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MAIN RESULTS OF THE EXPERIMENTS CONDUCTED DURING THE FLIGHT OF THE KOSMOS-1129 BIOSATELLITE AND THE STATUS OF PREPARATION OF STUDIES ON THE NEXT BIOSATELLITE

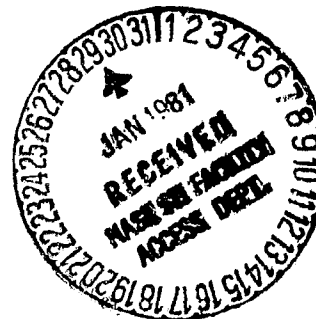
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MAIN RESULTS OF THE EXPERIMENTS CONDUCTED DURING THE FLIGHT
OF THE KOSMOS-1129 BIOSATELLITE AND THE STATUS OF
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The Kosmos-1129 biosatellite, which was launched into space on September 25, 1979, is the fifth automatic biologic laboratory. The first such laboratory, the Kosmos-605 biosatellite, was launched in 1973. /1*

The construction of the biosatellite is subordinated to completion of the main task: provision of a means by which various biologic experiments can be conducted during space flight up to 30 days and return of biologic subjects to the earth. The biosatellite consists of three chambers: the re-entry apparatus, the instrument aggregate chamber and a hermetic container with additional chemical sources of power.

The re-entry apparatus is the most complex chamber. It is in the form of a sphere with a diameter of about 2 m. The frame is made of aluminum alloy and the exterior has a heat-protective covering, which is essential during re-entry when it passes through dense layers of atmosphere. The re-entry apparatus has three round hatches, two for equipment assembly. The third hatch serves as the top of the parachute container. Inside the frame of the re-entry apparatus are situated the safety equipment and the scientific equipment with the biologic subjects.

Depending on the program of experiments and the constitution of the scientific equipment, the internal design of the re-entry apparatus is easily altered without substantial construction modifications, which is important for the experimental satellite.

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

The instrument aggregate chamber contains equipment that permits the biosatellite's orbital flight as well as a braking motor device for descent from orbit. /2

Tanks with compressed gas for the motors of the orientation system are mounted on the upper cone of the biosatellite's instrument aggregate chamber.

A full-scale model of the biosatellites has been set up in the Space Museum in Moscow.

The programs of scientific experiments in the flights of the five Kosmos biosatellites have been characterized by their order as well as by a gradual complication and deepening of the conducted investigations. Since 1975, that is, the flight of the kosmos-782 biosatellite, scientists from Czechoslovakia, Hungary, Poland, Bulgaria, Rumania, the GDR, the USA and France have taken an active part in these programs. Today we are pleased to note the highly productive collaboration of Soviet and American specialists in the preparation, performance and analysis of results of joint experiments that were conducted in the flights of three Kosmos biosatellites.

In these experiments fundamental attention was concentrated on the study of the biologic effects of such a unique factor of space flight as weightlessness.

Before the launch of the Kosmos-1129 biosatellite in many experiments on board the preceding biosatellites it was shown that weightlessness does not have a significant effect on the intracellular mechanisms of vital activity and does not promote the occurrence of pathologic or irreversible changes in the organism's physiologic systems. Moreover, in a study of rats in space flight conditions the appearance of moderately expressed stress and of specific adaptive changes in the locomotor apparatus, myocardium, blood system and some other physiologic systems of the organism was discovered. /2

On the basis of these data, the program of investigations on the

Kosmos-1129 biosatellite provided for a more in-depth study of the mechanisms of the adaptation of biologic systems to conditions of weightlessness.

Used as experimental subjects on board the Kosmos-1129 biosatellite were SPF Vistar rats, the drosophila fruit fly, eggs of the Japanese quail, higher plants, lower fungi and cultures of animal and plant cells.

