NASA TECHNICAL MEMORANDUM

NASA TM-75032

SCIENTIFIC EXPERIMENTS IN THE FLIGHT OF THE 1977 BIOLOGICAL SATELLITE (DRAFT PLAN)

USSR Academy of Sciences - Interkosmos Council

Translation of "nauchnyye eksperimenty v polete biologicheskogo sputnika 1977 g (plan-prospekt)," USSR Academy of Sciences, Interkosmos Council and Ministry of Public Health of the USSR, Institute of Medical and Biological Problems, Moscow, 1977, pp 1-49

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546 AUGUST 1977

STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No
NASA TM-75032		

4. Title and Subtitle	5. Report Date
SCIENTIFIC EXPERIMENTS IN THE FLIGHT OF THE 1977 BIOLOGICAL SATELLITE (DRAFT PLAN)	August 1977
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
USSR Academy of Sciences, Interkosmos Council	10. Work Unit No.

9. Performing Organization Name and Address	11. Contract or Grant No.
Leo Kanner Associates Redwood City, California 94063	NASw-2790
	13. Type of Report and Period Covered
	Translation
12. Sponsoring Agency Name and Address	14. Sponsoring Agency Code
National Aeronautics and Space Administration, Washington, D.C. 20546	

15. Supplementary Notes

Translation of "Nauchnyye eksperimenty v polete biologicheskogo sputnika 1977 g (plan-prospekt)," USSR Academy of Sciences, Interkosmos Council and Ministry of Public Health of the USSR, Institute of Medical and Biological Problems, Moscow, 1977, pp. 1-49.

16. Abstract

The physiological, biological, radiobiological and radiophysical experiments planned for the 1977 biological satellite are described. The biological experiments will involve rats, higher and lower plants, insects and other biological specimens carried on the biosatellite. The responses of these organisms to weightlessness, artificial gravity, cosmic radiation particles and general flight factors will be studied. The radiophysical experiments will investigate certain properties of cosmic radiation as well as the possibility of creating electrostatic and dielectric radiation shields under actual space-flight conditions.

17. Key Words (Selected by Author(s))	18. Distribution Statement
	Unclassified-Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified		

SCIENTIFIC EXPERIMENTS IN THE FLIGHT OF THE 1977 BIOLOGICAL SATELLITE (DRAFT PLAN)

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Introduction

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The purpose of biosatellite experiments is to study the principles governing the adaptation of physiological systems to the complex of factors involved in prolonged space flight, as well as to study numrous fundamental questions of general biology, particularly those dealing with the role of gravity in the growth, development and reproduction of organisms.

Soviet scientists were the first to conduct experiments with animals in space, and such experiments are continuing with much success. Experiments on three specialized biological satellites (the "Kosmos-605," "Kosmos-690" and "Kosmos-782") with various biological specimens have shown that prolonged weightlessness has no adverse effects on intracellular processes, including those associated with the transmission of genetic information and the accomplishment of cell division.

Investigations of the main physiological systems in animal organisms have revealed no pathological changes attributable to the action of weightlessness. At the same time, changes of both a specific and nonspecific nature have been discovered in a number of organs and tissues. The latter changes include signs of the activation of the hypothalamo-hypophyseo-adrenocortical system. Specific phenomena determined by the action of weightlessness include changes in the skeletomotor apparatus.

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* Numbers in the margin indicate pagination in the foreign text.

For example, changes in the muscular system have been manifested in mustular atrophy, a decline in muscular strength and elasticity, the growth of connective tissue, and a number of changes in metabolic processes. The following changes were found in tubular bones: osteoporosis of cancellous areas, a moderate thinning and rarefication of the cortical plate, a retardation of periosteal bone formation and mineralization, a retardation of longitudinal growth, and a decrease in mechanical strength. /2

Studies of the modifying effect of weightlessness on the radiosensitivity of organisms have shown that the development and course of radiation sickness in space are practically identical to its development and course under terrestrial conditions.

Centrifuge experiments were done for the first time in space aboard the "Kosmos-782" biosatellite. These experiments showed that the biological effects of artificial gravity under space-flight conditions are essentially the same as those of normal terrestrial gravity.

The experiments on the three biosatellites showed for the first time that high-intensity electric fields, which are of interest as cosmic-radiation shields, can be generated and maintained under the conditions of prolonged space flight.

Besides Soviet scientists, specialists from Czechoslovakia, Hungary, Poland, the United States and France participated in the experiments done on the "Kosmos-782" biosatellite.

Physiological, biological, radiobiological and radiophysical experiments will be conducted during the flight of the 1977 biological satellite. An overall list of these experiments is given in Tab. 1.

The physiological experiments planned for the 1977 biosatellite will attack a number of questions. First an attempt will be /3
made to evaluate the functional reserves of one of the most important systems, and the one responsible for the nonspecific adaptive responses of the organism: the hypothalamo-hypophyseo-adrenocortical system. For this purpose a stress function test (fixation stress) will be employed during the readaptation period.

A major goal of the experiment with rats will be to broaden our understanding of the skeletomotor apparatus, particularly the bone system. For this purpose a study of ectopic osteogenesis will be done in addition to traditional bone tissue studies.

The presence of a centrifuge on the biosatellite will make it possible to conduct artificial gravity experiments with mammals.

The biological investigations will include a study of the growth dynamics of higher and lower plants under weightless conditions, as well as the physiology, anatomy and genetics of insects.

Studies on the possibility of utilizing electrostatic and dielectric radiation shields during space flights, as well as studies on the effects of heavy cosmic-ray nuclei on various biological specimens, will be continued in the radiobiological and radiophysical experiments.

The flight experiment will be accompanied by a synchronous ground experiment which will commence five days after the start of the flight. The synchronous experiment, to be conducted in a mock-up of the biosatellite, will repeat all the conditions of the flight experiment with the exception of weightlessness.

The first study of biomaterial will be performed immediately after recovery of the landing capsule. For this purpose a mobile laboratory complex with all the equipment needed to conduct a specialized examination of the biological specimens will be transported to the recovery site. /4

All further investigations will be carried out in scientific institutions in the Soviet Union and abroad. The biological specimens returned by the landing capsule will be examined by Soviet specialists as well as scientists from Czechoslovakia, Poland, Hungary, Rumania, Bulgaria, the United States and France.

K-1241: Experiment with Rats /5

Performing agency: Institute of Medical and Biological Problems of the USSR Ministry of Public Health

The following physiological experiments with rats will be done on the biosatellite:

-- experiment under conditions of weightlessness;
-- experiment under conditions of artificial gravity

The main purpose of the experiments with mammals is to study further the mechanisms governing the adaptation of functional systems to the effects of prolonged weightlessness.

The satellite will carry 30 Wister rats free of pathogenic microflora. A special feature of the 1977 biological satellite is its two on-board centrifuges containing a total of 10 rats (group I); the purpose here is to study further the biological effects of artificial gravity as well as provide a control for the weightlessness experiment.

Each centrifuge is equipped with five individual holding cells, similar in design to those used on the "Kosmos-782."

Each centrifuge is 760 mm in diameter and rotates at a rate of 53.5 ± 3 rpm, creating 1 g at a radius of 320 mm (the provisional "longitudinal animal axis").

The remaining group of 20 rats, held in individual cells outside the centrifuges, is exposed to the effects of weightlessness in its "pure form."

Five animals from the centrifuge group and five from the main group will carry implanted biotelemetric sensors for measuring body temperature.

