BIOSATELLITE PROJECT

PIERRE M. HAHN

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Ames Research Center
Moffett Field, California, U. S. A.

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Of fundamental importance to our knowledge of basic biological processes, are the effects of the earth's gravitational field and periodicity on these processes. The incomplete and thus inconclusive qualitative scientific evidence which has been obtained from earth-bound investigations and limited flight tests must be augmented by experiments conducted in a state of weightlessness and removed from earth influences to define quantitatively the nature of these effects. This can be accomplished most feasibly by automated earth-orbiting biological laboratories.

Additionally, one of the major unknown factors in the development of long-range manned orbital and extended space environmental flights is that of the effects of weightlessness on man's psychophysiological systems. Since man himself cannot be fully instrumented to determine these effects and potential problems, a program of biological experimentation has been established to diminish this void in our knowledge of environmental effects, reduction of efficiency and other consequences. Through the use of primates and other organisms, information applicable to the effects of weightlessness and other environmental stresses can be obtained. Sensors can be implanted in the specimens to indicate the state of the central nervous system, cardiovascular system, respiration, body temperature and the nature and degree of hormone response.

Several efforts have been attempted during the preceding years to conduct a series of biological experimentation in the space environment. These programs, which included the BIOS and Discoverer flights, did not provide the quantity or quality of data to be generated by the BIOSATELLITE Project. Results from Projects Mercury and Gemini have provided some information on the effects of weightlessness on chimpanzees and man for limited periods of exposure; however, we cannot extrapolate with certainty results obtained from flights of several days to flights of several weeks. A program of prolonged exposures of biological systems for long periods is required in order to understand the stresses on man and to define the requirements for support of man during future space missions. A program of experiments with biological material exposed to such environments for periods of 3 to 30 days will be a meaningful step toward future progress in manned space flight.

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The primary scientific objectives of the BIOSATELLITE Project are:

a. To determine certain quantitative effects of weightlessness upon primates, small animals, plants and varied microbiological material - to add to basic biological knowledge and to contribute this knowledge for its application to long-duration manned, missions in space.

b. To determine the biological effects of the combination of weightlessness and a known source of gamma radiation to determine if there are any synergistic or antagonistic effects or if there are no effects. In this series of experiments, no studies are planned to determine the effects of ambient cosmic radiation.

c. To determine the effects on the biological rhythms of living organisms when removed from the Earth's rotational influences.

A series of six earth orbiting flights are currently approved for the BIOSATELLITE Project. For each flight a spacecraft with a recoverable experiment capsule will be placed into a nominally circular orbit by a two-stage Thrust Augmented Improved Delta Launch Vehicle. Orbital flight time will vary from 3 to 30 days, depending on the experiment aboard. Two duplicate 3-day flights will be made for the following purposes: (1) to determine the synergistic or antagonistic effects of combined weightlessness and radiation on animals, plants, and cells, and (2) to determine the effects of weightlessness on general biology experiments. The first of these flights was successfully launched on December 14, 1966 and the spacecraft orbited for 3 days. However, recovery of the experiment capsule was not achieved because of failure of the reentry vehicle retro-rocket to fire. Two flights 21 days each will be made to investigate the effect of the space environment on biological rhythms and the effect of weightlessness on cellular processes in plants and animals. Two flights of 30 days duration will be made to determine the effects of prolonged weightlessness on a primate's central nervous systems, cardiovascular systems, and behavior. All of these experiments require recovery for complete scientific success. The 3-day flights have no scientific value without recovery of the experiment capsule whereas the 30 and 21 day flights have significant scientific value without recovery.

The prime contractor for the design, development, fabrication, and test of the BIOSATELLITE spacecraft and integration of experiment hardware is the General Electric Company. The spacecraft consists of a reentry vehicle in combination with an adapter section which contains all the subsystems not required for reentry and recovery of the experiment payload. This spacecraft will be launch into orbit by a 2-Stage Thrust-Augmented Improved Delta launch vehicle.

LAUNCH VEHICLE

All BIOSATELLITE flights will utilize a two-stage, thrust-augmented improved Delta launch vehicle. The DSV-3G version will be used for the 3-day flight (flight B) and the higher-performance long-tank DSV-3N version will be used for the 30- and 21-day missions.