The flight of the Kosmos-1129 biosatellite lasted 18.5 days. The maximum distance of the biosatellite from the surface of the earth (at the apogee) was 406 km; the minimum distance from the surface of the earth (at the perigee) was 226 km. Practically simultaneously with the flight with a displacement of 5 days a synchronous control experiment was conducted on earth in a model of the biosatellite's re-entry apparatus. In this experiment, practically all the physiologically significant factors of the space flight with the exception of weightlessness were imitated. The remaining control experiments were conducted in laboratory conditions.

Analysis of the telemetric information received from the biosatellite during its orbital flight showed that the following atmospheric parameters were maintained in the pressure cabin with the biologic subjects:

content of oxygen	135-212 mm Hg
content of carbon dioxide	to 7 mm Hg
air temperature	22-25° C
relative humidity	56-66%

The content of gaseous trace contaminants in the air of the biosatellite's pressure cabin during the flight was judged on the basis of the results of studies of the content of several basic volatile products of the metabolism of the animals in experiments conducted in the earth-based model of the biosatellite's re-entry apparatus. The studies showed that the content of most of the trace elements was at levels significantly lower than the threshold concentrations that can cause a toxic effect with long-term, continuous action. Along with

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this a gradual increase in the concentration of carbon monoxide, the peak value of which was 52 mg/m^3 , was discovered. The results of animal experiments as well as the literary data gave reason to believe that the increased carbon monoxide concentrations discovered in the air of the biosatellite's re-entry apparatus in our experiments could not, in small periods of exposure, have any significant effect on the state of the organism's physiologic systems.

The dispersed content and quantity of aerosol particles in the air and the noise level in the biosatellite's re-entry apparatus did not exceed the permissible values.

During the biosatellite's flight and in the synchronous control experiment the rats were in individual cages of automatic maintenance units. Each 200 x 100 cylindric cage was fitted with a feeding dish, water dish, dome light, ventilation system and compartment for the experiments. Five cages were structurally united into one unit. On the Kosmos-1129 biosatellite there were six such units for the housing of 30 rats and one unit of new construction for the gregarious housing of seven rats. Thus there were a total of 37 rats on board the Kosmos-1129 biosatellite.

A nutritionally balanced pasty feed was used to feed the rats. The animals' food consumption and anabolism in the flight and earth-based experiments were practically identical. The animals' water consumption in the flight and the earth-based control experiments was not limited. The light day was 12 hours. /5

The animals' condition during the flight was checked through channels of the radiotelemetric communication by means of registration of the total motor activity and the body temperature. The construction of the devices for the registration of total motor activity was based on a noncontact method. The cage itself served as the sensitive element of the noncontact monitor. Intraperitoneally inserted transmitters with amplitude-impulse modulation of carrier signal radio frequency were used for the registration of the rats' body temperature.

Receiving antennae were mounted in the body of the animal cages.

In the flight and synchronous experiments the total motor activity was registered every 2 hours for 24 hours on odd days, and the body temperature was registered on even days.

The use of a specially constructed unit on board the biosatellite made it possible for the first time to record in flight the parameters of the animals' conditioned reflex responses to light stimuli by means of the character of the motor reaction in the vicinity of the feeding dish.

Positive conditioned reflexes had been developed and well reinforced in the animals before the start of the experiments (basic and synchronous). The differentiation had to be formed in the course of the experiment itself.

The results showed that during the flight there was a reduction of the rats' conditioned reflex activity, with weakening of both inhibitory and stimulatory processes. The number of "prolapses" of conditioned reflexes increased. The degree of the reflexes decreased, and the latent periods became longer. /b

Also seen was a leveling of response reactions to strong and weak conditioned signals in the middle of the flight (7-12 days).

By the end of the experiment the adverse changes in conditioned reflex activity were decreased, although they did not completely disappear.

The deterioration of the rats' conditioned reflex activity during the flight was moderate and reversible. This was indicated by the absence of gross disturbances in the function of the higher regions of the central nervous system, as well as by the appearance of signs of adaptive changes, primarily in the condition of the stimulating process.

