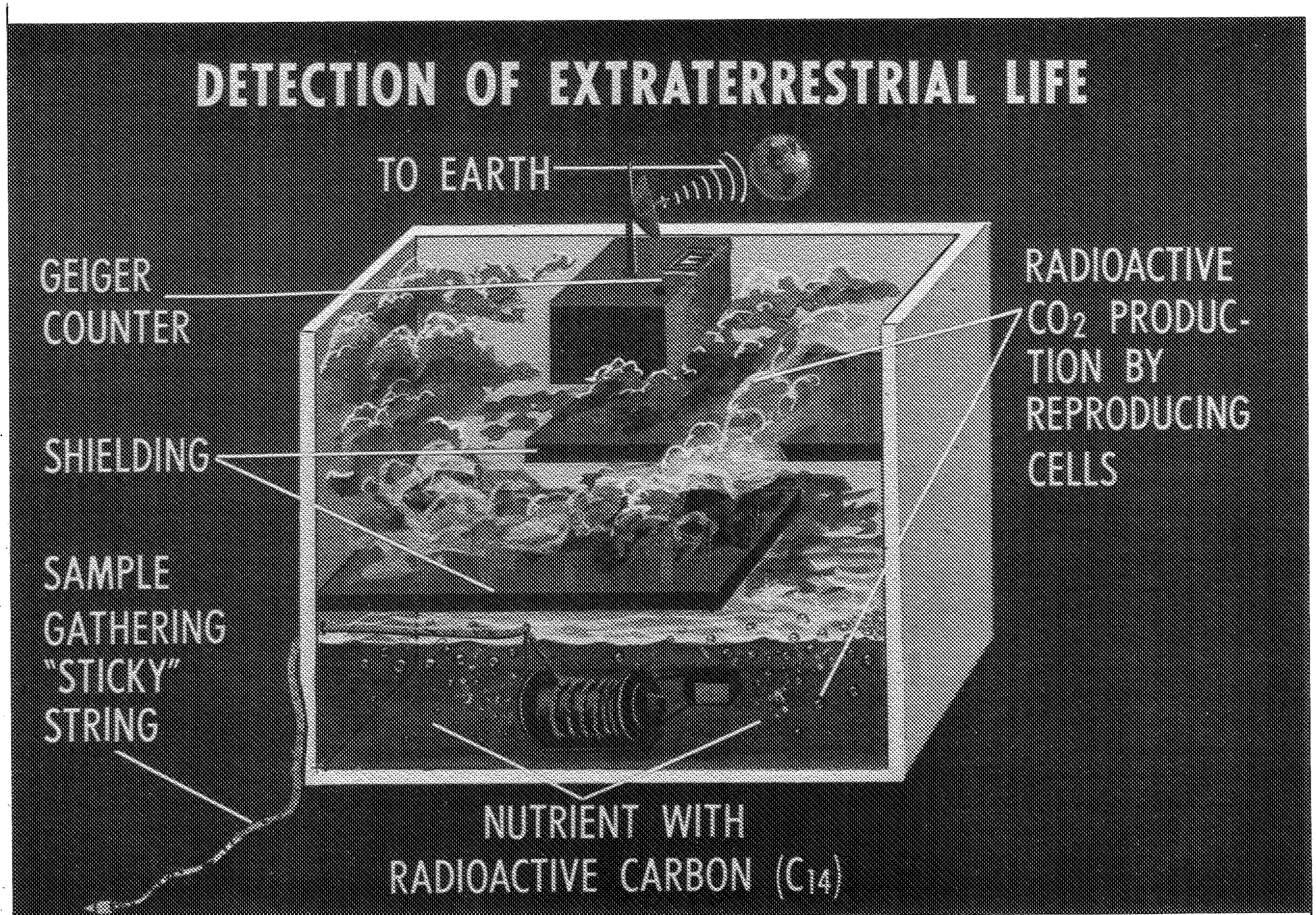
2. <u>18 Questions and Answers About Radiation;</u> USAEC, Pamphlet, 1960

3. Principles of Bioastronautics, S. J. Gerathewohl; Prentice-Hall; Englewood Cliffs, New Jersey, 1963.

4. Radiation and Human Mutation, H. J. Muller; Scientific American; November,1963.

5. Film: Our Mr. Sun: The Strange Case of Cosmic Rays, Bell Telephone Co.

6. Modern Space Science, Trinklein and Huffer; Holt, Rhinehart and Winston, Inc., New York, 1961. pp. 37-88, 74-75, 290, 301, 336-337, 441, 465, 484-485, 491.



Encourage students to work out the idea which is diagammatically represented above. It can be tied in with class discussions on the uses of radioactive materials and with extensions of hydroponics activities.

LIFE SCIENCE IN A SPACE AGE SETTING

C. PHYSIOLOGICAL STRESSES

Throughout the life of an organism, factors in its environment act upon it. Many of these factors such as gravity, the diurnal pattern of day and night, temperature fluctuations, the constant velocity of the earth as it rotates on its axis, and air pressure, are so persistent that we may never stop to consider them as stresses which limit our activities. Our understanding of some of these factors, particularly gravity, is still inadequate although the studies which are planned as part of our space age explorations may generate more fruitful theories or help to confirm some of the existing ideas. In this inquiry, two types of physiological stresses, temperature fluctuations and acceleration, will be considered in some detail. An outline of the interaction of these problems with the universes and inquiries is included below:

1. Temperature Fluctuations
   - a. Earth As A Universe
     - 1) No. 27 . . . And Not A Bit of Shade in Sight
   - b. Community As A Universe
     - 1) No. 28 Service with A Smile - if the Environment Is Willing

c. Home As A Universe

1) No. 29 What Shall I Wear, Mother?

d. Self-Contained Unit and Exosphere As A Universe

1) No. 30 Exploring Biothermal Extremes

2. Acceleration

a. Earth As A Universe

1) No. 31 As The Twig Is Bent . . .

b. Community and Home As A Universe

1) No. 32 Community on The Go

c. Self-Contained Unit As A Universe

1) No. 33 The View from Our Eighty-Seven Minute World

d. Exosphere As A Universe

1) No. 34 Eyeballs In, Eyeballs Out

D. Physiological Stresses 173
1. Temperature Fluctuations
a. Earth As A Universe

INQUIRY NO. 27

. . . AND NOT A BIT OF SHADE IN SIGHT
(Primer)

Would you have wanted to be a resident of Snag, Yukon on February 3, 1947? Perhaps you would have preferred Death Valley, California on July 10, 1913? What do these locations have in common? Actually, it is not what they have in common but rather, what they represent as records for the North American region which is of interest to us. Snag holds the record for the lowest officially recorded temperature at -81° F., while Death Valley (how appropriately named!) holds the record for the highest official temperature at 134° F. While these are rather impressive extremes of temperature fluctuation, they do not represent the lowest or the highest temperatures recorded in the world. Two communities in Siberia (no wonder its the land of the exiles!), Oimekon in 1933 and Verkhoyansk in 1892, recorded official temperatures of -90° F. A community in Libya, El Azizia, had the world's highest temperature on September 13, 1922 at 136° F.; the community of San Luis, Mexico tied that record on August 11, 1933, while a reading of 140° F. at Delta, Mexico, in August, 1953, has been challenged because of over-exposure to roof radiation. (What is this thing, "roof radiation"? - review Inquiry Nos. 23, 25.) Recent expeditions to Antarctica have reported low temperatures in August (How do you account for the time of year?) of -126° F.

Such record extremes are interesting to know about and even fun to locate on a map of the world (See Appendix for "Where, Oh, Where Has My Little Thermometer Gone?"); however, the temperature range within which life, as we know it on earth, can exist is quite narrow. Most estimates place it at somewhere near the freezing point of water (32° F., 0° C.) at one extreme and 140° F. (60° C.) at the other extreme. Does the high temperature figure surprise you? It should be interpreted with some care. When the temperature around you reaches such a high point, it does not mean that your own body temperature is that high. Remember that perspiration produces evaporative cooling to protect you from building up too much body radiation. Internal body temperatures over 109° F. (42.8° C.) or below 77° F. (25° C.) for any extended length of time will result in death, although such temperatures have been exceeded by individuals, specifically to 111° F. (43.9° C.) and 60.8° F. (16° C.). For most situations, our temperature regulatory mechanisms control our body temperature near the 98.6° F. (37° C.) ideal of which we hear so often.

In this inquiry, you will explore the biothermal range of life, attempting to simulate the heat output of animals with light bulbs, and then, to devise a closed system within which the biothermal range can be maintained. As in the other inquiries, your ingenuity and imagination will be your best allies.

This astronaut is literally "sweating out" one phase of his pre-flight Qual-fying examination. What evidence can be seen that he is in a heat chamber with an atmospheric temperature of $130^{\circ}F$.? Would you say he has been in the chamber for an extended period of time?

D. Physiological Stresses

1. Temperature Fluctuations

a. Earth As A Universe

INQUIRY NO. 27 . . . AND NOT A BIT OF SHADE IN SIGHT

Basic Concepts:

The temperature range within which active life exists is known as the biothermal range. The biothermal range for life as we know it is from some degrees below the freezing point of water (32° F., 0° C.) to about 140° F., or 60° C.

The planet Mars has a temperature range close to that of our planet, Earth.

The human body requires an external environment within a narrow temperature range.

All life forms are profoundly influenced by their physical environment.

Sequence - Summary

Comparison of the temperature range and biothermal range on:

1. earth
2. moon
3. other planets

A 100 watt light bulb is the "light bulb equivalent" of a man in the amount of normal body radiation released.

Activities - Illustrations

Devise a closed system which will maintain the biothermal range of a rat (mouse, frog, etc.).

Experiment with laboratory animals.

a. Hibernation and temperature change
b. Food habits and temperature change

What other "light bulb equivalents" can be experimentally determined?

What type of closed system can be devised, using the "light bulb equivalent" to simulate an organism such as mouse, rat or other animal?

What effect (if any) will temperature have on water and food intake?

Confine mice or other life forms in similar containers (gallon jars or cans). Paint one black, the other white or silver (which is a better heat reflector?). Measure water and food uptake over a period of time.

Encourage students to devise ways to measure the heat production of various animals.

<u>Useful Reference</u>:

<u>Space Medicine</u>, J.P. Marbarger, (ed.), University of Illinois Press, 1951, p. 34.

D. Physiological Stresses 178
1. Temperature Fluctuations
b. Community As A Universe

INQUIRY NO. 28

SERVICE WITH A SMILE - IF THE ENVIRONMENT IS WILLING (Primer)

As the autumnal temperatures in the northern part of the United States start to fall, approaching the freezing point of water and below, the travel agencies and vacation-time magazines increase their bombardment of residents of these sections of the country with alluring pictures of water skiers in Florida and of sunny orange groves in California. The snow bunnies who enjoy the ski slopes and the warm companionship around a glowing fireplace pay little attention to such appeals. However, on those nippy mornings when the family car starts to act up and the walk to school produces a numbed nose and tingly ears, the lure of these sunshine havens may indeed be irresistible. The migration of families to Florida and California over the past decade certainly bears out such a supposition The influence of temperature fluctuations on communities can thus be seen in a rather direct and dramatic way.

Other temperature variations also should be considered. The newly installed Floridian may need to be alert, during some seasons of the year, for hurricanes;

the farmer in the midwest still retains a storm cellar (modern-day version may be a rather glamorous family den) as a haven from tornados; and, the prudent Montana resident's spare tire compartment will include a set of tire chains and a shovel against the contingency of a snow storm, flash flood or road wash-out. The communities located in these areas must also consider these problems for, if the community's residents cannot be assured of services in times of extreme variations in temperature, the likelihood of the continued existence of that community is very small. How does your community handle temperature extremes? What are some of the by-products of these temperature extremes on your life? How does it affect your parent's ability to earn a livelihood?

In this inquiry, you will explore these various aspects of one physiological stress on the community, namely, temperature fluctuation. As you do, remember the comment of a New England farmer, who, when approached to help a stranded motorist with a flat tire, commented, "We give service with a smile, weather permitting."

D. Physiological Stresses
   1. Temperature Fluctuations
      b. Community As A Universe

INQUIRY NO. 28 SERVICE WITH A SMILE - IF THE ENVIRONMENT IS WILLING

Basic Concepts:

Changes and extremes in temperature affect community services. Extreme variations in temperature may endanger the continued existence of a community.

Sequence - Summary

Weather Bureau reports are essential to the safety of a community.

Climatic differences affect construction activities and results (expansion-contraction of materials) in a community.

Changes of temperature affect the food production (thus indirectly, the economic status) of a community.

Seasonal changes determine the types of recreational activities carried out within the community.

Activities - Illustrations

Encourage students to make and demonstrate weather instruments and to keep daily charts and reports.

Visit weather bureau. Read weather charts and reports.

Discuss with the class:
   The formation of various forms of precipitation.

Show films or pictures showing causes and effects of tornadoes, hurricanes, electrical storms.

Discuss how ice, sleet or rain may be hazardous to the community.

Encourage students to recount personal experiences of recreations related to your geographical location.

Encourage students to bring in pictures illustrating different types of recreation found in certain geographical locations.

Encourage students to plant seeds under different temperature conditions. Help them make charts displaying foods produced in temperate and tropical zones.

Help students demonstrate the thermal expansion of materials.

Discuss construction occurring during spring, summer, fall and winter months.

Encourage students to attempt to freeze a small portion of cement. Observe cracking when heated. Relate to highway construction. Explore the effects of extreme heat and cold on various metals? Strengths and weaknesses?

D. Physiological Stresses 182
   1. Temperature Fluctuations
      b. Home As A Universe

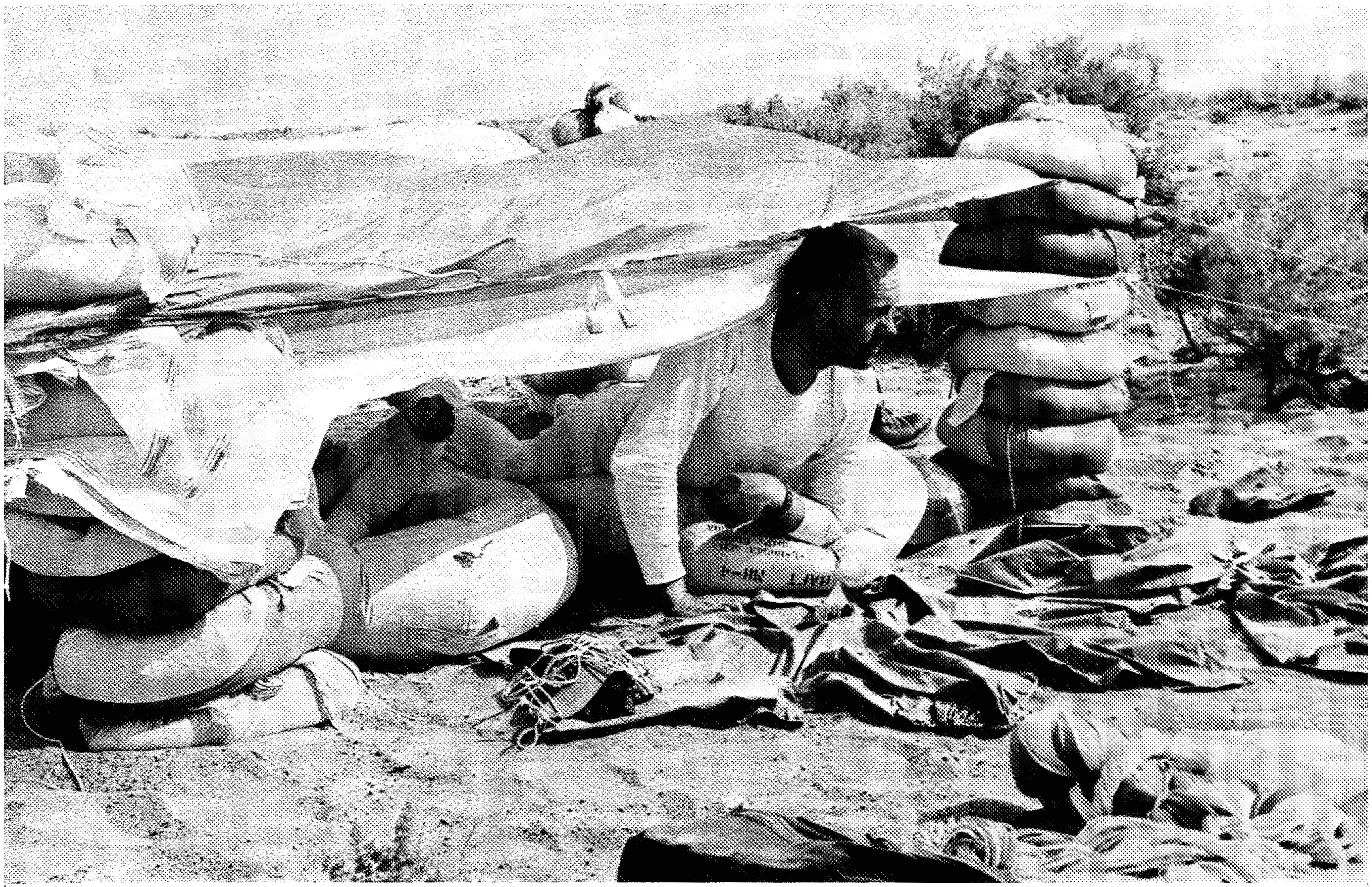
INQUIRY NO. 29

WHAT SHALL I WEAR, MOTHER?
(Primer)

What to wear -- this is a problem which we face every morning. Our decision is based on what the temperature (indoor and outdoor) and the day's activities will be. We are familiar with the different ways we try to remedy this situation -- regulating the quantity, type, and color of clothing; the amount of physical activity; the temperature of the surrounding air. However, there are involuntary mechanisms which also act to keep the body temperature at 98.6° F. -- namely, the hormonal and circulatory systems, and perspiration.

Normal body temperature is maintained by the proper regulation of the amount of heat lost to and absorbed from the environment. This exchange of heat is by conduction, convection, radiation and evaporation of water from the skin. When we have a fever or sunstroke or wear clothing inadequate for the external temperature and humidity, the normal balance between heat loss and production is affected. Our hormonal, circulatory and nervous systems give us cues which we learn to interpret so that the imbalance, whether it it is that we are too cold or too hot, can be corrected.

Scientists have found that the involuntary, regulatory mechanisms triggered by our hormonal and circulating systems are poorly developed in young children. Their body temperature varies with that of their environment in the same way as that of frogs and turtles (poikilotherms) so that, until the regulatory mechanisms are well established, parents must exercise care that temperature extremes do not occur in the young child's environment. Once the regulatory mechanisms are operating, the child can be likened to other "warm-blooded" animals (homeotherms) who respond to changes in external and internal temperature so that they are physically comfortable.



What precautions have these astronauts taken to help insure their survival in the desert? Note the double layer "tent" covering. Is there an advantage to placing the darker colored fabric as the top layer in the double layer "tent"? What additional steps would you foresee are necessary for their survival during desert nights?

D. Physiological Stresses
   1. Temperature Fluctuations
      c. Home As A Universe

INQUIRY NO. 29 WHAT SHALL I WEAR, MOTHER?

Basic Concepts:

Temperature variations within the home must be controlled for the physical comfort and well-being of its inhabitants.

Sequence - Summary

Heat and temperature can be measured within:
1. home
2. human

Heat is a form of energy. The kinetic energy of molecules is one form of heat, particularly applicable to gases.

Heat energy can be transferred by conduction, convection or radiation.

Dark, rough surfaces are better absorbers and radiators of heat energy.

Changes in body temperature may produce stress.

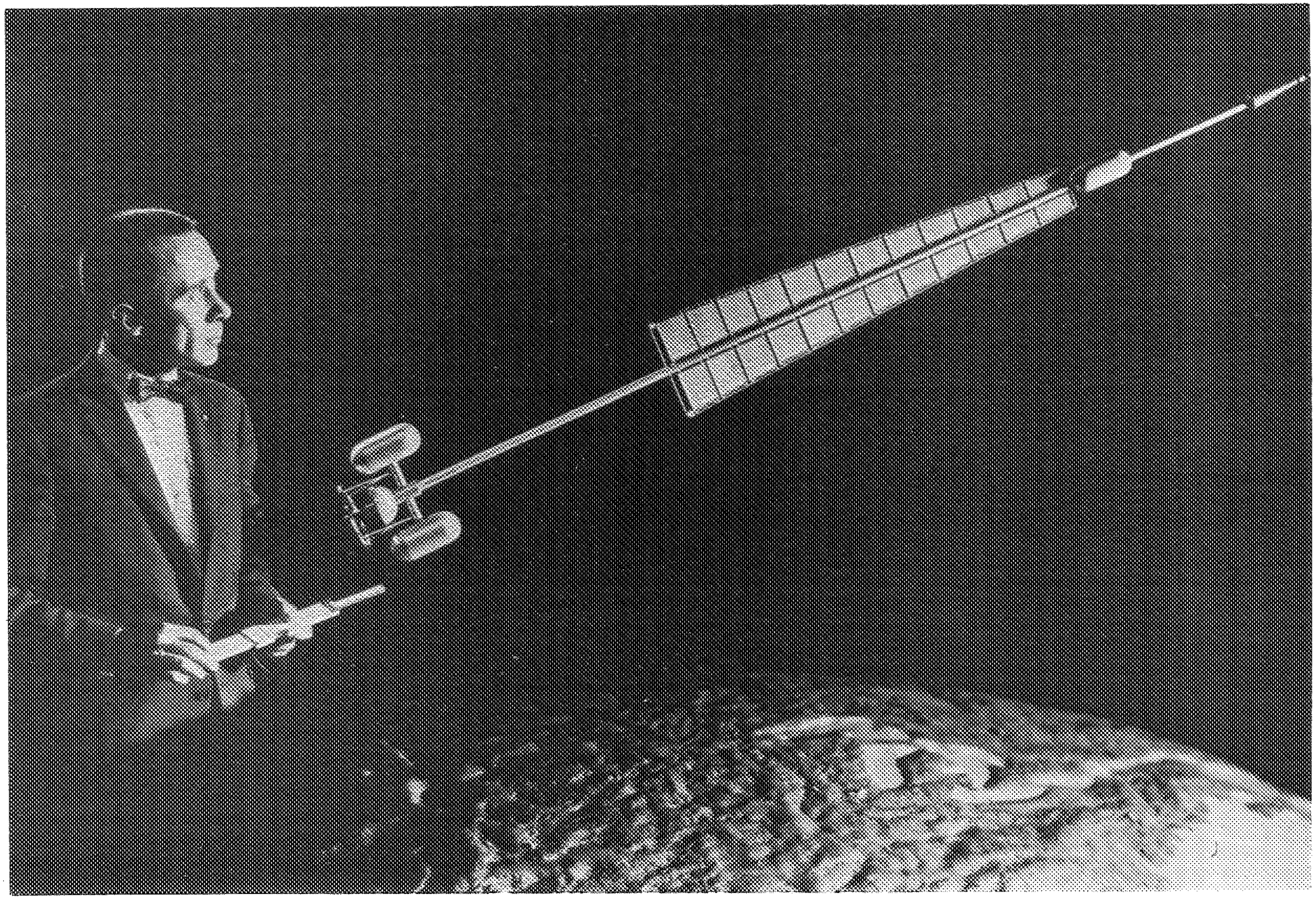
Activities - Illustrations

Encourage students to find out all the ways that temperature is measured in the house.

Help students experiment with various temperature devices:
1. Thermometer
2. Food thermometer
3. Thermostat

Explain the principles involved in function of thermometer, thermostat and radiometer.

Encourage students to examine old wives's tale: "If you count the number of cricket 'chirps' in 17 seconds and add 40, you find the air temperature." Locate a cricket and



The most arresting feature of thie electric space vehicle, intended for use on an eight man Mars Expedition, is the large area devoted to plates for the dissipation of energy from the liquid circulating through the nuclear reactor. These flat plates can be likened to a car radiator. Discuss the need for this type of energy transfer in the near-vacuum environment of space.

The amount of water vapor in the air affects the physical comfort of people.

Discuss:

1. What relation does color of a fabric have on heat absorption?
2. Are there some colors that make us feel hotter or colder, calmer or more active?

Encourage students to experiment with clothing of different colors. Use a thermometer to test heat absorption.

Place piece of different colored construction paper around bulbs of four thermometers. Place in sun. Observe. Chart and evaluate.

Use a magnifying glass to try to set light-colored and dark-colored paper afire -- note difference.

Place a thermometer in the ground and above ground. What does this tell you about heat absorption?

try it.

Help students plan an experiment to show how air friction produces heat. Example, suspend a rotating object in space (chair or ball).

Experiments with heat generated by friction and the elimination of friction to reduce heat. Discuss: What types of materials (surfaces) reduce friction?

Demonstrate the transfer of heat by radiation, convection and conduction.

Demonstrate heat conduction using:

1. Ball and ring
2. Bimetallic strip

Determine which materials are:

1. The best conductors?
2. The best insulators?

What does the temperature tell about the body? What is average normal temperature of other 'warm'-blooded organisms (rat, mouse guinea pig, etc.)?

Encourage a student to secure an interview with a doctor or a nurse to discuss the role of fever in disease. Make a chart of body tempertures for two weeks. (Define upper

What features have been incorporated into these fire control uniforms to minimize heat effects? By what process(es) does the carbon dioxide extinguisher operate to eliminate continued burning?

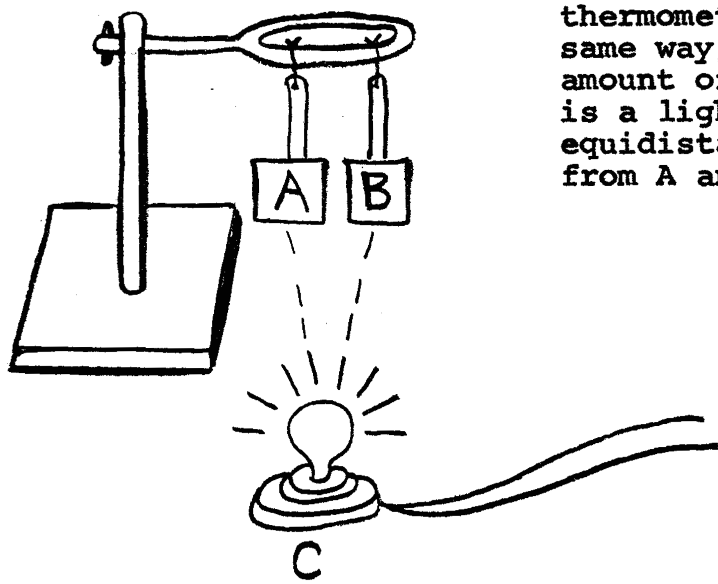
Activities - Illustrations (Con't)

and lower limits).

Make a list of reasons why changes in temperature indicate conditions of change in the body.

Discuss the influence of humidity on physical comfort. Encourage students to bring in pictures illustrating comfort when swimming, hiking, skiing and other activities. Discuss how the various modes of clothing would apply to situations in the home.

DIFFERENTIAL ABSORPTION OF LIGHT



A and B are equal size squares of paper, one white, and one black, stuck to thermometer blubs in the same way, with the same amount of adhesive wax. C is a light source which is equidistant and perpendicular from A and B.

Problem: Why do the thermometers read differently?

Episode Analysis:
When C is turned on, different amounts of light are absorbed and reflected by A and B causing different temperature readings on their thermometers.

Variables:

1. size of A and B
2. shape of A and B
3. size of light bulb (power)
4. color of light bulb
5. distance from light source
6. color of A and B
7. type of thermometer
8. texture of material

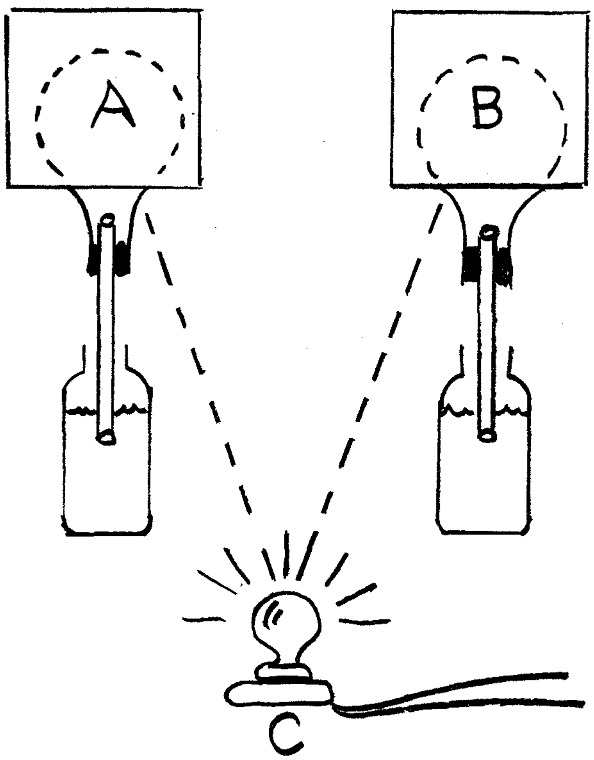
Critical Questions:

1. If A were larger than B, would the results be the same?
2. If A were farther away from C than B, what would happen?
3. If the room were dark, would the results be the same?
4. If we did this in outer space, would results be the same?

Cause-effect relationships:

1. light absorption-increases as the color becomes darker.
2. light reflection-decreases as the color becomes darker.
3. when light strikes an object, some of it is changed to heat.

LIGHT ABSORPTION



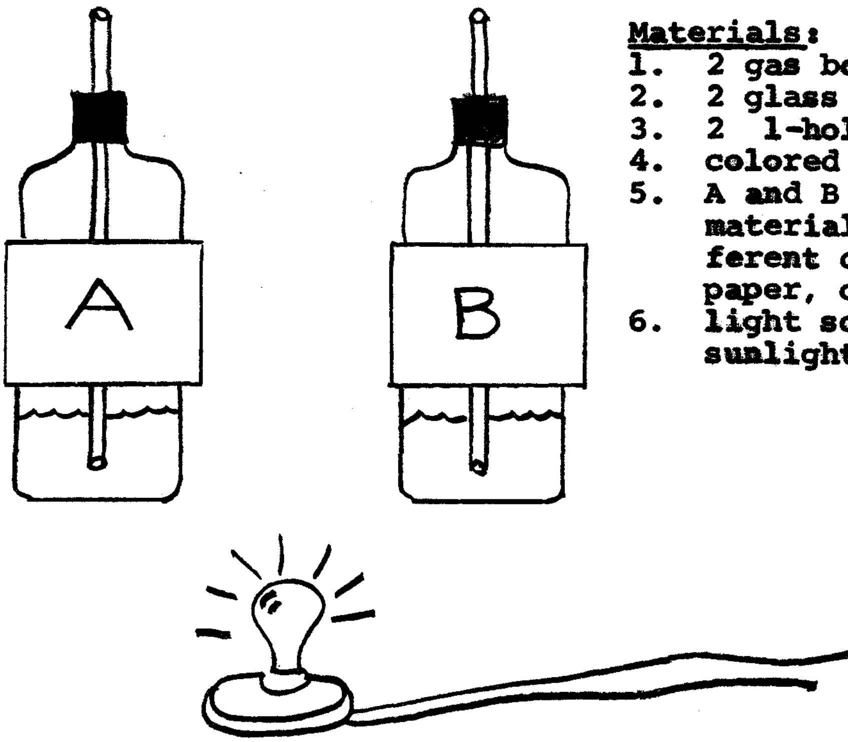
Materials:
1. 2 equal size squares of paper (A) black, (B) white
2. 2 Florence flasks
3. 2 gas bottles
4. 2 glass tubes
5. 2 rubber stoppers
6. colored water
7. light source (C); i.e., lamp, projector, etc.

