DOCUMENT RESUME

ED 077 655 SE 015 498

TITLE	Information for Teachers (Including Classroom Activities), Skylab Student Project.
INSTITUTION	National Aeronautics and Space Administration, Washington, D.C.
REPORT NO	EP-106
PUB DATE	Nov 72
NOTE	45p.
AVAILABLE FROM	Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (no price quoted)
EDRS PRICE	MF-$0.65 HC-$3.29
DESCRIPTORS	*Aerospace Education; Aerospace Technology; Instructional Materials; Science Activities; *Science Education; *Space; *Student Projects; *Student Research; Student Science Interests

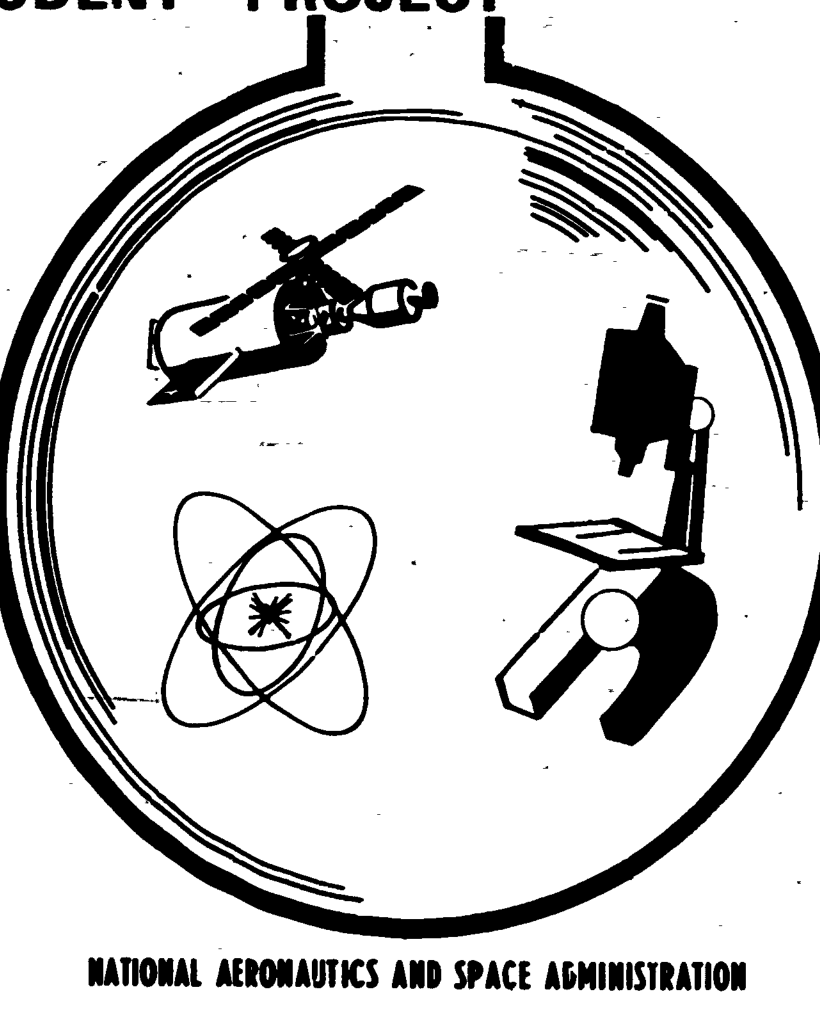
ABSTRACT

This program is intended to directly involve the educational community in space experiments, many of which can be related to existing curricula. Included in this first packet are: 1) a brief description of the Skylab Program and the National Science Teachers Association-National Aeronautics and Space Administration (NSTA-NASA) Skylab Student Program; 2) description of the experiment selection process for flight; 3) description of experiment performance; 3) summaries of each of the 25 national winning student experiments; 4) samples of the student proposals as submitted by the students; 5) related classroom activities. The descriptive portion of the booklet gives an impression of the working of "big" science as opposed to the kind of laboratory work most students are aware of. The experiment descriptions and classroom activities in some cases show the necessary integration of a number of sciences and the inclusion of engineering in carrying out projects in the complex environment of a space laboratory. (Author/EB)

INFORMATION FOR TEACHERS

(INCLUDING CLASSROOM ACTIVITIES)

Skylab STUDENT PROJECT



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Information for Teachers
(Including Classroom Activities)

Skylab Student Project

The Skylab Program is giving us our first opportunity to directly involve the educational community in space experiments–experiments proposed by students will fly on Skylab. Many of these can be related to existing curricula. In addition, a number of principle investigators from universities and government will cooperate with the NASA Educational Programs Division in allowing us to prepare future materials for use in the classroom.

Included in this first packet are:

A brief description of the Skylab Program and the NSTA-NASA Skylab Student Program

A description of the experiment selection process for flight

A description of experiment performance

Summaries of each of the 25 national winning student experiments

Samples of the student proposals as submitted by the students

Related classroom activities

The descriptive portion of this booklet gives an impression of the workings of "big" science as opposed to the kind of laboratory work most students are aware of. The experiment descriptions and classroom activities in some cases show the necessary integration of a number of sciences and the inclusion of engineering in carrying out projects in the complex environment of a space laboratory. It is our hope that these materials will be useful to you as a classroom teacher or science club director.

Should you wish to obtain a colorful wall chart descriptive of SKYLAB, you may order NASA FACTS–43, SKYLAB, from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Price 25 cents.

National Aeronautics and Space Administration
Washington, D.C.

November 1972

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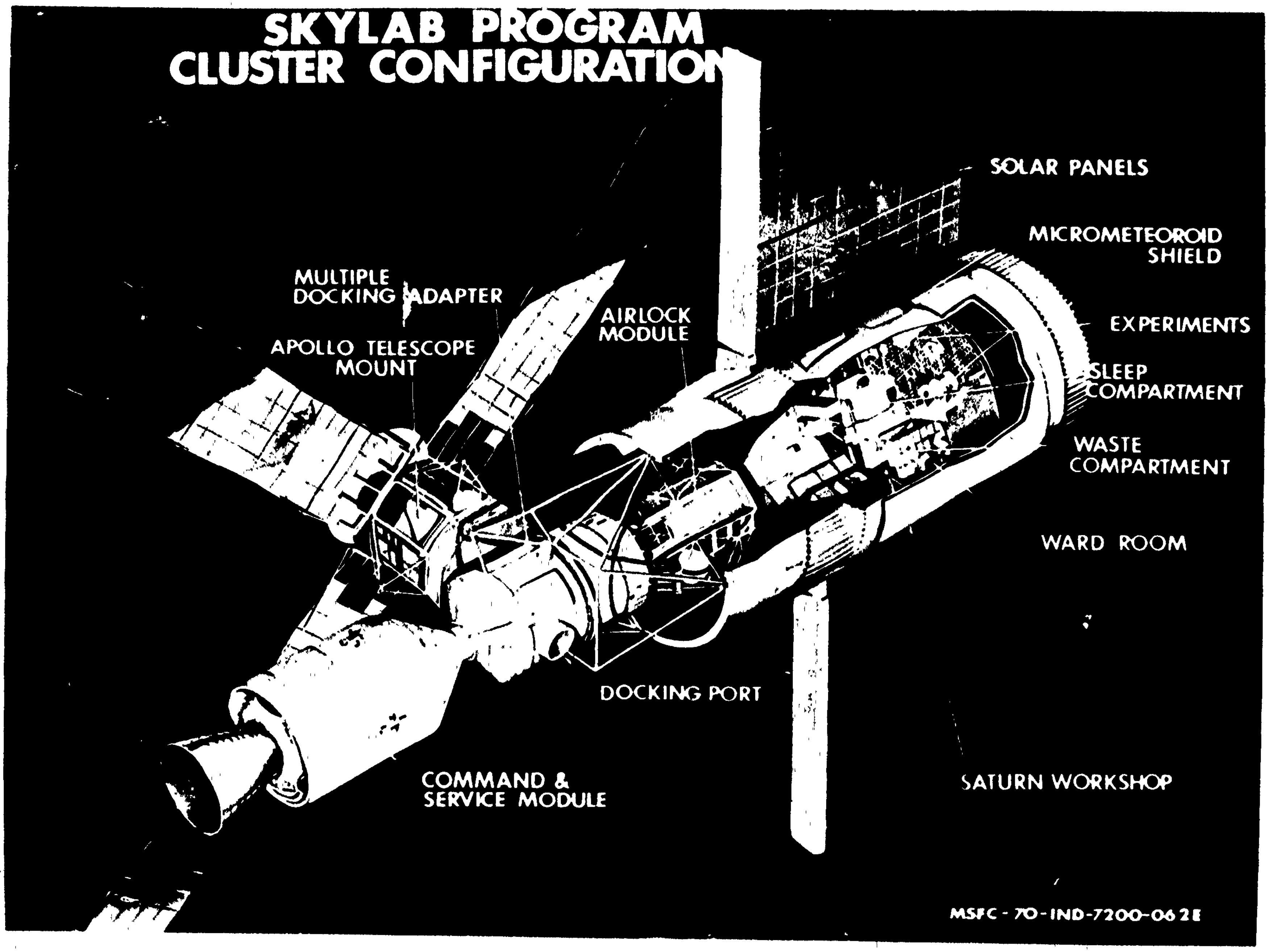

SKYLAB PROGRAM
CLUSTER CONFIGURATION
SOLAR PANELS
MICROMETEOROID SHIELD
EXPERIMENTS
SLEEP COMPARTMENT
WASTE COMPARTMENT
WARD ROOM
SATURN WORKSHOP
MULTIPLE DOCKING ADAPTER
APOLLO TELESCOPE MOUNT
AIRLOCK MODULE
DOCKING PORT
COMMAND & SERVICE MODULE
MSFC-70-IND-7200-062E

A Brief Description of the Skylab Program and the NSTA-NASA Skylab Student Program

I. OVERVIEW OF THE SKYLAB PROGRAM

A. SKYLAB

In 1973, three Americans will embark on the first of a series of earth orbiting missions using Skylab, the United States' first manned orbital scientific space station.

The Skylab orbiting station will serve as a workshop and living quarters for the astronauts as they perform investigations in the following categories: Physical Sciences, Biomedical Sciences, Earth Applications, and Space Applications.

During the eight month operational life-time of Skylab, three crews, each consisting of three men, will live and work in orbit for periods of one month, two months and two months respectively.

The objectives for each of the categories of investigation are summarized as follows:

Physical Science - To perform observations away from the filtering and obscuring effects of the earth's atmosphere in order to increase man's knowledge of the sun and of its importance to earth and mankind, and to increase man's knowledge of the radiation and particle environment in near earth space and of the sources from which these phenomena emanate.

Biomedical Science - To make observations under conditions different from those on earth and thereby increase man's knowledge of the biological functions of living organisms, and of the capabilities of man to live and work for prolonged periods in the orbital environment.

Earth Applications - To develop techniques for observing from space and interpreting earth phenomena in the areas of agriculture, forestry, geology, geography, air and water pollution, land use and meterology and the influence man has on these elements.

Space Applications - To develop techniques for operation in space in the areas of crew habitability and mobility, and in developing manufacturing techniques in space.

The Skylab cluster contains five modules: The orbital workshop is the prime living and working quarters for the Skylab crews. It contains living and sleeping quarters, food preparation and eating, and personal hygiene equipment. It also contains the equipment for the biomedical science experiments and for some of the physical science and space applications experiments. Solar arrays for generation of electrical power are mounted outside this module.

The airlock module is the prime area in which control of the cluster internal environment, and workshop electrical power and communications systems, is located. It also contains the airlock through which suited astronauts emerge to perform their activities outside the cluster.

The multiple docking adapter provides the docking port for the arriving and departing command/service modules, and contains the control center for the telescope mount experiments and systems. It also houses the earth applications experiments and space technology experiments.

The Apollo telescope mount houses a sophisticated solar observatory having eight telescopes observing varying wavelengths from visible, through near and far ultra violet, to x-ray. It contains the gyroscopes and computers by which the flight attitude of Skylab is maintained or changed and it carries solar arrays by which about half of the electrical power used by the cluster is generated.

The command and service module is the vehicle in which the crew travels from earth to Skylab and back to earth, and in which supplies are conveyed to Skylab and experiment specimens and film are brought down to earth.

Skylab will fly in a circular orbit about 235 nautical miles above the surface of earth, and is planned to pass over any given point within latitudes 50° north and 50° south of the equator every 5 days. In its orbital configuration Skylab will weight over 180,000 pounds and will contain nearly 13,000 cubic feet of work and living space.

B. THE SKYLAB STUDENT PROJECT

The Skylab student project was conceived as a cooperative venture of the educational community and NASA, with the objectives of introducing the educational community to the unique environment and vantage point of space, and to the technological processes by which this uniqueness can be used.

The National Science Teachers Association (NSTA), under contract to the National Aeronautics and Space Administration (NASA), formed a committee of science teachers, science supervisors, science teacher educators and NASA representative to design the overall project including the rules, procedures, forms and announcement posters. Over 100,000 announcements were mailed to teachers on the National Registry of Secondary Science Teachers. In return over 9000 science teachers requested entry kits for over 87,500 students who showed interest in the project. 3,409 proposals were submitted mostly as individual student efforts, however, the number of team proposals brings the total student participation to well over 4,000.

The first phase of the selection was conducted by judges selected by NSTA regional chairman in 12 regions. 305 regional winners were selected and these became the subject of the national selection process by which the 25 finalists were chosen. NSTA selected judges and NASA personnel were involved in the final selection.

A Description of the Experiment Selection Process for Flight

II. EXPERIMENT DEVELOPMENT PROCESS

In any program with complex systems interactions, such as Skylab, few changes can be introduced without rigorous analysis and a carefully planned development program. Characteristically the criticality of the change to the program is the greatest influencing factor in the change planning and activities. By definition, changes cover a wide spectrum—from revisions to procedures, to the introduction of totally new components or systems.

The 25 Skylab student project experiments identified as the national finalists are the latest examples of Skylab Program changes and are subjected to the same degree of impact evaluation as "baseline" Skylab experiments, systems or components.

A. PRELIMINARY DEVELOPMENT

The general approach to integration of the student experiments starts with a full understanding of the experiment objectives in order to properly identify experiment requirements such as heating, cooling, lighting, etc.; the parameters to which experiments are sensitive such as vibration, acceleration, etc., and the experiment characteristics to be demonstrated.

The next steps are to develop concepts for the experiment equipment or to identify existing equipment which will satisfy the experiment objectives and to define the environment in which the experiment is to be performed.

The universal gravitational constant experiment can be used as an illustration of this. In the experiment proposed the measurement of accelerations as low as 10^{-9}g was required. While Skylab is nominally a zero gravity facility, activities necessary to hold the vehicle in a specific attitude or to maneuver to a new attitude produce an environment in which acceleration levels as high as 10^{-3}g are frequently reached.

The experiment requirements must be evaluated relative to systems performance capabilities and limitations and mission and crew operations in order to confirm compatibilities and resolve incompatibilities.

An example of this compatibility analysis activity is the resolution of the potential crew activity and photography requirements of the spider web experiment. The data required from the experiment consists of motion picture coverage of the spider building the web, and still photographs of the completed web. At first analysis, these implied the need for a movie camera, with an astronaut operator, dedicated to observing and filming spider activities for significant time periods. Further study of spider behavior resulted in an automatic system in which the spider would trigger the photography while the crew was asleep, thus reducing crew activities to a simple set-up operation and completely eliminating any conflicts in movie camera needs.

Comparison of storage requirements and constraints with prelaunch stowage and close out activity schedules and launch environments must be performed and alternative plans evaluated in order to resolve potential incompatibilities.

The activities at Kennedy Space Center after delivery of Skylab vehicles and components follow a rigorous series of module mating, equipment and supplies installation, and checkout operations. A schedule for these operations has been prepared which contains rigid milestones and areas of flexibility. One of the rigid milestones is the stowage in the appropriate compartments and lockers of crew supplies such as food, clothing, etc., and experiment equipment—including student experiments. This is currently planned to be completed 45 calendar days before launch. Almost immediately after this, the workshop is closed for the last time until the crew enters in orbit. One reason for this apparently early closure is to enable a check of pressure tightness of the cluster.

Some of the student experiment specimens have severe stowage constraints such as limited shelf life without attention (e.g., the spiders), low temperature storage (e.g., the immunology specimens) or limited isolation from light (e.g., the cytoplasmic streaming specimens). These constraints can be supported by launching the specimens in the manned flights in which stowage occurs only a few hours before launch.

B. PRELIMINARY DESIGN REVIEW

Before detailed design for manufacture can commence, the status of the conceptual design and of the compatibility analysis must be evaluated in one of a series of reviews. The preliminary design review involves participation of members of each organization responsible for design, manufacturing, installation, data handling, crew operations, etc., to ensure that no potential problem has been overlooked. The students proposing the experiments, together with their teacher/sponsors, were invited to participate in order that their experiment objectives could be protected and that they better understand the development environment into which their experiments were to be included.

C. EQUIPMENT DEVELOPMENT

Following acceptance of the concept in the preliminary design review and its immediate follow-on activity of resolving issues identified in the review, detailed design can be completed and manufacture of flight, test, and training units can commence. Based upon the final design, definite plans must be prepared for development testing in which the performance of the equipment is verified, and qualification testing in which the ability of the equipment and specimens to survive environments to which they will be exposed is verified.

Also, at this time, definite plans must be prepared for training the crews in the performance of the experiment. Amendments must be made to other program documents such as stowage lists, flight plans, and photographic plans.

The flight plan changes entail considerable analysis of a number of parameters such as the time a crewman would spend in setting up, operating and shutting down the experiment; the times in the missions when the experiment may be, or must be, performed; and what other Skylab and crew activities may be occurring at the planned time. The photographic plan changes include the listings of detailed photographic requirements for each experiment, such as type of camera, lens, film, number of photographs, duration of photography etc.

Another area of planning which must occur at this time deals with ensuring that the required data from the experiment, and the supporting data, where necessary, are obtained, and that the means for reducing and analyzing the data will be available at the appropriate time and place.