A study of the effect of the conditions of space flight on bio-rhythms was continued during the flight of the Kosmos-1129 biosatellite.

In experiments on the Kosmos-782 and Kosmos-936 biosatellites it had been shown that the daily rhythm of motor activity (MA) and body temperature (BT) remains stable during the entire flight, and the distribution of the animals' activity and rest in the daily cycle remains normal.

In the given experiment the task was to study the process of the phase restructuring of the daily cycle of MA and BT in rats in flight after inversion of the light period phase. The second task was an evaluation of the circadian and minute rhythms in animals in the re-adaptation period.

Before and during the flight the rats were kept in conditions of artificial light in a "light-dark" regimen of 12/12. On the 10th day of the experiment the light period was inverted by doubling the dark time with a phase shift of 180°. After the flight the animals were kept in conditions of a inverted lighting regimen. /Z

The circadian rhythms were studied by FNR specialists in the postflight period as well by indices of the daily dynamics of diuresis and excretion of hydroxyproline and electrolytes with the urine.

The microrhythms of the minute range were studied by the indices of conditioned reflex motor reactions in painful reinforcement. The work was conducted by the procedures of K. Gekht and specialists of the GDR. The minute oscillations of the latent period and the times of the animal's run after presentation of the conditioned signal were determined.

In the experiment on the Kosmos-1129 biosatellite, before inversion of the light regimen, the normal daily rhythms of MA and BT were maintained in the rats. Immediately after inversion a unidirectional and uniform displacement of the MA and BT phases began, which continued

to the end of the flight (18.5 days) and exceeded 180° . The rate of the MA and BT phase shift after inversion in the flight did not differ from this index in the synchronous experiment.

After completion of the flight and the synchronous experiment, some disturbances of circadian rhythms were noted in the first observations, both by MA and BT indices and by data of the dynamics of diuresis and hydroxyproline and electrolyte excretion. The circadian rhythm of MA and BT was not clearly expressed in this period, but later became stabilized. The terminal phases of the rhythms of diureses and sodium and potassium excretion were shifted from the second half of the "dark" phase to the beginning of the "light" phase in the flight group. In these rats no rhythm of hydroxyproline excretion was detected, and the maximum excretion of phosphates and calcium was shifted to the beginning of the "dark" phase.

In the first two observations (5 and 10 days) the minute rhythms of the conditioned reflex motor reactions, the latent period and the running time in animals of the flight and synchronous groups were disturbed. No norm characteristic distribution of amplitudes and phase connections in the circadian cycle were found in this period. In subsequent observations (15-29 days) complete normalization gradually occurred in the animals of the synchronous experiment, whereas in the flight group of rats the rhythms of the minute range remained disturbed to the end of the observation period. /E

Thus, weightlessness and other factors of the flight did not affect the maintenance of MA and BT circadian rhythms in flight or the rate of phase restructuring in the course of the flight. However, the flight factors proved to be clearly unfavorable with respect to the organization and maintenance of normal rhythms of daily and minute ranges in the readaptation period.

Metabolism studies were significantly expanded in the experiments on the Kosmos-1129 biosatellite. In particular, for the first time in flight practice a special Soviet-American experiment to study the ef-

fect of weightlessness on the body composition of animals was conducted.

The total body mass, pure body mass (total body mass minus mass of the hair covering, the contents of the gastrointestinal tract and the contents of the urinary bladder), skin mass, mass of the musculoskeletal system (eviscerated carcass with tail) and the mass of all the internal organs were determined in this experiment. The content of water and fat was determined in the skin, the musculoskeletal system and the sum of all the internal organs. In the dried, defatted mass, the content of nitrogen, phosphorus, potassium, sodium, calcium, magnesium and creatine was determined.