Another five animals from the main group will carry aponeurotic detector plates to enable the study of radiation damage to cephalic nerve tissue in the region of charged-particle tracks. These animals will also be delabyrinthated in order to study the role of the vestibular apparatus in adaptation to weightless conditions. /6

Each animal holding cell is equipped with a complex of life-support systems: a feeder, a water dispenser, ceiling illumination, a system of fresh-air vents, a special grilled opening for the removal of solid and liquid wastes, and compartments for storing the wastes from each two-day period of the experiment.

Each holding cell is also equipped with a special measuring device which counts and sums the number of movements made by the rat over a 24-hour period. The food paste, specially developed for zero-gravity conditions, will be dispensed through the feeder at six-hour intervals. Water during the flight is unlimited. A chemical air-regeneration system will provide for the supply of

oxygen and the removal of excess carbon dioxide and gaseous contaminants from the atmosphere of the biology capsule. The proper temperature and humidity will be maintained by a thermoregulatory system with a dehumidifier.

The experimental animals will be supplied by the Institute of Endocrinology of the Slovakian Academy of Sciences of the CSSR.

The final selection of animals and their training for the flight will be carried out at the Institute of Medical and Biological Problems of the USSR Ministry of Public Health in accordance with the pre-flight training program (Tab. 2). /7

After the flight some of the animals (five from group I and ten from the main group (excluding animals with temperature sensors or delabyrinthation) will be killed immediately at the recovery site. They will be examined for functional and structural changes resulting from the action of weightlessness and compared with animals subjected to the artificial gravity created by the on-board centrifuges. The post-flight morphological and biochemical studies planned are listed in Tab. 3. The remaining animals will be killed on the 26th day of the readaptation period after a number of clinical and physiological studies have been performed (Tab. 4).

A list of the scientific institutions participating in the post-flight study of the rats is given in Tab. 5.

K-1242: Experiment with Higher Plants /8

Performing agency: Institute of Medical and Biological Problems of the USSR Ministry of Public Health, Moscow

The experiment with higher plants planned for the flight of the 1977 biosatellite will be done on corn sprouts (Zea mays) and crepis sprouts (Crepis capillaris). The purpose of the experiment is to:

1. study the role of gravity in the formation of cell structures responsible for cellular energetics (chloroplasts and mitochondria), particularly the effect of weightlessness on the development of the ultrastructure of these organelles as the seeds sprout during the space flight;

2. study the role of gravity in the formation of the genetic apparatus of the plant cell, including the effect of zero gravity on the duration of the mitotic cycle and the mutation rate.

The experiments will be conducted at a constant temperature (+25° C) in a device specially designed for nurturing sprouts under weightless conditions.

The device will be activated and water and fixing fluid supplied automatically on the 2nd, 4th, 6th, 8th, 10th, 13th, 16th and 19th days of the flight.

After recovery the device will be dismantled and the material photographed. Further analysis will be done under laboratory conditions using electron microscopy and cytological methods involving our own modification of the colchicine method. This will make it possible to trace the successive changes in the internal structure of cellular organelles, and to determine the duration of the mitotic cycle and the rate of spontaneous mutation in the meristematic cells of plants under weightless conditions.

These investigations will enable scientists first to learn /9

more about the genesis of cellular organelles and their ultrafine structure under weightless conditions, and second to obtain data on the effect of weightlessness on the rate of mitosis and the formation of the nuclear apparatus in plant cells.

K-1243: Experiment with Lower Plants /10

Performing agency: Institute of Medical and Biological Problems of the USSR Ministry of Public Health, Moscow

A representative of the lower phycomycetous fungi (Phycomyces blakesleeanus) will be used to study the morphogenesis, and particularly the growth characteristics, of lower plants under weightless conditions. Phycomycetes is a convenient species for analyzing the morphological, physiological and biochemical characteristics of the lower plants.

The fungi experiment will be done in the same device used for the higher plants and according to the same program.

Immediately after lander recovery and the dismantling of the device, the substrate with the fungal culture must be photographed and transferred to glass containers. Further analysis will be done in the laboratory.

This experiment is designed to reveal the role of terrestrial gravitation in determining the morphological and cytological parameters of a fungal culture at various stages of its development and will make it possible to study the distribution of cellular organelles during fungal growth under weightless conditions.

K-1244: Experiment with Insects /11

Performing agencies: Institute of Medical and Biological

Problems of the USSR Ministry of Public Health, USSR
NASA Ames Research Center, U.S.

The pomace fly (Drosophila melanogaster) of the Oregon-R strain will be the object of experiments on the 1977 biosatellite.

Soviet scientists will conduct genetic studies in which the rate of deletions and visible mutations in the sex chromosome as well as regressive, sex-linked and lethal mutations will be recorded.

Deletions are structural changes characterized by the loss of a chromosomal segment. A number of special methods are known for detecting the loss of a certain segment. The most straightforward approach is to analyze the specific changes which have appeared under weightless conditions during the flight.

Recessive lethal mutations generally involve gene changes, specifically a change in the sequence of bases in the nucleotides. The most simple method of recording these mutations is the Meller 5 method: males and females of two distant strains are crossbred, and in the second generation the number of cultures which do not have the expected members are counted.

The experiments are designed to study the effect of weightlessness on the occurrence of structural and biochemical changes in the genetic apparatus of the pomace fly and to identify the causes and nature of these changes. /12

The American specialists will concentrate on physiological investigations of processes, especially those that can affect the life span. They will measure the life spans of flies of various ages and perform a series of biochemical and behavioral tests which characterize age-related changes.

The experiments planned will broaden our knowledge of the effects of weightlessness on the molecular mechanisms of processes occurring in chromosomes and will provide information on the danger posed to hereditary structures by prolonged space flight.

Data will also be obtained on the intensity of vital processes under weightless conditions, the rate of which is a factor in determining the life span.

K-1245: The "Bioblok" Experiment /13

Performing agency: Institute of Medical and Biological Problems of the USSR Ministry of Public Health
Toulouse University, France

The purpose of the "Bioblok" [bioassembly] experiment on the 1977 biosatellite is to study the biological effects of heavy nuclei of galactic cosmic radiation (GCR) on the simplest animal organisms, cell colonies and plant seeds, as well as to study the effect of non-radiation flight factors. Another goal of the experiment is to investigate the properties of GCR heavy nuclei.

The biological effects of GCR heavy nuclei will be studied based on an analysis of the genetic, cytogenetic and somatic injuries produced in biological specimens exposed to heavy-particle bombardment during the flight.

The experiment will involve the use of special assemblies comprised of alternating layers of dielectric track detectors and biological specimens contained in plate holders. As heavy nuclei traverse these detectors, they produce radiation damage

along their path of motion which can be developed by chemical treatment into hollow cylindrical or conical tracks. By tracing these tracks through the "Bioblok" assembly it is possible to identify specific biological specimens through which heavy nuclei have passed. By analyzing the tracks in the dielectric detectors, it is also possible to determine the charge composition and energy of the particles.

Intact biological specimens will serve as controls. By studying the changes in these specimens and in those exposed to analogous conditions on earth, it will be possible to determine the effects of non-radiation flight factors. /14

The following biological specimens will be used in the experiment: artemia salina and kolpodia eggs; colonies of yeast cells; tobacco, squash and lettuce seeds. To create conditions optimal for the growth and development of some of the specimens during the flight as well as proper radiation exposure conditions, the bioassembly will be thermostatically controlled (8° C).

In order to calibrate the radiation detectors, the flight experiments will be paralleled by groundbased experiments with a charged-particle accelerator.

Nitrocellulose, lavsan and polycarbonate films, as well as nuclear photoemulsions, will be used as the radiation detectors.

The following tests will be employed to study the reactions of individual biological specimens to the action of heavy nuclei and the effect of non-radiation flight factors: inactivation and anomalies of cell division, anomalies of egg development, and the occurrence of genetic and cytogenetic changes.