Certain of the above development activities have already been performed in a preliminary form for some of the student experiments. Preliminary flight qualification tests on the type of spider to be used have indicated the possibility that the launch accelerations and vibrations, and the Skylab internal atmospheric conditions are acceptable to the spider. Opportunities for viewing Jupiter have been identified subject to the pointing constraints of Skylab. Preliminary concepts have been developed for analyzing solar astronomy photographs in the search for a planetary body within the orbit of Mercury.

Throughout all this activity, the program schedule must be recognized and the planning must ensure that major intermediate events such as completion of significant tests and delivery of training units occur at times which will allow the crew to become fully familiar with their use before launch.

D. ACCEPTANCE FOR FLIGHT

Successive reviews will be held to evaluate achievement of equipment performance and schedule requirements and to evaluate the compatibility with all elements of the Skylab vehicle and missions.

During this review process, gross incompatibilities in performance or in schedule will be evaluated relative to the criticality or importance of each experiment with the ultimate realization that rejection of the experiment at any time prior to installation might occur. If all reviews are favorable, installation of the equipment will occur at the appointed time and the experiment will be available for performance in flight.

A Description of Experiment Performance

III. EXPERIMENT PERFORMANCE

A. PRE- AND POST-LAUNCH ACTIVITIES

The prime prelaunch activities related to student project experiments are checkout and installation in accordance with previously developed plans. In most cases an operation check of the experiment equipment will be inappropriate as this would prevent performance in flight. In these cases, the pre-launch check would be a visual verification that the equipment is in the correct configuration for launch.

The stowage of the equipment occurs at the prescribed time (45 days before launch in the OWS, as late as 24 hours before launch in the CM) and involves placement in the assigned stowage lockers[1] using vibration attenuation materials as defined in stowage plans.

After launch and docking of the manned spacecraft with Skylab, two of the early activities performed by the crew will be the transfer of the chilled immunology specimens into the food refrigerator and the elodea plants to a point adjacent to a light for storage until the time for operation of the experiment.

B. OPERATION

Performance of the experiments will occur strictly in accordance with the planned opportunities as documented in the flight plan, subject however, to unavoidable contingencies which may have occurred to modify the conduct of the baseline Skylab activities.

One example of such a contingency would be the advent of dense cloud cover over an earth resources experiment observation site such that photography of the terrain would be impossible. Solar astronomy activities have been scheduled in the flight plan based on a hypothetical calendar of solar events. The real cycle of solar activity will obviously demand changes in crew activity from that postulated in the flight plan (the necessary flexibility has been developed in the mission planning and crew training programs) and may therefore impact the scheduled performance of other experiments—including student experiments.

In this event, experiment performances may be rescheduled in accordance with premission contingency planning; or, in a worst case condition, the performance may be abandoned.

Experiment performance includes, though not necessarily in strictly consecutive occurrences, removal from the stowage locker, set up in the assigned area, operation of the equipment, shut down and return to the stowage locker or disposal in the trash disposal area in accordance with a predefined rigorous disposal protocol.

C. Those student experiment components, specimens or films which must be returned to earth for processing or analysis must be prepared for stowage in the manned spacecraft at some predefined time before departure. After splashdown, they will be delivered to the appropriate location for processing and analysis.

D. ANALYSIS AND REPORTING

Analysis of student experiment data, like other Skylab experiments, is dependent on the availability of data in the required format. Depending on data processing requirements defined before the mission, and depending on NASA review of specific data, this could well be several weeks after the final manned spacecraft has returned to earth. Nonetheless, the participating students are required to submit reports of their experiments for inclusion in edited Skylab science reports and for application to the teaching profession to enhance science curricula.

Summaries of Each of the 25 National Winning Student Experiments

IV. EXPERIMENT DESCRIPTIONS

The following pages contain descriptions of the student experiments that are planned to be performed on Skylab. In addition to discussing the objectives, concepts, implementation and anticipated data for each experiment brief suggestions are included for possible classroom activities related to the experiment.

ED11 EARTH'S ABSORPTION OF RADIANT HEAT (ATMOSPHERIC ATTENTUATION OF RADIANT ENERGY)

Student Investigator-Joe B. Zmolek
Lourdes High School; Oskosh, Wisconsin
Teacher/Sponsor-William L. Behring

OBJECTIVE: The determination of the attenuation of visible and near infrared radiant energy through the Earth's atmosphere at various locations and under varying atmospheric conditions.

CONCEPT: Compare measurements of the radiant energy reflected from the Earth surface at the spacecraft altitude to simultaneously obtained similar measurements made at specific sites on the surface of earth. These ground data would include measurement of both incoming and reflected radiant energy.

IMPLEMENTATION: An onboard infrared spectrometer (Earth Resources Experiment Program Experiment S191) will measure radiation from the Earth in the 0.4 to 2.4 micron spectral region. Instantaneous ground coverage will be 0.213 x 0.213 nautical miles in extent. Simultaneous ground data will be available only when the spectrometer is viewing sites where supporting instrumentation is provided. (Ground instrumentation to be defined).

DATA: IR spectrometer output on computer compatible magnetic tape. Similar data may be available from aircraft flights over specific sites. 16mm camera film at 2 frames/second of the area which the IR spectrometer is observing.

DATA AVAILABILITY: Four to eight months following the processing of the experiment data. Estimated to be late in 1974.

CORRELATIVE CLASSROOM EXPERIMENTS:

1. Attenuation of simulated atmospheres utilizing a gas chamber and either photographic or photoelectric detectors.
2. Development of solar radiation [illegible]uation coefficients using ED11 data and comparing with known values (S[illegible] [illegible]nstant).
3. Derive local ground surface incident energy and study of influencing factors.

ED12 SPACE OBSERVATION AND PREDICTION OF VOLCANIC ERUPTIONS

Student Investigator-Troy A. Crites
Kent Junior High School; Kent, Washington
Teacher/Sponsor-Richard C. Putnam

OBJECTIVE: Infrared surveys from space of active volcanoes to support data from ground instrumentation, where available, in the preduction of volcanic activity.

CONCEPT: Acquisition of the infrared profile of available volcanoes to compare activity as measured by ground based tiltmeters and seismographs with the infrared profile. It is expected that imminent eruptions will be preceded by increased thermal radiation and higher local temperatures which could be sensed by an overpass by the spacecraft.

IMPLEMENTATION: Infrared spectrometer measurements in the 6.5 to 15.5 micron thermal spectral region over an area of 0.213 x 0.213 nautical miles; simultaneous multispectral scanner data in the 10.2 to 12.5 micron thermal region covering a conical line scan with an instantaneous field of view of 260 feet on the ground with associated 16mm boresight photograhy. Simultaneous multispectral 70mm photography in the 0.5 to 0.7 micron visible region covering a ground field of view of 88 nautical miles square with a dynamic ground resolution of 190 to 450 feet depending on the actual spectral region covered (i.e., the type of film used), six cameras are used all aimed at the same ground target and simultaneous high resolution, 4.5 x 4.5 in. photography in the 0.4 to 0.7 micron visible region covering a ground field of view of 58 nautical miles square with a resolution of 35 to 150 feet depending on the actual film used. The spectrometer and multispectral scanner will provide a high quality data bank for assessment of the thermal properties of these volcanoes within the targeting range of Skylab, while the photography in the visible region will provide an adequate base for plotting data.

DATA: IR spectrometer data on computer compatible magnetic tape, 16mm boresight photography in association with IR spectrometer. Multispectral scanner data on computer compatible magnetic tape. 70mm photographs, 4.5 x 4.5 inch photographs. 2¼ x 2¼ inch photographs of reconstructed imagery from scanner data.

DATA AVAILABILITY: Photographic data available approximately 30 days following the processing of film. Estimated to be late in 1973 to late in 1974. IR spectrometer and multispectral scanner data estimated to be available late in 1974.

CORRELATIVE CLASSROOM ACTIVITIES:

1. Writing of computer programs to reduce spectrometer and spectral scanner data to usable form.
2. Simulate thermal profiles of volcanoes by building miniature volcanoes using remotely detonated heat sources (e.g. thermite) buried in piles of calibrated soils.
3. Investigate published data from underground nuclear tests to determine related information.

ED21 PHOTOGRAPHY OF LIBRATION CLOUDS

Student Investigator-Alison Hopfield
Princeton Day School; Princeton, New Jersey
Teacher/Sponsor-Norman Sperling

OBJECTIVE: Photograph the two libration clouds on the moon's orbit at the Lagrangian (Trojan) points L_4 and L_5 of the Earth-Moon System.

CONCEPT: Photography of two of the points (regions) of gravitational equilibrium of the Earth-Moon System should reveal the existence of particle clouds collecting there due to zero gravitational potential existing therein.

IMPLEMENTATION: A study of the lunar libration regions is included as a portion of the baseline Skylab Program. The Apollo Telescope Mount (ATM) Joint Observation Program (JOP) 10 will utilize the white light coronagraph (S052) and the camera, telescope and photometer system of T027/S073 to view the libration regions, record their brightness and the polarization of the reflected light.

DATA: Film and computer compatible magnetic tape.

DATA AVAILABILITY: Skylab data expected to be available from late 1973 carrying on into late 1974 depending on the actual mission that data is acquired.

CORRELATIVE CLASSROOM EXPERIMENTS:

1. Calculate the time periods when photography of the libration clouds is possible using the Skylab mission profile, recognizing the ephemerides of Earth, the Moon and its libration clouds and Skylab.

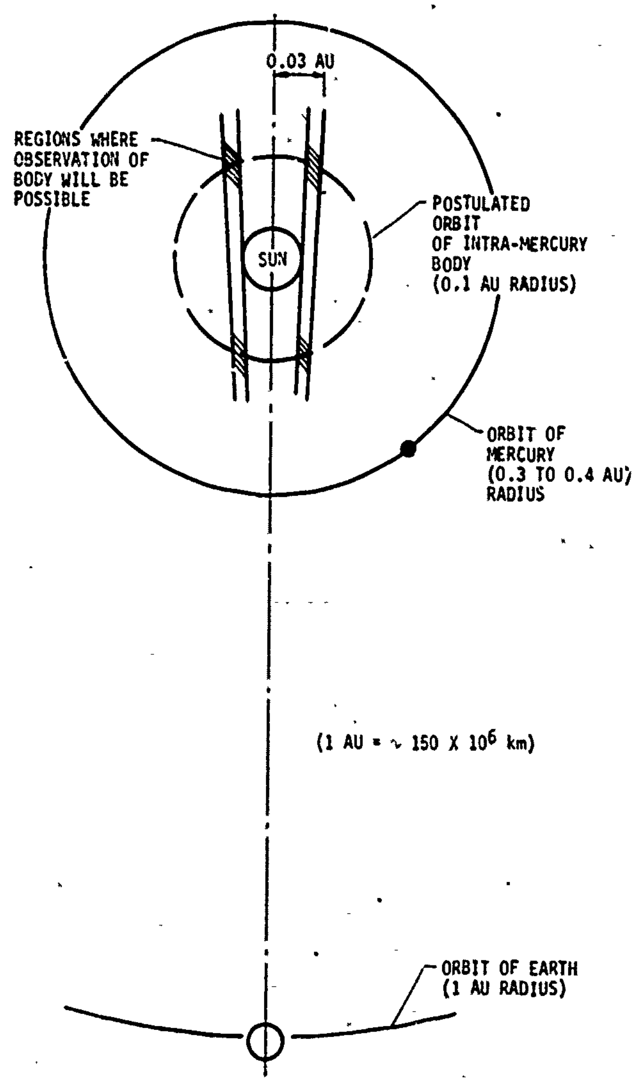
ED22 OBJECTS WITHIN MERCURY'S ORBIT

Student Investigator-Daniel C. Bochsler
Silverton Union High School; Silverton, Oregon
Teacher/Sponsor-John P. Daily

OBJECTIVE: Photograph objects within the orbit of the planet Mercury.

CONCEPT: Photographs of the region surrounding the Sun to a radius of $\sim$ .03 AU (4×10^6 Km) will be made. Photographs made when Mercury is in the line of sight will be compared to photographs made when Mercury is not, to aid in identification of planetary bodies (see sketch).

IMPLEMENTATION:	White light coronagraph (S052) photographs under the ATM Joint Observation Program (JOP) 6 specifics synoptic observations of the Sun twice daily throughout the Skylab mission. These synoptic photographs will satisfy the stated concept and will be examined to attempt to identify objects in Mercury's orbit. (∿ 30,000 photographs are taken of which only a small number can be expected to contain the target body).
DATA:	35mm film.
DATA AVAILABILITY:	From late in 1973 to late in 1974.
CORRELATIVE CLASSROOM EXPERIMENTS:	1. Calculate the time periods when Mercury and "Vulcan" will be in the field of view of the white light coronagraph, recognizing the ephemerides of Earth, Mercury and the postulated innermost planet Vulcan, and the viewing capabilities of the Skylab telescopes.



ED23 SPECTROGRAPHY OF SELECTED QUASARS

Student Investigator-John C. Hamilton
Aiea High School; Aiea, Hawaii
Teacher/Sponsor-James A. Fuchigami

OBJECTIVE: Obtain the spectra of quasars in the ultraviolet spectral region.

CONCEPT: Quasi-stellar radio sources (quasars) have been identified with radio telescopes and subsequently located with optical telescopes. The UV absorption of the earth's atmosphere has made it difficult, if not impossible, to observe the quasar spectra in the ultraviolet region. UV photography of any quasars within the field of view should enhance man's understanding of quasars.

IMPLEMENTATION: The ultraviolet stellar astronomy facility consisting of a reflecting telescope, and a spectrum dispersing prism will be utilized to scan the sky. Any known quasars within the 4.1° x 5.0° field of view of the telescope will be photographed and spectral data in the UV region thus obtained. The current observing program for the ultraviolet stellar astronomy experiment does not include known quasars; a special pointing maneuver will be required for this experiment.

DATA AVAILABILITY: Late in 1973. If mission schedules permit, additional data will be acquired on SL-4 yielding additional information late in 1974.

CORRELATIVE CLASSROOM EXPERIMENTS:
1. Determine the locations of known quasars and calculate the time periods these quasars can be observed.

ED24 X-RAY CONTENT IN ASSOCIATION WITH STELLAR SPECTRAL CLASSES

Student Investigator-Joe W. Reihs
Tara High School; Baton Rouge, Louisiana
Teacher/Sponsor-Helen W. Boyd

OBJECTIVE: Determination of the general characteristics and location of celestial x-ray sources, or to study the x-ray spectrum emitted from the Sun.

CONCEPT: The location of celestial x-rays will be determined by analysis of the simultaneous observations of specified celestial fields and general characteristics by use of sensors presently on Apollo Telescope Mount (ATM).

IMPLEMENTATION: ATM experiments S056, dual x-ray telescope or S054, x-ray spectrographic telescope will obtain data for characteristics and location of x-ray sources if the Skylab Joint Observation Program (JOP) 13 is implemented. This would permit the ATM to be rotated away from the Sun to observe celestial bodies away from the Sun. If JOP 13 is not implemented, only the x-ray spectrum emitted from the Sun will be obtained at S056 or S054. The spectral ranges of the data are: S054, 2 to 10 angstroms and S056, 6 to 60 angstroms.

DATA: S054 will return 70mm x-ray sensitive film and S056 35mm x-ray sensitive film. Both S054 and S056 will return proportional counter data in digital form on magnetic tape which will be telemetered from Skylab during the mission.

DATA AVAILABILITY: From late in 1973 to late in 1974.

CORRELATIVE CLASSROOM EXPERIMENTS:
1. Determination of celestial x-ray sources from published astronomical reference works.
2. Compare existing data with that obtained by Skylab to assist in determining characteristics of x-ray stellar classes.

ED25 X-RAY EMISSION FROM THE PLANET JUPITER

Student Investigator-Jeanne L. Leventhal
Berkeley High School; Berkeley, California
Teacher/Sponsor-Harry E. Choulett

OBJECTIVE: To attempt to detect x-rays from Jupiter and search for a correlation of the x-ray emission with both solar activity and Jovian radio emission.

CONCEPT: The verification of x-ray emission from Jupiter would establish various parameters associated with Jovian magnetic field, give some data on the radio noise storms erratically occurring on Jupiter, and give information about the solar wind at the radius of Jupiter. Due to the predicted extreme weak nature of the Jovian x-ray emission, there is some question as to the ability of present baseline instruments to measure these weak emissions.

IMPLEMENTATION: Apollo Telescope Mount (ATM) experiments S056, dual x-ray telescope or S054, x-ray spectrographic telescope will obtain data if Joint Observation Program (JOP) 13 is implemented. This would allow the entire ATM module to be rotated to observe celestial bodies away from the Sun. If JOP 13 is not implemented, Skylab will not be able to obtain data from this experiment. The spectral range of S054 is 2 to 10 angstroms and S056,6 to 10 angstroms.

DATA: S054 will return 70mm x-ray sensitive film and S056 35mm x-ray sensitive film. Both S054 and S056 will return proportional counter data in digital form on magnetic tape which will be telemetered from Skylab during flight.

DATA AVAILABILITY: From late 1973 to late 1974.

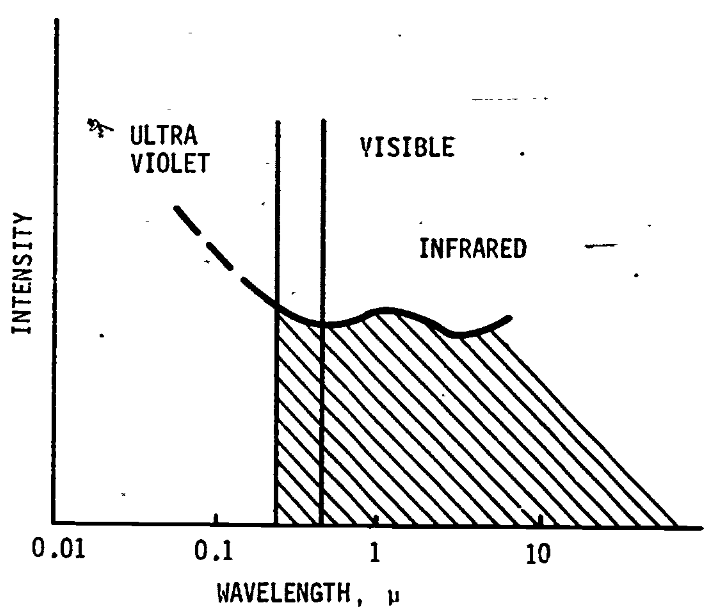
CORRELATIVE CLASSROOM EXPERIMENTS: 1. Study correlation of solar visible light, UV, and x-ray emission, and Jovian radio and x-ray emission.