The animals of the flight group markedly differed from the vivarium control by the high content of fat in all the body components; by an increase in the wet and dry mass of the internal organs, especially abdominal fat, of the gastrointestinal tract, liver, kidneys and cervical glands; by a decrease in total body weight, mass of the skin and musculoskeletal system, their dry defatted mass and water; and by a reduction in the quantity of creatine in the body. /9

Comparison of the data on the body composition of animals of the flight group and the synchronous control showed that the flight animals had less mass of defatted components and less mass of the skin and of the musculoskeletal system as a whole. Also noted in animals of the flight group were a reduction in spleen mass and an increase in kidney mass, which corresponds to previously obtained results. For the first time an increase in liver mass was detected. The flight animals also differed from the animals of the synchronous control by a lower level of hydration, especially of the skin and musculoskeletal system. In the dry defatted body mass a reduced creatine content was discovered. Soviet and American specialists obtained varying data on the total calcium content in the body of the animals.

No significant changes in the blood levels of ACTH, glucagon and glucose were discovered in the postflight investigation. At the same time, a significant increase in the insulin level was found, which in-

dicates an increase in the functional activity of the beta cells of the pancreas. Also discovered was an increase in the level of triiodothyronine against a background of increased concentration of thyrotropic hormone and decreased concentration of thyroxine, which indicates some reduction in the functional activity of the thyroid gland. These changes continued for 6 days after completion of the flight.

The functional load test in the form of 2.5-hour immobilization, which was done twice in the postflight period, showed a less marked reaction of the hypothalamus-hypophysis system (on the basis of ACTH content in the blood) in the animals of the flight group than in the control. /10

Moreover, the enzymatic system of cyclic adenosine monophosphate (cAMP) synthesis in the hypophysis of animals of the flight and synchronous groups reacted to immobilization with changes in the activity of adenylate cyclase and phosphodiesterase activity that were close in value, and namely by activation of adenylate cyclase and reduction of phosphodiesterase activity.

The space flight did not affect the content of nucleic acids in the Purkinje cells of the rats' cerebellar cortex and in their glial cells--satellites. The test with immobilization did not affect the content of nucleic acids in the rats of the flight group, but significantly increased their content in the rats in the synchronous control group.

In the liver of rats that were studied immediately after completion of the flight, no changes in DNA metabolism were discovered; the small changes concerned only RNA metabolism. The test with immobilization did not lead to a change in the RNA content in the liver, whereas the DNA concentration was increased reliably. The DNA polymerase system in the experimental animals reacted to immobilization as did that in the control animals, and the RNA polymerase system proved to be insensitive to the action of additional stress.

Immediately after the flight a significant ($1\frac{1}{2}$ times) reduction in the DNA content in the rats' spleen was discovered, which was evidently caused by the alteration in the cellular composition of this organ, but 6 days after the flight the DNA level no longer differed from the control. Immobilization of the animals in the postflight period led to a significant increase in the DNA concentration and reduction in the RNA content in the rats' spleen, and the effect of immobilization was expressed significantly stronger in the flight rats than in the vivarium and synchronous control groups. /11

An increase in the level of polydesoxyribonucleotides of approximately 2 times as compared to the control was found in the thymus of the rats of the flight group immediately after landing, and the content of DNA and RNA and the weight of the organ were significantly reduced. The level of polydesoxyribonucleotides had normalized 6 days after the flight, although the content of nucleic acids and the weight of the thymus were not restored.

The changes in the thymus caused by immobilization were expressed in a significant increase in the level of polydesoxyribonucleotides and a reduction of nucleic acids and organ mass. These changes were clearer in the flight and synchronous experiment groups than in the vivarium control.

No changes were found in the concentration of nucleic acids in the bone marrow and blood of the rats immediately after the flight. Six days after landing the concentration of DNA in the bone marrow had increased, whereas the RNA concentration in the blood was reduced as compared to the vivarium control. With respect to the effect of immobilization in the bone marrow of the flight rats, the concentration of nucleic acids had a tendency toward reduction (in contrast to the synchronous and vivarium control). A reduction of the blood DNA level was found as well.