Problem: Why does A produce bubbles faster than B?

Variables:
1. size of material
2. texture of material
3. color of material
4. intensity of light
5. distance from light

Critical Questions:
1. If A were placed farther from C than B, what would happen?
2. If A and B were cloth instead of paper, what would happen?
3. If B were larger than A, would the results be the same?
4. What would happen if we used red and yellow paper?
5. If we used a brighter light, would the results be the same?
6. How could we make A and B produce bubbles at the same speed?

DIFFERENTIAL ABSORPTION



Materials:
1. 2 gas bottles
2. 2 glass tubes
3. 2 1-hole stoppers
4. colored water
5. A and B equal size materials of different color; i.e., paper, cloth, etc.
6. light source; i.e., sunlight, lamp, etc.

Problem: Why do the liquids go up the tubes at different rates?

Variables:
1. size of material
2. color of material
3. texture of material
4. distance from light source
5. intensity of light
6. length of glass tube
7. size of bottle
8. amount of water in bottle

Critical Questions:
1. If A is larger than B, what will happen?
2. How could you make the water level in A rise more than in B?
3. If you used a stronger light, what would happen?
4. What would happen if you used a larger bottle in A than in B?
5. If there were more water in A than B, would the results be the same?
6. What would happen if you used a 2 foot long glass tube?

D. Physiological Stresses 188
    1. Temperature Fluctuations
        d. Self-Contained Unit and Exosphere As A Universe

INQUIRY NO. 30

EXPLORING BIOTHERMAL EXTREMES
(Primer)

Have you ever thought, as your family car was moving down the highway, "Gee, if we could only take off into the wild blue yonder and see the world that the astronauts talk about!" If such a thought has occurred to you, you may even have gone a step further and looked around you in the car to see how it, as a self-contained unit, might be modified for the trip. The car has been designed to provide for your comfort and safety under terrestrially-limited conditions. However, some of the techniques which have been perfected for the car may help you identify some of the problems which exist in the design of temperature fluctuation controls for any self-contained unit (dirigible, submarine, bathyscope, transcontinental airplane, etc.) or exospheric device.

Let us assume that you are going for a vacation and plan to travel by car from Alaska to the tip of South America. Such a trip would take you through the entire gamut of temperature conditions found in the world. What are some of the ways you will be able to insure your personal comfort over such a range of temperature fluctuations? A second problem to be considered is the "greenhouse effect". Have you heard of it? When infra-red rays pass through the glass panes of the automobile, they warm the surfaces they strike, including the seat covers and your skin. These surfaces, in turn, give off heat radiation which warms the air in the car and causes convection currents of air to form. So what? If the windows are kept closed, this extra heat in the air cannot escape from the car. Why? Right! It is because your skin and the seat covers give off heat radiation of longer wave lengths than the infra-red rays. The infra-red rays were able to pass in <u>and out</u> of the car through the glass; the longer wave lengths cannot. The car is thus a heat trap. How would you suggest the designers of a space craft handle this problem? Eliminate all windows? Use glass which blocks the passage of these undesirable wave lengths? Certain chemicals absorb radiant energy undergoing a change in their fundamental structure, and thereby changing in their capacity to absorb light. Such a process, which is reversible, is referred to as photochromism and may be an avenue for the resolution of the "greenhouse effect." In this inquiry, you may wish to explore this type of problem.

To encourage your thinking about the type and design of space craft and space suits, the following points are listed; they represent some of the conditions which must be satisfied for effective performance of such aids in an outer space setting:

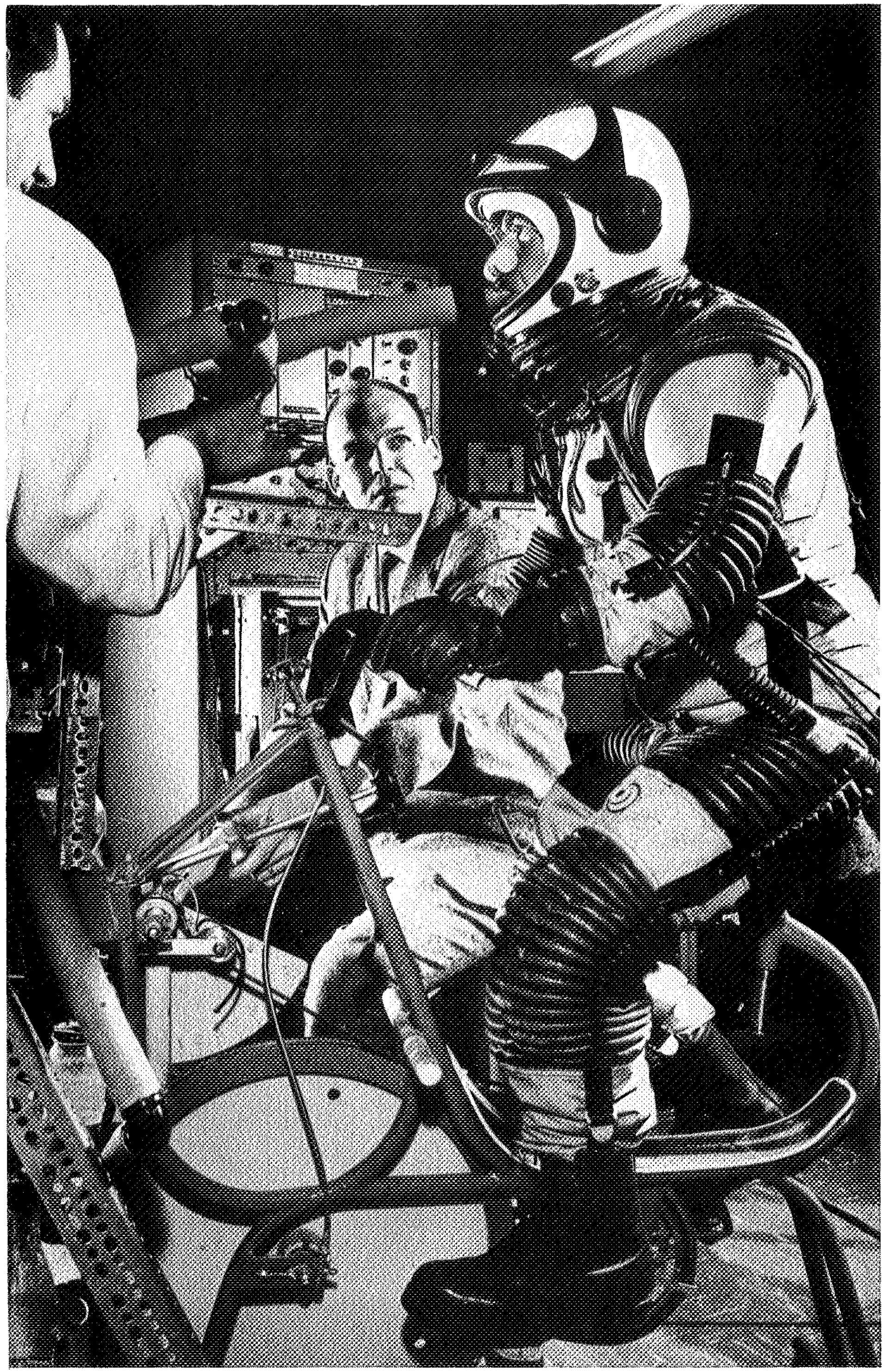
1. In the absence of an atmosphere, the sole form of heat loss is by radiation.

2. Radiant energy travels in waves along straight lines, its intensity at any distance from a source is inversely proportional (if you go twice the distance from the object, the intensity is one-fourth; if three times the distance, one-ninth; etc.) to the square of the distance from the object.

3. The more nearly vertical the rays of radiant energy, the greater the number that will fall upon a flat surface, and the greater is the amount of energy that will be received.

4. Dark, rough, or unpolished surfaces absorb or radiate energy more effectively than light, smooth, or polished surfaces.

5. Temperature control for space suits should be effective for outside temperatures of 215° F. and -250° F. To further this goal, it should be heavily insulated, power-heated and cooled.



Design engineers are perfecting space suit tests on a bicycle-like exerciser called an "ergometer" (an erg is a unit of work or energy in the metric system). The device into which the man is breathing measures his oxygen consumption and the amount of carbon dioxide he is exhaling. From tests of this type, the metabolic rate of the man, when various internal space suit air flow temperatures are introduced, can be determined.

D. Physiological Stresses

1. Temperature Fluctuations

d. Self-Contained Unit and Exosphere As A Universe

INQUIRY NO. 30 EXPLORING BIOTHERMAL EXTREMES

Basic Concepts:

The human organism functions best within certain ranges of temperature and humidity.

Heat radiation from normal body activity may build up excessively unless transferred.

Planets and moons are unevenly warmed.

Sequence - Summary

Compare regions of the earth regarding density of population, temperature fluctuations, and rainfall.

Review body mechanisms which aid in temperature control.

Review concepts of humidity and the procedure for determining relative humidity.

Activities - Illustrations

Design a space suit to withstand temperatures from +215° F. to -250° F.

Encourage students to investigate the extremes of temperature of both liquids and solids. Examples of cold materials would include liquid nitrogen, oxygen, solid carbon dioxide; hot materials would be liquid metals such as sodium, magnesium, and

Discuss temperature extremes possible in space, and particularly, on specific planets.

From a temperature fluctuation viewpoint, consider:

1. day and night on earth
2. winter and summer on earth
3. polar and equatorial regions
4. hot and cold sections of lunar surface
5. hot and cold sections of other planets
6. thermal plight of space travellers

superheated gases. Help them chart upper and lower temperatures. Discuss 0° Kelvin or "absolute zero".

Encourage students to recount unpleasant experiences they have had with hot and cold temperatures.

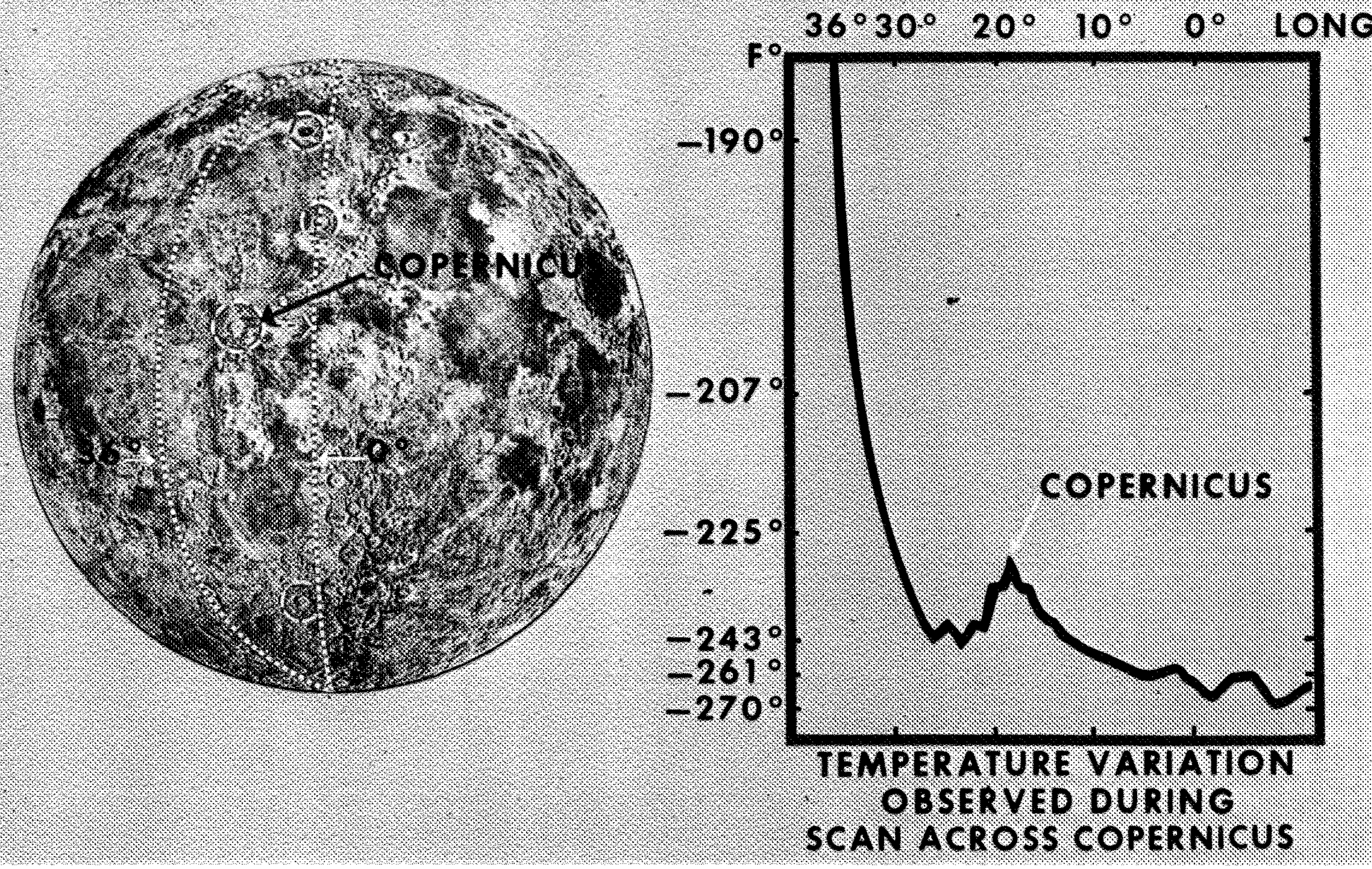
Have child wear plastic raincoat in sunlight, in the classroom, or in dark room. (Observe effects)

Ask child to sit in a non-ventilated room for brief period. Ask him to recount sensations.

Wrap a small piece of tissue around the bulb of a thermometer. Soak the tissue with ether, acetone or water. Then blow gently on paper. Why did the thermometer indicate a drop in temperature? Boil water in a teakettle. Where does steam go? Let it condense on various surfaces, including one with ice enclosed; empty; with warm water. Why does most condensation occur on a vessel with ice in it?

Put table of "gases-in-air" on board, for student information.

HOT SPOTS ON THE MOON



Help students interpret the graph as it relates to the photograph of the moon. The temperature scale should be read as positive (+) degrees, Fahrenheit. The term "Long" is an abbreviation for "Longitude", and is read from an arbitrarily established 0°longitude. The crater of Copernicus area is one of several being considered as the landing site for our first lunar explorations.

Activities - Illustrations (con't)

Secure a sling psychrometer and show its use. Permit students to use it for various places and times. Help them use chart showing wet and dry bulb temperatures.

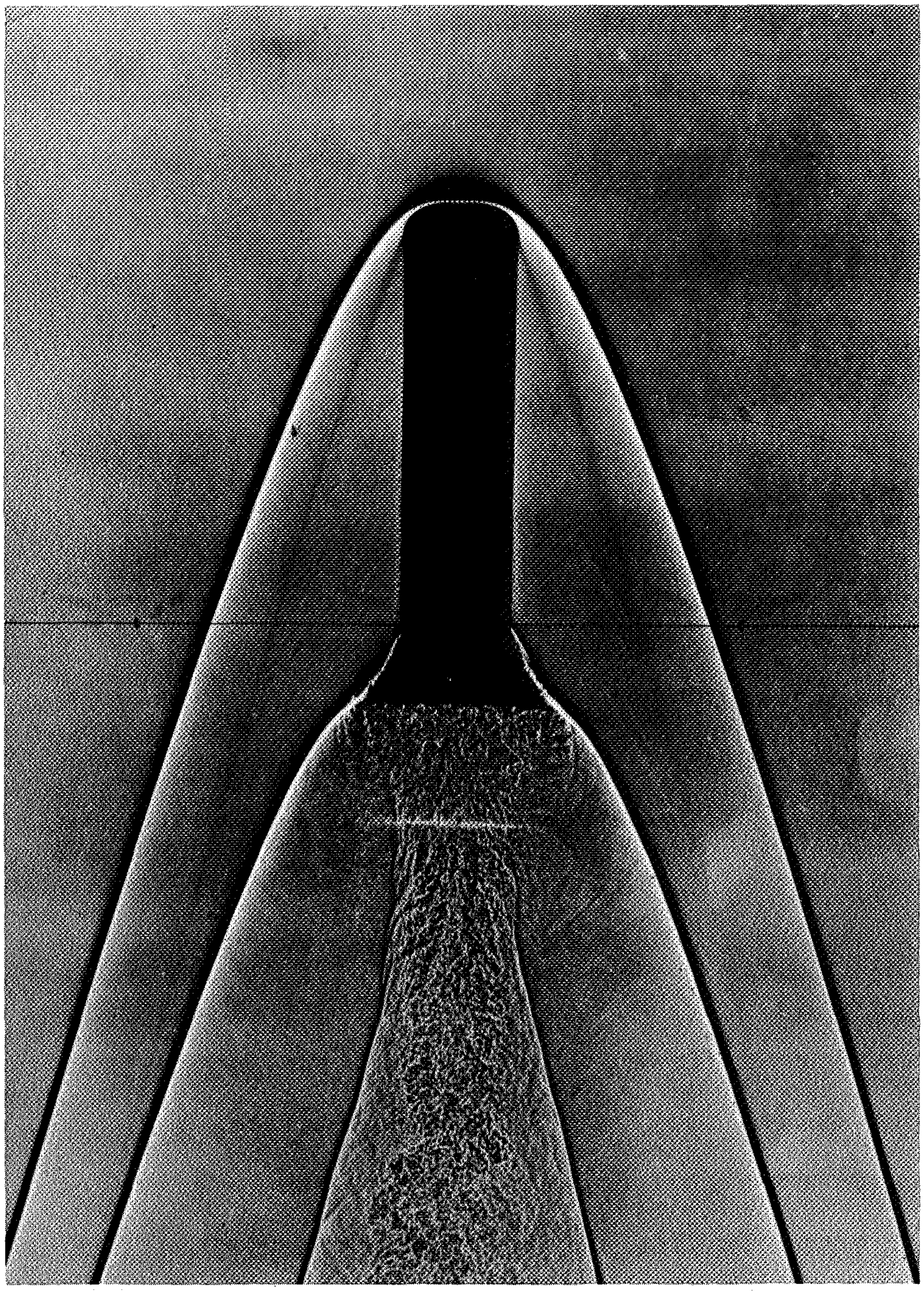
Have each student take his own body temperature at various intervals (assign). Compare readings in the group to show individual differences.

To illustrate the role of the skin as a means of controlling temperature, put ether or water on arm, blow gently, note cooling. Do same with plastic bag over arm after application of ether or water.

Compare functions of student's body (heart beat rate, respiration, recovery time, temperature, feeling of well-being, and any other "tests" the class wishes to compare) by collecting data from areas where environmental conditions could represent natural environments of the world. For example, a control set of data could be obtained from the classroom or average room at home, to compare with the following: (1) The same activities conducted in the boiler room of the school; (2) Activities conducted in the locker room when it is steamy and hot after showers; (3) Activities conducted outdoors if there is a seasonal contrast. Student conducting the experiment should keep clothing similar in all testing, although a further comparison could be made by changing clothing to adapt to environments and re-testing.

Results could be graphed. Measurements of humidity, pressure, and temperature should be made for each set of tests.

<u>Useful Reference</u>: <u>Photochromism</u>, Science and Math Weekly, Vol. 3, Issue 28, 1964.



This wind tunnel test of a model was designed to study the heat dissipation patterns associated with a blunt-nosed object. The strong shock wave generated by the blunt-nose protects the model against aerodynamic heating at high speeds; that is, air molecules striking and being struck release energy of motion which is converted to heat. This excess energy must be transferred or the model will undergo a change in state from solid to liquid to gas and "burn up". On reentry devices, an ablative shield of a plastic material is used. As the plastic is heated, it becomes liquid in nature and literally peels off the spacecraft, taking the energy (heat) it has accumulated with it. The process is referred to as "ablation".

D. Physiological Stresses 194
2. Acceleration
a. Earth As A Universe

INQUIRY NO. 31

AS THE TWIG IS BENT . . .
(Primer)

In the evening during the summer months in the Yosemite National Park, as the campers put away their cooking gear and relax after the day's activities, it is a practice for a member of the ranger staff to release a raft upon which a bonfire has been built, over one of the falls which border the Yosemite Valley. As the burning embers of the bonfire cascade over the edge of the falls, the campers in the valley enjoy the spectacle. If you have been one of the many millions who have witnessed this event, you can readily understand why the term "fire falls", is used to describe it. However, our interest in this event goes further. As the burning embers tumble over the falls, their path, as observed from below, is such that, at every instant, they appear to travel a greater distance than the instant before. This increased movement continues until, with an almost regretful last glow, they disappear. Perhaps you have observed a similar phenomenon when sledding down a hill. At first, you seem to go rather slowly, then begin to pick up speed, until, at the bottom you slow to a stop. Why this on our earth as a universe? What are some of its effects?

The force which is acting on the burning embers, your sled, and on all other objects on the earth's surface is the force of gravity. The change in the rate at which various objects move under the influence of this force is referred to as acceleration, and for objects falling through space (if we ignore the air resistance) it acts on them in the same way. That is, if you dropped a spark plug and a penny from the same height at the same time, they would both change in their rate of fall (accelerate) at the same time by the same amount so that they would end up at the same point (the ground) at the same time. Many examples of acceleration due to gravity come to mind: rocks falling off cliffs, pieces of glaciers breaking loose and crashing into the glacial lake at the glacier's receding base; meteorites hurtling through space; the passage of an avalanche down a snow-covered slope; trees, roots weakened by spring rains, majestically falling to earth; and hillslides, ponderous and impassive gradually becoming bellicose, destructive landslides. What other examples would you suggest?

Aside from the acceleration due to gravity, there are other types of acceleration. Any time an object changes its rate of movement, it can be said to have "accelerated". Thus, a centipede that ups its multi-leg movement an additional "step" per minute can be said to have accelerated. The rate at which it had been going was its "velocity" and, after accelerating, it is going at a new rate, it has a new velocity. The key idea is that acceleration is a change of velocity. When you later explore the circular or elliptical paths of satellites, you will extend this idea of acceleration as change of velocity to include acceleration as a change of direction when velocity remains constant. For the present, we shall not deal with this case.

If, then, when an animal starts from a standing position and begins to run, it is said to be accelerating and when he is running at a constant rate of speed, it is said to have a velocity of so many miles per hour, then, when it slows down and finally stops, what is it doing? There are two possible ways to answer this question. By the first way, if you consider the animal's first running as positive, you can call that portion of his movement "positive acceleration" and then its slowing down becomes "negative acceleration". By the second way, you can refer to his original picking up of speed from a standing position as "acceleration" and his loss of speed as "deceleration". You can apply both methods to the case where you pick up a rock and throw it in the air in hopes of hitting a rock first thrown up in the air by a friend. As your rock appears to "climb" into the air, it is being pulled down by the force of gravity, "negative acceleration" or "deceleration". It reaches a point where it appears to stop, zero or no acceleration, and then starts to drop, slowly at first and then increasingly more rapidly, "positive acceleration" or "acceleration" The pull of gravity which was being exerted on the rock is referred to as "1 g". In later inquiries you will be exploring various "g" forces as they may affect man's ability to live in his community, home, self-contained units and in the exosphere.

D. Physiological Stresses
    2. Acceleration
        a. Earth As A Universe

INQUIRY NO. 31 AS THE TWIG IS BENT . . .

Basic Concepts:

Falling objects are uniformly accelerated.

Acceleration due to gravity is responsible for many phenomena on the earth's surface.

Acceleration is the time rate of change of velocity.

Sequence - Summary

Examples of acceleration due to gravity's effect on plant and animal life:

1. action of water
2. landslides
3. filling in of lakes
4. glacial gouging of mountain ranges

Examples of acceleration over the earth's surface not associated with acceleration due to gravity:

1. footrace
2. wind on sails of ship

Activities - Illustrations

Discuss:

1. Ways that acceleration due to gravity have been observed by man over the centuries.
2. Role of gravity in the existence of an atmosphere on some planets and not on others (include our moon)

Demonstrate role of gravity in root response (geotropism).

Encourage students to act out various

3. cloud movement
4. windmill action
5. portions of a bird's flight

forms of positive acceleration, negative acceleration, and zero acceleration. Help them distinguish between acceleration and velocity.

1. Secure a long inclined plane and, after stationing students at various points, try to determine the distance travelled by a ball at the end of 1 second, 2 seconds, 3 seconds. Try it with two balls of the same size; with balls of different size but equal weight; and, with balls of different size and different weight.

D. Physiological Stresses
2. Acceleration
b. Community and Home As A Universe

INQUIRY NO. 32

COMMUNITY ON THE GO
(Primer)

The hustle and bustle of everyday activity in a community is a healthy indicator of its continued growth and prosperity. In the provision of many services for its members, the community leaders utilize, and in some instances, control acceleration. You may have already mentally identified some of the services. Transportation systems, whether by bus, train or airplane, involve the physiological stress of acceleration and deceleration (positive and negative acceleration). Elevators, escalators and the fireman's polished brass pole provide exciting images of a "fun" ride with the startling sensations involved being attributable to the accelerative effects. An icy street or doorstep may provide a too-sudden acceleration and deceleration which may result in a head lump or a pair of crutches as companions for several weeks. Many industrial processes utilize acceleration. The noisy piledriver with its alternating "hiss" - "plunk" - "hiss" etc.; the milk separator whirling in circles at high speeds to enable the milk producer to remove the cream from the milk (which floats on top, skim milk or cream?); and, the mammoth stamping machines which make our car's fenders with a single stroke are important industrial examples. But what of the need to control acceleration? Bordering your school are signs which read, "School Zone - Go Slow". In many cases, the rate of speed (velocity) is specified as "15 Mile Speed Zone". On the expressways, similar signs, indicating both minimum and maximum speeds are posted. Community control of velocity and changes in velocity by automobile drivers is an important public safety service. Perhaps your teacher also uses such controls when you are in the school halls. When she suggests you walk rather than run, she is concerned about the possible effects a change in your velocity may produce when you come in contact with other students or objects. Let us examine this change in velocity or acceleration - deceleration problem for a moment. If two objects, one weighing 50 lbs. and the other 100 lbs., were to be moving at the velocity which would you find easier to stop? To make the picture more graphic, assume one object were a 150 lb. track star and the other were a 240 lb. tackle for the Baltimore Colts. You would agree that, although they are going at the same velocity, the heavier objects would be more difficult to stop. It has a greater resistance to change in velocity, a property which is called inertia. It is your momentum (your mass, a measure of inertia, multiplied by your velocity) which, when you run down the hall, concerns your teacher.

In this inquiry, you will seek out ways whereby changes in velocity are both useful and a problem to the community and in the home.

Rocket sled testing to determine man's capacity to tolerate rapid acceleration and deceleration was among the earliest controlled-experiment approaches to the problem. Note the placement of sensors (accelerometers) and the need to place a strap across forearms, thighs and feet. What suggestions would you offer as to the ways this testing was recorded. What evidence in the picture can you single out to support your contentions?

D. Physiological Stresses
    2. Acceleration
        b. Community and Home As A Universe

INQUIRY NO. 32 COMMUNITY ON THE GO

<u>Basic Concepts</u>:

Velocity and changes in velocity must be controlled for the protection of community members.

Changes in velocity are an important aid in many industrial processes.

<u>Sequence - Summary</u>

Ways acceleration is useful to community members and in the home:

1. industrial uses
2. medical uses
3. home appliance uses
4. other uses as suggested by students

Controls which are placed on velocity and changes in velocity within the community or in the home:

1. speed limits

<u>Activities - Illustrations</u>

Demonstrate the action of a Babcock milk separator.

Encourage students to find pictures of various industrial uses of velocity and changes in velocity.

Ask students to describe their reactions when on a swing, on a ferris wheel, in an elevator and on various carnival "rides".

Help students compile a list of traffic rules which apply to velocity and changes in velocity.

2. automobile governors
3. traffic signs
4. banked curves on highways
5. others as suggested by students

Discuss drag strip racing.

Test a moving vehicle with a doll (or reasonable facsimile) fastened with a safety belt.
Try the same with the doll unfastened and compare results.

Build curves (flat and banked at various degrees) and test toy cars to see what affect banking has on sliding of car.

After a three-orbit space flight, this astronaut was asked to walk a balance rail. What factors in his recent flight could have had an influence on his orientation triad?

D. Physiological Stresses 205
2. Acceleration
c. Self-Contained Unit As A Universe

INQUIRY NO. 33

THE VIEW FROM OUR EIGHTY-SEVEN MINUTE WORLD
(Primer)

In order for an organism to survive in its environment it must be equipped with some mechanism or mechanisms that respond to stimuli from the environment. These responses enable the organism to orient itself to its surroundings and to react to all things, both inside and outside of itself.

One of the many special features of protoplasm is its property called irritability. In the higher animals a vast, intricate system of highly irritable tissue has developed which we call nerve tissue. The structure of nerve tissue is such that its very low irritability threshold (low level of stimulation produces a reaction) allows the organism to react rapidly to changes in its environment. Activities such as walking and talking depend on proper responses to stimuli. However, response in itself is meaningless and might even be useless or destructive unless it was properly interpreted and then acted upon. Not only must a system receive the stimuli, it must be able to interpret it rapidly and correctly in order to produce a desirable reaction. Most of us have either experienced or witnessed examples of misinterpreted stimuli due to the effects of fatigue, drugs or illness, which in some way has affected the body's ability to correctly interpret stimuli.

Stimuli are received and acted upon either consciously or unconsciously. Unconscious responses are called reflex actions. The human body is arranged in such a manner that damage to one or even more than one sensory mechanism does not necessarily mean we would be unable to continue to act within our environment. We are able to substitute other mechanisms to compensate for a loss. However, the greater the loss, the more difficult it is to compensate for the loss.

The ear is an organ of hearing and equilibrium, with the hearing portion being a rather recent evolutionary acquisition. In the lower vertebrates, such as the shark, the inner ear labyrinth is concerned entirely with equilibrium or balance, and there is no hearing as we know it.