The "Bioblok" experiment is expected to provide:

-- information on the biological effects of GCR heavy nuclei and establish a correlation between the parameters of the incident radiation and the severity of the damage produced;

-- information on the effect of non-radiation flight factors on biological processes;

-- information on the charge composition and linear-energy-loss spectra of GCR particles within the biosatellite;

-- information on the calibration of radiation detectors by means of the charged-particle accelerators in Dubna (USSR);

-- experimental data on the biological effects of heavy ions.

K-1246: The "Heat Transfer I" Experiment /15

Performing agencies: Institute of Biophysics of the Czechoslovakian Academy of Sciences, Brno
Institute of Medical and Biological Problems of the USSR Ministry of Public Health, Moscow

The experiment designated "Heat Transfer I" is designed to investigate the effect of weightlessness on the transfer of heat between a heated surface and the environment (air).

The equipment which will be used in the experiment was developed and built by Czechoslovakian specialists and includes:

-- an electrical dynamic katathermometer;

-- a tunnel with a ventilator for creating a calibrated air-stream velocity; and

-- an electronic control unit.

The device has a single-unit design and allows measurements both in the case of a stationary medium and at four different air-flow velocities.

The device is activated by connection to a 27-volt d.c. current source. At an ambient temperature of 20-25° C, a temperature of 37 ± 0.1° C is established on the surface of the sensor of the katathermometer within two minutes. This temperature is maintained with the aid of a bulit-in electric heater. Under the conditions established, the electric power required to maintain this temperature is a function of the air-flow speed and the ambient temperature. Four speeds of air flow past the sensor can be created by means of the tunnel-housed ventilator and the electronic control unit. /16

In accordance with the experimental program, the device is activated at two-hour intervals on odd-numbered days of the flight; each measurement cycle lasts a maximum of 15 minutes.

In each cycle a measurement is made of the electric power consumed in heating the sensor, as well as the ambient temperature. Information on the thermal conditions is fed into the onboard recorder in the form of voltage levels (from 10 to 6 V). The information will be interpreted and processed after the capsule is recovered.

By comparing the results of the flight experiment with the groundbased control, it will be possible to determine the difference in the cooling properties of the living environment in the satellite and on earth.

The results of the "Heat Transfer I" experiment may show ways to further develop the promising integral method of assessing the thermal properties of inhabited spaces, including the cabins of spacecraft.

K-1247: Electrostatic Shield Experiment /17

Performing agencies: Institute of Medical and Biological Problems of the USSR Ministry of Public Health, Moscow
All-Union Scientific Research Institute of Electronic Standards, Gatchina

The "autonomous" mode of electrostatic shield operation is the most advantageous in terms of energy consumption. In this mode a particle-deflecting electric field is generated when a high-voltage electrode is charged to the necessary potential by an external stream of electrons from the radiation belt; no high-voltage power source is required.

The purpose of the experiment is to investigate the principal features of autonomous electrostatic shield operation by using an electron gun to simulate a stream of electrons from the Van Allen belts, as well as to test the electronic hardware and materials used in the construction of electrostatic shields under actual space-flight conditions.

Investigations will center on:

-- the possibility of charging a high-voltage electrode by an electron beam;

-- the charge retention time of the high-voltage electrode;

-- the possibility of increasing the potential difference

between the electrodes by varying the interelectrode distance;

-- the magnitude of the interelectrode-space conduction current;

-- the "run-in" conditions for the working surfaces of the electrostatic shield model;

-- the size of the leakage current through structural materials;

-- the reliability of the products of electronic technology, including the satellite, under dynamic conditions;

-- the effect of space-flight conditions on materials used in the manufacture of electronic hardware; /18

-- measuring the pressure of the vacuum surrounding the spacecraft and within the electrostatic shield model.

A complex of scientific research equipment for simulating the operation of an electrostatic shield with a high-voltage electrode charged by an external electron stream (here, an electron gun) will be used in the experiment.

Test specimens of electronic hardware and materials will be attached to the outer surface of the landing capsule. The instrument compartment will contain a pre-programmed switching unit for controlling the electron gun and a low-voltage power supply.

The overall weight of this equipment is 90 kg.

The equipment will provide for the charging of the high-voltage electrode by an electron beam wich an energy of 0-100 kV and current of 5-60 μA, measuring the characteristics of the

electrostatic shield over a range from 10^{-6} to 10^{-12} A, measuring the potential over the range 15-150 kV, measuring the pressure within the model and near the surface of the satellite over the range 10^{-4}-10^{-7} mm Hg, and testing the integral circuitry under dynamic conditions and without an electrical load.

These electrostatic shield experiments are expected to provide:

-- first information on the possibility of storing a charge on a high-voltage electrode impinged upon by an electron beam;

-- first information on the time characteristics of the potential drop on an insulated electrode;

-- first information on the size of the leakage current through structural materials (insulators) in the presence of a vacuum surrounding the satellite;

-- data for studying the possibility of increasing potential differences by increasing the interelectrode distance; /19

-- data for studying the "conditioning" of insulated high-voltage electrodes charged by an external electron beam;

-- more accurate information on the conduction currents of a high-voltage vacuum gap;

-- data on the operational reliability of integral circuitry under space-flight conditions;

-- information on the effect of space-flight factors on materials used in the manufacture of electronic hardware;

-- information on the parameters of an actual electrostatic shield operating in the autonomous mode, i.e. with the high-voltage electrode charged by an external stream of electrons.

K-1248: Dielectric Shield Experiment /20

Performing Agency: Institute of Medical and Biological Problems of the USSR Ministry of Public Health, Moscow

The dielectric shield is based on the deflection and braking of charged particles by a powerful electric field (up to several MV/cm) created in a dielectric.

An optimal means of creating such fields is by the use of so-called radioelectrets, which are capable of storing a considerable electric charge under irradiation and retaining this charge for some time.

The purpose of the experiment is to study further the stability of stored electric charges under the influence of space-flight factors and the conditions of open space.

The dielectric specimens, charged in an accelerator, are carried into space in special containers mounted beneath the skin of the satellite. The containers are opened during the flight, thereby subjecting the dielectric to the conditions of open space. The containers are sealed before re-entry to prevent heating and possible damage to the dielectric specimens. During the flight a recording is made of the various factors acting on the dielectrics. Electric charge measurements are made in groundbased laboratories and are compared with control specimens.

It is expected that more information will be obtained on the effect of space factors on dielectrics charged to various

potentials. This will enable the next step to be made in the development of dielectric shields.

K-1249/K-206: "Iondose" Experiment on Radiation Dosimetry /21

Performing agencies: Institute of Medical and Biological Problems of the USSR Ministry of Public Health, Moscow
NASA Ames Research Center,
University of San Francisco, U.S.

This experiment is designed to study the dosimetric and spectrometric properties of cosmic radiations in near-earth space and to investigate the passage of charged particles of cosmic radiation through shielding material and biological tissue. Measurements will be made of linear-energy-loss spectra, charge compositions and the dose characteristics of cosmic radiations. Measurements both inside and outside the satellite are planned. Particular emphasis will be placed on investigating the characteristics of heavy nuclei of galactic cosmic radiation to facilitate the planning of future radiobiological experiments in space and in accelerators. One goal of the experiment is to standardize the experimental techniques employed by Soviet and American scientists. To this end, both American and Soviet detectors will be used on the biosatellite, and a cycle of experiments will be done on the concurrent calibration of the detectors in Soviet and American accelerators.

