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Chapter 3

Vladimir Ivanovich Yazdovsky: Biomedical Researcher Supporting Manned Spaceflight*

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The day of space triumph, when the first Earth-orbiting spacecraft was launched with a man onboard, has gone down in history. Since then, space exploration programs have well advanced. More and more space pioneers made their contribution to space exploration, in new technologies development, and in researching human capabilities.

Today, not everyone knows the names of the astronauts working on the International Space Station. But the name of Yuri Alexeyevich Gagarin, the first man to fly in space, is still known in all corners of our planet. A lot of people know the Chief Designer of Russian spacecraft, Sergei Pavlovich Korolyov. Meanwhile, the flight of Yuri Gagarin became possible not only due to the dedicated work of designers, engineers, and technicians who created the powerful rocket. The successful flight into space was also provided by the titanic work of scientists and experts in the field of aviation and space medicine [1, 3].

Human spaceflight was being prepared for over the previous 12 years. In Russia, Vladimir Ivanovich Yazdovsky was the leader of biomedical research for the preparation and implementation of manned spaceflight [4]. He is considered the patriarch of Russian space biology and medicine [5].

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Vladimir Yazdovsky was born on June 24, 1913, in the town of Ashgabat (also Ashkhabad, the capital of present-day Turkmenistan). His father was a collegiate councilor from an aristocratic Polish family. In addition to Russian and Polish, he knew several other languages. In a short time, the family moved to Petrograd, then to the town of Yelabuga. Here, V. Yazdovsky graduated from the nine-year school with honors. After his father's death, the family moved to Samarkand, where in 1933, V. Yazdovsky graduated from the Department of Land Reclamation of Higher Technical Cotton School, and began to work in Uzbekistan irrigation system office. In 1937, V. Yazdovsky decided to dedicate his life to the medical profession and entered Tashkent Medical Institute. He was still a student at the second course when he began to do surgical operations independently and decided to devote himself to neurosurgery. During this time, he also studied at Tashkent State Conservatory. On November 12, 1941, V. I. Yazdovsky received his medical degree and was appointed Head of reserve regiment health service in Kinel, a town in the Kuybyshev region. In July 1943, he became a divisional doctor of the 289th Guards Aviation Division, which took part in the liberation of Ukraine, Sevastopol, Pskov, and the Baltic states.

After the end of World War II, V. I. Yazdovsky served some time in this aviation division, and in 1947 he was transferred to Moscow Scientific-Research and Testing Institute of Aviation Medicine (SRTIAM) [7]. In that post, he often visited the design bureau of A. N. Tupolev, where he was involved in the development of hermetic aircraft cabins. In dealing with aircraft designers, he quickly established himself as a businesslike, energetic, competent representative of SRTIAM, well-versed in the problems of life-support systems, able to competently and clearly discuss problems, and identify ways to address them.

Andrey Nikolayevich Tupolev noticed these qualities and, in time, during conversations with S. P. Korolyev, advised him to instruct V. I. Yazdovsky to establish an organization of space biomedical research [11]. Shortly after this, Head of SRTIAM, Alexey Vasileyevich Pokrovsky, reported that V. I. Yazdovsky was appointed the leader of biomedical research on rockets and invited him to prepare a research program of biomedical support of high-altitude flights.

Vladimir Yazdovskiy was 36 years old when he and Sergey Korolyov were invited to meet the Minister of the USSR Armed Forces, Marshal A. M. Vasilevsky, and President of the USSR Academy of Sciences, S. I. Vavilov, to discuss the problems of rocket technology development. Under the supervision of V. I. Yazdovsky, the team was established, which included doctors A. D. Seryapin and V. I. Popov, and an engineer B. G. Buylov. They were to substantiate the possibility of human flight in near-Earth space, and to outline and set scientific and methodological problems in research, and organize opportunities to enable the environment of a living organism in space. And it was necessary to clearly determine the structure of research and to put forward ideas to justify scientific concepts and approaches, to suggest the principal directions of problems decided upon. V. I. Yazdovsky understood that human spaceflight was unthinkable without a multilateral approach to solving the problem [11]. It was necessary to ensure the safety of staying in a hermetic cabin when flying at a height of 100 km, to suggest methods of studying the status and behavior of animals in flight, to establish indicators for evaluating their physiological functions, to provide for the possibility of separating cabins for descent by parachute, and to ensure the efficiency of test and recording equipment. With this in mind, Vladimir Yazdovsky developed a program of biomedical support of high-altitude flights.