The first stage consists of a THOR vehicle augmented with strap-on Thiokol TX 33-52 solid boosters, and the second stage is the "improved" Delta. The spacecraft is enclosed in a NIMBUS fairing which is modified for final access to the spacecraft, for coolant umbilical pull-away, and for quick installation after experiment package insertion.

A special BIOSATELLITE attach fitting will interface the spacecraft with the launch vehicle. Separation will be accomplished by springs retained with explosive nuts built into the attach fitting. The 21-day configuration will incorporate sensors and a telemetry system for recording vibrations and acoustic noise from lift-off through injection into orbit. The attach fitting for the 30- and 21-day missions will have modified panels to reduce resonant vibrations.

SPACECRAFT AND SUBSYSTEMS

CONFIGURATION

The spacecraft configuration consists of two major sections: the reentry vehicle and the adapter section. The reentry vehicle is that portion of the spacecraft which contains the recoverable experiment capsule, deorbit, and recovery subsystems. The adapter section contains all of the equipment not required for deorbit, reentry, or recovery of the experiment capsule. The major components of the spacecraft are the forebody, recovery capsule, thermal cover, thrust cone, and the adapter section as illustrated in Figure one. The reentry vehicle will carry any one of the three recovery capsules which will be fitted for the 3-, 30-, or 21-day group of experiments.

ATTITUDE CONTROL SUBSYSTEM

After separation of the spacecraft from the launch vehicle, the angular rates are sensed by rate gyros and controlled with a nitrogen cold-gas reaction-jet system. During the orbiting phase the angular rates are maintained sufficiently low so that the accelerations to which the experiments are subjected are below 10^{-5}g for 95% of the time and below 10^{-4}g for the remaining time. For deorbit, two infra-red horizon scanners are used to sense the pitch and roll attitude and a magnetometer to sense the yaw attitude. The spacecraft is oriented to the proper deorbit attitude by means of the reaction-jet system.

POWER SOURCE

The prime power source for the spacecraft used on the 3-day mission consists of conventional batteries. A Gemini-type fuel cell will be used as the prime power source for the 30- and 21-day missions. A back-up battery will be provided to permit recovery of the capsule in the event of total fuel cell failure.

ENVIRONMENTAL CONTROL SUBSYSTEM

For the 3-day mission, electric heaters are used for thermal control. For the 30- and 21-day missions, an active thermal control system will be used to maintain the close temperature tolerances required on the proposed flight payloads. A closed coolant system utilizing a "space radiator" will be used for the primary temperature control system with a water boiler used to absorb peak loads. Water for the boiler will be provided by the fuel cell.

The cooling system consits of two liquid cooling loops, one in the adapter section and the other in the capsule. The capsule cooling loop controls the temperature in the capsule by means of a heat exchanger through which air is circulated. The capsule cooling loop dissipates heat into the adapter cooling loop through a heat exchanger. The adapter cooling loop also provides cooling for the fuel cell and other equipment and dissipates its heat load into space by means of the radiator together with the boiler for peak cooling loads.

LIFE SUPPORT SUBSYSTEM

The life support subsystem for the 3-day flight consists of air bottles to maintain a normal sea-level atmosphere, an air circulating fan, and a silica-gel bed for humidity control. For the 21- and 30-day flights, a two-gas nitrogen and oxygen system provides a normal sea-level atmosphere. The capsule air is filtered and humidified. Special equipment is provided to control odors, CO_2, CO and H_2S. For the 30-day flight, equipment is provided to dispense and measure food and water for the primate. Containers are provided for the collection and storage of feces in conjunction with bacteria control equipment. Urine is collected, production rates are measured and constituents are analyzed. For the 21-day flight, food and water are dispensed as a mixture. Urine and feces are controlled by absorption and evaporation.

REENTRY VEHICLE AND RECOVERY CAPSULE

The reentry vehicle is a 40-inch-base-diameter blunt cone consisting primarily of the forebody, recovery capsule, thermal cover, and thrust cone. The thrust cone supports the retro-rocket and related deorbit equipment. Most of the recovery equipment is mounted on the exterior of the recovery capsule with the parachute assembly enclosed by the thermal cover. Some recovery electronic components are contained within the recovery capsule. The forebody is a heat shield assembly which surrounds the recovery capsule and consists of a phenolic-plastic and glass-fiber substrate covered with phenolic and nylon ablative material.