Study of the reaction of cellular elements of the blood and lymphoid organs to the effect of space flight factors showed the presence of a

clearly expressed stress reaction 6-10 hours after the flight (neutrophilia, lymphopenia, decrease in the weight of lymphoid organs and the number of cellular elements, increase in the number of pyknotic cells in the thymus). To additional stress tests the reaction of the cellular elements of the blood and lymphoid organs in the animals of the flight group was the same as that in the control; the difference in absolute values of the studied indices between the experiment and the control after the tests was significant and statistically reliable. /12

The results obtained in the study of the activity of oxidative enzymes (malate and isocitrate dehydrogenases) and the glycolytic enzyme lactate dehydrogenase in the rats' subcellular liver fractions after flight indicate, on the one hand, suppression of the processes of the oxidation of substrates of the Krebs cycle in the mitochondria; on the other hand, suppression of the processes of glycolysis in the cytoplasm and, possibly, reinforcement of the processes of gluconeogenesis. Repeated stress tests in the postflight period did not have a noticeable effect on the activity of the studied enzymes in any of the groups of rats.

Determination of the activity of glycogen-splitting enzymes (alpha amylases and aldolases) in the ulna makes it possible to conclude that the rats' 18-day stay in space flight conditions causes some changes in the enzymatic activity of the organic matrix of the bone tissue, and that the reaction of the studied enzymes, which participate in the splitting of glycogen, is probably directed at removal of the adverse effect of weightlessness. A series of experiments with immobilization indicates that the detected changes in the activity of the studied enzymes can also occur in response to a nonspecific stress-producing impulse.

The results of the studies of skeletal muscles and the locomotor apparatus that were conducted on the Kosmos-1129 biosatellite on the whole confirmed the previously discovered dependence of the expression of the changes that occur in different skeletal muscles in conditions of weightlessness on the degree of the muscles' participation in anti-gravitation function. Thanks to wider cooperation of specialists of /13

other countries and scientific organizations of the USSR in the experiment on the Kosmos-1129 biosatellite it was possible to significantly strengthen our understanding of the picture and mechanisms of adaptive changes in the muscles and bone tissue.

The results confirm the previously stated hypothesis that the reaction of the antigravitation muscles to weightlessness not only has features of functional atrophy, but also has a clearly adaptive character. Also confirmed were data, which were obtained in an experiment on the Kosmos-936 biosatellite, showing that the changes in the physiologic characteristics of the rats' antigravitation muscles (soleus, shoulder triceps) are related to adaptive changes of the contractile properties of the muscles' functional proteins. For the first time it was shown that these changes are caused by restructuring of the submolecular composition of the contractile proteins, which is accompanied by a change in the spectrum of isoenzymes of myosin in the muscle fibers, which are differentiated by the content and properties of the low-molecular protein fragments. The resultant data indicate the possibility of the transformation of the phenotype of muscle fibers from slow to rapid in space flight conditions. There are reasons to believe that the signs of the activation of catabolic processes in the muscle that were noted in the experiment are related to switching on of the control mechanism of the proteins' life duration "for the purpose of" accelerating the process of the transformation of the phenotype of the muscle fibers, which are adapting to the new biomechanics of contraction in the conditions of the experiment. Morphologic studies of the muscles, which were carried out in the given experiment by specialists of the USA, do not contradict the above stated considerations.

Studies of the bone tissue, which were conducted by specialists of the USSR and the USA, clearly showed that such changes as the volume and intensity of resorption as well as the intensity of periosteal bone formation are more clearly expressed in the tibia than in the bones of the shoulder. During study of the rats, American specialists obtained essentially new data on the reaction of the bone tissue of the vertebrae and the vertebral column as a system. In the flight group of animals

a reduction was found in the strength of isolated vertebrae, and an increase was found in the sensitivity of the vertebral column as a whole to mechanical loads. It was discovered that this change in the sensitivity to a load was unevenly distributed along the length of the vertebral column and that the readaptation period, 29 days, was insufficient for complete restoration of the mechanical strength of the skeleton.