The program had philosophical and methodological direction and covered a wide range of problems. Biological subjects should exist in an environment and in conditions under the influence of flight factors, to meet natural physiological and hygienic needs, with the presence of significant risk and stress, under combined action of all the factors of flight. Given the significant risk and complexity of spaceflight, it was necessary to conduct a large series of animal experiments to validate the possibility of rocket flight and develop measures and devices to ensure the animals' safety [10, 11].

As chief of the already-established laboratory for this program of biomedical support of high-altitude flights, Vladimir Yazdovsky organized field sessions of the Academy of Medical Sciences, organized at the Institute in 1949.

Vladimir Yazdovsky reported the starting points of the program—to obtain information on the effects of the factors of spaceflight on the organism as a whole, explain the purpose of required device and instruments, and the training methodology. There were many questions and accusation to V. I. Yazdovsky and some scientists rejected the reality of space biology. But on the whole, the proposed program was adopted, and its validity was confirmed through the further development of manned spaceflight.

In 1950, the first science-research work in the field of space medicine, "Physiological and hygienic substantiation of flight opportunities in special conditions," was included in the research plan of SRTIAM. With his usual thoroughness V. I. Yazdovsky began to study the papers on space biology, published in the United States, as corresponding information was absent in the Soviet science literature. In experimental space research in the U.S.A., monkeys were used because their physiology is close to humans. However, monkeys are often marked by disruptions of the nervous system, and they had to be given anesthesia, which influenced the compensatory response of the organism. Therefore the decision was taken to use dogs as "pioneers of the Universe" [7].

In the selection of animals for spaceflight, V. I. Yazdovsky was guided by the following considerations: dogs had to endure a stay in a confined space in a special outfit, with fixed imposed, or implanted, sensors for a long time. The animals should develop or acquire conditional reactions and reflexes rapidly. The adverse effects observed in the animals should be easily transferable to what we might expect in people. In addition, it was important to easily get information about their condition when exposed to spaceflight factors and to ensure their needs for food, water, and oxygen. Dogs have biological similarities to a man, but respond well to training. They quickly get used to a fixed position of the tray of food in the cockpit and to the suit, and have a significantly lower weight. In addition, dogs have more resistance to disease and to environmental factors. Thus, in the interest of spaceflight, V. I. Yazdovsky preferred dogs [11].

For the experiments with dogs, female mongrels were selected. Equipment was adjusted so the animal could be restrained for a long time without wear or diaper rash. The head of the rocket was equipped with a sealed cabin, with a volume of 0.28 m^3 for the accommodation of the dogs, a life-support system, and recording equipment. The layout of the cabin was duplicated in SRTIAM for the experiments. And animals were appropriately trained and subjected to research on the nervous system, peculiarities of their physiological systems' functioning, and their behavior under different conditions. Conditioned reflexes were observed to ensure the adaptation of the animals to the dynamics of actual flights. In the laboratory, there were conditions created to simulate or model the effect of various spaceflight factors. In real flights, research was organized to combine the influence of flight factors on the body's systems, and the animal as a whole.

On June 22, 1951, V. I. Yazdovsky, A. D. Seryapin and V. I. Popov took part in launching of geophysical rockets, which had a hermetically sealed cabin with the dogs, Dezik and Tsygan. After 15 minutes, the animals safely returned to the Earth. This flight proved the possibility of a safe stay of living organisms at space altitudes. In 1951, there were five successful flights of single-stage geophysical rockets with animals. Not all were successful. However, it was established through experimentation that animals could successfully withstand a short-term impact of weightlessness.

In 1952, for biomedical support, launches of high-altitude rockets, such as R-1 and R-2A, and achieved altitudes of 110 km V. I. Yazdovsky, A. D. Seryapin, V. I. Popov, and SRTIAM Head, A. V. Pokrovsky, were awarded the Stalin Prize.

Then there was a pause in rocket launches until 1954. At that time, a more powerful rocket was developed. During this period, V. I. Yazdovsky summarized research in the hermetic cabin developed for jet aircraft and their crew life-support systems [9]. In 1955, V. I. Yazdovsky was preparing a candidate dissertation and received a medical degree. However, he continued to conduct rocket launchings with animals onboard, to an altitude of 110 km. From July 1954 to February 1955 there were six rocket launches of animals to an altitude of 100–110 km. In 1956, the rockets with animals aboard were launched on rockets to an altitude of 212 km, then more than 450 km.