The recovery capsule contains the experiment payload and all of the thermal-control, life-support, and electric-power equipment necessary to sustain the experiments during the period of deorbit, reentry and recovery.

SEPARATION AND DEORBIT SUBSYSTEM

The separation subsystem consists of a separation switching assembly and components for mechanical and electrical interconnection of the adapter and the reentry vehicle. Upon receipt of commands from the spacecraft programmer, the switching assembly will sequentially sever the mechanical and electrical interconnections between the adapter and the reentry vehicle and initiate physical separation of the two vehicles for deorbit. The separation subsystem equipment is mounted in the adapter.

The deorbit subsystem consists of the thrust cone on which are mounted a deorbit programmer and other components to accomplish the following events:

a. Reentry vehicle spin about its roll axis at a rate required to maintain the de-boost angle during retro-firing to an accuracy consistent with the desired vehicle dispersion.

b. Retro-fire which imparts sufficient velocity to the vehicle at the selected angle to the orbit velocity vector to change its orbital trajectory to a reentry trajectory.

c. Reentry vehicle despin to a rate which maintains stability yet allows aerodynamic forces to orient the vehicle to a heat shield forward attitude for reentry.

d. Subsystem separation from the reentry vehicle when its function has been completed to reduce reentry weight and permit operation of the recovery subsystem.

RECOVERY SUBSYSTEM

The recovery subsystem's function is to retard the vehicle velocity after reentry to a sufficiently low rate of descent to accomplish aerial retrieval or to minimize impact loads for retrieval after a water landing. Fine and coarse acquisition aids for location and retrieval are provided. A recovery beacon is activated prior to separation of the reentry vehicle from the adapter. After reentry at a preselected vehicle velocity, the thermal cover is explosively ejected which extracts and deploys the 7 ft. diameter decelerator parachute. The forebody is then released and drag from the decelerator parachute separates the recovery capsule from the forebody. After a preselected period of time the decelerator parachute is released from the capsule and at the same time extracts the main 36 foot diameter parachute in a reefed condition. After a preselected period the reefing line cutters allow the main parachute to deploy to its full diameter and the recovery capsule decelerates to the final equilibruim descent velocity which is compatible with the requirements for air retrieval or safe water impact. A dye marker disperses upon contact with sea water.

TELEMETRY, TRACKING, AND COMMAND

Commands for spacecraft operations emanate from the ground or from an on-board programmer timer in the reentry vehicle.

Ground commands cannot be received by the reentry vehicle once it separates from the adapter, and all entry and recovery commands are from two programmers.

Each programmer measures time intervals and contains logic circuits to originate the events in timed sequence.

The programmer timer provides regular time pulses used for the programmed experiment events and for the spacecraft clock.

A one word storage programmer commands separation at the precise time on orbit to reach the planned recovery point. It is started by ground command, timed to one-tenth of a second, which orders a predetermined time delay (40 minutes to 7.5 hours) before the beginning of separation commands.

A back-up fixed interval timer can also, if needed, start separation events by timed ground command.

Ground commands are received by one of two redundant sets of command receivers and decoders in the adapter. These route commands to the tracking beacon, telemetry transmitters, programmers, separation programmer, attitude control subsystem, and experiment subsystem.

The ground command system uses a tone digital technique with a capacity of 70 separate commands.

The spacecraft carries PCM/FM telemetry equipment for use during launch and orbital flight and FM/FM telemetry for use during reentry and recovery.

Additional data is stored by the seven-channel tape recorder in the recovery capsule. This recorder stores experiment and engineering data during launch, orbital flight, reentry, and recovery and for up to six hours after sea landing, if required.

The spacecraft reports its orbital position by tracking beacon, with a continuous signal at 136.05 mc. One of two redundant beacons is selected by command to radiate 100 milliwatts via an omnidirectional antenna. Tracking stations measure position of the spacecraft, and this data is used to calculate the spacecraft orbit.

EXPERIMENTS

BIOLOGY

The individual experiments selected for the BIOSATELLITE Project are listed in Table one by flight mission. The objectives and principles of operation of each major experiment grouping are described below.

3-DAY MISSION

GENERAL BIOLOGY

Experiments have been selected in the area of General biology to determine the effects of zero gravity and the space environment upon the metabolism and growth of various organisms, and upon the rhythmicity of biological systems.

The metabolic and growth experiments are designed to determine the effects of weightlessness upon biological specimens. Growth and development of frog eggs and amoeba cell division and food assimilation will be observed.

