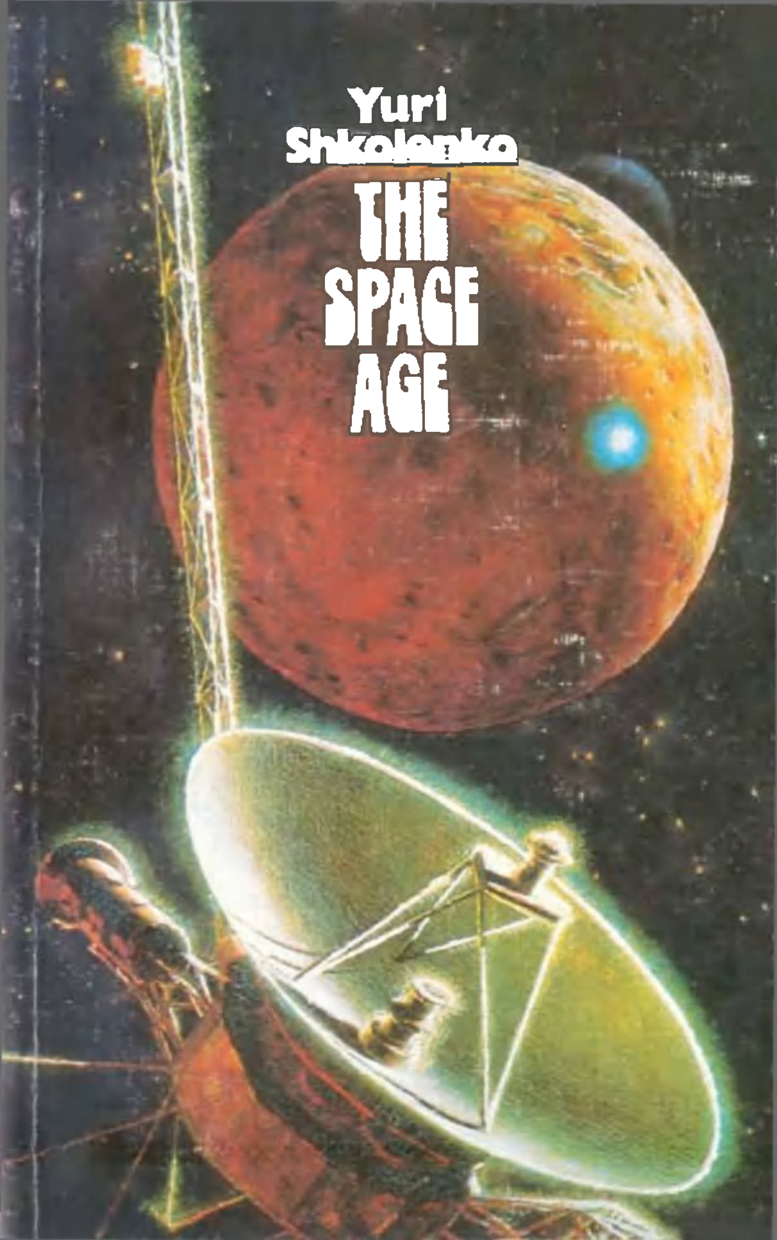
Yuri Shkolenko

THE SPACE AGE



Yuri
Shkolenko

THE SPACE AGE

Progress Publishers
Moscow

Translated from the Russian
Designed by *Anatoly Tsvetkov*

Ю. А. Школенко

Космический век

На английском языке

This book provides a comprehensive picture of men's achievements in the study and conquest of outer space, and examines the prospects of the development of space exploration, and the use of outer space for the benefit of the human race.

The author traces the views on the Universe held by philosophers and scholars in different ages, looks at the place and role of man in the Universe, and demonstrates the leading role played by Russian and Soviet scientists in the theoretical and practical study and conquest of outer space. He emphasises the planned, comprehensive and peaceful nature of Soviet space programmes, and examines the interaction of men and outer space from the scientific, socio-political and moral viewpoints. He also criticises the inhumane, idealist and mystic interpretations of the space age, and reveals the lethal danger contained in the US doctrine of the militarisation of outer space.

Printed in the Union of Soviet Socialist Republics

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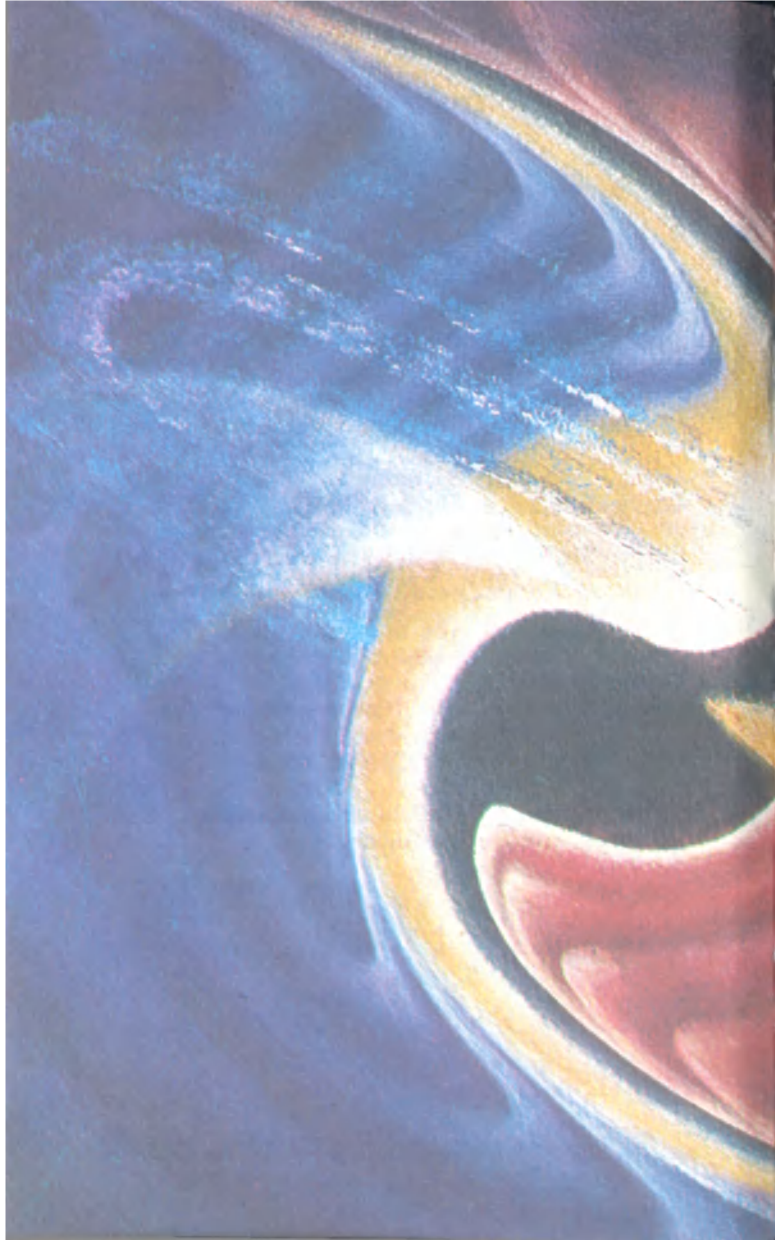


My main purpose in life is to do something useful for my fellow-men, not to live my life in vain, to propel mankind forward, if only by a fraction. That is why I became interested in that which gave me neither bread nor power, but I am in hopes that my work, perhaps soon, perhaps only in the distant future, will yield society heaps of grain and vast power.

Konstantin Tsiolkovsky

About the book

Epoch-making events in the development of life and intelligence on earth often occurred gradually and imperceptibly. It took millions of years for the coelacanthine fish, crawling from one diminishing body of water to another, to grow accustomed to life on dry land, and thereby preparing the way for land animals, mammals and man. That same dry land also saw the emergence of technology, the use of specially devised instruments and means of affecting the environment, the specifically human method of existence in the natural environment. It is precisely this technology, in the form of space-missile facilities, which has enabled life to move out into another environment, that of outer space. Such is, as one might put it, the evolutionary significance of the space age, the age that began on October 4, 1957, when the USSR launched the first artificial satellite.

Cosmonautics is a multi-faceted branch of science, the embodiment of the scientific and technological revolution, drawing into itself the latest achievements in the development of new materials, fuels, and computers. It is linked with a large number of sciences, technological trends and social phenomena, from astronomy and astrophysics to medicine and biology, from meteriology to geography, from psychology to jurisprudence, from navigation to radio and television broadcasting. It is capable of bringing both good and evil, from the observation and control of natural processes and economic activity on the planet to the militarisation of space and the danger of a space war, which would be comparable with the natural cataclysms that occur in the Universe.

A manned spaceship or station, with its life-support system and relations among the crew, resembles a miniature earth. And our planet, with its mineral and living resources and almost five thousand million inhabitants, could be compared to a huge natural spaceship which began its orbit around the sun more than four billion years ago.

The space age requires that we ponder over its complexities in order to harness its advantages for the benefit of mankind and avert its dangers.

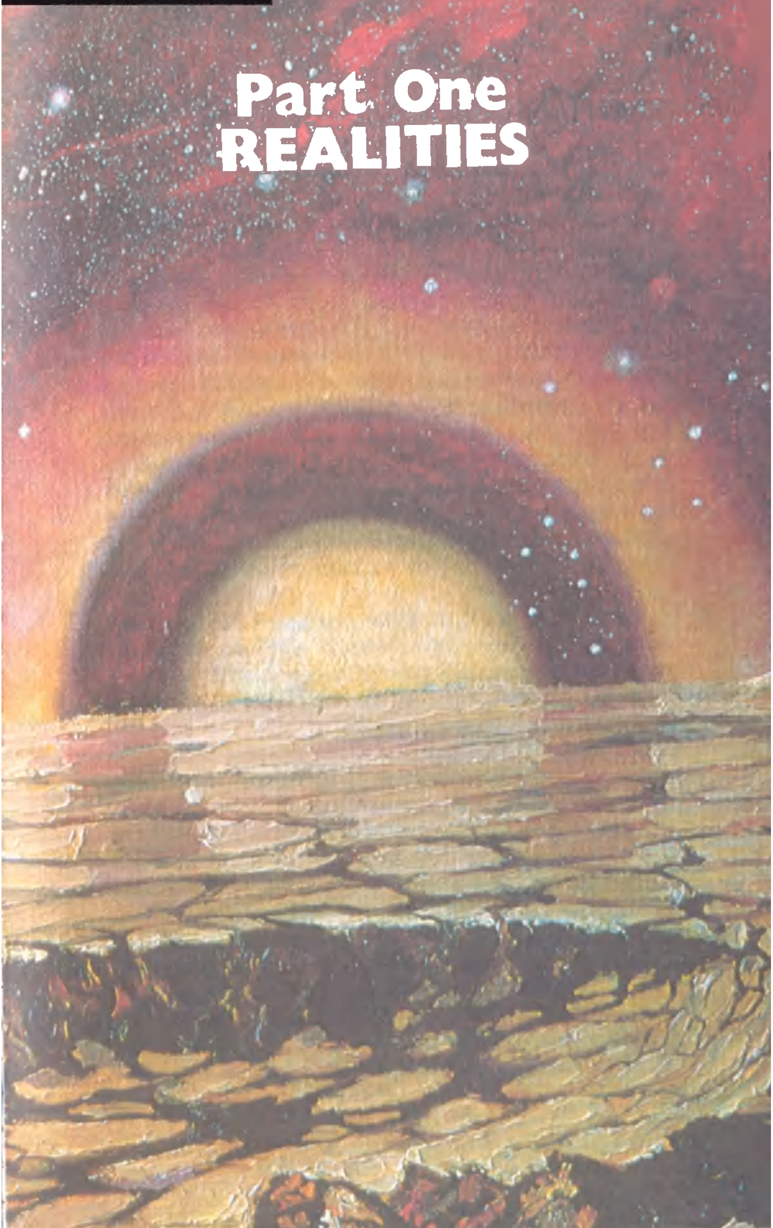
The Universe has always attracted men's attention, but this previously took the form of passive contemplation far removed from the daily cares of men.

The process of reflecting upon the significance of cosmonautics and space flight follows, naturally enough, in the wake of the events themselves, but then it begins to take the lead. The philosophical and psychological perception of space, the formulation of an integrated concept of the space age, its benefits and its dangers, is one of the facets of the science of cosmonautics.

The author, Yu. A. Shkolenko, is a doctor of philosophy and a journalist. In his book he has combined reflections on the fundamental processes occurring in the space age with a lively description of the everyday, practical aspect of cosmonautics. He takes the reader into the cabin of a spaceship, into the living module of an orbital station, shows him the experiments performed by the cosmonauts, and then offers him a glimpse, through the porthole, of the earth and other nearby planets, and of worlds unimaginably remote. As a result, the reader who has never been in space and is unlikely ever to go there, has nonetheless the opportunity to acquire a cosmic view of the world and, rising above his 'earth-bound' daily life, can form a new concept of his place and role in the Universe and on earth and appreciate the need for lofty moral principles and humane forms of social existence.

Vitaly Sevastyanov,
Pilot-Cosmonaut of the USSR,
twice Hero of the Soviet Union

Part One
REALITIES



Chapter One

Early History

It would be a great error to think that the space age began suddenly and, therefore, accidentally, removing other, purely earth-orientated alternatives of human development. Man's exploration of space has its immediate technological pre-history, which lasted for several decades until that memorable event which took place in October 1957—the launching into an orbit around the earth of a Soviet 83 kg shining sphere with two radio transmitters—and a conceptual pre-history which reaches back down the centuries. It is with this conceptual pre-history that we will begin.

What signs serve to show that men have become social beings and thus become distinct from the animal kingdom? It is customary to name two such signs: 1) labour and the production of implements of labour, in other words—technology (we may recall here Engels' formula 'labour created man himself'); 2) society, collectivity, socium or the social entity as a means of interaction and human social life as distinct from the herd form of life of animals and anthropoid apes. We would add a third sign that follows from the first two: the creation of an environment that does not exist naturally upon the surface of the earth.

Indeed, the mastery of fire and clothing made of skins were the first means by which men began to create a stable artificial environment which protected them against fluctuations in the temperature and seasonal changes. The transition from hunting and gathering to stock-breeding, tilling and crafts guaranteed a stable supply of food. Modern housing, the food and the consumer industries are essentially the same phenomena. Then it was the neolithic revolution, which began around six thousand years ago and which consisted essentially in the consumption of natural products being replaced by the consumption of cultivated and man-made products. In this sense, the scientific and technological revolution taking place in the second half of the 20th century may be considered a continuation of the neolithic revolution.

However, if men have surrounded themselves with a microclimate which differs considerably from the natural macroclimate of the planet earth, then, strictly speaking, they can already be considered 'astronauts', although they remain on the surface of the planet. Therefore, from the neolithic age onwards, men acquired the ability for autonomy in relation to the earth. This ability, it is true, has now led to a situation in which the microenvironment created by men has overtaken the macroenvironment of the earth, and there is scarcely a corner on the globe left which is not affected to some degree or other by anthropogenic activity, and mankind finds itself on the brink of a global ecological crisis. However, this same ability has also enabled men to move out into space. The microenvironment has outgrown the macroenvironment and is now rising to the level of a megaenvironment–a universal environment.

That men are proportional to the Universe was one of the central ideas of ancient mythology and, later, of classical philosophy. The anthropomorphic gods of Ancient Egypt and Greece predominantly dwelled in heaven, but, we emphasise, they were *anthropomorphic* deities. Man was the standard of unlimited power that extended beyond the confines of the

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The first satellite goes into orbit

earth, which even then, and not only to the modern astronaut, appeared 'small'. Hence the natural emergence of non-geocentric ideas among the thinkers of the ancient world. In ancient Greece, Anaximander suggested the possibility of there being a plurality of worlds, and Epicurus, developing this idea further, even situated the gods between these worlds. Long before Nicolaus Copernicus, the Roman philosopher Lucretius Titus Carus asserted that not only was the earth not the centre of the Universe, but that the Universe itself has no centre.

Alongside these 'cosmic' views concerning the place of man in the universal system, there also arose 'astronautical' views in which men left the earth, albeit only in their imagination, and moved into inter-stellar space; and these ideas first arose in mythology. Daedalus of Crete made wings of eagles' feathers glued with wax for his son, Icarus. However, the sun melted the wax, and Icarus perished. The Christian tradition saw this myth as a moral allegory: men always face failure if they try to resemble the gods, whose 'natural environment' is heaven. However, there is another detail of the myth of Icarus which should not be forgotten: Icarus and Dedalus had together flown out of the labyrinth where king Minos had imprisoned them. Daring cannot be quashed, especially when it is necessary to escape from labyrinths and overcome obstacles. In *Icaromenippus* by the ancient Greek philosopher and satirist, Lucian of Samosata, another mortal, Menippus, sets out on a space flight, and this time he succeeds, covering Olympus in confusion.

However, the 'astronautical' line of thought developed no further for the next 1,500 years, either in philosophy or fiction. During the Middle Ages, astronomy was dominated by the geocentric view of the world expressed by Aristotle, and formulated as a theory by Ptolemy. Men felt no need to leave their 'central planet', even in their imagination, although others, such as Lucretius Carus, had denied that such a centre existed.

The old concepts had to be removed, but on the basis of calculation and logic. A revolution in astronomy was needed, and this was brought about in the 16th century by Nicolaus Copernicus. In his *De Revolutionibus Orbium Coelestium*, Copernicus sketched a non-geocentric picture of the planetary system, in which the earth became merely another planet orbiting the sun. The vast geocentric 'almagest', the 'majestic structure' of Claudius Ptolemy, a Greek astronomer of the 2nd century A. D., in which the planets were presented as orbiting the earth together with the sun, weaving a complex pattern across the skies because they were all revolving around the sun, crashed in ruins under the pressure of the simple and elegant system of Copernicus. (In addition, this theory also made use of a principle formulated two centuries earlier by English philosopher William of Occam: one should not multiply the number of essences unnecessarily.)

The loss by the earth of its 'central' position did not signify the 'humiliation' of man, who until then had thought himself to inhabit the heart of the world beneath the firmament. In the 17th and 18th centuries there appeared the first imagined space journeys–bold and humorous, but with a kernel of rationality. In his novel *Histoire Comique des Etats et Empires de la Lune*, Cyrano de Bergerac travelled to our natural satellite in a chariot drawn by eagles, and the 'driving force' was a dove which the driver held on the end of a fishing rod in front of the eagles. Jonathan Swift, in his *Gulliver's Travels* depicted the flying island of Laputa, which was held in its orbit near the earth by a giant magnet. Moreover, one of the Laputan scholars predicted the existence of two small (relatively small, that is, the size of a mountain) satellites of Mars. Two such satellites were discovered 150 years later by Asaph Hall, who called them Phobos and Deimos, and when, another hundred years later, they were photographed from the unmanned interplanetary station *Mariner*, they were shown to be, indeed, 'flying mountains'. As for the flying island, space engineers are today already drawing up plans for its construction, and are confident that it can be built using modern technology. Swift was not, of course, a 'clairvoyant', but very often the 'play of ideas' coincides with future reality.

In Swift's day, however, no one imagined how difficult space flight would prove to be. Fontenelle, the first populariser of astronomy and a contemporary of Swift, believed that the inhabitants of other worlds were so close to each other that they could exchange information by pigeon post. [1]

The first flight in outer space was preceded by the long process of getting into the air. In actual fact, the atmosphere and outer space were previously thought of as essentially one and the same: the ancient Greeks, for example, thought that the stars were fiery turbulences in the atmosphere. That is why the first flight by the Montgolfier brothers in an air balloon in 1783 was, at the time, an event as significant as the flight of Yuri Gagarin in the spaceship *Vostok* in 1961. A balloon filled with heated air—what could be simpler! There is evidence that Russian serfs went up in similar balloons 200-300 years earlier. However, arriving at such a simple method proved

[1] Bernard Le Bovier de Fontenelle, *Entretiens sur la pluralité des mondes (1686)*, Libraire Armand Colin, Paris, 1909, p. 57.

long and complex, for men first had to abandon the deceptively alluring idea of directly imitating nature by constructing wings, and opt for a truly 'cosmic' line of research that had no analogue on earth, for here there are no naturally existing air balloons.

(Although in the catastrophic eruption of Krakatoa in Indonesia in the last century, some of the rocks hurled out of the crater acquired orbital velocity and, perhaps, escape velocity, and became either earth satellites or left earth's orbit altogether; in the Antarctic, rocks have been found that are thought to have been 'expelled' by powerful volcanoes on Mars.)

Flying was, in the 19th century, both a hobby and a symbol of scientific and technological advance. Air balloons, aerostats and dirigibles seemed to be almost natural attributes of the air. They appear in almost all the novels by Jules Verne. The Paris Communards sent their call for a proletarian revolution from the beseiged capital by means of air balloons. At the turn of the century, aeronautics paved the way for aviation, for flying machines heavier than air, and it was only then that people began to take note of the aerodynamic qualities of the bird's wing. This same period saw the birth of scientific theories of space flight which laid the groundwork for the approaching 'post-aviational' stage of navigation above the surface of the earth.

The development of a scientific theory of space flight—as the later development of space technology—proved far from straightforward. It involved investigation and even error, from which, however, rational concepts emerged. The idea of space travel was already in the air at the end of the 19th century, although at the time only air balloons and the first flying machines had actually left the ground. Moreover, it is worth noting that Russian philosophical thought played no small part in formulating and propagating the ideas of space travel, earning as a result the designation 'Russian cosmism'.

In his later years the well-known Russian playwright A. V. Sukhovo-Kobylin wrote a philosophical essay entitled *The Teaching of the Universe*, in which he predicted three stages of human history: the telluric (earth), the solar (sun) and the sidereal (the stars).[1] Scientists still use these three divisions when talking of the stages in man's future conquest of space or discussing the possibility of the existence of extraterrestrial civilisations at various levels of development.

N. F. Fyodorov,[2] a librarian at the Rumyantsev (now Lenin) Library in Moscow and a complex and contradictory character, developed a theory of the exploration and transformation of extraterrestrial space in his *Philosophy of the Common Cause*. The ideas he expressed in this theory were part of a wider and totally mystical concept of 'patrification' or the "resurrection of ancestors" and the physical regeneration of past generations, and the transformation of the Universe into a memorial complex. However, at that time the idea of entering outer space was, in itself, rational.

The feasibility of this idea was not slow to reveal itself. In those same years (end of the 19th-beginning of the 20th century), Konstantin Eduardovich Tsiolkovsky was laying the theoretical foundations of space flight. Today his name is famous throughout the world. In Kaluga, where he taught at the local gymnasium, there is a magnificent memorial to the scientist, and scientific and educational work is conducted in the large building that houses the Tsiol-

[1] *History of Philosophy in the USSR*, Vol. 3, Moscow, 1968, p. 323 (in Russian).

[2] N. F. Fyodorov, *Works*, Moscow, 1982 (in Russian).

kovsky State Museum of the History of Cosmonautics, built to resemble a large observatory and standing on the steep bank of the river Oka. The first Soviet spaceship, *Vostok*—and it was on a craft similar to this that Yuri Gagarin first escaped earth's gravity—can be seen nearby, white against the blue of

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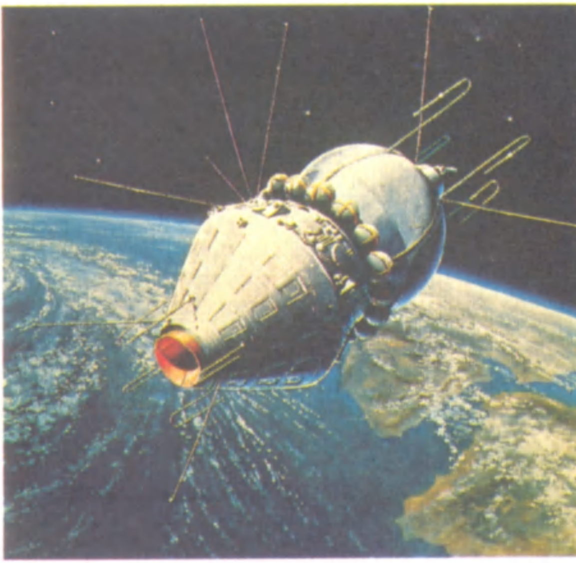

Vostok up above the earth

the sky and the green of the forest. The small wooden house in which Tsiolkovsky lived has also been turned into a museum, and next to it, in the park, a stela stands on the scientist's grave. One might say that the whole of Kaluga lives 'under the sign' of Tsiolkovsky. In the 1890s and 1900s, however, Tsiolkovsky was, for his fellow residents of this provincial town, a man 'ahead of his time' (to quote the words of Sergei Pavlovich Korolyov, the designer of the first Soviet spaceships): no one understood him, and his ideas were seen as pure fantasy and eccentricity by everyone, from his neighbours to the government officials of tsarist Russia.