Various types of detectors will be employed in the joint Soviet-American experiment. Soviet specialists are installing two C-1 analyzers on the 1977 biosatellite: one on the outer surface of the satellite and one within the landing capsule. The dosimetric unit, measuring 130 x 130 x 480 mm and weighing 6 kg, will house the Soviet detectors (nuclear emulsions, dielectric /22
track detectors and thermoluminescent dosimeters [25% of total

volume of unit]), the American detectors (nuclear emulsions, dielectric track detectors, thermoluminescent dosimeters, uranium and neptunium foils [25% of total volume of unit]), as well as a joint detector package (50% of total volume of unit). These detectors will be used to measure the linear-energy-loss spectra of cosmic-ray particles, the charge composition of the radiation and its dosimetric characteristics within the satellite. To determine the extent to which the unit is shielded by equipment, it has been suggested that gamma thickness measurements of the biosatellite be made. Groundbased calibration experiments will be done in accelerators using the same detectors.

It is hoped that in the "Iondose" joint Soviet-American experiment it will be possible to:

-- obtain information on the linear-energy-loss spectra of galactic cosmic radiation particles in the LEL range from 2 MeV/cm to 10^4 MeV/cm in open space and within the spacecraft;

-- obtain information on the LEL spectra of radiation-belt protons in the region of the Brazilian anomaly;

-- measure the charge composition of cosmic radiations in near-earth orbits;

-- measure the streams of heavy galactic-radiation nuclei and their microdosimetric characteristics in order to assess the radiation hazard to astronauts and to plan future radiobiological experiments in space;

-- estimate the yield of secondary radiations from the inelastic interactions of heavy galactic-radiation nuclei with shielding material and biological tissue;

-- calibrate the detectors concurrently in heavy-ion /23

accelerators in the cities of Dubna (USSR) and Berkeley (U.S.) for the purpose of unifying experimental techniques;

-- test experimentally the technique of estimating the passage of cosmic radiations through shielding material and tissue based on data from measurements of particle streams and spectra outside and inside the satellite and data on the shielding of internal detectors by equipment and structural masses determined by gamma thickness measurements;

-- devise experimental techniques in heavy-ion accelerators which will aid in designing future radiophysical and radiobiological experiments in Soviet accelerators;

-- obtain experimental data on the biological effects of heavy ions in accelerators; such data are needed in order to perform the corresponding experiments in space.

Table 1. List of Scientific Experiments on the 1977 Biosatellite

/24

a) Шифр эксперимента	b) Название эксперимента	c) Исполнители
К-I24I	d) Эксперимент с крысами: e) – невесомость; f) – искусственная сила тяжести величиной I g.	g СССР, h ЧССР, i ПНР, j ВНР, k СРР, l НРБ, m США, n Франция.
К-I242	o) Эксперимент с высшими растениями.	g СССР
К-I243	p) Эксперимент с низшими растениями.	g СССР
К-I244	q) Эксперимент с насекомыми (дрозофилой линии Орегон Р).	g СССР, m США
К-I245	r) Эксперимент "Биоблок".	g СССР, k СРР, n Франция.
К-I246	s) Эксперимент "Теплообмен-I"	g СССР, h ЧССР.
К-I247	t) Эксперимент по электростатической защите.	g СССР
К-I248	u) Эксперимент по диэлектрической защите.	g СССР
К-I249/ К-206	v) Эксперимент по радиационной дозиметрии "Иондоз".	g СССР, m США.

Key: a - Experiment number; b - Name of experiment; c - Performing countries; d - Experiment with rats; e - Weightlessness; f - Artificial gravity (1 g); g - USSR; h - CSSR; i - Poland; j - Hungary; k - Rumania; l - Bulgaria; m - United States; n - France; o - Experiment with higher plants; p - Experiment with lower plants; q - Experiment with insects (Oregon-R-strain pomace fly); r - "Bioblok" experiment; s - "Heat Transfer I" experiment; t - Electrostatic shield experiment; u - Dielectric shield experiment; v - "Iondose" experiment on radiation dosimetry.

Table 2. Plan for the Pre-Flight Examination of the Animals (Experiment K-1241)
[Table continued next page]

a) №№ пп	b) Наименование работ	c) Сутки до полета
I.	Наблюдение за общим состоянием животных, динамикой веса и поведением.	25 - 0
2.	Отоскопическое обследование.	24, 2
3.	Микробиологические обследования (оценка бактерицидной активности кожи хвоста и микрофлоры зева).	25 - 23, I6, 6
4.	Гематологические исследования (морфологическая картина периферической крови).	25 - 23, I6, 6
5.	Изучение поведенческих реакций животных.	I6 - I3, 9 - 5
6.	Проведение балансных исследований по показателям водного и минерального обмена. Проведение водно-солевой нагрузки.	I2 - I0
7.	Исследование газообмена.	7 - 6
8.	Определение работоспособности животных по статической выносливости.	I4 - I3, 7 - 6
9.	Изучение функции равновесия.	I4 - I3, 7 - 6
I0.	Изучение вестибулярной функции электронистагмографическим методом.	I4 - I3, 7 - 6
II.	Изучение рефлекса переворачивания и приземления.	I4 - I3, 7 - 6
I2.	Привыкание животных к опытным условиям содержания.	I0 - 5

Table 2, Cont.
[Key next page]

I	2	3
I3.	Перевод животных на полетный пастообразный корм и режим освещенности I2:I2.	I5
I4.	Контроль температуры тела и двигательной активности животных.	I6, I5
I5.	Окончательное распределение животных по экспериментальным группам: полетной, синхронной, виварийного контроля.	6 – 5
I6.	Вживление внутрибрюшинно передатчиков температуры тела.	22
I7.	Патоморфологическое обследование (выборочно I0 крыс).	25, 0
I8.	Инъекция животным глицина C^{I4}.	20
I9.	Инъекция животным деклоницина.	3
20.	Инъекция животным антигена.	3

Key to Tab. 2: a - Sequence number; b - Steps in preflight procedure; c - Days before flight; 1 - Observation of animals' general condition, weight dynamics and behavior; 2 - Otoscopic examination; 3 - Microbiological examination (bactericidal activity of tail skin and microflora in throat); 4 - Hematological study (morphological picture of peripheral blood); 5 - Study of behavioral responses; 6 - Water and mineral metabolism studies, water and saline loading; 7 - Gas-exchange study; 8 - Determination of animals' working capacity based on static endurance; 9 - Study of equilibrium function; 10 - Electronystagmographic study of vestibular function; 11 - Study of inversion and landing reflex; 12 - Training for holding conditions; 13 - Transition to flight food (paste) and 12:12 light-dark cycle; 14 - Check of animals' body temperature and motor activity; 15 - Final division of animals into experimental groups: flight, synchronous, vivarium control; 16 - Implantation of intraperitoneal body-temperature sensors; 17 - Pathomorphological examination (10 rats selected at random); 18 - Injection of C^{14} glycine; 19 - Injection of declomycin; 20 - Injection of antigen; Note: 1. An analogous examination will be performed during preparation for the synchronous experiment; 2. The first declomycin injection (step 19) will be given to all animals three hours prior to the flight experiment.