ED26 A SEARCH FOR PULSARS IN THE ULTRAVIOLET WAVELENGTHS

Student Investigator-Neal W. Shannon
Fernbank Science Center; Atlanta, Georgia
Teacher/Sponsor-Dr. Paul H. Knappenberger

OBJECTIVE: To study and photograph pulsars in the ultraviolet wavelength.

CONCEPT: One pulsar, in the Crab nebula, has been photographed from Earth in the visible light and radio spectrum. This pulsar's light intensity curve rises as it enters the ultraviolet region (see sketch). Verification of this phenomenon could be of value in studying other pulsars in the ultraviolet region by the use of existing Skylab experiments within the category of UV stellar astronomy.



REPRESENTATIVE INTENSITY PLOT OF PULSAR LIGHT EMISSIONS

IMPLEMENTATION: An onboard Skylab experiment, S019 ultraviolet stellar astronomy will photograph several targets to be selected by the student investigator and the principal investigator of S019. S019 has a field of view of 4.1° x 5.0° and uses a special spectrographic film having high spectral resolution down to wavelengths of 1400 Å.

DATA: A total of 150 slides, 33mm x 40mm in size, will be returned for data analysis; however, the total number relating to pulsars is not yet determined.

DATA AVAILABILITY: Photographic data will be available approximately 30 days after the mission. Data reduction information should be available in late 1973 or early 1974.

CORRELATIVE CLASSROOM EXPERIMENTS:
1. Correlation of ground acquired visible data with Skylab data.
2. Determination of pulsar locations with ground sightings.
3. Search for anomalous data in returned Skylab data.

ED31 BEHAVIOR OF BACTERIA AND BACTERIAL SPORES IN THE SKYLAB AND SPACE ENVIRONMENT

Student Investigator-Robert L. Staehle
Harley School; Rochester, New York
Teacher/Sponsor-Alan H. Soanes

OBJECTIVE: Observation, under controlled conditions, of the survival, growth and mutations of bacterial spores in the Skylab environment.

CONCEPT: Compare physical characteristics such as colony morphology, and colony growth patterns of bacteria colonies innoculated and grown in the zero 'g' environment with those of an identically controlled ground experiment. Comparison of cell morphology may be possible subject to specimen return to earth capabilities.

IMPLEMENTATION: Agar filled petri dishes will be innoculated with various species of bacteria spores inflight. The agar to be used has yet to be defined. Basic nutrient or blood agars are being considered. The specific bacteria spores which have yet to be defined, will be transported to orbit, embedded in polyvinyl alcohol film which will dissolve on contact with the agar thus exposing the spores. The cultures will be incubated at 35°C in the IMSS Incubator with periodic observation and photographic sessions, to record colony development. After a specified period of time colony growth will be attenuated by cooling the cultures to 4°C. This temperature will be maintained if the cultures are returned for laboratory study.

DATA: Color photography and specimen return.

DATA AVAILABILITY: Late 1973.

CORRELATIVE CLASSROOM EXPERIMENTS:
1. Duplicate flight experiment on the ground utilizing both the Skylab atmosphere and normal Earth atmosphere.

ED32 AN INVITRO STUDY OF SELECTED ISOLATED IMMUNE PHENOMENA

Student Investigator-Todd A. Meister
Bronx High School of Science; Bronx, New York
Teacher/Sponsor-Vincent G. Galasso

OBJECTIVE: The two objectives of this experiment are: (A) to determine the effects of zero gravity on the response of cells to chemical stimuli (chemotaxis), and (B) to determine the effects of zero-gravity on the antigen-antibody reaction (antigenicity) in Vitro.

CONCEPT: This experiment attempts to determine whether or not the environment of Space, as defined by the limits of the Skylab spacecraft, induces changes in two representative immunological processes common to the Earth environment. The first of these (chemotaxis) is the response of cells to specific chemical stimuli. The second (antigenicity) is the immune-response mechanism which helps man to protect himself against certain infections and diseases.

IMPLEMENTATION: The Chemotaxis study utilizes a modified Sykes/Moore type apparatus which is composed of two (2) identical chambers separated by a methyl-cellulose membrane. A suspension of Guinea Pig macrophages is injected into one chamber, and a chemical stimulant (Casein) is simultaneously injected into the companion chamber. The macrophages will attempt to move toward the stimulant and, in so doing, become trapped in the membran filter. The Antigenicity study utilizes a radial immunodiffusion plate filled with an agar suspension of a specific antibody. In this technique a human antigen is injected into the antibody-filled agar forming a precipitate wherever concentrations of both antigen and antibody are optimum. This precipitate appears as a cloudy white ring surrounding the point at which the antigen was introduced. The extent to which the ring migrates (i.e. the diameter of the ring) is a direct function of the concentration of the antigen.

DATA: The chemotaxis membrane is returned to Earth for analysis. Color photographs are taken of the antigenicity plates.

DATA AVAILABILITY: Late 1973 or early 1974.

CORRELATIVE CLASSROOM EXPERIMENTS: Comparable chemotaxis and antigenicity experiments for comparison with Skylab Flight results.

ED41 A QUANTITATIVE MEASURE OF MOTOR SENSORY PERFORMANCE DURING PROLONGED INFLIGHT "G"

Student Investigator-Kathy L. Jackson
Clear Creek High School; League City, Texas
Teacher/Sponsor-Mary K. Kimsey

OBJECTIVE: Measure changes in motor sensor performance resulting from prolonged space flight and compare Skylab performance data with existing baseline data and that obtained during pre and post-flight analysis.

CONCEPT: An established sensory performance maze will be utilized to exercise the crew members motor sensory skill in a task performed in a physically "relaxed" mode.

IMPLEMENTATION: The standard Eye-Hand Coordination test apparatus, as developed by the Human Performance Group of the Department of Industrial Engineering at the University of Michigan, has been modified for use on Skylab. Data will be recorded on the Skylab audio tape recorder together with milli-second time marks. The test subject is required to insert a probe of 2mm in diameter in each of a series of 3mm diameter holes in a maze. The probe must be inserted in the correct sequence; the times from hole to hole and total elapsed time are recorded. Release of the data will be subject to approval by the MSC Flight Crew Operations Division and the Life Sciences Division.

DATA: If available, the analysis of inflight data.

DATA AVAILABILITY: Expected in late 1974.

CORRELATIVE CLASSROOM EXPERIMENTS: Repeat flight experiment in statistically significant replications in both the Skylab atmosphere and normal atmosphere. Compare this data with that obtained from Skylab and existing baseline data.

ED52 WEB FORMATION IN ZERO GRAVITY

Student Investigator-Judith S. Miles
Lexington High School; Lexington, Massachusetts
Teacher/Sponsor-J. Michael Conley

OBJECTIVE: Observe the web building process and detailed structure of the web of the common cross spider (Araneus Diadematus) in both a normal environment and the Skylab environment.

CONCEPT: Motion Picture photographs of the spider building the web reveals the mechanics of the methodology of the construction process. Still photographs of the completed web enables detailed analysis of the web including size, total thread length, number of radii, number of spirals per quadrant, shape and regularity.

IMPLEMENTATION: Spiders, acclimated to the Skylab ambient environment in an Earth gravitational field, are launched in the Command Module and deployed to a cage launched in the Orbital Workshop. Automated motion pictures are taken during the attempts to build a web and still photographs made of the completed web early, about half way through and as late as possible during the assigned mission.

DATA: 16mm motion pictures and enlargements made from 35mm film.

DATA AVAILABILITY: Expected early in 1974.

CORRELATIVE CLASSROOM EXPERIMENTS:

1. Duplicate the inflight experiment on the ground using the spacecraft atmosphere and normal atmosphere, using several spiders to establish statistics on spider adaptability to unusual environments.
2. Compare results of flight experiment with results from similar tests on drugged spiders as carried out at the North Carolina Institution for Mental Health in an effort to identify the specific physiological basis for inflight behavior.

ED61/62 PLANT GROWTH IN ZERO G AND PHOTOTROPIC ORIENTATION OF AN EMBRYO PLANT IN ZERO GRAVITY

Student Investigator-Joel G. Wordekemper
Central Catholic High School; West Point, Nebraska
Teacher/Sponsor-Lois M. Schaaf

Student Investigator-Donald W. Schlack
Downey High School; Downey, California
Teacher/Sponsor-Jean C. Beaton

OBJECTIVE:

1. Observation and recording differences in root and stem growth and orientation of radish seeds germinated in the Skylab environment, compared with normal environment germination and development.
2. Assessment of whether or not phototropism can serve as a substitute for geotropism for radish seeds germinated and developed in the Skylab environment.

CONCEPT: Individual seed groups, implanted in space, are subjected to specific, but different light levels. Periodically, photographic records of the embryonic seed development are made for ground based analysis.

IMPLEMENTATION: Eight seed groups are implanted in individual compartments in a container filled with clear agar. Each of six compartments of the container is supplied with a neutral density filter to enable variation in total light impinging on the container. The ratios of light level inside each compartment to the light falling on the outside of the filters are 1/1 (clear filter), 1/2, 1/8, 1/16, 1/32 and 1/64. The remaining two compartments have opaque covers. The sides of the container are transparent to facilitate photography, and are fitted with hinged covers to prevent light entry except through the filter covers. The partitions between compartments are black to provide a satisfactory background for photography. Photographic records along the principal axes of the container are made once a day for six consecutive days, and then alternate days for six more days.

DATA: Photographic enlargements made from 35mm film.

DATA AVAILABILITY: Late in 1974.

CORRELATIVE CLASSROOM EXPERIMENTS:

1. Duplicate flight experiment in both the Skylab atmosphere and in a normal atmosphere. (Note, in this case additional control groups and differing light orientation can be studied using a clinostat to determine if an "equivalent light level" can be developed to correspond to the gravity effect).

ED63 CYTOPLASMIC STREAMING IN ZERO GRAVITY

Student Investigator-Cheryl A. Peltz
Arapahoe High School, Littleton, Colorado
Teacher/Sponsor-Gordon B. Scheele

OBJECTIVE: Observation of the effects of zero gravity on cytoplasmic streaming in plants.

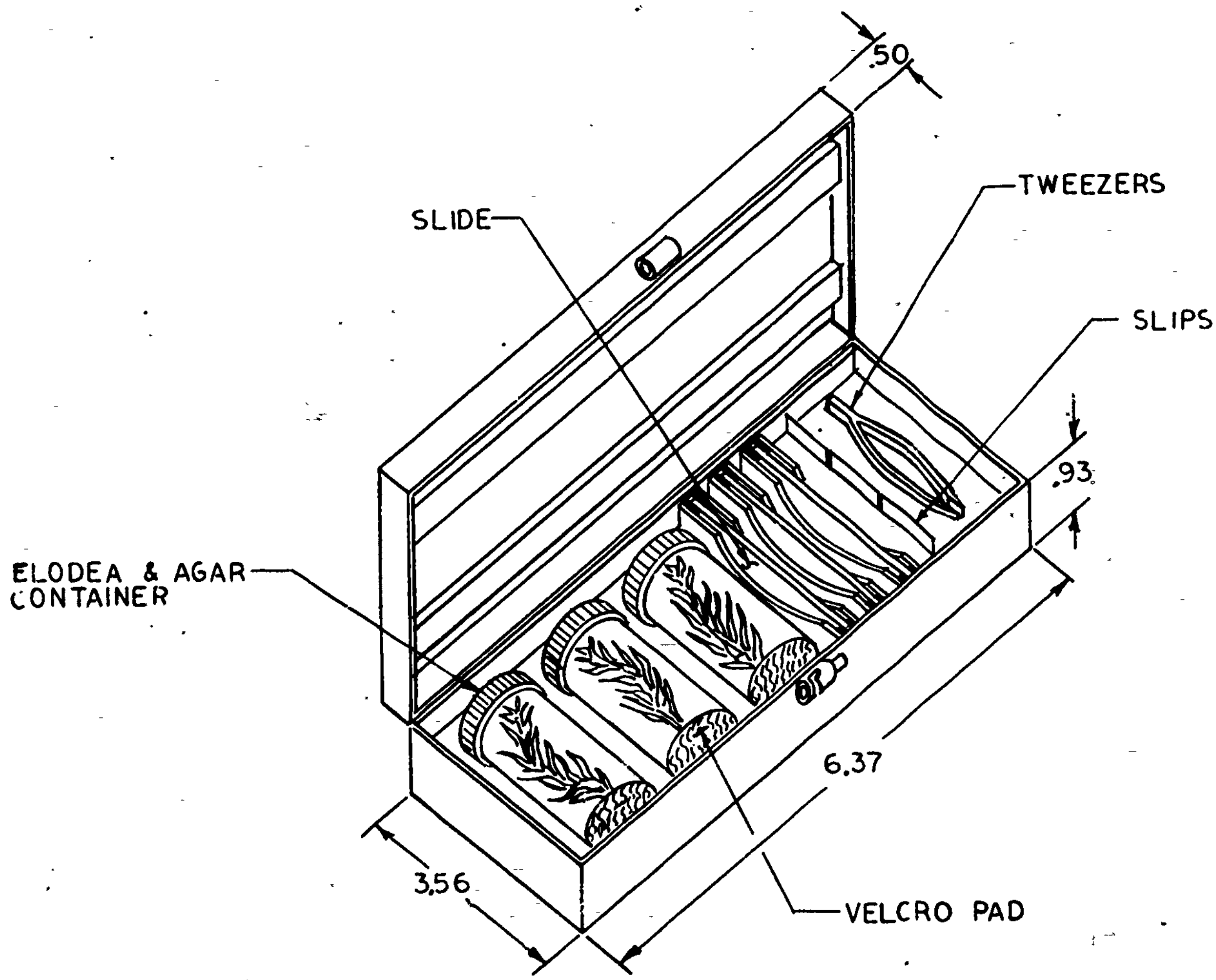
CONCEPT: A leaf of a living plant will be observed under a microscope to identify the existence, or lack, of protoplasmic streaming.

IMPLEMENTATION: In this experiment, a sprig of the water plant, elodea, will be placed in a transparent container, containing a nutrient agar, near an existing light source of sufficient level to maintain photosynthesis throughout a Skylab mission. As convenient, once early in the mission and once late in the mission, a leaf of the plant will be placed under a microscope and examined for the presence of streaming. 16mm movies of the streaming process will be made through the microscope to enable assessment of the quality of the streaming.

DATA: 16mm movie film.

DATA AVAILABILITY: Expected early in 1974.

CORRELATIVE CLASSROOM EXPERIMENTS:
1. Repeat the flight experiment in an Earth environment with both the Skylab atmosphere and normal atmosphere and compare photographic records to identify any differences.



ED72 CAPILLARY ACTION STUDIES IN A STATE OF FREE FALL

Student Investigator-Roger G. Johnston
Alexander Ramsey High School, St. Paul, Minnesota
Teacher/Sponsor-Theodore E. Molitor

OBJECTIVE: Demonstration of capillary and wicking actions in the Skylab environment.

CONCEPT: Observe and record with motion picture photography capillary and wicking actions as a function of: 1) capillary tube diameter; 2) screen weave; and 3) fluid viscosity.

IMPLEMENTATION: Three modules, two capillary and one wicking, provided with "zero face" bladders filled with colored fluid with proper valving to initiate "flow" will be photographed at 24 frames/sec. The fluids used are:

capillary flow - water with suitable dye
- krytox oil with suitable dye
wicking - water with wetting agent and dye to simulate liquid hydrogen.

DATA: 16mm movie film.

DATA AVAILABILITY. Expected in late 1974.

CORRELATIVE CLASSROOM EXPERIMENTS:

1. Calculate equivalent capillary diameter in one 'g' environment to duplicate space flight experiment.
2. Utilizing calculated capillaries repeat experiment in a one 'g', 5 psi environment.
3. Utilizing samples of the screen material (see page 28 for addresses of Supplier) repeat the wicking experiment in a one 'g', 5 psi environment.

ED74 ZERO GRAVITY MASS MEASUREMENT

Student Investigator-Vincent W. Converse
Harlem High School; Rockford, Illinois
Teacher/Sponsor-Mary J. Trumbauer

OBJECTIVE: Demonstration of the methods of mass measurement utilized on baseline Skylab systems.

CONCEPT: Develop a simple mechanical system satisfying the fundamental equation $Mx + KX = O$. With appropriate initial conditions, the displacement X as a function of a time is a sine wave, ideally of single frequency $W = K/M$ where K is the spring constant and M the total mass of the system.

IMPLEMENTATION: A simple cantilevered beam supporting a lumped mass at one end is set into oscillation. The frequency of oscillation is a function of the basic beam properties and the lumped mass. Calibration will be done in orbit using known masses. TV photography will provide real time, or near real time, coverage of the experiment, with 16mm movie film as back up.

DATA: TV tape record and 16mm movies.

DATA AVAILABILITY: Expected in late 1973 or early 1974 if received in normal telemetry. If received as live TV, sometime during the summer of 1973.

CORRELATIVE CLASSROOM EXPERIMENTS:

1. Calculate fundamental frequency of cantilevered beam system.
2. Verify calculations by oscillating beam in a horizonal plane and in a vertical plane.