At the same time, V. I. Yazdovsky led medical research for the development of space suits and sealed cabin life-support systems. They ensured the dogs' safe ejection in specially designed suits. The results of biological research of the upper atmosphere and outer space were carefully studied, compiled, and analyzed. At the initiative of Vladimir Yazdovsky, an informational edition on space biology and medicine was published [6]. He became an editor and author of most of the articles of the first Russian textbook on space biology and medicine. It was the start of the formation of a Russian school for scientists in the field of space biology and medicine.

In 1956, a decision by the Ministry of Defense established a science and research division at the Institute for research and medical support of flights in the upper atmosphere. V. I. Yazdovsky was appointed Head of this division. Under his leadership Oleg Gazenko, Abram Genin, Alexander Seryapin, Armen Gyurdzhian, Igor Balakhovsky and others were involved in the preparation of dogs for orbital flight. For the flight scheduled for November 3, 1957, a mongrel Layka was selected from a group of ten dogs. The hermetic cabin of the satellite was equipped for monitoring the physiological status of the animal by system, registering electrocardiogram, blood pressure, respiratory rate, and motor activity. Because the satellite was not equipped with rescue capability or ejection or landing systems, it was clear that the dog would not return to the Earth. But animal research was, in the figurative expression of Vladimir Yazdovsky, an important stage of "biological sensing the future routes of spaceflights and checking the reliability of all the systems of the spacecraft." The flight of Layka had a great significance. It summed up existing biological research, as a result of which scientists received indisputable practical evidence of the possibility of flying animals in weightlessness.

After Layka's flight, Sergey Korolyov instructed Vladimir Yazdovsky to organize a dog's preparation for a one-day orbital flight and subsequent return to the Earth. This job was received with enthusiasm. To perform an orbital flight and return to the Earth, the dogs were trained carefully to accustom them to a container, space suit, acceleration, and vibration. The necessary conditional and unconditional reflexes were established. A diet was developed, and the dogs were trained to eat from automatic feeders. A waste collection device was developed and there was provided an opportunity to transfer research data to the Earth.

Under the direction of Alexey Pokrovsky and Vladimir Yazdovsky this research in the Institute was conducted by Abram Genin, Oleg Gazenko, Ada Kotovskaya, John Kasyan, Alexander Seryapin, Eugene Yuganov, and others. According to Soviet practices of the time to conceal important experts' identities, they published the results of their research under the pseudonyms A. V. Petrov, V. I. Yakovlev, A. M. Galkin, O. G. Gorlov, A. R. Kotova, I. I. Kosov, A. D. Serov, and E. M. Yugov.

On January 5, 1959, a resolution was adopted by the Central Committee of the CPSU and the USSR Council of Ministers, "On strengthening research in the field of biomedical support of spaceflight." The USSR Ministry of Defense, in cooperation with the Academy of Sciences, the State Committee for Defense Technology, and the State Committee for Aviation Technology was instructed to develop and adopt a comprehensive plan for research and development work in institutes and design offices for the biomedical support of manned spaceflight. In accordance with this resolution, the Scientific-Research Testing Institute of Aviation Medicine was converted to the State Scientific-Research and Testing Institute of Aviation and Space Medicine (SSRTIASM) of the first category.

On March 14, 1959, in accordance with this resolution the Air Staff Chief published a directive about opening of advanced research in SSRTIASM in the field of:

- aviation and space hygiene of cabins and suits, uniforms and special equipment, food and aviation and space toxicology;
- aviation and space physiology, including high-altitude physiology, acceleration and weightlessness, physiology of hearing, speech, and vestibular analyzer, physiological optics;
- rocket flight safety, the effects of spaceflight, medical selection and training of crews for rocket ships.

Independent divisions were established for flight labor research, biochemical and radio-biological studies, psychology, medical research of air accidents, and the development of scientific and experimental equipment.

Andrey Grigoryevich Kuznetsov was appointed Chief of GNIIIAKM, and Head of a third department was Vladimir Ivanovich Yazdovsky. The tasks of large-scale biomedical research were the following:

- developing and testing life-support systems in ground-based experiments and individual means of manned spaceflight security;
- conducting astronaut training for flight;

- research in flight of the efficiency of life-support systems and rescue, study of the effect of spaceflight factors on the astronaut's body and its function, revealing methods' adequacy for selection and training.