PLANT PHYSIOLOGY

A series of experiments in the area of Plant Sciences has been selected to study the effect of weightlessness on growth, development, and metabolism. The experiments will investigate in a weightless state the following biological phenomena: epinasty, plageotropism, tropism, polarity, sporogenesis, and embroygenesis. The information to be obtained from the epinastic and plageotropic curvature of leaves will not only provide morphological data but will further enlarge our knowledge of hormonal and biochemical response.

RADIATION BIOLOGY

Some experimental evidence indicates the possibility of a synergism between weightlessness and radiation. That is, when biological material is exposed simultaneously to radiation and gravity, the biological effect may be greater than the sum of the effects resulting from separate exposure to these environments.

Several biological experiments have been developed for incorporation in the 3-day BIOSATELLITE flight program during which the biological material is exposed to an on-board source of gamma radiation of known strength.

Included in these genetic studies are experiments concerned with mutational changes in neurospora, tradescantia, habrobracon, drosphila, tribolium, and bacteria. These experiments utilize biological materials whose genetic characteristics have been studied extensively and whose radiation effects are well known.

The radiation exposure required by the various experiments will be provided by means of a radiation source contained within the vehicle. This source will be 85 Strontium. By properly placing experiments relative to the source, radiation exposures varying from 300 to 6,000 roentgens are obtained.

A duplicate set of experiments will be carried in the spacecraft in a location shielded from the radiation source to serve as a control in assessing the effects of radiation under conditions of weightlessness. These effects will be compared with those measured by ground controls conducted concurrently with the flight.

Although there will be some small amount of ambient space radiation in a BIOSATELLITE flight which will result primarily from protons, the short exposure would not be large enough to have any biological consequence. The total dose from ambient radiation should not exceed the equivalent exposure of one roentgen per day at the altitudes planned for the BIOSATELLITE flights. Dosimeters to measure this ambient radiation will be placed in the shielded control area of the spacecraft recovery capsule.

30-DAY MISSION

The intent and purpose of the subhuman primate flights is to determine by direct and absolute means, central nervous, cardiovascular, and metabolic processes which cannot be accurately determined in the human primate.

3.3.1.2.1 NEUROPHYSIOLOGY AND BEHAVIOR

Modifications in the functional capability of the nervous system are anticipated during long confinement under weightless conditions. These modifications must be examined deep within the brain, at the level of the nerve fiber and synapses, and in the behavioral performance of the subject.

The mode of examination is as follows:

a. Alteration in electrical potentials produced by the deep brain probes in the temporal lobe, thalamus and reticular formation.

b. Behavioral performance - alteration in patterned (pre-learned) responses of moderate complexity.

c. Galvanic skin resistance - two leads, one on sole of foot, the other on medial surface of calf or thigh.

3.3.1.2.2 CARDIOVASCULAR PHYSIOLOGY

It is the consensus of the investigators in this field that the cardiovascular system will experience a hypodynamic effect at zero-gravity resulting in significant changes in the distribution of blood to vital organs. Abrupt reentry into a gravity field will result in severe physiological insult to the system.

A thorough and comprehensive study of the cardiovascular system will indicate the validity of this hypothesis. Negation of these hypotheses will considerably alter the present evidence gathered in cardiovascular physiological studies conducted on bedfast and water-immersed subjects. Changes in cardiophysiology will undoubtedly alter the general physiology of the specimen. Investigation of these phenomena will be examined by the following methods:

a. Blood pressure dynamics. In-dwelling catheters attached to pressure gauges will provide a measurement of arterial and venous pressures.

b. Respiration. Measurements will be obtained from electro-cardiogram leads.

c. Electro-cardiogram. The standard three-lead technique will be used.

CALCIUM TURNOVER

Prolonged inactivity results in marked mobilization, redisposition and excretion of calcium. This is the expected result of the restrained primate.

The severity and areas of mobilization and redisposition will be established by preflight and postflight radiographic measurements of carefully selected anatomical sites. Excretion of calcium will be established by chemical analysis of urine specimens collected in flight.

URINALYSIS

Analysis of the urine for concentration of calcium, creatine, and creatinine will be performed. These determinations will be made on aliquots of 6-hour urine samples during the entire 30-day flights. Flight data will be telemetered. Preflight, flight, and post-flight data will enable evaluation of the effects of weightlessness on the metabolic constituents analyzed.