We said earlier that Tsiolkovsky is now known to the world as the founder of theoretical cosmonautics. However, it would seem that he is not known to everyone, and not known sufficiently, for 'discoveries' are also made in this area. In 1976, an international symposium of the history of technology was held in Kaluga, at which Melvin Kranzberg, a professor from Georgia, USA, delivered a report on the then much-discussed idea of 'space islands'—human colonies in space—put forward by the American physicist Gerard O'Neil. However, Professor Kranzberg began his report by describing how amazed he had been by Tsiolkovsky's accurate engineering calculations for such 'space colonies', which he had just seen on display at the History of Cosmonautics Museum. Tsiolkovsky had anticipated O'Neil, even in the smallest details, by more than half a century.

Tsiolkovsky advanced his idea of jet propulsion for flight in space in 1883. And only about ten years later Russia and Britain were testing the first steam-powered aeroplanes. Jet propulsion was, one might have thought, a familiar and tested concept. Missiles powered by gunpowder had been invented by the Chinese in antiquity, and had long been used both as fireworks and as weapons in different armies, including the Russian army in the 18th and 19th centuries, and therefore the jet-propelled shells for the Katyusha rocket launchers, used by the Soviet Army in the Great Patriotic War, already had a venerable ancestry. However, while it is far more effective to make use of wings in the earth's atmosphere, beyond the earth's atmosphere jet propulsion is the only possible.

No other principle has yet been discovered by modern science (leaving aside abstract-theoretical ideas about 'sailing ships' propelled by the 'solar wind'—that is, by the current of particles emitted by the sun). It was his appreciation of this fact, namely that jet propulsion is the only principle applicable for space travel, and his work on the design of flying machines that would be able to travel beyond the earth's atmosphere that are the source of Tsiolkovsky's undying fame.

It is at this point that we enter the recent history of cosmonautics, the period that prepared for the conquest of space. And it should be pointed out that this recent history of cosmonautics immediately assumed an international character, thus confirming a social law discovered by Karl Marx and Frederick Engles, according to which the requirements of social production at a given stage lead to simultaneous technical discoveries and inventions in different countries; it is precisely this technical need which 'advances science more than ten universities'. [1]

Shortly after Tsiolkovsky, similar ideas about space travel were put forward by Robert Goddard (USA), Herman Oberth (Germany) and Robert Esnault-Pelterie (France). In the 1920s and 1930s the first experimental rockets were launched, powered by liquid fuel. In 1933, the Group for the Study of Jet Propulsion (GIRD), which included Sergei Pavlovich Korolyov, the future chief spaceship designer, launched the Soviet liquid-fuel rocket *GIRD-09* on a testing ground near Moscow. It reached a height of 400 metres. Today, Soviet geophysical rockets

[1] Karl Marx and Frederick Engels, *Selected Correspondence*, Progress Publishers, Moscow, 1975, p. 441.

Vertikal reach a height of more than 400 kilometres, but the importance of the first step is no whit diminished thereby, for without this first step, the others could not have followed.

This experimental stage in practical space flight showed that men had acquired sufficient scientific knowledge and technological know-how to send flying apparatus beyond the pull of earth's gravity. Only the Second World War prevented this from being achieved. It was not until twelve years after the war had ended that men were able to realise their old dream of travel in space. In 1957, International Geophysical Year, under the auspices of the United Nations, the Soviet Union launched its first artificial satellite, known in Russian as a sputnik, and this Russian word became part of every language round the world. Space flight has become a reality.

However, space flight is not merely the realisation of a technological possibility. It is also the first *social* act by mankind still surrounded by controversy and doubt. Should we be seeking to penetrate outer space when here, on our tiny planet, we have so many concerns and problems? We will soon reach the moon not with the help of spacecraft, but climbing up the towering heap of rubbish which is being produced by a civilisation unable to harmonise with the natural environment. Indeed, what is there to attract man in a lifeless Universe where the mineral kingdom rules amidst blazing heat or freezing cold, but where no trace of biological life has as yet been found, not even a microbe. Is not man's journey into space 'a triumph of intellect but a tragic failure of reason...' as was asserted by the world-famous physicist, Max Born?[1] What draws men beyond the

[1] Max Born, *My Life and My Views*, Charles Scribners's Sons, New York, 1968, p. 154.

earth, save idle curiosity?

There are many questions, and in this flood of questions one important fact is overlooked. The first space flight, which took place in the 1950s, was not only a display of human genius, but also a *requirement* of human existence.

The first achievement of the scientific and technological revolution that is still underway was the harnessing of atomic energy. This was the first time that men had reproduced and made use of processes that do not occur naturally on earth, but take place as nuclear synthesis inside the sun and other stars. In other words, before he had even moved out into space, man had begun to stimulate cosmic processes on earth. Unfortunately, this outstanding achievement by Homo sapiens received practical expression in the atomic explosions over Hiroshima and Nagasaki, and it was only later that the idea of the 'peaceful atom' emerged: the energy released by the splitting of the atom was put to use at atomic power stations.

Other technological processes based on natural phenomena that do not occur on earth have also become widespread: the use of deep vacuum and extremely low temperatures to produce new alloys and compounds, medicines and single-crystal semiconductors. Weightlessness made it possible to produce hitherto unknown compounds which it is impossible to create in conditions of earth's gravitation owing to the different specific weights of their components, for example, a homogeneous mixture of metal and gas which yields a material that is durable, light and heat-resistant; and also new forms such as seamless hollow spheres, necessary in the ball-bearing industry, in precision instrument-making, and—in the future—architecture.

Television broadcasting could only be further developed thanks to the launching of television satellites (otherwise the whole planet would have been covered with a network of broadcasting towers), and satellite technology is also used to monitor natural processes on a global scale, and the effect upon them of human activity.

Finally, it was also necessary to develop fundamental research. In order to penetrate further into the secrets of the microworld, particle accelerators were built, which are yet another example of the simulation of processes which occur naturally within galaxies. At the same time, the direct investigation of the macroworld—astronomy and astrophysics—were reaching the limits of their possibilities in terms of observation from the earth, since the earth's atmosphere does not let through the bulk of the cosmic radiations that carry information about the Universe.

The desire to discover 'new lands' led to the exploration and development, to some degree or other, of every corner of the globe. The age of great geographical discoveries has long since become past history. Men stood on the threshold of 'the crisis of discovery', preparing to share the fate of an old retired explorer... or to make great cosmic discoveries.

Thus man's flight into space, the arrival of the space age, is no accident, nor the result of an inventive whim. Men were brought to space exploration by the sum total of their material and intellectual requirements.

The above is but a brief outline of the pre-history of cosmonautics. In reality, it lasted thousands of years and we will make further individual excursions into it. For the most part, however, the rest of this book is devoted to the three decades of space-flight history, and the prospects for its future development, a development which has no visible limits in space or time. Cosmonautics penetrates the present and is oriented on the future.

Chapter Two

Homo Cosmicus

'Homo cosmicus'—cosmic man. We are not seeking with this term to introduce into biological classification a new species intended to replace Homo sapiens, but rather to point out that man in the cosmos is, in many ways, a special being.

Up to date, just some 200 people have been in space, and although this number will continue to increase, the overwhelming majority of the inhabitants of the earth will never leave their planet, their native 'spaceship'. Nor is it likely that this 'majority' will live somewhere other than on the earth at any time in the future. That is why, in this book we are seeking to familiarise this majority with the sensations and impressions experienced by professional astronauts, so that the reader will then be able better to understand the grandeur of astronautics and the multiplicity of its economic, industrial, social, psychological, ethical, aesthetic, philosophical and world-outlook 'offshoots'.

108 minutes, or one turn round the earth, was the journey that awaited the first cosmonaut, Yuri Gagarin, launched into space aboard the spaceship *Vostok* on the morning of 12 April, 1961, from the Baikonur cosmodrome in Kazakhstan. Afterwards, this short space journey was called 'a leap into the unknown'. And indeed, what lay ahead had been totally unknown. Man had come to understand and master the phenomena of air and water over a long period of time. Man lives within the earth's atmosphere, and is able to sail on and below the water.

A. Leonov

Voskhod-2

But what is it like up there, in space? Of course, the same constellations, the same blackness, as can be seen from the earth, but man had never found himself 'face to face' with the Universe. Would he survive the psychological pressure? What unexpected situations might he find himself in, protected not by the hundred-kilometre thick shield of the earth's atmosphere, but by the walls of his spaceship, which were less than a centimetre thick and vibrated when he tapped on them from inside?

Gagarin passed the test. The one thing he could not refrain from was truly 'cosmic' excitement at the sight of the earth from space, when, in the words of Pushkin,

And quickly dawn replaces dusk,
Leaving night just half an hour.

This is how dawn on earth actually occurs, but out in space you can actually see with your own eyes how the dawn covers half of the globe. This awe remained with the 27-year-old cosmonaut even after he had landed. Following Gagarin, people felt calmer and more confident as they set off into space. 'He opened the way into space for us all', said Neil Armstrong, the first man to step onto the moon.

Spaceships like the *Vostok*, which had room for only one cosmonaut, who could neither move for physical excercise nor float in weightlessness for psychological relaxation, are no longer used. We will begin our description of an actual manned space flight with the modern *Salyut*, whose living modules are comparable to the first-class cabins on board a ship. These living quarters are, of course, smaller in area at the moment than the normal apartment, yet nonetheless, each cosmonaut entering the space station for the first time is amazed at the hundred cubic metres of space inside the *Salyut*, although he has long become familiar with the model used for training on earth. A hundred cubic metres of living space not just anywhere, but in lifeless space!

The *Salyut* stations functioned as orbital homes for a good fifteen years. Since 1986 a new generation of stations has come into service—the even more comfortable *Mir* with individual cabins for rest and sleep, and, although of about the same volume, more spacious thanks to more rational interior design. Some of the equipment is located on modules which are moored to the station. Fitted with six rather than two docking facilities, the *Mir* station makes it possible to set up in near space not merely a laboratory, but an entire research institute.

And so—the launch. The roar of the engines, the pressure of gravity... Five hundred seconds 'at explosion level', as Vladimir Gubarev, journalist and astronautics correspondent put it. And then the engines shut off, you feel something like a light jolt in the back, followed by silence. It is only afterwards that you enter the world of sound, the noise of the instruments, various, and sometimes inexplicable, creakings and scratchings.

Meanwhile you begin to experience the much-talked about sensation of weightlessness. At first, particularly following the pressure of the launch, you feel an amazing sensation of lightness, of flight, of soaring. However, there is really no room to soar: *Soyuz*, which has long since ceased to be a spaceship and become merely a manned transport vehicle, while being larger than the old *Vostok* is considerably smaller than the flying laboratory and residence known as *Salyut* and even less so than the present *Mir*. In any case, there is no time to savour those first minutes and hours of weightlessness, for there is a great deal of work to be done—preparing to ad-just the flight-path, approach the orbital station and dock with it.

It is no easy task to link up with this 'house in space' orbiting at a speed of eight kilometres per second (orbital velocity, which launches the vehicle into orbit round the earth, but is insufficient to enable it to leave the earth and fly off into outer space), to locate it and approach the docking device. There can be a malfunction in the instruments, and the astronaut can himself make a mistake. Then the docking fails, and you have to return to earth and begin all over again. However, this happens very rarely: the transport ship is reliable, and its crew know their job, manoeuvring their craft with the skill of pilots, only with even greater precision or 'delicacy'.

At last, docking is completed! First it is checked to make sure it is airtight, and then the transfer begins, that is, you open the hatch and, moving cautiously, without any hasty or unnecessary movements, 'swim' into the orbital station.

The astronauts look round. The planning is strictly rational, with nothing that is not absolutely necessary. This 'spartan' environment might come as a shock if the crew had not previously become accustomed to it during training in the model. Control panels, indicators, portholes, boxes with instruments and food rations, hatches, clamps, lights, ventilators... Like any new resident, the astronaut thinks about the changes he will make (for example, the chemical air purifiers or the electrical accumulators which have reached the end of their working life), and about the additions he will make. That was how a television set first appeared on the orbital station. It had not been planned in the original design of *Salyut-6*, but it turned out to be essential to the psychological well-being of the astronauts, for live contact with the control centre, and also with their wives and children, and simply for relaxation. The astronauts watch concerts and sports programmes. However, they do not have much time to spare to watch television as a space station is, first and foremost, a place of work.

Many other things are delivered after the residents have arrived. They are brought by the unmanned transport ships *Progress*, which also bring fuel for the station's engines, newspapers, letters, fresh fruit and vegetables.

It happens that without men a 'space home' gets desolated and cooled. On arriving to *Salyut*-7, which was in automatic flight round the earth from autumn 1984 to summer 1985, Vladimir Dzhanibekov and Viktor Savinykh found it in a deplorable state: there was no power supply from the solar batteries, the instruments were dead (the cosmonauts knew when still on earth that there was no radio communication with the station), the temperature in the compartments was below zero, the water in the tanks was frozen. The new hosts had to do a great deal to breathe new life into their 'space home' and make it inhabitable.

Life on board an orbital station is very similar to life at the polar stations, which is yet further confirmation of the age-old 'cosmic' desire of man to penetrate into places that would appear totally unsuitable for human habitation. However, there are, of course, more dissimilarities than similarities: weightlessness, the deadly cold and the vacuum beyond the walls of this orbiting home. However, the single most striking difference is weightlessness.

This new condition, totally unknown to life on earth, leads to speculation about possible and 'extravagant' evolutionary paths followed by biological forms of existence. However, for the moment we will talk about just one representative of biological life—man.

The newly-born infant, who, in his mother's womb, has been in a condition similar to that of weightlessness, begins immediately after birth to adapt to the force of gravitation, a process which continues for several years: he learns to orientate himself and move in space, to walk. But what would happen if the human being were to remain, even after birth, in a state of weightlessness? This is a perfectly realistic possibility in terms of long space flights in the future. The experts assert that this Homo cosmicus would remain essentially the same as his fellow-men, only slightly thinner and taller, rather like the people in the paintings of El Greco. However, weightlessness would bring with it numerous new factors affecting the physiology and habits of man as they emerged and developed during the three hundred thousand years of human life spent in earth's gravitation.

We will therefore begin with weightlessness, and continue our description of life aboard the orbital station.

After a few hours of euphoria—the carefree, joyous feeling of lightness—weightlessness begins to make itself felt in less pleasant ways. Blood begins to rush to the head. Herman Titov, the second cosmonaut, who spent a whole day in orbit about four months after Gagarin, sometimes had the feeling that he was flying upside down. A similar sensation was experienced by other novices taking part in their first space flight. When describing their experience, astronauts often use the term 'crushes'. You would think that these two ideas—'weightlessness' and 'crush ing'—were incompatible, yet nonetheless that is how the astronauts describe it.

The first few days are the most difficult. You lose your appetite, you cannot co-ordinate your movements, and your face swells up till you can no longer recognise yourself in the mirror. On returning from their 18-day flight on board *Soyuz-19* in 1970, Andrian Nikolayev and Vitaly Sevastyanov were at first unable to walk unaided; the cosmonauts even had the impression that they could feel the weight of their internal organs. It took them six months to recover completely from their adaptation to weightlessness.

This is why, on board the orbital stations, where the astronauts live and work for several months, the flight programme includes compulsory daily physical exercise lasting for several hours and using special equipment—a bicycle-ergometer, a moving track, weighted suits to activate the muscles, vacuum-suits to stimulate blood pressure in the lower half of the body... The astronauts run from three to five kilometres every day on the moving track, apart from the other exercise. These excercises, intended to counteract the negative effects of weightlessness, reveal their effectiveness on the return to earth: the astronauts basically re-adapt to life on earth within a few days.

However, during the stay in space, weightlessness nonetheless makes its own demands. It obliges the astronaut to change his habits and reflexes, to adapt, by force of will, his body and his movements in order to execute what would seem to be the simplest of functions necessary in daily life. When turning a nut, you risk leaving the nut itself unmoved while you yourself revolve around it, unless you have taken the preliminary step of finding a point of support. Archimedes' proud exclamation 'Give me a place to stand and I will move the earth' known to us from our schooldays, here becomes a rule of life. At first you are constantly banging yourself on cor-

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The launching of the rocket-carrier *Soyuz* ners and dropping things 'upwards'. Vitaly Sevastyanov even found that his socks did not wear out in the usual places, but at one side, where he propelled himself forward from the floor, walls or ceiling (though calling these surfaces 'floor', 'walls' and 'ceiling' is here purely conventional, as they are completely 'equal').

Unloading the large containers from the *Progress* transport ships requires particular skill. One man can manage them quite easily, as they have no weight; however, they do have mass and inertia, and you have to learn by experience how to get them to move through the space inside the orbital station.

The label 'Made for weightlessness' could be affixed to almost every object used by the astronauts. The electric shaver has a special hair-collector to prevent the hairs drifting through the air. Ball-point pens are fitted with little containers of compressed gas to force out the ink paste. A hammer does not rebound after a blow: it is hollow, and inside the cavity there are little metal balls that absorb the recoil. (It is worth noting at this point that a hammer like this could also be used on earth in order to avoid accidents. This small example illustrates an important point: some of the innovations introduced by space technology gradually find practical application in ordinary life, from solar battery panels to long-distance medical examination.)

The astronauts wash using special hygienic napkins. Water behaves very strangely in conditions of weightlessness—forming into a drop the size of a fist, or covering any object it meets in its path with an even layer of liquid. Once a month the astronauts take a bath. A polyethylene bag is zipped shut. Then from overhead—or, more accurately, from the side of the head—come water and hot air. The water, drawn by the current of air, flows over the body of the astronaut and then runs into water-tanks. The astronaut uses a sponge and soap, and wears goggles to prevent the soap going into his eyes. He breathes through a pipe, rather like an underwater swimmer. Here, in this mundane, everyday detail, life on board an orbital station resembles not a polar camp, but the work of frogmen.

How do people sleep in this orbiting home? There are no beds, as they are not necessary. The astronauts sleep in sleeping-bags, fastening themselves down with straps. Some prefer to sleep on the ceiling, as there is more space. Aboard the *Mir* station it is better to sleep in the cabins, for there it is quiet, and one is not disturbed by the glitter of the equipment. Vitaly Sevastyanov noted that, if the arms are left free while you are asleep, they begin to circle of their own accord in front of the face, 'floating' freely. So, if you want to sleep peacefully, it is better to wrap yourself up like a babe in swaddling clothes. Once more we have a comparison with a newly-born infant, who, as we have already mentioned, is more accustomed to weightlessness than to earth's gravitation.

Finally, you must not forget, if you do not have a cabin to yourself, to pull down the blinds over the portholes so as not to be woken up by the sunrises and sunsets, which occur every 90 minutes, with each orbit of the space station.

Even sleeping is no easy matter on board a spaceship. Just try sleeping when you are in a permanent free fall! That, in fact, is what weightlessness amounts to... The satellite, be it a spaceship or a space station, on reaching orbital velocity, continues to orbit around the earth precisely because it is constantly falling towards the earth, but the curve of its fall coincides with the curvature of the globe, so that it never actually falls. At first, some astronauts found they were unable to sleep in space without sleeping-pills. Afterwards, however, they adapted. Usually the astronauts dream about the earth, its scents, the rain. This is quite understandable: life away from the earth intensifies affection for everything associated with the earth. In later chapters we will discuss the far-reaching consequences of this fact, and not in dreams but in reality, about 'nostalgia' for the earth, a sense of protectiveness towards it, about the practical help which astronautics can provide in the life and work of men on their own planet.

And now it is time to get up. Straight from the sleeping-bag to the food-warmer. While you are washing and dressing, breakfast is prepared—tinned meat, curd in tubes, crisp-breads—each item to be eaten 'in one mouthful' so that there should not be any crumbs, which would immediately begin to float around the cabin; breakfast ends with tea or instant coffee.

The problem of eating in space had to be solved literally from scratch. Nothing was known—neither how solids and liquids would be 'swallowed', nor what the effects might be on the sense of taste. During his 108-minute flight, Yuri Gagarin did not have time to get hungry, but he ate and drank as part of his space programme. 'Everything happened just as it does on earth', he reported afterwards. Herman Titov's flight programme also contained the instruction: 'Try to eat'.

The sense of taste does, in fact, vary slightly in weightlessness. Everything tastes rather insipid, and you particularly enjoy various spices and condiments. When fresh cucumbers, onions, lemons, and apples started to be delivered to the crews on board the space station, they were eagerly welcomed as an agreeable supplement to food that was either tinned or sublimated (sublimated food is quick-chilled and then dehydrated in a vacuum; as a result the food retains its nutritive value and its flavour, and needs only the addition of water to become edible).

The transport ships and visiting expeditions, which stay at the orbital station for about a week, remain its best supply system. People out in space will continue for some time to be supplied form the earth. However, it will be difficult for future expeditions to other planets, which may last for several years, to take with them a large quantity of food products. They will have to produce at least some of their food on board their ship, creating their own 'agriculture' and their own ecological system, with its own recycling system–from waste products to consumable products. For the moment, the only practical implementation of this idea is the partial purification of used water (which is then used not as drinking water, but for other purposes), and this is very important, as there is only a limited water supply on board the ship. However, this is only the beginning.

Tsiolkovsky phantasised about living beings in outer space. He saw them as taking from their environment only the radiant energy of the sun, with all the life processes occurring within their own closed internal system. 'The cycle of gases, liquids and dissolved solids is accomplished within the living organism, and not through the medium of the external environment. The surface of the body, supplied with small, wing-shaped appendages irradiated by the sun, serve as a laboratory for the production of strength and life.'[1]

Almost no one believed Tsiolkovsky. And today

[1] K. E. Tsiolkovsky, 'Visions of Earth and Sky'.–In: K.E. Tsiolkovsky, *Path to the Stars. A Collection of Science Fiction*, Moscow, 1960, p. 71 (in Russian).

there are no reasons to believe that living organisms can live in space unprotected by technical devices and without supplies of vital resources. However, if, instead of the hypothetical living organism, you imagine a space station and its inhabitants, viewed as an integral whole, then Tsiolkovsky's image acquires a certain validity. This space station is indeed a 'laboratory for the production of strength and life'. And the 'wing-shaped appendages' are the solar battery panels.

Research into the regeneration (reproduction) of living systems in space is continuing, and will be discussed in the next chapter, where we will look not only at the problem of space and man, but also space and life in general. Meanwhile let us continue our description of the amazing space-earth world which is created by the combination of space and the habitation created by man within this space.

When conducting visual observations of the earth from space, the astronauts often see minute details: the wake of a ship crossing the ocean, a line of motor vehicles on a motorway. Vitaly Sevastyanov spotted the house in which he was born, surrounded by cypress trees. Theoretically this is 'impossible'. The first photographs taken of the surface of the earth by unmanned spacecraft from approximately the same height did not make it possible even to judge whether the earth is inhabited or not. These photographs, it is true, were of poor quality.

The high level of 'resolution' by the human eye in space is now under study and will continue to be investigated. Perhaps the physical abilities of the eye are here reinforced by psychological factors. It's possible that Sevastyanov, looking down at the earth as if it were a map, was simply able to imagine exactly where his house was situated, and mentally traced a line from the clearly visible port of Sochi to his house, surrounded by cypress trees. However, Alexei Leonov saw the solar 'cap' during sunrise in space—an atmospheric phenomenon that was photographed only later.

We cannot exclude the possibility that condi-

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Dawn in space

tions in space improve the functioning of the senses. It is suggested that the colour range perceived by our primitive ancestors was very limited, and that they could not distinguish between the light blue of the sky, the dark blue of the ocean and the green of the vegetation (it is thought that this is true of many animals). However, constant comparison and contrast finally led to the differentiation of these colours. May not the view of the earth from space constitute a new step forward in the differentiation and increasing sophistication of man's visual perception of the external world? And perhaps, at some future date, the ash-grey scenery of the moon, the uniformly reddish plains of Mars and the pale-green rocks of Venus will come alive with various colours. However that may be, the view from the porthole of a space station gives rise to serious reflections, places before us a whole scientific problem, indeed, a problem that is not only scientific, but also aesthetic. This is something else we will be discussing later.

From time to time furrows appear on the external surface of the porthole windows. These are the traces of micrometeorites which have struck the glass. Thus 'looking out of the porthole' is a relatively safe, but nonetheless not entirely carefree occupation. You can never forget the emptiness of space that lies beyond, crossed by microparticles travelling at incredible speeds. The furrow usually measures about 1 1/2–2 millimetres. And what if the particle had been a little larger? That is extremely unlikely, but there is always the remote possibility. For—we stress yet again—only a few millimetres of metal panelling separate the world where life is possible from the world in which life, totally unprotected, perishes instantly.