Post-flight Morphological and Biochemical Studies (Experiments K-14.1)

No.	Step in post-flight procedure, organs and systems studied, indices	Material studied	Number of animals	Country	Remarks
1	2	3	4	5	6
1.	Histological study of bones.	Tibia	20 rats (10 centrifuge + 10 weightless)	USSR	One tibia from each rat.
2.	Biochemical study of bone mineral composition.	Femur and humerus, mandible	20 rats (10 centrifuge + 10 weightless)	USSR	One femur, humerus and mandible from each rat.
3.	Study of mineral composition.	Femur and tibia	5 rats from weightless group	USSR	One femur, tibia and humerus from each rat.
4.	Determination of new bone growth and resorption. Determination of bone strength and mineralization. Morphological bone studies.	Femur and tibia	20 rats (10 centrifuge + 10 weightless)	U.S.	Performing agency will receive one femur and one tibia from each rat.
5.	Study of mineral composition, histological structure and growth of bone.	Femur, tibia, scapula and cranial crest	5 rats from weightless group	Poland	One femur, tibia and scapula from each rat.
6.	Biochemical study of bone marrow.	Humerus	20 rats (10 centrifuge + 10 weightless)	CSSR	One humerus from each rat
7.	Biochemical study of hydrolytic enzymes in bones.	Radius and ulna	25 rats (10 centrifuge + 15 weightless)	USSR	

1	2	3	4	5	6
8.	Study of chromosomal damage in bone marrow cells.	Humerus bone marrow	5 rats from weightless group	Bulgaria	One humerus from each rat.
9.	Histological study of bone marrow.	Ilium	25 rats (10 centrifuge + 15 weightless)	USSR	
10.	Cytological study of bone marrow.	Sternum	"	USSR	
11.	Study of proliferative capacity of bone marrow stem cells.	Humerus	5 rats from weightless group	CSSR	One humerus from each rat.
12.	Study of ectopic osteogenesis.		5 rats from weightless group	USSR U.S.	
13.	Histological, histochemical and electron-microscopic muscle study.	Soleus, gastrocnemius, quadriceps femoris, extensor digitorum longus, diaphragm, forelimb muscles	20 rats (10 centrifuge + 10 weightless)	USSR	Muscles taken from one hind limb and one forelimb.
14.	Biochemical investigation of fractional composition of proteins, ATP-ase activity and lipids.	Soleus, gastrocnemius, quadriceps	20 rats (10 centrifuge + 10 weightless)	USSR	Muscles taken from one limb.

1	2	3	4	5	6
15.	Biochemical study of carbohydrate metabolism and ionic composition of muscles.	Sol, Gast, EDL, plantaris, diaphragm and tibialis	5 rats from weightless group (Sol, Gast, Quad); other muscles from 20 rats (10 centrifuge and 10 weightless)	USSR	
16.	Study of amino acid composition of muscles, nucleotide content, glycolysis rate, acetylcholine and cholinesterase activity.	Quadriceps, forelimb muscles	20 rats (10 centrifuge + 10 weightless)	USSR	
17.	Electron-microscopic and histochemical study of muscles.	Soleus, gastrocnemius	5 rats from weightless group	Poland	One muscle from each rat.
18.	Study of the mechanical properties of glycerinated muscle fibers.	Soleus, extensor digitorum longus	5 rats from weightless group	USSR	
19.	Biochemical study of blood plasma.	Blood plasma	from 25 rats	USSR	
20.	Assay of blood-plasma lipids.	Blood plasma	from 20 rats (10 centrifuge and 10 weightless)	CSSR	
21.	Assay of catecholamines in plasma.	Blood plasma	"	CSSR	
22.	Biochemical study of nucleotides.	Formed blood elements	25 rats	CSSR	

1	2	3	4	5	6
23.	Study of glycolysis and ATP in erythrocytes.	Formed blood elements	25 rats	USSR	
24.	Determination of hemoglobin structure.	"	10 rats (5 centrifuge + 5 weightless)	USSR	
25.	Histological study of lymphoid organs.	Spleen, thymus, inguinal lymph nodes	20 rats	USSR	1/2 spleen and 1/2 thymus from each rat.
26.	Biochemical study of lipids and DNA in lymphoid organs.	Spleen, thymus	20 rats (10 centrifuge + 10 weightless)	USSR	1/2 spleen and 1/2 thymus from each rat.
27.	Biological study of nucleic acids and enzymes controlling their metabolism in the spleen and thymus.	Spleen, thymus	5 rats from weightless group	USSR	1/2 spleen and 1/2 thymus from each rat.
28.	Immunological studies.	Spleen, plasma	5 rats from weightless group	France	1/2 spleen and 0.1 ml plasma from each rat.
29.	Cytochemical study of RNA and protein in spinal cord, brain and intravertibral ganglia.	Lumbar region of spinal cord, cortex of dermomotor analyzer, intravertibral ganglia	20 rats (10 centrifuge + 10 weightless)	USSR	
30.	Biochemical study of the cholinergic structures of the brain and spinal cord.	Cervical and lumbar enlargement of spinal cord, frontal, occipital and temporal cortex of brain, cerebellum	20 rats (10 centrifuge + 10 weightless)	USSR	

1	2	3	4	5	6
31.	Biochemical study of choninesterase.	Thoracic cord	5 rats from weightless group	USSR	
32.	Biochemical study of catecholamines and the enzymes involved in their metabolism in the hypothalamus.	Hypothalamus	20 rats (10 centrifuge + 10 weightless)	CSSR	
33.	Biochemical study of serotonin, histamine, catecholamines and their precursors in the spleen, hypothalamus and cortex of the brain.	Brain cortex	5 rats from weightless group	USSR	
34.	Histological study of hypothalamus.	Hypothalamus	5 rats from weightless group	USSR	
35.	Cytochemical study of enzymes of energy metabolism in the brain.	Medulla oblongata	20 rats (10 centrifuge + 10 weightless)	USSR	
36.	Histological study of hypophysis.	Hypophysis	20 rats (10 centrifuge + 10 weightless)	USSR	
37.	Biochemical determination of ademilate cyclosis.	Hypophysis	5 rats from weightless group	CSSR	
38.	Histological study of epiphysis.	Epiphysis	25 rats (15 weightless + 10 centrifuge)	Rumania	
39.	Histological and histochemical study of adrenal glands.	Adrenal glands	20 rats (10 centrifuge + 10 weightless)	USSR	One adrenal gland from each rat.

1	2	3	4	5	6
40.	Assay of catecholamines and the enzymes of their metabolism in the adrenal glands.	Adrenal glands	20 rats (10 centrifuge + 10 weightless)	CSSR	One adrenal gland from each rat.
41.	Assay of corticosterone in the adrenal glands.	"	5 rats from weightless group	USSR	One adrenal gland from each rat.
42.	Determination of corticosterone production and the response to corticotropin.	"	5 rats from weightless group	CSSR	One adrenal gland from each rat.
43.	Histological study of the thyroid gland.	Thyroid gland	25 rats (10 centrifuge + 15 weightless)	USSR	1/2 gland from each rat.
44.	Biochemical study of thyroid gland hormones.	Thyroid gland	20 rats (10 centrifuge + 10 weightless)	CSSR	1/2 gland from each rat.
45.	Histological study of testes.	Testes	25 rats (10 centrifuge + 15 weightless)	USSR	One testis from each rat.
46.	Morphological and cytogenetic analysis of the testes.	Testes	25 rats (10 centrifuge + 15 weightless)	Bulgaria	"
47.	Histological study of the kidneys and bladder.	Kidneys, bladder	20 rats (10 centrifuge + 10 weightless)	USSR	One kidney from each rat.
48.	Biochemical study of the kidneys.	Kidneys	"	USSR	"
49.	Determination of osmotic gradient and sodium-potassium activity of ATP-ase.	"	5 rats from weightless group	CSSR	Two kidneys from each rat.