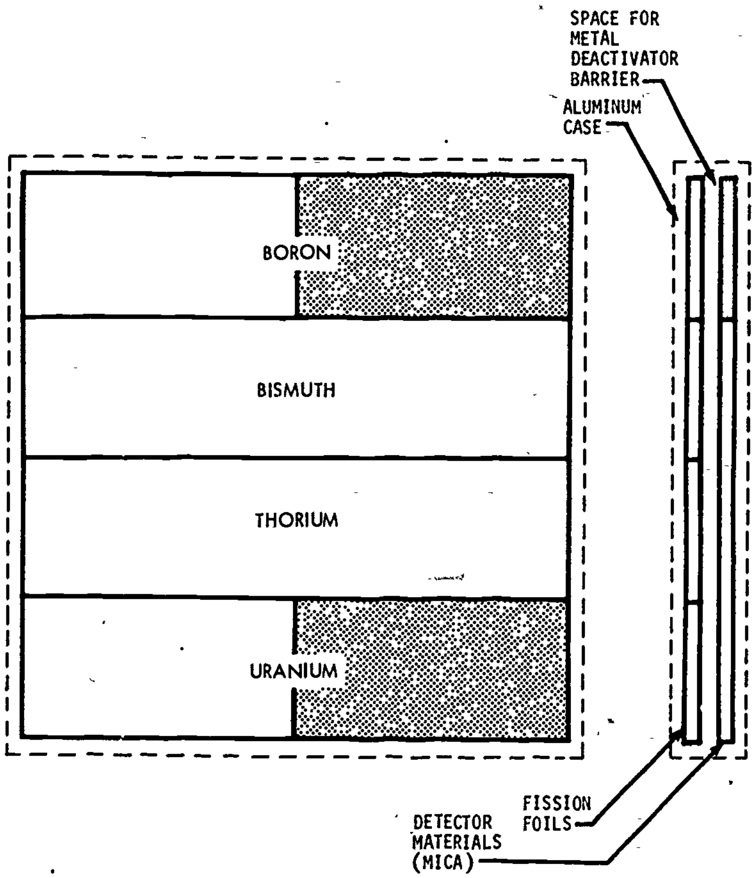
ED76 EARTH ORBITAL NEUTRON ANALYSIS

Student Investigator-Terry C. Quist
Thomas Jefferson High School; San Antonio, Texas
Teacher/Sponsor-Michael Stewart

OBJECTIVE: Measurement of the ambient neutron flux existent in the orbital workshop and attempt identification of the contribution from each of three sources: 1) Earth albedo neutrons; 2) solar neutrons; 3) cosmic ray secondary neutrons.

CONCEPT: Neutron detectors which can identify neutrons of varying energies are mounted in several locations in the OWS utilizing the OWS water tanks to thermalize (moderate) the high energy impinging neutrons. The, now, low energy neutrons react with a primary target producing fission particles which in turn interact with a detector material (mica and cellulose triacetate) damaging the polymer chains. (see sketch). These materials are then chemically treated to remove the damaged material leaving a readily identified "track" indicating the impingement of a low energy neutron.

IMPLEMENTATION: Ten detectors are used; each consisting of a flat aluminum package containing a layer of fission foil and a layer of detector material. The fission foil is constructed of four materials: Uranium (235_u) Boron (10_B) Bismuth (Bi) and Thorium (Th) arranged as in the accompanying sketch. The 235_u and 10_B foils are further divided by having an overlay of Cadmium (Cd) over a portion of each.



SKETCH OF NEUTRON DETECTOR

The detector foil consists of two materials—muscovite mica and cellulose triactitate. The mica is the detector for fissions in the 235_u, Bi and Th; the triacitate records fissions in 10_B.

All of the detectors are deployed as early as possible in the first manned mission. Four are deactivated at the end of this mission and are returned to earth for analysis. The remaining 6 are deactivated and returned to earth at the end of the final manned mission after almost 8 months exposure.

DATA: Analysis of returned detectors.

DATA AVAILABILITY: Late 1974.

CORRELATIVE CLASSROOM EXPERIMENTS:

1. Theoretical calculations of track densities using postulated neutron fluxes, fission material cross sections, etc.
2. Exposure of various radiation dosage detectors (simulations of flight experiment detectors and "film badge types") to varying radiation environments and analysis of detected fluxes.

Samples of the Student Proposals as Submitted by the Students

PHOTOTROPIC ORIENTATION OF AN EMBRYO PLANT IN ZERO GRAVITY

Objectives: To determine whether light can provide for total plant orientation in the absence of gravity. If part one proves true, what is the minimum intensity of light that is needed?

Background: On earth, a germinated seedling can be placed in any position and the radicle will invariably turn the embryo plant "downward" and the hypocotle "upward". This is because of positive root tropism toward gravity and negative stem tropism away from gravity. In the absence of gravity, will the plumules and the stem of the embryo plant reacting positively to phototropism guide the *entire* plant including the root system for its directional orientation? If so, how much light intensity is needed?

Hardware Description: The experiment consists of *twelve smaller vessels (4 1/2" x 4 3/4" x 5 1/4")* having all six sides transparent with one removable side. There will be twelve larger enclosing vessels (4 3/4" x 5" x 5 1/2") having all sides opaque so that no light is admitted. Ten light bulbs of different intensities (1/8, 1/4, 1/2, 1, and 10 candle powers) two of each intensity. Two batteries will be needed, one for powering the lights and one for backup. (The type to be used will be determined by testing before the flight.) The seed type recommended for use is radish. Clear agar is required to fill the transparent vessels. An identical set of the above hardware will be needed for the school laboratory.

Protocol: Fill the twelve transparent vessels with agar before the flight. The agar is not used as a source of nourishment (the cotyledons provide this) but simply to hold the embryo plant in position away from the sides of the vessels (Fig. 1) and it also provides the moisture needed to growth. Germinate the seeds before placing them in the agar. Now put one sprouted seedling in the center of the transparent vessels (see Fig. 1). Take one set of photographs now. Each set consists of one photograph taken from each of the six sides of the transparent vessel. The vessels are then placed inside the opaque containers. Two vessels are kept in total darkness as controls. The lights should be placed in the top of the remaining ten opaque containers (see Fig. 2). The lights should be turned on at the beginning of the experiment and the time should be noted. The lights will remain on throughout the project and never be turned off. Put the containers inside the locker (Fig. 3) and leave them undisturbed until the next set of photographs. Every 24 hours take the transparent vessels out and photograph the progress of the seedlings. Care should be taken so that the vessels are not jolted, causing the seedlings to move from their original position while the experiment is in progress. The experiment will terminate at the end of fourteen days.

Data Return: A series of photographs taken from the same position every twenty four hours will provide an indepth study of the effect of zero gravity on phototropic orientation of the seedlings. Test samples kept at the school will also be photographed at the same periods of time as they were in space to provide comparison. In addition, observation should be made of (1) the orientation of the roots with respect to light, and (2) the reaction of the two control plants in an environment completely void of either light or gravity.

WEB FORMATION IN ZERO GRAVITY

Objectives: To compare the web of a spider in a zero gravity environment to one constructed on earth.

Background: It is believed that gravity is an important factor in the designing of a web because construction requires the spider to attach a thread to an object and then to land on another working area. To orient itself in space, a spider owns organs sensitive to touch in their joints, which report stresses due to gravity. It is not known how the insect would react when deprived of their sense of position. Perhaps a web could not be formed. Spiders' webs have previously been studied while the weaver has been under the influence of drugs. Specialists try to interpret the inner workings of the spider's mind through these deformed structures: For example, spiders under the influence of caffein construct an erratic and haphazard web, indicating the hyperactivity of their mind. The purpose of this experiment is to determine whether the spider can function normally deprived of this sense of balance. Perhaps other senses such as touch and taste could make up for the loss. Should the web show a feeling of disorientation in the spider, it would provide a clue as to how other insects react to a weightless environment. Eventually, subsequent experiments made with more advanced animals in the same situation could show how reason and abstract thinking offset the disturbing external influences on behavior.

Hardware Description: A transparent plastic box divided into two compartments: The larger section contains the spider. Its food supply is provided by drosophilia, which are housed in the second small compartment. Available to the fruit flies is a sticky mash for nourishment. Separating the two sections is a wire mesh, which allows the drosphilia to pass freely, but prevents the spider access to the second compartment. Larva, developing in the food supply, would hatch at a rate of three a day, providing continuous sustenance. Recommended as the species of spider to be utilized is Epeiridae; a small common, orb weaving family of spiders.

Protocol: Two sets of equipment will be used, one in Skylab and one in an earth laboratory. Time lapse photographs will be taken of each setup, with a light source to illuminate the imperfect web. Continuous filming could be used as an alternative method. A small section of film should be made of the attempts of each spider to erect a web.

Data Return: The photographs taken at corresponding times will be compared to the type of web made and the speed at which it was constructed. The film clips will also be viewed in order to note the contrasting methods of each species to devise a web.

PLANT GROWTH IN ZERO GRAVITY

Objectives: To compare root and stem growth in radish seedlings in a zero gravity environment with such growth on earth.

Background: Roots exhibit a positive geotropism in which they grow downward toward the earth's center of gravity. Stems show a negative geotropism in which they grow away from the gravitational pull of the earth. It would be interesting to determine the influence on plant growth in an environment of zero gravity.

Hardware Description: Relatively simple apparatus would be required for this experiment. Ten pairs of glass plates approximately 8 cm. square, are needed for the experiment on Skylab and for the identical test conducted in the school laboratory. Radish seeds, approximately five to ten, are spread on moist filter paper and a glass plate is put on either side with the resulting packet secured together with a rubber band. The ten sets of plates with filter paper and seeds between them are then arranged vertically in a small pan lined with a moist porous sponge. When the moisture is depleted in one sponge, another moist sponge stored in a plastic bag may be substituted. The moisture rises in the filter paper by capillary action and is necessary for the germination of the seeds.

Protocol: As the seeds germinate, the growth of stem and root can be observed. At a specified interval of approximately three days after germination, a set of plates is removed and preserved by freezing or color still photographs may be taken through the plate of the root and stem growth. Again, at an interval of either one or two days, another set of plates is photographed and/or preserved. This process is continued at the same interval until all the plates are used up. The procedure is followed the same on earth.

One set of plates could be turned around 180° in the school laboratory and on Skylab to see the new orientation or growth of root and stem.

The advantages of this experiment are found in the little space, maintenance, and germination period required. The experiment could easily be repeated by having additional sets of plates and seeds ready but without the moisture added for initiating germination.

Data Required: When plates and seedlings are returned to earth, the measurement and direction of root and stem length at the various stages can be compared with seedlings kept on earth. Comparison of the color photographs, if these were made, can also be studied.

POSSIBLE CONFIRMATION OF OBJECTS WITHIN MERCURY'S ORBIT

Objectives: To investigate reports of sightings of objects within the orbit of the planet Mercury.

Background: In years past and just recently there have been unconfirmed reports of sightings of an object or objects within the orbit of Mercury. The Skylab project offers a clear and undistorted view of the Sun which would permit the observing and photographing of the region near the sun where an object or objects could be detected. Also, the length of Skylab's mission would allow for a relatively long term study of the near sun region and photographs taken at regular intervals during the mission would keep an object from going undetected.

Hardware Description: The white-light Coronagraph to be available on Skylab could be utilized for this experiment. A possible extension of the outward range of the coronagraph from 6 solar radii to approximately 40 solar radii would permit more extensive photographing and observation of the near sun region. Also, very fine grained photographic film would be used to minimize distortion.

Procedure: At two day intervals photographs would be made with the coronagraph to detect an object or objects which would come into view near the edge of the sun.

Data Return: Photographs made during the mission will be returned for detailed analysis and evaluation.

EARTH'S ABSORPTION OF RADIANT HEAT

Objectives: To demonstrate the effects of the atmosphere at various locations upon the absorption of radiant energy. To arrive at a coefficient of atmospheric absorption at specific locations and during specific weather conditions.

Background: There has been disagreement about the changing weather conditions. The most logical explanation is that the increasing man made atmospheric changes shield the Earth from some of the sun's rays. Simultaneous readings of the intensity of ultra violet and visible light will be taken on the Earth's surface and at a point directly above it from Skylab. Readings will be taken at each 100 Hz. between 4000 angstroms and 8000 angstroms. Such reading will be taken one, at a heavily populated area and another, at a sparsely populated area. There should be no cloud cover and both locations should be approximately the same altitude. To compare the results a coefficient will be arrived at by the ratio of the Skylab's intensity over the Earth's intensity reading: *Skylab/earth*

Hardware Description: Two identical pairs of photoelectric tubes and monochromators, both sensitive to ultra violet and visible light, will be provided along with an x-y chart or meter readout. The monochromator divides specific waves of sunlight while the photoelectric tube measures the intensity of each wave. One set of hardware will be flown with Skylab, the other will be retained on the designated points on Earth. Both sets of data will be retained on the x-y recorders.

Protocol: The experiment will be performed in two parts identically: simultaneous intensity readings will be taken in Skylab and on Earth while Skylab is directly above the indicated points on Earth.

Data Return: The radiant energy before and after reaching the Earth's atmosphere will be compared by comparing the *Skylab/earth* intensity ratio. The amount of radiant energy absorbed by the Earth's atmosphere will then be calculated. Also a comparison between the heavily populated area's atmosphere and the sparsely populated area's atmosphere will be made.

PHOTOGRAPHY OF LIBRATION CLOUDS

Objectives: To photograph the two libration clouds on the moon's orbit, 60 degrees before and 60 degrees after the moon.

Background: These cloud-like objects were discovered about fifteen years ago by the astronomer K. Kordylewski of Poland. They are situated at the Lagrangian points L_4 and L_5 of the earth-moon system. The French mathematician Lagrange discovered these points. He imagined a situation with the sun, S, and two plantes, A and B. If the three bodies were at the corners of an imaginary equilateral triangle (triangle SAB was equilateral), then A and B would follow identical elliptical orbits around the sun, with their major axes inclined to each other at a 60 degree angle. At the Lagrangian points of Jupiter and the sun the Trojan asteroids have been found, numbering fifteen to twenty. Little research has been done concerning our libration clouds on Earth, and not much is known about them. Skylab will be orbiting above the Earth's atmosphere, enabling decent photographs to be made since the atmosphere will not be able to block out the light. Diagram A shows Earth's Lagrangian points.

Hardware: The hardware would consist of a camera with large telephoto lens covering a 7 or 8 degree area of the sky. The negatives produced should be as big as possible, and the shutter speed slow. Black and white film would be used for clarity, and to use as much light as possible. Some sort of device to compensate for the motion of Skylab would be needed to mount the camera on.

Protocol: A series of overlapping photographs of both libration points L_4 and L_5 would be taken, covering a radius of 15 degrees centered on each cloud. Each series would be taken from a different angle from the particular libration point: one directly opposite the cloud at the libration point, one taken from Skylab 30 degrees ahead of the cloud, and one 60 degrees behind. These different views should provide much information about the depth and composition of the clouds.

Certain conditions must exist. The cloud in question must be out of the Milky Way. It must be near its full phase to maximize its brightness. This would occur approximately 4.9 days before full moon and 4.9 days after.

Data Return: Photographs would be taken, and studied upon their return to Earth.

Related Classroom Activities

PREPARATION OF A SIMULATED SKYLAB ATMOSPHERE

It is desirable to prepare five (5) gallons of atmosphere at a time. (Five gallon carboys used for distilled water are usually readily avilable.)

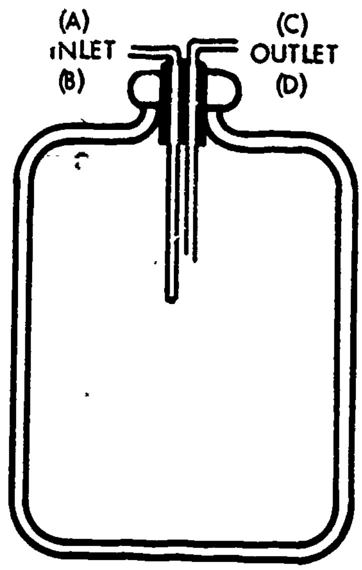
Set up the carboy and oxygen generator as shown in Figure 1. Slowly pass one mole of oxygen through the carboy.

The most convenient method for generating oxygen is to allow water to flow drop-wise on sodium peroxide. This provides purer oxygen and is far safer than the use of potassium chlorate.

Let stand for a period of time to allow for mixing, then withdraw a eudiometer of the gas for analysis. This method lends itself conveniently to analysis by allowing white phosphorus to react with the oxygen in the gas. We may assume that the remaining gas is nitrogen. The small amount remaining which is carbon dioxide will not interfere with the activities. The desired composition is 74% oxygen, 26% nitrogen. If the oxygen percentage is too low, pass more oxygen through the system. Continue until the desired percentage is reached. Allow sufficient time for equillibration.

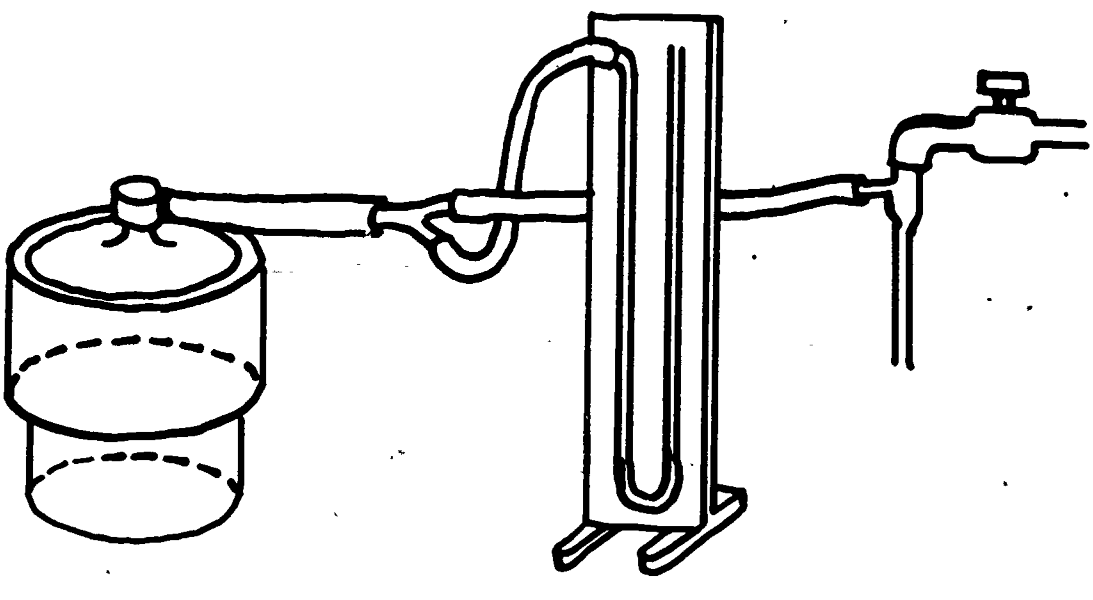
To remove gas, merely allow water to flow into the carboy from an elevated reservoir.