Under the leadership of Vladimir Yazdovsky a series of special studies in medical safety of manned flight, and determining medical and technical requirements for a hermetically sealed cabin of the spacecraft, were conducted. Much effort and many creative ideas were required for the development of an air regeneration system, and to provide food and water, maintain the required temperature and humidity, provide an ejection seat and space suit, create a wearable emergency reserve, as well as equipment for distant monitoring astronauts' health and physiological studies, and correct operation of the onboard life-support systems during the flights. Concepts and unique technologies of reversible sorbents using carbon dioxide and its utilization were developed, as well as the production of oxygen by the electrolysis of water. Particular attention was given to the design of equipment for protecting a cosmonaut's activity, including in the case of ship cabin depressurization, and prevention of hypothermia after landing, or in case of a water landing by parachute in low temperature conditions. Special research on the selection and effectiveness evaluation of a heat-suit and its modes of ventilation at different temperatures and humidity in the cabin was conducted. There were protective properties estimated for the space suits up to great extremes of pressure. Equipment for oxygen delivery to the helmet of the space suit was developed, to maintain proper gas composition, and possibilities and conditions of many days stay in the space suit. On the ship, a space suit without a mask, personal protective equipment, life-support systems, and landing with ejection seat and in the ship were tested [14]. That research provided the basis for the final decision for a human flight in the spaceship *Vostok*.

On August 18, 1960, the canines, Belka and Strelka, were launched into space. For the first time after an orbital flight, a spacecraft with animals returned to the Earth. This orbital flight of one-day duration showed that zero gravity, landing g-force overload, and space radiation do not pose a threat to animal life. All the technical systems of the ship, including the life-support system, and descent and landing systems, functioned properly. This successful launch and return of the spaceship were a harbinger of human spaceflight.

In 1959, the Council of Chief Designers decided to proceed with the development of a satellite for human spaceflight. Under the chairmanship of academician M. V. Keldysh, a meeting was organized at which the issue of human flight was discussed in detail, including the selection of candidates for astronauts, their further training, and the development of life-support systems, security, and returning to the Earth. There was no doubt that a jet fighter pilot should go on the first spaceflight. An important role in the organization of astronaut selection was played by a medical commission, specially created for this purpose, which included prominent medical figures A. N. Babijchuk, A. A. Vishnevsky, N. S. Molchanov, A. G. Kuznetsov, V. I. Yazdovsky and others.

Under the leadership of Vladimir Yazdovsky, a series of special studies on medical safety of manned spaceflight, was conducted, in order to settle medical and technical requirements for the hermetically sealed cabin of the spacecraft. This research provided the basis for the final decision for the possibility of human spaceflight in a *Vostok* spaceship.

Under the guidance of V. I. Yazdovsky in SSRTIASM and in the Central Science-Research Aviation Hospital (CSRAH) a project proceeded, titled "Development of Guidelines for Selection of the Crew Members of Rocket Flight Vehicle." The hospital opened a special department of functional diagnostics for screening and post-flight inspection of astronauts. The selection of astronauts was carried out in accordance with the Directive of Air Force Chief of Staff. For the selection process, there were physicians connected with aviation units and military-medical commissions, which evaluated military pilots' health status. They viewed more than 2,000 pilots of fighter aircraft. The end result was that 206 pilots were sent to the aviation hospital for health and clinical examination.

According to the results of clinical and functional examinations, the group of astronauts included: Major P. I. Belayev, Captains P. R. Popovich and V. M. Komarov, First Lieutenants I. N. Anikeev, V. F. Bykovsky, V. V. Bondarenko, V. S. Varlamov, V. V. Volynov, Yu. A. Gagarin, V. V. Gorbatko, D. A. Zaikin, A. Ya. Kartashov, G. G. Nelyubov, A. G. Nikolayev, M. Z. Rafikov, G. S. Titov, V. I. Filatov, E. V. Hrunov and G. S. Shonin and Lieutenant A. A. Leonov [11]. The methods of clinical and psychological examinations of astronaut candidates were later refined and improved, but the principles of professional selection of astronauts, developed by specialists at the State Scientific-Research and Testing Institute of Aviation and Space Medicine, and the Central Research Aviation Hospital, proved to be viable.

At the end of 1959 a scientific discipline, "Space Biology and Medicine," was introduced and its goals and objectives were formulated: to study the effect of spaceflight and develop protection from adverse effects; to elaborate the requirements for life-support systems, and the means of escape for crew members in case of emergencies; and the development of clinical and psycho-physiological methods for the selection and training of astronauts.