In the ontogenesis experiment no progeny were obtained from the rats exposed in space flight conditions. Therefore a reserve variant of the program was used, the goal of which was study of long-term consequences of space flight, including the possible effect of weightlessness and other factors on the male gametes. Males who had been exposed in weightlessness conditions were mated with intact females 5 days and 2.5-3 months after the flight. In the first variant of the experiment the ejaculate consisted of spermatozoa that had been subjected to the effect of weightlessness in the "mature" state; in the second variant were spermatozoa that had been subjected to the effect of space flight factors at the stage of a stem cell of spermatogenesis--spermatogone.

In the interval between these matings, 4-5 weeks after the flight, the males of the flight, vivarium and synchronous groups were mated with females of the corresponding groups. By this time the males' ejaculate consisted of spermatozoa that had been subjected to the effect of space flight factors at the stage of second order spermatozoa and type B spermatogones. /15

No significant reduction in the number and weight of offspring was detected in any of the mating variants.

With the mating 5 days after the flight, an increase in the number of females was noted in the progeny of the flight and synchronous groups: 122-124 (to 100 males), with 91 in the vivarium control, which may be a result of the different stressor situations that took place in the two situations. In the study of the soft tissues and internal or-

ans of the newborn offspring by Wilson's method in this series of experiments an increase in the number of baby rats with deviations from the norm was noted in the progeny of the flight males up to 37%, with 11% in the synchronous and 19% in the vivarium control. All the deviations in the progeny of the control groups were represented by edema and hemorrhages; in the progeny of the males who had been in flight, in addition to this, anomalies of the internal organs were seen: hydrocephalus, ectopia renis, increase in the urinary bladder (19% of the deviations).

Study of the physical development in the first month of life of the baby rats obtained from the mating of males from the flight group with intact females 5 days after the flight showed that they lagged behind the progeny of the synchronous control. The delay was manifested in later detachment of the ears, opening of the eyes and appearance of fur, in an increase in the number of specimens that moved little, etc.

With mating of males from the flight group with intact females 2.5-3 months after the flight, no increase in the number of anomalies of the internal organs in their progeny as compared to the progeny of the control males was discovered. In this series of experiments the animals were examined on the 21st day of pregnancy. The rate and characteristics of postnatal development were not studied.

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The relative weight of the internal organs in the first month after birth in all the mating variants was the same in the progeny of the flight and the control animals; small fluctuations were related to fluctuations in the number of baby rats in the litter.

Before the baby rats reached 30 days of age, a one-time immobilization stress test was conducted on them, just as on the adult animals after the flight. On study of the cytogram of the peripheral blood, no difference was found between the progeny of the experimental and control animals in any of the mating variants either before or after the test. At the same time, study of the animals' behavior in a Lech-

man labyrinth in a number of cases showed less tolerance of the stress test in the progeny of rats that had been in flight.

On the basis of the limitation in our materials and the great variability of the characteristics of laboratory animals, we believe that it would be premature to draw conclusions regarding the possible adverse effect of flight factors on the generative function of mammals. At the same time, the obtained data alert us to and indicate the necessity of continuing and expanding investigations in this direction.

Along with the so-called physiologic experiments on rats in the flight of the Kosmos-1129 biosatellite, a number of experiments directed at further study of the biologic role of the force of gravity were conducted.

The results obtained in the experiment with cultures of animal cells once again showed that weightlessness does not cause irreversible structural changes in the cells of mammals and does not lead to genetic changes in the cellular generation that is formed in flight conditions. /17

An experiment with the lower fungus *Physarum polycephalum*, which is a multinucleate unicellular organism, deserves mention. On the basis of observations of the migration of this fungus on the surface of the substrate, a hypothesis that in weightlessness the intensity of protoplasm movement apparently decreases was put forth.