1	2	3	4	5	6
50.	Electron-microscopic study of the inner ear.	Inner ear	25 rats (10 centrifuge + 15 weightless)	USSR	
51.	Histological study of the lungs.	Lungs	"	USSR	
52.	Biochemical study of catecholamines and the enzymes of their metabolism in the myocardium.	Myocardium	20 rats (10 centrifuge + 10 weightless)	CSSR	1/2 myocardium
53.	Biochemical study of contractile proteins, their enzymatic activity and lipids in the myocardium.	Myocardium	"	USSR	1/2 myocardium
54.	Biochemical determination of the catecholamine content of the myocardium.	Myocardium	5 rats from weightless group	USSR	
55.	Electron-microscopic study of myocardium.	Myocardium	20 rats (10 centrifuge + 10 weightless)	USSR Poland	One 2x2 section from each heart
56.	Electron-microscopic study of retina.	Eyes	10 rats (5 weightless + 5 centrifuge) on 26th day of readaptation period	U.S.	Two eyes from each rat.
57.	Study of the enzymes which transform carbohydrates to lipids.	Liver	20 rats (10 centrifuge + 10 weightless)	U.S.	1/2 liver from each rat.
58.	Biochemical study of lipid content of hepatic nucleic acids.	Liver	"	CSSR	600 mg from each liver.

1	2	3	4	5	6
59.	Biochemical study of the enzymes of catecholamine metabolism and other enzymes in the liver.	Liver	20 rats (10 centrifuge + 10 weightless)	CSSR	2.5 g from each liver.
60.	Biochemical study of protein synthesis in the liver.	Liver	5 rats from weightless group	Hungary	2/3 liver.
61.	Biochemical study of oxidative-metabolism enzymes in the liver.	Liver	20 rats (lo centrifuge + 10 weightless)	USSR	500 mg from each liver.
62.	Biochemical study of the glycolysis rate and amino acid metabolism in the liver.	"	5 rats from weightless group	USSR	200 mg from each liver.
63.	Biochemical investigation of the nucleic acid content and the activity of the enzymes involved in controlling their synthesis.	"	"	USSR	1.2 g from each liver.
64.	Histological study of the liver.	"	20 rats (10 centrifuge + 10 weightless)	USSR	
65.	Biochemical study of white and brown adipose tissue.	White and brown adipose tissue	25 rats (10 centrifuge + 15 weightless)	CSSR	
66.	Biochemical, histological, histochemical and electron-microscopic study of submaxillary glands.	Submaxillary glands	"	USSR Rumania	One gland from each rat.

1	2	3	4	5	6
67.	Biochemical, histological, histochemical and electron-microscopic study of the pancreas.	Pancreas	25 rats (10 centrifuge + 15 weightless)	USSR Rumania	1/2 pancreas from each rat.
68.	Biochemical, histological, histochemical and electron-microscopic study of the stomach.	Stomach	"	USSR Rumania	1/2 pancreas from each rat.
69.	Biochemical, histological, histochemical and electron-microscopic study of the small intestine.	Small intestine	"	USSR Rumania	
70.	Morphological study of Fater-Pachinni bodies	Pads of paws	"	USSR	

Note: 1. Analogous studies will be done on the animals from the synchronous experiment and the vivarium control group.

2. For study No. 4, the left and right tibias and left femur will be taken from six animals of the vivarium control group.

Table 4. List of Clinical and Physiological Studies during the Readaptation Period (Experiment K-1241)

No.	Operation	Number of animals	Readaptation days
1.	Observation of animals' general condition, behavior and body-weight dynamics.	15	0 - 25
2.	Injection of declomycin.	15	5

No.	Operation	Number of animals	Readaptation days
3.	Determination of body temperature and motor activity.	15	7, 9, 15
4.	Otoscopic examination.	15	0, 10, 25
5.	Hematological study (morphological picture of peripheral blood).	15	0, 3, 6, 11, 16, 25
6.	Microbiological study (assessment of bactericidal activity of tail skin and microflora in throat).	15	0, 3, 6, 11, 16, 25
7.	Gaseous-exchange study.	15	3, 6, 11, 16, 25
8.	Assessment of animals' behavioral responses.	15	3, 6, 8, 10, 11, 14 - 21, 25
9.	Balance studies based on indices of water and mineral metabolism. Assimilability study of proteins, fats and carbohydrates. Determination of the ion-regulatory function of the kidneys (water and saline loading test).	15	0, 1, 2, 4, 5, 12 - 13
10.	Study of the degree of spontaneous hemolysis during the erythrocyte lifetime.	15	3, 6, 8, 10, 11, 14, 16 - 25
11.	Functional stress test (immobilization stress)	15	0, 16
12.	Determination of animals' working capacity based on static endurance.	15	0, 3, 6, 11, 16, 25
13.	Study of equilibrium function.	15	0, 3, 6, 11, 16, 25
14.	Electronystagmographic study of vestibular function	15	0, 3, 6, 11, 16, 25
15.	Study of the inversion and landing reflex.	15	0, 3, 6, 11, 16, 25

Note: Animals will be given another declomycin injection on the last day of the synchronous experiment.

Table 5. List of Scientific Institutions Participating in the Experiments on the 1977 Biological Satellite

No.	Name of Institution	Country
	K-1241: Experiment with Rats	
1.	Institute of Medical and Biological Problems of the Ministry of Public Health of the USSR	USSR
2.	Central Scientific Research Institute of Traumatology and Orthopedics imeni Priorov of the USSR Ministry of Public Health	USSR
3.	Central Scientific Research Institute of Stomatology of the USSR Ministry of Public Health	USSR
4.	Institute of Evolutionary Physiology and Biochemistry of the USSR Academy of Sciences	USSR
5.	Institute of Biochemistry imeni Bakh of the USSR Academy of	USSR
6.	Institute of Physiology imeni Pavlov of the USSR Academy of Sciences	USSR
7.	Central Scientific Research Institute of Gastroenterology of the Moscow Municipal Executive Committee	USSR
8.	Institute of Medical Radiology of the USSR Academy of Medical Sciences	USSR
9.	Institute of Nutrition of the USSR Academy of Medical Sciences	USSR
10.	Central Scientific Research Institute of First Aid imeni Sklifasov of the RSFSR Ministry of Public Health	USSR
11.	Institute of Aviation Medicine, Warsaw	Poland