Yet, when you look out of the porthole, it is not a sense of danger which is uppermost. The orbital station is not only spacious, but sails majestically above the earth. Every astronaut notes this majesty. Noiselessly, unhurriedly, without any apparent effort, the space station orbits the earth in just 90 minutes, plunging into the darkness of night, and then re-emerging. The solar battery panels cut across whole continents and oceans. They are somewhat reminiscent of the wings of early aircraft—angular and flimsy. Then these flying machines were able to rise into the air for only a short while, and not very high. And now! The human eye takes in whole seas and countries. Of course, it is not the thin wing-panels that are carrying the space station on its course, but the laws of celestial mechanics, which man has come to understand and apply.

Even music can be heard in this triumph of near space flight. Nor is this merely a poetic phrase in our story, but is a fact witnessed to by the astronauts themselves, and confirming the profound link between the senses of sight and sound. The sense of solemnity, majesty, ineffable harmony, born of the sense of sight, captivates all the senses and forces them to respond in unison. The ancient Greek mathematician and philosopher Pythagoras spoke of 'the music of the spheres'. The ideal proportions of the Universe, he had argued, lead to ideal harmony, 'the voice of the gods'. In fact, the 'music of the spheres' arose thanks to human genius; we can boldly assert that this harmony of the spheres is based on the harmony of the sphere of the earth and the technology created by human hands.

Yet even more impressive is the emergence of man into open space when he leaves the spaceship or space station. Only his spacesuit separates him from space. Here is the image of the modern Icarus, without wings, perhaps, but far more powerful and invulnerable than the mythical hero of the Greek legend. The first step into space was taken by Alexei Leonov in 1965, when he left the *Voskhod-2*. It took place in daytime and lasted for twenty minutes. During that time Leonov was able to see the whole territory of the USSR, from the Black Sea to the Soviet Far

East. He experimentally tested the spacesuit and the functions of physical co-ordination and movement in space. Preparations had to be made for the work to be undertaken by subsequent space crews outside their spaceships—and indeed this was to be work, and not merely floating about in space.

For the *Salyut* space crew, leaving the space station became 'routine': instruments and sensors attached to the hull had to be checked and replaced, minor defects rectified. Aboard the *Mir* stations, these excursions will be even more frequent, particularly for scientific purposes. Yet even a brief spell outside the space station is a complex business and evokes unexpected sensations in each astronaut leaving the air lock (depressurising chamber) to go out into the emptiness of space for the first time. When the antenna of a radiotelescope, jettisoned on the completion of a radio-astronomical programme got caught on the hull of the space station, flight-engineer Valery Ryumin had to climb out to free it. He said that, when he was crawling along the long hull of the space station, he sometimes felt as if he was tumbling headlong down a fire-ladder from the top of a high building.

The year 1983 saw the birth of a new and highly promising profession—that of cosmonaut-fitter. Vladimir Lyakhov and Alexander Alexandrov went outside *Salyut-7* to fit additional solar battery panels. More such panels were added by Vladimir Dzhanibekov and Victor Savinykh in 1985. In the future, large installations and entire space settlements will be built out of blocks and fittings delivered from earth, and later constructed on site of lunar and asteroid material. However, we will talk of this later, in the chapter on the industrialisation of space.

Such sorties into space are also made by American astronauts from *Shuttle* spacecrafts. They use individual reactor packs so that they are independent of the spaceship. Leonov used a 'cord', rather like an umbilical cord connecting him to the mothership. However, subsequent progress in no way diminishes the grandeur of the first steps. If Gagarin was the first to fly beyond the earth's atmosphere, Leonov was the first to float in space outside a spaceship, thereby providing information about the effects of free-floating in space on the human being as valuable as the information provided by Gagarin on the effects of flight aboard a spaceship.

There is one additional 'detail'. Until now American astronauts have not undertaken any construction work in space. Sometimes they leave their spacecraft in order to carry out repair work on their satellites (for example, in 1984 the crew aboard *Challenger* carried out repair work in orbit on the satellite *Solar Maximum*, which had been launched four years earlier to collect data on solar physics, but which had operated for only eight months), and to learn... how to seize satellites belonging to others. However, that is already another topic, that of space piracy, and also a first step, only a step, towards the militarisation of space, to which we will refer from time to time in subsequent chapters.

However, let us return to peaceful work in space. We must now look at certain personal, socio-psychological aspects of life and work in orbit. Is it lonely in space? Today, if we are to speak the truth, to a certain degree it is. Outwardly, life in space is regular and monotonous. There should be no surprises, no unexpected happening during a space flight. This stability is ensured by the work of a large number of people who test the constructions for reliability and the control systems for faultless operation, creating duplicates and 'triplicates' for the most crucial elements. The unexpected in space is only a step away from the dangerous, and therefore it must be avoided. In January 1986, the spacecraft *Challenger* broke up in the lower stratosphere following an explosion in one of its solid-fuel boosters. Seven astronauts perished. According to American experts, this catastrophe could have been avoided by more thorough technical preparation of the *Shuttle* for its space flight.

Loneliness does not, of couse, mean separation and isolation from everyone, as was the case when astronauts were prepared for one-man flights in surdochambers. Now astronauts fly at least in pairs, and, together with visiting expeditions, they sometimes number four, six, or even eight, as was the case in 1969 with the joint flight and closing of the spacecraft *Soyuz-6*, *Soyuz-7* and *Soyuz-8*. We have already mentioned radio and television contact with earth.

However, most of the time, day after day during the course of many months, there are just two, or perhaps three cosmonauts living together. In 1982 Anatoly Berezovoi and Vladimir Lebedev spent 211 days in space. In 1984, Leonid Kizim, Vladimir Solovyov and Oleg Atkov spent 237 days in space (the longest period to date). Once the cosmonaut Georgi Grechko conducted an experiment with students. He proposed that two of them simply stay together in a room. The two students lasted only six days. In part this was because they were doing nothing most of the time. Astronauts are busy every moment of the time, for even their leisure activities are geared to maintaining their work efficiency.

However, for all the difficulty of having daily contact with only one, or less frequently, two other people, and finding oneself otherwise cut off from normal human intercourse (the urban dweller often engages in more than one hundred daily contacts

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Above the earth

with others), solitude is by no means an ideal for the astronaut. It would be a complete mistake to imagine them as gloomy and constantly working, tolerating each other's company only out of necessity.

Sometimes the cosmonauts have a bit of fun. Pyotr Klimuk tried to fly around the spacecraft living module riding a vacuum cleaner, rather like some modernised wizard on a broomstick. It did not work, as there was too little propulsion. But he had tried! Georgi Grechko would tap on the wall of the space station during his leisure time, causing small flakes from the outer hull to float off. These he photographed, and then, on his return, showed them to his friends: 'Look, "flying saucers" belonging to extraterrestrial beings.' And many believed him. (We will take a look at the latest 'astronautical' superstitions in the chapter on extraterrestrial civilisations.) Michael Collins, the American astronaut who wrote a book about the first manned landing on the moon, described how refuse jettisoned in space and accompanying the spacecraft for several days, would blaze like many-coloured constellations, and then added the amusing yet telling comment: 'Sometimes it takes only very little to provide genuine aesthetic pleasure!'

We might end this chapter on such a 'comic note'. However, the astronauts return home. When the hatch of the landing craft opens and the astronauts remove their space helmets, their first impressions and 'recollections' are the smell of the grass, the breeze, the soil.

Tsiolkovsky supposed that, on returning to the earth, the inhabitants of the 'space colonies', artificial dwellings constructed in space, would feel strange and unfamiliar. In addition to earth's gravity, which would restrict their movements, they would find the earth cold and damp, and the stars distant and dim.[1] Well, perhaps it may be so when thousands upon thousands are living in space, when children are born there. However, for some time to come men will be going into space not to live there permanently, but to undertake work–difficult but interesting and, most importantly, necessary and useful work, and mainly in near space. He feels the impact of gravity as he felt the impact of weightlessness, but for the rest he is unspeakably happy to rediscover the earth, its fields, rains, snows and people.

However, we called this chapter 'Homo Cosmicus'. We have attempted to show that the dawn of the space age is a turning point in the evolution of Homo sapiens, who has now begun to acquire new qualities correlating him to the Universe. And, indeed, we have seen what unusual physiological and psychological qualities are developed by the human astronaut, seen how he looks afresh at his natural environment, and seen also the grandiose scientific and technological tasks that now face him.

This chapter is by way of an introduction. We have referred more than once to those phenomena and problems which arise when giving a simple description of everyday life and work in a spacecraft and orbital station. First of all, however, we will look at a broad question of fundamental importance for the future of astronautics. This is the question of the interrelationship between life and the Universe, and whether they are, in the final analysis, contraindicated to each other. To answer 'yes' would mean to agree with the British astronomer

[1] K. E. Tsiolkovsky, 'Beyond the Earth'.–In: K. E. Tsiolkovsky, *Path to the Stars. A Collection of Science Fiction*, op. cit., p. 245.

James Jeans, who declared that the nature of the Universe is totally hostile to any form of life (we will examine this point of view in greater detail in the concluding chapters of this book), and that life is 'a sickness of an ageing planet'.

Is that really the case? Until now men have known about life only within the strict confines of the planet earth. For thousands of years man considered the earth to be his sole Universe, the place where life had emerged and where, one day, it would end (here is yet another problem, that of 'the end', which we also promise to examine). How will life react when it finds itself face to face with the true Universe, a Universe which presents the natural world as it is, so to speak, and, not as it appears when seen in the distorting mirror of the earth.

Chapter Three

The Universal Dimensions of Life

Hence life, which we, human beings, are representatives of along with other species, stands out before us a phenomenon belonging to the earth alone. Modern science possesses evidence, however, that even while living matter was being generated on earth, it was linked to space by thousands of threads. We need only recall that our sun is, in essence, the energy source for all life on earth.

Today the connection of life on earth with phenomena occurring in the space surrounding our planet and in the Universe as a whole is becoming increasingly well understood, although it has obviously not been learned in full. Life on earth arose in the very earliest stages of the formation of the earth itself. Highly simple living organisms existed on it even 3 1/2 billion years ago. Fossils of them have been found imbedded in ancient rocks. Some scientists believe that organisms capable of photosynthesis, that is, of using light energy for transforming mineral substances into nutritive ones, existed even earlier—4.2 billion years ago. Recalling that today the earth's age is placed at 4 1/2-5 billion years, it becomes apparent that life on it is inextricably related to it and is not merely some casual or late-coming companion. (It would be pertinent to recall here that living matter has always been an active force participating in the formation of the planet's upper layers and deposits of useful minerals such as petroleum, coal, natural gas, limestone, ores, and in creating the earth's gaseous membrane, the atmosphere.)

One must not thus speak of life as an attribute of a 'planet growing old'. Could it be, however, that it really represents a 'disease' which immediately struck the still young planet, or, to put it in scientific terminology, the primary-phase earth? Generally speaking, disease is an anomalous phenomenon linked to chance. Hence, the question may be put in another way: did life on our planet originate by accident?

Our answer is 'no'. It was not merely earth-bound forces and conditions which gave rise to life on earth—in the final analysis, it was qualities and attributes of space, of the metagalaxy, the entire visible Universe, which had a hand in the process. The development of life on earth led to the appearance of man. In contemporary cosmology, the science of space, the appearance on our planet of rational creatures—mankind—as stipulated by space-related factors, was expressed in the 'anthropic principle' (from the ancient Greek word 'anthropos', meaning 'man'). The anthropic principle states that the entire evolution of the Universe, from the big bang of the metagalactic 'egg' through the formation of stars, both stationary and stable, planets around them, including those in optimal orbits for the appearance of life, and up to life itself, has led to the appearance of man. The ancient idea of the unity of the macrocosm (the Universe) and the microcosm (man) has now been seized upon and buttressed by science.

If for no other reason than its astronomical span of existence already, life on earth must be termed a phenomenon of space. But the duration of its existence is not the point. Aside from the life-creating effect of the sun, an ordinary star within the family of stars, there is another highly important but still not fully explored aspect of space's interaction with earth organisms, and that is the reaction of these organisms to the effect of gravitation, that fundamental force throughout the Universe. In a certain sense, all life on earth, the structure and development of every organism, is determined by the force of gravity. Man's ability to walk upright, which has promoted him from the world of four-legged animals and, in a way, surmounts gravitation, has likewise elicited a fundamental restructuring of his body, freeing his upper limbs, the hands, for labour and thereby encouraging the rise of rational thinking.

Geological and paleontological research gives reason to believe that the earth's gravitation has not always been the same. We know that, in addition to revolving about the sun, the earth also rotates about the centre of the galaxy. Some scientists think that our gravitation may vary depending on the position of the earth and sun within the galactic orbit, affecting, in turn, the biosphere. It is thought that life emerged from the ocean, where it was born, onto dry land, and that the first birds and later mammals appeared during lower gravitation periods. It is possible that an increase in gravitation at the end of the Cretaceous period wiped out the group of reptiles—land dinosaurs and pterodactyls. These mostly massive animals could not manage their own weight. Thus, cosmology offers its own reply to one of the greatest mysteries of life on earth—why the dinosaurs suddenly vanished.

There are, certainly, other lines linking earth and space, as well—for example, when large meteorites hit the planet. Evidence of meteorites striking the earth's surface is to be found in abundance in spite of centuries of wind and water erosion. It is believed that such strikes, which were more frequent in the distant past than in historical times, may have, in certain instances, led to serious geological faults, to glaciations (owing to atmospheric haze caused

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Sections of the spaceship *Soyuz* are jettisoned on returning to earth by the impact and, consequently, a diminution in the sun's heat), and to flooding after the dust had settled and the ice melted. It may even be that the biblical tale of the world flood (which, apparently, was really just a local flood, and not a 'world' one) is the story of one such event passed down in legend.

The link between space and life on earth can perhaps be most graphically seen when we turn to that most prodigious mystery of the Universe—the mystery of the specific process and mechanism of the origin of life. The hypothesis of Academician A. I. Oparin has become prevalent in our era. It says that life resulted from the evolution of simple organic compounds which formed out of the gases which made up the earth's atmosphere long ago. Bombardment by ultraviolet rays from the sun (i.e., a space factor)—and this was extremely heavy at the time without the protective ozone layer—might account for the energy source which got the organic synthesis mechanism going. This hypothesis has been partially substantiated in laboratory experiments, although a living substance has yet to be obtained. It also accounts for the discovery of starting molecules needed in complex organic compounds—ammonia, methyl and ethyl alcohol, methylamine, formaldehyde, et al.—in interstellar space and in other galaxies.

Other views exist besides Oparin's hypothesis. For example, being considered today are various suppositions with the term 'panspermia' common to them and which base themselves on the notion that life was brought to earth from beyond. Back at the turn of the century the Swedish natural scientist Svante Arrhenius proposed the idea that spores of the simplest organisms may be floating about the Universe impelled by light pressure (whose existence had been proven by that time by the Russian physicist P. N. Lebedev). Upon landing on some planet, they could, in certain instances, give rise to life. Other scientists think that meteorites or comets might be conveyors of embryonic life. Organic carbon compounds making up the cement of life as we know it have occasionally been found on meteorites reaching the earth's surface. It should be noted, however, that while hypotheses of life being brought to earth from other worlds do not contradict the principles of philosophical materialism, they nevertheless still do not answer the central question of biology: how and under what conditions did the transition from non-living to living take place? How did the 'spores of life' originate and where did they come from?

Be that as it may, life on our planet owes its origination to a combination of space and planetary conditions and is now itself, after lengthy evolution and in the person of man, going out into the Universe. This is evidently the pattern of life's development pertaining now to the future, and not the past. Space, planet, and space again—the universal cycle of life being demonstrated now by mankind. By venturing beyond the boundaries of its birthplace, earth, life reveals whither it would go—space. This is the 'evolutionary' significance of the space age we are in.

Microorganisms from the earth can be found as far up as 100 km, the limit of terrestrial life's natural expansion into space. With the help of rocket engineering, however, not only can man himself go up into space ('artificially'), he can also take plants and animals with him. At the outset (what is being done now) the effect of space flight on specimens of earth life is studied, with the exploration and settling of a new living space facing us in the long run.

Biological experiments in space have multiple purposes, helping to resolve practical problems of space travel such as determining how dangerous orbital flight is for a living creature (which obviously includes man), finding ways of making plants a part of the life-support system, and using them as carbon dioxide absorbers and oxygen and food suppliers during flight. What is more, biological experiments in space are of fundamental scientific importance, helping, for instance, to ascertain the effect of radiation and weightlessness on one of life's mysterious mechanisms, the genetic code, the record of hereditary traits passed on from parents to children, from one living organism to another.

Study of how organisms behave when placed in weightlessness for long periods of time is unquestionably important both for practice and for science. Under earth conditions this state can only be simulated (by, say, exercises wherein the cosmonauts don spacesuits underwater) or else can be created for a few minutes' duration at most (practising in a steeply descending airplane). Scientists believe that once a living being's reaction to weightlessness is understood, it will be possible to experimentally ascertain the role of gravitation in the emergence and formation of life on earth, that is, to solve a critical scientific and world-outlook problem—the testing of the cosmological hypothesis brought up earlier that it is gravitation which determines the principal stage in life's development.

Biological experiments in space are a delicate and highly specific affair. We might begin with the fact that they are often conducted on remote-controlled satellites without the immediate participation of the researcher. To this end, complex and, at the same time, maximally light and compact instrumentation is employed—all cargo put into orbit must meet this criterion. For higher animals, automatic systems are devised to supply them with oxygen for breathing, food and water, and to remove their bodily waste products. The first living creature to leave earth was the dog Laika, which was sent into space in 1957 on the second Soviet satellite a month after the launching of the famous first Sputnik. Dogs continued to be sent aloft thereafter and would return alive and well. In 1983 and 1985 some chimpanzees flew in space and likewise came back safely to earth.

To this point cosmonauts have not taken higher animals with them on manned flights. Experiments on living material in space are complicated and quite difficult. With no gravitation on the spacecraft one cannot put tools, experimental animals, nor even plants out on the table. Neither can you set out containers for nutritive, dyeing, or fixing solutions–before you know it, everything will be floating about the cabin. Not only does this mean the experiment's failure, it also entails a threat to the entire programme of the flight and maybe even to the crew's health. Tiny drops of liquid suspended in the air could get into a person's respiratory passages or cause complex equipment to malfunction. Neither can all substances be kept in open vessels. Those even slightly injurious (and biologists must work with such substances not infrequently) must be hermetically sealed. It remains to be added that even on lengthy flights lasting many months the cosmonauts' schedules are planned out to the minute, and that they carry out numerous other programmes besides just biological ones. This gives rise to one more requirement that must be made of all experiments: maximal simplicity of the operations they involve.

As to how scientists untangle the ball of contradictions between the tasks of research and the hard and fast restrictions on the conditions for carrying it out, managing nevertheless to come up with interesting experiments, we might refer to experiments done with drosophila fruit flies. These insects, veterans of cosmo-biological research, have been sent aloft both in bio-satellites and manned vehicles and made journeys to the moon and back in the *Zond* exploratory probes. Keeping the flies in space does not entail much fuss. They need no special life-support cubicles, doing well enough in an ordinary test-tube with a little nutritive bouillion placed in the bottom. Drosophila experiments on the *Salyut* space stations were conducted in special thermostatic chambers at a constant, strictly controlled temperature. A bio-container for experimenting with developing larvae and pupa consists of four plastic test-tubes fitted into the slots of a foam-plastic test-tube holder. The container is placed inside the chamber, which is thermostatically regulated to maintain a temperature of +25°C. The apparatus, which has flown on the *Soyuzes* and *Salyuts*, is both light and compact and requires no special care or attention in flight. When the experiment is over and one generation of flies has been raised, the bio-container is removed from the chamber and sent down to earth on the next transport vehicle. It is far more interesting, however, to get several generations of drosophila in weightlessness, as this yields true 'ethereal creatures', to use Tsiolkovsky's terminology, which not only develop, but are also born in space. Terminology is obviously besides the point—this is experimental confirmation of one of the Kaluga scientist's boldest hypotheses.

A different device has been created for experiments of this type. It is a plastic cube each side of which is about 10 cm in length. It is divided inside into compartments with nutritive medium and doors between them. In flight the cosmonauts take the cube out of the thermostatic chamber as necessary

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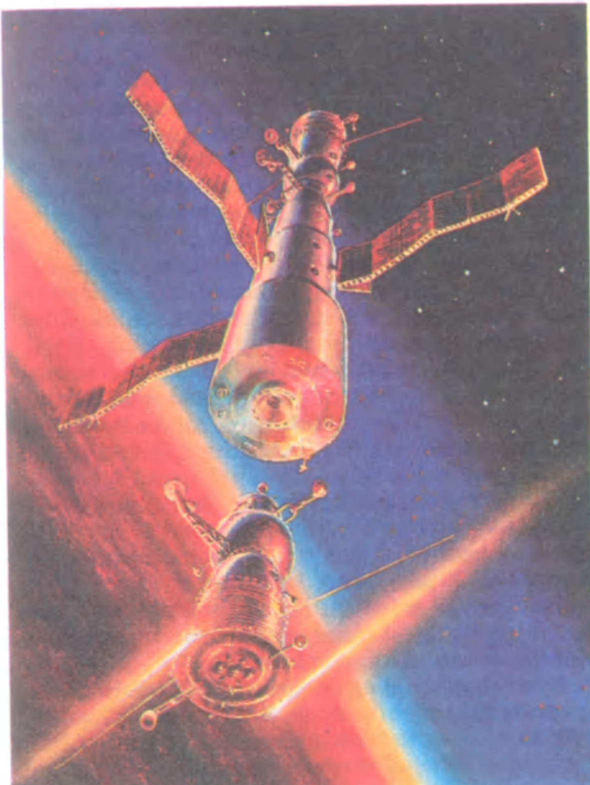

Progress comes in to dock

and open the door for the insects in the first compartment to go into the second. The flies leave eggs in their new living quarters, giving life to the next generation. Pure space larvae result from these eggs, and these larvae, in turn, become pupa and then flies. As adults, they are then transferred into the next compartment to raise the next space progeny. This is just what happened in reality, too. Maybe they are only drosophila flies, but living creatures are capable of living and multiplying outside the earth. This important and highly promising conclusion drawn from the experiment proves that life and space are not contraindicated to each other.

This applies to the plant kingdom as well as the animal. The growing of plants in space is linked to the attractive and still today romantic side of the Universe's conquest by man–distant space travel. Productive space hothouses would provide cosmonauts on such flights with oxygen and food, as well as reprocess life-function waste products instead of 'uneconomically' jettisoning them. But there is another point, too. Man will always need his familiar earth environment. Heading into the vast recesses of space, he will certainly take with him a small part of his native planet, taking trouble to look after plants and include them in his space decore. This will aid him in preserving his psychological equanimity. Even today looking after green sprouts is a favorite activity of the cosmonauts.

Space botany is older than manned space flight. A tradeskancia branch, a flowering houseplant, orbited the earth before Gagarin on one of the test flights of the future *Vostok* spacecraft. So far many plant species have gone up into space: onion, pea, wheat, corn, cabbage, dill, and lettuce. 'Oasis' is the name of the unit used to grow higher plants in. By space standards, it is big. The 'Oasis' that went along on the *Soyuz-6* weighed about 20 kg and was 455x520 mm. This provided a small isle of plant life in the void of space. Its main part is the cultivation chamber where the actual growing of the plants takes place. The crop grows in vessels whose bottoms contain, instead of soil, an inset soaked in nutritive solution. Plants need good lighting to develop normally, and so the unit has its own light source which substitutes for the sun. An air current to renew the atmosphere in the cultivation chamber is created by a fan. This is an utter necessity in weightlessness, since the mingling of air layers which we are accustomed to on earth—the rising of warm air and descending of cold due to their weight difference—is absent here. The watering procedure is a unique one. Water on the station is kept in a special tank from which it is pumped directly to the roots which, incidentally, also need ventilation and therefore get aired from time to time.

One must go to all these links to set up a garden or orchard in space today. At first things did not go as well as they might have: the plants would start out growing fine, then quickly shrivel up and die. Only one bean plant was brought to flowering. It was an arabidopsis, a tiny plant with small flowers which does not misbehave on earth. Some specialists were even saying that there was nothing wrong with that, since in space plants would not have to be grown for a whole cycle from seed to seed; one could restrict himself to obtaining a green mass, the way corn is grown to the stage of milky-wax ripeness in the temperate and northern parts of the Soviet Union. New planting material is easily obtainable from earth as seeds do not take up much room and keep for a long time.

But if plants do not develop normally in space, then it must be that something on the spaceship does not suit them. How, in the final analysis, will that 'something' affect the cosmonauts' health? Optimists maintained that plants do poorly in orbit because we have yet to learn how to take care of them properly. Man himself has managed to condition himself to weightlessness, even though it causes a considerable re-ordering of things in his body: fluids are displaced to the upper part of the body, blood volume is diminished, and the water-salt balance is altered. These and other changes lead, in turn, to differences in the functioning of the cardiovascular system and in the muscle and bone tissue. All the same, with the aid of various prophylactic measures (exercising and special suits we have already mentioned) and a balanced diet the absence of the body's usual environment can be made up for. In a certain sense, man has it easier in space than a plant, as he can consciously regulate his life function, make up for food items his body may lack, and provide compensating physical influences for it. Specialists worked long and hard perfecting methods of raising plants in space and at length achieved their aim. While on the *Salyut-7* space station cosmonauts Anatoly Berezovoi and Valentin Lebedev planted in the 'Phyton' (ancient Greek for 'plant') arabidopsis seeds which grew and yielded seeds!