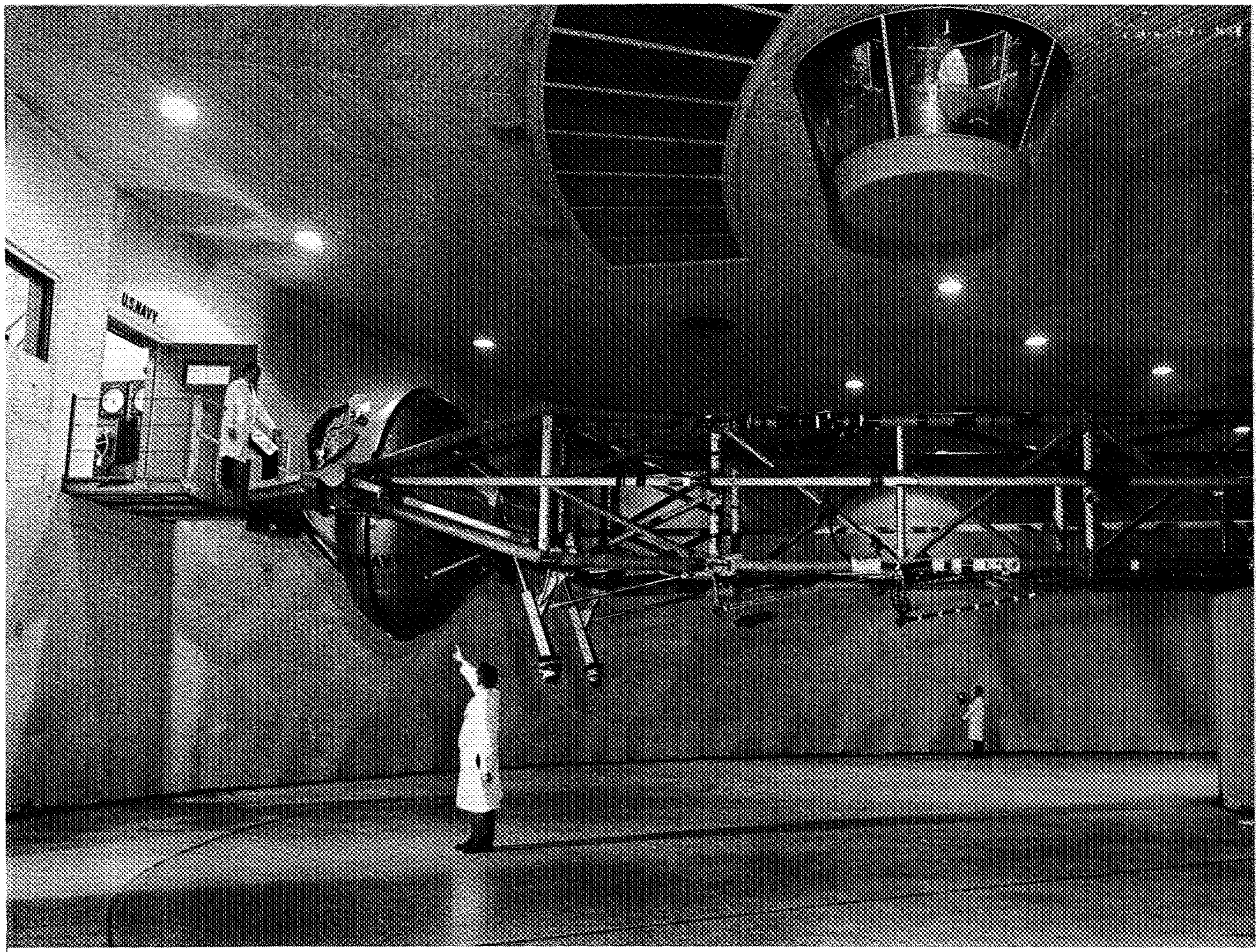
Within the human inner ear labyrinth are three semi-circular canals. Each of these canals is oriented in a different direction so that any movement by the head affects one or more of the canals. Each canal is filled with fluid so that as the head moves, the movement of the fluid acts on nerve endings which then 'tell us', through interpretation by the brain, how we are oriented in relation to the earth.

Man is most frequently involved in movements in the horizontal plane, as in walking, and for some poorly understood reason, movements in the vertical plane tend to produce sensations of nausea. This is a factor in seasickness, which can be greatly alleviated by lying down, thus changing the movement of the fluid in the canals from the vertical to the horizontal. Perhaps you have "left your stomach downstairs" while standing in a rapidly rising elevator. If so, you have experienced a sensation based on the same principle of disturbance caused by rapid vertical motion.

Destruction of the inner ear causes profound equilibrium disturbances. An experiment performed on a pigeon, in which the semi-circular canals were destroyed, resulted in the animal's inability to either stand or fly, although in time it relearned how to maintain equilibrium through the substitution of another sensory mechanism; sight. However, if it were blindfolded, the pigeon had the same equilibrium (balance) disturbances again.

The proper use of all our sensory mechanisms is developed through the learning process. Experience has taught us to evaluate stimuli, and,therefore, the more receptors we have in good functioning condition, the faster we are able to collect information and correctly interpret the nature of the world around us.

In this inquiry, you will test your own orientating senses and explore the problems which are associated with the operation of self-contained units when accelerative factors are present. In your mind's eye, you may join one of the astronauts and get his view of our eighty-seven minute world.



This device is a human centrifuge designed to test the human tolerance to high "g's". The seat inside the rotating chamber is swiveled so that the astronaut's head is toward the center of the circular track. Visual, auditory and sensory information are available to the control operator in the ceiling pod. What type of sensory data would be most useful to know if you wished to determine the physical condition of the astronaut at a particular "g"?

D. Physiological Stresses
  2. Acceleration
    c. Self-Contained Unit As A Universe

INQUIRY NO. 33 THE VIEW FROM OUR EIGHTY-SEVEN MINUTE WORLD

Basic Concepts

The human body includes systems which, operating together, provide orientation information.

Sequence - Summary

Three systems provide orientation:

1. Inner ear (vestibular)
2. Sight
3. Kinesthetic (muscle sense)

The three systems are known as the orientation triad. Any two of the triad will suffice for ordinary situations.

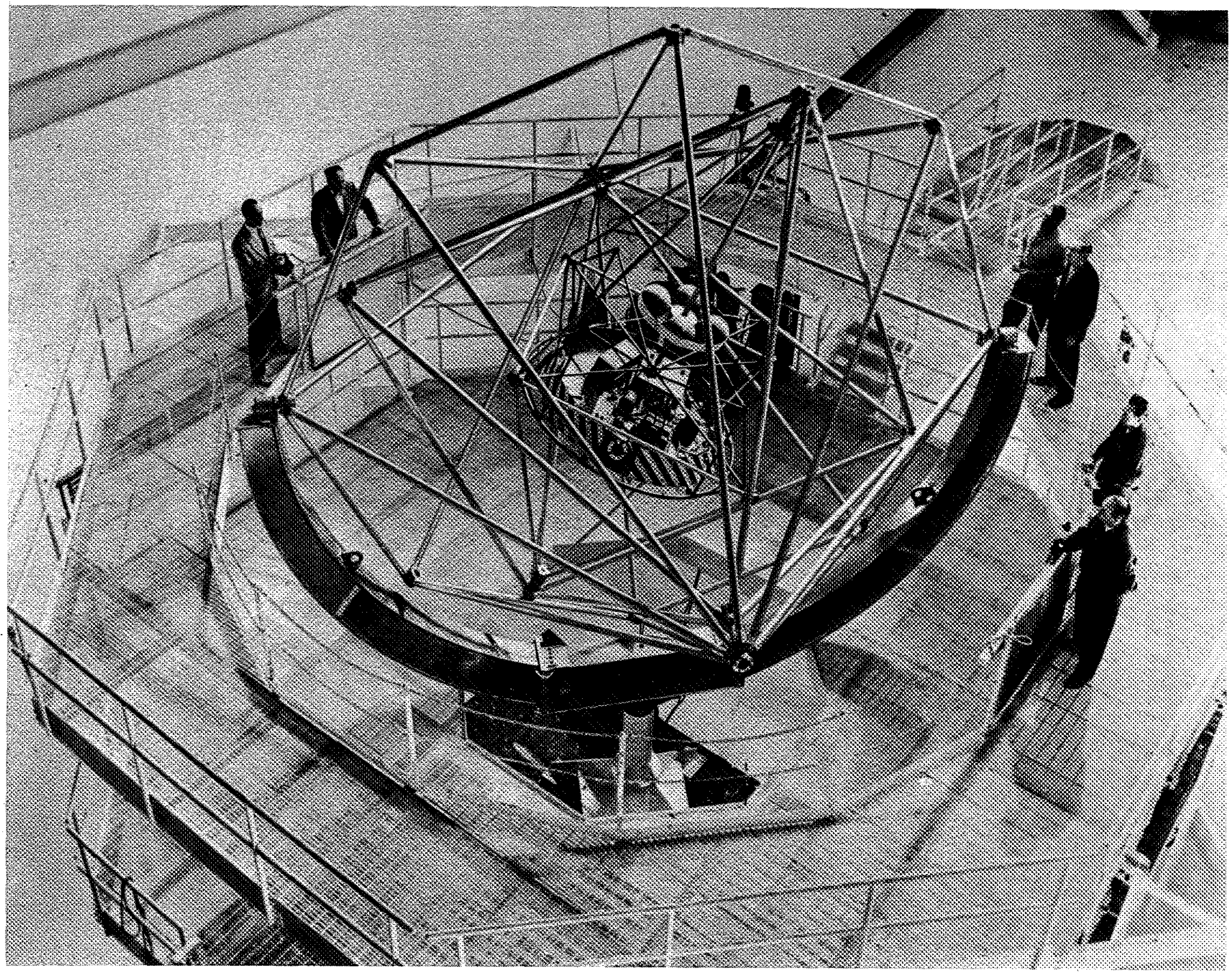
The orientation triad, under certain conditions, will produce false information.

Activities - Illustrations

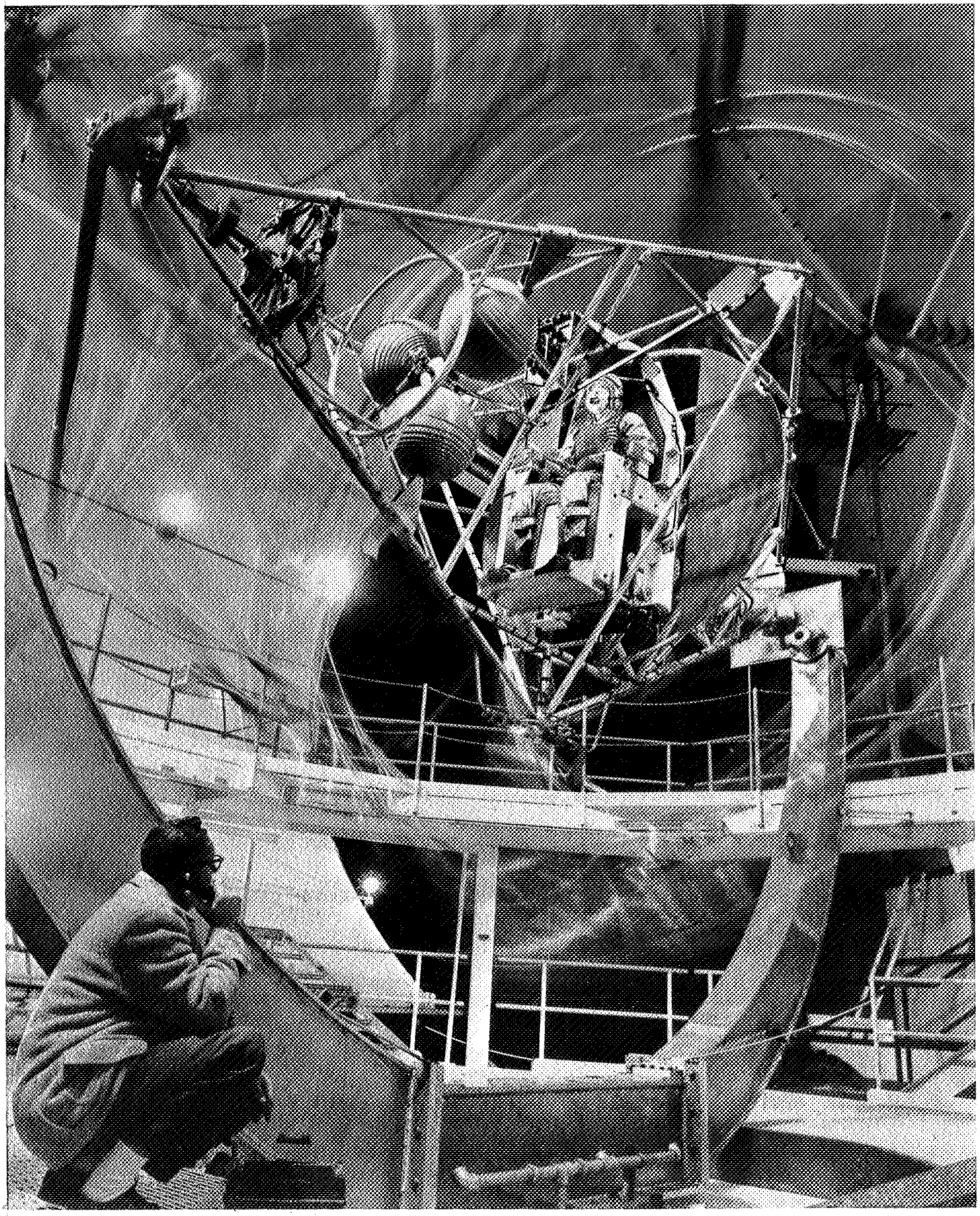
Discuss with the students:

1. How do we know we are standing upright?
2. Can we still tell our position without the information provided by our eyes? How?
3. Are we able to tell we are moving in a car when our eyes are closed?

Revolve partner on rotating stool (20-25 revolutions), stop suddenly. Ask him to walk in a particular direction. With partners, blindfold seated student and tilt his chair in several different directions? Can he orientate? While student is revolving clockwise on chair, ask him to look quickly over his left shoulder. Sensation? Possible cause?



Can you trace out the three paths of movement, pitch, roll, and yaw, on this device. By simulating the action of a tumbling capsule in space, this device can be used for training and orientation purposes. Encourage a student with handicraft talents to construct a model of this MASTIF (Multiple Axis Space Test Facility). Contrast this photograph with the one in which the astronaut has stabilized all axes.



The astronaut controls the three paths of movement, pitch, roll and yaw, by releasing jets of compressed carbon dioxide gas. These jets either increase or decrease the rate of rotation along one of the three axes. Note the position of equilibrium at the time of the photograph; with all three axes stabilized, the astronaut, in the view of the observer, is in a fixed position.

D. Physiological Stresses 210
2. Acceleration
d. Exosphere As A Universe

INQUIRY NO. 34

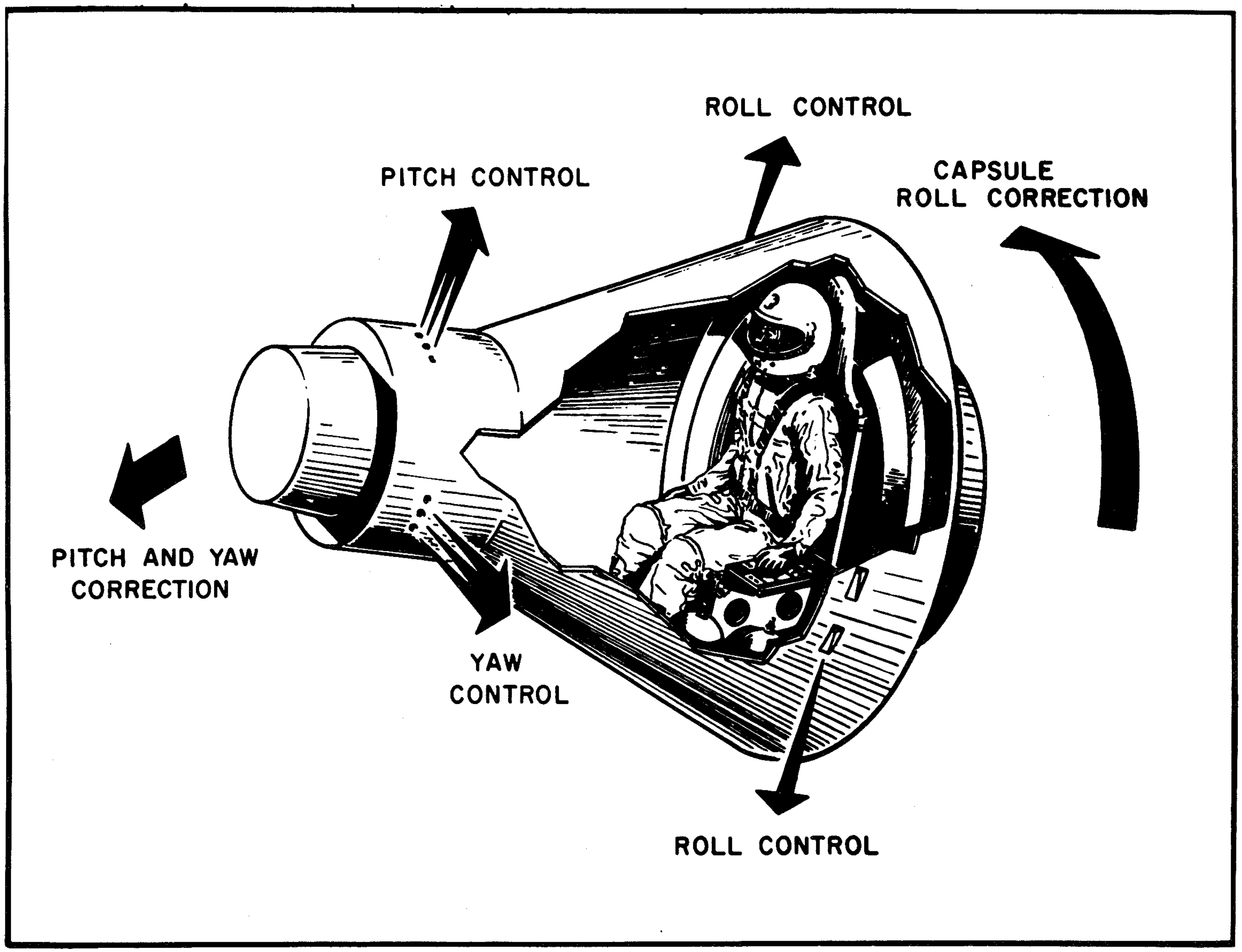
EYEBALLS IN, EYEBALLS OUT
(Primer)

On a piece of paper, draw two lines meeting at right angles. Such a figure would be useful in describing two-dimensional objects such as squares or rectangles. To make our drawing three-dimensional, we would have to shift to some type of perspective drawing, or simply assume that a third line is present, going from where your eye is located, through the point where the two lines met, and out the back of the paper. Either solution to our three-dimensional problem is not very satisfactory. A problem along the same lines arose when interest in the exosphere was directed to the problem of acceleration and the human body. While on the surface of the earth, we can conveniently refer to acceleration away from the earth as positive, and acceleration toward the earth as negative. Even when a pilot goes into the earth's atmosphere, he still has a reference point, the earth, even though he now has a three-dimensional situation. The astronaut also has a three-dimensional situation but cannot rely on earth for any up or down reference point. The problem thus arose, "What to do?"

Airplane pilots have developed their own language to explain the various directions which an aircraft can go during flight. If you assume that there is a point on the airplane, behind the pilot's seat and between the wings, where all of the weight of the airplane is located (center of gravity), then you can follow this explanation of the three basic directions, pitch, roll, and yaw, in which an aircraft can move during flight. If the nose of the aircraft goes down and the tail goes up, the movement along that direction is "pitch"; if one wing goes up and the other wing goes down, possibly completing an entire circle, the movement along that direction is "roll"; and, if the nose of the plane goes to the right, tail to left, and then the nose goes to the left, tail to the right, while you are trying to keep the nose pointed straight ahead, the movement along that direction is "yaw". An astronaut also can use these three directions, pitch, roll and yaw, to describe the path of flight his spacecraft is making. However, since each movement produces an acceleration of its own, how can he describe his sensations so that design engineers can be sure that the equipment they are assembling will satisfy the astronaut's needs? A rather elaborate system was devised so that the three-dimensional drawing that was mentioned earlier appeared as though the point where all three lines joined was the location of the astronaut's heart. (Make a drawing to satisfy yourself as to the way in which this would work. Do you see any drawbacks?) During the centrifuge and MASTIF Testing (device which provided all three directions, pitch, roll, and yaw simultaneously) with the astronauts, they developed a new terminology, based on the effect of the various movements on the fluid of the eyeball and consequently, on the eye muscles which control eye movement.

When there is a change in direction by the head, the fluid in the eye, at rest in its present position, resists any shift to a new position. This resistance is referred to as the inertia of position. When the fluid does move, it is accelerated to the same velocity as the movement of the entire head. When the head stops, the fluid, now in motion, continues to press against the muscular walls of the eyeball as it gradually slows down (decelerates) and comes to rest in the new position. This pushing against the wall of the eyeball as the fluid decelerates puts tension on the eye muscles which control eye movement, and this tension is interpreted by the brain. Some people report it this way: "We stopped so fast, I felt as though my eyes were going to pop out!" The astronauts capitalized on this accelerative-decelerative behavior of the fluid of the eye by using it to describe the various forces which they felt acting on them. Thus, the term, "eyeballs in" would indicate accelerative force (measured in "g's") tending to press the eyeballs toward the back of the eye sockets. Similarly, the terms, "eyeballs out", "eyeballs left", and "eyeballs right", were created and thus become a useful means for referring to the effective direction of the various accelerative forces acting on a human in space.

In this inquiry you will discover the kinds of experiments which have been carried out to reduce or eliminate acceleration problems as barriers to our excursions in space.



Correlate this diagram with the primer discussion. Encourage students to prepare drawings which illustrate the three paths of movement, with the common point of intersection being located at the astronaut's heart.

D. Physiological Stresses
  2. Acceleration
    d. Exposphere As A Universe

INQUIRY NO. 34 EYEBALLS IN, EYEBALLS OUT

Basic Concepts:

Physiological reactions to acceleration along three axes simultaneously (pitch, roll, yaw) in space differ from reactions to acceleration on earth.

Sequence - Summary

What are the physical effects of increased acceleration on the body?

1. Loss of balance
2. Visual changes
3. Muscular control and reaction
4. Orientation

Activities - Illustrations

Discuss relative rates of acceleration and physical comforts in cars, trains, planes, rockets. (See Appendix -, "This Is No Time To Blackout, Charlie")

Discuss:
  What factors will determine an increase of speed and direction?

Improvise a centrifuge. Conduct experiments with mice, increasing acceleration and time of exposure at various speeds. Chart observations.

Activities - Illustrations (Con't)

Useful References

Bioastronautics, Schaefer, (ed.), The Macmillan Company, 1964. pp. 4-26.

See Appendix VII, *The Influence of "4 g's" on Mice*, Jones, Douglas, (Abstract of student project).

Encourage students to experiment with an air puck.

Use a stream of air (compressed) to change direction and retard motion.

Design a small balsam rocket.

Use a CO_2 cartridge to produce thrust. Demonstrate rapid acceleration by mounting cartridge on straw. String a long line with line passing through straw. Discharge CO_2 cartridge.

Demonstrate Newton's Laws of Motion (See Glossary of Terms). Relate each effect to the problem of acceleration of humans in space.

E. PSYCHOLOGICAL STRESSES

Psychological stresses such as anxiety, disorientation and isolation are a part of our surroundings. As teachers in our role of counselor, friend, and confidante, we are often aware of the presence of such stresses and their impact on a student's behavior in the classroom. In preparing this material, it was our belief that this area should be included in the conceptual framework. You may find yourself seeking new techniques and resource materials as the students attempt to search out information and raise questions about these various psychological stresses.

An outline of the interaction of the stresses, universes, and inquiries is included below:

1. Anxiety, Disorientation and Isolation
    a. Earth As A Universe
        1). No. 35 Thor Is Angry Today
    b. Community As A Universe
        1). No. 36 The Ants Came Marching, Two-by-Two
    c. Home As A Universe
        1). No. 37 Home - An Anchor or a Sail?

d. Self-Contained Unit and Exosphere As A Universe

1). No. 38 Through Rain, Sleet or Snow . . .

E. Psychological Stresses 218
   1. Anxiety, Disorientation and Isolation
      a. Earth As A Universe

INQUIRY NO. 35

THOR IS ANGRY TODAY
(Primer)

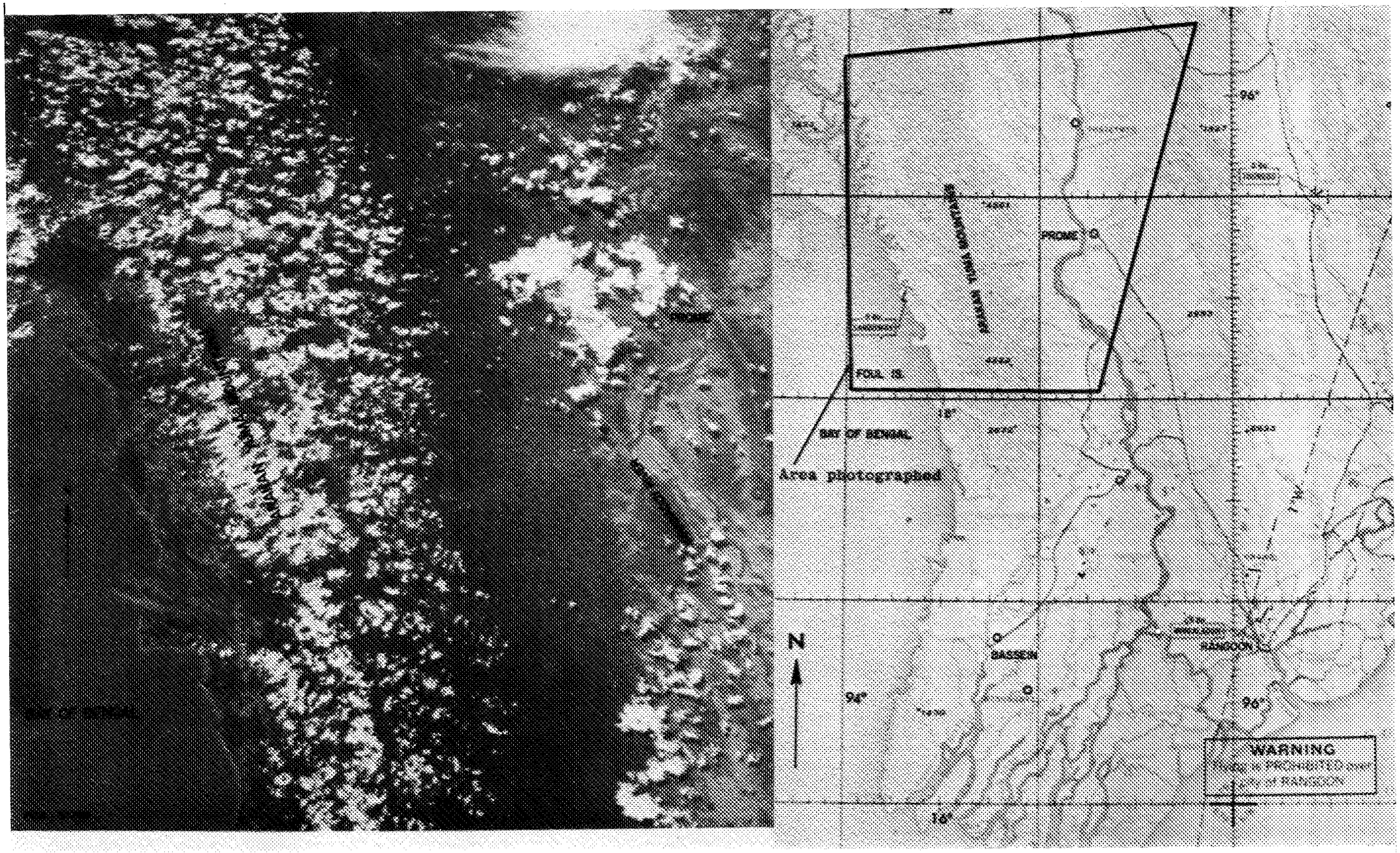
Since the beginning of time, man has been seeking explanations for events which influence his everyday life and livelihood. One of the earliest attempts to explain events was the use of **superstitions. It was man's** way of coping with the anxiety-producing phenomena of his own environment. To eliminate the "fear of the unknown", such explanations served a useful purpose. However, they were based on the limited information which was available, often without recourse to the recorded observations of others. One of the prevalent areas for superstition, even today, is in weather forecasting.

Despite the existence of modern weather forecasting techniques, we often make a weather forecast for our own use by a casual inspection of the sky. On the basis of the sequence of weather events which we are aware of in our immediate vicinity, we often can make reasonably good predictions to cover the next twenty-four (24) hours. In many parts of our country, the farmer recognizes that, when the wind shifts into the East and clouds appear in the Southwestern horizon, rain or snow often follows within the next twenty-four hours. To the mariner, a rapidly falling barometer indicates a severe windstorm. Forecasts of this nature, based entirely upon observations of weather in the immediate vicinity have been made by man for many centuries, although there is no record indicating the existence of any public or official weather service, based solely on such methods.

One of the greatest advances in weather forecasting came with the discovery that broad zones covering hundreds of square miles frequently experienced the same type of weather at the same time; these zones of similar weather characteristics also tended to move from place to place over the earth in reasonably predictable patterns. The construction of weather maps marked the beginning of our modern scientific weather forecasting techniques. Weather maps are charts on which weather observations, received from many stations and based on observations taken at the same time, are plotted on graphs and analyzed. The "weather picture" over large areas can thus be seen and studied.

The sequence of steps from superstition to observation, and finally, to ordered procedures for study and prediction, which has emerged in the field of weather forecasting is paralleled in our study of man's behavior patterns. In the absence of bodies of information, accumulated over time, and seeking ready solutions to the behavior of people, man has created a large body of superstitions. Only in recent years has an attempt been made to systematically study the human behavior patterns and to confirm or disprove these "old wives' tales". The area of study is referred to as "psychology", and from the work that has been carried out, much useful information regarding the psychological stresses such as anxiety, disorientation and isolation, which are the topics for study in this inquiry, has been developed.

In this inquiry, we shall look at man's first attempts to explain the phenomena which most directly affected his; namely, the forces of nature in the form of storms, seasons and animal movements.



Encourage your students to locate features indicated on the aerial map on the aerial photograph. Discuss the relationship between the topographical features (bay, mountains, valleys, etc.) and the location of the various cloud formations.

E. Psychological Stresses
   1. Anxiety, Disorientation and Isolation
      a. Earth As A Universe

INQUIRY NO. 35 THOR IS ANGRY TODAY

__Basic Concepts:__

Many laws or principles which govern our world have been discovered and implemented as common practice since the days when people relied solely on superstitions to predict or forecast the weather.

Superstitions are usually based on cause-effect relationships.

Weather phenomena can be explained by scientific laws, or principles.

__Sequence - Summary__

Weather phenomena (observed)

1. Precipitation; rain, hail, sleet, snow, etc.
2. Temperature: hot, cold
3. Humidity
4. Storms
   a. Thunder and lightning
   b. Hurricanes
   c. Typhoons
   d. Tornados
5. Atmospheric Conditions
   a. Pressure
   b. Winds
   c. Clouds

__Activities - Illustrations__

Perform the heat of evaporation and condensation demonstration. Use a __calorimeter__.

Squeeze a wet sponge to illustrate (condensation) precipitation.

Discuss and demonstrate the methods of heat transfer.

1. Convection
   a. Move a hot object from point A to point B
   b. Build a convection box to show convection currents

Weather Superstitions

1. Dew indicates a good day ahead; a dry morning is a sign of showers.
2. If the air is humid, rain is most frequent at the turn of the tide.
3. Smoke that curls downward and lingers means an approaching storm.
4. Lightning from the west or northwest will reach you; if from the south or southeast it will pass you by.
5. Sky full of cirrus clouds portends disturbance and rain on its way.
6. Birds sit it out before a storm.
7. Aching joints portend foul weather.
8. A veering wind is a sign of fair weather. Backing wind means rain.
9. Falling soot indicates a lowering of air pressure.
10. Red sky in the morning means foul weather. Red sky at night indicates fair weather.
11. The wider the middle brown band of the Wooly Bear the milder the approaching weather.