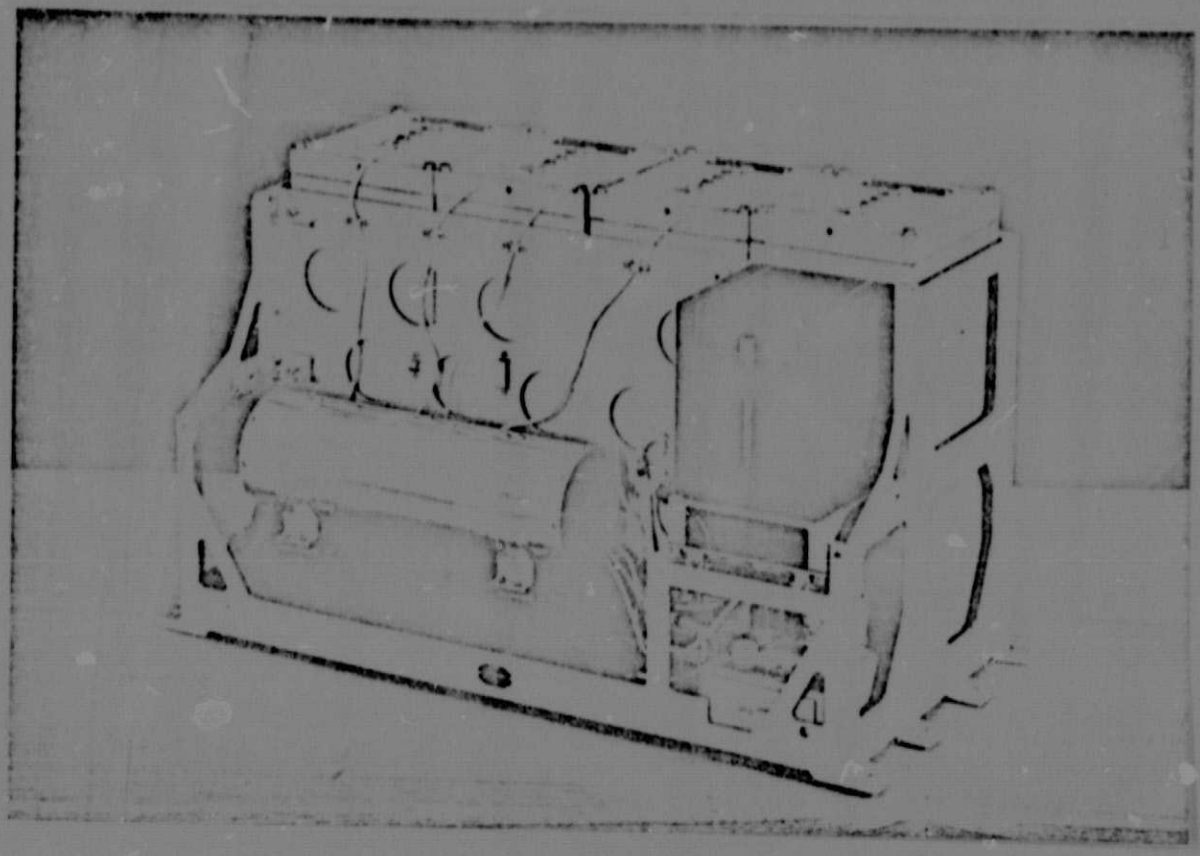
No.	Name of Institution	Country
12.	Institute of Experimental Endocrinology of the Slovakian Academy of Sciences, Bratislava	CSSR
13.	State University imeni P. Shafarik, Koshitse	CSSR
14.	Institute of Physiology, Bucharest	Rumania
15.	Curie National Scientific Research Institute of Radiobiology and Radiohygiene, Budapest	Hungary
16.	Institute of X-Ray Technology and Radiobiology of the Medical Academy, Sofia	Bulgaria
17.	L. Pasteur Institute	France
18.	University of Paris	France
19.	Dosimetry Laboratory of the Fontenay-aux-Roses Center	France
20.	NASA Ames Research Center	U.S.
	K-1242: Experiment with Higher Plants	
1.	Institute of Medical and Biological Problems of the USSR Ministry of Public Health	USSR
	K-1242: Experiment with Lower Plants	
1.	Institute of Medical and Biological Problems of the USSR Ministry of Public Health	USSR
	K-1244: Experiment with Insects (Oregon-R-strain pomace flies)	
1.	Institute of Medical and Biological Problems of the USSR Ministry of Public Health	USSR

No.	Name of Institution	Country
2.	NASA Ames Research Center, U.S.	U.S.
	K-1245: "Bioblok" Experiment	
1.	Institute of Medical and Biological Problems of the USSR Ministry of Public Health	USSR
2.	Institute of Nuclear Physics of the Atomic Energy Commission	Rumania
3.	Laboratory of Medical Biology of the Department of Medicine of Toulouse University	France
4.	Laboratory of Corpuscular Radiation of the Strasbourg Nuclear Research Center	France
	K-246: "Heat Transfer I" Experiment	
1.	Institute of Medical and Biological Problems of the USSR Ministry of Public Health	USSR
2.	Institute of Biophysics of the Czechoslovakian Academy of Science	CSSR
	K-1247: Electrostatic Shield Experiment	
1.	Institute of Medical and Biological Problems of the USSR Ministry of Public Health	USSR
2.	All-Union Scientific Research Institute of Electronic Standards	USSR
	K-1248: Dielectric Shield Experiment	
1.	Institute of Medical and Biological Problems of the USSR Ministry of Public Health	USSR