21-DAY MISSION

GENERAL BIOLOGY

Experiments have been selected in the area of General Biology to investigate the effect of weightlessness on gross body composition in the rat and to to determine the effect of the space environment upon the rhythmicity of biological systems and upon the metabolism and growth of organisms. The circadian component of biorhythmicity as affected by orbital flight is being studied in the rat by measurements of temperature, activity, and feeding.

The cell dynamics of a living tissue culture of human liver cells will be photographed to study the effects of weightlessness on isolated human cells.

PLANT PHYSIOLOGY

A plant experiment will be conducted to study plant physiology and morphogenesis under a state of weightlessness.

EXPERIMENT HARDWARE

3-DAY MISSION

DESCRIPTION

The experiment hardware for the BIOSATELLITE 3-day flights fall into two broad categories: (1) Weightless experiments and (2) Radiation/weightless experiments.

a. The weightless experiment hardware packages are mounted on the aft mounting plate inside the recovery capsule where they will experience a weightless environment but receive no exposure from the on-board radiation source. The following experiments are placed in this category:

Experiment

P-1017 - Pepper Plant

P-1020 - Wheat Seedlings

P-1035 - Amoeba culture

P-1047 - Fertilized Frog Eggs

b. The radiation/weightless experiments are grouped around the on-board radiation source at appropriate isodose distances on the forward mounting plate. There each experiment will experience its desired gamma-ray radiation dose as well as a weightless environment. In addition, each radiation experiment has a "control" package mounted on the aft plate shielded from the radiation. The following specimens are placed in this category:

Experiment

P-1037 - Neurospora spore

P-1039 - Tribolium beetles

P-1079 - Habrobracon

P-1123 - Tradescantia plants

P-1135 - Lysogenic Bacteria

P-1159 - Drosophila adults

P-1160 - Drosophila larvae

30-DAY MISSION

DESCRIPTION

The experiment hardware for the 30-day mission can be divided into five major sets of components; those being furnished by Ames Research Center, University of California at Los Angeles, University of Southern California, Jet Propulsion Laboratory, and General Electric Company.

The equipment supplied by ARC consists of a clock, two dosimeters, and a primate restraint. The clock will be photographed simultaneously with the primate's head and shoulders, and the dosimeters will measure the ambient radiation dose received inside the experiment capsule.

The equipment supplied by the University of California at Los Angeles and manufactured by the Northrop Space Laboratories consists of three major assemblies: Signal Conditioners, Behavior Panel and Behavior Programming Electronics. The signal conditioner assembly is mounted just behind the head of the primate and amplifies physiological signals, ten EEG, two EMG, two EOG, one GSR, and two temperatures. In addition to the physiological measurements, a microphone is mounted on the signal conditioner to measure ambient peak noise. The output of each signal conditioner is compatible with the spacecraft telemetry and where necessary with the on-board tape recorder.

The Behavior Panel is mounted in front of the primate on the forward rack of the spacecraft. It is an electro-mechanical device that presents the two behavioral tasks (Delayed Matching and Visuomotor) to the primate in order to assess his performance.

The assembly of the Behavior and Programming Electronics and their associated power supplies is mounted in the recovery capsule. This assembly is the central programming and distribution point for the operation of behavioral tasks and resulting measurement. It programs the camera, the tape recorder, and the food dispenser; it distributes signals received from the spacecraft timer and command decoder to the proper logic to alter preprogrammed sequences; and it controls the type of data obtained and recorded during behavioral tasks, launch, orbit, and recovery phases.

The equipment supplied by the University of Southern California is manufactured by the University and by Ford-Philco Corp., Western Development Division. This equipment consists of Heparin Containers, Pumps, Batteries, Transducers, and Signal Conditioners for the measurement of blood pressures, respiration by impedance changes, and ECG.

The equipment manufactured by the Jet Propulsion Laboratory consists of a minature automated urinalysis device. It receives aliquots of the urine produced by the primate and analyzes constituents during the orbit phase of the mission. Measurements of calcium, creatinine, and creatine concentrations are made every six hours on an integrated urine sample. This equipment is mounted in the adapter section of the spacecraft and is not recovered.