The results of an experiment with the higher plant *Arabidopsis thaliana* are of considerable interest. The plants, planted in soil at the rosette stage, completed a full cycle of development in weightlessness in the 18.5 days, put forth buds, bloomed and gave germinative viable seeds. With these seeds it was shown that in the conditions of space flight with illumination and maintenance of other conditions of cultivation, higher plants can develop favorably and pass from vegetative growth to generative development.

The experiment with the Japanese quail (*Coturnix coturnix*) eggs

showed that weightlessness is not a principal obstacle to the normal embryogenesis of birds. Analysis showed that the cause of the lag in the development rate of the embryos in flight, the increase in the percentage of their mortality and the appearance of structural anomalies is not the absence of gravity but breakdown in the humidification system in the incubator.

The experiment with the drosophila fruit fly was directed at a study of gravitation preference. It was conducted in an instrument that was a centrifuge with four arms in the shape of a cross. Three feeding dishes were situated in each arm of the cross at varying distances from the center. On revolution of the centrifuge at a rate of 53 rpm, AG* was created equal to 0.3 g in the area of the first feeding dishes, 0.6 g in the area of the second and 1.0 g in the area of the third. Ten days before the flight a parent culture with drosophila eggs such that flies would begin to come from it on the first day of flight was placed in the central feeding dish with nutrient medium. Gravitation preference was determined after the flight by the number of pupae and their shells in the feeding dishes and in close proximity to them. /18

Analysis of the results of this experiment showed that the distribution of pupae and larvae in the areas with different AG* values was identical. This means that the entire range of studied accelerations from 0 to 1.0 g is uniformly indifferent for drosophila and for its embryonal development and genotype.

In an experiment on lettuce seeds (*Lactuca sativa*) the frequency and nature of chromosomal injuries were studied. During the flight the seeds were found in special biologic containers that were attached inside and outside the biosatellite together with plastic radiation detectors. These detectors were intended to record the flow of heavy charged particles and to study their physical characteristics, as well as to identify the places the particles passed through the biologic subjects. For registration of the total dose, in the same place there were thermoluminescent dosimeters, the postflight study of which showed

*AG= artificial gravity

that for the whole flight the average total dose in the internal and external containers was 0.3 and 0.6 rad, respectively.

In the external container it was discovered that 0.5% of the seeds had heavy charged particles in them; in the internal container, 4.8%. /19
The greatest number of impacts occurred in cotyledons (41.8%).
In the root and stalk meristems the number of impacts was insignificant: 4.8 and 3.0%, respectively. In the seeds in which heavy charged particle impact had been recorded the number of chromosomal aberrations was 2-2.5 times greater than in seeds without heavy charged particles. On analysis of the frequency of chromosomal disturbances with respect to the place of heavy charged particle impact it was shown that the most sensitive target in the seed is the area of the root meristem.

The distribution of absorbed doses of cosmic radiation behind thin screens in the thickness range from 0.0035 to 0.15 g/cm² was studied for the first time on the Kosmos-1129 biosatellite. The surface dose in a 0.02 g/cm²-thick layer behind a 0.0035 g/cm² screen was 2490 ± 130 rad for the flight, that is, the force of the dose was equal to 125 rad/day. With increase in the thickness of the protective screen the size of the dose sharply diminishes, and behind a screen 1 g/cm² thick it is 0.5 rad. The fluxes of heavy charged particles with linear energy transfers of linear energy loss₁₀₀₀ of 200 keV/mcm were 5.4 ± 0.7 and 3.7 ± 0.9 particles/cm² outside and inside the biosatellite, respectively. Analogously, the fluxes of neutrons were 1.7 x 10⁶ and 2.0 x 10⁶ neutrons/cm², respectively.

Such in general features are the main results of the experiments conducted in the flight of the Kosmos-1129 biosatellite. These results were presented in more detail at the KOSPAR session in June of this year in Budapest and at the international symposium on gravitation physiology in Budapest in July of this year.