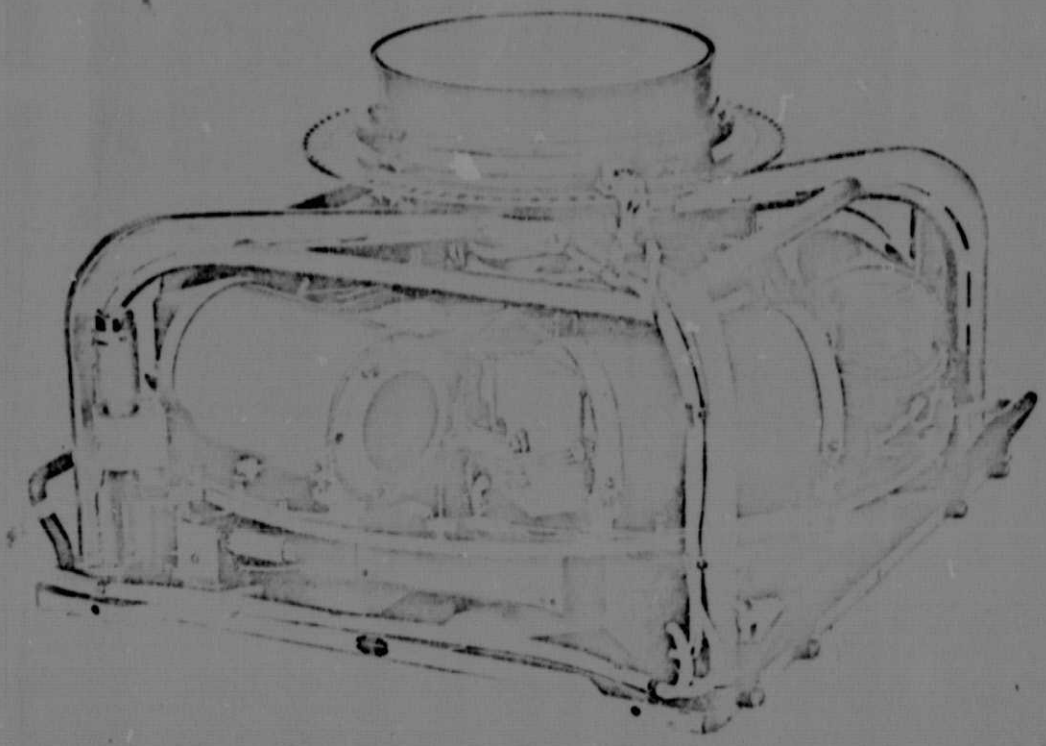
No.	Name of Institution	Country

K-1249/K-206: "Iondose" Experiment on Radiation Dosimetry

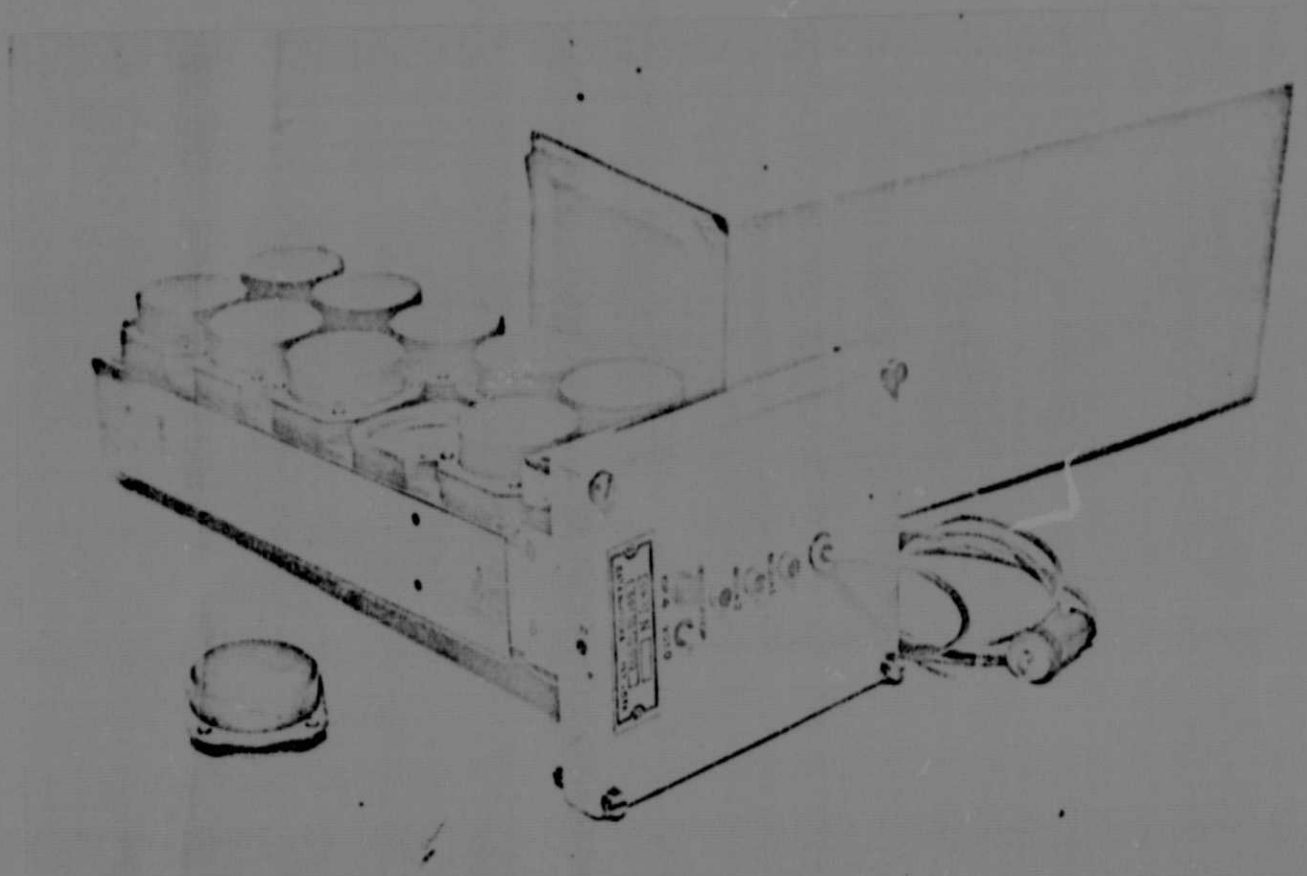
1.	Institute of Medical and Biological Problems of the USSR Ministry of Public Health	USSR
2.	NASA Ames Research Center	U.S.
3.	University of San Francisco	U.S.



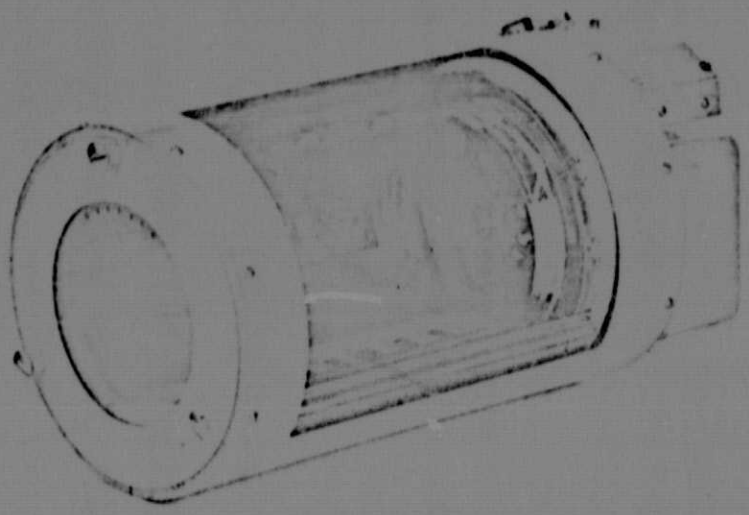
Unit for biological investigations, including a thermostat for the Soviet-French "Bioblok" experiment, "biofixators" (4) and the instrumentation for the Soviet-Czech "Heat Transfer I" experiment.



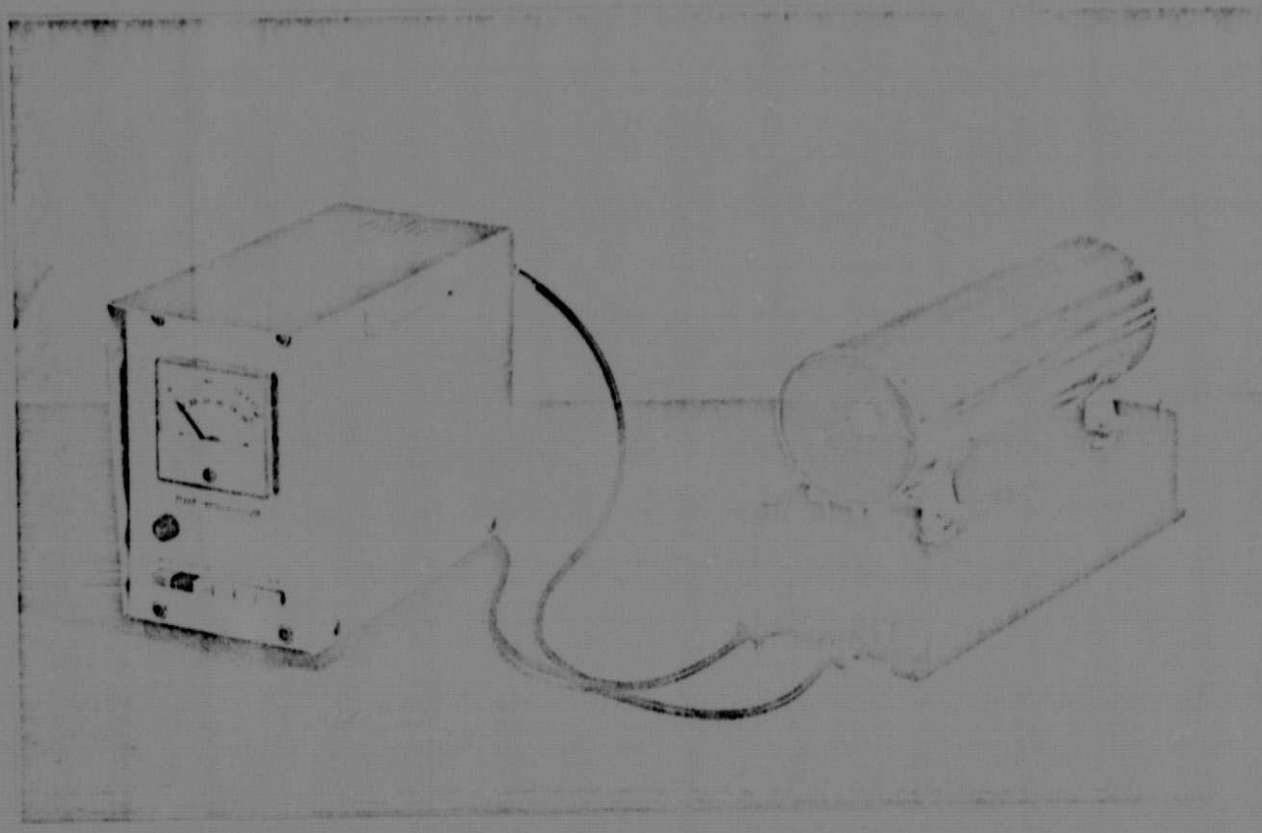
Centrifuge for creating artificial gravity in rat experiment.



Automatic "biofixator" for conducting experiments with plants during space flight.



A single rat holding cell from the on-board centrifuge.



On-board equipment for performing biophysical investigations (Czech design).