In 1959, V. I. Yazdovsky received the degree of Doctor of Medical Sciences for space biomedicine research and became a professor the next year. V. I. Yazdovsky was organizing the direct training of astronauts for spaceflight. In accordance with the directive from the Chief of the Air Force on January 11, 1960, Cosmonaut Training Center (CPC) was created. Evgeniy Anatolyevich Karpov was appointed Chief of this center. In March 1960, N. P. Kamanin, E. A. Karpov, V. I. Yazdovsky and V. Y. Klokov were searching carefully and found a place for building CPC near Schelkovo town, not far from Moscow. To work in CPC, doctors came from all areas of aviation medicine: occupational health and physiology (A. S. Antoshenko, A. A. Lebedev), otolaryngology (I. M. Arzhanov), ophthalmology and physiological optics (V. A. Baturenko, G. F. Hlebnikov, N. H. Eshanov), neurology (N. V. Kuznetsov), biochemistry (A. S. Krasovsky), therapy (A. V. Nikitin), and others.

Under V. I. Yazdovsky's leadership, for the first group of astronauts, a program of biomedical training was developed, along with parachute, flying, and technical training programs [12]. On March 14, 1960, V. I. Yazdovsky read an introductory lecture on aerospace medicine to the first group of astronauts. Lectures were also read by K. D. Bushuev, M. K. Tihonravov, B. V. Raushenbah, K. P. Feoktistov, V. I. Sevastyanov, S. M. Alekseyev and other designers of rocket technology and their systems, and scientists and experts in different areas of knowledge required for pioneering space efforts [11].

The program of astronaut training for spaceflights included not only theoretical preparation, covering most important aspects of aviation and space medicine, but also a complex of special tests and exercises, during which it was a question of selection of an astronaut for the first spaceflight.

In the first phase, it was necessary to improve an overall physical status of astronauts and develop the required special physical qualities. In the second phase, it was necessary to improve tolerance to accelerations and the adaptation to weightlessness and to vestibular effects. As a result, the astronauts attained increasing levels of efficiency, endurance, strength, speed, and moving coordination, which were needed to be able to perform during a spaceflight.

Parachute training was carried out for the development of the needed skills to perform a parachute jump within the design features of the *Vostok* spacecraft. Parachute jumps were considered a good way to improve emotional and volitional qualities. Jumps were executed on the land and on the water, day and night, with high and low altitudes, with the delay and without the delay of parachute deployment. In preparation for spaceflight, Yuri Gagarin completed 43 parachute jumps, German Titov, 46.

A specially designed stand-simulator was used for training and improvement of skills required to operate during the flight, and to study each astronaut's individual characteristics. Meanwhile, actions to be taken in emergency situations were worked out. The greatest difficulty concerned the transmission of information from the ship by radio-telegraphy to the ground about the working of the equipment and systems, and an astronaut's actions and his status. Special attention was given to training on a treadmill, using the Khilov swing and Barany chair, and also training in baro-, thermo-, and isolation-chambers, and on the shaker and centrifuge. The loads were increasing constantly, and the astronaut candidates, to tell the truth, did not like such training. The astronauts had to learn to estimate their status during overheating as they were training to operate in conditions of high temperature. The workouts were conducted in a heat chamber, because the possibility of the air temperature increasing onboard of the ship was highly probable.

Due to the impact on astronauts during takeoff and landing with large accelerations, the important part of their training was devoted to centrifuge training. At the beginning, rotations of astronauts on the centrifuge were conducted, in order to observe the effect of long lateral acceleration, and to estimate their individual tolerance to accelerations on the basis of recording values or changes in physiological parameters of the body, such as frequency of breathing, heart rate, and electrocardiogram readings. Then training rotations were conducted to increase astronaut resistance. To prepare the body for the effects of spaceflight factors, a lot of attention was paid to physical training.

Considerable time was devoted to flights of astronauts on a flying laboratory equipped specially to create short-term weightlessness. To do this, fighter jets were first used for training, followed by specially-equipped Tu-104 aircraft. In these flights, weightlessness was created for 35–40 seconds. This provided an opportunity to assess the reaction of the organism, to study the effect of weightlessness on the cardiovascular and respiratory systems, and vision and speech during radio exchange, movement coordination, and eating. As a result, it was concluded that short-term effects of weightlessness on the human body do not cause adverse sensory reactions, do not affect astronauts' general health, do not violate the motor coordination and do not invoke abnormal responses from the cardiovascular and respiratory systems.