21-DAY MISSION

DESCRIPTION

The experiment hardware for the 21-day mission consists of the following:

a. Experiments P-1093 and P-1145

A group of 8 pie shaped cages houses 8 white rats, one in each cage. A nutrient programming and dispensing system supplied each rat with sufficient food and water in measured amounts, and a cage-lighting system provides the rats with a programable light/dark regime. A data acquisition system in incorporated which consists of telemetry transmitters implanted in each rat, antennas in each cage, receivers, light sensors, thermisters, a core memory data storage unit, and a logic sampling unit. This system will provide data on rat temperatures, rat activity, rat feeder actuations, cage light status, and cage air temperature to the spacecraft telemetry system.

b. Experiment P-1003

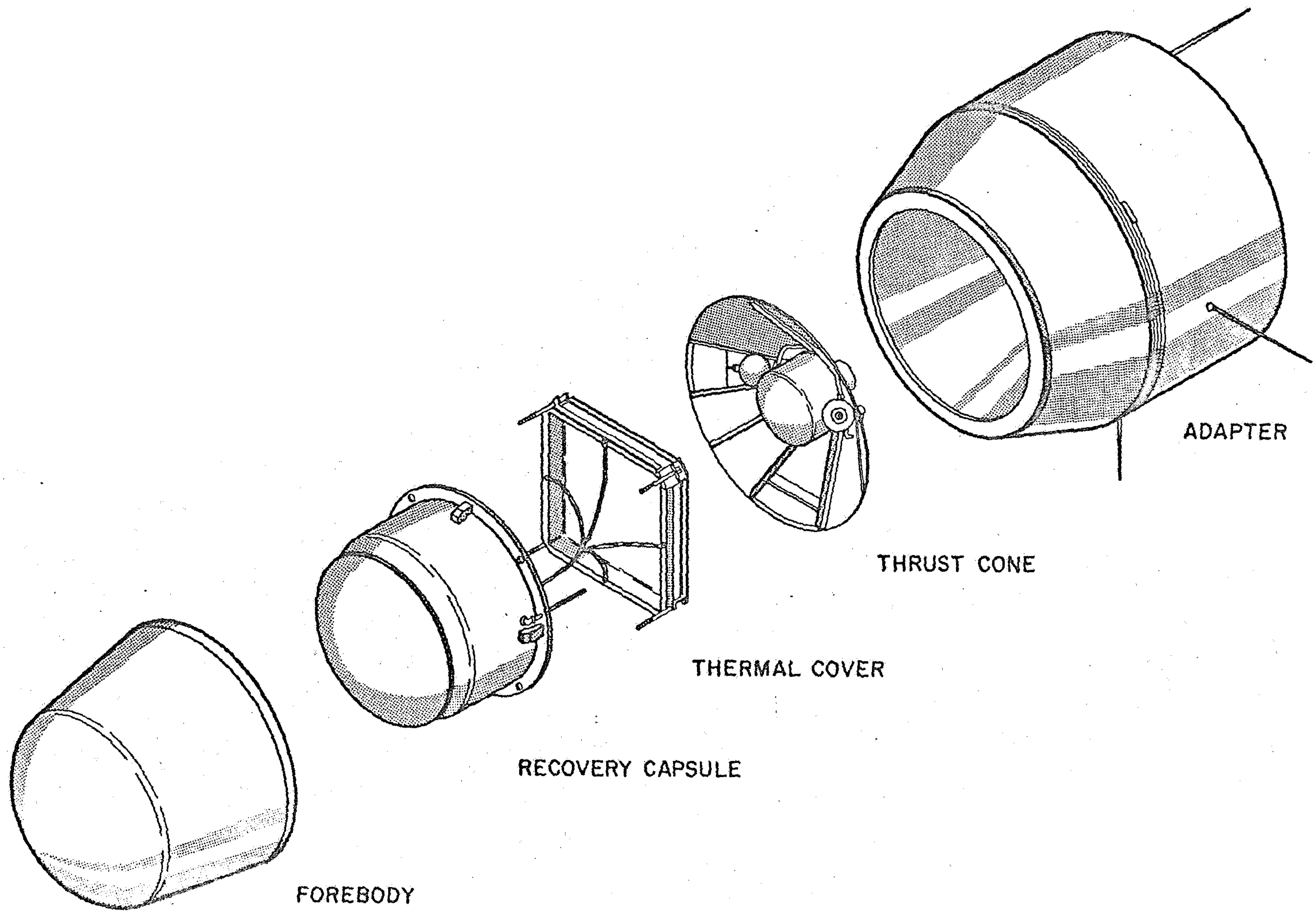
Plant modules will house 5 growing arabidopsis plants and their nutrients. A seed module will be provided for holding arabidopsis seeds. Two cameras for taking stereoptic photographs of the growing plants at programmed times will be installed. An Accutron chronometer will provide time and day information for interpreting the time lapse photographs. A power inverter and light system will supply continuous light for plant growth. A water chamber and a pyrotechnic release system will provide for irrigating the seeds at the desired time.