Agriculture in space will be difficult, but has it been easy on earth so far? Is it really all that simple even today on our planet? Early man experienced the threat of starvation and dying off before he hit upon switching over from gathering the ready 'fruits of nature' to agriculture (and from hunting to cattle-breeding). Tsiolkovsky's fantasy predictions of space greenhouses with tremendous fruits, of branches which would not bow down in the weightlessness, and where the sun's energy would be plentiful and constant round the clock, have proven not so easily realisable as, perhaps, the scientist himself thought. But there will be greenhouses in space! The little arabidopsis has proven their potential to work.

Incidentally, the green surface of all plants on our planet exceeds the surface of the earth itself by a factor of about 300 and is comparable in area to the surface of the giant planet Jupiter. Hence, plants are genuinely space creatures living right beside us and making very active use of the energy of our nearest star, the sun.

Up till now we have been speaking of transporting earth life into space and of its artificial cultivation there. But is there not somewhere in the impenetrable depths of the Universe some other extraterrestrial life form? So far space exploration has yet to discover anything living either in open space or on any other planet in the solar system. (Neither has astronomy provided any evidence of life existing outside the solar system.) Astronauts on the first American lunar expeditions were strictly quarantined upon returning to earth so as to keep from bringing back any hypothetical lunar germs of unknown qualities which, because unknown, could potentially be highly dangerous and hard to counteract. The precautions proved unnecessary, however, as the moon is sterile and lifeless. It is true, though, as subsequent experiments have shown, that this has not prevented earth seeds–cabbage, carrot, lettuce, and radish–from coming up splendidly in sterile lunar soil brought back to earth. One amateur Dutch tulip-growing society even requested a handful of lunar soil from the USSR Academy of Sciences in order to come up with a new variety of tulip, a flower much renowned in Holland.

There likewise has proved to be no life on Venus. The landing vehicles of Soviet automated *Venera* probes have shown the temperature and pressure on the surface of the 'morning star' to be such that no living thing could withstand them. No life has been found on the red planet, Mars, either, although until recently it was supposed that not only was there life on it, but even advanced civilisation. The old question, 'Is there life on Mars?', gets a negative answer. On the other hand, another question now crops up: will there be life on Mars? Modern science does not rule out a positive answer. Soviet biologists and technicians have devised an earth installation known as 'Artificial Mars'. The natural conditions (soil, temperature, the composition and pressure of its rarefied atmosphere, and the comparatively heavy bombardment of ultraviolet light from the sun) which really exist on Mars and have become known from information obtained by space probes, have been recreated in it. It has turned out that representatives of the 'third kingdom', bacteria (the first two kingdoms being the plant and animal), can survive the Martian conditions fine. This corroborates the crucial supposition of scientists that the 'fragile' life in the earth's atmosphere and aqueous environment (the epithet 'fragile' came from looking at our planet and its biosphere from space) is not all that fragile.

Neither can one consider absurd the views of some scientists that some kind of simple life forms could be living in Venus's cloud cover or in the upper layers of Jupiter's atmosphere.

But proving that earth life forms can exist and propagate in space still remains the primary thing. Life is capable of many things. Of its multiple qualities we have singled out its predilection to spread into space and, one might even say, its space essence.

'I am in hopes that my work, perhaps soon, perhaps only in the distant future, will yield society heaps of grain and vast power,'[1] wrote Tsiolkovsky (and these words we have already quoted in the epigraph to our book). The space age has already denoted man's greatness. Grain will also grow in space. Space exploration, however, is aimed primarily at getting 'heaps of grain' to come up on earth. The import of the developing space age consists in the fact that space science is turning ever more to face our own planet.

[1] K. E. Tsiolkovsky, *First Model of a Purely Metallic Aeronat Made of Corrugated Iron*, Kaluga, 1913, p. 1 (in Russian).

Chapter Four

Spaceship Earth

We brought up the analogy between the earth and a spaceship back in the introduction. That space science is turning its face ever more towards the earth was said by Luigi Napolitano, the President of the International Astronautical Federation. This was at the Federation's 1973 congress held in Baku. He said that man had long looked at the heavens from earth, but now the time has come to look at the earth from the heavens.

At about this same time, the early 1970s, man began seriously pondering the negative effects of his management of the earth. From about the middle of our century onward people's activities have been as broad-ranged and concentrated as the global natural processes responsible for the weather, climate, and other conditions of our inhabitation of the earth. But their grandeur has ceased to be a token of exultation and well-being, for nature has been unable to assimilate civilisation's by-products and is retreating against the onslaught of growing industrial production and proliferating modes of communication (transportation networks which take up arable land, automobiles and airplanes polluting the air, tankers and supertankers leaving oil streaks over virtually the entire surface of the World Ocean). Urbanisation has likewise swelled disproportionately—from space, urban-industrial agglomerates can be seen forming innumerable strips of dust and smoke giving our blue-and-white planet a new, ominous gray-and-brown shade.

Much can be invested in the image of spaceship earth. It is not merely a way of thinking about our planet as a natural 'ship' going round in its orbit for billions of years. It is also an expression of con-

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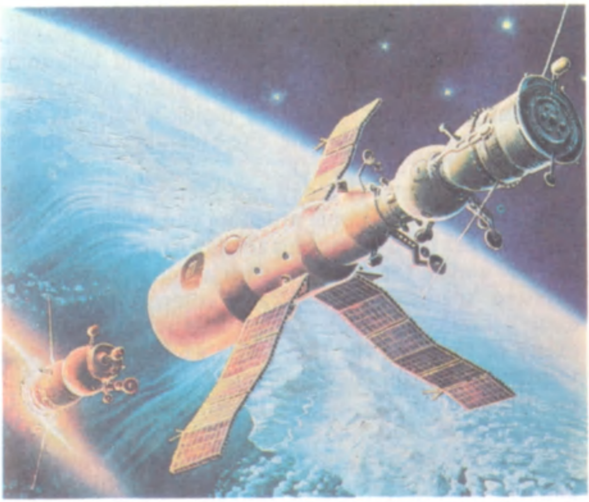

A new team of cosmonauts arrive on board the *Salyut* space station

cern that our 'ship' keep going on its faultless, error- and 'accident'-free voyage. The image originally circulated among space-programme specialists, but later entered into everyone's awareness. Photographs of lunar landscapes with a crescent earth on the black backdrop of space were instrumental in shaking up the ordinary perception of landscape and sky. It was as though people had stepped outside themselves and were seeing themselves and their home from a whole new perspective. The planet earth, with the long familiar outline of its continents, was nevertheless perceived as something new and extraordinary: it's one thing to see a globe, but quite another to see the actual earth itself the size of a globe. The earth appeared not as some common heavenly body, but as the most unique and amazing object in space, a node for 'fragile' life in a world of dead bodies where the 'fourth' kingdom, the mineral kingdom (after the three living ones–animal, plant, and micro-organism), is either frozen or raging wildly (as the sun's protuberances or the fire-breathing volcanoes of Io, a satellite of Jupiter).

Spaceship earth is today not merely an image, it designates reality. People are more and more realising that man has been making his already exceedingly long journey amidst the stars on rather a well equipped and adjusted 'spaceship' whose 'cargo compartments' (the earth's interior) contain considerable reserves of necessary matter. For the time being we have altogether plentiful, albeit unrenewable, mineral resources which no 'transport crafts' supply us with. It is protected from hostile and detrimental outside influences, low temperatures, a deep vacuum, and fierce radiation by durable armour–no few millimetres of metal, either, but rather many many kilometres of atmosphere. Building this perfect spaceship has taken, as we have mentioned, over 4 billion years of continuous evolution, with myriads of living organisms–predecessors of the modern biosphere–playing a crucial part in it. They were able to adapt to the violent activity of the young planet, its frequent, catastrophic earthquakes, volcanic eruptions, and constant thunderstorms in a sky of cloud and dust, and overcome, stabilise, and put life into the surrounding world. It is life and life alone which has created the planet we now live on, giving it its mineral resources, free oxygen in the atmosphere and the ozone layer in the upper atmosphere to protect against the sun's ultraviolet rays, fatal if in excess. The biosphere, in conjunction with the noösphere (the sphere of ratiocination—from the ancient Greek word 'noos', meaning the rational mind) has proven to be the great geological force, as Academician V. I. Vernadsky, the Soviet geochemist and thinker, said, which transformed an erstwhile lifeless heavenly body into a living system, diffusing both its granite depths and gaseous membrane with life.[1]

From the heights of space man has likewise seen that his planet, which used to seem immense, is not all that big in actuality: you can cover it up with your palm, looking from your spacecraft porthole. Man's endeavours on it have already left noticeable traces of desolation. Where there used to be forests now stand landscapes eaten away by erosion. One can make out conflagrations in the taiga and steppe, and see the smog of the cities. Ecological science today bears witness that not only is everything living on earth closely interconnected, the thread of life is firmly interwoven into the non-living environment surrounding it. This unity must not be thoughtlessly violated. The imprudent utilisation of our natural resources is tantamount to throwing life to the winds and leaving man without a future.

Up until now all natural residual products of life function have been used by nature itself—by animals feeding on carrion; by plants growing on rotted material; and in the end, by bacteria turning organic matter into minerals. Nowadays, however, nature cannot cope with many industrial waste products,

[1] V. I. Vernadsky, 'A Few Words About the Noösphere', In V. I. Vernadsky, *The Biosphere. Selected Works on Biochemistry*, Moscow, 1967, pp. 353-358 (in Russian).

particularly those which are synthetic or radioactive. Synthetic articles nature never does assimilate, while the half-life of some of the components of radioactive wastes (i.e., the length of time before they pose no danger and can be utilised by nature) equals the entire written history of mankind. They are buried in salt caverns, the shafts of worked out mines, and in ocean troughs, where they will remain for millennia as a constant threat to life. Spaceship earth has no way of dumping waste-bins into open space, and we haven't the chance, like Michael Collins, to admire their multicoloured luminescence. More likely we ourselves will get to the moon on a garbage heap that civilisation starts. This alone indicates the prudence and foresight which our billions of crew members ought to exercise in conserving their environment.

Not only have space studies firmly backed up scientists' warnings on nature's fragility, they have also pointed the way to preserving nature. Orbiting satellites regularly monitor natural processes and man's economic activities on the ground. They monitor pollution of the seas by petroleum products and tell of the dangerous effects that poorly planned methods of extracting minerals have on nature (for example, removing topsoil during strip-mining without subsequently restoring it). They also see forest fires and the short-sighted use of arable land (ploughing up the land completely, cutting down forests, and soil erosion all cause dust storms no less powerful than those on Mars which sometimes for months on end have prevented the planet's surface from being satisfactorily photographed). They watch the migration of locusts and the spread of other agricultural pests, report on crop maturity and fish reserves in the oceans, and observe bird migrations and the condition of the polar ice-packs.

Our descendents will appraise in their own way the gradual penetration of space. But even now we can, albeit quite arbitrarily, divide the first decades of the space age into three stages. First came the breakthrough into space, which was important for the very fact that it broke the chains of earth's gravitation and sent equipment and later man himself into the region beyond the atmosphere.

The second stage was the 'impatient' study of space in all possible and accessible directions. It was a time of reconnoitring experiments whose purpose was to study near space, the earth, moon, sun, planets in the solar system and carry out medical and biological research from earth orbit, including study of man's behaviour while in space flight.

Lastly, the third and present stage of space exploration is characterised by systematic research in all the above-mentioned areas. While the second stage of space exploration went relatively evenly, since as much as possible had to be learned, if only in the rough, of extraterrestrial nature, its previously inaccessible conditions and potentialities, now, at the third stage, when we can utilise the results of the first two stages, it is becoming increasingly apparent which area gets priority over the others for its significance to both science and the economy.

That area is the exploration of the earth from space and space exploration for the good of man. While man previously strove intentionally to get into space so as to leave his planet in future and conquer other worlds, now, having actually spent time in space, he has realised that the point of space research is to serve man as the inhabitor of earth.

This tack by no means stultifies space studies or experiments not directly connected to study or monitoring of the earth. Our planet and the area surrounding it are not isolated from the rest of space.

Any and all information on the Universe corresponds to earth needs, if not immediate ones, then to more distant ones.

The need to preserve the environment, the living and non-living nature around us with its air, water, and other riches, is man's most immediate and press-

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Morning on the green planet

ing concern today. The ecological problem stands second in urgency now only to the problem of averting thermonuclear war and maintaining peace (we will speak elsewhere of this latter problem in regard to utilisation of outer space).

What is the relation of space exploration to the earth's ecological situation? To better appreciate what will be said further on, let us begin with its fictitious, distorted relationship, one which has, notwithstanding, its supporters and advocates.

There exists a kind of 'ecological' grounding for the thesis of the coming 'emigration' of mankind from earth. In industrially advanced capitalist countries, where signs of the ecological crisis are the most formidable, there is literature which predicts that pollution of the atmosphere and exhaustion of reserves of oxygen and other natural resources will get so bad that people will be compelled to live in an artificial environment, breathing oxygen out of tanks like the traffic cops on Tokyo's car-clogged streets do. People will have to live in air-conditioned houses (which is already quite common) and have doors which seal shut as tightly as spacecraft hatches. This in principle is tantamount to settling a primordial heavenly body. So would it not be better then to leave the decimated, exhausted earth and take up the quest for 'fresh' lands; even be they lifeless at first, at least they would be pristine and not decimated.

One cannot agree with this view. It falsely shows the role of space exploration in eliminating the threats to the earth's ecology. And what will become of the other, 'fresh' lands if the same worthless, anti-ecological practices are repeated on them? One might well use Hegel's concept of 'bad infinity' towards such practices: they are like an event or action which endlessly copies itself without making any qualitative improvements.

The exploitation of space is not the result of some 'ecological instinct', man's impetuous urge to create the conditions and means for escaping from earth. It is rather elicited solely by our demands for developing production, engineering, science, culture, and civilisation. We must speak not of man's departure from earth into space, but rather of a kind of expansion of earth into space, using space's capacities and potentialities to improve earth's ecological, energy, raw-material and food situation. To get more to the point, we need speak of the qualitatively new object of human attention and activity which the unified earth-near space system makes up.

A spacecraft's cockpit is not just a 'miniature earth' which the cosmonaut has taken with him, but neither is it open space which would instantaneously kill him if it were not for the protective gear. It is something else again, combining space conditions (weightlessness, the lack of day or seasonal cycles) and earth conditions (pressurised atmosphere, temperature, water, food). Spaceship earth today is also *something else again*, being neither space nor the former earth which, without space travel, would not permit people to observe it in its entirety. Neither could they provide themselves with information about natural processes on the earth's surface, nor, as in future, utilise the sun's ample surplus energy, or get goods manufactured in space or do much more which we shall tell about in greater detail here and in other chapters.

'Earth is the cradle of reason, but one cannot go on living in the cradle forever.' This popular locution belongs to Tsiolkovsky,[1] and indeed, in the space age man's rational mind has penetrated beyond the earth's boundaries, leaving its terrestrial cradle, having outgrown it, and not only mentally, but now physically, too. However, as opposed to those favouring flight from earth into space, Tsiolkovsky sup-

[1] K. E. Tsiolkovsky, *Jet Flying Apparatus*, Moscow, 1964, p. 140 (in Russian).

posed that man would transform and build up both space and the earth. And this is just what he is doing now, a shining confirmation of the scientist's prediction. The only thing Tsiolkovsky could not forecast is the tight interweaving, the mutual complementing of man's interests in space and on earth. It is not merely that space and earth, like parallel and, hence, non-intersecting worlds, have begun to be settled and mastered by people—it is rather a single, fused space-earth world. But only practice has been able to lead to the fixation of this fact in the theoretical awareness.

For many centuries the earth has fully satisfied the requirements of man and society.

Men, as Karl Marx has noted, have treated nature with the 'naive ingenuousness' of owners and consumers thinking that nature's treasures will always be *inexhaustible*. In the 20th century scientific-engineering and social progress have attained a point where, by many parameters, the earth has discovered its limitations, and consequently, has exposed the limitations of man's former attitude towards nature, as well.

What specifically does space science give for the regulating and harmonisation of society's relations to nature on earth? What it gives today may be expressed by the single word *information*. Is this a lot or a little? Information has always been thought of as something non-material without which one could seemingly get along okay. This is far from true, though. An individual sensorially isolated from the world, getting no visual, aural, or other information about the environment, would physically perish. Society, too, would perish without information and communication. Today information, just as science (which is also information), is becoming a direct productive force. Computers, industrial robots, and entire automated enterprises are based on it. It is the heart of the contemporary revolution in science and engineering. With its aid social institutes are perfected and the personality formed. Hence, the space effort keeps us informed about the earth. This process is effected through many channels, a few of which we may tell about.

Remote Scanning of the Earth's Surface and Monitoring of the Environment. Remote-control satellites in the *Kosmos*, *Meteor*, *Meteor-Priroda* series and, of course, first the manned *Salyut* stations, and now *Mir*, study earthscapes, survey natural resources and help make weather predictions. The so-called 'X-ray' effect of our planet was discovered by space means. Both ocean depths and the interior under dry land can be looked into from an orbiting vehicle. The planet's structure, so it turns out, is not completely concealed by a mirror surface of water, nor by deserts, steppes, forests, and snows. Photos made in various spectral regions, particularly in the infrared (heat) region, as well as X-rays and other regions, fix the finest shades and tonal transitions, allowing the outline of the ocean floor or the geological structure of the earth's crust under the alluvial surface soil to be seen. This makes it possible to do a broad study of the planet's geological composition and the distribution of useful minerals; tectonic phenomena can be watched and the location and intensity of earthquakes and volcanic eruptions predicted.

So-called generalised processes—ones which encompass the entire globe in their effects—are studied on the very surface of the earth and in the atmosphere, too. A space vehicle designed for earth observation is therefore sometimes called a 'macroscope'. As opposed to a microscope, which enables one to see bacteria, molecules, and even tracks of atoms otherwise invisible to the naked eye, a 'macroscope' allows one to take in immense quantities, see broad-scale structures and processes also ordinarily beyond man's vision, even from airplanes or aerostats.

Or we might take one of the 'subtle' observations as an example. We have stated that satellites provide information on fish reserves in the seas and oceans. How is this done? From the trace of light left by fish schools on the water's surface and by studying its own particular spectrum one can tell not only about their mass migrations but even what species of fish they are. On the side one gets information on the availability of zoo- and phytoplankton, the food of fish and sea mammals (phytoplankton also supplies the lion's share of the world's free oxygen).

Space meteorology enables the long- and short-term prediction of weather conditions to be refined and perfected. It has the additional prospect of elucidating the entire mechanism of the earth's weather formation (three-fifths of the earth's surface, covered by ocean water, was virtually unmonitored by the weather bureau until the advent of satellites; most weather happens to be 'made' over this vast expanse of water). It may also allow for the weather and climate to be regulated, which would be an age-old dream come true for farmers the world over.

Lastly, spacecraft can be effectively used to reveal man's detrimental impact on nature. They can calculate the extent, area, and nature of water and air pollution, spot changes in the plant world, determine the rate of desertification. Satellite information helps industrial sites to be wisely chosen and the best conditions for urban construction to be found.

It is not just happenstance, then, that many fundamental and applied sciences about the earth—geology, geophysics, geography, and geodesy—are now taking on a whole new 'space' dimension. What, for example, is space geography? Satellites, especially those with polar orbits, as they cover just about every part of the globe many times over during their lifetimes, ensure timely and detailed map compilation of all the world's continents and islands. What colossal efforts it took and how quickly the maps went out of date when this was done by aerial photography in years past! What's more, repetitive mapping of the same portions of the globe yield a picture not only of the state these areas are in, but also of their dynamics and the processes going on in them. The geographical map has truly come to life, just as fixed pictures come to life when put together in a cartoon.

Taking geophysics, it has been joining up with general planetology and making up a part of it in the space age. Using the space era's (and not just astronomy's) methods and means to study the moon and planets of the solar system definitely has significance for the earth. The structure of the moon's surface, which has not previously been touched by man nor subject to the destructive effect of wind and water, gives us an idea of the primordial earth and its present geological underpinning eroded by rapid and violent terrestrial processes, including anthropogenic ones, i.e. man's economic activity. Mars and Venus, planets of the earth group, have now been adequately studied to serve as natural models of the distant past and—who knows?—perhaps the distant future, too, of our own planet (we shall thoroughly discuss other objects in the solar system in a later chapter).

Space Navigation, Communications, and Broadcasting. Space technology stands out the most in its informational aspect in the areas of navigation, communications, and broadcasting.

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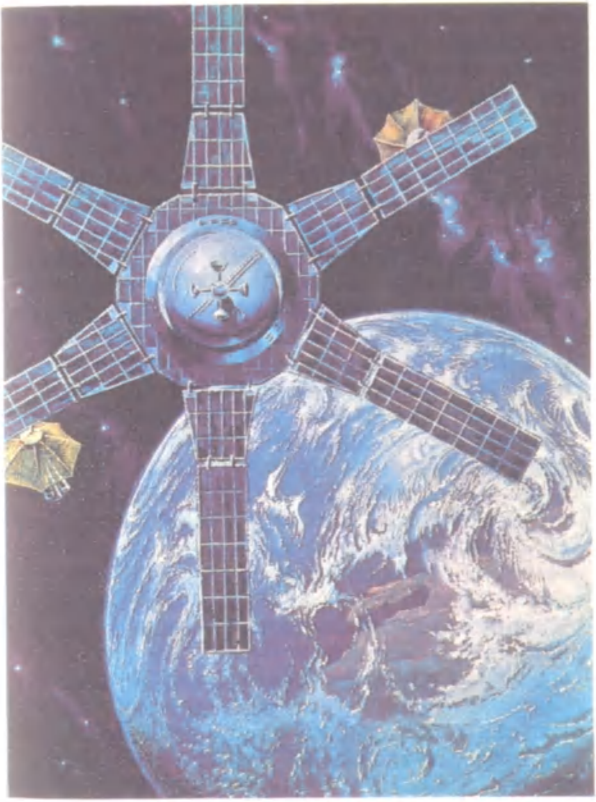

The *Molniya* communications satellite

Navigational satellites, which raise the precision of determining the bearings of sea vessels and airliners to within a few metres, have already saved many lives. Soviet satellites, which participate in the international system of searching, locating, and rescuing disaster-stricken people, have more than once relayed the exact bearings of American, Canadian, and other vessels which have met with accident. This enabled the crews of those vessels to be rendered prompt aid.

It is important to take note here of what might be called a factor of world outlook. It has long since been proven that a great number of nautical accidents and disasters in certain waters are explained by busier sea traffic in these areas. This is true, for example in the so-called 'Bermuda Triangle', the area between the Bermuda Islands, Florida, and Puerto Rico. However, rumour insists on attributing the disappearance there of ships, yachts, and airplanes to aggression on the part of alien beings, i.e., one could say, to the influence of space, only not an earth-guided influence. It would be sufficient to rely on genuinely earth-guided devices, though, and equip every yacht or airplane with a special emergency radio-buoy. A space navigational satellite could then get a fix on the exact place and time of an accident, helping not only to rescue the victims and elucidate the circumstances of the mishap, but also to 'rescue' people from superstitions.

And now for communications and broadcasting through space, that most clearly apparent embodiment of the informational essence of the revolution in science and engineering. The Orbita network of receiving stations for radio and television signals from communications satellites went into operation in the Soviet Union in 1967 for the 50th anniversary of the October Revolution. There are now over 100 such stations scattered about the land in the most hard-to-get-at locations such as the Far North, the Far East, Siberia, and in mountain locales; i.e., they have been placed where it would be difficult or impossible to lay a chain of earth relay stations. Sometimes the station, with its slow-moving parabolic radio mirror continuously pointed at the communications satellite like a sunflower to the sun, is the first building to be erected amidst an utter wilderness with no traces of civilisation to it.

Countries of the socialist community, from Cuba to Mongolia and Vietnam to the GDR, utilise a similar communications and broadcasting system by the name of Intersputnik. Both systems, the domestic and international, are served by an entire pleiad of communications satellites—the *Molniya* in three modifications, the *Ekran*, the *Raduga*, and the *Gorizont.*

Dozens of communications and broadcasting satellites are now orbiting above us, with their best route being about 36,000 km above the equator. The velocity of a spacecraft plying this orbit is in accord with the earth's speed of rotation about its axis (their angular velocities coincide). The craft therefore gives the appearance of hovering motionlessly at a certain point in the sky (for which reason it is called a geo-stationary or geo-synchronised satellite) and is able to retranslate radio and television broadcasts round the clock over wide areas. The effect is like that of a TV tower such as you see in any big city, only one which extends an incredible distance into the sky.