2. Conduction
   a. Show that heat movement is similar to falling dominos.
   b. Spoon in hot cup of coffee.
3. Radiation
   a. Use a radiometer near a heated iron.

Weather superstitions survey to determine the percentage of a population who believe or do not believe in particular superstitions.

Encourage students to correlate observed weather phenomena and superstitions related to them.

Help students start weather data collecting projects.

1. Weather superstitions
2. Forecasts from newspapers, Radio, T.V. etc.
3. Animal behavior - singing insects, birds, etc.

Set up a long-term series of astronomical observations.

1. Seasons and climates
2. Positions of the sun and earth's temperature
3. Climatic belts and geography
4. Temperature zones

ACTIVITIES-ILLUSTRATIONS (Con't)

Encourage students to build a model weather station

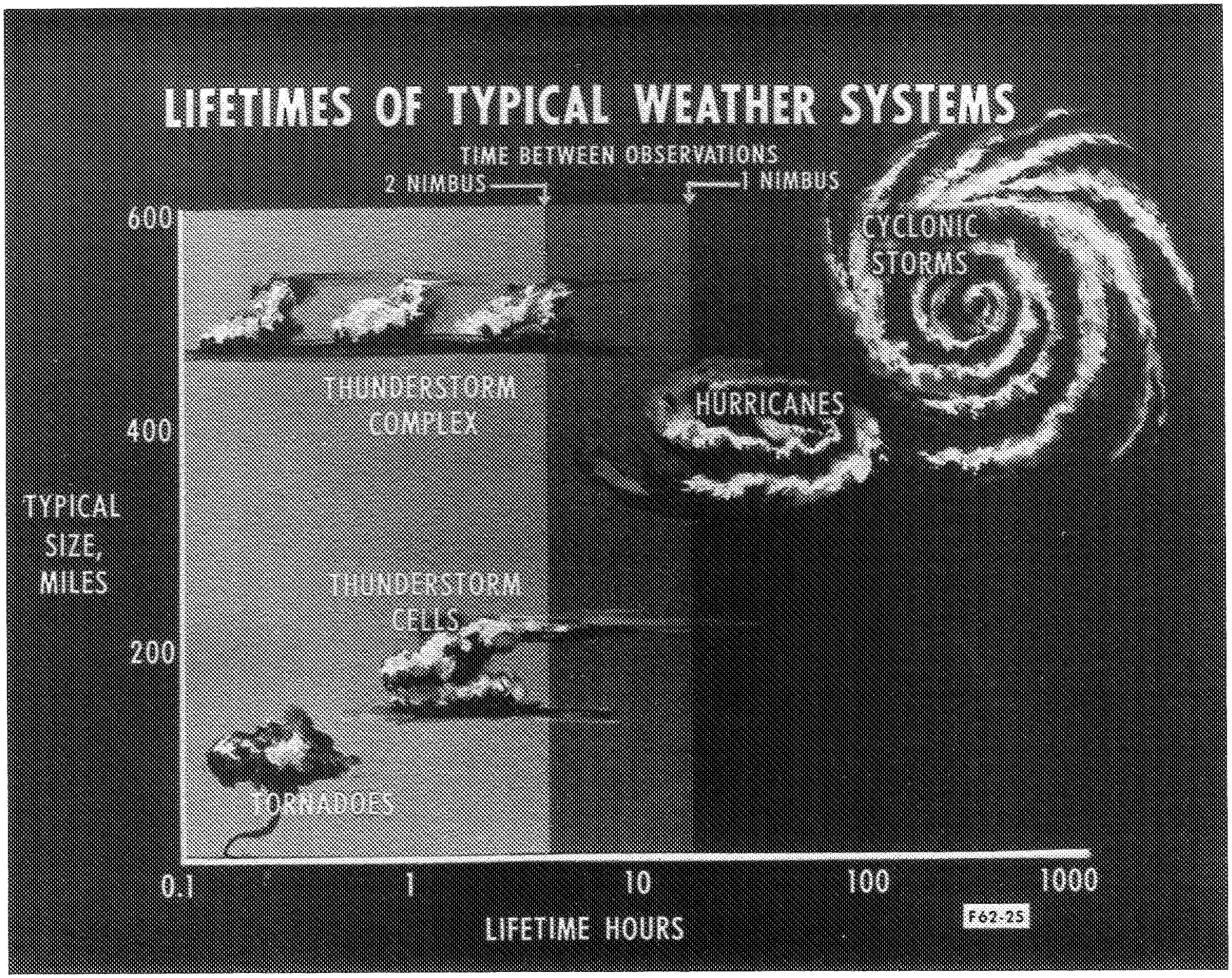
Ice filled glass container - watch droplets of H_2O collect on the surface. (Dew point determination).

Open pan of H_2O on radiator to show evaporation as related to temperature.

Observe the disappearance of a puddle on a windy day.

Observe what happens to steam when kettle is cooled.

Encourage students to observe the smoke from exhausts of cars in winter.



Encourage your students to contrast the duration of these various "anxiety-producing" natural phenomena with their own feelings as to the threat each represents.

E. Psychological Stresses 224
   1. Anxiety, Disorientation and Isolation
      b. Community As A Universe

INQUIRY NO. 36

THE ANTS CAME MARCHING TWO-BY-TWO
(Primer)

Social insects are fascinating to observe. If you have ever seen a bee hive in action or read about the social life of a termite, you will be aware of the high order of organization which is present. As long as each drone does its task, and each soldier remains alert, these two social organizations remain active and productive. Our community pattern of operation has many parallels to that of these insect forms. Within our community, tasks, such as fire control, police protection, road maintenance and many others, are the responsibility of particular segments of the total community. A break-down in the operations of any one of these community units will disrupt and, in line with our inquiry, disorient the members of the community. Rather dramatic examples of such disorientation include the 1906 earthquake and fire in San Francisco; the Chicago Fire ignited by the fractious "O'Leary cow"; and, the Good Friday earthquake and tsunami along the Alaskan coast in 1963. From your own experience, or newspaper and television viewing, many other examples may come to mind.

A second psychological stress present in any community is anxiety. The best example that immediately comes to mind is the housewife who, while on vacation hundreds of miles from home, wakes up in the middle of the night, shakes her husband awake and proclaims, "I forgot to unplug the iron!" The husband to reduce the anxiety, may respond, "Well, if the house had burnt down, we'd have heard from the fire department by now. Go back to sleep, dear." Our community setting does trigger various anxieties. We are dependent upon others for many of our services; these services are often vital to our well-being and comfort. Concern about our physical and social environment is present in all of us. In this inquiry, you will want to explore some of the causes of anxiety, and some of the "anxiety reducers" which are present in any effectively functioning community.

The last psychological stress to be considered is isolation. There are many forms of isolation: an animal may be stranded on a sandbar in the middle of a river (geographical isolation); some animals aggressively attack each other except during the mating season (cyclic isolation); some life forms are found only in certain areas with a certain temperature range and annual rainfall (ecological isolation); or, climatic conditions such as snow, monsoons or ice may restrict contact with other similar animals during parts of the year (seasonal isolation). Within the community, there are other forms of isolation. If a group of classmates choose up sides for a game, and you are not chosen, that's a form of isolation; if you are in an elevator that fails to work properly, that's a form of isolation; or, if you have a very contagious disease and are quarantined, that's yet another form of isolation These last examples were deliberately chosen to illustrate examples of isolation which were not of your own choosing, and therefore, would produce considerable stress. You may deliberately choose to be isolated; alone with a book by the fireplace on a snowy day, or alone for a long walk through the woods in the fall of the year, with the autumn leaves "snowing" on the forest floor may be an attractive recreation for you. One might generalize and say that the degree of stress that isolation creates depends upon the duration of the isolation and the extent to which it is involuntary.

E. Psychological Stresses
1. Anxiety, Disorientation and Isolation
b. Community As A Universe

INQUIRY NO. 36 THE ANTS CAME MARCHING TWO-BY-TWO

Basic Concepts:

Community disorientation is an interruption or disruption of agencies or conditions on which the community is normally dependent.

Anxieties arise from physical and social environment.

Man reacts to the stresses of anxiety in the direction of reduction.

The degree of stress that isolation creates depends on the duration of isolation and the extent to which it is involuntary.

Sequence-Summary

1. Disorientation:
Community organization is vital and in order to be successful, must be functional.

The community is an interrelated phenomenon. (There are many types of interdependencies).

Activities-Illustrations

Collect and interpret data from news media on a natural disaster as it affects the community in which it occurred.

Use ant communities to observe effects of interruption or disruption of conditions such as
a. Removal of queen
b. Invasion

The Biotic Community Concept:

a. This is an assemblage of populations living in a prescribed habitat.
b. It is a loosely organized unit to the extent that it has characteristics additional to the individual and population components.
c. It is made up of a natural assemblage of various sizes.

Major communities are almost wholly independent of adjoining communities when they are of sufficient size and completeness.

The community can be considered as a unit organism.

Any organism is the sum of its parts and the parts of the community are the individuals and groups that are in it.

Any condition that comprises an emergency for the whole community may result in community disorientation.

c. Flood
d. Food shortage

2. Anxiety:
   Causes of anxiety:
   a. Lack of information
   b. Prejudices
   c. Misunderstandings
   d. Fatigue
   e. Isolation

Discuss personal experiences in adjustment to a change in social contacts such as a new neighborhood, new school, new class, new teacher, etc.

   Effects of anxiety:
   a. We tend to get "silly".
   b. We don't do things as well.
   c. We are more likely to get into scraps with others.

Discuss personal experiences, books, movies dealing with effects which have been ascribed as anxiety-induced.

   Reducers of anxiety:
   a. Fire protection
   b. Police protection
   c. Penal system
   d. Communication on person-to-person and leader-to-community levels.

Discuss the way in which policemen, firemen, lifeguards, etc. act as "anxiety reducers."

3. Isolation
   Psychological isolation
   a. Race
   b. Language
   c. Economic
   d. Cultural

Encourage students to role play in the following situations:
   a. Spanish-speaking student in a group of only English-speaking students.
   b. Negro student in a group of

Physical isolation
a. Lack of communication and transportation.
b. Community protection due to illness, physical or mental
c. Perceptual isolation (handicapped)

white students.
c. Poor child in group of wealthy students.
d. A student not accepted by the group.

List types of punishments most disliked.
a. Role play these:
   1) Student absent from school
   2) Child lost in a large city
   3) No radio or TV
b. Isolate baby chicks or birds and observe their behavior.
c. Role play being blind, deaf, or crippled.

What public health measures are taken in the case of an epidemic?

What controls are placed by the society on our behavior toward each other in the area of crime?

E. Psychological Stresses 231
  1. Anxiety, Disorientation and Isolation
    c. Home As A Universe

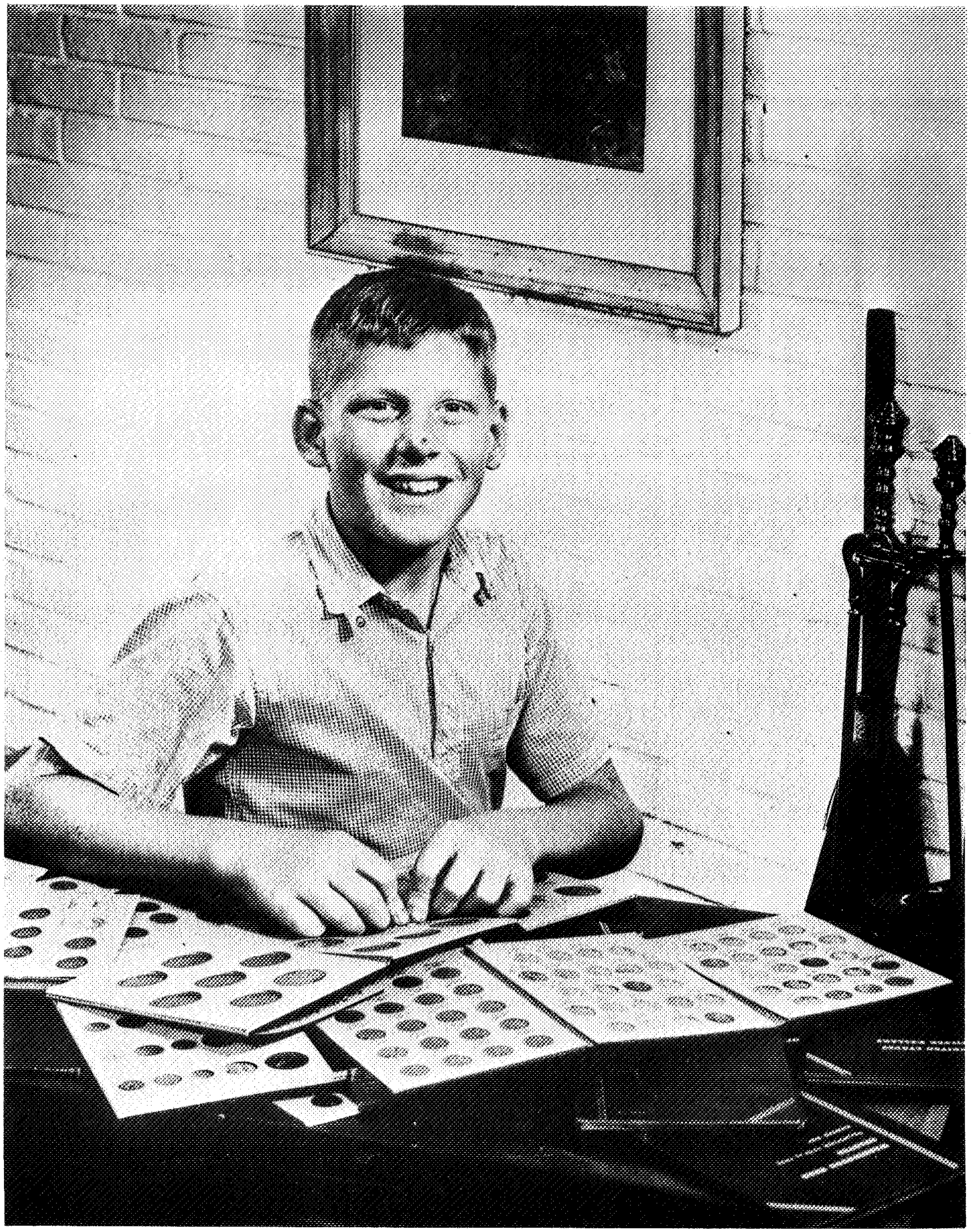
INQUIRY NO. 37

HOME - AN ANCHOR OR A SAIL?
(Primer)

If one of your parents told your brother and you that you would receive twenty dollars if you would sit in your room all day without doing anything, would you do it? Would a need for money be important enough to you that you would be able to hear the sounds of your friends having fun outside without having a sinking feeling in your stomach, a pounding heart or a rapid pulse? If your brother were to go out with his friends and you were to remain in your room, psychologists would say that his learned need is acceptance by his friends and that yours is money.

Each one of us, even members of the same family, have different learned needs. Each of us seek things which we feel we must have if we are to survive. These needs determine how we act and what we think about. They are mental, emotional, and physical. Examples would include a need for social status, for love and acceptance from one's parents and friends, for ample meals, for comfortable temperatures, and for much or for little physical activity. Are these needs essential to survival?

Consider the member of your family - what are the needs of each person? What are the ways each person satisfies his needs? Seeking ways to satisfy one's needs gives man a reason and purpose for living. If we know the psychological needs of the members of our family and can contribute toward their satisfaction, our family life situation is improved. Skill in achieving this goal takes time; however, it does point the way for us to learn how to make friends outside of our family circle.



Involvement in hobbies is one way to satisfy learned needs. What other avenues are available to your students?

E. Psychological Stresses
1. Anxiety, Disorientation and Isolation
c. Home As Universe

INQUIRY NO. 37 HOME - AN ANCHOR OR A SAIL?

Basic Concepts

Man needs a purpose for his activity--(or lack of it). Man's mental, emotional, and physical needs must be met in order to survive.

SEQUENCE-SUMMARY

Needs which are present in humans:
1. Social status
2. Love and affection
3. Material goals
4. Food
5. Recreation
6. Others as suggested by students

Ways to achieve a balance of needs to opportunities and abilities:
1. Purposeful activity
2. Long-range planning
3. Reliance on others to help maintain mental balance

ACTIVITIES-ILLUSTRATIONS

Place two children in each of two different rooms.
1. Group A--Nothing to do.
2. Group B--Choice of activity--NOT school work. Leave for a period of time. Return to class.
3. Have them evaluate their reactions:
   a. How did you feel?
   b. What did you think about? Etc.
4. Group tabulation of choices and/or individual charts of:
   a. Food
   b. Recreation
   c. Needed activity and amount
   d. Temperature at which comfortable

ACTIVITIES-ILLUSTRATIONS (Con't)

Useful Techniques For Teachers:

Research reading on all basic concepts.
Films--better for teachers as background, than for children in many cases.
Professional personnel - lecture or informal talk and quiz period.
Discussion groups - on basic questions.
Interviews.
Wall mural or frieze.
Movie - child made. Puppet show
Dramatization, Demonstration.
Dialogue, Monologue.
Charts.
Scrapbooks - Individual, Group
Original stories - poems

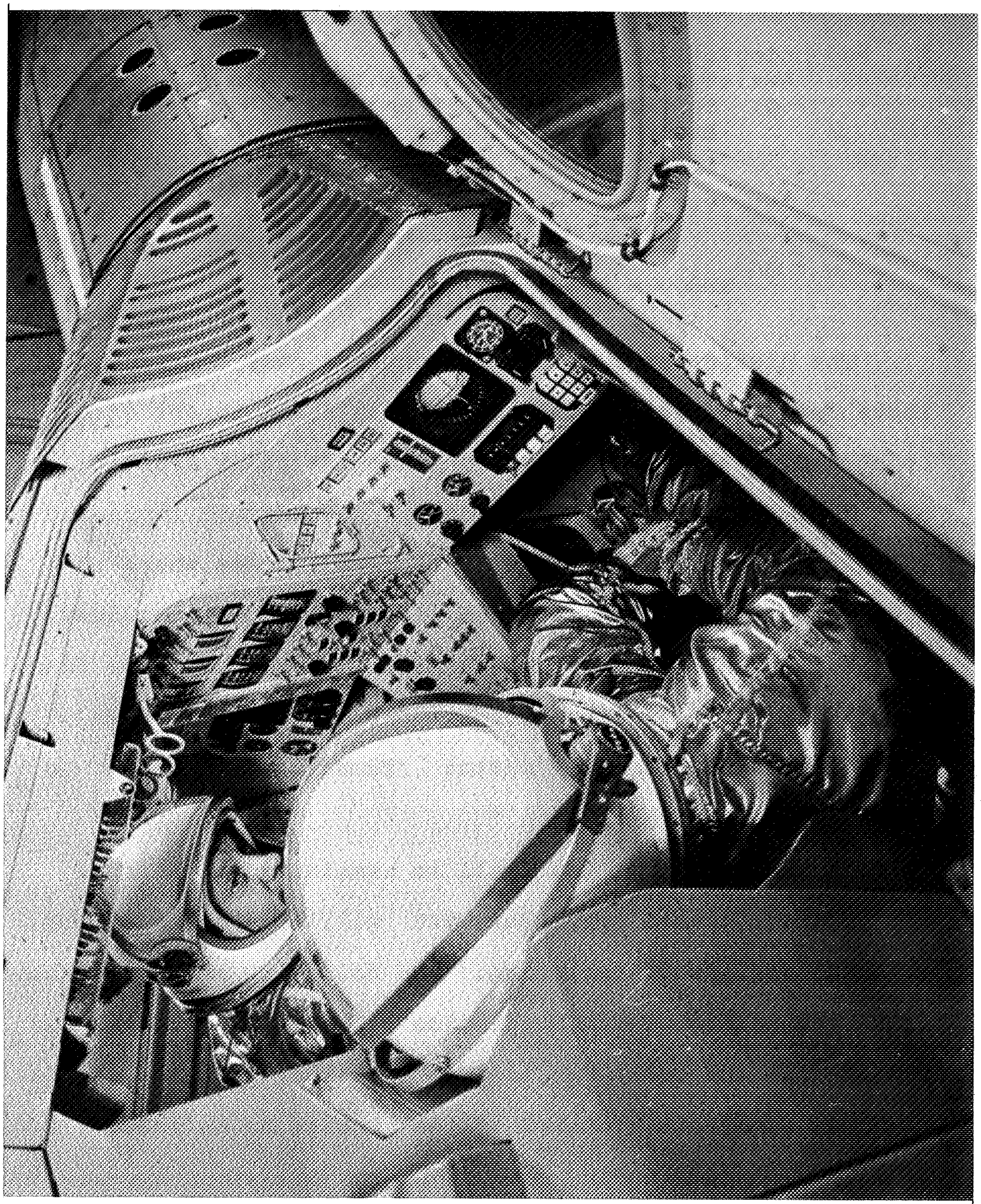
e. Noise--kind preferred--tolerated amount
f. Time--need to know--value of
g. Rest--amount

5. Recall and/or draw, tell dramatize...
   a. Any time when YOU were very happy. (Observe what people are involved directly or otherwise in individual's pleasure).
6. Do group sociogram--note ISOLATES??? No one chooses a particular person as partner or group member.
7. Discuss:
   a. What people do we NEED?
   b. If you could only choose one person to be with for this time, WHO would you choose? (NOTE significance of choices, and relationship with individuals.
8. Recall personal experiences:
   a. "You can have all you want of..." Result????
   b. "You can do...as much as you like..."!!!!

ACTIVITIES-ILLUSTRATIONS (Con't)

c. What happens when you <u>want</u> something and CAN'T <u>have</u> it??

d. What happens when you <u>need</u> something and CAN'T <u>get</u> it??



What problems would you forsee for two men who may need to sit, side-by-side for periods of time exceeding three weeks?

E. Psychological Stresses
1. Anxiety, Disorientation and Isolation
d. Self-Contained Unit and Exosphere As A Universe

INQUIRY NO. 38

THROUGH RAIN, SLEET, OR SNOW . . .

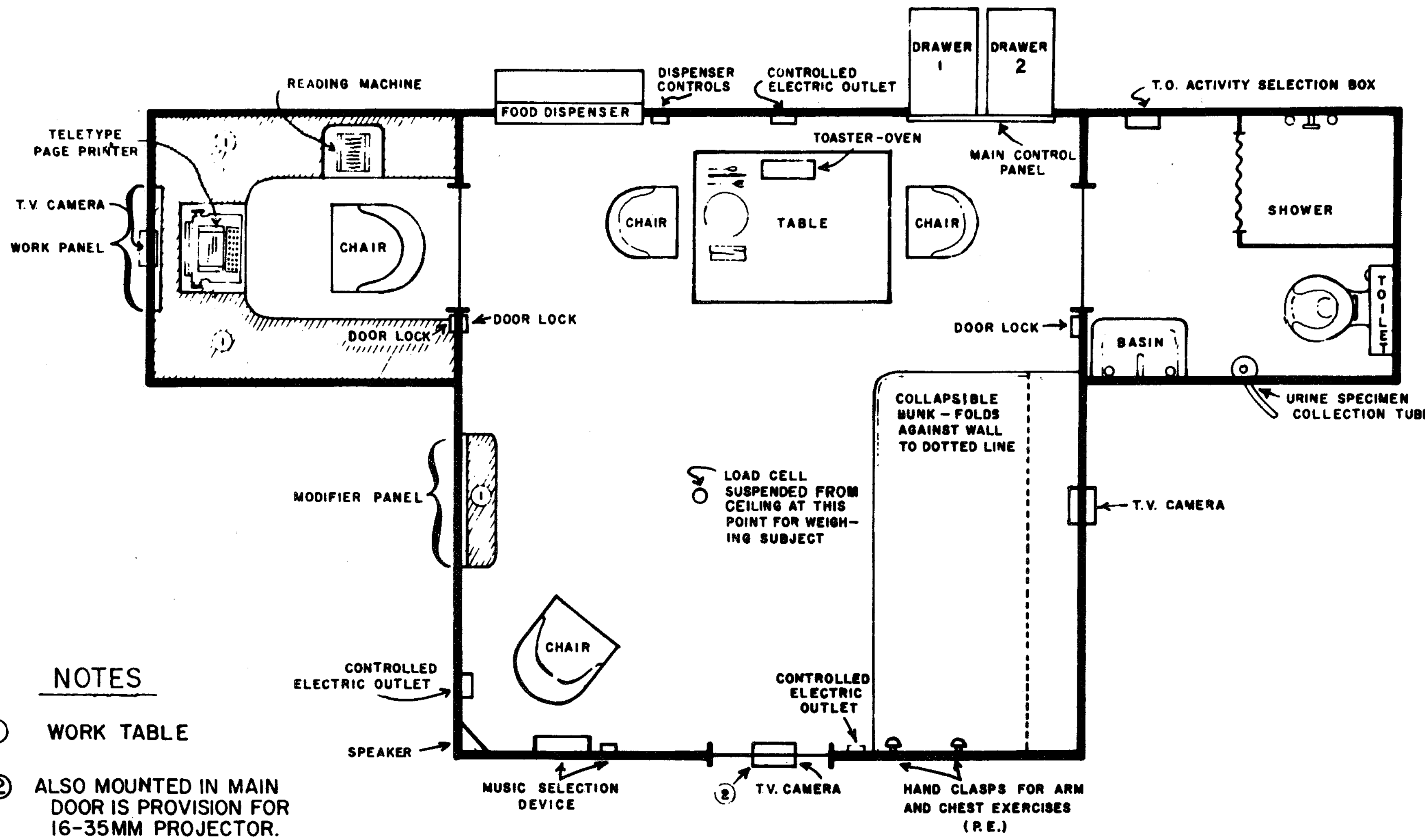
The history of our country contains many stories of instances of man's devotion to duty in the interest of our country's growth. The first Pony Express rider crossing hostile territory, and the Lindbergh solo flight represent outstanding examples of individual performances where endurance while isolated from one's fellow man was required. Less glamorous but equally significant examples can be found in military and civilian occupations, perhaps best exemplified by the postman's motto: "Through rain, sleet or snow, the mail goes through."

In this inquiry, you shall be examining how man, in his progress toward space conquest, will need to cope with extended periods of isolation. The following excerpt, taken from "The Mind and Its Integration", by Donald O. Hebb, was reported in the book, Man and Civilization: Control of the Mind; it sums up the nature of the problem to be solved:

> An outstanding feature of the isolation experiment was the demonstration that intellectual work - mental activity initiated from without - is wholly essential to the human being. Now, in one way this is nothing new, except for showing how strong such a need can be; but mostly we have concealed the fact from ourselves, in the first place by giving a special name, "play", to work that is done for

its own sake, thus not classing it as work, and in the second place by assuming, when the question comes up of the man who likes useful work, who likes his job and does not want to retire, that this is an acquired motive, the result of long-established habit.

. . . One strategic consideration in the control of the mind, then, is man's insatiable need for intellectual activity, environmentally initiated but self-paced. It is, of course, equally obvious that there is a great deal of intellectual activity that he is opposed to: he objects to work when it is imposed from without, when it is not of his own choosing, and especially when it is in any way monotonous.

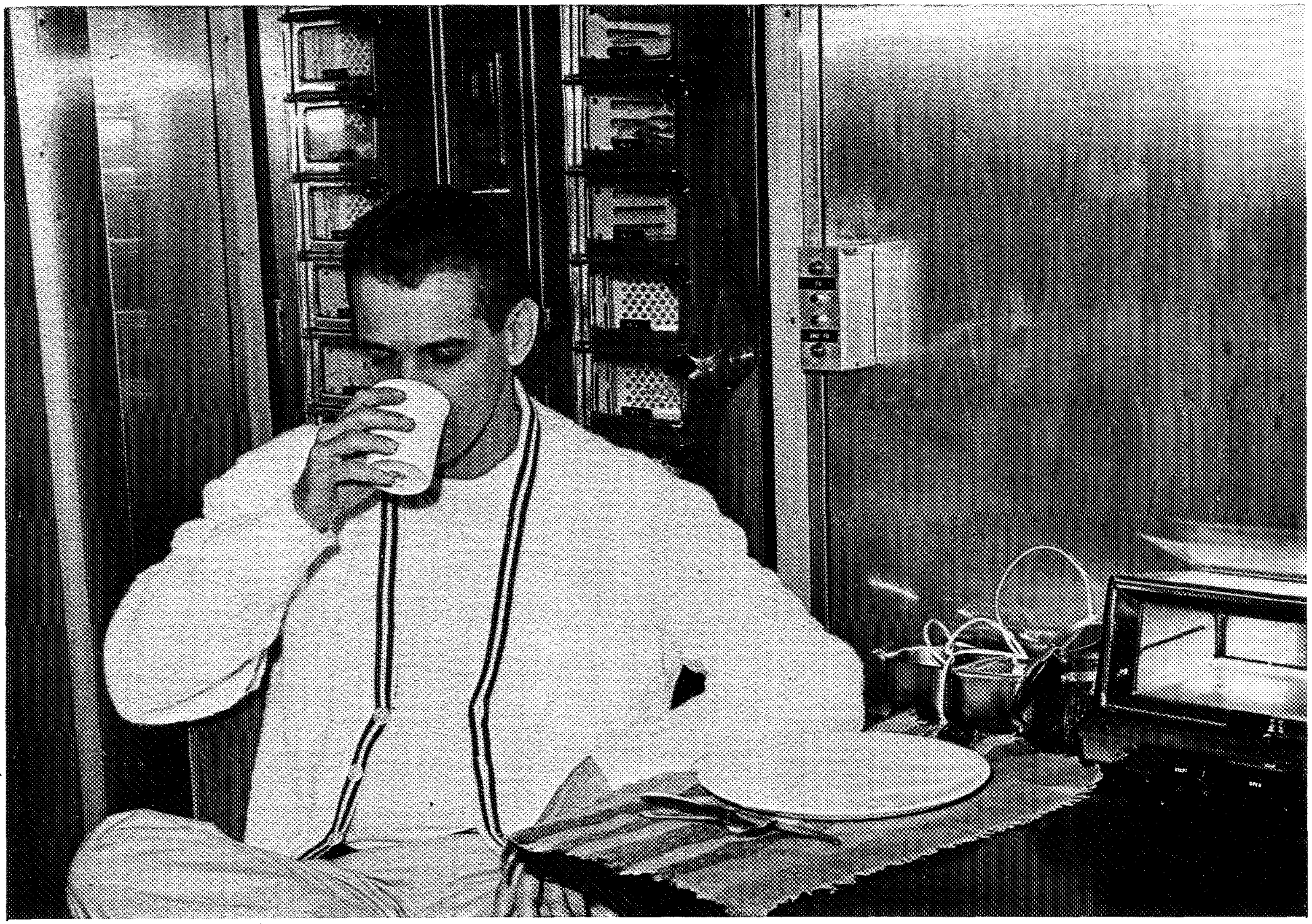


NOTES

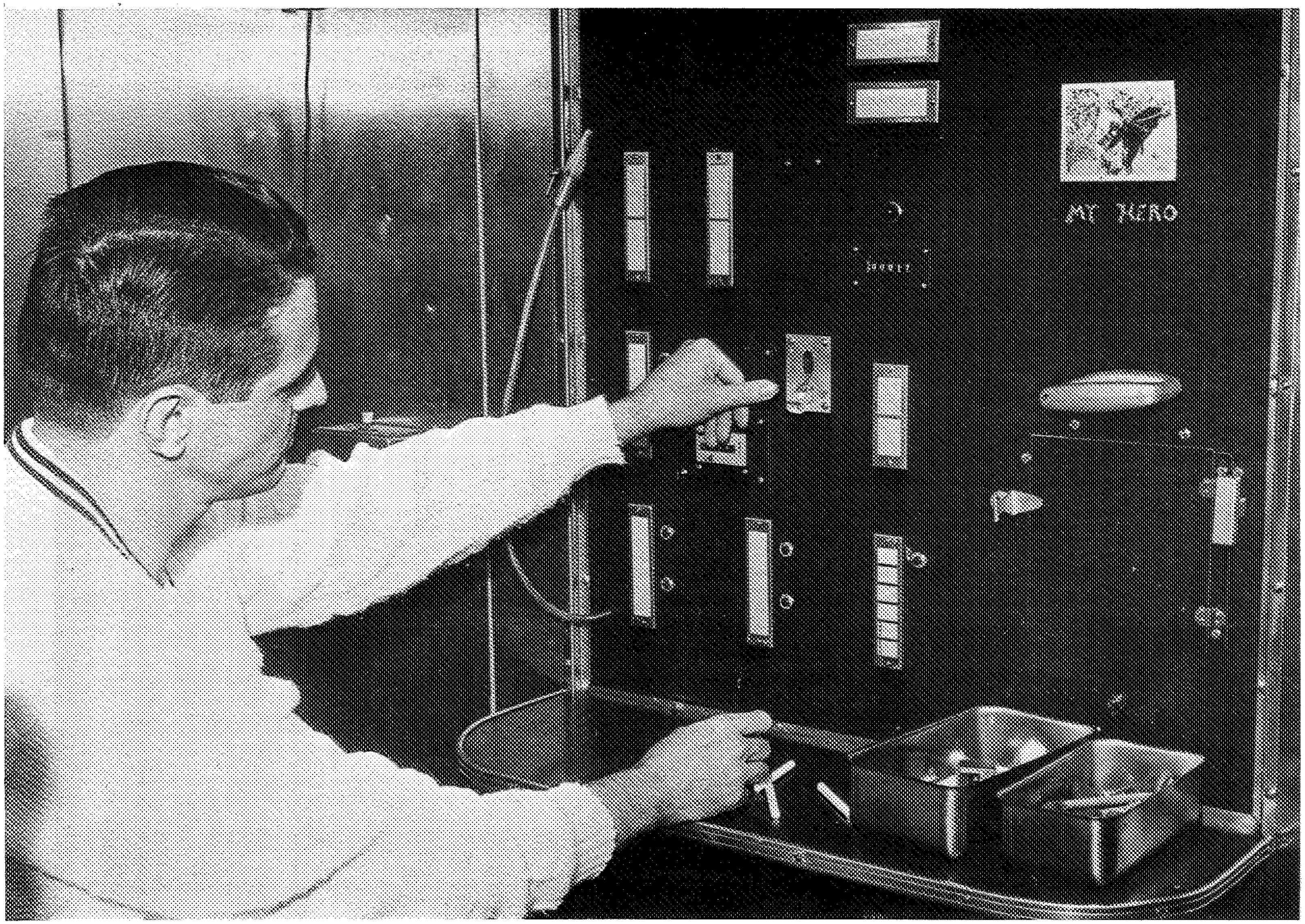
① WORK TABLE

② ALSO MOUNTED IN MAIN DOOR IS PROVISION FOR 16-35MM PROJECTOR. A SCREEN HANGS ABOVE THE TABLE.