An alternate approach would be to set up a nitrogen and oxygen generators and fill containers 74% by volume with oxygen then the remaining volume with nitrogen.



(A) OXYGEN GENERATOR
(B) WATER RESERVOIR
(C) TO EUDIOMETER
(D) TO TEST CHAMBER

To utilize this atmosphere, two methods should prove satisfactory in most of the activities. One method involves the use of a vacuum desiccator. Fill the vacuum desiccator with the gas (at ambient pressure or evacuate and run in the gas). Place the experiment package in the desiccator, attach the vacuum line to a "y" tube with one tube leading to a mercury manometer and the other to a



water aspirator. Open the valve of the desiccator, turn on the water. When the pressure is reduced to 258.57 torr (5 psia) close the valve. One may then remove the manometer and aspirator. The other method consists of placing the experiment package on the plate of a vacuum pump and covering with a bell jar. A method for determining the pressure within the system is necessary. For example a small aneroid barometer (which will read down to 258 torr) may also be placed inside. Reduce the pressure and re-pressurize with the Skylab gas mixture and re-evacuate. Repeat this procedure until satisfied that the composition of gas within the system is indeed 74% oxygen.

It is possible that the reader may devise a more effective system with the materials available to him.

EARTH'S ABSORPTION OF RADIANT ENERGY

AREA: Earth Science, Physics

LEVEL: Secondary

SKYLAB CORRELATION: ED-11

CONCEPT: To compare the measurements of radiant energy and related parameters from the surface of the Earth and points above the Earth to radiant energy detected at spacecraft altitude

MATERIALS:

1. Thermometer
2. Sling psychrometer
3. Barometer
4. Anemometer
5. Light Meter
6. Ladder
7. Light aircraft (optional)
8. Correlative information from Skylab
9. Orbital Path data for Skylab
10. Pyranometer[1]

BACKGROUND: We do not know if any relationship exists between radiant energy emitted and reflected from the Earth and weather information. Perhaps some relation does exist. The purpose of this activity is to provide a data bank of information, subsequent compiling and analysis may shed some light on the dynamics of large scale weather formation. The idea is to provide ground truth data to correlate with ED-11.

ACTIVITY:

1. Determine the orbital passes for Skylab. (Note that Skylab will retrace its ground track approximately every five days (4 days, 22 hours, 6 minutes). Data should be taken within several minutes of Skylab passing over the zenith.
2. At the time of overflight, record the pertinent ground truth information:
   a. data and time of day
   b. altitude (above sea level)
   c. ground surface temperature
   d. air temperature
   e. relative humidity
   f. barometric pressure
   g. wind speed and direction
   h. total solar incident radiation measurement (pyronometer data)
   i. Visual description of prevailing weather conditions such as type of cloud cover, clear, hazy, overcast, rain, snow, hurricane, tornado, smog, etc.

SUGGESTIONS: Albedo may be measured by comparing ratio of incident light to the reflected light with a light meter. Data from Skylab will be available in late 1974.

[1] The pyranometer is made up of two units–a ratemeter and a probe. The ratemeter can be constructed from material usually found in a high school laboratory. The probe has to be purchased. Information on how to build the ratemeter and the price of the probe can be obtained from:
Yellow Springs Instrument Co.
Yellow Springs, Ohio 45387

PLANT GROWTH AND PHOTOTROPIC ORIENTATION IN EARTH AND SKYLAB ATMOSPHERE

AREA: Botany

LEVEL: Secondary

SKYLAB CORRELATION: ED61/62

CONCEPT: To observe and record the differences and similarities in root and stem growth between those of radish seeds germinated on Earth and those aboard Skylab.

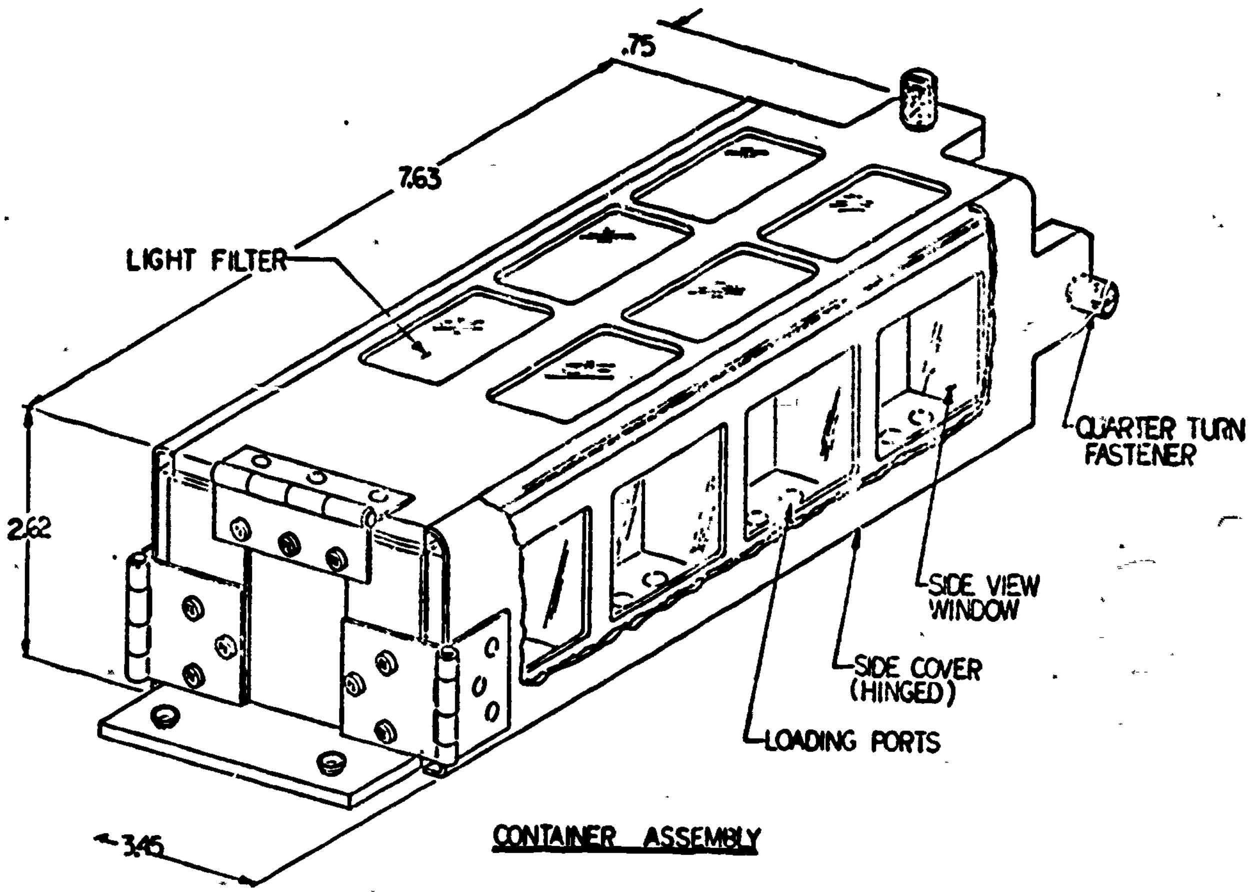
MATERIALS:

1. Radish seeds
2. Agar
3. Growth chamber (see directions)
4. Simulated Skylab atmosphere
5. Neutral density filters (See directions)
6. Camera
7. Lights
8. Bell jar, vacuum pump, mercury manometer

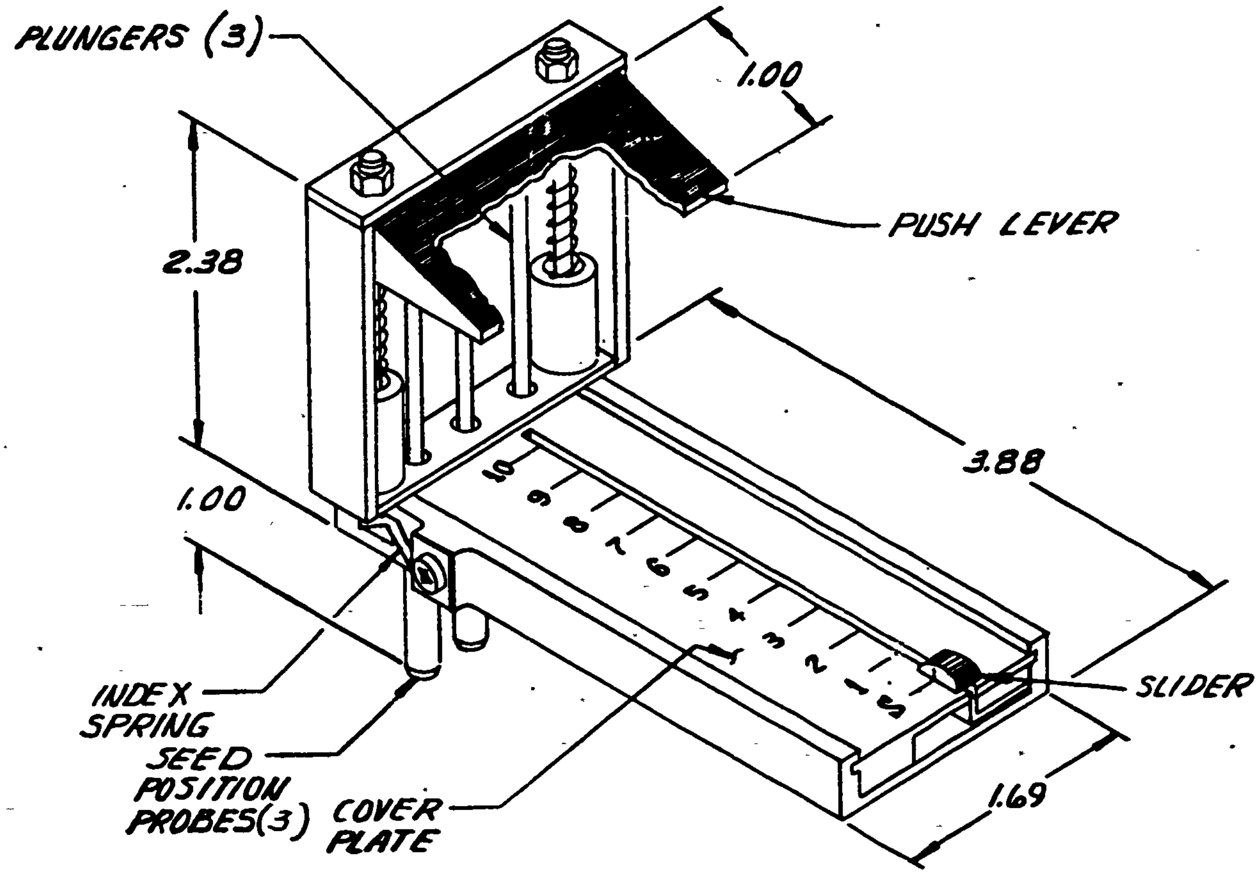
BACKGROUND: The properties of geotropism and phototropism are quite well known and are studied in every introductory biology class. However, the degree to which phototropism occurs in the absence of a gravity field is not known. Actually Skylab will have a gravity varying from 10^{-3} to 10^{-9} "g's". It is believed that the gravity of the moon (which indeed does cause tides) has an effect upon germination ("plant subsurface crops in the dark of the moon and above ground crops in the light of the moon"). Question, what is the perceived gravitational attraction of the moon upon objects at the surface of the Earth?

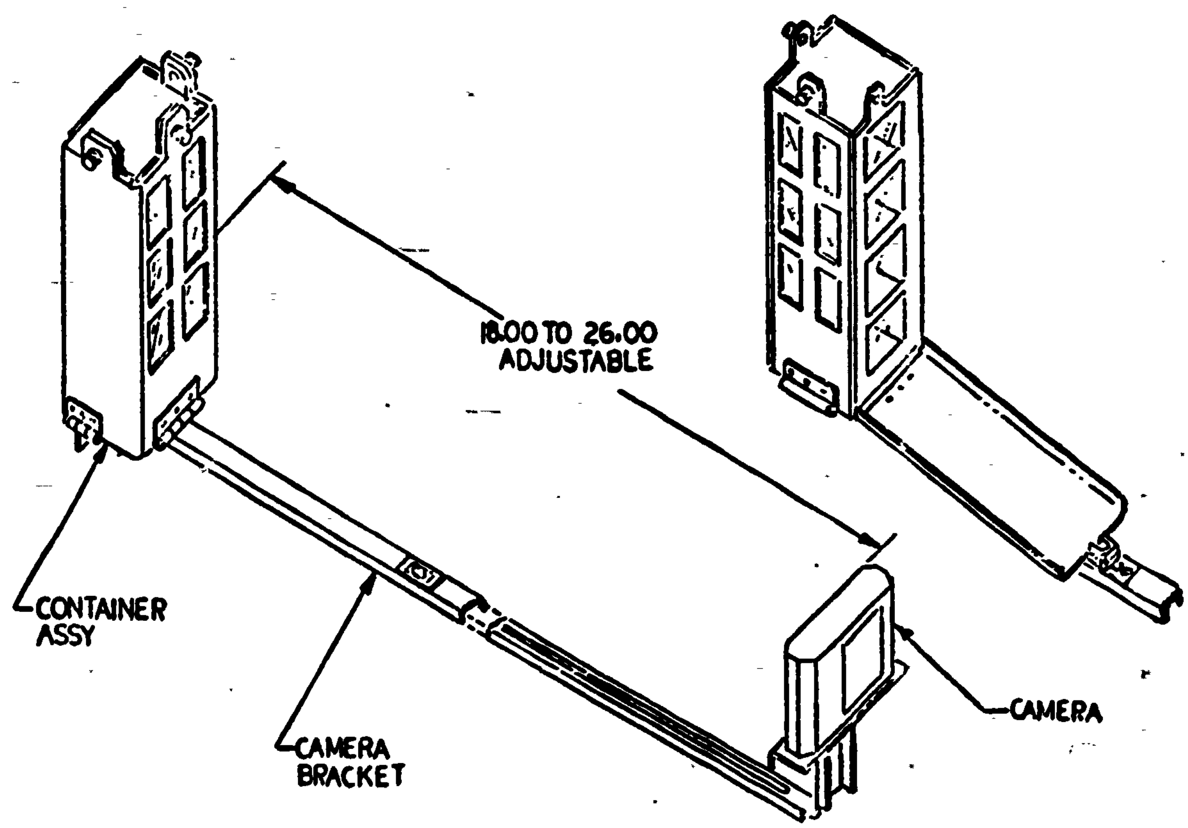
ACTIVITY:

1. Prepare the test chamber (See directions on page 20)
2. Prepare the neutral density filters.



CONTAINER ASSEMBLY


PLUNGERS (3)
1.00
PUSH LEVER
2.38
3.88
1.00
10
9
8
7
6
5
4
3
2
1
SLIDER
INDEX SPRING
SEED POSITION PROBES(3)
COVER PLATE
1.69


18.00 TO 26.00 ADJUSTABLE
CONTAINER ASSY
CAMERA BRACKET
CAMERA

3. Fill the chambers of the test box with agar and place a number of viable radish seeds in each of the eight chambers.
4. Close the sides and the cover. Keep between 20° and 25°C. Illumination level 45 foot candles at the surface of the filters. At periodic intervals record the growth by quickly opening the side of the box, photographing and reclosing. Repeat for the opposite side.
5. Compare the results over a period of time.
6. Compare your results with those aboard Skylab.
7. Repeat the procedures using a simulated Skylab atmosphere. Place the container in a bell jar full of simulated Skylab atmosphere, reduce the pressure to 257.6 torr and let stand for a period of time. In this case, it will be necessary to restore atmospheric pressure in order to open the sides for photography unless the atmosphere container (bell jar) is sufficiently transparent to allow photography. Compare the results with Earth gravity and atmosphere and also those of Skylab gravity and atmosphere.

SUGGESTIONS:

1. Devise a system for keeping the system under Skylab atmospheric conditions and opening the sides for photographic purposes.

PREPARATION OF NEUTRAL DENSITY FILTERS

Desired density may be obtained by photographing a neutral gray test card (obtainable from Kodak or your local photographic dealer). The filter will approximate the dimensions of a 35mm frame. Thus you may use the negative for the filter.

The filters used in ED61/62 are 1:1; 1:2; 1:8; 1:16; 1:32; 1:64. (1:1 is clear, 1:2 is 50% attenuation, etc.). However, these are to be used for the Skylab lighting conditions, the lamps will emit between 6 and 9 candle power.

SPIDER WEB FORMATION

AREA: Zoology, Geometry

LEVEL: Secondary

SKYLAB CORRELATION: ED-52

CONCEPT:

To observe and compare the building process, detailed structures of the web of the common cross spider (araneus drodematus) in an Earth environment and variable atmospheres with the results from the Skylab environment.