According to Biblical legend, the builders of the Tower of Babel failed in their attempt to erect an edifice up to the abode of God himself. But the Bible's authors could not even have imagined that man would one day learn how to build not a tower, but something which, without any foundation or support, could operate in a high orbit for dozens of years. By the way, as the Bible has it, God kept the tower from being built by mixing up the tongues of the builders so they could no longer communicate with one another. The space 'Tower of Babel', however, does the opposite in aiding nations to understand one another and bringing people and cultures together. The intermingling of tongues is not destructive. But obviously goodwill and respect in relations between countries are needed, otherwise information via satellite turns into misinformation and a way of causing psychological disintegration in nations and individuals. It becomes, to put it another way, a kind of space weapon which, unfortunately, our nearby space is beginning to fill up with. But that is not man's principal route into the Universe, rather merely a detour. Let us continue our narration along the main road of peace and co-operation.

Like other orbits, geo-stationary ones are one of many examples of how what would seem to be absolutely 'empty' space is really another invaluable gift of nature which man is starting to take advantage of in multiplying his wealth this time by using outer space. One of space's significant resources is the fact that it is just that—space. It oughtn't to be discounted that in a few hundred years we may have real rings like those of Saturn in the space where our communications satellites are orbiting. They could house communications and broadcasting transmitters, solar power plants beaming energy down to earth, laboratories, enterprises, and places to live. This would be a human version of astro-engineering, signs of which astronomers have so far vainly sought as evidence of extraterrestrial civilisations.

But now we are getting off on another topic—that of space's industrialisation. It adjoins the preceding topic because the coming development of certain branches of industry in space, immediate energy consumption for this purpose in space itself, the transporting of ecologically harmful waste products, particularly radioactive ones, from earth manufacturing to safe spots in deep space—all this, in turn, is to ameliorate the ecological situation on earth and make life more comfortable there. Space science strives not merely to provide earth with information, but to assume a goodly measure of the planet's economic burdens, as well.

But the point is not merely shifting burdens over. Space promises a new industrial revolution, a revolution in production environment to follow that of mechanisation (the industrial revolution of the 18th-early 19th centuries) and computerisation (the scientific and technological revolution of our era).

Chapter Five

The Industrialisation of Space

The industrialisation of space... The combination of these two words today may engender some surprise. The study and conquest of space for the purpose of obtaining scientific information is a familiar concept, but industrialisation? As pertains to space, this notion seems fantastic and maybe even somewhat scary: can it really be that factories, smoke-stacks, and smog blotting out the stars will be put up in the pristine sky, virtually the last reserve of nature still as yet scarcely touched by man? Certainly not! The industrial landscapes in space will look entirely different from those which currently surround us on earth. What will they be like? For now, we can only let our fantasy roam on this matter, although even now we have some starting points. We shall come back to this presently, taking note that it would not be quite correct to speak of space's industrialisation only in the future tense.

As has already been mentioned, a new branch of space science, communications and broadcasting, opened up back in the mid-1960s. Communications satellites are space enterprises in the most direct sense of the notion "enterprise". Space industrial production, obviously, still as an experiment, dates back to 1969 when cosmonauts Georgi Shonin and Valery Kubasov used the Vulcan apparatus for metal-welding in weightlessness and vacuum on board the *Soyuz-6*. We may note in passing that the vacuum in space is so deep (virtually absolute) that when other cosmonauts would leave the *Salyuts* to go into open space

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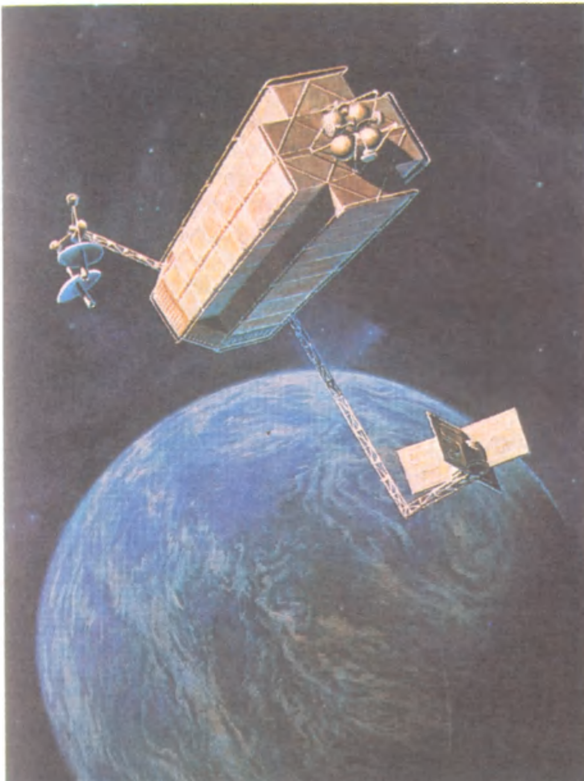

'Shelves' in space

for repair and assembly work, they were confronted with the so-called 'sticking effect'. Items that were not firmly fastened down would stick to the outside lining of the station, a circumstance that will evidently be taken into account by space assemblers and builders of the future.

Spectacular and extraordinary prospects are opening up for earth's residents—extraordinary because of the unusual, for us, effect of physical laws outside the earth. Structures of open-work design can extend many kilometres there, join together into 'necklaces' whose length, in principle, is not confined by anything.

Tsiolkovsky wrote about 'necklaces' of this type. One of the points of his step-by-step settling of space was put like this: 'Industry develops in space'.[1] This was the first pronouncement in history on space's industrialisation, and it was made in 1926 when industrialisation had only just become one of the tasks of the Soviet state. Developing this point of his programme in many works both before and afterwards, Tsiolkovsky wrote about production sections in space 'many versts' long, about shipping starting materials not from earth, which would cost too much, but from the moon and asteroids, about creating artificial gravity for homes and hothouses not on earth, about the behaviour of freight with mass and inertia but with no gravitational pull, and about many other details which today have either become reality in space practice or else are 'being discovered anew' in engineers' calculations, such as the 'space islands' of American physicist Gerard O'Neil.

What, then, are the main trends and particulars of space industrialisation which the space age has brought us right up to?

[1] K. E. Tsiolkovsky, *Collected Works*, Vol. 2, Moscow, 1954, p. 273 (in Russian).

Solar battery panels began to be used in the very first years of practical space flight. Their silicon disks turn the sun's light energy into electricity used to power equipment on the craft. We perceive the area of space near the sun to be black emptiness, but really it knows no darkness. The sun sends out a constant powerful stream of light and heat. Our earth gets but one part in every 2 billions of it. Could this share not be augmented and spaceship earth powered by additional solar energy which, in the ecological sense, is much 'cleaner' than energy obtained from burning oil, coal, or gas?

This question is virtually the first point on the order of the day for industrialising space. The orbiting of light reflectors to direct giant light beams to the night side of the planet would be a partial and most simple solution (simple from the perspective of the energy transfer principle, but far from simple in the design of technological sense). A reflector 3-5 square kilometres in area made of foil and weighing a total of about 1,000 tonnes (and weighing nothing at all after being placed in orbit) could light up an area of 90,000 square kilometres with a strength of 100 full moons (20-30 full moons if overcast). Up to now light has been measured in candles, but now, in moons! The transmission of sunlight alone would have indisputable advantages, say, for the Far North where nights last for 6 months. Everything from cities and highways to greenhouse farming would benefit from the extra light. The Far North could even become someday a new breadbasket thanks to energy from space.

But the possibilities for using space as an energy source for the earth are not exhausted with illumination of the earth's surface by sunlight reflected from space mirrors. The threat of using up the earth's energy resources has been forcing scientists and engineers to give increasingly serious thought to power stations in geosynchronous orbits. And who knows whether space energy won't be an alternative (or significant supplement) to future energy production based on controlled fusion reactions, which thus far have been produced only in the laboratory.

There are several power plant projects scheduled for space. One proposes the deployment of gigantic solar arrays hundreds of square kilometres in area. These would be very similar to the ones now installed on spacecraft. The electricity generated by them would be converted into microwaves and relayed to ground antennas without recourse to wires. Another project has an orbiting turbine which would be activated by gases heated by focusing the sun's rays, the focusing to be done by mirrors each several kilometres in diameter.

The present level of science and engineering is such that the first experiments on transmitting energy from space to the earth may be started before our century has run out. The industrial construction and running of space power stations belongs, certainly, to 21st century energy science. Mankind will then have become a space civilisation in the direct sense of the word, for people will not only be making flights into space, but also utilising its material resources in stepping up consumption of the sun's practically inexhaustible energy. Soviet radio astronomer N. S. Kardashev, who is also engaged in the radio search for extraterrestrial civilisations, classifies civilisations of the first type as having harnessed their planet's energy, those of the second type, as having harnessed the energy of their sun, while those of the third type have harnessed their galaxy's energy. Thus, in the 21st century we can expect the status of a civilisation of the second type.

Obviously not everything will go smoothly. There will be complications and a multitude of complex engineering problems, but in all likelihood, it is not they which will prove the most serious. Specialists are very much concerned by ecological problems. We might take the microwave 'channel-columns' which will carry the energy to earth. These emissions are harmful and even fatal for living organisms; for example, the 'columns' will down flocks of migratory birds which accidentally run into them. When you consider that the area of the receiving antenna will be on the order of 100 square kilometres and that hundreds of such antennas will be needed, then you can appreciate the concern. Everything must be carefully studied and pondered over. Nevertheless, energy of this type from space will be much less harmful than current methods of energy use, and without a growing energy economy, we believe that mankind will no longer be a civilisation. People cannot remain people without science, scientific experiments (often requiring much energy), engineering, and the production of material goods.

There is also the danger of intolerable atmospheric pollution. This is rather odd at first glance, as space power plants would seemingly be utterly clean in this regard. Not only would the plant produce electricity without spewing out dust, smoke, and gases like earth plants, the plant itself would be thousands upon thousands of kilometres from the earth! However, in order to get materials and equipment into space to build powerful enough plants, billions of tonnes of chemical fuel would have to be burned, and in rather a short time, in rocket engines. Such a blow to nature on earth, which is already having a rough time of it, would be unlikely not to leave its effects.

Does it not turn out then that our schemes to get inexhaustible and cheap energy from space are unrealisable? No. Right today a way around the above-described difficulties is being mapped out. By using lasers, which are both more powerful and more 'subtle', we can do away with the complications connected with the deleterious effect of microwaves. And in order to prevent atmospheric pollution by the lift-off of rockets a rocket engine of another type must be devised. It might use laser or electromagnetic energy, the latter of which could accelerate a body still on earth to orbital velocity.

All the same, the cardinal solution to the problem, albeit apparently more remote in the future, lies in something else. The complete and authentic industrialisation of space is not limited, obviously, to merely its energy aspect. Like any industry, space industry will have to manufacture goods, find the raw materials for their manufacture in space itself (using other heavenly bodies and not bringing them from earth), and likewise to get the energy it will require from space (Tsiolkovsky spoke about all of this). Then the ecological and technological difficulties we were just talking about will be removed, just as will the threat of the earth's thermal pollution. Here we mean providing too much energy from space, which could lead in the long run to catastrophic climatic changes: melting of the polar ice-caps, elevation of the oceans, and flooding of a large part of the world's land mass.

The replacement of manual labour by machines was the crux of the industrial revolution which took place in the late 18th-early 19th centuries. This meant the liberation of man's muscles. It is true that much physical labour has been retained even today, but with the introduction of industrial robots, the scientific and technological revolution is making inroads upon it. A robot is not just a machine, but to a large extent, an independent and self-functioning

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Transporting an asteroid

machine which embodies one other aspect of today's revolution in production: the liberation of some of man's mental functions and operations (now entrusted to machines). This process has come to be known as cybernetisation of production.

The new industrial revolution, although not near, nevertheless shows signs visible to the attentive observer and is directly related to the conquest and use of space. It entails a radical change in the very conditions of production and the production environment (with the unconditional preservation and development of the achievements of previous revolutions, first of all, with the liberation of man from excessive physical burdens and certain functions in production management). Weightlessness, which we have already said much about, a deep natural vacuum, super-low temperatures in any shadows in space, and an abundance of solar energy in illuminated places—all these are the principal new conditions.

Among the many different functions of the multipurpose orbital space station we may now single out one: even though experimental it is the most authentic production guild in orbit today.

One noteworthy fact we do not always realise is that nearly all the materials people use for manufacturing the things they need have gone through a liquid or gaseous state. Minerals and rocks were melted in the recesses of the earth; at one time many of the objects surrounding us were melted metal. Our planet's gravitational forces have a decisive effect on both the liquid and the gaseous state. Not only is everything that exists on earth created under gravity, the omnipresent force of gravity also interferes in the technological processes connected with the melting and evaporation of matter. Light strata of liquid and gas float above heavy ones; admixtures are unevenly distributed in alloys. For this reason it is difficult to manufacture uniform alloys from metals of different density; it is hard to get an ideally even structure from a semiconductor. But all of this is necessary for modern engineering and manufacturing.

Our era is seeing the rise of a new field called space materials science. It is still a scientific field, not yet having progressed to an industrial one. But in this age of revolution in science and engineering, science is becoming more and more a direct productive force, and materials science is turning into materials manufacturing, even today (for example, on the *Salyut-7*) acquiring, properly speaking, not only a scientific, but a direct industrial significance, too. For instance, space-manufactured semiconductor single-crystals are entirely suitable for earth electronics, the only difference being that semiconductors of that type are much harder to make on earth.

Space is opening up the opportunity of obtaining substances with improved qualities and of trying out engineering processes not possible under earth conditions. Scientists believe it possible to obtain in space orbit about 500 new materials from substances which cannot be fused on earth.

We have already mentioned the first smelting and welding of metals in space. Back then that caused an uproar. Smelting has become common on the *Salyut* stations, being carried out in electrically heated kilns. A special mixture is made up on earth, soldered in an ampule, brought up into space, placed in the kiln, melted down, and then cooled according to a special programme. Both the smelting and the cooling must be done in such a manner that a semiconductor crystal with uniform structure is obtained. These crystals are much needed today in the radio industry, optics, medicine, and the scientific equipment industry. They are used for making transistor radios, tape recorders, miniature information and control devices (microprocessors) which 'stuff' robots full and which, in time, will become part of our everyday life, making an enormous amount of information, both general and technical or applied, available to everyone.

One invaluable material for many branches of science and engineering is CMT, a semiconductor consisting of cadmium, mercury, and tellurium. It is used in manufacturing heat detectors employed in physics, engineering, and medicine. For example, certain diseases, cancer among them, can be diagnosed early with an instrument known as a heat scanner, which makes the heat given off by the human body visible. By looking at the image produced by the instrument, physicians can find damaged areas in the body which will soon cause serious illness.

It must be added that there are also people who possess the ability to 'see' heat, although to a much lesser extent. They are incorrectly thought to have ESP, and likewise there are, unfortunately, mere charlatans who take advantage of this 'trend' in folk medicine. Precise heat-scanning instruments would, it seems likely, eliminate the ESP-pretenders and leave them without work.

Obtaining a CMT with the necessary characteristics and quality on earth involves an engineering cycle which may last up to half a year. What is more, product yield, the ratio of final product to starting components, is not sufficiently high. The cosmonauts have been getting good crystallisation results in only 130 hours. A CMT single-crystal can be grown with uniform distribution of composition over 50 per cent of its length.

Certain crystals grow with dizzying speed in weightlessness. Germanium and silicon single-crystals, for example, increase at the rate of a centimetre a minute! It may be that in future, solar battery arrays will not be built or assembled, but grown right there in space. On balance, we can see a new branch which may be called the 'crystal industry' emerging before us. It promises a degree of development unimaginable under earth conditions.

Not only are metallurgists and specialists in the manufacture of semiconductors looking with anticipation towards space, so are glass-makers, for whom the earth's gravitational pull is a serious hindrance. They, too, must obtain a high internal uniformity and evenness of distribution of additives. Much depends on what one adds to the glass, too: some terbium and cerium, and the glass will act as an optical shutter letting light in in only one direction; introduce a certain amount of silver compounds and the glass will get dark in the light and get light in shadow; adding some neodymium will permit it to emit laser beams. Conditions in space will also help glass-makers to evenly distribute additives in the material and do away with impurities. This is not easy to achieve on earth, even if one observes ideal working conditions. The walls of the preparation vessel give impurities into the glass mixture at the high temperature (about 1,500°) needed to make glass. To avoid this, the glass is sometimes melted in platinum crucibles, but this is also no answer, as even platinum occasionally contaminates the product. In addition to everything else, platinum, being a precious metal, drives up the product's cost.

In weightlessness, one can do without crucibles altogether. The molten mass floating unhindered in space will be held in place by sound waves emitted through a gaseous medium in the production area. They will entirely suffice to stabilise the 'fiery spheres' in space. Refractory additives can be used to give a product having a surface that will require no mechanical finishing (which greatly diminishes the glass's durability). Cosmonauts have already started making glass in space. Different kinds of glass mixture have been tried, including silicate, borite, and phosphate. In brief, the glass industry is also getting its start in space.

The manufacturing of pharmaceuticals, especially vaccines, promises to become another important space industry. Vaccines are used for treating and preventing many illnesses,—from the flu and poliomyelitis to hepatitis and cholera.

The technology of obtaining vaccines is based on separating and purifying different substances in centrifuges and adsorption columns. The process is a time-consuming one which yields little product for the effort invested. The same laws of gravitation which cause substances to separate into light and heavy get in the way again, for the different components ought to be separated on another basis. There is electrophoresis, for example (the effect of an electric field)—one method of sorting out biological material. Earth's gravitation makes it ineffectual, however, for the components to be separated settle to the bottom of the reservoir where they get intermingled by heat currents. One can reconcile oneself to this drawback if he is working in the laboratory, but it is extremely difficult to when working on an industrial scale. A space version of electrophoresis has already been tried out with success by Svetlana Savitskaya on a visit to the *Salyut-7* in 1984.

Getting away from the subject of the medical industry but still on the subject of medicine, we might point out that the effects of weightlessness are now being studied from the perspective of treating certain cardiovascular diseases. Specialists think that there will come a time when people will learn

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Close to the moon

to cure many ailments by weightlessness and that clinics and sanatoria will be set up in space.

And so we have the construction industry. Let us move on, then, to the subject of construction in space and its function, nature, and purpose. We may once more start with a very specific example. Experiments are already underway in space to try to build structures there; tools which space workmen will find helpful are being tested.

An instrument known as the Isparitel has functioned on the *Salyut* station. It was used to dust a metallic film onto various substrates (shapes). This operation has long been a common one on earth but may be needed in space, for instance, to refurbish coatings which have gone out of order or to put the reflective layer onto mirrors of space telescopes and orbital transmitters of sunlight to earth. If a thickened layer of metal is dusted onto a section sublayer, then a product with good hardness and durability is obtained. It could be either part of a space house, or of a radio telescope spreading for many kilometres in the zero gravity, or part of a solar array for a space power plant.

Here is another method of preparing building structures in space. A membrane is made out of a cloth permiated with a polymer and inflated. One can select a polymer that will harden under the influence of the sun's ultraviolet rays. Building material made like this quickly acquires the necessary firmness.

Hence, space science is bringing us in a specific, business-like way closer to posing and solving not just an industrial problem, but one of philosophy and world outlook: the problem of man's settling space. At the outset, space will be lived in by workers such as steel- and glass-makers, metal- and construction workers, and assembly and medical personnel. There will be few of them for an enormous work front. Automation, cybernetisation, and robotics, the children of the revolution in science and engineering, will perhaps be even more needed in space than on earth. Human beings can not only design, but also remotely control production processes in space, mostly without leaving earth. But one way or another, space will have to be made fit to live in.

The first scientific ideas of inhabiting space belong to Tsiolkovsky. We have already cited his thoughts on industrialising the solar system. They seemed a wild and meaningless fantasy back when the scientist voiced them in the first decades of our century, but now, in the concluding decades of the same century, they are beginning to emerge before us in fine detail and take on reality. It is true that Tsiolkovsky not only thought the industrial use of energy and matter in space and on other heavenly bodies to possess good prospects, he believed that people's inhabiting space, where they would be free of the 'chains of gravity' tying man to earth, was also quite feasible. For this reason he wrote at length of 'space colonies' which would form 'necklaces' first around the earth, and then around the sun.

Tsiolkovsky's ideas about the rebuilding of space about the earth and sun and transforming and giving life to the inanimate nature which has surrounded our planet from the beginning are being developed and concretised both in the land which gave the world the 'Kaluga dreamer' (before the October Revolution Tsiolkovsky was a gymnasium teacher in the provincial town of Kaluga) and the founder of theoretical space science, as well as abroad.

The American physicist Gerard O'Neil, whom we have already mentioned, came out with a plan in the 1970s to build 'space islands' where tens or hundreds of thousands, perhaps even millions, of people would live. It was a time of ecological boom, alarmism, and fear of nature's destruction before the onslaught of industry and the population explosion. O'Neil therefore suggested periodically sending into space 'superfluous' industry and 'extra' population.

Before him, another American physicist, Freemair Dyson, proposed the wild plan of 'scattering' the planets, including earth, in order to create a solid sphere about the sun. This sphere could then be populated from within, thereby increasing by a factor of a million the land surface suitable for life. The sun's energy would also be used 100 per cent. (This plan has come to be called 'Dyson's sphere'.) We believe there to be no need for such grandiose and risky, if not outright reckless, enterprises. After all, at some point the entire Dyson's sphere will be populated, and then where do you go? What is more, a civilisation living on a completely artificial structure (in the literal sense of the word) is unlikely to prove very durable. Earth, man's cradle, will continue being his home and primary domicile for a long time to come. But this home must be improved upon, which is just the point of conquering and industrialising space. This means defusing the threat that our planet's energy and raw-materials resources will dry up, giving its people a broad range of new goods and materials, and helping to avoid the global ecological crisis to which excessive industrialising is leading.

In the three decades of the space age people have created many machines which fly beyond the earth, from the first spherical satellite to an orbiting space station whose crew carries out a tremendous range of work. One must think that space enterprises and industrial centres will be 'weightless giants' with multipurpose functions. They will contain production complexes, energy blocks, services for observation and monitoring of the earth's environment, observatories, laboratories, and recreation areas. From time to time transport ships will dock at the platforms of these space combines, bringing a new shift of personnel and necessary materials, and taking back to earth finished goods which people would know nothing of had they not dared to go up into space.

So, space construction is expanding—for the time being, of course, only in our imagination, but this imagination is based on our first inklings of a reality which will unfold not very far in the future.

We have already said that mass-scale construction in space, involving shipment of all starting materials from the earth, will entail ecological and technological difficulties and dangers. We might add besides, that it hardly seems expedient or promising to go on depleting an already greatly depleted planet on the brink of an ecological, raw-material, and energy crisis. In the initial stages, much obviously will be done from earth materials and on earth, being shipped up into orbit in finished form to be put together by workers there. That will be the case until industry in space acquires the ability to fend more for itself. But those who will make space livable on a broad spatial and temporal scale will do their building using raw materials available there.

But where can they be had? First of all, on the moon. Our nearest neighbour in the heavens is already attracting the serious attention of scientists and engineers precisely as a source of raw materials and building supply. Metallic iron, it has turned out, can be extracted from the lunar soil by using weak magnetic fields. Our natural satellite also contains aluminium, silicon, magnesium, titanium, chromium, and manganese. Lunar soil is also suitable for manufacturing glass able to withstand greater mechanical stresses than 'earth' glass. It can be made into basalt casting blocks and pipes which fear no acid or base.

Such are the capacities of that unattractive looking, grayish moon rock which time and again has been brought back to earth for thorough study of its composition and characteristics.

A plan for transporting freight from the moon might also be imagined. An electrically operated device imparts a velocity of 2.36 km/sec to a freight container, enough to send it clear of the moon's gravitation (an escape velocity of 11.19 km/sec is needed on earth—the second space velocity for earth conditions). In space, a catching device equipped with a rocket engine waits for the containers. It brings them to the construction industrial site.

Apart from the moon, the millions and billions of rocks, chunks of matter, and asteroids (small planets) drifting in the belt between the orbits of Mars and Jupiter will also, apparently, become raw materials suppliers. It is much farther to them than to the moon (by two orders of magnitude, speaking mathematically, for the distance is a matter not of hundreds of thousands, but of tens of millions of kilometres), but transporting them is much easier. In principle, one can treat them just as the freight brought up to the *Salyuts* by the *Progresses* and now delivered to the *Mir* stations: give them an accurate nudge and they will go to where is needed. Towing them is even easier than towing icebergs from the Antarctic to areas with little fresh water—in Australia or on the Arabian peninsula (and this idea has been worked out). By the way, hypothesis has it that many of the bodies in the asteroid belt are made up of frozen water. So, these 'space icebergs' can also be sent at a slow speed to supply space settlements and enterprises with water.