The programs of experiments are being developed and the scientific research apparatus is being constructed in the USSR for the next Kosmos biosatellite, the 15-day flight of which is scheduled for the third

quarter of 1982.

The program of experiments in the flight of this biosatellite is for us nontraditional. For the first time in the Soviet practice of medical biologic flight experiments, macaque rhesus primates (*Macaca mulatta*), have been selected as study subjects. Two monkeys aged 3 and 4 years and weighing up to 5 kg will be on board the biosatellite in special capsules. /20

During the entire flight the monkeys will be in special chairs in a fixed position. A pasty ration has been developed to feed the animals; it will be given through mouthpieces twice a day. The contents of the ration include casein, butter and vegetable oil, rice and wheat flour, potato starch, sugar, dextrins, apples, raisins, eggs, tea and salt and vitamin mixtures. A daily norm of the ration contains 32 g protein, 17 g fat and 165 g carbohydrate. The calorie content of the ration is 960 kcal per monkey per day. Additionally, the monkeys will receive fruit juice as a reward for correct completion of the tests specified by the program of experiments.

The animals' condition during the flight will be monitored by such indices as the ECG, body temperature, frequency of movement and eating. Also planned is transmission of the television image of the monkeys to the Flight Control Center.

The main tasks of the physiologic studies on primates in the flight of the next Kosmos biosatellite are studies of the state of the vestibular apparatus, skeletal muscles, cardiovascular system and biorhythms in conditions of weightlessness and in the period of readaptation to the earth's gravity. Many morphologic and biochemical studies are also planned for the postflight period.

The function of the otolithic apparatus and the semicircular canals will be evaluated in the resting state and also with their stimulation--standard vertical changes of the position of the monkeys together with the chair and standardized horizontal deflections (random turn of the head in the direction of a target). /2

During these studies the following will be recorded: neurogram of the vestibular nucleus, electrooculogram, mechanogram of head movement, encephalogram of the sensory region of the cortex and tensogram of pressure on the lever.

Physiologic mechanisms of the adaptation of the skeletal muscles to weightlessness and the monkeys' motor functions will also be studied in the conditions of the presentation of functional loads. Recording of an electromyogram of the gastrocnemius and anterior tibial muscles, a dynamomyogram of the gastrocnemius muscle and a mechanogram of treadle movement is planned.

Study of the function of the monkeys' cardiovascular system in flight conditions will be conducted jointly by Soviet and American specialists. Proposed for this is recording of the arterial pressure and linear blood flow rate in the carotid artery, impedance of the chest cage and an electrocardiogram.

Biorhythms of the body temperature and the monkeys' motor activity will also be studied in the joint Soviet-American experiment.

Numerous biotechnical tests of different variants of the scientific research equipment and systems of housing the monkeys on board the biosatellite have been made, procedures for the clinical physiologic selection of monkeys for the flight have been chosen, procedures for the general and special training of the monkeys for the stay in the flight capsule are being developed, etc. Without a doubt a large amount of work remains for the preparation of the experiments with the monkeys; however, much has already been accomplished, which inspires optimism with respect to the possibility of timely and high-quality completion of all the planned tasks. /22

Continuation of the experimental studies on white laboratory rats is planned for the flight of the biosatellite in 1982. In particular, programs are now being developed for embryologic experiments that will be conducted in two variants. In the first variant a group of rats

consisting of 6 females will be impregnated before the flight (5 days before the launch). The second variant of the experiment is planned such that impregnation will occur during the flight. This experiment will be conducted on a group of rats consisting of three females and one male.

In the course of these experiments data will be obtained on the effect of weightlessness on individual stages of embryonal development, as well as data on age changes in the resistance and reactivity of an organism that has spent part of the embryonal development period in conditions of weightlessness.

For this purpose an experiment to study the energy metabolism with the use of a highly sensitive on-board calorimeter is also proposed for the next biosatellite. Germinating seeds of higher plants and insect pupae will serve as the subjects of the investigation.