MATERIALS:

1. Common female cross spider (araneus drodematus)
2. Test chamber (See Directions on page 20)
3. Spider food (common household fly)
4. Skylab atmosphere (See Directions on page 20)
5. Camera
6. Lamp

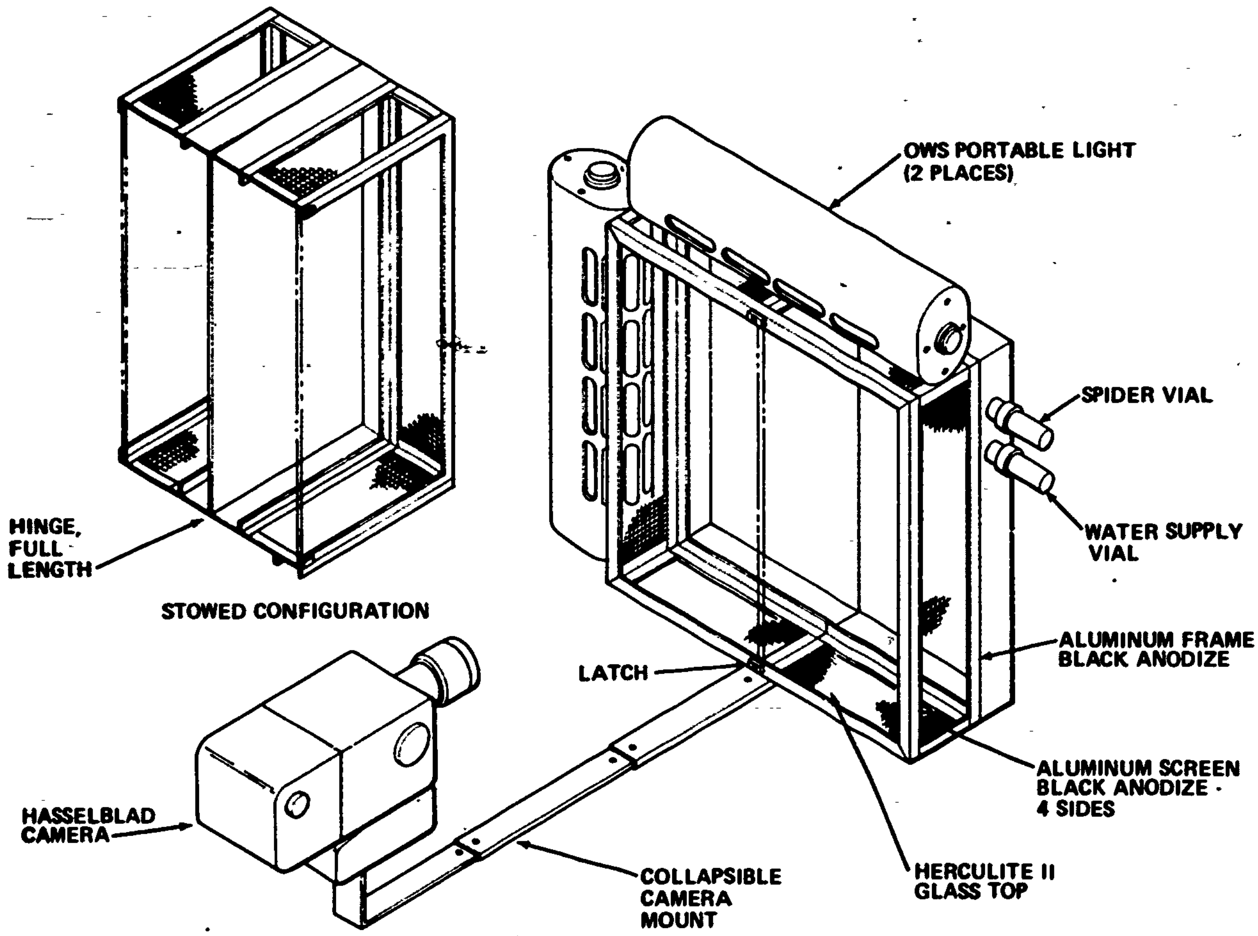
BACKGROUND:

Spiders are motivated to build their web in order to survive. In their normal mechanism the spider uses its leg as a unit of linear measure, body mass (weight) to determine thread thickness, will establish necessary mesh size, and select the right angle between the first radii. The spider is the epitome of recycling as it eats the old web and regenerates it the next day to build a new web. Depending upon the size, the spider usually will require between 20 to 30 minutes to build its web. Spiders may not build webs when it is light, when they are not hungry, or when they do not feel acclimated to surroundings. Once a spider commences building a web it will continue until the web is completed.

ACTIVITY:

1. Build the chamber in order that Earth results may be compared directly with Skylab results. Size is 15" square by 4.5" deep. Black aluminum screen can be used to replace Herculite II glass top. Back panel must be black.
2. For the first trial use the Earth atmosphere. Place the spider in the chamber.
3. Time lapse motion pictures would be valuable. A sequence of still photographs may serve as well.

4. Record the following information:
   A. Total Space occupied by the web.
   B. Mesh size
   C. Total length of thread
   D. Thread size (diameter)
5. Web analysis:
   A. Photograph the web using a black background and side lighting.
   B. Analyze the photograph
      1. Size
         a. Thread length
         b. Number of radii
         c. Number of spirals per quadrant
         d. Area (catching, center, frame)
      2. Shape
         a. Ratios of north-south to east-west radii
         b. Ratio of vertical to horizontal diameter
      3. Regularity measurements
         a. Radial angles
         b. Spiral angles
6. Repeat procedure for simulated Skylab atmosphere. Allow time for spider to acclimate to reduced pressure. (Have extra spiders acclimating.)



SUGGESTIONS:

1. Place spider chamber on a centrifuge and determine web formation for increased force.
2. Perform 1 g environment adaptability and increased g test on a number of spiders to develop statistics on the adaptability of the breed of spider.

CAPILLARY ACTION IN VARYING GRAVITY

AREA: Chemistry, Physics

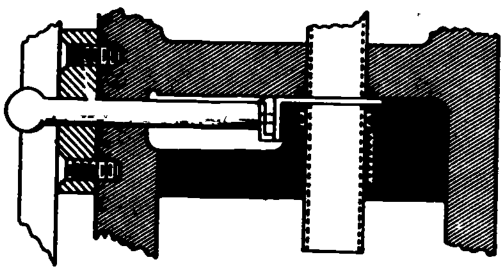
LEVEL: Secondary

SKYLAB CORRELATION: ED-72

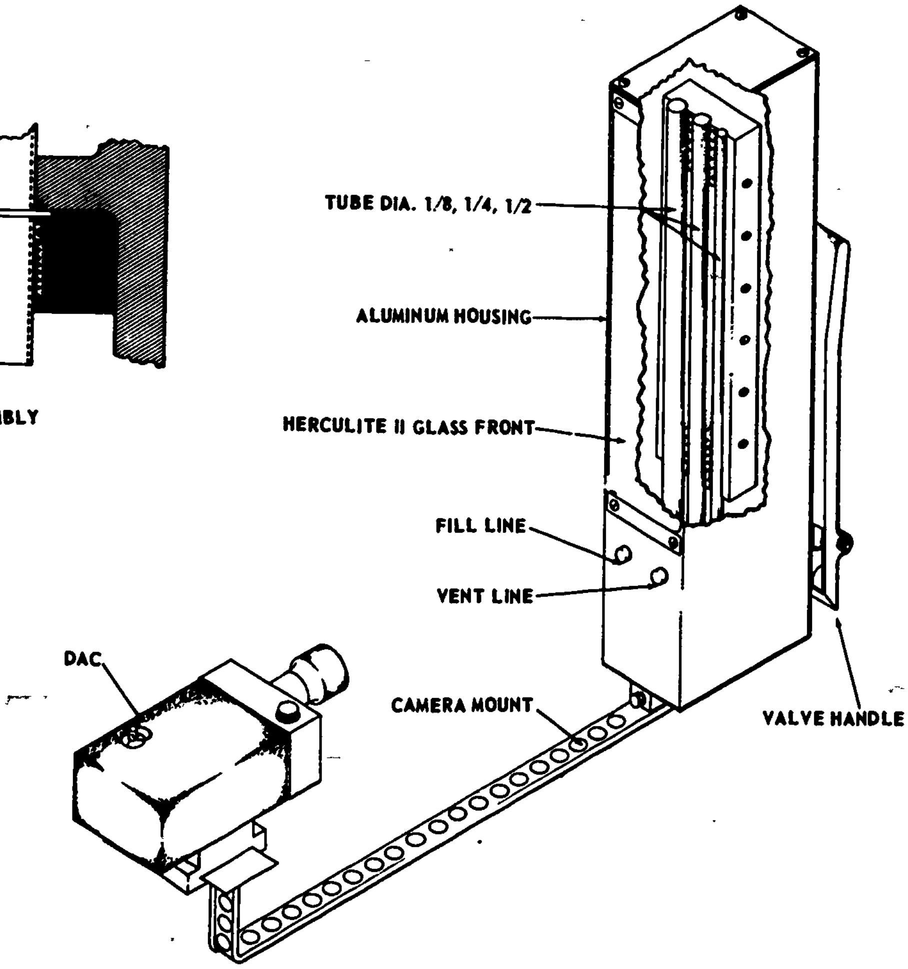
CONCEPT: To determine both capillary and wicking action as a function of a) capillary tube diameter, b) wicking screen weave (denier) and c) fluid viscosity for Earth gravity and other conditions.

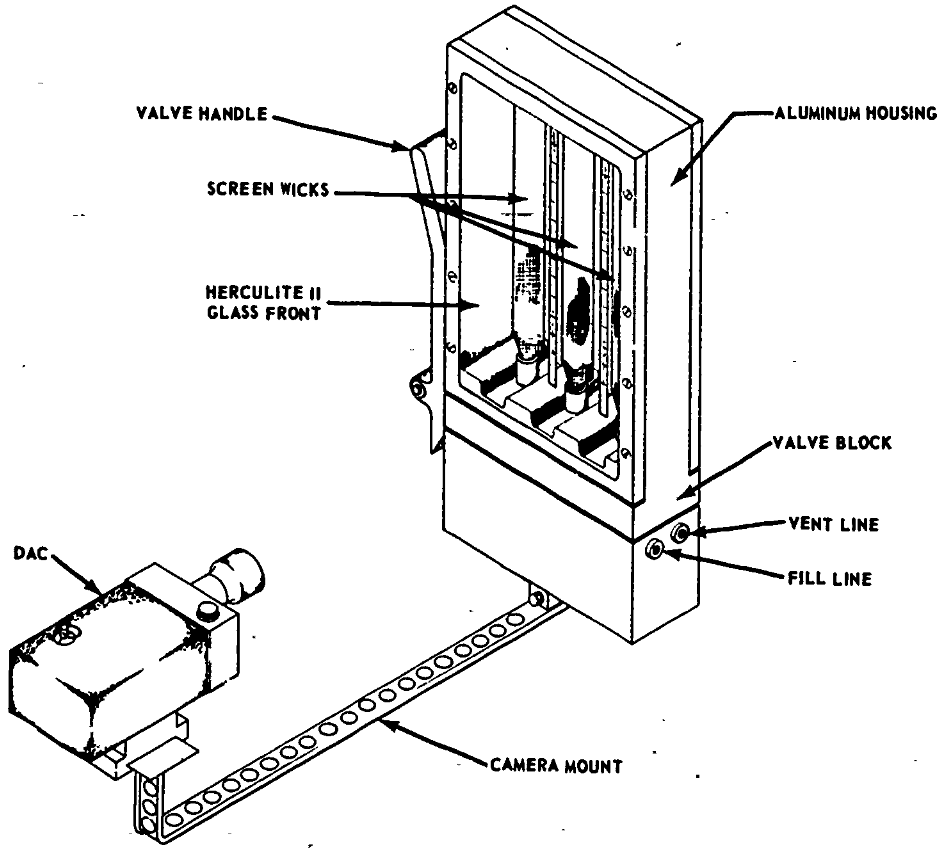
MATERIALS:

1. Capillary tubes (0.318, 0.635, 1.27 cm i.d.)
2. Stainless steel wicking (325 x 2300 Dutch twill weave wire diameter .0015/.0010 mm., 200 x 200 plain weave wire diameter .0015/.0010 mm., 200 x 600 plain Dutch weave wire diameter .0015/.0010 mm.)
3. Assembly for above
4. Krytox 143 AB oil (viscosity 434.7 centipoise, density 1.89 g/cm^3)
5. Wetting agent
6. Distilled water (3.3 x 10^{-3} centipoise)
7. Motion picture camera



VALVE ASSEMBLY





8. Simulated Skylab atmosphere
9. Vacuum pump and bell jar or water aspirator

BACKGROUND: Capillary action is indeed a function of the viscosity, tube diameter, and nature of the tube composition and fluid. However, capillary action has not been quantified for conditions other than "normal Earth conditions". This activity proposed to study both capillary and wicking action under a variety of conditions including the effect of a lower pressure.

ACTIVITY:

1. Prepare the capillary and wicking action devices as shown in the directions. To facilitate the operation, it would be advantageous to have one capillary and one wicking set up for each liquid tested. This will eliminate the necessity for thorough cleaning and drying in between runs.
2. Measure the height of the capillary action for each combination.
3. Repeat the tests for simulated Skylab atmospheric conditions. Place the set up in a bell jar of simulated Skylab atmosphere reduce the pressure to 258.57 torr and take a reading.
4. Compare the results.

SUGGESTIONS:

1. Compare the results obtained with those from Skylab.
2. Compute the equivalent inside capillary diameter in order to duplicate the Skylab conditions.
3. By means of a centrifuge (and a camera) determine the effect in increased "g" forces upon capillary action. (One might try a rapidly moving elevator.)
4. Place the test chamber and motion picture camera in a container which will insure that the equipment and camera survive the fall, and drop it off of a tall building in order to simulate free-fall.

Note: Krytox Fluorinated Oil, Krytox 143AB is a product of E.I. Dupont DeNemours and Co., Inc. Petroleum Chemicals Division, Wilmington, Delaware 19898.

Stainless steel wicking is available from Kresilk Products Inc. (3 addresses):
525 Monterey Pass Rd., Monterey Park, California 91754 or
420 Sawmill River Rd., Elmsford, N.Y. 10523 or
2434 Dempster St., Des Plaines, Illinois 60016.
(order 1 piece 1½"x48" of each size; this will approximate the minimum order of $15.00)

LOCATION OF SELECTED QUASARS

AREA: Astronomy, Physics

LEVEL: Secondary

SKYLAB CORRELATION: ED-23

CONCEPT: Quasi-stellar radio sources (quasars) have been identified with radio signals and some have subsequently been located by means of optical telescopes. Because most of the ultraviolet radiation is absorbed by the Earth's atmosphere, the determination of ultraviolet radiation eminating from these quasars has been difficult.

MATERIALS:

1. Data on location and characteristics of known quasars
2. Telescope
3. Camera attachment and high speed black and white (e.g. Tri-X) film
4. Kodak Wratten 18A Filter

BACKGROUND: Ordinary photographic film is sensitive to the near ultraviolet (also referred to as the "long wave" ultraviolet) 320 to 400 nm is just outside the range of human vision. This ultraviolet radiation *will* penetrate glass. For the middle (280 nm - 320 nm) or short (200 nm to 280 nm) quartz lenses are needed. The purpose of this activity is to determine whether any near ultraviolet energy can be detected in the vicinity of the selected quasar. The Wratten 18A filter will effectively block all visible radiation. The problem of focus must be considered, as the ultraviolet image will be formed in *front* of the film plane, one must either guess at the focus, or decrease the aperature by two stops to increase the depth of field.

ACTIVITY:

1. Select a known quasar and determine its location. Determine the time and location from your viewing position. Calculate this information for a series of "viewings" in order to have a choice of clear nights.
2. On a clear night (haze readily absorbs blue and ultraviolet) set up the telescope, camera, filter, etc. Determining the exposure will be a guess. Thus it may be helpful to make a series of exposures.
3. After processing the film examine the exposures. Were you able to detect any evidence of ultraviolet radiation? Is it in the vicinity of the quasar?

DETERMINING NEUTRON FLUX DENSITY

AREA: Physics, Chemistry

LEVEL: Secondary

SKYLAB CORRELATION: ED-76

CONCEPT: Neutrons may be detected by their interaction with atoms especially those with a large cross section, the product produces fission and other decay products themselves which may be determined. ED76 is concerned with determining the neutron flux density with respect to three sources; earth albedo, solar, and cosmic ray (secondary) neutrons.

MATERIALS:

1. Neutron film detector
2. Radiation sources
3. Etching and detection means

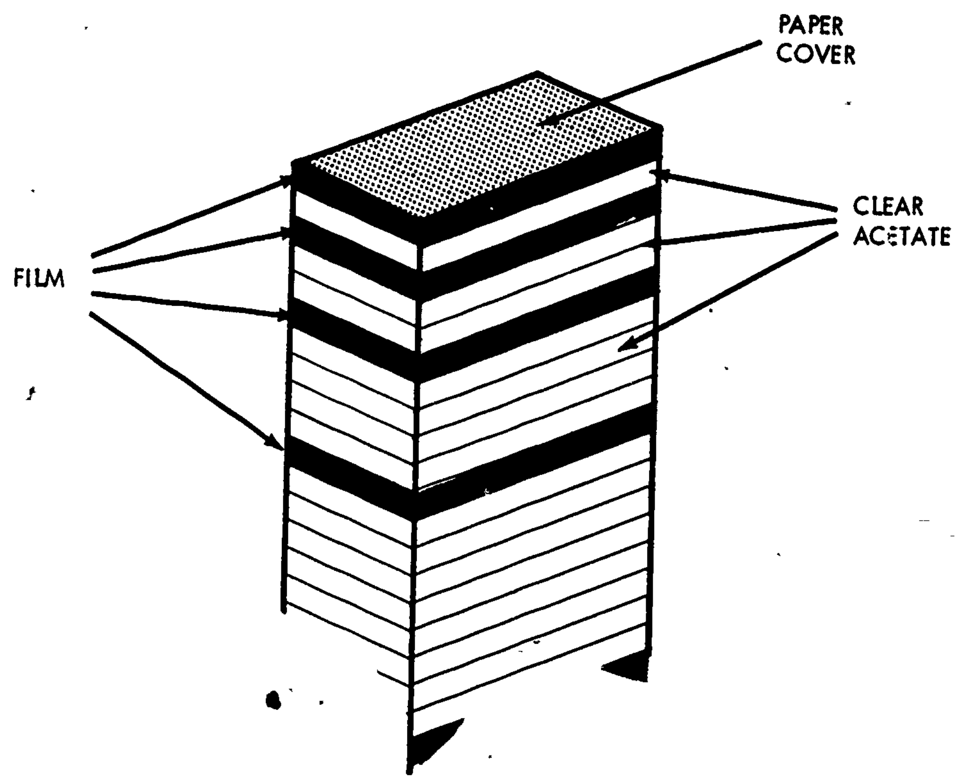
BACKGROUND: When neutrons collide with heavy atoms there is a large probability that the neutron will interact with the nucleus and the resulting product will be unstable, thus producing either fission products or decay by alpha or perhaps beta and gamma. This resulting radiation may in turn interact with organic polymers destroying or altering the polymeric structure. These changes in the chemical composition of the polymer (plastic) may be detected by chemical means. A simple method employs chemical etching of the plastic. The tracks being susceptible to chemical attack will be etched. Another method involves photographic means, however, if the target materials themselves are radioactive, it is quite difficult to distinguish between sources of the tracks.