Great importance was given to the training of astronauts in a flight suit in a sealed mock-up of the *Vostok* cabin. There they performed elements of flying a mission, recorded the data of their original neuropsychology status, work activity and basic physiological functions of the astronauts. The convenience of working in a space suit was checked, as well as the position of sensors and electrodes for registering physiological functions, and nourishment.

According to the results of selection and training, a group of six astronaut candidates was selected for accelerated preparation for spaceflight. It included V. S. Varlamov, Yu. A. Gagarin, A. Ya. Kartashov, A. G. Nikolaev, P. R. Popovich and G. S. Titov. In the training process, A. Ya. Kartashov and V. S. Varlamov were excluded from the team for medical reasons. Instead, G. G. Nelyubov and V. F. Bykovsky were included in the group of candidates for the first flight.

On January 17–18, 1961, Yu. A. Gagarin, G. S. Titov, G. G. Nelyubov, A. G. Nikolaev, P. P. Popovich and V. V. Bykovsky passed the exam on readiness for a spaceflight. First, practical skills of the astronauts for spaceship piloting were evaluated on a simulator, and then their theoretical knowledge in the field of space medicine and exploration and engineering of ship's life-support systems was tested. Yu. M. Volynkin, and V. I. Yazdovsky as members of the examination committee evaluated their space medicine knowledge.

In January 1961, the number of staff of the Cosmonaut Training Center increased to 250 employees. They began to be equipped with modern test equipment: treadmill, optokinetic drum, a rocking platform, the rotor, and others. For the medical department of the Center, more doctors of various specialties were invited: R. B. Bogdashevsky, V. I. Lebedev, V. I. Legenkov, A. N. Litsov, I. A. Kolosov, O. N. Kuznetsov, F. A. Solodovnik, A. V. Sorokin, N. D. Radchenko, I. K. Tarasov, N. V. Ulyatovsky, I. O. Chekirda, etc.

On February 25, 1961, State Scientific-Research and Testing Institute of Aviation and Space Medicine received new staff. Lieutenant General Yuvenaliy Volynkin became Head of the Institute. The Institute staff was doubled. The Departments of Aviation and Space Medicine were created. V. I. Yazdovsky was appointed Head of the Space Medicine Department—Deputy Chief of the Institute. And he started a biomedical preparation for the first manned spaceflight. The structure of his department consisted of the division of air circulation in closed system in spacecraft cockpits, headed by E. Ya. Shepelev; the division of physical and chemical air regeneration methods, headed by A. D. Seryapin; the division of research spacecraft conditions headed by A. G. Kuznetsov; the division of spaceflights safety, headed by S. A. Gozulov; the division of space physiology, headed by O. G. Gazenko; the division of radiobiology research, headed by P. P. Saksonov; division of space simulators, headed by A. P. Kuzminov; and the division of transcripts and scientific analysis of radio telemetry information, headed by G. V. Altuhov.

This enabled the development of large-scale research in many fields. But not everything went normally. At the end of a ten-day stay in a hyperbaric chamber under reduced pressure, on March 23, 1961, V. V. Bondarenko died tragically. After removing sensors and wiping the place of their attachment with cotton soaked in alcohol, he threw it and it landed on a heated spiral hotplate. There was a fire, which broke out on his woolen tracksuit. The attendants could not open the door to the chamber without aligning the pressure inside and outside the chamber. And when that was done, it was too late. Doctors fought for his life for eight hours, but could not save him. The tragedy was felt deeply, and procedures modified accordingly. In the future, training in a hyperbaric chamber was excluded from the training of astronauts.

At this time, Vladimir Yazdovsky was at Baykonur launch complex busy preparing the first manned flight into space. An important preliminary step in its preparation was the launch of the *Vostok* spacecraft on a single-orbit flight program. The purpose of the experiment was to test spaceship's automatic space suit catapult carts and a life-support system, as well as check *Vostok*'s parachute system, bailout system, and landing trolley with associated contents. These flights used mannequins in a suit with multiple sensors of accelerations. Inside a mannequin figure there were mice, guinea pigs, white rats, insects, bacteria, fungi, enzymes, bacteriophages, culture of cells, algae, plants and seeds.