c. Experiment P-1084

A closed system will be used for culturing the Chang Liver tissue. A pump will be utilized for replacing the medium periodically. A camera will be provided for taking photographs of the tissue. A power converter and stroboscopic light will provide light for photography. Electric heaters and thermostats will maintain the tissue culture and medium at a temperature of $98.6 \pm 1°F$.

Drs. Ekberg and Adey have elaborated on the biological work done* for the 3 and 30-day flight experiments. The BIOSATELLITE is one of the first satellites used for Experimental Science instead of Observational Science. The preceding exposition gives a general indication of the complexity of this minature space laboratory.

* This Meeting.



Exploded View of BIOSATELLITE Spacecraft

Figure One

Table One

BIOSATELLITE Experimenters

3-DAY MISSION

EXPERIMENT	TITLE	SCIENTISTS	AFFILIATION
P-1017	Liminal Angle of a Plageotropic Organ Under Weightlessness	Dr. S. P. Johnson Dr. T. Tibbitts	North American Aviation Inc.
P-1020	The Effect of Weightlessness on Growth of the Wheat Coleoptile	Dr. S. W. Gray and Dr. B. F. Edwards	Emory University Emory University
P-1035	Nutrition and Growth of Pelomyxa Carolinensis During Weightlessness	Dr. R. W. Price Dr. E. E. Ekberg	Colorado State University General Electric Co.
P-1037	Mutagenic Effectiveness of Known Doses of Gamma Irradiation	Dr. F. J. De Serres Dr. B. B. Webber	Oak Ridge National Laboratory Oak Ridge National Laboratory
P-1039	Synergistic Factors Influencing Embryonic Differentiation and Development in the Space Environment	Dr. J. V. Slater	University of California, Berkeley
P-1047	Effects of Sub-Gravity on Cellular Phenomena of Developing Frog Eggs	Dr. R. S. Young Dr. J. W. Tremor	NASA Headquarters Ames Research Center
P-1079	Mutagenic Effectiveness of Known Doses of Gamma Radiation in Combination with Weightlessness on Habrobracon	Dr. R. C. von Borstel Dr. R. H. Smith Dr. A. R. Whiting Dr. D. S. Grosch Dr. R. L. Amy	Oak Ridge National Laboratory Oak Ridge National Laboratory Oak Ridge National Laboratory North Carolina State University Southwestern University
P-1096	Emergence of Seedlings with Zero Gravity	Dr. C. J. Lyon	Dartmouth College
P-1123	Determination of Influence of Zero Gravity on Mutation Process Using Controlled Gamma Ray Exposure	Dr. A. H. Sparrow Mr. L.A. Schairer	Brookhaven National Laboratory

Table One

BIOSATELLITE Experimenters

3-DAY MISSION (Continued)

EXPERIMENT	TITLE	SCIENTIST	AFFILIATION
P-1135	Induction of Lysogenic Bacteria in the Space Environment	Dr. R. H. T. Mattoni	NUS Corporation
		Dr. W. R. Romig	University of California - LA
		Dr. W. T. Ebersold	University of California - LA
		Dr. E. C. Keller	NUS Corporation
		Dr. F. A. Eiserling	University of California - LA
P-1138	Effects of Weightlessness on the Orientation of Root and Shoot of Corn	Dr. H. M. Conrad	Resources Planning and Control Corporation
		Dr. S. P. Johnson	North American Aviation
P-1159	Effects of Zero-Gravity on Radiation-Induced Mutations in Mature Reproductive Cells	Dr. E. Altenburg	Rice University
		Dr. L. S. Browning	Rice University
P-1160	Possible Effects of Zero-Grovity on Radiation-Induced Somatic Damage	Dr. I. I. Oster	Bowling Green State University