ACTIVITY:

1. Prepare test films.
2. Place the test films in strategic locations (e.g. on roof of school pointed upward to catch cosmic radiation; pointed downward to detect Earth albedo neutrons; etc.).
3. Etch the films and determine direction of radiation.

SUGGESTION:

A photographic means may be employed as follows: Make a "sandwich" of photographic film and clear plastic as shown below. Note that each film is placed at a proportionately further distance. After exposure and development one may restack the film and clear sheets. Determine (in three dimensions) the source and direction of radiation.



VOLCANIC STUDY

LEVEL: Secondary | AREA: Earth Science Physics | SKYLAB CORRELATION: ED-12

CONCEPT:

Volcanos should display an increase in thermal infrared (far IR) prior to the visible and near infrared radiation increase. Consequently, the near infrared should be apparent before the red end of the visible spectrum.

MATERIALS:

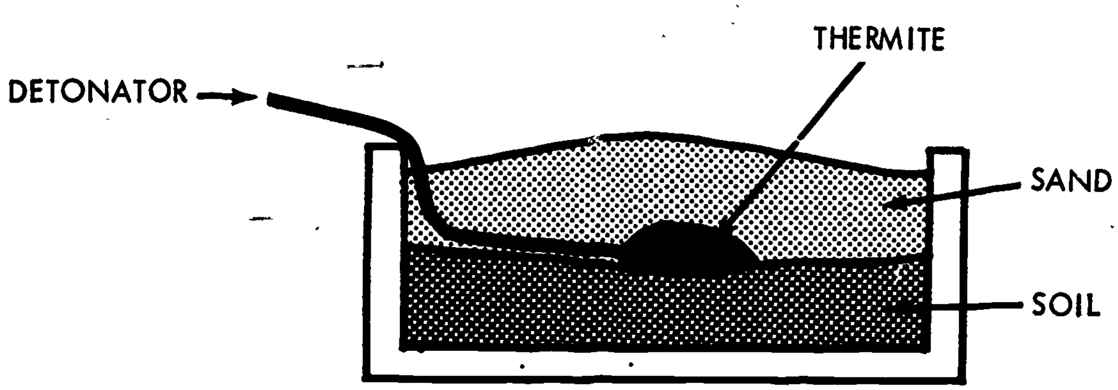
1. Camera. Preferably a 35mm camera with rapid film advance such as Robot, Canon Dial, etc. A 16mm motion picture camera would be excellent. (High speed infrared film is available in 16mm, but *not* 8 or Super-8.)

2. High Speed Infrared Film
3. Filter to block visible (Kodak Wratten 87, 87C, 88A, 29+47B)
4. Thermite mixture (Fe_2O_3+Al)
5. Electric starting method for igniting thermite.
6. Dry sand and earth
7. Box

BACKGROUND: Infrared photographic film is sensitive from about 700 nm out to about 900 nm. There are special spectragraphic film emulsions available which extend the range to about 1200 nm; however, these are not generally available from your local camera store. This range of the infrared is not to be confused with the thermal infrared which generally lies between 12000 and 25000 nm. However, the purpose of this activity is to determine if the photographic infrared preceeds the visible appearance of volcanic activity. (ED-12 will be using photographic infrared as well.)

ACTIVITY:

1. Set up the test volcano as shown below.
2. Thermite can be dangerous, consequently safe procedures must be exercised. The thermite should be set off by an electric triggering device from a distance. The camera, mounted on a tripod at a safe distance above the volcano, should be operated by a cable release. Individuals in the vicinity (camera operator, volcano igniter) should wear appropriate safety goggles, etc. It would be wise to practice at least once in order to determine the characteristics of the thermite volcano.
3. Each time the volcano is arranged be certain to use precisely the same quantity of thermite mixture as well as the same quantity of Earth above.
4. For each test take a series of photographs (depending upon the cycling time of the film advance): a) prior to ignition; b) the instant of ignition; c) as rapidly as possible during ignition and finally after the volcano breaks the surface and is visible.
5. This test series may be made with no filter (which will admit blue, some red and the near infrared) and with the 89 series filter (or its equivalent which will block all visible light).
6. It may be necessary to run test exposures because light meters are not sensitive in the infrared. Also infrared focuses *behind* the visible image (i.e. film plane); therefore, it is necessary to stop the lens down at least two stops and use a slower shutter speed in order to insure a sharp image.
7. High speed infrared film may be processed in D-76 or any black and white film developer. It will be necessary that all films be processed in the same manner in order that the density and contrast be the same for each roll of film.



SUGGESTIONS:

1. Obtain some spectragraphic film and repeat the experiment out to 1200 nm. Is there any photographic difference?
2. What effect does atmospheric interferance have upon this measurement? Try placing a chamber in between the thermite bomb and camera. Fill the chamber with various

components of our atmosphere (e.g. water vapor, sulfur dioxide, nitrogen dioxide, etc.).

3. How many molecules lie between the surface of the Earth and Skylab at 235 nautical miles altitude?

BIBLIOGRAPHY:

1. Kodak publications on infrared photography, filters, films, may be quite helpful.

THE SEARCH FOR A PLANET BETWEEN THE SUN AND MERCURY

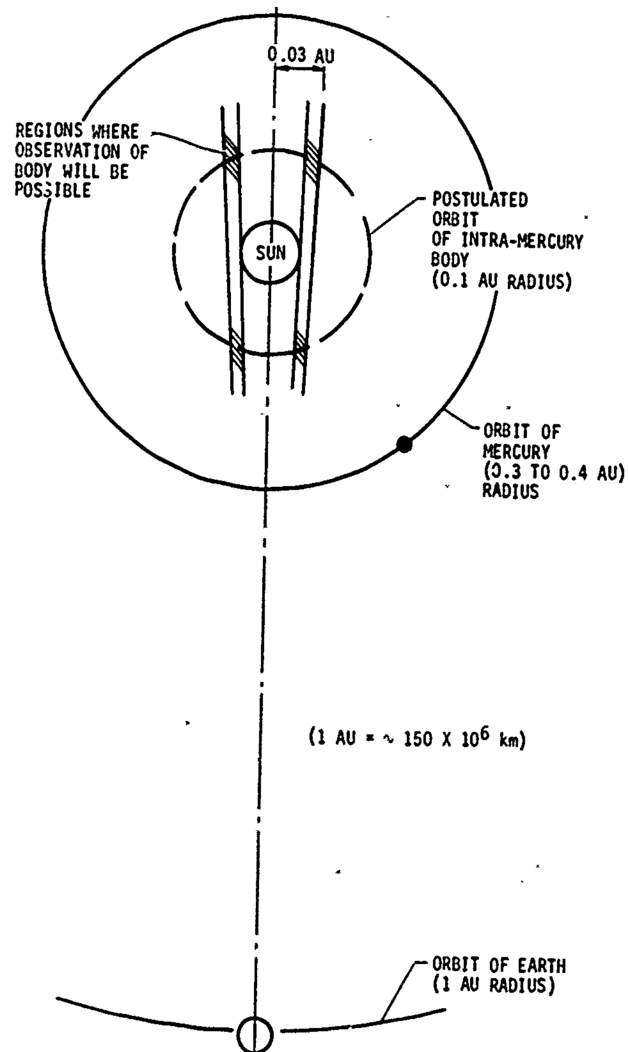
LEVEL: Secondary AREA: Astronomy, Physics SKYLAB CORRELATION: ED-22

CONCEPT: It has been postulated that a planet (usually called "Vulcan") exists between Mercury and the Sun. If this is the case, the problem exists of being able to detect it visually against the relatively bright solar corona.

MATERIALS:

1. Information on the hypothesized planet "Vulcan" (Suggested size, temperature, albedo, period, etc.)
2. Figure below.
3. Necessary materials to construct a model

BACKGROUND: For simplicity we may consider the following information. Skylab's White Light Coronagraph will be able to "see" about 3 x 10^6 miles on either side of the sun (0.03



A.U.). "Vulcan" has been predicted to be approximately 0.1 A.U. from the sun. Mercury is between 0.3 and 0.4 A.U. from the sun and has a period of about 88 days. The radius of the sun is about 10^4 km and "Vulcan" approximately 150-200 km. We may consider that the solar side of "Vulcan" would be heated to a dull cherry red. The problem then becomes that of determining when "Vulcan" will be within our line of sight, and whether it will be visible against the celestial background. The appearance of the solar corona will, of course, make seeing difficult.

ACTIVITY:

1. Consider the information in relation to Figure. Determine when Vulcan will be at points 1, 2, 3, 4. (Which are within the visibility of the White Light Coronagraph yet as far from the sun as possible.)

   Determine the visual difference of "Vulcan" between points 1 and 2. Compare the visual differences of "Vulcan" between points 1 and 2 with 3 and 4. Determine those times when Mercury will be nearby, although not obscuring "Vulcan".
2. Considering these factors of size, distance, relative brightness, and location, construct a scale model of the Mercury-"Vulcan"-Sun system.

SUGGESTIONS: Postulate another method for determining the existence of "Vulcan."

BIBLIOGRAPHY:

Spaceflight Magazine, May 1972, pg. 199. (British Interplanetary Society Publication)
Larousse Encyclopedia of Astronomy, pgs. 60-61
Conquest of Space by Willy Ley, pgs. 150-152.

MEASUREMENT OF MOTOR SENSORY PERFORMANCE

LEVEL: Secondary — AREA: Biology, Psychology — SKYLAB CORRELATION: ED-41

CONCEPT: To determine if any changes occur in the motor sensory performance as performed by a standard maze, when the subject is subjected to changes in environment such as zero gravity, different atmospheres, etc.

MATERIALS:

1. Standard Maze (See Directions below)
2. Stylus (A regular A. B. Dick mimeograph stylus is the correct size.)
3. Tape recorder

BACKGROUND: This activity employs a standard maze which records a tone each time the stylus is placed through a hole correctly and a different tone when the stylus touches the side of the hole. Because each movement does not require the same speed (i.e. different angles and directions require varying time), a computer program may be used for analyzing the results; however, semi-quantitative results may be gained by considering overall speed and number of errors.

ACTIVITY:

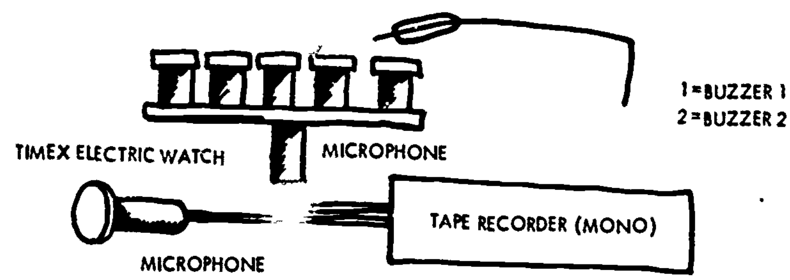
1. Prepare the maze
2. Have subjects run the maze under optimum conditions (recording the tones on tape for a record). Several of these runs are needed for the baseline information.
3. Place the subject under stress and compare the changes.
4. If possible try other conditions (within the limits of safety!).

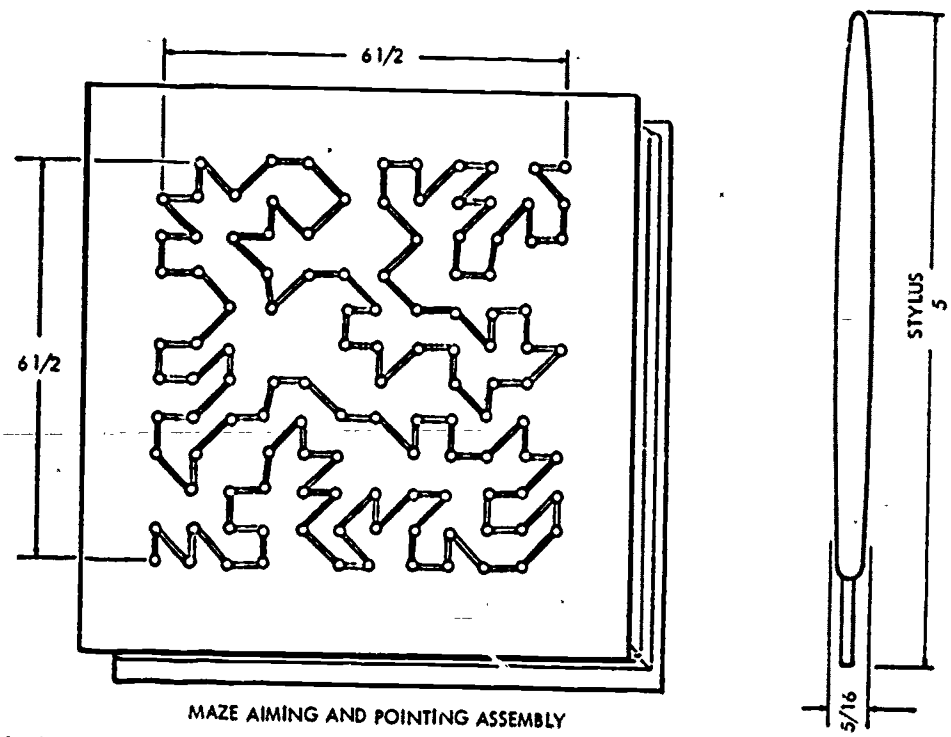
SUGGESTIONS:

1. If sufficient data is taken for the Skylab crewmen, it may be possible to obtain information about one crewman (anonymous) prior to departure, early in his mission, during the middle of his mission, and near the termination of the mission.

DIRECTIONS FOR CONSTRUCTING STANDARD MAZE

Construct the maze out of metal such as aluminum or steel. Drill 1/8" holes at the particular locations. Using paint or ink, mark the lines on the maze as indicated. (These indicate the direction of travel.) Place the maze on another piece of metal with an insulating layer (such as styrofoam) between. The insulating layer should be about 1/4" thick.





MAZE AIMING AND POINTING ASSEMBLY

Attach the lead wires from the maze to its speaker (buzzer) to the battery. Attach the lead wires from the bottom plate to its speaker (buzzer) to the battery. Attach the wire from the terminal of the battery to the stylus.

MASS MEASUREMENT IN ZERO GRAVITY

LEVEL: Secondary AREA: Physics, Chemistry SKYLAB CORRELATION: ED-74

CONCEPT: Measurement of mass in a zero gravity environment is a problem whose solution requires other means than equalized forces upon a fulcrum or the customary double pan balance. Measurement of the inertia of a system is one method. The use of an oscillating beam is being used aboard Skylab (M172, M074 and ED74).

MATERIALS:
1. Spring steel, hacksaw blade, etc.
2. Clamps
   (OR Inertial Balances from P.S.S.C. Physics; Science: A Process Approach (A.A.A.S.)
3. Solid Masses

BACKGROUND: The balance is set up and calibrated for a given mass. Determine the sources of error such as any oscillation of the mass, torsional forces, torqueing forces, etc. The oscillation distance should be kept equal throughout this experiment. Once the balance characteristics are known and standardized. The balance may be calibrated for a known series of masses. After this the balance may be changed in its direction.

When the beam is parallel to the ground, gravity is not a factor. Try the beam in a vertical position (mass up or mass down?).

ACTIVITY:

1. Set up the balance with the beam in the horizontal position.
2. Determine the period for a series of known masses by counting a number of oscillations (try timing 50 then 100, then 200 etc., to demonstrate the benefits of larger samples).
3. Plot the results. (For accuracy it should be necessary to make several determinations of each mass).
4. Change the position of the beam. Try it with the beam downward, etc.
5. Again plot the results for the same series of masses.
6. Is there any difference? Does this balance work on the same principle as a pendulum? Do you believe that this type of device can be effectively used to measure mass in a zero or low gravity environment?

SUGGESTIONS:

1. A problem exists in measuring the mass of liquids. They tend to oscillate thus damping the oscillations of the balance. Is this a function of viscosity, liquid-to-volume ratio in its container, quantity of liquid, or what? (HINT: A liquid may be frozen, its mass measured, melted and again measured under varying conditions.)

CYTOPLASMIC STREAMING IN PLANTS

LEVEL: Secondary AREA: Botany SKYLAB CORRELATION: ED-63

CONCEPT:

A living plant such as elodea will exhibit the property of the cytoplasmic flowing or moving about within the cell in a circular fashion. This property is called cyclosis or cytoplasmic streaming. Factors such as temperature effect changes in the rate of streaming.

MATERIALS:

1. Elodea (or any plant exhibiting cyclosis may be substituted) (e.g. nitella, chara, pollen grain, avena (oats) tradescantia stamen hairs)
2. Microscope
3. Microscope Slide
4. Simulated Skylab atmosphere (See Directions on page 20)
5. Environmental controls

BACKGROUND:

This activity deals with the observation and determination of the extent of cytoplasmic streaming under Earth conditions of gravity, atmosphere, lighting and temperature. These may be compared to conditions of the lighting level, temperature and the atmosphere of Skylab. These results may be compared to the results from the experiment being conducted aboard Skylab.

ACTIVITY:

1. Become familiar with the property of cytoplasmic streaming by examining an elodea leaf under the microscope. (100 power to 400 power).
2. Ascertain the factors which effect a change in rate of streaming. Make measurements at temperatures several degrees above and below ambient.
3. After making these comparisons, one may wish to run a corollary experiment duplicating, the Skylab temperature, lighting level, and atmosphere. The ambient Skylab temperature will range from 13°C to 32°C and average about 20-25° and lighting level from 6 to 9 foot candles. These may be accomplished easily in any laboratory. The Skylab atmosphere is a different situation, the pressure is 258.6 torr (5 psia) with a composition of 74% oxygen and 26% nitrogen. This atmosphere may readily be prepared. (See Directions on page 20). The low pressure may be accomplished by using a vacuum desiccator or a bell jar and vacuum pump. It is only necessary to reduce the pressure to approximately one-third atmosphere. Although caution should be exercised to guard against implosion, this does not require high vacuum technique. One may place the elodea in the Skylab temperature, lighting, atmosphere environment for a period of time, open the system, and quickly examine

a leaf. This is inconvenient, however, and means to examine the plant under Skylab atmospheric conditions should be devised utilizing your equipment.

4. The following effects need to be tested: plant susceptibility to darkness, plant light requirements, plant life support requirements. Examinations should be made at time intervals (weekly or bimonthly) for plants subjected to Skylab conditions as well as Earth conditions.