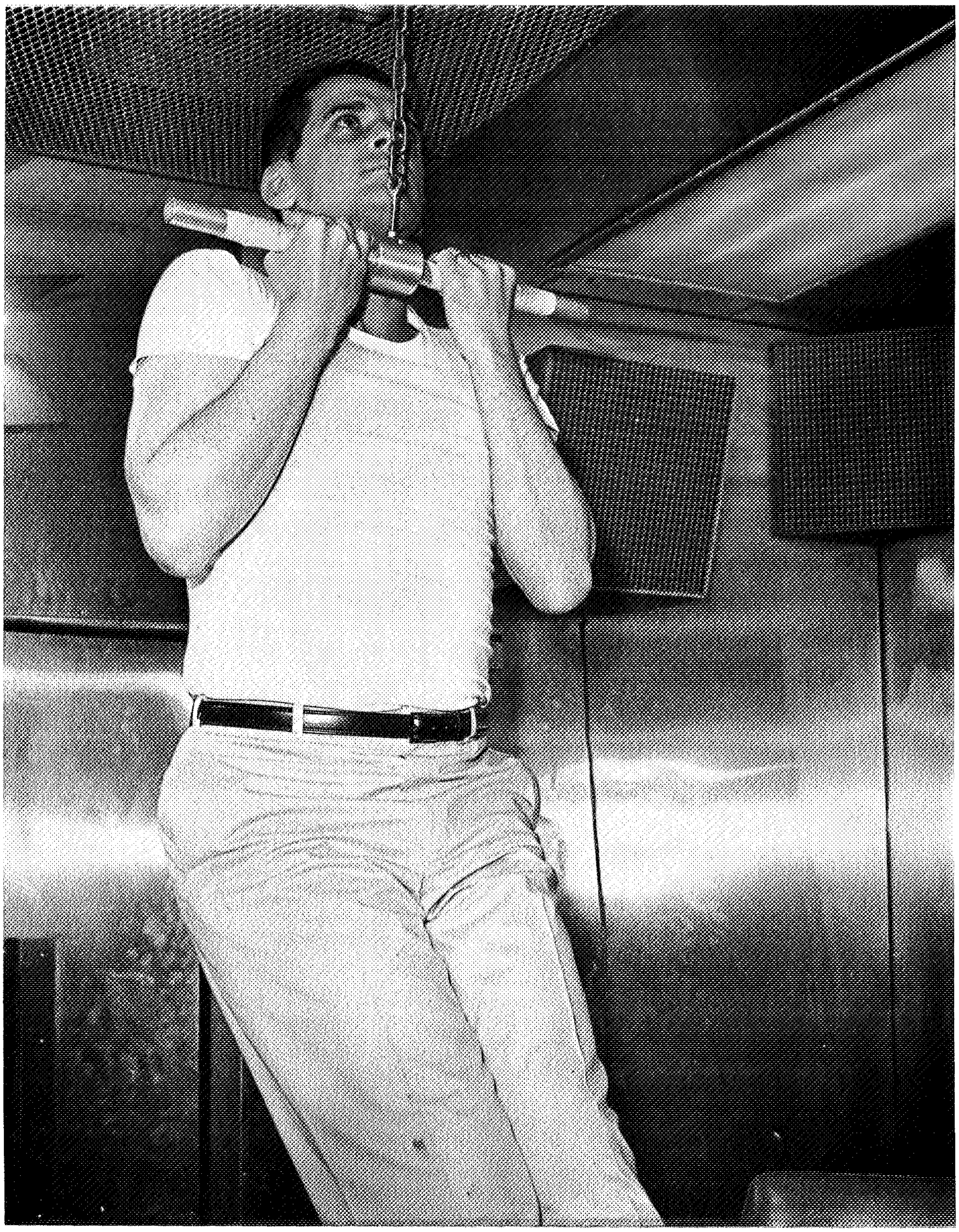
Review the details of this room with your students and relate it to the next five photographs. What problems can the students suggest which might arise for the volunteer who remained in this room for five months in complete isolation?



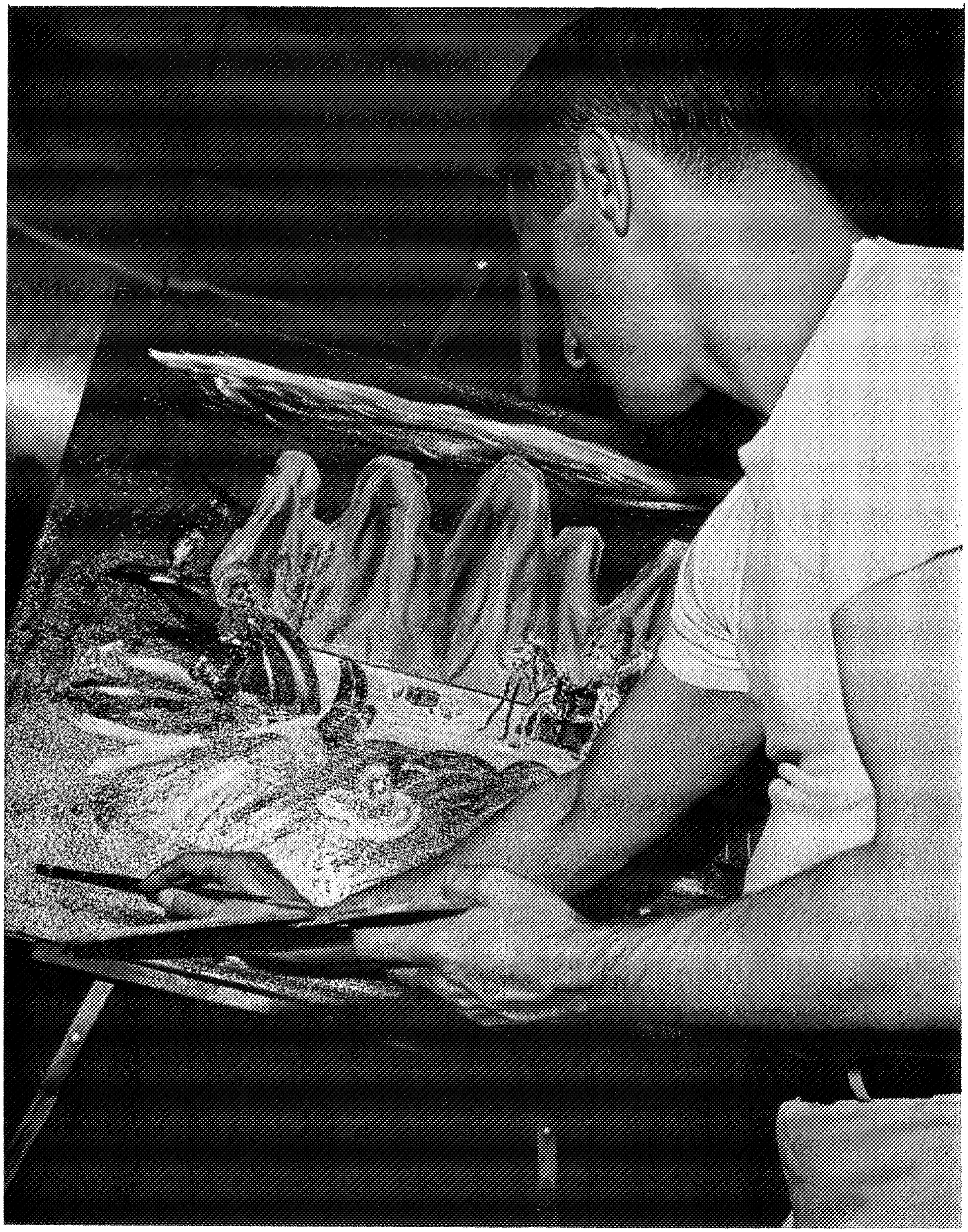
This is a re-enactment of a meal eaten during the five months of voluntary confinement by this individual. In the background is a vending type machine which can make either hot or cold food available. The volunteer can select from either side of the machine a predetermined number of items of food which were stored in a predetermined quantity.



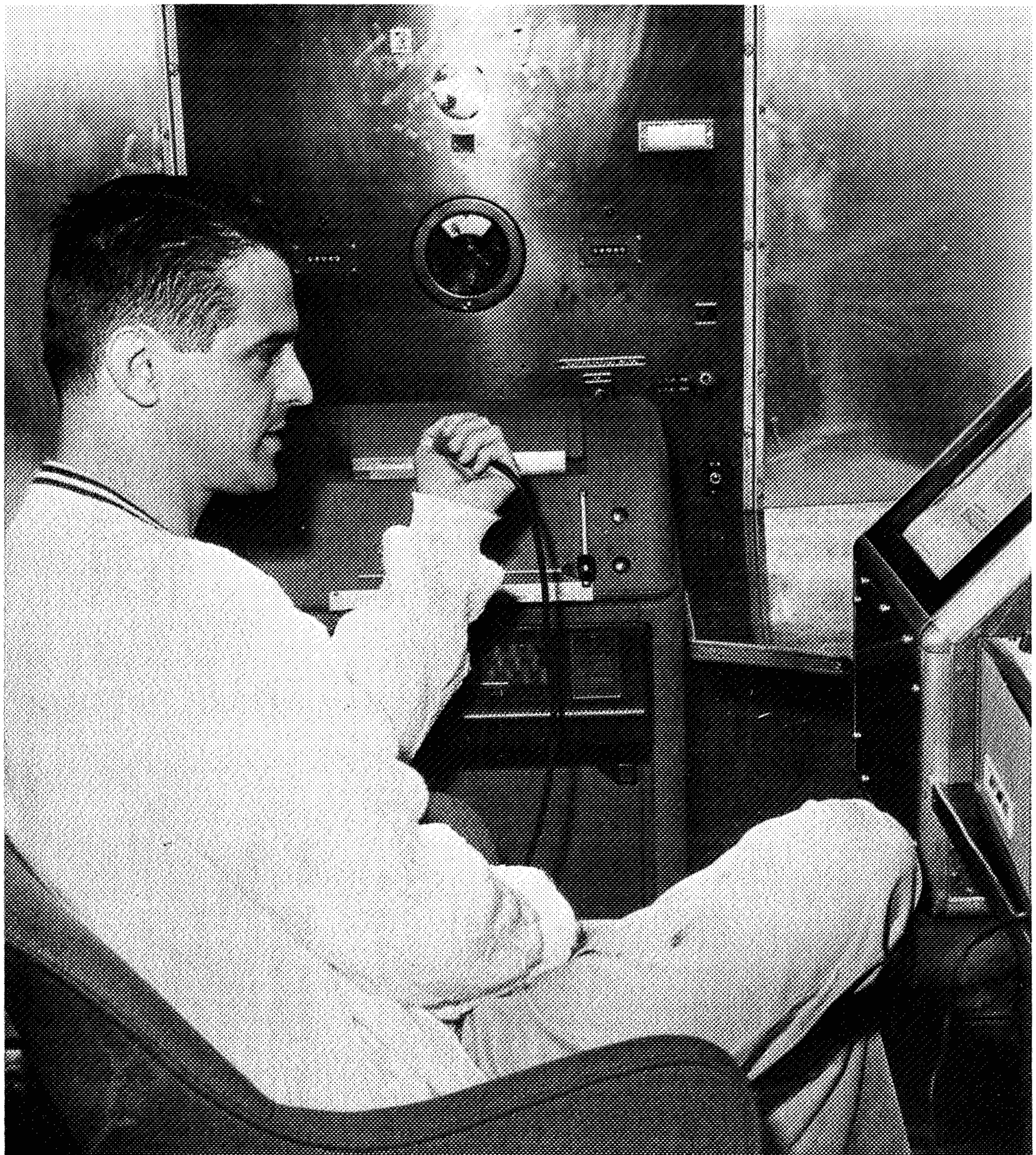
This isolation chamber volunteer reenacts the procedure wherby he received cigarettes as a reward for giving the requested number of responses to the various signal lights on the panel. What factors would you suspect might be present which would interfere with the volunteer's reaction time and perceptions of what is requested of him?



The volunteer, in the isolation chamber for five months, re-enacts how he weighed himself while in confinement. When the "WEIGHT" light was lit on the panel, he was required to place his weight on an electronic weighing device. His weight was recorded automatically only after a certain preset percentage of his entire weight was placed on the scale.



The painting, a project by this volunteer during his five months of isolation, is a Western scene. Of what value are activities such as this during periods of isolation.



The use of the reading machine is re-enacted by the volunteer who remained in the isolation chamber for five months. The material selected by the observers was projected onto the face of the machine and consisted of passages from electronics, astronomy, history and light reading.

E. Psychological Stresses
   1. Anxiety, Disorientation and Isolation
      d. Self-Contained Unit and Exosphere As A Universe

INQUIRY NO. 38

THROUGH RAIN, SLEET, OR SNOW . . .

<u>Basic Concepts</u>:

An individual's <u>inner motivation</u> affects his attitudes toward his circumstances

<u>SEQUENCE-SUMMARY</u>

Knowledge eliminates fear...so,
1. Study research
2. Create appropriate types of recreational activity
3. Experiment

List reasons that enable an individual to survive in conditions of extreme temperatures.

Because of lack of atmosphere and the period of revolution, temperature changes would be more easily compared to day and night temperature rather than seasonal temperatures. (Day and night temperatures in desert vs. seasonal changes in any location).

<u>ACTIVITIES-ILLUSTRATIONS</u>

Discuss pictures - showing men involved in occupations involving extremes of temperature
1. Blast furnace
2. Dairy refrigeration

Why are they so occupied?

Observe dry ice:

1. Would you like to touch it? How does it feel? Discuss.
2. Place dry ice in liquid (water). Why does this now bubble? Touch knife to ice. What do you hear?

Assign pupils to space trip. "You are the astronaut of the day! Are you ready to do?" Record reactions - positive; negative.

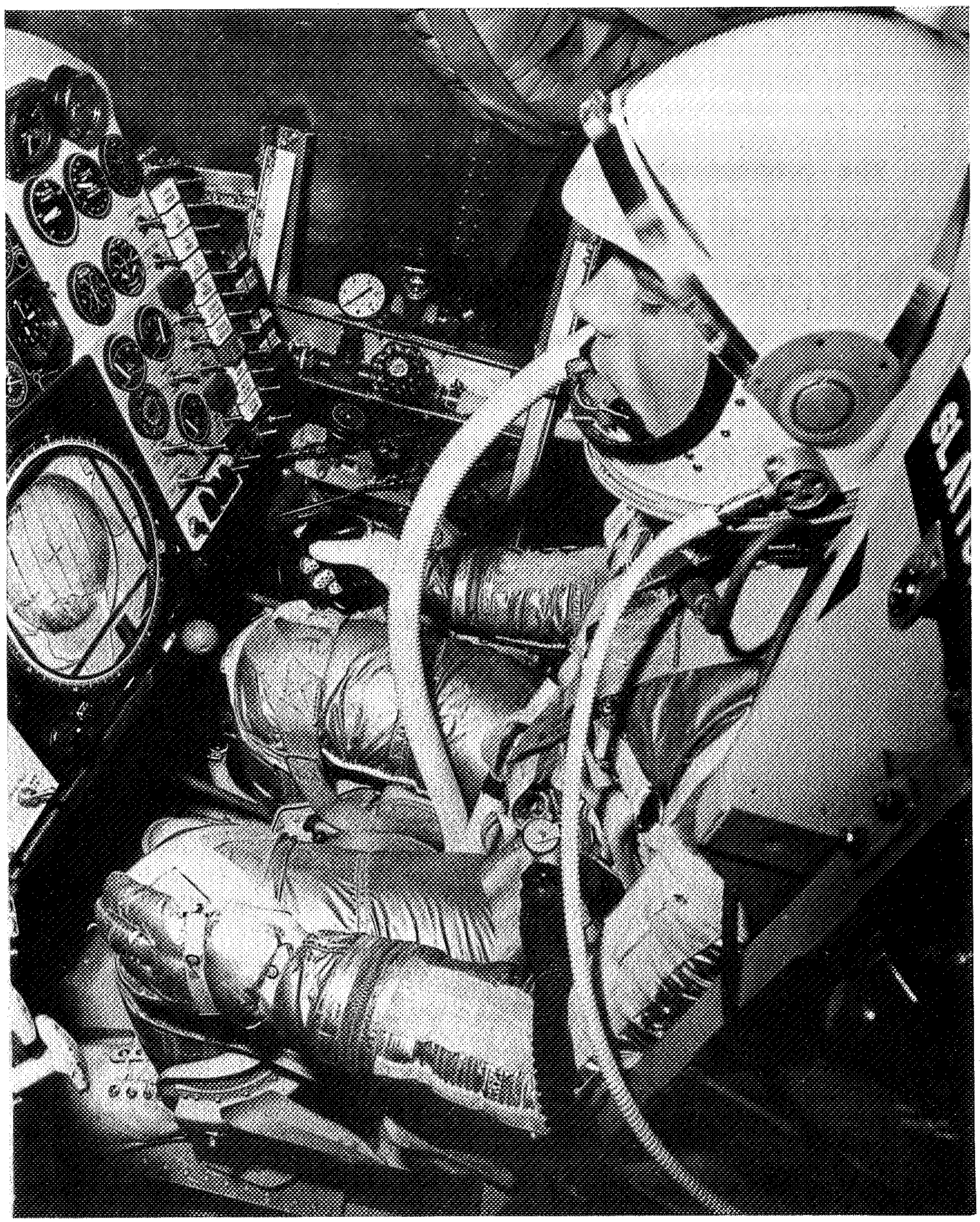
Activities-Illustrations (Con't)

Design your own space suit to fit YOUR own personal needs (as to heat and cold). Present chart with large design of space suit.

1. Analyze each part (helmet, gloves, boots, etc.)
2. Relate to WHY you wear each now on earth.
3. Discuss related research on each, relating to heat and cold and physiological reactions.

Construct your own space cubicle so it meets personal safety requirements for heat and cold extremes.

1. What temperatures at home are most comfortable.
2. Discuss with reference to men vs. women.
3. Make charts



How is Knowledge an "anxiety-reducer" for this astronaut?

CHAPTER IV

THE FUTURE

The conceptual scheme which has been presented and developed in this manual should serve as a skeleton onto which new developments can be attached. Specific projections as to "what's over the next hill?" will not be introduced in this section. However, some guidelines for the selection of content are listed for your reflection and action:

1. Content should be sought which will contribute to the student's understanding that research produces unpredictable returns, and that foresight has a limited scope.

2 Whereever possible, the "all is possible" frame of mind approach should be avoided It is preferable to identify the existing limits which preclude the achievement of an event. Such limit setting is then the starting point for student inquiry, and should be presented as such. Avoid presenting limit setting as though it represented a <u>fixed</u> limit to human endeavor.

3. Content should be sought which reflects man's attempts to simulate, on earth, conditions which are found on other planets, satellites and galaxies (as these become known). En-

courage students to see the need for building "models", both physical <u>and</u> mental of their universe.

4. Content should be sought which enables students to better understand that the path to the solution of any given problem is strewn with new questions and problems. The open-ended nature of inquiry needs to be so clearly implanted that the student will gain a sense of security in his coping with problems having no immediately resolvable answers.

As a final comment, a restatement of the underlying principle upon which this work is based is in order: implementation of instructional materials must come from the teacher who is aware of the resources available, and who then tailors the material to the individual and to the classroom setting.

APPENDIX I

WHO ARE YOU BIOLOGICALLY?

This student activity may serve as a stimulus when the topic of life science in a space age setting is introduced. The various tests which are part of this simulated physical check-up can be re-introduced as the various sub-topics (biologistics, toxicology, radiation, physiological stress, psychological stress) are explored. The ingenuity of the teacher and her awareness of the interests of the students are the critical factors in the application of this material.

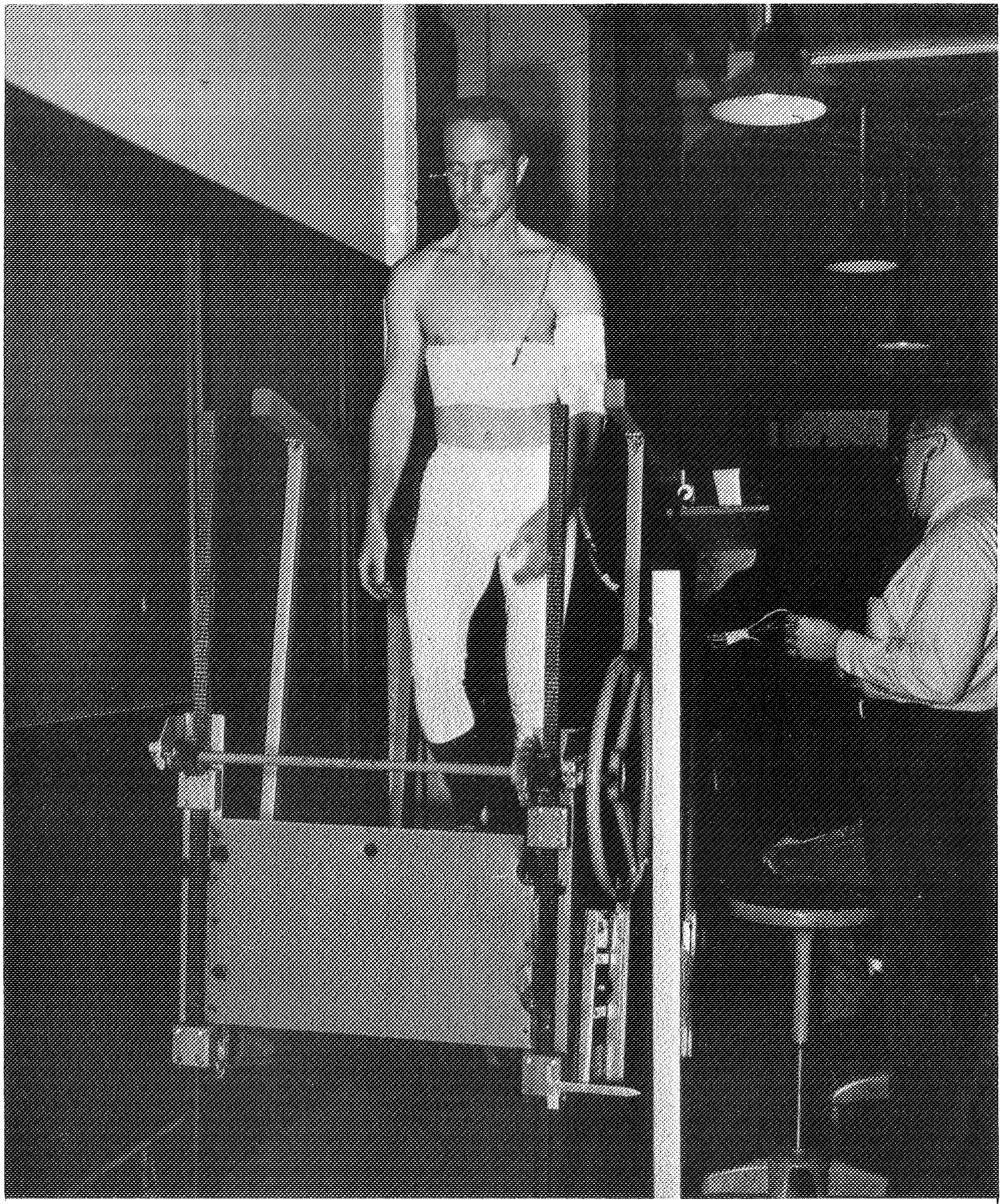
> Who are you biologically? What kind of information does your body produce as you are reading these words? How does your body maintain itself in the face of change? What kinds of regulatory and protective devices do you have which keep you in a state of dynamic balance?
>
> You can explore these questions as you take a mythical "Pre-Space Flight Physical Check-up". Work with a partner and take turns on each section. Record your results in column 1 and add any comments. Repeat the "check-up" at home before going to bed. Have one of your parents be your partner. Record

your results in column 2.

On the last page, write a report about yourself and answer the questions which started this section.

	1*	2*	Comments
Weight			
Height			
Age (years, months)			
Sex			
1. Pulse rate			
a. sitting			
b. standing			
c. lying down			
d. exercise (one step 15 times)			
e. after exercise - wait 2 minutes			
2. Respiration (do this while taking pulse)			
a. sitting			
b. standing			
c. lying down			
d. exercise (one step 15 times)			
e. after exercise - wait 2 minutes			

*Don't forget to indicate units (lbs., years, cts./min. etc.)



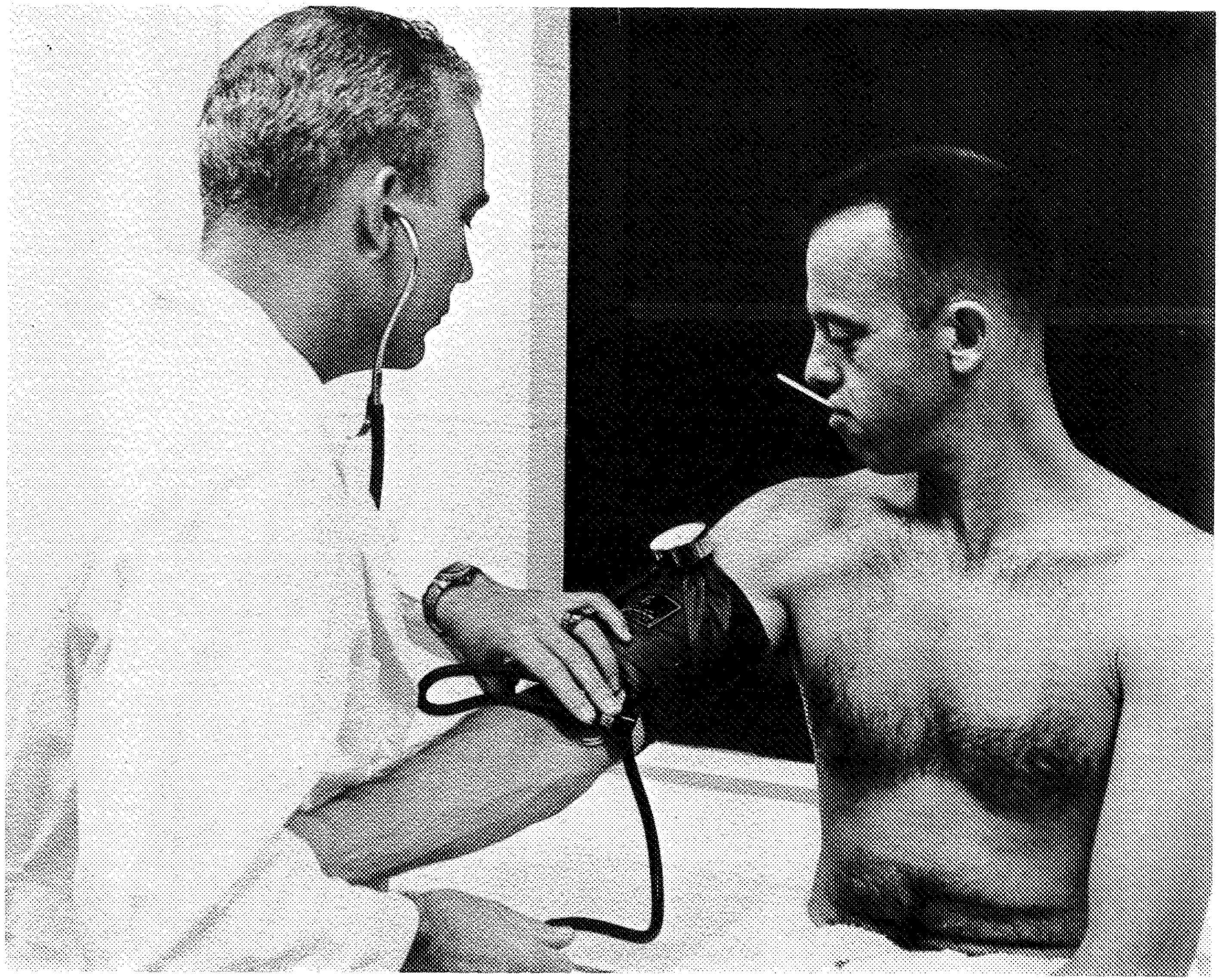
This is a treadmill test. Can you detect what types of sensors are being used to check on the astronaut's response to the physical stress?