A dog, Chernushka, was in a spaceship-satellite, placed into orbit on March 9, 1961, and another dog, Zvezdochka, was in a spaceship-satellite, orbited on March 25, 1961. In the United States, these satellites were called "Noah's ark." The animals survived the orbital flights. In V. I. Yazdovsky's opinion, a successful completion of these space experiments meant the end of a preparatory period for a manned flight into space [8]. On the basis of these two launches, opinion was resolved on the possibility of human flight in the *Vostok* spacecraft. On April 3, 1961, the government decided to launch a manned spacecraft.

Already three days before Yuri Gagarin's space start, V. I. Yazdovsky started eating a space food diet to ensure the food quality for spaceflight and gave the order to install sensors under the mattresses of Yu. A. Gagarin and G. S. Titov to determine how they sleep. In the morning they learned that they slept very well. On the evening before Gagarin's flight, S. P. Korolyov, M. V. Keldysh, V. I. Yazdovsky and some others talked with the astronauts. Suddenly on the radio, on "Voice of America" they heard that the Russians are preparing the launching of the first human spaceflight in the next few hours. All present were surprised at such unexpected American awareness about the upcoming launch.

S. P. Korolyov and V. I. Yazdovsky were walking around the astronaut's houses during the night, discussing the upcoming launch. It was a very important moment for them. S. P. Korolyov was responsible for the design and equipment and reliability of the ship. V. I. Yazdovsky was responsible for the medical and biological training and flight safety.

Vladimir Yazdovsky directly led a group of physicians, to evaluate the functional state of the astronauts before the flight of Yuri Gagarin. The group consisted of L. G. Golovkin, F. D. Gorbov, A. R. Kotovskaya, I. T. Akulinichev, and A. V. Nikitin. They conducted a medical examination, measured blood pressure and pulse, and checked the position of biosensors. V. I. Sverschek helped Yuri Gagarin don his space suit. S. M. Alekseev, chief designer of life support systems, was there as well. For monitoring Yuri Gagarin's status in flight and the collection of scientific information, medical equipment "Vega-A" was used, as well as radio communication, radio telemetry, and television systems. In flight, the registration of electrocardiogram data, respiratory rate of the astronaut, and other data were provided through transmission to the Earth. Furthermore, there was a transmission of sound pulse signals by radio. Comparing the results of medical monitoring of Yuri Gagarin before the flight, during the launch of the spacecraft into orbit, and his in-flight performance, changes in his physiological indicators were within the acceptable range [11].

After the flight Yuri Gagarin was a little tired, but remained active in communicating with others. No abnormalities in his health were identified. The flight of Yuri Gagarin lasted only 108 minutes, but gave reason to hope for the success of space missions of longer duration. The flight of the *Vostok* spaceship marked the beginning of conducting medical experiments in space with astronauts.

For their contribution to the preparation and implementation of Yuri Gagarin's spaceflight, the State Scientific-Research Testing Institute of Aviation and Space Medicine was awarded the Red Star Order, and its 92 employees were honored with state awards. Vladimir Yazdovsky was awarded the Order of Lenin for the preparation and implementation of the first manned spaceflight.

As Science Deputy Head of the Institute V. I. Yazdovsky organized medical care for the spaceflights of G. S. Titov, A. G. Nikolayev, P. R. Popovich, V. N. Tereshkova, and V. F. Bykovsky. It was difficult to determine what should be the duration of the second manned spaceflight. Based on physiological data from previous studies V. I. Yazdovsky, suggested carrying out three orbits. Yuri Gagarin also supported this proposal. G. S. Titov and his understudy A. G. Nikolaev, by contrast, called for a flight of one-day's duration. S. P. Korolyov found a compromise: to prepare the flight for a one-day duration, but to complete the flight after the third or fourth orbit if the astronaut felt poorly. V. I. Yazdovsky agreed with this proposal, because S. P. Korolyov assured him that the descent of the spaceship would be possible, in this case.

The flight of G. S. Titov on *Vostok-2*, lasted more than 25 hours. It was possible to study the dynamics of physiological functions in connection with the circadian rhythm and prolonged exposure to weightlessness, and to evaluate support systems' effectiveness.