It will obviously be handier to have construction sites located not very far from earth so that quick contact might be maintained with them and people and equipment sent up the easier. Certain areas around the earth and sun are perfect for industrialisation, as though nature itself intended it that way. We have already mentioned the 36,000 km high

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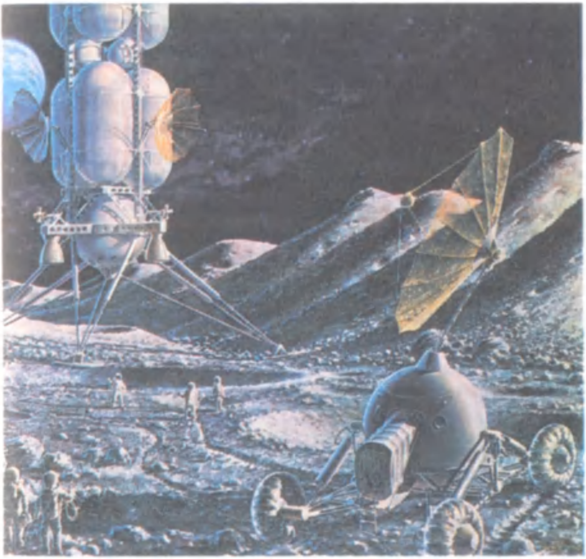

'Moon buggies' on the moon

orbit for geo-stationary communications satellites and, apparently, solar power plants of the future. In addition, the moon's orbit has two so-called libration points, one more gift of nature, whose spatial peculiarities might themselves be thought of as gifts (even the 'emptiness' of space, let us reiterate again, has its attributes and advantages). Should a spacecraft be launched from earth so that at the time of lying in circular orbit round the earth it is in the area of one of these points, then its further movement would be highly stable. Not only will the moon's gravitation not pull it out of its orbit, on the contrary, it will keep it in it, obviating the need to expend energy on orbital corrections. It may be supposed that it is these two points which will become space's first industrial capitals.

Thus, an industrial wave of conquering and utilising space awaits us on the heels of the present information wave. The process of comprehending this circumstance, just as many others about space exploration, often leads to certain old and nearly forgotten ventures and hypotheses being resuscitated and re-thought (we shall have occasion to encounter this again). One time, at the Tsiolkovsky Scientific Readings in Kaluga, the name of Johann Heinrich von Thünen, the German economist and geographer of the late 18th-early 19th centuries who proposed the wave theory in economic geography, was brought up. According to Thünen, the economic development of any territory proceeds from a city-centre to the peripheral areas. At first, something akin to survey work is conducted. The territory's potentials and resources are singled out and industry shifts to them, with the city remaining the coordinating and directing centre. Something similar is going on in space with the planet earth acting as centre. It will long remain the focus of management, scientific thought, forward engineering and technology for developing the 'periphery' of space, having done away with the unnecessary burden of industry and become an ecologically comfortable home for man.

All this is so. But we have neglected to talk about one other field which, frankly, we did not want to bring up at all, especially in this chapter on far-reaching *creation* plans for space. But there is also military industry, the militarisation of space which, unfortunately, is today becoming just about the most palpable reality in the American space programme. The re-usable space *Shuttles* now in operation carry out not so much scientific and research missions as purely military ones, testing laser weaponry for shooting down foreign satellites (we have already told of exercises to capture them) or being outfitted for delivering nuclear strikes in future.

In the 1930s residents of several US cities once fled their homes in panic for the suburbs or country, tying up highways and railroads. They took seriously a radio show by director Orson Welles on H. G. Wells' *The War of the Worlds* about earth's being attacked by octopus-like Martians. Nowadays everyone knows that not only does Mars not have bellicose intelligent creatures, evidently, it has not even the simplest bacteria. The threat from space comes from people on earth itself.

At the same time, far advanced in years, Tsiolkovsky was writing his short philosophical essays, the manuscripts of which have come down to us. It would be fair to call Tsiolkovsky not only the founder of scientific space study, but also space's first humanist. He was deeply convinced that the Universe could not be made to serve people fruitfully without their solidarity and mutual aid—on the part of both of those going into space and of those staying behind on earth.

So far, study of space has shown it to be lifeless, dead. But it is already opening up many of its riches—energy, material, and spatial—to man. It is difficult to exploit, but promises much. A second-type civilisation, which, as we have already mentioned, is a completely developed space civilisation, the type mankind of the 21st century is called upon to be, is not compatible with internal contradictions of its own. Scattered social forces will not suffice for conquering the forces of the Universe. We would like to believe that the far-reaching tasks and opportunities opened up for mankind by space science and engineering will promote the social unity of earth's inhabitants on the principles of humanism, reason, and justice, that is, those qualities which alone are worthy of Homo sapiens turning into a Homo cosmicus.

Man's pattern of behaviour is determined to a large extent by the pattern of his thinking and world-view. And it strikes us that a world-view, meaning literally a 'view on the world', will be all the broader and profounder, the broader and profounder the visible world is. Therefore, we shall continue our story of that Universe being opened to man by space science and the latest astronomy and astrophysics. This time we will be concerned with deep (to the limits of the solar system) and super-deep space (beyond the solar system).

Chapter Six

The Heavenly Ecumene

'Ecumene' means 'universe' in ancient Greek. Not the Universe we mean today, i.e., the entire boundless world surrounding us, but only that part of it which man has brought into his domain (cf. 'oikologia', or ecology, the science of the inhabited, settled world). In early antiquity, the Mediterranean Sea basin was the ecumene, as the Greeks simply knew no other world. Nowadays, we are justified in calling not only the entire globe the ecumene, as there is practically not a single nook left on it which has not felt one way or other an anthropogenic, human impact, but also a goodly part of the solar system—from Mercury to Uranus, for man-made space probes are already functioning within this range.

Moreover, we have already mentioned (Chapter 3) that the most recent cosmology has accepted the so-called anthropic principle (from the ancient Greek, 'anthropos', 'man') according to which those conditions which have coalesced in the entire material world known to us—the metagalaxy at a certain stage of its development—should be considered the sum of conditions ensuring the origin of life and, later, intelligence on our planet. Otherwise, our earth itself might never have been formed. But if this is so, then, strictly speaking, the 'ecological niche' and potential ecumene of man is all of space out to the very farthest galaxies. Obviously it will not be physically possible to reach these far boundaries, but astronomy, working along with space science (putting astronomical instruments into orbit) is even today allowing us to see and theoretically conquer the metagalaxy. People also need to know the 'large nature' of the Universe to broaden and develop their culture and horizons and for well thought-out, scientifically based actions in the 'small nature' of the earth and space in its immediate vicinity.

In just about any astronomy textbook one can find an old drawing of a traveller who has come to the 'edge of the world' and peeked across at the 'other side' of the visible sky. Zigzags, stripes, and even a pair of ordinary spoked wheels is what he sees. This drawing is evidence of the complete ignorance of what might lie beyond the black sky with its star and planet points. At the same time, it graphically expresses the irrepressible urge to see the world beyond the earth, even if it means going to the very 'edge of the world'.

The area beyond the earth, called the 'sky' from time immemorial, has always been accessible to the gaze of man, who kept track of the stars and learned how to find direction and compile calendars for agriculture by them. But space, with its visible heavenly bodies, still remained an abstraction, a terra incognita, an unexplored land whose details were hidden in profound depths. Incidentally, it was Galileo Galilei who, using the telescope he constructed back at the beginning of the 17th century, saw mountains on the moon and discovered Jupiter's first four satellites, while the solid ashen of the Milky Way was broken up ('resolved', in the language of specialists) into myriad stars.

In our era, astronomical engineering is being complemented by space rocketry, making it possible to land space probes on the moon, Venus, and Mars and photograph the giant planets of Jupiter, Saturn, Uranus and their satellites and rings from up close. Space in the vicinity of the sun, once abstract, has also been 'resolved' by what we have learned of the atmosphere, land, and exotic landscapes of other planets and by the study of lunar soil brought back to earth laboratories.

The moon is the closest natural object to us in space. By chance coincidence, 'the whim of nature', its disk is approximately equal to that of the sun for an earth observer. But who can make himself look at the blazing solar disk for more than a fraction of a second? Even with the naked eye one can discern features on the moon such as giant craters and dark-looking 'seas'. Telescopes and other astronomical instruments, all the more, provide the opportunity to adequately study the structure of the lunar surface and some of its physical features. But they cannot do everything. Neil Armstrong, the first human being to leave his footprints on lunar terrain, was not certain until the very landing of the lunar module in 1969 that he would not be sucked under by a waterless, dusty lunar 'swamp' akin to quicksand in places along the shoreline of the British Isles (in actuality the layer of dust proved to be quite fine).

Continuing, it is plainly impossible to see the back side of the moon using ground astronomy methods. This is why one half of the moon was a complete mystery to people right up until the second half of our century. One hundred fifty years ago Auguste Comte, the founder of philosophical positivism, said that it was man's lot never to see the back side of even the nearest heavenly body to us, thereby indicating the impotence of man's attempts to fathom space. His words were repudiated in 1959 when the Soviet unmanned *Luna-3* probe took pictures of the unseen side of the moon (a very mountainous terrain

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In a lunar crater

virtually without 'sea' plains). The world press dubbed these pictures 'the photographs of the century'. Nevertheless, the thesis of the unknowability of the Universe continues to be upheld by idealist philosophers and theologians in concord with them. For example, the West German 'religio-scientific' observer Hoimar Ditfurth [1] maintains that the Universe is the work of a creator whose intentions we will never know. But the Universe being discovered by people and so different from anything we are accustomed to on earth all the same exists according to a single scheme, i.e. natural laws, the laws of nature itself and nature's evolution.

Albert Einstein, who conceived the theory of relativity, believed that nature in the Universe exists and evolves according to the laws of causal harmony—the interconnection and interdependence of all things. In the 17th century the Dutch materialist philosopher Baruch Spinoza, damned and exiled by the Jewish community for his atheistic views, risked his life (today Ditfurth puts only his reputation on the line in espousing his theistic views while simultaneously maintaining their 'scientificity'), in formulating the thesis that nature is a reason unto itself (causa sui), a thesis corroborated a thousand times over by the entire course natural science has taken since. Space science, along with the latest results of astronomy and astrophysics, corroborates the same thing for the thousand and first time. Nature's 'scheme' lies within nature itself.

We'll begin our unraveling of this 'scheme' with the moon, which has been studied by space science most fully of all the objects in space. The surface

[1] Hoimar Ditfurth, *Wir sind nicht nur von dieser Welt. Naturwissenschaft, Religion und die Zukunft des Menschen*, Hoffmann und Campe, Hamburg, 1981.

of the moon is now known better in some respects than certain hard-to-get-to areas of the earth. Photographs taken from lunar orbits and the moon's surface have been made available to everyone—those same moonscapes with the finest details right down to individual bits of soil that Galileo was the first to see. These moonscapes have proven to be both monotonous and extremely unusual. They are monotonic, and yet a multitude of hues radiates from them. As they reflect light at various angles, the grey lunar rocks, cliffs, and smoothish, as though melted down, hills and mountains give off an overflowing rage of brown, ashen, and greenish colours.

The uppermost layer of soil (regolith) which covers the moon like a dense, gossamer shroud is structurally similar to fine, moist sand. Walking on it, one's feet tend to skid slightly because of numerous minute grains of volcanic glass. On a sunny day (and every day is a sunny one there, since there is no atmosphere or cloud cover), the sky stays black, but it is difficult to make out the stars, as they are screened by streams of light. Such are the contrasts of the lunar 'monotony'.

On earth, the gray lunar rocks brought back as specimens do not look like anything special, taken from airless space as though from water. For science, though, they are more valuable than the most brilliant stones. Every particle of the soil contains the story of events which occurred in the moon's interior or on its surface. Among the moon rocks transported back to earth are samples whose age exceeds four and a half billion years. It is possible that they witnessed the early period of our stellar-planetary system's formation. Such ancient rocks have yet to be discovered on earth. Traces of the past are concealed on our planet by the myriad changes its surface has undergone due to the influence of the atmosphere and water, as well as those of life, which emerged long ago.

Analysis of the samples showed many interesting characteristics of lunar matter some of which we mentioned in talking about future mining on the moon. Lunar soil has been found to contain, for example, chemically pure, unoxidised iron which is obtained with great difficulty on earth (the metallurgical skill of the ancient Indians who created the famous 'iron column' which has not rusted for many centuries continues to elicit amazement). There is also a great amount of combined oxygen (up to 40 per cent) in the moon's soil. We have also spoken of how splendid the soil is for plants, even though nothing has ever grown in it. Here we have genuinely valuable--and plentiful!--resources for both future industry and settlements in space.

Two hundred odd years ago the English astronomer William Herschell wrote of the moon: '... For instance, seeing that our Earth is inhabited and comparing the Moon with this planet: finding that in such a satellite there is a provision of light and heat: also, in all appearance a soil proper for habitation full as good as ours, if not perhaps better--who can say that it is not extremely probable, nay beyond doubt, that there must be inhabitants on the Moon of some kind or other? For my part, were I to choose between the Earth and Moon I should not hesitate a moment to fix upon the Moon for my habitation.'[1] Herschell was certainly mistaken, but by all that much? Who knows, it could be that in some future century, after man has built the moon up and con-

[1] *The Scientific Papers of Sir William Herschell*, Vol. I, London: published by The Royal Society and The Royal Astronomical Society and Sold by Dulau And Co., Ltd., 1912, p. XC.

structed inhabitation zones on it, Herschell's words will prove just.

Our space effort has once again opened up to us the planets lying closest to the sun—Mercury, Venus, and Mars. They belong to what is known as the earth group, as they have certain fundamental features in common with our planet: matter and structure of one type, and single, main patterns of formation at a very important, early stage of their existence. But for all the similarities, each planet is very much unlike the others.

Mars, named after the ancient Roman god of war for its reddish ('bloody') hue, was thought possibly to harbour a highly developed civilisation right up until the beginning of practical space flight. It all started in 1877 when the Italian astronomer Giovanni Schiaparelli discovered a network of completely straight lines on Mars which he called 'canals'. However, in the pictures beamed back by the American *Mariner* and Soviet *Mars* probes, the lines resolved into irregular chains of craters reminiscent of lunar craters. Schiaparelli's telescope was too imperfect by today's standards. (For the fantasy-minded, we may offer the hypothesis that a super-distant 'X-ray effect' was at work and that a 'Martian civilisation' or its remains are imbedded deep in the Martian soil.) Even after launching the first few man-made satellites of the earth, there were scientists who seriously hypothesised that the Martian satellites Phobos and Deimos, which orbit the planet approximately at its equator, might be giant artificial structures. But they, too, appeared as asymmetric slabs of stone 15-20 km in diameter (nicknamed 'orbiting mountains') when captured on film by interplanetary space probes.

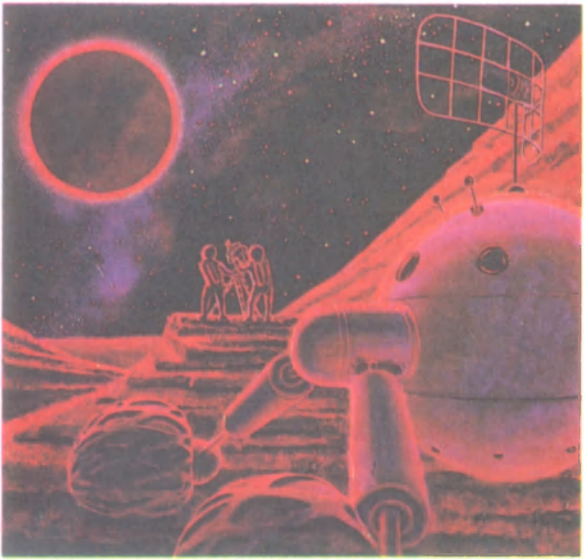
There is no civilisation on Mars. The *Viking* spacecraft which landed on Mars did not find even a single microbe on it (the craft took soil samples and analysed them on the spot for any signs of life in them). Mars resembles the moon. But this latter statement is not altogether true. Before us we have a world very much unique and having its own mysterious and hectic history. The planet's atmosphere, which consists mainly of carbon dioxide, is much less dense than earth's cushion of air. Its density at the surface is the same as that of the earth's atmosphere at an altitude of 35 km. Mars' sky is dark purple. The median daily and annual temperatures on Mars are below the freezing point of water. It may get up to +25°C at the equator at noon in summer, but this 'tropical heat' does not last long. The temperature stays above zero for no more than a few hours. At night it can get down to –90°C. A fierce cold prevails at the poles even in summer: around –60°C in the day and –140°C at night.

Bleak, rust-red plains cover much of the expanses of the Northern Hemisphere. Biting winds bluster at will, shifting around huge volumes of sandy soil which piles up in great layers in depressions and at crater edges.

The winds are largely responsible for the contour of the land on Mars. The famed Martian dust storms often envelope the entire planet. The winds cover extensive fields with sand dunes and 'lick away' ancient craters. Lone craters do just the opposite, getting raised up as though on a pedestal. The sand-like soil around them is swept away by the wind and they crop out above the surrounding plain like quaint memorials to something which has disappeared in the past.

Stormy processes took place on Mars in the past. Where, for example, did the forked channels which look to be carved out by flowing water come from? Even now there is a lot of water on Mars. There is reason to believe that Mars may be nearly completely girded in ice armour. Only alluvial soil covers it. The thickness of the ice varies from one kilometre at the equator to five kilometres near the poles. It is made up of water and carbon dioxide given off

A. Leonov, A. Sokolov



Eclipse of the sun

as the planet evolved. Mars' snow-white polar caps, each of which melts down greatly in summer, are easily visible through a telescope. They are composed of a relatively thin layer of hard carbon dioxide which first accumulates over age-old water-ice, then evaporates from it.

The stormy streams of the past were evidently related to vigorous volcanic activity some tens of millions of years ago. Mars has a huge mountainous land known as Pharsida, equal in area to a quarter of the planet's surface. Volcanic forces raised up the surface here over older continents. One of the peculiar features of the area are its tremendous volcanoes, perhaps the biggest in all the solar system. The highest one rises up to a height of 27 km. Another giant is a bit lower, at 24 km. A web of canyons branches out of Pharsida's centre. Fissures can get up to 100 km in breadth. Their walls plummet down for 5 km in two kilometre ledges.

Such are the dimensions by which Mars measures its violent past, when volcanoes were still active and streams of lava and water flowed. Evidently Mars also had a rather dense atmosphere originally, and perhaps even the first inklings of life or pre-life which could develop no further. Whether this is so or not will be shown by further research and exploration —also unquestionably of great importance in elucidating the particulars and conditions of earth life's evolution.

Venus is earth's second nearest neighbour. After the moon, it is the brightest object in the sky. It is no wonder people are interested in it. Astronomers have long known that, in size and mass, Venus is very similar to our planet and is surrounded by a dense atmosphere. Its impenetrability used to give rise to bold hypotheses and wild fantasies. It was long thought that the same physical conditions prevailed on Venus as on earth at an early period in its history. The land mass was believed to be covered by luxurious green vegetation. The forests of the continents and blue waters of the oceans were supposedly filled with reptiles like those which used to dwell on earth in far bygone times.

The fairy tale of the twin planet was so compelling that at times it obscured facts obviously contradicting it. When radio astronomers picked up signals indicating that Venus's surface was hundreds of degrees hot, not everyone would believe the signals, some thinking that they came not from the surface, but rather from the Venusian ionosphere. Thus, even though facts are hard to fight, as the saying has it, they do not always readily dispense with a biased hypothesis.

There have been many space probes to Venus, a number of which were designed to make a soft landing on the surface. These latter have allowed us to get to know the morning star literally face to face: heaps of rocks extending into the distance. (The sun is never visible in the sky there because of the heavy cloud cover, but diffused light is adequate for photographing in the visible light spectrum; a dry, ash-bluish fog of carbon dioxide enshrouds only far distances). The planet's overall relief began being mapped in 1983-1984 using radar photography on the Soviet *Venus-15* and *Venus-16* probes. The craters, mountain ranges and valleys of this planet, which bears the name of the goddess of beauty, have been given women's names–Ekaterina Dashkova, President of the St. Petersburg Academy of Sciences, Anna Akhmatova, a Soviet poetess, and the two American women-astronauts who so tragically died in the explosion of the *Challenger* spaceship–Christa McAuliffe and Judith Resnik.

Venus as it really is, then. Its dense atmosphere is comprised almost wholly of carbon dioxide. Pretty white clouds resembling earth clouds are only a rare poisonous mist made up of concentrated sulfuric acid droplets. The pressure of the air column at the surface is about 90 atmospheres, or the same as at one kilometre deep in the earth's ocean (while we may recall that on Mars it is the same as at a height of at 35 km on earth). The temperature of the air at the surface is 500°C! Tin, lead, and zinc melt at this temperature. The heat is evenly distributed, as the air is virtually still (there are winds only at an altitude of 50 km). There is not even a temperature *difference in the illuminated and night-time sides* of the planet. The greenhouse effect applies, with the sun's heat (on the whole not much more than what the earth receives) being retained and multiplied by the heavy CO_2 atmosphere. Darkness and brownish twilight envelopes Venus during the greater part of its day which is 118 times longer than an earth day. Only at noon does it get like an overcast day on earth.

Venus has a large range of landscapes characteristic of planets of the earth group: depressions, elevations, mountains, plateaus, volcanoes, and deep extensive fractures in the crust. Large craters (200 km in diameter and more) are a rarity on Venus.

The *Venus-9* probe landed on a rather steep slope (with an incline of 20-30 degrees) on the edge of a mountainous region. The camera showed in the foreground a talus consisting of rocks measuring up to 70 cm across and 20 cm high. These pieces of stone were resting on a broken, fragmented layer of ground. They seemed to have rolled down from somewhere up above. 'Somebody up there was doing some road work,' wisecracked one of the specialists who studied the pictures.

The tenth Soviet probe came down in a level, rocky desert. It landed on a slab of rock less than 3 metres high. The rock may even have cracked when the craft hit it. The surrounding terrain looks like an area where magma has been ejected onto the surface.

The *Venus-13* and *Venus-14* probes possessed colour vision, in contrast to their predecessors. The rocks showed up as dark-grey, and the soil between them as brownish-black. The colours, then, just as the climat, are 'harsh', even though that term is usually applied to the cold and wind, neither of which exists on Venus. The 'mineral' life could be quite active though, with extant volcanoes and 'Venus'-quakes.

Of planets in the earth group, only Mercury, the planet whose orbit is nearest the sun is left to take up. In outward appearance and dimensions, Mercury is the planet most like the moon, and even scientists have trouble distinguishing photographs of it taken by space probes from those of the moon. Like the moon, it, too, has no atmosphere.

There is a hypothesis that Mercury was once a moon of Venus but, under the influence of tidal forces caused by the sun, was displaced into a heliocentric orbit. There is a more general hypothesis that both the moon and Mercury were at one time the largest objects in the asteroid belt between Mars and Jupiter, but that later, for some reason, they left the zone. (The American cosmologist Immanuel Velikovsky explains this reason by an extravagant hypothesis not supported by other astronomers. He believes that at some period after the first human civilisations appeared, Venus was ejected as a comet by volcanoes on Jupiter. As it was streaking past into its present orbit, it supposedly pushed earth back into a more distant orbit, which was the reason a new calendar was invented.)

The asteroid belt, which is made up of tens of thousands of minor heavenly bodies discernible through powerful telescopes and, so it seems, millions more not discernible, has yet to be investigated by space science. The American *Pioneer* and *Voyager* interplanetary probes passed through the belt without hitting or photographing a single rock. This belt of future, as we have said, building material for space industrialisation is still awaiting close, scrutinising study. For now its origin remains an enigma. Is it a solar ring which did not form into a planet, or a planet which exploded, turning into a ring? The hypothetical former planet has even been given a name–Phaeton–which was, in ancient Greek mythology, the name of the son of Helios, the god of the sun. The son entreated his father to let him drive the chariot of the sun for one day, but was unable to control the horses. The chariot got too close to the earth, and in order to save the planet, Zeus struck the lad down with a thunderbolt.

It may be no more than a legend, but it is didactic and relevant today. Man, who has and continues to gain control over the truly cosmic forces of nature, first and foremost, the energy of atomic fission and thermonuclear synthesis, must dispose of these forces wisely and solicitously; otherwise, his will be the fate of 'Phaeton's civilisation', which with certain fantasy of artists really did exist and ended by destroying itself. Thus, an ancient myth without any scientific backing but pregnant with social and moral implication, becomes relevant and elevated to a planetological level.