	1*	2*	Comments
3. Eye Tests			
a. Blind spot - move a dot around until not visible at some point. Keep one eye closed, focus open eye on some spot in room.			
b. Color perception - use color charts with numbers (project slide for whole class), use wool matching.			
c. Corresponding points - Hold up two pencils, one behind the other about a foot apart. When you focus on one, see the other as double.			
d. Distance - Use a Snellen eye chart.			
e. Astigmatism - Use a projected cross on screen. Will appear blurred on one side.			
f. Angle of vision - Use a target, moving it around the head while the head is kept stationary. (Discuss tunnel vision.)			

*Don't forget to indicate units (lbs., years, cts./min. etc.)

	1*	2*	Comments
g. Location (one eye closed) - Hold up one finger, focus on it and then alternately close your eyes; note apparent shift in position of finger with respect to background.			
h. Interpretation - Use corresponding points experiment. Close right eye and see image on left disappear. Even though the rays going to right eye are the ones shut off, we think the left image disappears. This occurs because the rays cut off had fallen on the outer half of the right retina, and through experience, we have learned to project objects to the left part of the field of vision when light rays impinge on that part.			
i. Night vision - Look at star directly, shift glance slightly, note clarity. (Fovea, visual purple, cones.)			
4. Blood Pressure (Discuss diastolic, systolic pressure)			

*Don't forget to indicate units (lbs., years, cts./min. etc.)



What information is being secured about this astronaut's physical fitness? Note the shaved area on his chest where sensors will be placed during space flight activities.

	1*	2*	Comments
5. Put one hand in hot water. Put one hand in cold water. Observe circulation effect.			
6. Breathe through a straw into water with dilute ammonium hydroxide (NH_4OH) and several drops of phenolpthalein - Record time to change color. Repeat after exercise for 30 seconds.. Record time to change color.			
7. Breathe on piece of wire gauze - feel gauze. (Heat dissipating problem in space suit.)			
8. Reflexes: a. Corneal - touch cornea with a piece of thread. Eye blinks. (CAUTION: Teacher should demonstrate this and point out that, since the eye is an extension of the brain, it is delicate and should be treated carefully.)			

*Don't forget to indicate units (lbs., years, cts./min. etc.)

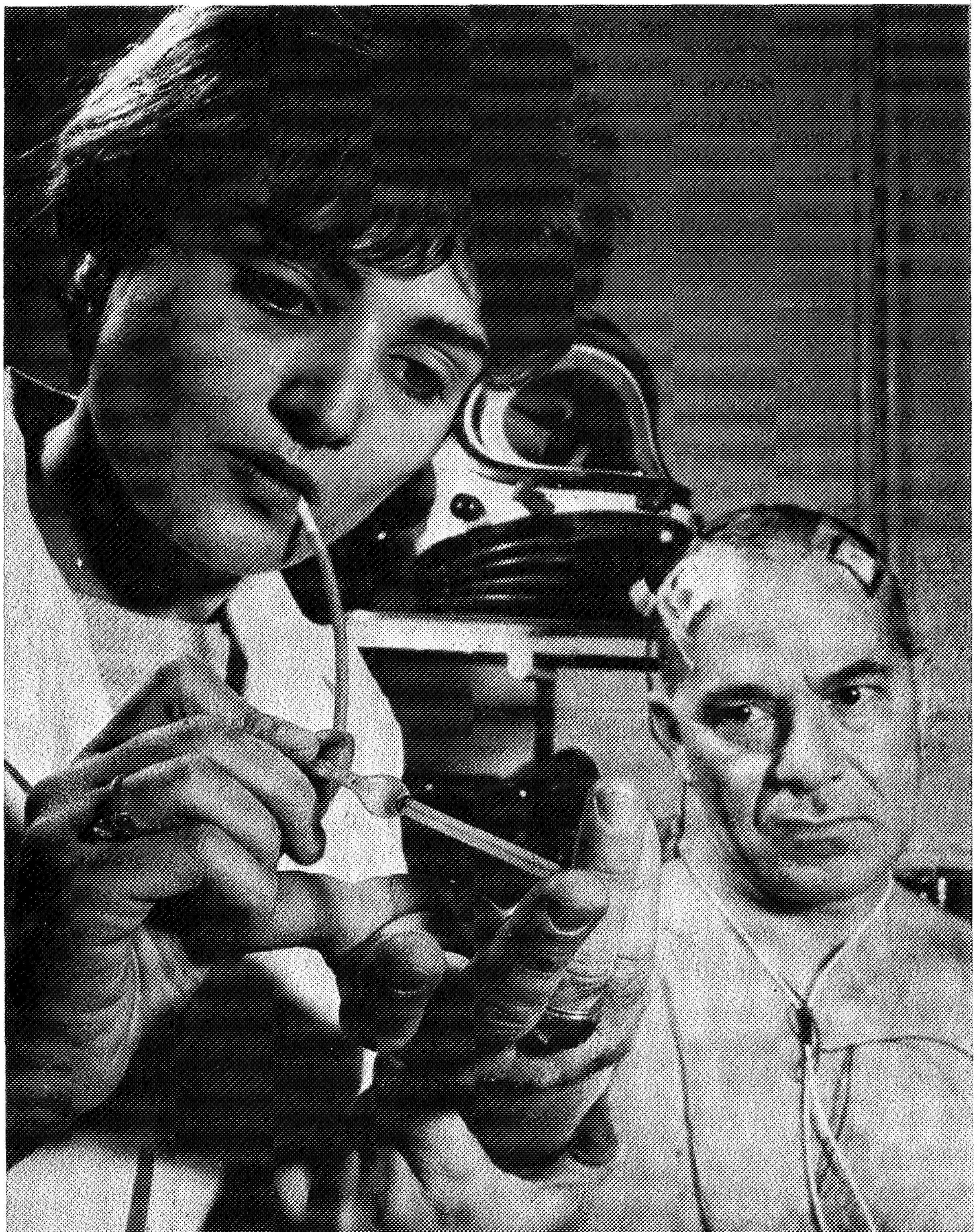
	1*	2*	Comments
b. Accommodation - Light - have students cover one eye for 30 seconds and then uncover it. Partner should observe and compare pupil size.			
c. Capillary - Hold ice cube in hand. Have original blood supply cut-off, then a flooding of area with blood.			
d. Knee jerk, one knee over the other. Use rubber-tipped hammer.			
e. Pharyngeal reflex - touch pharnyx with cold rod, get regurgitative behavior. Rod at room temperature will not give any response.			
f. Bring in a lemon to room. See if students salivate.			
9. Pain, heat, cold, pressure centers.			
a. Use two probes. Use a small area on back of hand held where student cannot observe what is being done with it. Locate pain, heat, cold, pressure centers. Plot them on a piece of graph paper.			

*Don't forget to indicate units (lbs., years, cts./min. etc.)

	1*	2*	Comments
10. Vision a. After images (stare at colored piece of paper) See complementary colors. b. Use Isohari color charts for determining color blindness. c. Look at incandescent light 2 feet away for 30 seconds. Close eyes.			
11. Spin a person 10 times in a swivel chair. Observe path taken.			
12. Reaction test: Hold a dollar bill between partners thumb and index fingers. Place it so that his fingers would close on the engraving of Washington. When you release the dollar, he is to attempt (without moving hand) to catch it with thumb and index finger. Give no warning as to when you will release dollar bill.			
13. Balance test: a. Walk a white line for 20 feet			

*Don't forget to indicate units (lbs., years, cts./min. etc.)

	1*	2*	Comments
b. Walk a rail (if available) for 20 feet.			
c. Stand on one foot for 30 seconds.			
d. Shift to other foot and repeat for 30 seconds.			
e. Stand on one foot. Close your eyes. Repeat with other foot.			
f. Stand on one foot. Cover ears with palms of hand. Repeat with other foot.			



What information can be gained from blood samples which will help designers build a better space suit? This space environment engineer has been testing a back-pack life-support system. Notice the various heat, moisture sensors on his body. How do these sensors help the designer?

APPENDIX II

WHICH WAY DID HE GO?

This problem solving example* is illustrative of some of the things that the space age has visited upon us. Most of us, if asked which way is up and which way is down, would have a ready answer. But is this answer satisfactory in the space age?

To the Student

Using a globe or a beach ball and some toy soldiers or other representations of men that can be fastened to the globe or ball with rubber cement, consider the problem of up and down as though you were an observer out in space far enough to look at the entire earth.

What ways can you think of as ways for defining up and down? Should it be related to the gravitational field of the earth?

Once you are away from the earth which way is to be considered as up and which way is to be thought of as down? Is it going to be such that the direction of your feet is down and the direction above your head is up? Can you think of advantages in defining up and down as related to yourself?

To the Teacher

This is a problem in definition. It offers an opportunity to bring the importance of good definition in scientific work into your science classes. Establishment of an expanding frame of reference is the end in view. This can be carried on until the grade level of comprehension is exhausted.

As examples such words as pressure, force, temperature, hot vs. cold, etc., have undergone this development into precisely defined words for scientific use. As man expands his thinking about venturing out into space he forces this process of precise identification of frames of reference upon himself.

It would be well to suggest that the class enumerate the various situations in which they might find themselves where up and down

*Taken from "Problem Solving Through Science," Northern California Science Committee, May 1959.

What other possible situations can you think of that make a definition of up and down somewhat difficult to make?

Can you develop a satisfactory definition so that it can be used anywhere within our solar system? Remember that this definition might be solely for scientific purposes and not necessarily one that you would use in a conversation with your friend while standing on the street corner.

would be involved. This requires an order of development from the locality, to the earth, to intermediate space positions, to the moon, to other planets, to the sun, etc., on out into space. We stand in various places on and in the earth. We are enroute by rocket between planets. We stand on the moon or on another planet. Which is up and which is down in all these situations? Can a good definition for the up and down idea be formed that would cover all of these situations?

After presenting the material, the question is raised, "On the moon, where is the North Pole?" For a group of students meeting weekly in an after-school program (PALS), a range of responses emerged and, following a lively discussion, the students were invited to prepare accounts of their solution to the problem. Three of the compositions submitted by the students are presented below. No editing of the material was attempted. How would your students respond?

A. Ode of A Teacher.

Barbara Sevall - ninth grade

My name is Friday, Thursday Friday, that is. I am a Kindergarten teacher. My class of kindergarten geniuses was to be the first people on the moon. Most of the parents were elated to see their darlings off, though I could never see why.

When we reached the launching field, the children's curiosity began to grow. As I listened to them, I was amazed at the variety of subjects they discussed - toy trucks, magnetic differences in the poles of the moon, purple snakes, and effects of gamma radiation. My thoughts of the moon were interrupted by a piercing shriek, none other than Billy NonobeHah. His inquisitive finger was stuck fast in the ship. Billy had unscrewed a screw and did the normal thing - stuck a finger in it. After fifteen minutes of coaxing, the slightly dilapidated pinkie came out. The robots systematically herded my class aboard. They grabbed each child by the seat of his pants and unceremoniously dumped him into a special chair. The chair was like a sack and a string was wisely pulled tightly around each child's middle. The door closed, the countdown began, the lift-off, and finally we were off to the moon. After the ship had gone for five hours, I was besieged with intelligent questions - When do we eat, how much farther, where's the restroom, when do we go home, and where are we? I let out a frantic scream, took out my tranquilizer (pair of earplugs) and fell asleep. When I awoke the ship was on the moon. My class, already in space suits was ready to go. I took out a face cloth, wiped the chocolate off their faces, (who brought gum and candy aboard?) and cautiously led the way out. Someone gave me a push and there I was standing on the lunar surface. I told Billy to get my Chevron moon map. I found that I left it on earth. Oh well, you can't win them all. It was imperative that my motley crew of 5 yr. olds (with IQ's of 200) get to the North Pole 3:00 E.S.T. Using my past experience as a Girl Scout I looked up at the stars, but the stars weren't the same. I called for my Jiffy North Pole Finder. It was "just a LITTLE SMASHED UP".

My class and I sat around. One of the girls started drawing pictures in the moondust. Suddenly, the light shone! I took out my portable sextant, looked down at the earth's North Pole, figured my angles. The North Pole (earth) was point A, the point at the equator was the apex, B, and the moon's N.P. was C. 66 -1/2° from where we were standing was the moon's N.P. In other words 760-1/2 miles from where we were standing! Revving up our Beanie Copters we started to the N.P.

My class made it in record time. We found the capsule there and took off when trajectory was right.

When I reached home I was awarded a medal for stupidity above and beyond the call of duty. The children? They were greeted by glum and dejected-looking parents.

B. How I Found the North Pole on the Moon
or
Mr. Alcorta's Plight

Art Levit - ninth grade

Here I was, hurtling towards the moon at 27,000 miles per hour - risking my life in a rocket made by the Lux Rocketry Club of Galileo High School in San Francisco and an idiotic thought came into my mind; I did not know where to find my missing person on the moon!

It all started when Mr. Louis Alcorta, Lux Bio-Chem Instructor, ate a dinner prepared by the female members of the Lux Bio-Chem. The effect of the dinner was such that

Mr. Alcorta decided to use the new rocket developed by the Rocketry Club. Unfortunately one of the students miscalculated and Mr. Alcorta landed on the moon. (It was supposed to be an orbital flight.) He had food and a short wave radio and each he could use for a period of one month. He also had a pressure suit and plenty of oxygen (don't ask me where he got them). It was my job to retrieve Mr. Alcorta because we needed another driver for the Quincy trip.

I just remembered that I had no way of finding Mr. Alcorta except I knew that he landed on the bright side of the moon and that he would probably remain there for a while anyway. (I considered the light side of the moon to be that side on which earth was visible.)

When I landed I asked Mr. Alcorta where he was over the S.W. radio "...a tenth of a mile from the North Pole on the bright side", came the reply. I was just about to ask him where the North Pole was and how he knew whether it was the South or North Pole when I turned around to find my radio, with the hand strap broken, floating down into a crater. The radio went out of sight in the dark crater so now I didn't have one. Should I try to find Mr. Alcorta or get another driver for the Quincy trip? After I had flipped a coin to decide the previous issue (which decided I must look for Mr. Alcorta) I did some quick figuring.

The period of rotation on the moon is equal to the period of revolution, thus one hemisphere of the moon, the same one, always faces the earth, the other directly opposite the earth. Now I could see that the shadow on the moon does not remain stationary but makes a complete revolution once a month.

Now my problems were solved. If I was to stand on the point (or points I should say) where the bright side meets the dark side the shadow would move by me in a period of time UNLESS I stood on an axis where the shadow would appear to remain stationary.

The first day (or night) thereafter I walked to the general area where the dark and bright sides meet. I stayed at this point for twenty-four hours and the shadow moved considerably by me. I walked two hundred miles farther (which took no effort) and again observed the shadow bypass me. Then as I walked the next two hundred miles I observed my earlier calculations to be correct; the shadow moved in the opposite direction than it had the two previous times. I walked back one hundred miles - here I again observed the shadow moving in the opposite direction than the first two times. I then moved slowly, five miles at a time, until I found a spot where the shadow seemed not to move. I stayed here for two days and the only movement noticable was negligible. This was the general area where I would find Mr. Alcorta.

I combed the area within the one-tenth of a mile on the bright side then, just in case, on the dark side but no Mr. Alcorta! I was mad. I had gone to all this work, two weeks to be exact, and I had not found Mr. Alcorta. Now we would not have a driver for the Quincy trip. Then it came to me...it was too simple. There are naturally two poles and he was at the other one. I wondered why he thought it was the North Pole!?

To find the other pole was simple. I walked around the moon once and counted my steps, which were theoretically equal after I had stuck a stake in the ground where I was standing on the axis. This takes 70 days so I used jet propulsion. I came back to the pole and went halfway around the moon again by dividing my previous steps in half and walking that many steps. I stood to see if the shadow moved, it did not. Then I again combed the area. Then I saw why Mr. Alcorta called this the North Pole. Two twentieths (I did this to make it sound different) of a mile from the pole there was a red and white striped pole made of candy. Santa Claus was there and I asked him where Mr. Alcorta went. He replied that Mr. Alcorta had just found a space ship of some kind twenty miles off and he went over there. Santa also said that as far as he was concerned he liked it here, with no nagging wife and reindeer, and planned to spend his declining years here.

When I arrived at the ship, there was Mr. Alcorta eating all the clam chowder we had made from the clams caught at the clamming expedition He greeted me with a "What took ya so long?" that made me want to ask him the same question.

When we landed on earth again all the Lux Bio-Chemmers greeted us and fed us more clam chowder which again prodded Mr. Alcorta to go to the moon but we proved to him that the food wasn't that bad.

EPILOGUE

Mr. Alcorta wasn't able to drive on the Quincy trip, unfortuantely, for he became sick from eating too much chowder but he got over it soon.

Note: The shadow would deviate in the period of a year so this must be performed within a month to get accurate results.

C. An Experiment in Space

John Hart - eighth grade

If only he had a bathtub...he knew about the way the water went down the drain, clockwise in the northern hemisphere, counter in the southern. But would it work on the slowly-turning moon? And he'd need to find the poles before he decided which was which.

John Smith's assignment was to beat the glorious people's cosmonauts at mapping the moon. To do it, he needed a north pole. The only way he could think of to find the north pole was to take the opposite of what the Russians picked. And he couldn't find <u>any</u> pole.

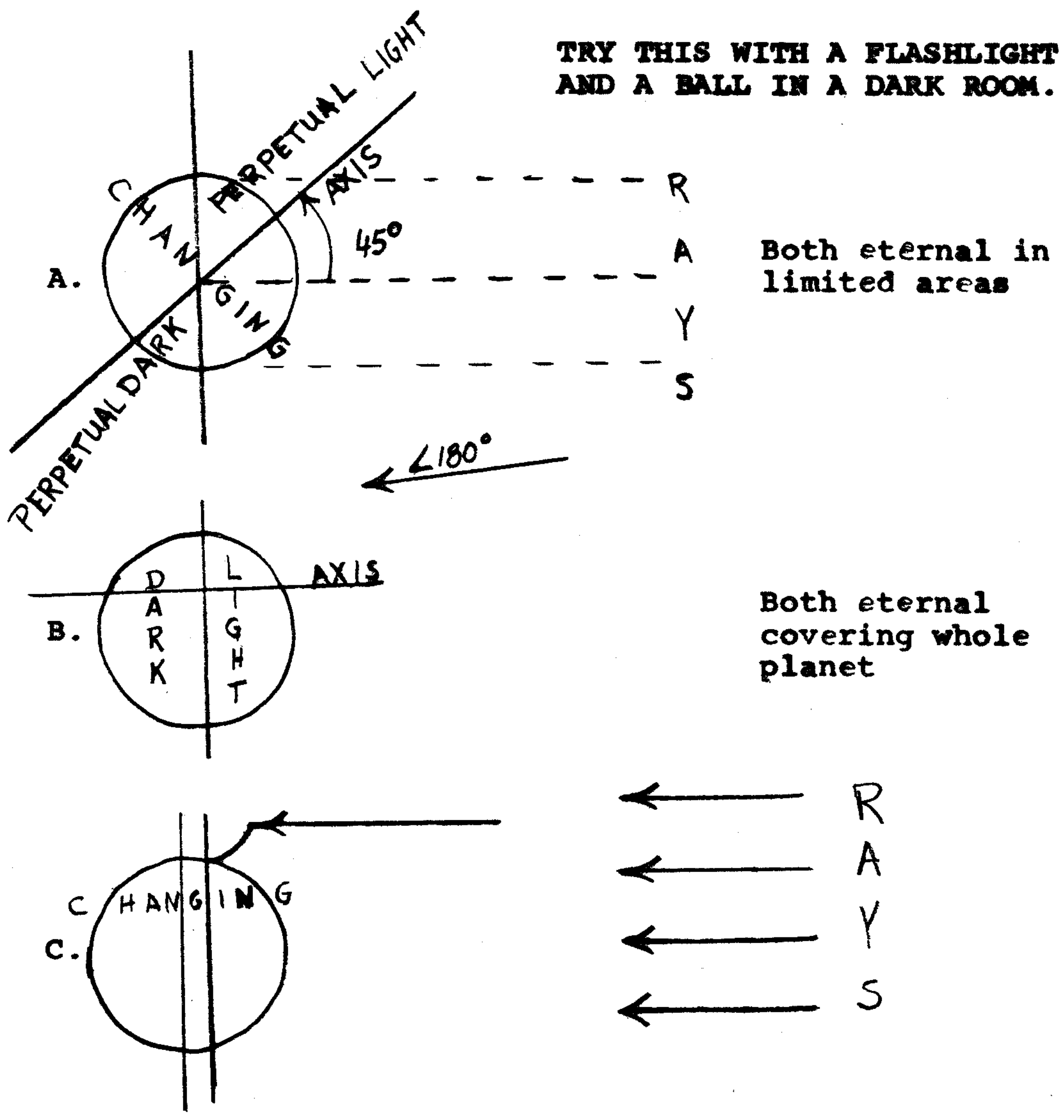
3000 miles away, Titov Gagarin Ivanovsky was having the same problem. His assignment was to beat the imperialistic American astronauts at mapping the moon. And <u>he</u> needed a north pole.

Smith turned the radio dial and sent his daily message, confident and defeated. The answer came back much sooner than it should have. In Russian Titov Gagarin was sending his daily message, dutifully hopeful. Suddenly a startled voice said in English, "What are <u>you</u> doing here?"

In three days, they had admitted to each other that they were mapping, which everybody knew anyway. In four days they had admitted they were stuck. In a week they knew how to get unstuck.

As far as they knew, the moon had no perpetual day or night. Therefore its axis was at right angles to the sun, and its terminator would revolve around that axis. It would travel a shorter distance per a given time near the poles than anywhere else. Since the ships were so far apart, they could time the terminator-difficult but not impossible-and triangulate to find a pole, where the terminator would merely rotate, only one pole could be found without a change of position. (See Illustration)

This didn't decide which pole this was. In the end, they flipped a coin-the only standard when no other is conformed to.



APPENDIX III

THE EFFECT OF TEMPERATURE ON OXYGEN INTAKE BY COCKROACHES

Respiration is one of many outward signs of the steps used by living animals to release the energy from their foods. Releasing carbon dioxide, fecal material, body heat (warm blooded animals), are additional indications of living animals' ability to obtain energy from their foods.

The respiratory rate of an organism is influenced by several factors. By using a respirometer, it is possible to measure the influence temperature has on the amount of oxygen used by an organism, large or small, cold or warm blooded.

List of materials used:

Water bath - any large container such as an aquarium.
Large mouthed jars - peanut butter, pickle or mayonnaise jars.
One-hole rubber stoppers - to fit the size of jars used.
Glass tubing - 5 mm. standard (one foot in length), 1 mm. capillary (two, 36 inches in length).
Rubber tubing, wire, rubber bands, medicine dropper.
Graph paper - ruled in mm. squares.
A board - 6" x 36" for mounting graph paper.
KOH - potassium hydroxide (15% solution).
Filter paper - soak filter paper in KOH solution.
Glass vials - ½" diameter, 1½" long
Manometer fluid - a pinch of detergent in 10 ml of water, add a few drops of red ink or food coloring.

Procedure:

Set up the apparatus as indicated in Illustration No. 1. Glue the graph paper to the board and fasten it securely to some steady support. Fasten the 1 mm. capillary tubing to the board. It is important that the tubing remain horizontal at all times. Use a small leveler to make sure it remains horizontal. Bend two pieces of 5 mm. tubing (6" or more) to 90 degrees and insert them into the rubber stoppers. (CAUTION: Always wet the tubing and stopper. Wrap the glass tubing in a towel so that in the event it breaks you will not be cut.)

Place a suitable rack in the water bath. A stirring device in the bath will improve the accuracy of your reading. Fold two pieces of filter paper and soak in the 15% solution KOH. (CAUTION: Keep the KOH solution off hands and clothing!) Using a pair of forceps or tweezers, place the paper in the glass vials. Stick the wire support of the vials into the rubber stoppers. Make sure they are secure.

Bottle A is the thermo-barometer. It is used to correct for gas volume changes. Bottle B is the experimental chamber. Place the organism of your choice into bottle B. Cork both bottles tightly. Attach the capillary tubes to the glass tubes of the bottles by means of short pieces of rubber tubing. Allow about five minutes for the bottles to come to the same temperature as the water bath. Put a drop of manometer fluid at the end of each capillary tube. Record the distance traveled (in mm.) by the drop at uniform time intervals. If the drop moves slowly, record every 5 minutes, if rapidly, record every minute. Be sure to record temperature.

The respirometer works on this principle: The organism uses oxygen and gives off carbon dioxide. The carbon dioxide is absorbed by the KOH on the filter paper. This leaves a deficit in the gas pressure which is compensated for by the movement of the drop of fluid in the capillary. The formula for the volume of a cylinder is:

$$V = \frac{\pi d^2 l}{4}$$

in which d= diameter, l= distance drop travels. The value .7854 can be substituted for $\frac{\pi}{4}$ so that the volume calculation can be simplified to:

$$V = .785\ d^2 l.$$

TABLE 1

VOLUME OF OXYGEN (mm^3) USED BY A COCKROACH AT VARIOUS ENVIRONMENTAL TEMPERATURES

Time Minutes	Temperatures & Tests (1) 62°F.	(2) 68°F.	(3) 100°F.	(4) 102°F.
5	7	6	0	0
10	18	11	0	0
15	26	33	23	0
20	31	38	12	8
25	34	42	16	43
30	0	0	62	45
35	44	0	102	86
40	59	0	110	92
45	0	0	141	96
50	0	0	232	120
55	0	0	277	149
60	0	0	288	152

Discussion of Results:

The results of four tests, each conducted at a different temperature, are shown in table 1. For the most part, the data indicate that the amount of oxygen used by cockroaches is related to the temperature of their environment. At 62° and 68° Fahrenheit, for a period of 30 to 40 minutes, (see column 1 and 2), the amount of oxygen used per experimental animal (cockroach) increased gradually. This was followed by an abrupt decrease in the amount used below a level which could be measured with the respirometer. This condition prevailed during the remaining 20 minutes the tests were in progress.

On the other hand, the data from column 3 and 4 suggest that the amount of oxygen used by the cockroach was below a measurable level at the beginning of the tests and for the first 10 to 15 minutes the tests were in progress. This was followed by a fairly rapid increase in oxygen consumption which continued until each test was terminated. This reduced use of oxygen below a level that could not be measured with the respirometer is one of several aspects of the data which needs further investigation.

Noticeable similarities occurred in the behavior of the cockroach during tests 1 and 2, and tests 3 and 4. Bodily movements lessened during the time both tests (1 and 2) were in progress. The cockroach remained practically motionless, moving one leg or antenna occasionally. While tests 3 and 4 were in progress however, the cockroach was very active, moving about, climbing up the side of the container, and so on.

The relationships or factors between the amount of oxygen used and the activity level of the cockroach at various temperatures can be explored with this technique.

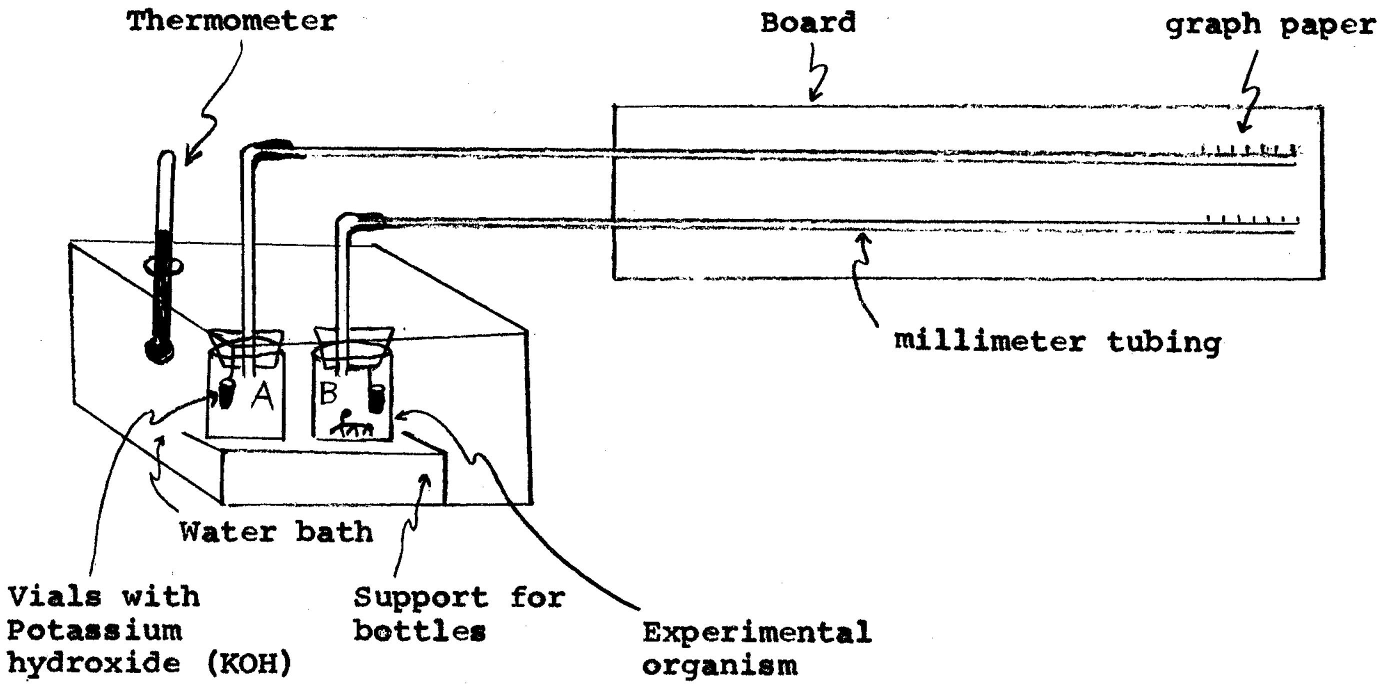


Illustration No. 1 Set-up for an Experimental Respirometer

APPENDIX IV

SOME OBSERVATIONS ON THE BREATHING RATE OF A FROG AT VARIOUS TEMPERATURES

Material list.

Live frog
Thermometer
Cubed or crushed ice
Two large beakers

Procedure: Fill a beaker about one third full of water. Put cubed or crushed ice in this water and then place the live frog in the beaker. Observe the frog's behavior as the temperature lowers. Wait ten minutes and then count the number of times the frog "swallows" (movement in throat region) over a 60-second period. Wait one minute after taking the first reading, and take another reading. Take a total of three readings or as many as time will allow, then compute an arithmetic average and record the data. To measure breathing rates at various temperatures, remove the frog from the beaker and add warm water slowly until a desired temperature is reached. Return the frog to the beaker and wait ten minutes before counting the rate of "swallowing" as before. Continue this procedure, proceeding from lower to higher temperatures, as long as time will permit, plot the collected data on graph paper. It is suggested that extremely low and high temperatures be avoided until technique has been perfected.

Discussion and conclusion: On the basis of collected date, which show the number of times a frog "swallows" while subjected to various temperatures, it is possible to conclude, at least tentatively, as the temperature of the surrounding medium of a frog is increased the breathing rate of the frog is also increased.