During his flight, G. S. Titov carried out manual photography of the Earth's surface and manual piloting of the ship for the first time, and conducted tests to assess motor coordination and the dynamics of mental processes. A complex of vestibular and psychological tests was performed. Data were collected from the electrocardiogram, on the breathing rate, kinetocardiogram, and on sound pulse signals. In flight, vestibular and optokinetic-parasympathetic nervous system disorders were identified. After the flight, significant physiological changes persisted. In the article by V. I. Yazdovsky, O. G. Gazenko, and A. M. Genin, "Physiological Studies on *Vostok-2*," they noted that "particular attention was paid to discomfort during the orbital flight, characterized by an astronaut as a condition close to motion sickness. These feelings were expressed in dizziness and nausea. They became noticeable during sudden head movements and the monitoring of fast moving objects. Over time, these phenomena increasingly attracted the attention of astronauts and created some discomfort."

The results of G. S. Titov's flight led to the conclusion that, in conditions of weightlessness the daily rhythm of sleep and wakefulness is not disturbed, but there is an increase in the sensitivity of the vestibular apparatus to accelerations and therefore a need for effective ways of preventing autonomic and sensory disorders in flight. In addition, the astronaut selection and training systems needed improvement. Actual trends of estimating an astronaut's vestibular sensitivity and factors of influence were defined, and a training system proposed for spaceflight. For these purposes, in the final stage of the training a three-night astronaut stay in a simulated cabin of the *Vostok* spaceship was planned. In addition, at this stage there should be an estimated readiness of astronauts to perform individual elements of flight tasks, assess custom fitting equipment, test the flight diet, and test the control of water supply quality and the system of sensors for physiological parameters registration [13, 14].

In view of the results of the first spaceflight, onboard equipment for health monitoring was modernized. In addition to the main part of that equipment, "Vega-A," "Reflex" and "Neuron" equipment were also included. These physiological indicators have played a major role in objectifying the diagnosis of vestibular disorders in astronauts. During the coordinated simultaneous flight of A. G. Nikolayev on the *Vostok-3* spaceship and P. R. Popovich on *Vostok-4,* there was radio communication between the astronauts and with the ground flight control center, and photography of the planet's surface. Piloting of the ship and its orientation were done in a manual mode, and vestibular and psychological tests were conducted, as well as physical exercise and some other experiments. As a result, doctors identified significant nervous and emotional stress during the critical phases of flight, the short-term illusion of the astronaut's spatial position, the sharp increase in pulse rate, and the phenomenon of "gray veil," or gray, red, or black bands at aerobatic accelerations, during braking when entering the atmosphere, and/or landing [16].

In 1964 V. I. Yazdovsky was appointed Chief of the sector of the Institute of Biomedical Problems. Soon he became Deputy Director for Science of the Institute, and with his energy and perseverance, dealt with the problems of training and ensuring long-term spaceflights. In 1967, V. I. Yazdovsky went to work at Bioengineering Research Institute, where he headed the development of advanced life-support systems for long-duration spaceflights.

In 1962, in recognition of V. I. Yazdovsky's contributions to the science development of biomedical problems of space exploration, he was elected a full member of the International Academy of Astronautics and was awarded "Grand Gold Medal" of the International Academy of Aviation and Space Medicine [2].

Colleagues, numerous students, and friends appreciate V. I. Yazdovsky's exceptional human qualities: indomitable energy, extraordinary performance, creative spirit and initiative, integrity, sincere generosity, compassion, and loyalty. From working with him, talking and learning from his experience, has grown a whole galaxy of prominent Russian scientists in the field of space biology and medicine, still developing his ideas and covenants. They cherish the memory of V. I. Yazdovsky, whose professional knowledge, spirit of innovation, scientific intuition, assertive character, and creative passion contributed to the formation of space biology and aerospace medicine.

V. I. Yazdovsky died on December 17, 1999, but up to the last day of his life he was interested in space problems. He was a scientist with amazing human qualities, broadest erudition, and rare communication skills. He generously shared his knowledge and experience with young scientists, loved, supported, and took care of them. And they answered him with deep gratitude and sincere respect and great love. V. I. Yazdovsky, inquisitive researcher, bright and sunny personality, will forever remain in the memory of those, who were fortunate enough to know him and speak with him. A memorial plaque of the founder of Russian aerospace biomedicine, V. I. Yazdovsky, is set in the buildings of the former State Scientific-Research Testing Institute of Aviation and Space Medicine [6].

In 2013, the 100th anniversary of the birth of Vladimir Yazdovsky was celebrated. For his scientific contribution to the preparation and fulfillment of manned spaceflights V. I. Yazdovsky deserves to remain in the memory of mankind forever.

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