Even if space probes have not given us any pictures of asteroids, space exploration will soon acquaint us, perhaps, with comets, the solar system's most exotic bodies. In March 1986, a whole international flotilla of interplanetary spaceships passed by Halley's comet. The Soviet unmanned stations *Vega-1* and *Vega-2* and the West European *Giotto* transmitted television images of its core. This proved to be dark and covered with craters and hills, and to be irregular in shape, somewhat like a potato, a ground-nut

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Parachute above Mars

or even dumbells, and about the size of a large city. It is suggested that this core is a lump of ice covered with a thick crust of dust and punctured by geysers throwing out steam. The glowing halo, larger than the earth, which surrounds the core is composed of dust and gas. The tail of the comet stretches for millions of kilometres. One time a small comet, or rather, a piece of one, slammed into the earth's atmosphere and exploded over the Siberian taiga, knocking down a great number of trees. This was the well-known Tungus Meteorite of 1908 whose comet nature has recently been finding ever greater confirmation.

Let us press on, however, with our trek across the solar system and consider the giant planets beyond the asteroid belt.

We have already related how the orbiting cosmonauts, in leisure moments or for televised reports, let large, fist-sized drops of water flow from their drinking water vessels and float slowly about the space station module in weightlessness. But can you imagine a 'drop' with a mass some three hundred times greater than the earth's? Though hard to imagine, one such drop can be said to exist: Jupiter, the solar system's largest planet. What is more, Jupiter irradiates more energy of all types than it receives from the sun. Jupiter is occasionally called 'the star which did not happen'.

Obviously, Jupiter can be compared to a drop of liquid only in a relative way. It would be more correct to say that, from the perspective of physics, the planet behaves in certain respects similar to fluid bodies in hydrostatic equilibrium. Space science has provided us with astronomical and astrophysical observations which show that Jupiter has an atmosphere of helium and hydrogen 1,000 km thick, under which is a layer of liquid molecular hydrogen, and below that, a membrane of liquid metallic hydrogen. In the centre is a smallish iron-silicate core. Saturn, our system's second largest planet, has a similar structure.

The giant planets have proven to be highly interesting formations, having numerous satellites and rings. That Saturn has rings has long been known, for they are easily visible in a telescope, but that Jupiter also has a ring 6,000 km wide and one km thick was discovered only in the late 1970s from space pictures. The existence of this ring was predicted, however, by Soviet astronomer S. K. Vsekhsvyatsky two decades beforehand.

Let us begin with the satellites. Galileo, as we have mentioned, saw Jupiter's four brightest satellites in his seeing tube, and nothing could then be said about them except that they existed and glowed with reflected sunlight. We now know of Jupiter's having 16 satellites and Saturn, 17. Space exploration has given us the chance to see and study these satellites–one more group of heavenly bodies with a hard membrane–from up close. It must be said that they have more differences than between planets of the earth group. This is evidence of the lack of life in the solar system (except for earth), but also of the singular diversity, richness, and activity of its mineral kingdom.

One more circumstance. Neither Jupiter nor Saturn with their satellites (and rings) are, strictly speaking, planets; they are rather systems of cosmic bodies, models, in their own right, of the solar system itself. It may be that this is an oblique sign that most stars, including those which, like Jupiter and Saturn, did not 'make' it, have their own planets, some of which may have life and even intelligence (we will speak of this in greater detail in the next chapter on the problem of extraterrestrial civilisations).

One Jovian satellite, Io, about the size of our moon and yellow-bronze in colour, was seen to possess several simultaneously active, fire-breathing volcanoes. They were powerful volcanoes, hurling debris to an altitude of 200 km. In all, hundreds of volcanic craters were discovered on Io, each dozens of times larger than any on earth. Verily a small land of large volcanoes! Io's colour is explained by its being covered with a layer of sulphur compounds. On the whole, one gets a picture reminiscent of Dante's inferno, the only difference being that it is happening not in a nether region of the earth, but far off in the heavens.

Europa, another of Jupiter's satellites, has the smoothest surface of any object studied thus far in the solar system. Differences in elevation on the satellite do not amount to more than a few dozen metres. It is a perfect billiard ball, and also about the size of the moon. To all appearances, Europa's entire surface is covered with a thick crust of water-ice, making a kind of global-scale skating rink.

Saturn's moon Iapetus (named after a mythological titan whom Zeus threw down into Tartar) could better be called the Two-Faced Janus. One side of it is noticeably brighter than the other. Why is not yet known. (This, incidentally, is an illustration of the process of learning about nature: the more we learn, the more new enigmas crop up.)

Saturn's largest satellite, Titan (larger than the planet Mercury), is surrounded by an atmosphere of nitrogen—at last a heavenly body with a gaseous membrane similar to earth's (earth's atmosphere is made up of nearly 80 per cent nitrogen). And once more a riddle: why is Titan's atmosphere made up of nitrogen? After all, earth's free nitrogen, just as its free oxygen, was formed by the activity of ancient living organisms!

But Saturn's rings have, perhaps, proven even more exotic than its moons. That the planet is encircled by wide rings has long been known, Galileo having discovered them simultaneously with Jupiter's moons. Five rings can be seen from earth, but pictures relayed by American *Voyager* probes have shown that there are actually hundreds. The largest of them is made up of a layer of slabs 15 metres across wrapped in a cloud of small, about 10 cm particles. The rings are for the most part spread out concentrically, one inside another, but there are also rings which interweave. It is highly difficult to explain this structure, as it likewise is to explain the perplexing excresences on the rings which link them like bicycle spokes. One cannot help but think back to that old drawing we were speaking of at the beginning of this chapter: the unknown artist did not even suspect that there really are 'wheels' in the depths of space.

In 1986 *Voyager* passed close by Uranus. It discovered a further ten satellites circling this planet in addition to the five already known, registered eleven rings and ... a brown cloud over the south pole, very similar to an eye. 'Uranus is gazing at the earth,' joked the scientists. Let us recall that the poles of Uranus lie almost on the plane of its orbit; it is as if the planet had tipped onto its side, and from time to time one of its poles points in our direction. Therefore the description of Uranus as 'gazing at the earth' is not purely poetic.

And beyond Uranus? Beyond are more planets, satellites, and rings. Astronomy knows of their existence. Space science does not yet know the details of their structures, but it will know them.

The world seen through the 'eyes' of space vehicles has appeared before us different from the fantasies of the past and yet fantastic in its own realness. Homer once sang of the wanderings of the mythical Odysseus. The Greeks knew of the world basically just the Mediterranean basin, as we have mentioned, but even in this 'mini'-world Odysseus managed to visit a one-eyed Cyclops giant, sail in his flimsy little ship past the monsters Scylla and Charybdis, and past the ruinous singing sirens, tying himself to the mast and stopping up his oarsmen's ears with wax (on 'automatic regime' so to speak). Limitless fantasy expressed our ancestors' passion for discovering and learning about things, for expanding their ecumene. Today's real miracles are being described not only, and not so much, by poets as by the outwardly dry and rigorous accounts of researchers. We meant to give a living picture of the non-living world of the solar system—from the tiniest specks of lunar soil to the gigantic Jupiter and rings of Saturn, which are over a hundred thousand kilometres in diameter.

But the solar system is far from being the entire Universe or even the galaxy, our local family of stars. It will be a long time still before Odysseuses of the future will venture beyond the orbit of Pluto, the last planet known to us in the solar system. But space science is also revealing the advantage allowing the eyes and ears to be opened, to see and hear life in parts of the Universe where man will not soon step foot (if ever he steps foot in them): the distances are too incredibly vast, and although the mind can comprehend them, the emotions cannot accept them. We are speaking now of extra-atmospheric astronomy, the branch of astronomical science which has grown up on the 'tree' of space science.

Astronomy, the ancient science of the sky, has always been terrestrial. It was from earth and earth alone that people, first with the unaided eye, later with the help of optical instruments, and from about the middle of our century, radio telescopes, have looked at and listened to the Universe. Space flight has enabled astronomic instrumentation to be put into space, liberating astronomers from their age-old enemy, the earth's cushion of air, which makes observations of the heavens difficult and holds back the main body of information about the nature of the Universe.

Astronomers obtain information on heavenly bodies by registering the electromagnetic radiation emanating from them. The light of the sun, planets, and stars, their radio voices and other identifying characteristics are all types of electromagnetic radiation with various wavelengths.

Each type takes in its own definite collection of wavelengths. Oscillations with a wavelength of one millimetre or more we call radio waves, while those with a wavelength of less than a one hundred millionth of a millimetre are called gamma rays. These are the extremes at either end of the electromagnetic spectrum, at least from the contemporary perspective. (It may be that someday we will transcend these limits and begin picking up gravitational or neutrino waves—for now but hypothetical.) Between them fall visible light, infrared (heat), ultraviolet, and X-rays.

All through its centuries-old history astronomy has used only a narrow chink in the vast electromagnetic spectrum—the region from about four to eight hundred thousandths of a millimetre, i.e., those waves which we sense as visible light. Light penetrates the earth's atmosphere virtually without distortion. Some portion of infrared and ultraviolet waves, which lie adjacent to visible light, also reach the ground, as do radio waves from one centimetre to 20 metres in length. The atmosphere does not allow in any other waves.

It has turned out that the richest portion of the electromagnetic spectrum, yet another truly invaluable natural resource providing multifarious kinds of information about the cosmos, was inaccessible to man. The firmament of stars appeared to be immobile and silent. 'The eternal silence of these

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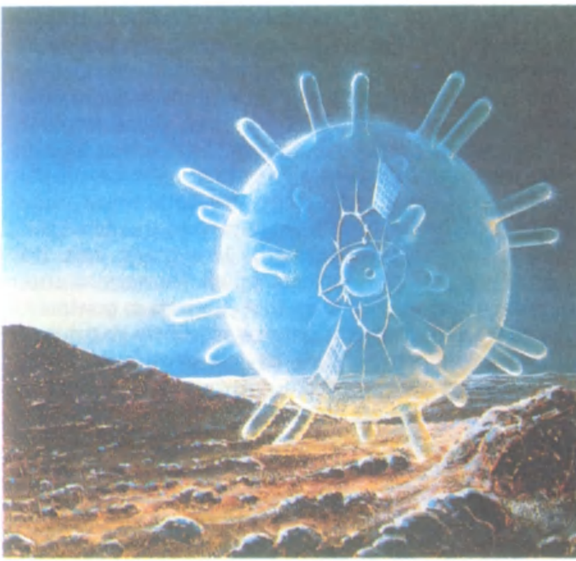

A Martian pneumatic cross-country vehicle

infinite spaces strikes me with terror,' exclaimed Blaise Pascal, the 17th century French mathematician, physicist, and philosopher. Every now and again unintelligible and, once again, quiet catastrophes were witnessed, as for example the explosion of a supernova in 1054 as recorded by Chinese astronomers. Its detritus is now known as the Crab Nebula, a powerful source of radio emissions.

The invention of the radio telescope, a new piece of astronomic instrumentation, has thrown wide the door to the extraterrestrial world. The Universe has started speaking to us. The voices of the sun and planets were heard, as were those of nebulae and interstellar gas clouds. The echoes of bygone catastrophes (as with the aforementioned supernova) and the natural signals of other galaxies became audible. Amazing objects were discovered, such as pulsars, which emit well-defined radio impulses so invariably precise that they have given rise to speculation as to whether they may not be of artificial origin (even now they are sometimes called 'beacons of the Universe'). Quasars were also detected—quasi-stellar objects behaving like stars, but not stars. They are the farthest of all formations from us and emit so much energy that it seems in contradiction to what our present physics considers possible.

The world surrounding us has proven to be far from measured or tranquil, but rather is in constant flux, giving off incredible amounts of energy. Matter is re-fused in the interior of stars and jetted outward in exploding flares. The enormous gravity of the super-dense remains of dead stars raises it to a temperature of hundreds of millions or billions of degrees. It is ejected into space by their magnetic fields at velocities approaching that of light (300,000 km/sec), sending out signals on its state throughout the electromagnetic spectrum, particularly in its energetic, shortwave portion (X-rays and gamma rays). The more energy matter possesses and the greater its temperature and velocity, the shorter its fundamental wavelengths.

The entire spectrum had to be utilised and the atmosphere's armour, which protects all living matter on earth but exacts 'payment' by blocking basic information about the Universe, overcome. This is the reason extra-atmospheric astronomy has come into being. Astronomy outside the earth–astronomical and astrophysical instruments aboard spacecraft–is a highly promising child of the space age and is receiving feverish development. By making an entire ocean of electromagnetic waves open, covering the entire spectrum, it promises a new astronomical revolution, just as the industrialisation of space will beget a new industrial revolution.

Extraterrestrial astronomy is a comparatively young science, but it has already succeeded in providing many times more information about the Universe than the old, earth-based astronomy. The new science appeared on the heels of the Second World War with the first test shots of the *V-2* rocket, extracted as booty from the German arsenals. Just a few years before they had been raining terror on England, but now were being used for the peaceful promotion of knowledge, an unexcelled example of how quickly swords can be reforged into ploughshares. It is also instructive evidence that space science and the work preceding it were begun as peaceful enterprises, as opposed to, say, aviation, which at first was military in nature (in the First World War) and only later turned civilian (in the 1920s).

For a fairly long while the only object studied was the sun. One of the reasons for this was because the sun has the greatest, and sometimes a decisive, effect on life on earth and it was important to get to know its properties in the 'new light' in addition to the visible light our luminary emits. In carrying our narration from the solar system to Universe beyond, we, too, will begin with the sun, as it al-

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ready belongs to the Universe at large, being a most typical star in it and the one nearest us.

The sun belongs to the G 2 spectral class, which encompasses stars known as 'yellow dwarfs', which are relatively small and emit most of their energy in the visible portion of the spectrum. It is certainly no accident, either, that the vision of man and most animals—the chief means of receiving information about the surrounding world—developed such as to respond to precisely this waveband. Had our sun different characteristics, earth's higher species would have other sense organs, the most important of them perhaps being attuned to thermal (infrared) or ultraviolet rays. Many nocturnal animals and insects, deep-water fish, earthworms, and so on respond to completely different wavebands than man does.

This subject has direct 'outlets' into science fiction, giving it an entirely scientific foundation for plot-lines about extraterrestrial life and civilisations and how their representatives might look somewhere in the galaxy or metagalaxy. It also concerns philosophy, or more specifically, the theory of knowledge, demonstrating that ideas of the world depend significantly on the ways and forms of perceiving it: like the astronomical instruments of the past which were only optical, man with just his sight alone or even with his other senses, too, takes in the world through a rather narrow slit. Were this slit in another portion of the electromagnetic spectrum, man's surrounding world would also appear to him in a different 'light'. Properly speaking, this is the way it appears to him now, with technical devices, here meaning astronomical, astrophysical and space engineering, expanding and adding new colours to his picture of the world.

Hence, the sun's principal energy is radiated in the visible and infrared bands, with very little coming out in the form of X-rays or other short waves. Why then has interest in them arisen? The point is that the 'portrait' of our star drawn by an X-ray 'brush' brings us to the mysteries of one of the sun's most interesting physical phenomena, solar flares. Soviet cosmobiologist A. L. Chizhevsky, a contemporary and friend of Tsiolkovsky's, has shown them to affect our health, psyche, and mood. X-rays provide us with information on the chemical make-up of the sun's outer cover and on the particulars of sun-earth ties.

Rocket experiments in the early postwar years were merely the beginning, with a genuinely broad attack on the sun's secrets being conducted by practical space science. The earth's second artificial satellite went into orbit in November of 1957 from the Baikonur cosmodrome. It contained on board not only the dog Laika, but also instruments for studying X-rays and ultraviolet rays emitted by the sun. Other satellites followed: the *Kosmoses, Electrons, Interkosmoses, Prognoses,* and, of course, all the *Salyuts*, whose crews always include in their programme study of the sun. The *Mir*, a new generation station with its research module, opens up new opportunities in this field of study.

Here we have an X-ray photograph of the sun in hand. The customary regular solar disk is absent. Instead, we see a wispy patch of variable brightness, meaning that the sun gives off X-rays unevenly. They emanate from disparate regions heated to several million degrees and in the corona, the sun's upper atmosphere.

It is natural and understandable that instruments should pick up the X-ray emissions of the star closest to us, but the X-rays reaching us form the unfathomable depths of the galaxy and even from other galaxies were a great surprise to scientists. No one could imagine what kind of objects in the Universe might

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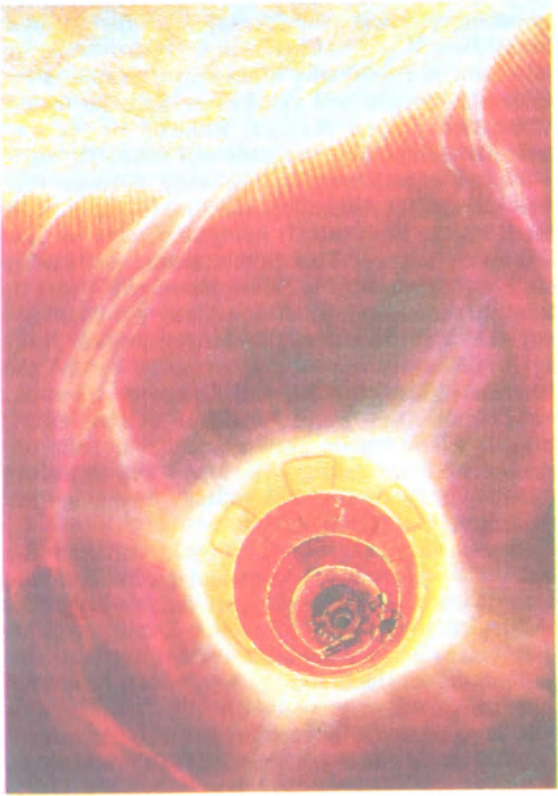


On the surface of Venus

be capable of producing such powerful X-rays. Stars appeared to be too weak to be the sources, meaning something else had to be emitting them.

X-rays from the sun travel 150 million kilometres to reach the earth. Measuring this distance by the usual astronomical yardstick, the speed of light, they travel a distance of 8 light minutes. The distance to the first few stars closest to us ranges from 4-odd to 8 or 9 light years. Even this remoteness is difficult to conceive, and yet the overwhelming majority of stars in our galaxy are many times farther away. An abyss of 25,000 light years separates our sun from the galactic centre (presumably a dense, spherical accumulation of stars in the region of the constellation Sagittarius but obscured by interstellar dust).

There exists an incontrovertible law of nature which is troublesome to those monitoring the far reaches of space: the intensity of waves being emitted from a source decreases in proportion to the square of the distance the waves have traversed. Hence, X-rays from ordinary stars would simply not reach us. About 600 X-ray sources have been found so far, half of them located in other galaxies (which are a minimum of several million light years away). They are being studied actively and in detail by both unmanned vehicles (for instance, the *Astron*, launched by the USSR in 1983), and by cosmonauts utilising special instruments, such as the Filin X-ray telescope installed on the *Salyut-4* station.

Cosmonauts Pyotr Klimuk and Vitaly Sevastyanov did some good work with the Filin. They were able to record several dozen X-ray sources. Some extremely interesting data were gathered on an X-ray object in the constellation Cygnus. The object coincides in its position in the sky with a very weak star invisible to the naked eye and located somewhere from 6 to 15 thousand light years from us. There are serious reasons for believing that this is no ordinary star, but a close pair consisting of a star and a black hole, an exotic formation predicted by Albert Einstein's theory of relativity but which no one has been able to detect for certain thus far. In a black hole, matter, including light photons, caves back in on itself due to potent gravitational forces. An ordinary star located anywhere in the vicinity will drastically 'lose weight' because its matter is drawn into the measureless reaches of the black hole. Before it vanishes the matter is spiralled around and heated to a temperature of a billion degrees, emitting, in the process, a powerful stream of X-rays.

Whether this hypothesis of the black hole is correct or not, further investigation will show. So far, for example, the unmanned Astron has discovered a so-called 'fast burster'—a binary star system made up of a dwarf and a neutron star, both of which are exceedingly dense but sizewise are comparable respectively to, say, the earth and a large city. The neutron star pulls gas across from the atmospheric cushion of the dwarf, heats it to tens of millions of degrees and 'produces' a nuclear explosion, the process being repeated every six or so months.

Whatever the case, it can already be said that space studies have embarked on the experimental verification of the theory of relativity which seemed like a pure abstraction, a 'mind game' without practical application either to the time it was formulated at—the early part of this century—or to any time in the future.

Then again, this was about the kind of reaction which Nicolaus Copernicus' non-geocentric conception of the world drew in the 16th century. It took 300 years for Copernicus' theory to be proved, with the French astronomer Leverrier using it to calculate the orbit of an unknown planet beyond

Uranus. The German astronomer Galle then discovered it in the heavens. It was named Neptune. The Copernican theory is now used, one might say, on a daily basis in space navigation. Who knows, maybe Einstein's theory will also be utilised in it someday? Thus do great problems dealing with our world outlook become practical tasks later on.

Spacecraft are likewise participating in search of an answer to the fundamental question for science and our Weltanschauung—the origin of the Metagalaxy, or the known Universe. The *Prognoz-9*, launched in 1983, is one such vehicle. The satellite's orbit was set at 1,000 km minimal distance to the earth, and 700,000 km maximal (i.e., twice as far as the moon). Such an orbit reduces the effect of interference from the earth and other nearby objects in space in the study of deep space using radio and other equipment.

An instrument was put aboard which detects the barely audible radio echo given off by the Universe on the day it was born, about 15 billion years ago. This echo is called background radiation and is proof to this day of the 'act of creation' of our world—not, obviously, of any divine act, but of 'self-creation', a transition from a state which modern science knows nothing of yet. That was the explosion of the metagalactic 'egg', an incredibly dense mass measuring in size no more than our present solar system but containing all the myriad galaxies now running away from one another. Background radiation has so far shown itself to be isotropic (uniform from every direction). The finer measurements of the *Prognoz-9* are permitting anisotropic, or nonuniform, radiation to be differentiated, making it possible to 'reconstruct the configuration' of the great event of the far distant past and shed new light on the enigma of the entire world at large in which we live.

'The man who does not know the world he lives in does not know where he is,' said Marcus Aurelius, the 2nd century A. D. Roman emperor and philosopher. But if man does not know where he is, neither does he know who he is. Man's perception of the world, which is formed from what he knows of the external world, always 'closes back' on man himself.

* * *

In this part of the book we have examined what we have termed 'reality'. We have tried to abstain from fiction and abstract judgements. The reality of the space age has proven more incredible than anything fiction could invent, while space practice has come up against problems of world outlook which are seemingly too general and philosophical categories seemingly too abstract.

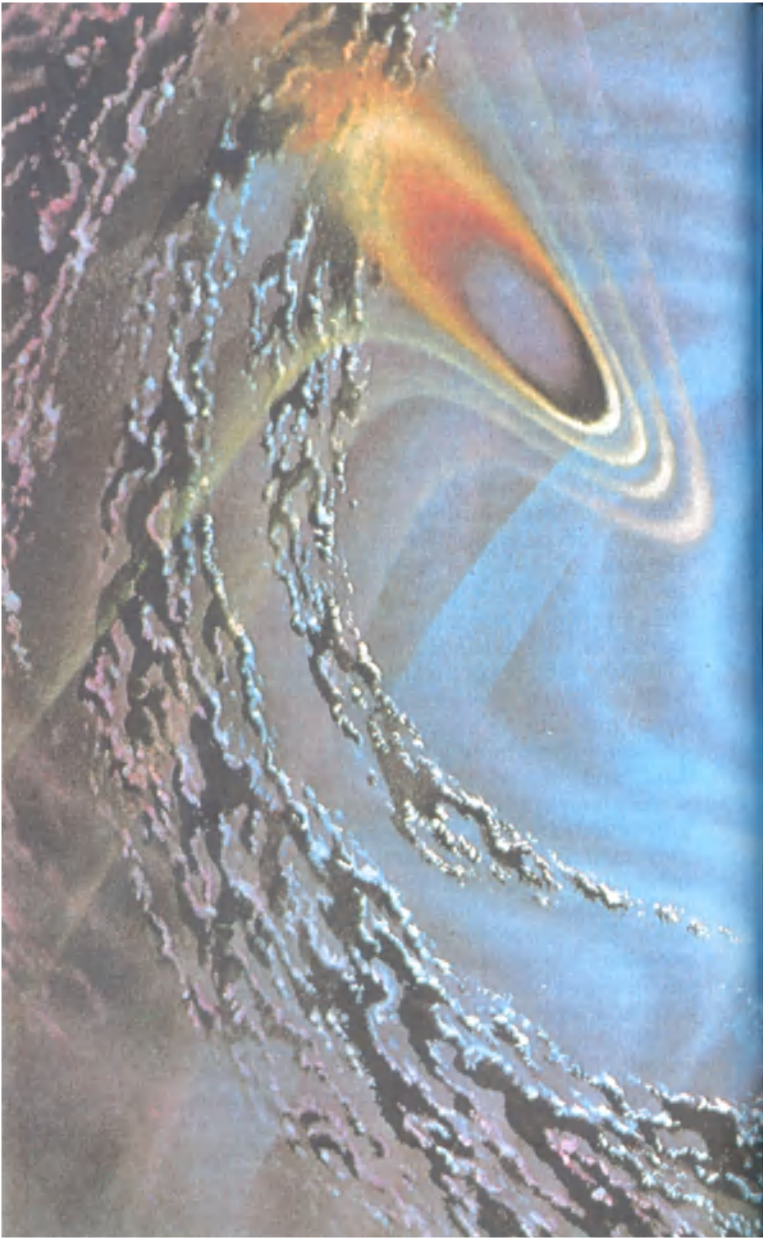
Space and man, and space and life have not turned out to be contraindicated one for another. In this regard, venturing into space is but a natural expansion for life, which once came about in the watery layer of the planet earth. It is also the expansion of intelligence, for man is beginning to humanise and socialise nature not only on earth, but beyond it, as well—communicating to it, so to speak, his own qualities of humanity and sociality.