Sources of error include the failure to determine the breathing rate of the frog used in the experiment prior to placing it in the water at the beginning of the experiment, and the use of the opening and closing of the nares (nostrils).

Raise these questions:

1. Is is possible to determine the breathing rate, by visual means, of a frog completely submerged in water.
2. Is is possible for a frog to remain completely submerged in water indefinitely?
3. Is there a temperature above or below which the breathing rate of a frog will remain the same?
4. What effects do temperature reductions have upon the breathing rates of a frog?

Table 1. Breathing rate of a frog in response to various temperatures.

Water temperature	"Swallowing" Rate	Arithmetic mean
12°C.	6 10 8	8
23°C.	24 21 20	21
33°C.	32 33 31	32

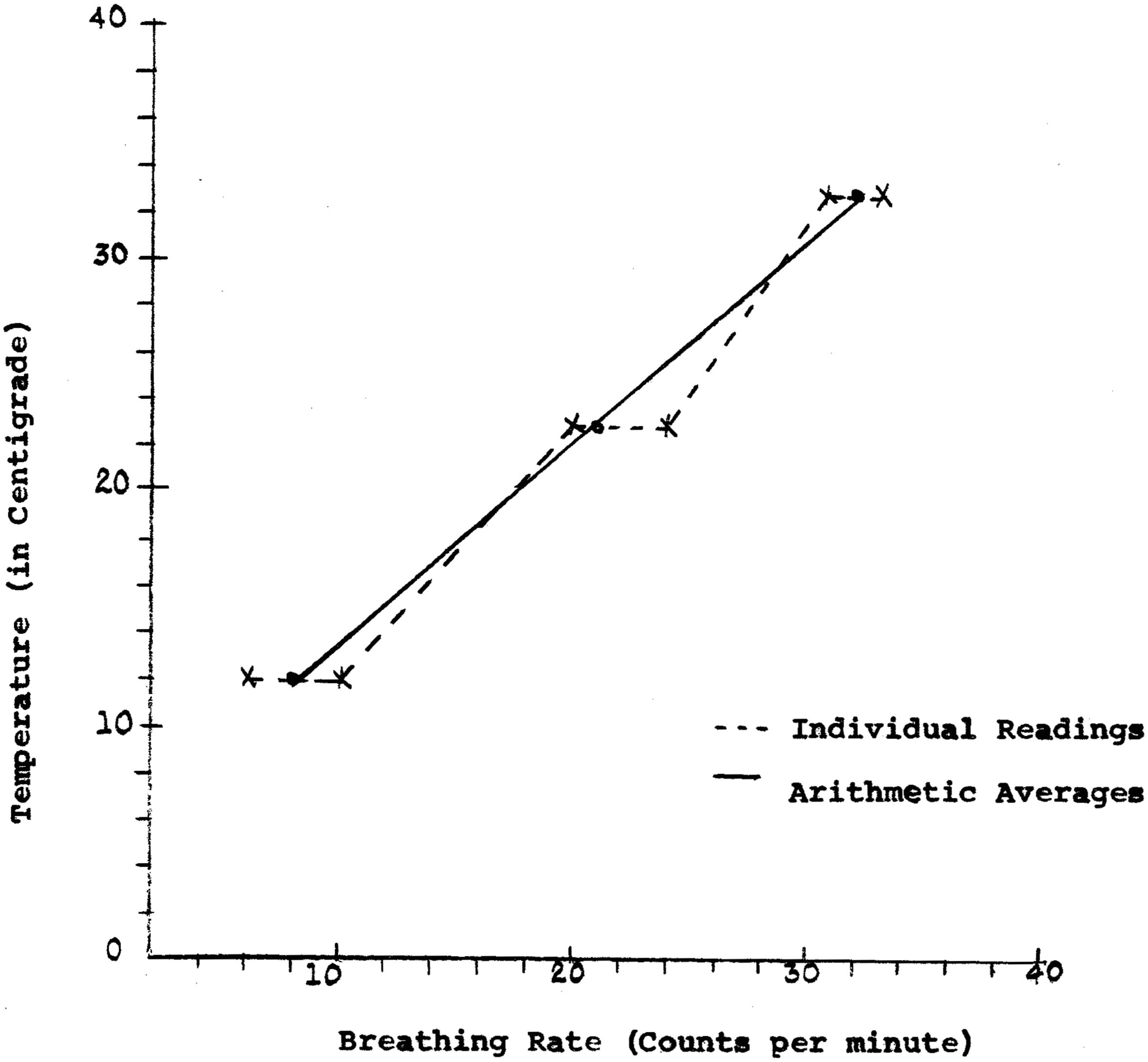
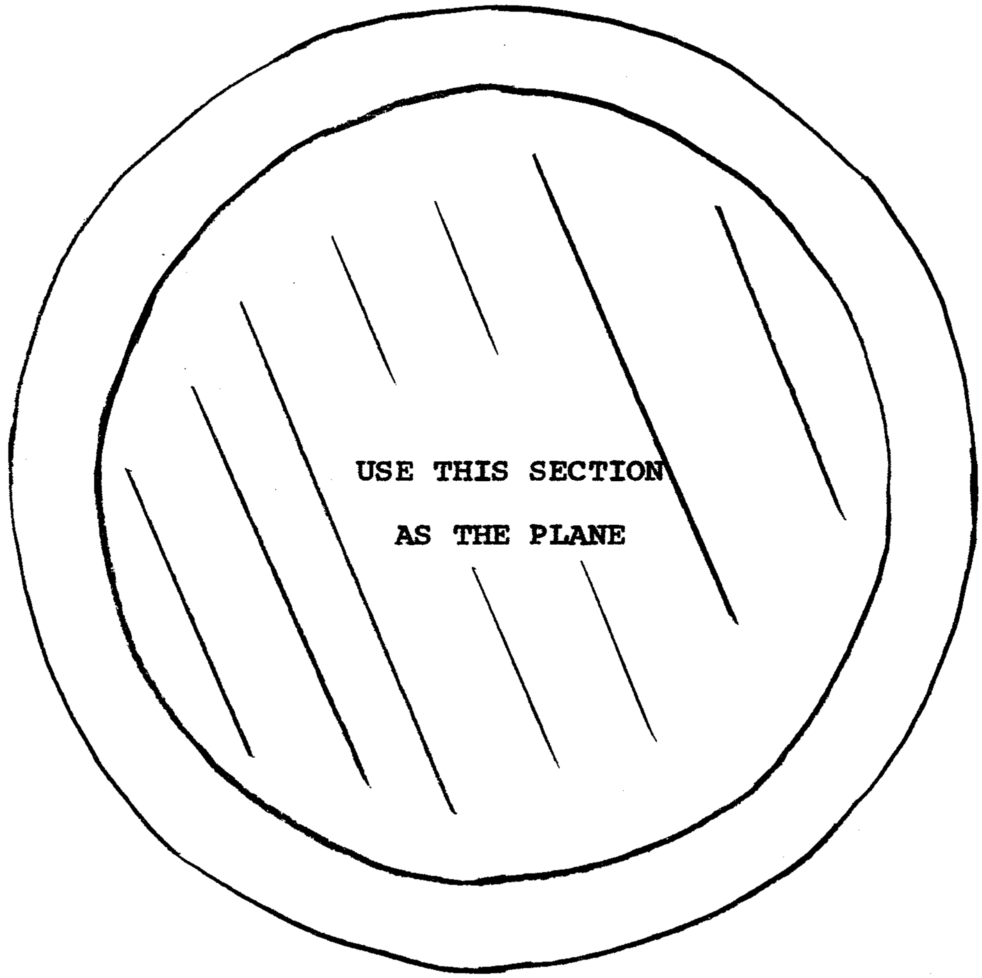


Table 2. Graph of Breathing Rate of a Frog

APPENDIX V

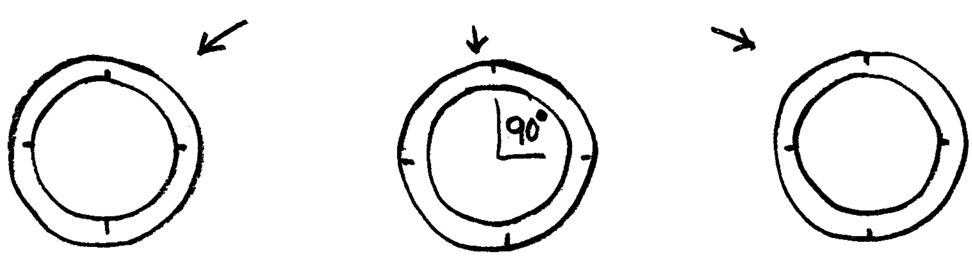
PROJECT GLOBE

The pattern on the next page can be used to make a globe. By use of this three-dimensional sphere, a better understanding of the inclination of the earth's axis, satellite movements about the earth (apogee, perigee) and gravitational effects can be developed.

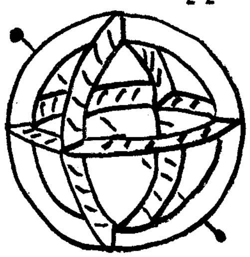


Cut three or more

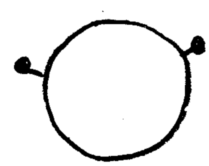
Make openings accordingly



Assemble and use center from one of the circles as a plane or support for a larger thin circle to indicate orbital relationships.



Place pin with colored head to indicate various positions.



APPENDIX VI

THIS IS NO TIME TO BLACKOUT, CHARLIE!

The following outline is included for the teacher's reference in discussing the effect of "g" (acceleration due to gravity) with students:

I. Concept of "g"
   A. By definition: A "g" is one times your own weight.
   B. When "g" forces are experienced, weight increases or decreases while mass remains constant.
   C. A person weighing 150 lbs. and experiencing 2 "g's" would calculate his weight at 300 lbs.

II. "g" forces in conventional aircraft
   A. Rapid change in altitude or position sets up a "g" force
   B. Steep dive and pull out
      1. As an aircraft changes direction in an arc, the pilot tends to go to outside of circle; hence, he is pressed against seat of aircraft increasing his weight proportional to the degree of pullout.
      2. Steep turns result in "g" forces
   C. Fluid characteristic of blood allows it to pool in lower regions of body due to the forces present. This results in a relatively gradual loss in vision (gray-out) and eventually complete loss of vision (black-out). If forces continue, a loss of consciousness will develop.
   D. A great increase in weight (high "g") will partially immobilize pilot while forces are present.
      1. Hands get very heavy
      2. Neck may snap down
      3. Whole body may be paralyzed (meaning arms, legs and neck)

III. Protection against "g" forces
   A. Tightening muscles in abdomen
      1. Yelling
      2. Grunting
   B. Anti-"g" suit or pressure suit
      1. Anti-"g" suit equalizes pressure on calves, thighs, and abdomen
         a. Suit has air bladders which are inflated with compressed air depending on intensity of "g" forces.
         b. Suit is plugged into hose in cockpit which allows suit to be inflated automatically.
      2. Pressure suit used primarily for high altitude protection
         a. Cockpit is pressurized
         b. If pressurization goes out or if aircraft climbs to an altitude that exceeds the capabilities of the pressurization system, pressure suit automatically inflates keeping one atmosphere (15 psi) on the pilot (the drop of atmospheric pressure at 60,000' may cause blood to release dissolved gases rapidly, popularly known as causing "blood to boil".)
      3. Pressure suit may serve as anti-"g" suit

IV. Negative "g's"
   A. Negative "g's" result in <u>pushing</u> maneuvers in flight rather than pulling maneuvers. (pitching movement)
   B. Negative "g" forces cause the blood to rush <u>to</u> head rather than <u>from</u> the head. This may cause a partial loss of vision due to excess blood in eye region (red-out)
      1. Very painful
      2. Occasionally is serious condition hours after flight is over
         a. headaches
         b. dizziness
   C. No protection from negative "g's" other than careful flying

V. Weightlessness
   A. A state of "zero-g" (free fall)
   B. Accomplished in flight by initially <u>pushing</u> aircraft over faster than a falling body, then holding that attitude while falling body is suspended in space within aircraft
   C. Continuous state of falling

VI. "g" forces in rockets
   A. Positive "g's" not a result of centrifugal force
      1. Constant acceleration drives pilot to "floor" with a force proportional to acceleration of rocket.
      2. "g's" sustained for longer period than in conventional aircraft
   B. Weightlessness
      1. Result of capsule continuously falling toward earth
      2. Pilot is in continuous state of free fall

APPENDIX VII

THE INFLUENCE OF "4 g's" ON MICE

The following abstract was prepared by Douglas A. Jones, Grosse Pointe High School, Grosse Pointe Michigan. It was written while he was a junior but covers a three-year span of activities related to the specific problem, the influence of "g's" on mice. It is included in this material to provide a concrete example of student-teacher generated study and research. The student gives special recognition to his junior high school science teacher, Mr. Bruce Westling, Pierce Junior High School, Grosse Pointe, Michigan, for the support and encouragement he provided.

ABSTRACT
(Douglas A. Jones)

This paper reviews my studies of the influence and effect that higher gravities, as simulated by centrifugation, have on mice. Extensive research has been done only with short term exposures, as, for example, when training astronauts.

Long term exposures were first used by Dr. Knight in 1806 with a study on the direction of seed growth under higher "g" forces. One hundred and fifty years later, in 1953, Dr. Gray at Emory University and

Dr. Matthews of Cambridge, England, continued this research. Dr. Gray studied wheat growth at up to 500 gravities or "g's". Dr. Matthew studied rats at 3 "g's". Sparked by this study, Dr. Wunder, University of Iowa, began investigations with fruit fly larvae at up to 5000 "g's", and with hamsters, mice, mouse tumors, and turtles at 2-7 "g's". In 1955 Dr. Smith at Davis University, California began experimentation with poultry.

A 1961 Time magazine article of Dr. Wunder's investigations interested my biology teacher and me. I was curious to learn more of centrifuges, centrifugation and Dr. Wunder's work. Later I visited Dr. Wunder at the University of Iowa to talk with him about his procedures, methods, and results.

1961-62 Project

For my centrifuge I obtained a 1/25 horsepower motor and a bomb sight mechanism (both of which were war surplus), a voltage regulator, a plastic pedestal, a metal wall-shelf bracket, and two cages covered on five sides by sheet metal. My experimental animals consisted of seven mice, four designated as "experimental", and three designated as "control".

A gravitational force of 2 "g's" was sustained for 119 days. This force was continuous except for a ten-minute interval each day required to food and weigh the mice, and to clean the cages.

The experimental mice appeared to adapt to the greater "g" force after the first week. During this week there was a weight loss by the mice followed by a weight gain. A permanent decrease in the rate of growth remained.

The leg femurs and hearts of the experimental mice were heavier and larger than the control mice. The experimental mice were able to mate and bear young as were the control mice. However, the draft caused by the one uncovered side of the cages was believed to be responsible for pneumonia of the new-born mice, resulting in their premature death.

1962-63 Project

To experiment with more mice at a greater "g" force, a second pair of cages and a new set of aluminum covers for all four cages were secured. The covers were designed to reduce the amount of draft on the older mice as well as additional protection to new-born mice.

For 100 days, thirteen mice were exposed to 4 "g's" except for the fifteen minutes required to feed and weigh the mice, and to clean the cages.

Adaptation and weight averages were similar to the averages of the previous experiment at 2 "g's", though there appear to be less physical activity by this experimental group. The hearts and femurs were heavier and enlarged. The bone density of the experimental mice was not significantly different from that for the control mice.

Mating and the birth of young occurred during centrifugation. Although the cage covers reduced the openings in the cage, the doubled speed increased the rate of evaporation. Pneumonia was contracted by the new-born mice with their subsequent loss.

It was interesting to note that after the experiment was concluded the remaining experimental mice consumed a larger quantity of food and grew at a faster rate than the control mice.

1963-64 Project

This project is now in progress. Improvements in the centrifuge include an improvement in the drive between the motor and the drive roller and ball bearings of the bomb sight mechanism. The cages and covers were replaced by gallon paint cans. The new "cage" eliminates drafts when the lid is sealed. There is a ¼ inch hole on the lid of the container along with a filter to allow a gentle flow of air to the mice.

Criterion to be used for this experiment will include the weight averages, respiration rate, basal metabolism rate, blood pressure, blood smears, and examination of femur, tibia, fibula, medial condyle, heart, lungs, and stomach.

Summary

From my experiments, I have found that mice were able to eat, live, and reproduce comfortably under the additional stress of increased gravity to 4 "g's".

APPENDIX VIII

WHERE, OH, WHERE HAS MY LITTLE THERMOMETER GONE?

This student activity is designed to encourage students to be more aware of the weather extremes found over the world's surface. The two-dimensional nature of the map on the next page limits the amount of interpretation students can give to the locations where the various temperature, rainfall, and wind speed records occurred. It is suggested that a relief map of the area be secured so that the relevance of major mountain chains, local geographic features and related vegetational factors can be graphically demonstrated.

To use the map and weather extreme information, the following is suggested:

1. Duplicate the world map, numbering the locations which you wish to use.

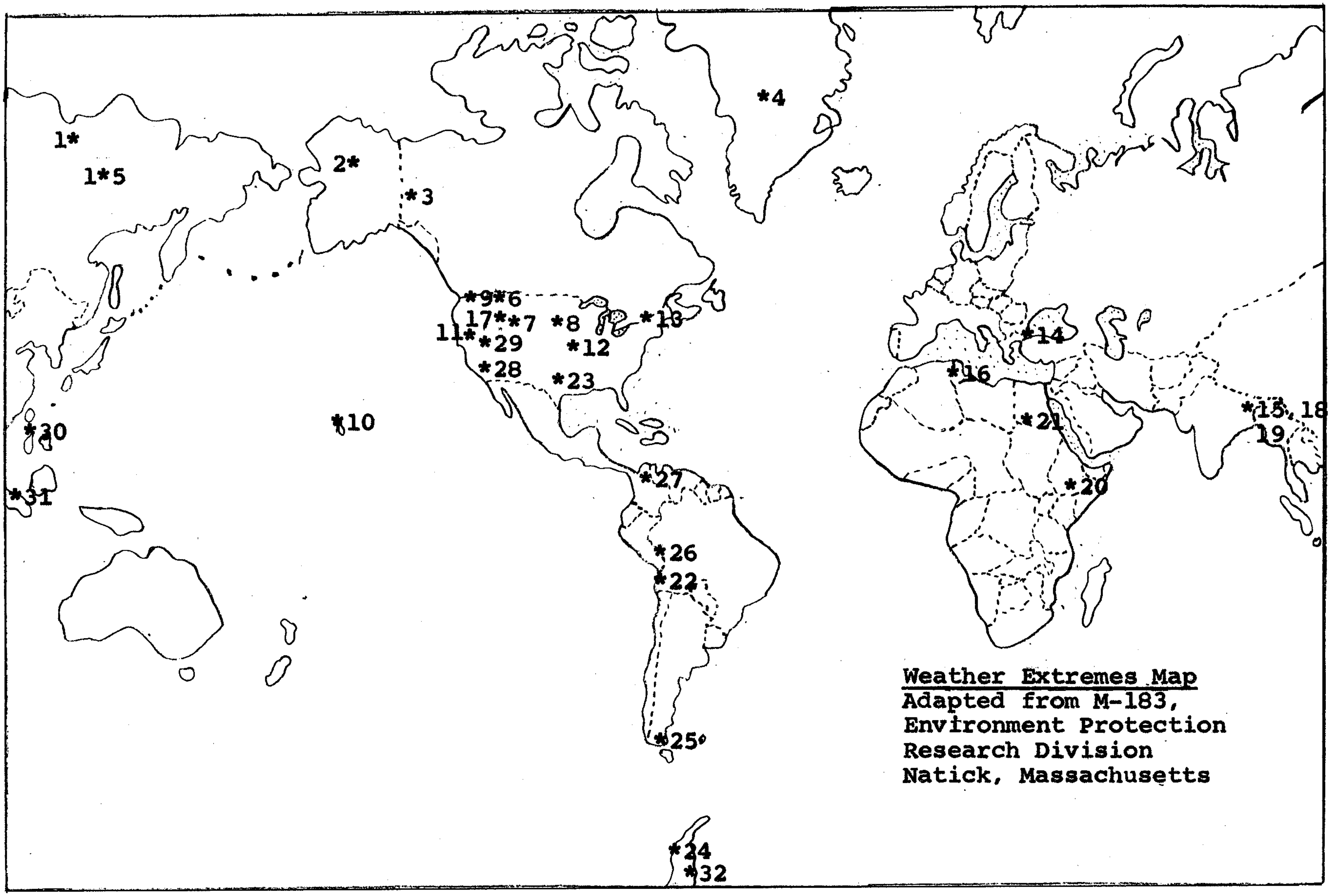
2. On a separate page, list the various weather extremes which you wish to have the students locate. The specific location associated with the weather extreme may be omitted, dependent upon the goal of the lesson. A lesson in geography might include the name of the location on the original world map (see no. 1) without the weather extreme information, or vice versa.

3. Follow up on students' questions, encouraging them to secure additional information on the various locations, particularly topographical features which may account for the specific weather situation.

	Record	Location	Finding
1.	World's Official Lowest Temperature	Oimekon (1933) Verkhoyansk (1892) Siberia	-90° F.
2.	Alaska's Lowest Temperature	Tanana, Jan. 1886	-76° F.
3.	North America's Lowest Temperature	Snag, Yukon Feb. 3, 1947	-81° F.
4.	Greenland's Lowest Temperature	(At 9820 Ft) Dec. 6, 1949	-87° F.
5.	World's Unofficial Lowest Temperature	Oimekon, Siberia	-108° F.
6.	U.S. Greatest 24 Hr. Temperature Fall	Browning, Mont. 23-24 Jan., 1916	44° F. to -56° F.
7.	U.S. Lowest Temperature	Rogers Pass, Mont. 20 Jan., 1954	-70° F.
8.	U.S. Greatest 2 Minute Temperature Rise	Spearfish, S. D. 22 Jan., 1943	-4° F. to 45° F.
9.	U.S. Greatest AV. Annual Precipitation	Wynoochee, Wash.	151 in.
10.	World's Greatest AV Annual Precipi- tation	Mt. Waialeale, Kauai, Hawaii	472 in.
11.	AV Daily Total Solar Radiation	Soda Springs, Cal. In July Each Year	750 GM CAL/CM^2
12.	World's Greatest 42 Minute Rainfall	Holt, Mo. 22 June, 1947	12 in.
13.	World's Highest Surface Wind Speed	Mt. Washington, N.H. 12 April, 1934	231 mph
14.	Europe's Greatest AV Annual Precipi- tation	Crkvice, Yugoslavia	183 in.
15.	Rain in one 5 Day Period	Cherrapunji, India Aug. 1841	12½ Ft.

16.	World's Highest Temperature	El Azizia, Libya 13 Sept., 1922	136° F.
17.	U.S. Greatest 24 Hr. Snowfall	Silver Lake, Colo. 14-15 April, 1921	76 in.
18.	World's Greatest Rainfall for 1 Yr.	Cherrapunji, India Aug 1860-July 1861	1042 in.
19.	World's Greatest Rainfall per Calendar Month	Cherrapunji, India July 1861	366 in.
20.	World's Highest AV Annual Temperature	Lugh Ferrandi, Somalia	88° F.
21.	No Rain in 19 Yrs. Record of Observation	Wadi Halfa, Sudan	
22.	No Rain for 14 Yrs.	Iquique, Chile	
23.	U. S. Unofficial Greatest 12 Hr. Rainfall	Thrall, Tex. 9 Sept., 1921	32 in.
24.	Antarctica's Lowest Temperature	21-22 July, 1934	-83° F.
25.	Rain (AV)	Bahia Felix, Chile	325 Days per Yr.
26.	World's Lowest AV Annual Rainfall	Arica, Chile	.02 in.
27.	South America's Greatest Av Annual Rainfall	Buena Vista, Colombia	342 in.
28.	U.S. Highest Temperature	Death Valley, Cal. 10 July 1913	134° F.
29.	U.S. Greatest Single Season Snowfall	Tamarack, Cal. 1906-1907	884 in.
30.	World's Greatest 24 Hr. Rainfall	Baguio, Luzon 14-15 July, 1911	46 in.

31.	AV Annual Thunderstorm Days	Buitenzorg, Java	322
32.	Annual AV Temperature Estimated Lowest	Adelie Land, Antarctica	-30° F. (At 2000 M)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Weather Extremes Map
Adapted from M-183,
Environment Protection
Research Division
Natick, Massachusetts

APPENDIX IX

GLOSSARY OF TERMS

ACCELERATION DUE TO GRAVITY - Acceleration of a body falling freely in a vacuum; varies slightly in different localities as a result of variations in the distance from the center of mass of the Earth.

ALPHA PARTICLE - Helium nucleus, a close combination of two neutrons and two protons--positively charged. Alpha particles are emitted from the nuclei of certain radioactive elements.

APOGEE - An object is said to be in apogee when it is at its greatest distance from the Earth.

ASTROBIOLOGY - A branch of biology concerned with the discovery or study of life on other plants.

ASTRONAUT - A person actively engaged in flying through space, or one who navigates through space.

ASTRONAUTICS - The art and science of flying through space or sending winged guided vehicles or missiles through space.

ATMOSPHERE - Gaseous envelope surrounding the Earth or other planets.

ATMOSPHERE - The normal or standard. Unit of pressure which will support a column of mercury 760 mm. high (29.92 inches) at 0^{o} C., sea-level 1 normal atmosphere = 14.72 lb./sq. in. Atmospheric pressure fluctuates from day to day.

AUDIBILITY, LIMITS OF - The limits of frequency of sound-waves which are audible as sound to the human ear. The lowest is approximately 30 vibrations per sec., corresponding to a very deep vibrating rumble, and the highest in the region of 30,000, corresponding to a shrill hiss.

BETA PARTICLES - β particles. Term applied to swiftly moving electrons, when emitted by radioactive substances.

BETA RAYS - B rays. Stream of beta particles; possess greater penetrating power than alpha rays and are emitted with velocities in some cases exceeding 98% of the velocity of light.

BIOASTRONAUTICS - Astronautics considered for its effects upon animal or plant life.

BIOCHEMISTRY - The chemistry of living material.

BIOPHYSICS - The application of physics to the study of biology.

BIOSPHERE - That part of the earth and its atmosphere in which animals and plants live.

CALORIE - Unit of quantity of heat. The amount of heat required to raise the temperature of 1 gm. of water through 1° C.

CALORIE, LARGE - Kilogram-calorie. 1000 calories. Written Calorie, used for identifying energy values of foods.

CATALYSIS - The alteration of the rate at which a chemical reaction proceeds, by the introduction of a substance (catalyst) which remains unchanged at the end of the reaction. Small quantities of the catalyst are usually sufficient to bring the action about or to produce a vast increase in its speed.

CATALYST - Substance which alters the rate at which a chemical reaction occurs, but is itself unchanged at the end of the reaction. The enzymes are organic catalysts produced by living cells.

CHLOROPHYLL - Green pigment contained in the leaves of green plants. Absorbs energy from sunlight to enable the plant to build up sugar.

CONVECTION - Transference of heat through a liquid or gas by the actual movement of the fluid. Portions in contact with the source of heat become hotter, expand, become less dense and rise; their place is taken by colder portions.

COSMIC RAYS - Very energetic radiation falling upon the Earth from outer space, and consisting chiefly, if not entirely, of charged particles.

COSMIC RAY SHOWERS - High-energy electrons passing through the atmosphere lose energy rapidly, chiefly by the process of 'collision radiation'; i.e. the electron, on passing through the electric field of an atomic nucleus, emits a photon. This photon, after travelling a short distance, is absorbed by interaction with a nuclear electric field giving rise to a positron and an electron. The conversion of a photon into an electron and positron in this manner is called 'pair production'. This pair of newly-created particles produce two further photons by collision radiation. These photons are again absorbed, giving rise to more electrons and positrons. This process continues, producing a cascade or shower of particles, until the final electrons and positrons created possess insufficient energy to emit the 'collision radiation'.

COSMOGONY - Theories as to the origin of the heavenly bodies.

CURIE - Measure of the activity of a radioactive substance. Originally defined as the quantity of radon in radioactive equilibrium with 1 gm. of radium. Now extended to cover all radioactive isotopes by the definition 'that quantity of a radioactive isotope which decays at the rate of 3.7×10^{10} disintegrations per second'.

DECIBEL - The decibel is a unit used to compare, or indicate changes in levels of sound intensity.

DIALYSIS - Separation of colloids in solution from other dissolved substances (crystalloids) by selective diffusion through a semi-permeable membrane. Such a membrane is slightly permeable to the molecules of the crystalloids, but not to the larger molecules or groups of molecules in the colloidal state.

DIASTASE - Enzyme contained in malt. Converts starch into maltose during brewing.

DOPPLER EFFECT OF SOUND - Change of pitch of sound (i.e. frequency) received by an observer, due to relative motion between the observer and the source, the motions being measured with respect to the air considered at rest. As an example, the whistle of a moving train appears to be higher in pitch when moving towards an observer than when receding from him.

DOPPLER PRINCIPLE - To an observer approaching the source of any wave motion, the frequency appears greater than to an observer moving away; thus light emitted by a receding body would appear more red (red light being of a lower frequency than other colours) than if the body and the observer did not move relatively to each other. This has found important applications in the study of the nature of the Universe.

EARTH - Planet having its orbit between those of Venus and Mars. Sphere, slightly flattened towards the poles. Equatorial radius 3964 miles; polar radius 3950 miles. Mean density 5.53; mass 5.87×10^{21} tons.

EARTH'S CRUST, lithosphere - Consists of an outer layer of surface soil of varying thickness lying upon a mass of hard rock several miles thick.

EARTH'S CRUST, CHEMICAL COMPOSITION OF - The approximate estimated percentages by weight of the chief chemical elements composing the Earth's crust are: oxygen 47%, silicon 28%, aluminium 8%, iron 4.5%, calcium 3.5%, sodium and potassium 2.5%, carbon 0.2%, phosphorus and sulphur 0.1% each.

EAST-WEST ASYMMETRY OF COSMIC RAYS - The observed intensity of cosmic ray particles coming from the West is greater than that coming from the East at any given latitude. This asymmetry is due to the deflection of the primary charged cosmic ray particles by the magnetic field of the Earth, and indicates a preponderance of positively charged particles in the incoming radiation.

ECOLOGY - The study of the relation of plants and animals to their environment.

ECOSPHERE - A layer in a sphere inhabited by living organisms or suitable for the life of such organisms, as a layer of space about the sun extending from and including Venus through Mars, or the biosphere of the earth, especially that part of the troposphere extending to about 13,000 feet.

ELECTRON - Elementary particle, approximately 1/1840 that of a hydrogen atom.

ELEMENT - Substance consisting entirely of atoms of the same atomic number.

ELEVEN-YEAR PERIOD - A periodic change in occurrence of sunspots, the cycle being complete in approximately eleven years.

ENZYMES - Organic substances produced by living cells, which act as catalysts in chemical changes. Enzymes are specific in their action; i.e. each enzyme affects only one type of chemical reaction.

ERGOSTEROL - Member of the sterol group of organic compounds; occurs in small amounts in the fats of animals; converted into vitamin D_2 by the action of ultra-violet radiation.

EXOSPHERE - The outermost layer of the earth's atmosphere, above the IONOSPHERE; it blends into outer space.