SUGGESTIONS:

1. Compare other plants, do they respond to the same degree?
2. Although observations may be made visually, motion picture sequences may be made. Sequences may be made at normal speed of 18 or 24 fps; however, 12 fps is sufficient.

BIBLIOGRAPHY:

Most standard botany and general biology laboratory manuals contain experiments on cytoplasmic streaming.

BEHAVIOR OF BACTERIA AND BACTERIAL SPORES

LEVEL: Secondary | AREA: Microbiology | SKYLAB CORRELATION: ED-31

CONCEPT:

To compare the physical characteristics such as cell and colony morphology and colony growth patterns of bacterial colonies in an Earth environment of gravity and atmosphere to a simulated Skylab conditions of atmosphere. These results may also be compared to bacterial colonies grown aboard Skylab.

MATERIALS:

1. Bacteria (suggested species: bacillius subtilus, Eschericia coli, Micrococcus radiolarans, Spirillum serpens, clostridium sporogenes, staphylococcus epidermidus; spreptococcus lactis) (If bacterial spores may be obtained in a polyvinyl alcohol disc this will eliminate the need of inoculating technique. This is the method which will be employed on Skylab.)
2. Nutrient agar
3. Petri dishes
4. Simulated Skylab atmosphere (see directions on page 20)
5. Vacuum desiccator
6. Water aspirator or vacuum pump
7. Incubator (to hold desiccator)
8. Camera

BACKGROUND:

What effect does gravity have upon the growth of bacteria colonies? This experiment may be run in conjunction with ED31 aboard Skylab. We may compare Earth conditions to Skylab conditions; however, we may also duplicate the Skylab atmosphere in which the cultures will be growing. This atmosphere consists of 74% oxygen and 26% nitrogen at a pressure of 258.6 torr (5 psia). The culture plates may be placed in a vacuum desiccator and the pressure reduced sufficiently. (See directions) For convenience in handling, the bacterial spores are imbedded in polyvinyl alcohol. This disc may simply be placed in the petri dish to facilitate inoculation. (The polyvinyl alcohol will dissolve.) These are commercially available. However, for this activity, standard sterile inoculation techniques may be employed.

ACTIVITY:

1. Prepare the simulated Skylab atmosphere.
2. Inoculate the culture plates with the chosen bacterial spores.
3. Incubate two plates at 35°C in an Earth environment (control).
4. Inoculate two plates and immediately place them in a vacuum desiccator containing the Skylab atmosphere. Reduce the pressure to 258.6 torr, close the desiccator and place it in an incubator at 35°C. (If a sufficiently large incubator is unavailable, place the desiccator *and* the control plates in an insulated box which is warmed to 35°C.)
5. At intervals of growth, photograph the colonies.
6. Record the following information: a) percent germination; b) cell morphology; c) colony morphology.
7. Compare these results to those of ED-31 aboard Skylab.

SUGGESTIONS:

1. Are the results the same with different bacteria?
2. Are the results the same with different growth media?
3. How do other atmospheres affect the growth?

BIBLIOGRAPHY:

Any standard bacteriology or microbiology manual will provide sufficient background information for techniques.

LIBRATION CLOUDS, LAGRANGIAN POINTS, TROJAN POINTS

LEVEL: Secondary AREA: Mathematics, Astronomy SKYLAB CORRELATION: ED-21

CONCEPT:

A two body system rotates about its barycenter; however, there are five points about this system in which a third body of negligible mass is relatively stable. These points, called Lagrangian points, equilibrium points, or Trojan points, were postulated by Lagrange. Dust clouds appear at these points in the Earth-Moon system. This is thought to be responsible for the existence of the Gegenschein in the Earth-Sun system.

MATERIALS:

1. Telescope
2. Ephemeris

BACKGROUND:

If one considers the Earth-Moon system and neglects the effects of the Sun and other bodies, there are five locations at which all forces acting on a third body (of negligible mass) will be at equilibrium. These are called libration, equilibrium. Lagrangian, or Trojan points. (see figure on page 37)

Of these five points, the three collinear points, L1, L2, L3 are unstable consequently if a body were placed at any one of these points, it would tend to move out of the equilibrium position. However, L4 and L5 are stable. Note that both points are equidistant from the Earth and Moon thus forming equilateral triangles.

ACTIVITY:

1. Consult an ephemeris and determine the precise time and location for sighting either the L4 or L5 point. If the night is sufficiently dark and clear you can find these libration clouds with a telescope. There are many factors such as the contrast between the clouds and celestrial background, the Earth's atmosphere, and the characteristics of the telescope. It is very difficult to see these clouds.
2. If the libration cloud is visible, is it possible to photograph it?

SUGGESTIONS:

1. Consider the advantages of a libration point located spacecraft. For example, communications satellites located at L4 and L5 of the Sun-Earth system (i.e. they would have orbital periods equal to the Earth). How much of the far side of the Moon would each be able to "see"? Could this be used for communication with lunar exploration on the "far side" Moon?
2. There exist small groups of asteroids at the Lagrangian points L4 and L5 of the Sun-Jupiter system. These are called Trojan points. However, the Trojans wander some 20° from the points (as measured from the Sun). From the ephemeris, calculate when the points should be visible here on the Earth. Can you detect them with your telescope?
3. The Gegenschein, a faintly visible light observed just after sunset in the ecliptic plane in a direction opposite that of the Sun, may be due to the solar illumination of an accumulation of particles at point L3 of the Sun-Earth system. How far away, what angle with respect to the zenith, how long after sunset is the Gegenschein visible?

BIBLIOGRAPHY:

Glasstone, Samual, "Sourcebook on the Space Sciences," Princeton, New Jersey, D. Van Nostrand D., Inc., 1965, 937pp.

Roy, Archie E. "The Foundations of Astrodynamics," New York, N.Y., The Macmillan Co., 1965, 385 pp.

LOCATION OF PULSARS AND THEIR ULTRAVIOLET ENERGY

LEVEL: Secondary AREA: Astronomy, Physics SKYLAB CORRELATION: ED-26

CONCEPT:

For the pulsar discovered in the Crab nebulla, it has been determined that the plot of intensity vs wavelength indicates that the intensity increases at the blue end of the

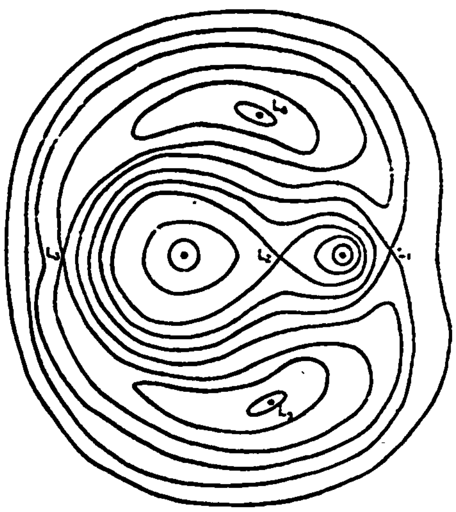


FIGURE 1
CONTOURS SHOWING COMBINED GRAVITATIONAL-ORBITAL FORCE FIELD ON A SMALL MASS NEAR TWO CELESTIAL BODIES, ONE OF WHICH IS VERY LARGE; "RESTRICTED 3-BODY PROBLEM" RESULT.

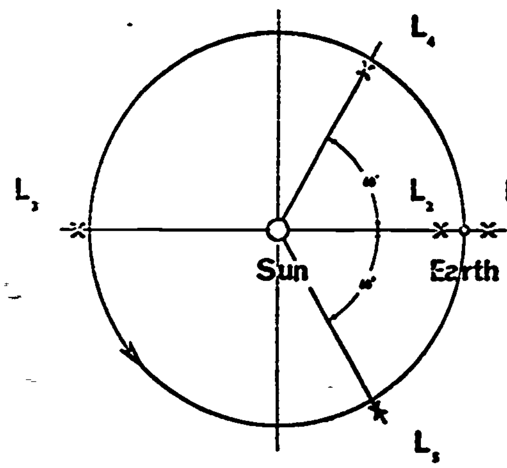


FIGURE 2
SUN-EARTH CELESTIAL REPRESENTATION WITH FIVE LAGRANGIAN POINTS INDICATED. THE L_4 AND L_5 POINTS MARK LIBRATION REGIONS WHERE INTER-PLANETARY DUST MAY ACCUMULATE.

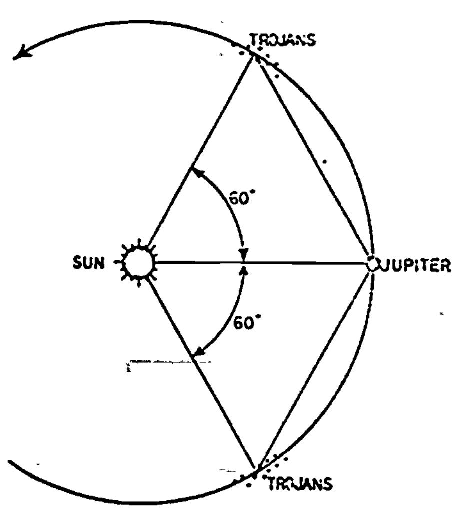


FIGURE 3
SUN-JUPITER SYSTEM'S REPRESENTATION WITH TROJAN ASTEROIDS NEAR LAGRANGIAN POINTS L_4 AND L_5 ORBITING BOTH SUN AND JUPITER.

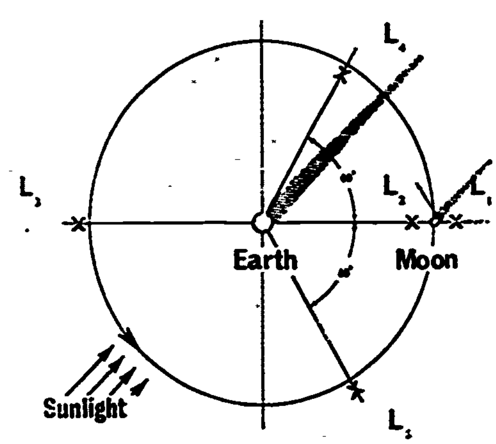


FIGURE 4
EARTH-MOON GEOMETRY ON APOLLO 15 SHOWING HOW L_4 REGION CAN BE PHOTOGRAPHED WHILE LUNAR ORBITING CSM IS IN DOUBLE UMBRA.

visible spectrum giving rise to an indication that the ultraviolet radiation may be much more intense. However, presently we do not know whether this is unique for the pulsar on the Crab nebula or typical for all pulsars.

MATERIALS:

1. Information on location of known pulsars
2. Telescope
3. Camera mounting attachment
4. Camera
5. High speed black and white film (Tri-X)
6. Kodak Wratten 18A Filter

BACKGROUND:

Ordinary photographic film is sensitive to the near ultraviolet (also referred to as the "long wave" ultraviolet) 320 nm to 400 nm which is just outside the range of human vision. This ultraviolet radiation *will* penetrate glass. The ultraviolet from about 200 nm to 320 requires quartz lenses, and the shorter wavelengths (usually called "vacuum ultraviolet") require more sophisticated techniques.

In photographing the near ultraviolet, we must consider the problem of focus because the ultraviolet image is in focus in *front* of the film plane when the visible image is in focus. Therefore, one must either guess at the focus or stop the lens down by about two stops to increase the depth of field.

ACTIVITY:

1. Determine the location of known pulsars. Determine the times and location for viewing from your location.
2. Select a pulsar and compute its viewing location and time for several nights to insure having a clear night for observation as haze and moisture will absorb blue and near ultraviolet.
3. Set up the telescope, camera and filter. The exposure must be determined by guess. It may be necessary to make a series at different exposure times.
4. After processing, examine the negatives. Do you determine any evidence of ultraviolet radiation?

SUGGESTIONS:

1. In order to prepare a plot of wavelength vs intensity, take a series of exposures (after determining the optimum exposure) using different filters and identical exposure times.

Filter	*Wavelength Transmitted*
18A	300 nm to 400 nm (long wave ultraviolet)
47 B	400 nm to 500 nm (blue)
61	490 nm to 600 nm (green)
29	600 nm to 700 nm (red)

IN-VITRO IMMUNOLOGY: ANTIGENICITY

LEVEL: Secondary AREA: Biology, Immunology SKYLAB CORRELATION: ED32

CONCEPT:

The reaction of an antigen to antibody is a function of concentration. Is this effect gravity influenced?

MATERIALS:

1. Ouchterlony slide (or substitute)
2. Blood serum (antigen)
3. Anti Gamma G (antibody)
4. Agar media
5. 5% acetic acid
6. 0.05M Phosphate pH 7.0 buffer solution

7. Syringe
8. Microscope

BACKGROUND: The ouchterlony is filled with a gel medium containing the antibody. Holes are drilled at specific intervals to facilitate adding the antigen at precise locations (see diagram). Serially diluted antigen is added at each hole. The reaction between the antigen and the antibody is concentration dependent.

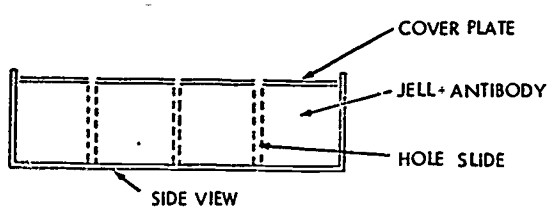
ACTIVITY:

1. Prepare the ouchterlony slide.
2. Prepare the media gel with anti gamma G. (This is temperature dependent and before use must be kept between 2 to 8°C.)
3. Serially dilute the blood serum.
4. Place equal volumes of the diluted blood serum in the holes in the ouchterlony slide.
5. Place the cover slide on top and incubate for 24 hours at room termprature (20° to 25°C).
6. Fix the slide by flooding with 5ml 5% acetic acid allowing to stand for several hours, adding 0.05M phosphate buffer, then remove fluids.
7. Place slide under the microscope. Photograph the results.
8. Compare Earth results with those obtained on Skylab.

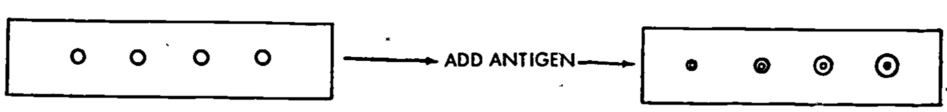
SUGGESTIONS: What effect would the presence of a Skylab atmosphere (75% oxygen at 258.6 torr) have upon antigenicity?

IN-VITRO IMMUNOLOGY : OUCHTERLONY SLIDE

RADIAL IMMUNO DIFFUSION PLATE



SIDE VIEW



TOP VIEW

IN VITRO IMMUNOLOGY: STUDY OF CHEMOTAXIS

LEVEL: Secondary AREA: Biology, Immunology SKYLAB CORRELATION: ED32

CONCEPT: To determine the effect and extent of cell movement toward or away from a chemical substance (chemotaxis) for Earth atmosphere and simulated Skylab atmosphere subjected to Earth gravity compared to Skylab conditions of atmosphere and zero gravity.

MATERIALS:

1. Chamber (Modified Sykes/Moore Chamber) (see diagram)
2. Guinea pig macrophages (1 ml per trial)
3. Casein (1 mg.ml) (1 ml per trial)
4. Methanol, absolute
5. Distilled water
6. Syringe
7. Millipore filter
8. Camera
9. Simulated Skylab atmosphere
10. Bell jar and vacuum pump -or- vacuum desiccator and water aspirator

BACKGROUND:

Guinea pig macrophages are introduced into the chamber simultaneously with a casein stimulent solution. The millipore filter separating the two chambers will entrap materials passing through from one chamber to the other. After sufficient time has elapsed, the filter is removed and analysed to determine the extent of chemotaxis.

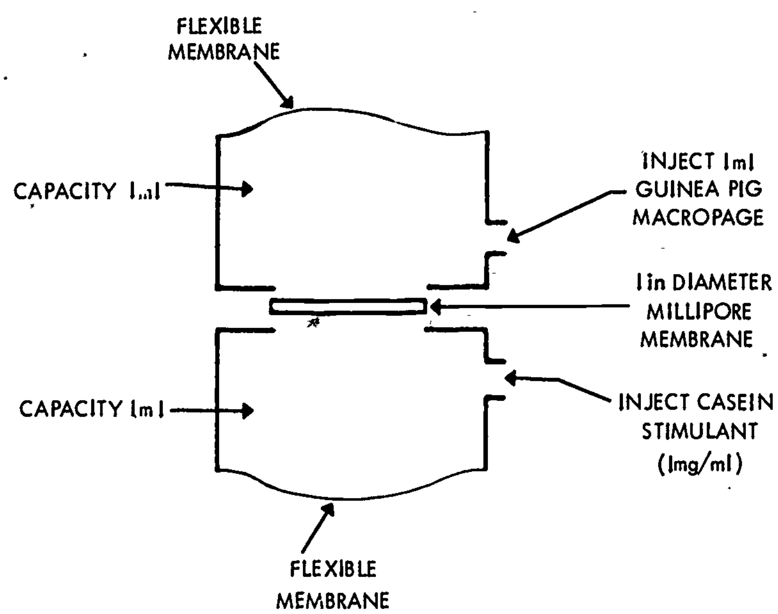
ACTIVITY:

1. Set up test chamber.
2. Simultaneously inject guinea pig macrophages and casein solution into chamber compartments.
3. Allow the chamber to stand at room temperature (20° to 25°) for 48 hours.
4. Flush each cell with 5 ml absolute alcohol followed by a rinse of 5 ml distilled water. Retain the micropore filter with entrapped solids. Discard the fluids.
5. Analyse the filter to determine the extent of chemotaxis.
6. Repeat the experiment using a simulated Skylab atmosphere. This may be accomplished by rapidly filling the chamber, placing it in a vacuum desiccator of Skylab atmosphere and reducing the pressure to 258.6 torr and closing the valve. Let stand for 24 hours at room temperature. Slowly open the valve and allow pressure to increase to ambient. Quickly remove the chamber, fix, flush, and remove filter (as in procedure 4) and analyse.
7. Compare the results from Skylab to those obtained with Earth gravity and atmosphere as well as those with Earth gravity and Skylab atmosphere.

SUGGESTIONS:

What affect does time have upon this phenonema? What about temperature?

MODIFIED SYKES MOORE CELL



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