EXPLOSIVE DECOMPRESSION - Physical and physiological phenomena caused by sudden decrease in atmospheric pressure.

FATS AND OILS - Natural organic compounds which occur in plants and animals and serve as storage materials. The distinction between fats and oils is one of melting point; the term oil is usually applied to glycerides liquid at 20° C., the others being termed fats.

FERMENTATION - Chemical change brought about in organic substances by living organisms (yeast, bacteria, etc.) by enzyme action.

FILTER - Device for separating solids or suspended particles from liquids. Consists of a porous material through the pores of which only liquids and dissolved substances can penetrate.

FILTRATE - Clear liquid after filtration; substance which has been filtered, containing no suspended matter.

FILTRATION - The process of separating solids from liquids by passing through a filter.

FIXATION OF ATMOSPHERIC NITROGEN - Manufacture of compounds of nitrogen for use as fertilizers, from the free nitrogen in the air; made necessary by the increasing shortage of natural nitrogen compounds in the nitrogen cycle. This shortage is caused partly by increased cultivation of the soil due to increase of populations, and partly by the loss of nitrogen compounds from animal waste products by sewage disposal into the sea. Certain bacteria in the soil fix atmospheric nitrogen.

FIXED AIR - Former name for carbon dioxide, CO_2.

FOOD PRESERVATION - Prevention of chemical decomposition and of the development of harmful bacteria in foods. Generally effected by the sterilization of the food by heating in sealed vessels, i.e. canning; or by making the conditions unfavourable for the development of bacteria, by pickling, drying, smoking, etc.

FOOT-CANDLE - Unit of illumination. One lumen per square foot.

FOOT-POUND - Practical unit or work. Work done by a force of 1 pound weight acting through a distance of 1 foot.

FORCE - External agency capable of altering the state of rest or motion in a body; measured in dynes or poundals.

FREEZING - Change of state from liquid to solid; takes place at a constant temperature for any given substance under a given pressure.

g - Symbol for the value of the acceleration due to gravity.

GAMMA-RAYS - γ rays. Electromagnetic waves of very short wave-lengths, shorter than those of X-rays. Produced during the disintegration of radio-active elements.

GAS - Substance in the gaseous state, always occupying the whole of the available space in the containing vessel, and consisting of molecules moving freely in space.

GEIGER COUNTER - Instrument for the detection of ionizing radiations, capable of registering individual particles. Consists normally of a fine wire anode surrounded by a coaxial cylindrical metal cathode, mounted in a glass envelope containing gas at low pressure. A large potential difference, usually about 1000 volts, is maintained between the anode and the cathode. The ions produced in the counter by an incoming ionizing particle are accelerated by the applied potential difference towards their appropriate electrodes, causing a momentary drop in the potential between the latter. This voltage pulse is then passed on to various electronic circuits by means of which it can, if desired, be made to work a mechanical counter.

GEL - Colloidal solution which has set to a jelly, the viscosity being so great that the solution has the elasticity of a solid.

GENETIC EFFECT - In radiobiology, inheritable changes resulting from the absorption of ionizing radiations.

GEOLOGY - Scientific study of the Earth's crust.

GERMICIDE - Substance capable of destroying bacteria.

GLUCOSE - $C_6H_{12}O_6$. Colorless crystalline soluble sugar. Occurs in honey and sweet fruits. Other sugars and carbohydrates are converted into glucose in the human body before being utilized to provide energy.

GLYCOGEN - Complex carbohydrate formed from glucose and starch in the liver and other organs of animals, serving as a sugar reserve.

GREENHOUSE EFFECT OF AN ATMOSPHERE - The glass roof of a greenhouse lets the short waves of sunlight and heat pass through, but is nearly opaque to the longer heat waves that radiate from soil, plants and heating units inside. The atmosphere of a planet acts in the same way.

Sunlight and heat pass through the air without heating it, but they are absorbed by water and earth, and so heat the surface. Longer waves of heat radiate from the earth and are absorbed by the air, and these heat the air.

This gives a climate that makes life possible on the earth. The moon, with no atmosphere, has great and rapid changes of temperature between day and night, which help to make life there impossible.

HAEMOGLOBIN - Red colouring matter (respiratory pigment) present in the red corpuscles of blood; consists of a protein, globin, combined with a pigment, haem. Serves to carry oxygen, which is breathed in, round the body in the form of an easily decomposed compound, oxyhaemoglobin.

HEAT - Energy possessed by a substance in the form of kinetic energy. Usually measured in calories. Transmitted by conduction, convection and radiation. The chief observable physical effects of a change in the heat content of a body may include rise in temperature; change of state from solid to liquid (melting), solid to gas (sublimation) and liquid to gas (evaporation and boiling); expansion; and electrical effects.

HETEROGENEOUS - Not of a uniform composition; showing different properties in different portions.

HORMONES - Specific substances produced by the endocrine glands of the body, regulating many functions of the organism. Organic compounds of a very complex nature.

HUMIDITY OF THE ATMOSPHERE - A measure of the water vapour present in the air. May be given in terms of relative humidity, or as absolute humidity, the mass of water present in a cubic meter of the air.

HUMUS - Vegetable matter decomposed by the action of bacteria and other living organisms.

HYDROGEN PEROXIDE - H_2O_2. Gives off oxygen readily, used as a disinfectant and bleaching agent. Strength of solution usually given in terms of 'volume strength'; thus, 10 volume hydrogen peroxide will evolve 10 times its own volume of oxygen gas.

HYDROPONICS - Cultivation of plants without the use of soil, by the use of solutions of those mineral salts which a plant normally extracts from the soil.

HYDROSPHERE - Watery portion of the Earth's crust, comprising the oceans, seas and all other waters. Composition by weight is given as oxygen 85.8%, hydrogen 10.7%, chlorine 2.1%, sodium 1.1%, magnesium 0.14%, not more than 0.05% of any other element being present. The chief constituents are water, H_2O, sodium chloride, NaCl, and magnesium chloride, $MgCl_2$.

INFRA-RED RAYS - Invisible heat radiation, radiant heat. Electromagnetic waves possessing wave-lengths between those of visible light and those of wireless waves. Infra-red radiation has the power of penetrating fog or haze.

ION EXCHANGE - Certain substances have the power of acting on solutions containing ions, such as solutions of salts, and replacing some of the ions by others.

IRRADIATION - The exposure to radiation.

ISOTOPES - Atoms of the same element, i.e. having the same atomic number but differing in atomic weight, are called isotopes of that element. The isotopes of an element are identical in chemical properties, and in all physical properties except those determined by the mass of the atom. The different isotopes of an element contain different numbers of neutrons in their nuclei. Nearly all elements found in nature are mixtures of several isotopes.

ISOTOPIC WEIGHT - The atomic weight of an individual isotope expressed on a scale on which the most abundant isotope of oxygen has a weight exactly equal to 16. Isotopic weights are very nearly whole numbers.

JUPITER - Planet, having nine small satellites, with its orbit between those of Mars and Saturn. Largest of the planets. Mean distance from the Sun=483 million miles. Sidereal period ('year')= 11.86 years. Mass approximately 318 times that of the Earth. Surface temperature probably about -150°C.

KILOGRAM - 1000 grams. Practical metric system unit of mass and weight. 2.2046 lb.

LATENT PERIOD - In radiobiology and health physics, the interval between an exposure to radiation and the appearance of its effect.

LATENT TISSUE INJURY - In radiobiology and health physics, an injury owing to exposure to radiation which does not manifest itself for some time.

LIFE ON OTHER PLANETS - Life, as we know it, requires air, water and temperatures within rather narrow limits.

The moon, other satellites and Mercury have no atmospheres and no water. The giant planets and Pluto are so far from the sun that their temperatures are too low, and their atmospheres are made up of poisonous gases.

Venus is cloud-covered so that we can see nothing, but the apparent absence of water and oxygen and the presence of a large amount of carbon dioxide, seem to make life very questionable if not impossible. Mars has a thin atmosphere, apparently a little water and is not impossibly cold.

LIGHT - Name given to the agency by means of which a viewed object influences the observer's eye. Consists of electromagnetic waves within the wave-length range 4×10^{-5} cm. to 7×10^{-5} cm. approximately; variations in the wave-length produce different sensations in the eye, corresponding to different colours.

LIGHT, VELOCITY OF - Mean value is 186,326 miles/sec.

LIGHT-YEAR - Astronomical measure of distance; the distance travelled by light in one year. Approximately 6 x 10^{12} miles (6 million million miles).

LIQUID - State of matter intermediate between solid and gas; has a definite volume, but assumes the shape of the vessel in which it is contained.

MARS - Planet, with two small satellites, having its orbit between those of the Earth and Jupiter. Mean distance from the Sun=141.5 million miles. Sidereal period ('year')=687 days. Mass approximately one-ninth that of the Earth. Probably possesses an atmosphere containing oxygen. Surface temperature about 6°C. No evidence of conscious life on the planet is available.

MASS - It is a matter of observation that a force applied to a body produces an acceleration proportional to the force. The constant of proportionality is the mass of the body.

MAXIMUM PERMISSIBLE LEVEL OR LIMIT (MPL) - In radiation physics, the tolerable DOSE RATE for humans exposed to nuclear radiation. (At present, the internationally established recommendations stipulate an MPL of 0.3 roentgen per week.)

MERCURY - Planet with its orbit nearest the Sun. Mean distance from the Sun=36 million miles. Sidereal period ('year')=88 days. Mass approximately one twenty-ninth that of the Earth. Probably at a high temperature, and without an atmosphere.

METER - Unit of length in the metric system. Length of the International Meter (preserved in Paris) = 39.37 inches.

METRIC SYSTEM - System of weights and measures originally based upon the meter. This was intended to be 1/10,000,000 of a quadrant of the Earth through Paris.

MOLECULE - Smallest portion of a substance capable of existing independently and retaining the properties of the original substance.

MOON - Satellite of the Earth. Mean distance from the Earth, 239,000 miles; synodic month 29.5 days, sidereal month 27.3 days. Mass approximately 1/81 that of the Earth; diameter quarter that of the Earth. Devoid of water or an atmosphere.

NEAR INFRA-RED OR ULTRA-VIOLET - The shortest infra-red or the longest ultra-violet wave-lengths; i.e. those wave-lengths of these two types of radiation which are 'nearest' in magnitude to those of visible light.

NEPTUNE - Planet with one satellite. Orbit lies between those of Uranus and Pluto. Mean distance from the Sun, 2793 million miles. Sidereal period ('year'), 164.8 years. Mass approximately 17 times that of the Earth. Surface temperature probably below $-200^{\circ}C$.

NEUTRINO - Fundamental uncharged particle, the existance of which has been postulated in order to preserve the laws of conservation of mass and energy and conservation of momentum in certain nuclear reactions. The neutrino has zero or very small rest mass.

NEUTRON - Electrically uncharged particle possessing a slightly greater mass than the proton. A constituent of all atomic nuclei except the normal hydrogen nucleus, which is a single proton. Owing to the absence of electric charge, the neutron can pass readily through matter.

NEWTON'S LAWS OF MOTION - The fundamental laws on which classical dynamics is based. 1. Every body continues in its state of rest or uniform motion in a straight line except in so far as it is compelled by external forces to change that state. 2. Rate of change of momentum is proportional to the applied force, and takes place in the direction in which the force acts. 3. To every action there is an equal and opposite reaction.

NITROGEN CYCLE - The circulation of nitrogen compounds in nature through the various organisms to which nitrogen is essential. Inorganic nitrogen compounds in the soil are taken in by plants, and are combined by the plants with other elements to form proteins, the form in which nitrogen can be utilized by the higher animals. The result of animal waste and decay is to bring the nitrogen which the animals had absorbed in the form of proteins, back into the soil in the form of simpler nitrogen compounds. Bacterial action of various kinds converts these into compounds suitable for use by plants again. In addition to this main circulation, a certain amount of atmospheric nitrogen is 'fixed' (i.e. combined) by the action of bacteria associated with the roots of leguminous plants, and by the action of atmospheric electricity; while some combined nitrogen is set free by the action of denitrifying bacteria.

NUCLEUS - Vital central point; particle of matter acting as center; e.g. a particle of dust will act as a nucleus for the condensation of water in mist.

NUCLEUS, ATOMIC - Positively charged body, consisting of positively charged protons and neutral neutrons, constituting the main mass of the atom.

PERIGEE - The Moon or the Sun are said to be in perigee when they are at their least distance from the Earth.

PERIMETER - The distance all round a plane figure; e.g. the perimeter of a circle is its circumference.

PERIPHERY - The external surface or boundary of a body; the circumference or perimeter of any closed figure.

PERPETUAL MOTION - Concept of a machine which, once set in motion, will go on for ever without receiving energy. It is impossible to make a machine which will go on for ever and be able to do work, i.e. create energy without receiving energy from outside.

PERSISTENCE OF VISION - The sensation of light, as interpreted by the brain, persists for a brief interval after the actual light stimulus is removed; successive images, if they follow one another sufficiently rapidly, produce a continuous impression. Use is made of this in the movie projector.

PERSONAL EQUATION - A systematic error in observations due to the characteristics of the observer; it is the difference between the true reading and that made by the observer.

PHYSICS - The study of the properties of matter and energy.

PITCH OF A NOTE - Measure of the frequency of vibration of the source producing the note; a high frequency produces a note of high pitch.

PLANETS - Heavenly bodies revolving in definite orbits about the Sun. Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto.

PLUTO - Planet with its orbit outside that of Neptune. Discovered in 1930. Mean distance from the Sun, 3,671 million miles. Sidereal period ('year') 248.4 years. Mass approximately that of the Earth. Surface temperature probably below $-200^{o}C$.

POLARIZATION OF LIGHT - Ordinary light consists of electric (E) and magnetic (H) vibrations taking place in all possible planes containing the ray, the vibrations themselves being at right angles to the direction of the light path; i.e. light is a transverse wave motion. For each E vibration the associated H vibration takes place in a plane at right angles to it. In plane-polarized light, the E vibrations are confined to one plane, called the plane of vibration, and hence the associated H vibrations are also confined to one plane, the plane at right angles to this, called the plane of polarization.

POWER - Rate of doing work. Measured in units of work per unit time.

PROTEINS - Class of organic compounds of very high molecular weights (18,000-10,000,000) which compose a large part of all living matter. Protein molecules invariably contain the elements carbon, hydrogen, oxygen and nitrogen; often also sulphur and sometimes phosphorus. Proteins are essential in food; their function is to be build into the body-tissues. The usefulness of a protein in food depends upon the nature of the amino acids from which the particular protein is built up, since some amino acids necessary to the human body cannot be made within the body. Typical proteins are albumin in egg-white; casein in cheese; foods containing a high percentage of proteins include cheese, lean meat, fish and eggs.

PROTON - Positively-charged particle having mass approximately 1840 times greater than that of the electron and charge numerically equal to that of the electron. Constituent of all atomic nuclei.

PROTOPLASM - Highly complex colloidal substance containing protein-like materials; essential constituent of all living cells.

RADIATION - In general, the emission of any rays, wave motion or particles (e.g. alpha particles, beta particles, neutrons) from a source; usually applied to the emission of electromagnetic waves.

RADIOACTIVE - Possessing, exhibiting or relating to radioactivity.

RADIOACTIVE EQUILIBRIUM - A state ultimately reached when a radioactive substance of slow decay yields a radioactive product on disintegration. This product may also decay to give a further radioactive substance, and so on. The amount of any of the daughter radioactive products present after equilibrium has been reached remains constant, the loss due to decay being counterbalanced by gain from the decay of the immediate parent.

RADIOACTIVE TRACING - Any two isotopes of an element are chemically identical. Thus, by introducing a small amount of a radioactive isotope, called a tracer, the course taken by the stable isotope of the same element can be followed or traced by detecting the course of the accompanying radioactive isotope by suitable means. This can be done in various ways; e.g. Geiger Counter.

RADIOACTIVITY - The spontaneous disintegration of unstable atomic nuclei to give more stable product nuclei, usually accompanied by the emission of charged particles. The most common types of radioactive change result in beta-particle emission and are (1) a neutron present in the unstable nucleus is converted into a proton with the emission of an electron and a neutrino. The product nucleus is an isotope of an element of atomic number exceeding that of the original element by unity. (2) A proton present in the unstable nucleus is converted into a proton with the emission of a positron and a neutrino. The resulting isotope has an atomic number one less than the original nucleus. Alpha particles are emitted only by certain radioactive isotopes of the heavier elements. Alpha particle emission results in a daughter nucleus of an atomic number smaller by two than that of the parent. Gamma-rays accompany the alpha or beta particles when the product nucleus is formed in an excited state.

RADIOBIOLOGY - That branch of biology which studies and deals with the effects of radiation on living organisms.

RADIOISOTOPE - A radioactive isotope of a chemical element.

SATELLITES - Bodies rotating in orbits round the planets; e.g. the Moon is a sattelite of the Earth.

SATURN - Planet, with nine small satellites, and surrounded by characteristic rings. Orbit lies between those of Jupiter and Uranus. Mean distance from the Sun, 886 million miles. Sidereal period ('year'), 29.46 years. Mass, approximately 95 times that of the Earth. Surface temperature, about -150°C.

SATURN'S RINGS - Three concentric rings, probably composed of the remains of a broken-up satellite, which are seen round the planet Saturn.

SIDEREAL YEAR - See Year.

SOLAR SYSTEM - A system of nine planets-Mercury, Venus, the Earth, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto-and of a belt of asteroids revolving in elliptical orbits round the Sun. The orbits are nearly circular, and lie very nearly in the same plane.

SPACE - The entire universe beyond the atmospheric envelope of the earth; the near-vacuum in which the solar system, stars, nebulae, galaxies exist.

SPACE BIOLOGY - A branch of biology concerned with life as it may come to exist in space.

SPACE MEDICINE - The new branch of medical science concerned with the prevention and alleviation of adverse effects of various aspects of space travel (zero-gravity, intensified exposure to cosmic radiations, psychological and psycho-neurotic effects, etc.) on human beings.

SPACE-SICKNESS - A general term for the expected physical and psychological effects of zero-gravity on human beings.

SPACE-TIME - The development of the theory of relativity has led to the disappearance of a clear-cut distinction between a three-dimensional space and an independent time; in the modern view, space and time are considered as being welded together in a four-dimensional space-time continuum.

STARS - Fixed stars. Heavenly bodies of a nature similar to that of the Sun; intensely hot, glowing masses, situated at enormous distances from the solar system, the nearest being over 4 light-years away.

SUN - Incandescent, approximately spherical, heavenly body, round which the planets rotate in elliptical orbits. Mean distance from the Earth, approximately 93 million miles; diameter, about 866,000 miles; mass, 2×10^{27} tons; mean temperature, 5700°C.; average density 1.4. Spectrum analysis shows that it is composed of many of the elements found in the Earth, and no others.

SUN-SPOTS - Large patches, which appear black by contrast with their surroundings, visible upon the surface of the Sun. Owing to the rotation of the Sun, they appear to move across its surface. Their appearance is spasmodic, but their number reaches a maximum approximately every eleven years. Connected with such phenomena as magnetic storms and the Aurora Borealis.

TEMPERATURE - The temperature of a body is a measure of its 'hotness' or 'coldness', primary physical ideas which themselves cannot be precisely defined. It may, however, be said that the change in temperature of a body is a measure of the change in energy of the atoms or molecules of which the substance is composed. Measured in degrees Centigrade, Fahrenheit, or absolute.

TERMINAL VELOCITY - If a body free to move in a resisting medium is acted upon by a constant force a body falling under the force of gravity through the atmosphere, the body accelerates until a certain terminal velocity is reached, after which the velocity remains constant.

ULTRAVIOLET RADIATION - The invisible electromagnetic radiation beyond the violet end of the spectrum of visible light, of wavelengths ranging, roughly, from 4000 angstroms down to 400 angstroms.

ULTRA-VIOLET RAYS - Electromagnetic waves between visible light waves and X-rays. The longest ultra-violet waves have wave-lengths just shorter than those of violet light, the shortest perceptible by the human eye. Affect the photographic plate; their action on ergosterol in the human body produces vitamin D. Radiation from the Sun is rich in such rays; they may be produced artificially by the mercury vapour lamp.

VENUS - Planet with its orbit between those of Mercury and the Earth. Mean distance from the Sun, 67 million miles. Sidereal period ('year'), 225 days. Mass, approximately 0.8 that of the Earth. There is no evidence of oxygen in the atmosphere of the planet, which is probably surrounded by a mass of clouds. The temperature is probably higher than that on the Earth.

VITAMINS - A group of organic substances, occurring in various foods, which are necessary for a normal diet. Absence or shortage leads to various deficiency diseases. Before the chemical nature of any of the vitamins was known, they were named by the letters of the alphabet.

Vitamin A - $C_{20}H_{29}OH$, occurs in milk, butter, green vegetables and in liver, especially of fish. Deficiency causes 'night-blindness' and ultimately more serious eye troubles; the resistance of the mucous membranes to infection also decreases. This vitamin can be made in the body from carotene.

Vitamin B - Originally regarded as a single substance, has been shown to be a whole group of compounds termed the vitamin B. complex; these occur in wheat-germ, yeast and other sources. B_1, aneurin, protects from neuritis, muscular weakness and digestive disturbances; serious deficiency causes beri-beri. B_2 lactoflavin or riboflavin, promotes growth in the young and probably plays an important part in the health of the skin.

Vitamin C - Ascorbic acid, occurs in the juice of lemons and oranges and in fresh vegetables; deficiency causes scurvy.

Vitamin D - Calciferol, occurs together with vitamin A; it is formed in the human skin by the action of sunlight. It controls the deposition of calcium compounds in the body; deficiency causes rickets. Absence of vitamin E, which occurs in green vegetables and wheat-germ, causes sterility in women. In addition to all these, numerous other vitamins have been discovered in recent years.

X-RAYS - Electromagnetic waves of the same type as light. Produced when cathode rays (a stream of electrons) strike a material object. X-rays affect a photographic plate in a way similar to light. The absorption of the rays by matter depends upon the density and the atomic weights of the material. The lower the atomic weight and density, the more transparent is the material to X-rays. Thus, bones are more opaque than the surrounding flesh; this makes it possible to take an X-ray photograph (radiograph) of the bones of a living person.

YEAR - Measure of time; commonly understood to be the time taken by the Earth to complete its orbit round the Sun. The civil year has an average value of 365.2425 mean solar days; 3 successive years consisting of 365 days, the fourth or leap year of 366. Century years do not count as leap years unless divisible by 400. The tropical or solar year, the average interval between two successive returns of the Sun to the first point of Aries, is 365.2422 mean solar days; the sidereal year is 365.2564 mean solar days.

ZERO GRAVITY (astronautics) - The state that prevails at the point of region where the pull of gravity is cancelled out by the centrifugal force, resulting in a sensation of "weightlessness."

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Subsequent to the completion of this report, the books listed below were published by Holt, Rinehart and Winston as titles in the Holt Library of Science, Space Science Series:

Gardner, Marjorie H., Chemistry in the Space Age.

Henry, James P., Biomedical Aspects of Space Flight.

Young, Richard S., Extraterrestrial Biology.

NASA's Aerospace Bibliography, in a third edition to follow the Aeronautics and Space Bibliographies listed above as items 14 and 15, was scheduled for publication in February, 1966.

ANNOTATED BIBLIOGRAPHY

This group of books related to the biological aspects of the space age were reviewed by Miss Shirley P. Bierma for the Education Services Division, NASA under the title, "Fifty Books About the Aerospace Age." Vocabulary level was established by use of the Dale-Chall list and formula.

SPACE MONKEY - Olive Burt - John Day Co., 1960. Vocabulary - 5th, 6th grade. This is the story of the capture, selection, training and space flight of the first creature to go into space and return alive - the squirrel monkey, Miss Baker. The simple writing style is best for 4th grade and young or immature 5th graders. The book gives a clear picture of Miss Baker's training, the methods used to protect her as she took her trip into space, and what has happened to her since.

AVIATION AND SPACE MEDICINE - Martin and Grace Caidin - Dutton, 1962. Vocabulary - 7th, 8th grade. The format of this book might discourage a casual intermediate reader, but any student interested enough to get past the first chapter would find a fine book about the physical problems of Man in Flight, or Man in Space. The authors include mention of many historical flights made to prove Man could safely fly, and those made to test devices to help him go higher. Their main point is that aerospace medicine's purpose is to save the lives of the men who climb above our planet and beyond it. Most sixth grade readers, even top ones, would not read this book without a high degree of motivation. Any student not a top reader would find the concept development difficult. It is, however, a very good book.

STATIONS IN SPACE - Donald Cox - Holt, Rinehart, & Winston, 1960. Vocabularly - 11th, 12th grade. This is a book of possibilities. Mr. Cox introduces the idea of the space station by comparing such a station to the way stops used by the Pony Express. He then describes many of the ideas men have had for "space stations" beginning with early sciencfiction writers like De Bergerac, Verne, and Lasswitz, and up to modern scientists such as Oberth, Ley, Von Braun, and Ehricke. Though the author defines "station" rather liberally, and includes exploratory vehicles for outer space as well as more permanent satellites, his descriptions make fascinating reading. He makes all this sound so simple. Any intermediate reader interested in the subject would enjoy the book. Scientific information to back up his statements is missing.

ROCKETS THROUGH SPACE - Lester Del Ray - Winston, 1960 (revised). Vocabulary - 7th, 8th grade. One of the most interesting books out on the subject. The author begins by comparing man's venture into space to the theory of the lobe fin (fish) pioneering in a change from life in water to life in air - "almost like a man changing from a life in air to one in space." He then discusses the atmosphere of the earth, historical ascents into the air and beyond (balloons, planes, rockets), how a rocket works, what is in "space" (how empty it is, planets, galaxies, radiation, meteorites, etc.), requirements for man's survival in space, weightlessness, orbits, gravity, space stations, what we expect to find on the moon and on other planets, colonization in space, and predictions for the future. Written in an easy, readable style that doesn't "talk down", this book can be read and thoroughly enjoyed by interested readers of average intermediate ability, but probably the better or more mature readers at this level would get more from it. Good interested 6th graders should have little difficulty with it.

<u>MAN'S REACH INTO SPACE</u> - Roy A Gallant - Doubleday, 1959. Vocabulary - 9th, 10th grade. Mr. Gallant has written clearly and interestingly about man's limitations in the world of space, taking the time to use examples and illustrations for clarification. He discusses the tests scientists are performing to learn more about these weaknesses and the devices being developed to protect man as he goes further and further away from home. The book is quite large - about 9 x 12 - and attractively printed. The illustrations are well done and attract the reader's attention. They fit into the text in the right places. Although the text is best fitted to a good reader, a highly interested average reader at 5th or 6th grade could enjoy it.

<u>SPACE VOLUNTEERS</u> - Terence Kay - Harper, 1960. Vocabulary - 9th, 10th grade. The first pages of this book set the pace for a fast-moving, personalized account of the "space volunteers" who are testing out theories about man in space before he goes too far. There are 15 chapters about human guinea pigs who submit themselves to rocket sled deceleration tests, weightlessness, high altitude balloon flights, temperature-pressure tests, and so forth. It reads almost like a story. The book would appeal to intermediate readers of average ability and above. The vocabulary would probably be too difficult for the slow readers, even if they were interested. Fifth and sixth graders especially would appreciate the book. It would make good reading aloud.

<u>MAN ALIVE IN OUTER SPACE</u> - Henry B. Lent - MacMillan, 1961. Vocabulary - 7th, 8th grade. An account of the many tests and experiments conducted by space surgeons to find the answers needed about space flight before Man was sent into orbit. The author describes the famous rocket-sled tests by Colonel John Stapp, balloon capsule tests with space surgeons inside, isolation tests, animal flight tests, altitude chamber tests for the effects of oxygen starvation, sudden decompression, closed system environments

to provide food, water, waste disposal, oxygen, etc., centrifuge tests for the effects of increased gravity ("g" forces), weightlessness tests - all the tests to make space flight safe. The print size and writing style of the book would be easy enough for good 5th and 6th grade readers. The descriptions of the tests, and reasons for them, would appeal to their sense of adventure, though the author does not "fictionalize" his account. Enough individuals are described in test situations to make it seem personal to the reader.

<u>LIFE BEYOND OUR PLANET</u> - Dr. Dan Q. Posin - McGraw Hill, 1962. Vocabulary - 9th, 10th grade. Though the vocabulary and much of the material is beyond the average intermediate grader, Dr. Posin has written a fascinating book on the probality of life somewhere else in the universe. He begins his book with a short story about communication with another planet, and goes on to discuss ways in which we may already have revealed ourselves to other Beings. He mentions possible star-candidates for life on one of their planets, and considers the possibilities for chemistries, beings, forces, and energies not found within our solar system (so far as we know). Dr. Posin includes many diagrams to illustrate his points, and attempts to give the reasons behind the theories he presents. It is an excellent book. A good, interested 6th grade reader could gain considerable information from it.

The following group of book reviews were prepared by members of the workshop; the names of the reviewer is included with each review:

PROFILES OF THE FUTURE - Arthur C. Clarke. Reviewer: Ted Wynne. Almost all areas of earth and space are touched upon with predictions of what is to come. Clarke stresses ideas that what limits our thinking about future is a failure of nerve and of imagination on the part of scientists. Of value to teacher for speculation about future. Elementary student - perhaps - 5th and 6th grader (good readers, special abilities class). Junior high student - Yes, with the idea that science is changing so rapidly even scientists' concepts may be wrong. Stimuli: In area of electromagnetism, miniaturization of electronic parts might be demonstrated by trying to make models of TV sets or radios out of balsa wood, plaster of paris, soap or any other acceptable material. These would be made as tiny as possible and still recognizable. The children would use their own talents in making these. Comparison with transistor and electron tube as to size could be made by bringing in transistor and electron tube.

SPACE MEDICINE - John P. Marbarger (ed.) Reviewer: Leon Stein. Biological requirements of external environment. Orientation in space (Chapter Title). Bioclimatology in rocket flight. Of value in the hands of the teacher, and possibly advanced junior high school students, but not elementary students. Basic Concepts: In particular: pressure, temperature, orientation.

HOW TO SURVIVE ON LAND AND SEA - Issued By The Aviation Training Division Office of the Chief Naval Operations United States Navy. Reviewer: Kenneth L. Rogers. Survival in the jungle, desert and artic country depends largely on resourcefulness. Of value in hands of teacher, elementary students and junior high students. Basic Concepts: You can live longer on your stored energy by relaxing mind and body and guarding against exposure and extreme temperatures.

<u>PROJECTS: SPACE</u> - Judith Viorst. Reviewer: Leon Stein. Algae as food, Oxygen regeneration, Closed environmental systems, Extra-terrestrial life. Of value in the hands of teacher, but not elementary or junior high students. Basic Concepts: Some but primarily of value for number of stimuli for follow-up. Stimuli: Many throughout entire book. Illustrations: Many open-ended student projects.

<u>101 SIMPLE EXPERIMENTS WITH INSECTS</u>, H. Kalmus, Reviewer: Sister Therese Michelle. The book supplies us with various means of demonstrating conditions or stresses which when placed on insects will affect their metabolism, respiration, temperature, and reaction to light. Applications can be made (to some degree) to man when placed under similar stresses. Material useful for junior high school students or very able intermediate grade level student.

☆U.S. GOVERNMENT PRINTING OFFICE: 1968 O—289-644