Space has not proven detrimental either for the earth, where people now live and will go on living for an indefinite period. This has come about precisely because of a 'human', i.e., peaceful use of space for the good of all the world community. The conditions and opportunities of space and earth are mutually complementary and mutually useful. Space is assuming the 'blow' of industry and allowing the earth to be made ecologically comfortable. Thanks to space science, space is providing man with loads of information on the Universe, earth, and man himself as he reveals his new abilities in a setting he has never been in before.

We have been telling of space and space science in fine detail–sometimes too fine–about the properties of the atmospheres and soils of heavenly bodies, the trickiness of weightlessness, and about the cosmonauts' daily schedules and dreams. We got away from philosophy and down to specifics so as to aid the reader visit space himself, as it were, as an ordinary observer and as a professional cosmonaut. Philosophy is built on concrete experience and concrete knowledge alone. Only then does it seem cogent and necessary.

But one cannot get around looking at space science and the space era from the position of philosophy and world outlook. Space science has a multiplicity of purposes and goals. The space age runs through all aspects of social life, from everyday life to ideas. It cannot be understood in anything less than its whole capacity, just as the cosmos itself cannot be comprehended without being seen in toto.

In the second part of the book we shall continue with both our specific discussion about the Universe and with its exploration by man. But this discussion will be more a 'humanitarian', general scientific, and philosophical one than one of natural science or engineering. We shall attempt to raise the great questions of an intelligent principle (unquestionably material) in the system of the Universe, about mankind as a potential factor in the Universe's evolution, about the features of man's personality in the space era, about the distant and very far distant prospects for mankind, and even about the 'point of life', that old philosophical and ethical question, and how that question appears now in the light of the progress of space science which, as it is turning out, is far transcending the contours of just one more area of the revolution in science and engineering.



Part Two
REFLEXIONS

Chapter Seven

The End and Beginning of Aelita

Aelita is a beautiful Martian woman in a fantasy novel written in the early 1920s by Soviet writer Alexei Tolstoy. The revolutionary zeal of the young and world's first socialist state found a cosmic measurement: the novel has a proletarian revolution being carried out on Mars, too.

Fifty years later the most precise instruments of landing vehicles found not even a single microbe on Mars. Life has been found nowhere in the solar system, and none of the optical, radio, gamma, or other telescopes sent into space has found any signs of activity or signals of artificial origin anywhere in the visible Universe.

The English philosopher Bertrand Russell once spoke of the 'terror of cosmic loneliness'[1] as an unresolvable tragedy of the human race and each person. Has space science made this 'terror' worse with its experimental confirmations of our loneliness, or has it, to the contrary, helped dissipate it? The question is not simple, but let us try to answer it.

The idea of an inhabited, or 'living' Universe is, if you please, an innate idea with man, perhaps even a kind of intuition which science must reckon with ('intuition' is an altogether scientific category). We have already mentioned that the idea of a multitude

[1] Bertrand Russell, *History of Western Philosophy and Its Connection with Political and Social Circumstances from the Earliest Times to the Present Day*, George Allen and Unwin, London, 1983, p. 14.

of inhabited worlds was inherent to ancient philosophy. In this connexion it is appropriate to recall the words of Marx about the ancient Greeks who, he said, will forever remain our teachers, for they were the bearers of 'this magnificent objective naivete, which makes everything shine, as it were, naked, in the pure light of its nature, however dim that light may be'.[1]

The Renaissance, so called because it saw many elements of ancient culture, philosophy, and world-view reborn, was also the renaissance of the idea of the spread of life and intelligence in the Universe. Nicolaus Copernicus and Giordano Bruno, titans of the time, lived in the same century, the 16th. But while Copernicus' non-geocentric picture of the world has subsequently received brilliant and faultless confirmation, Bruno's picture of the world—that of a living Universe—up to now has not the least factual proof.

Mankind has been forced to abstain from illusions of living anywhere near 'brothers in intelligence'. 'We came in peace for all mankind' was the inscription left on the moon in 1969 by the first Apollo crew. The inscription was more wishfulness than reality and not only because mankind had still not established peace within itself, but also because, properly speaking, there was no one to address it to. A certain 'elegant' hypothesis was popular shortly before the space age: there are symbols on the back side of the moon, never seen from earth, that an advanced civilisation has visited it. They came to the back side of the moon so that human civilisation would develop sufficiently to be able to find the symbols and comprehend them using its own space engineering. But by the time people had landed on the moon there

[1] Karl Marx, Frederick Engels, *Collected Works*, Vol. I, International Publishers, N. Y., 1976, p. 500.

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Approaching the sun

were already pictures of its back side showing a wild mountainous land and nothing more.

The hypothesis of the artificial origin of the Martian satellites Phobos and Deimos held on right up until the very second that photographs of them taken by an interplanetary space probe showing them as ordinary stone slabs were made. The distant stars then became the nearest objects which might harbour life and intelligence.

Hence, many scientific hypotheses have been refuted and whole volumes of fantasy literature have 'grown morally old'. And it must be confessed that from the psychological standpoint this breaking of ideas, 'the great giving up' of overly optimistic suppositions of an extraterrestrial civilisation 'alongside us' has not passed altogether painlessly.

Among philosophers and specialists in astronomy and astrophysics a kind of anti-Bruno's hypothesis has begun coming to the fore, holding that intelligent life or life of any kind whatsoever may not exist outside the earth.

What do these views mean? The Copernican worldview put an end to the idea of the earth as the centre of the firmament. What would have become of modern science were scientists still holding to the geocentric universe of Aristotle and Ptolemy? Modern science would simply not exist, as knowledge of the world cannot advance with a knowingly distorted overall idea of it leading to false principles, methods, etc. The Ptolemaic system may perhaps suffice for amateur marine navigation inasmuch as it can be interpreted, after a fashion, as a projection of the true location and movement of the visible stars onto the earth. But Ptolemy's system is obviously not suitable for cosmic navigation, for which the Copernican system has already come in necessary in practice. Meanwhile, Giordano Bruno's multitude of inhabited worlds was a logical sequel to the Copernican system. And if now the thesis of earth's possible uniqueness in the biological (and, even more so in the social) regard is being advocated, then it is tantamount to the notion of the earth as the biological centre of the Universe and the centre of intelligent life. This is why such views may be dubbed 'neo-Ptolemaic', for they imply, in essence, a rebirth of Ptolemy's system—not in the sense of celestial mechanics, but in the no less important sense of an unfounded 'localisation' of life and intelligence. It is our conviction that this rebirth is an idealistic reaction to recent events in space linked to man's doings outside the earth, the exploration of space. The hypothesis that only one point in the Universe, the earth, is unique in relation to the Universe's infinity can have no natural scientific or materialistic grounding, for it is in no way connected to scientific notions of the material world on the whole and will find in it no arguments in its favour (even though arguments favouring the hypothesis that extraterrestrial civilisations or life forms do exist have also yet to be found).

We have already mentioned the anthropic principle in modern cosmology, according to which an intelligent creature, man, arose because of an agglomeration of conditions, a so to speak 'concurrence of circumstances' throughout the metagalaxy, or that Universe which we know today. This is really true, too, for under other conditions our life might never have arisen, or at least not at that astronomical period when it really did arise. But from this it by no means follows that the conditions which favoured life in the metagalaxy were focused exclusively on the earth, an ordinary planet near an ordinary star located in a spiral near the edge of an ordinary galaxy in the metagalaxy, a system of enormous families of galaxies.

Frederick Engels, who, of course, shared the notions of natural science common in his time, the 19th century, including hypotheses about the wide spread of civilisations in the Universe, believed life and intelligence in the solar system existed 'at most' on three planets, Venus, Earth, and Mars. He further saw this state of affairs as a 'colossal waste of matter and motion in nature',[1] since there still remained five other planets in the solar system without life (the sixth, and ninth in all, Pluto had not yet been discovered in Engels' lifetime). But how incredibly 'wasteful' nature must be on a universal scale to exist for the sake of life and intelligence on earth and earth alone.

The conception of earth's and man's uniqueness which we are examining certainly tends only to intensify Russell's 'terror of cosmic loneliness'. As a kind of counterbalance to this conception and its 'terror' a version is stubbornly supported in the mass consciousness (though not in scientific circles) that extraterrestrial beings visit our planet from time to time.

'This creature had two eyes, two ears. But... it had no nose. The skin was creased and rough. The monster breathed, as it were, through the pores of its rough skin.'[2] This is a story about one of the members of the crew of a 'flying saucer', which is ascribed to a Caucasian peasant. There are scads of similar such stories which were born at the threshold or in the early years of space flight. They have absolutely no authenticity in fact or science and are the last cry of a 'daydreaming mankind' compelled to give up hoping for any contact with creatures from other worlds soon.

[1] Frederick Engels, *Dialectics of Nature*, Progress Publishers, Moscow, 1974, p. 209.

[2] *Minuit* (Canada), August 5, 1968, p. 3.

The dubiousness of such 'observations' can be judged by the following completely reliable observation. In the USA, dozens of 'witnesses' who had supposedly seen crew members of unidentified flying objects (UFOs) were polled and criminological methods used to come up with a composite portrait of an alien being. The result was a human with a puby body, a large, bald head, pointed ears, and a frighteningly penetrating glance who was dressed in the suit of an altogether earth cosmonaut. As we can see, this is a medley of non-scientific conceptions of man's future biological evolution, of traditional devil images, of the Superman stereotype from the comics, and information on the outfitting of crews for earth spacecraft. There is not a grain of new information, just an imaginative combination of known elements. Imagination has always possessed these traits, whether in mythology, literature, or art.

To us in the 20th century myth-making seems something which has receded for good into the distant past. Yet it exists to this day. The Soviet ethnographer Valery Sanarov did an interesting study[1] showing that stories about UFO encounters carry on the tradition of 'true', so to speak, stories from old and not-so-old times about man's brushes with the 'other' world of witches, goblins, sprites, and ghosts. Sanarov catches general features such as underscoring the extraordinary nature of the occurrence while averring its supposed authenticity; the suddenness of the object's appearance; the most common setting being in pitch darkness at night in an isolated area; fear, impotence, and 'petrification' of the subject; and the very swift, sudden disappearance of the object. Hence, a dispassionate study of these phenomena of

[1] V. I. Sanarov, 'UFOs and UFO-nauts in the Light of Folklore'.–In: *Sovetskaya etnografia*, 1979, No 2.

consciousness and psychology (but not reality) indicates that myth-making is able to exist now, as well, in the latter half of the 20th century. Only now, in its 'saucer' form, it lacks the prime ingredient of the myth-making of yore, viz., the glorification of

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On Io, a satellite of Jupiter

man and his might.

The vulnerability, lack of originality, and obvious lack of scientificity of the latest mythology certainly has turned more of less serious researchers away from 'sensational' UFO reports. At the same time, it has impelled some of them to take the search for clues of 'aliens' from the present to the distant past. In the material and written monuments of the earth's ancient civilisations they are trying to reveal signs of the influence of supercivilised 'aliens' on semi-wild humankind.

The field associated with such searches has come to be the 'paleo-contact' hypothesis. There is even an international Ancient Astronaut Society whose members interpret, in the spirit of space research, different fragments of cultural heritage let us by ancient man.

Here are a few examples most popular with adherents of the paleo-contact hypothesis. Rock depictions of people in ritual clothes and masks at Tassili (the Sahara) are interpreted as figures of alien astronauts recorded by people of the paleolythic era. The remains of a megalithic structure at Stonehenge, England, as a true-to-life model of the solar system obviously unknown to early man. The bas-relief on a sarcophagus of the Mayan culture at Palenque, Mexico, as the portrayal of a pilot in a spaceship. The huge straight-line strips and earth-top drawings in the Nasca Valley, Peru, which are of a ritual religious origin,[1] as landing and take-off strips and direction markers for alien spacecraft. Erich von Däni-

[1] Miloslav Stingl, a Czechoslovakian ethnographer, traveller, and writer, expounds an interesting, if controversial, hypothesis in his book *The Star Worshippers* (Prague, 1980). The ancient Peruvians may have sent the embalmed bodies of notable decedents aloft in hot-air balloons long before the latter were inventd by the Montgolfier brothers in France. In sending the balloons up towards the sun, which the Peruvians worshipped, they may have wanted the gods and deceased to 'see' from a high altitude their earth drawings which, incidentally, acted as a kind of calendar for determining the sun's annual crossing of the ecliptic, which was important for agriculture.

ken, who has achieved a measure of renown as the author of 'documentary' books and films on the fantastic (*Reminiscences of the Future, Back to the Stars, Sowing and Space,* et al.), even goes so far as to claim that all human civilisation was created by aliens from another world.

Arbitrary interpretation of pictures of the Martian surface taken by space probes makes for a peculiar variation on the paleo-contact hypothesis. Pyramids and the head of a sphinx like those in Egypt are 'seen' and 'reconstructed' in certain of the planet's entirely natural landscapes.[1]

An in-depth examination of the ideas of paleo-contact does not enter into our task. Neither is there a need to, for all the examples given above, as well as many others, are much more convincingly interpreted as earth phenomena and not space ones. What is more, holding to the earth interpretations are professionals and specialists in archeology, ethnography, and history, while the paleo-contact hypothesis is more the subject of amateur studies and often provides no more than plot material for fictional works on the fantastic. For example, megalithic structures, large and especially small ones, are to be found all over the world and indicate a commonality of early beliefs and rituals. Rock drawings are also common everywhere and so numerous that virtually any kind of fantasy hypothesis can be conjectured from or buttressed by them. The entire array of biological and historical sciences has proven that man and his history have evolved independently without the aid of any alien forces from other worlds.

Insofar as the 'liberties' taken in interpreting the

[1] See, for example: Vladimir Avinsky, 'Are There Pyramids on Mars?'–In: *On Land and Sea*, Moscow, 1983 (in Russian).

Martian landscapes are concerned, we cannot help but recall a dialogue between Hamlet and Polonius from the Shakespearean tragedy:

> *Ham.* Do you see yonder cloud that's almost in shape of a camel?
> *Pol.* By th' mass, and 'tis like a camel, indeed.
> *Ham.* Methinks it is like a weasel.
> *Pol.* It is like a weasel.
> *Ham.* Or like a whale.
> *Pol.* Very like a whale!

We have been telling of contemporary 'space flight' myth-making and of 'paleo-contact speculations' not because they need to be refuted by science. The problem is that they bear a rather great world-view burden, and one of a negative nature quality at that.

One can see from Sanarov's research essay that we have a situation baring and 'repeating' the gnosiological roots of religion. Many authors abroad who have studied the 'saucer' variation of people's modern attention to space have not failed to notice this. The French astrophysicist Pierre Guérin writes that many religious sects arise in our time after observing 'flying saucers' and receiving messages from their 'crews'. In essence, he goes on, all the world's religions supposedly came about in this manner.[1] In developing the hypothesis of paleo-contact the American astro-engineer Joseph Blumrich has been reconstructing an alien 'landing craft', interpreting Ezekiel's biblical vision in a 'paleo-contact' spirit.[2] The English histor-

[1] See: P. Guérin, 'Le problème de la preuve en ufologie.'– In: J.-C. Bourret (ed.), *Le nouveau défi des OVNI*, Edition France-Empire, Paris, 1976, p. 268.

[2] See: J. Blumrich, 'Les vaisseaux spatiaux du prophète Ezechiel'.–In: *Impact. Science et société*, UNESCO, Vol. XXIV, No. 4 (1974), pp. 347-354.

ian Raimond Drake asks the question, 'Is Christianity not indebted to people from space for its existence?'[1]

Generalising the particulars of this line of the by *no means scientific* research of the problem of contacting alien civilisations, French information specialist Jacques Vallée reasons thus: even if we are concerned with modern myth-making the myth has material strength, for many many people believe in it.[2] Thus, Karl Marx's widely known tenet of the *idea* as material force if it has captured the masses is replaced by the tenet of the *myth* as material force if it has also captured the masses. But a myth acting as material force not only distracts people from the real tasks and opportunities of the space age, but is also a socially dangerous phenomenon bearing people away to a kingdom of mysticism and the absurd. This is why we have considered it our due to direct the reader's attention to the existence and unbecoming essence of modern 'cosmicised' myth-making, recalling the words of Lenin that closing one's eyes 'even to the most absurd doctrines, up to and including extreme obscurantism is, of course, undoubtedly harmful...'[3]

Our narration, then, has so far in this chapter gone under the symbol of total negation: space science has not discovered any signs of life or intelligence in the solar system; modern astronomy, including that put beyond the atmosphere, has not witnessed any phenomenon of artificial origination. Evi-

[1] R. Drake, 'Hommes de l'espace dans l'Antiquité'.–In: J. Bergier, G. Gallet (eds.), *Le livre des anciens astronautes*, Paris, 1977, p. 124.

[2] See J. Vallée, *Le college invisible*, Edition Albin Michel, Paris, 1975, p. 253-256.

[3] V. I. Lenin, *Collected Works*, Vol. 3, Progress Publishers, Moscow, 1984, p. 632.

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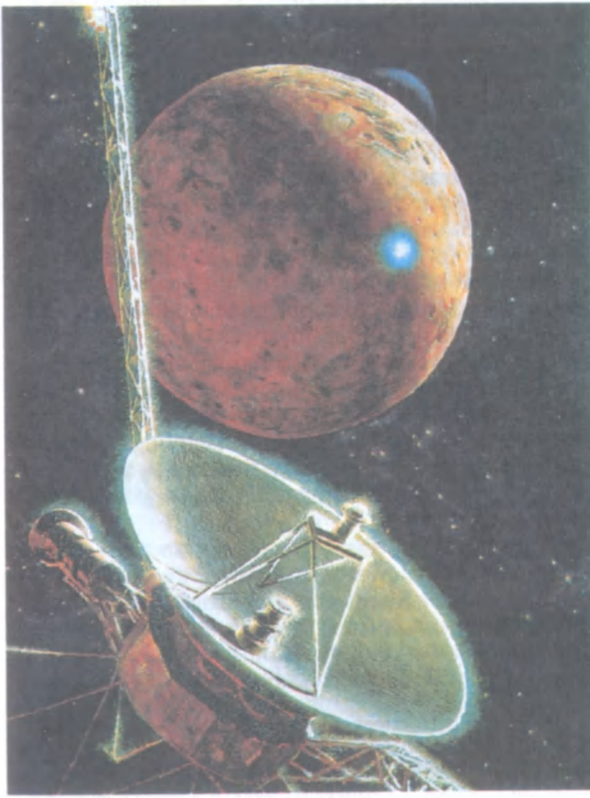

A photograph of volcanoes on Io

dence of 'aliens', either in our time or in the past, has not been confirmed by science. But, as the reader will recall, we have also rejected the hypothesis that life and intelligence on earth are unique. What are we to do? How can we get away from these wholesale and mutually exclusive negations to something positive?

The absence of life on the solar system's celestial bodies certainly sharply removes the possibility of finding it in time and space. This statement is not very consoling for today's enthusiasts in the quest for extraterrestrial civilisations. However, the strip of recent disappointments concerning intelligent neighbours heated by the same sun we have should teach us patience and logical consistency in solving probably the most complicated problem of all posed by mankind.

Of the nine planets in the solar system, we now know that only our earth possesses life–developed life, at any rate. There is no reason to believe this to be an exclusive case. It is much more probable that many suns with planetary systems are in the same situation. In other words, any possible sphere of life and intelligence is a certain spatial zone optimally separated from the central luminary and possessing one or two inhabitable planets. This, in essence, is the way it should be, since organic life exists within strictly defined physico-chemical bounds (for example, life flourishes within a temperature range of -70° to +80°C, even though bacteria living at temperatures higher than the boiling point of water have been found recently around lava fissures of underwater volcanoes). It may therefore be expected that life forms on a planet in some other 'solar system' might, in spite of its tremendous spatial distance from us, nevertheless resemble those on earth, if not outwardly, then at least elementally.

And what might the common elements be? It is hard to say, but it is already possible. First off, they have to do more with the intelligent stage in the evolution of any life and social laws rather than biological laws. How life comes about, how complex molecules of organic matter turn into living systems which organise and reproduce themselves is still a question of many enigmas. How intelligence comes about, or how a living form acquires qualities of sociality, which is the same thing in many respects, does not hold many mysteries any more, we feel sure. And with the problem of intelligence being fundamentally a sociological and not a biological one, its fundamental solution on a sociological level has been achieved in Marxism.

Such a solution was proposed by Frederick Engels in *The Part Played by Labour in the Transition from Ape to Man*. In it he showed that intelligence does not arise without reason and 'on an empty spot', but is rather the result of a combination of the germs of collectivism ('community') and social labour which used and later also manufactured the implements of labour. The process of mutual interaction of labour, implements, and social relations is certainly being carried on and developed, honing and perfecting the abilities of Homo sapiens. However, the 'chain reaction', to use 20th century language, even though assigned in the turbid depth of time is clear enough in itself.

We think that the considerations advanced here permit us to speak of general, fundamental characteristics, 'invariants' of the formation and development not only of human, but of any hypothetical civilisation in the Universe. The basic, central, general characteristic of any conceivable civilisation may be thought to be contained in a certain agglomeration of creatures making up a collective, a society whose members transform their environment to suit them, using the implements and know-how of such a transformation.

Without the world of implements and engineering civilisation is inconceivable. Its interaction with nature would otherwise not differ at all from the interaction of living species with the environment and between themselves. Such a 'civilisation' ascends no higher than a biological form of motion, that is, it merely does not exist, but stays an animal population. For this reason, to show intelligent aliens in the form of 'intelligent' mould on rocks, 'thinking' trees, a 'thinking' ocean, etc., the way science fiction frequently does, is to depart from Engels' labour theory of civilisation which we have just extended from humanity to any civilisation in the Universe. What's more, it is a departure without offering any other alternative, in other words, without ascertaining the *reasons* for the appearance of intelligence. Fantasy is boundless, but at times it ceases to be scientific. Stationary vegetation on rocks cannot be intelligent if for no other reason than because it is stationary. A single 'organism' (the ocean) cannot acquire intelligence any more than can a human being deprived of contact with others like himself. (We might recall cases of children getting lost in the jungle and becoming irreversibly wild, or the loss of intelligence not by literary, but by historical Robinson Crusoes.)

Hence, society and the world of implements (technical and technological) are the two pillars which the world of intelligence, the world of civilisation are based on. We are firmly convinced that intelligence cannot come about in any other fashion. If it can, then how so should be described, whether the suggestion is made in theoretical endeavours or science fiction, for intelligence and civilisation cannot come about withot having some reason for doing so.

The following thought concerning possible contact with extraterrestrial civilisations belongs to Stanislaw Lem, a Polish science-fiction writer and philosopher, 'We may discover an intelligence differing from our own conceptions of intelligence so greatly that we will not even care to call it Intelligence'.[1] This is hardly very accurate. Mankind is certainly a civilisation in the Universe, meaning that any other civilisation must have something fundamentally in common with us, otherwise we not only would be entitled not to consider such a 'civilisation' intelligent, there would in fact be no intelligence, but rather some elemental phenomenon of nature beyond our comprehension.

This is the first socio-philosophical conclusion from looking at the hypothesis that intelligent life of non-earth origin exists in the Universe. But one other conclusion may be drawn based on that 'sad' circumstance that space exploration has failed to find either intelligence or life in the solar system and that, consequently, there can be none anywhere close to us. Let us begin by quoting from the article 'God in Space' by English theologian and cosmologist C.S. Lewis: "I have wondered before now whether the vast astronomical distances may not be God's quarantine precautions. They prevent the spiritual infection of a fallen species from spreading."[2] It is evident that Lewis has no very flattering opinion of his fellow men, but he is also deluded. We do not mean his illusion concerning the existence of God (it seems unlikely he could be dissuaded of it), but rather his error concerning the complete and 'funda-

[1] Stanislaw Lem, *Summa Technologiae*, Krakow, 1967.

[2] C. S. Lewis, 'God in Space'.–In: *The Coming of the Space Age*, Ed. by Arthur G. Clarke, New York, 1967, p. 279.

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A meeting with Titan

mental' isolation of seats of intelligence from one another in the Universe (which would really be tantamount to our being all alone in the Universe). The earth has even now revealed itself to some hypothetical observer within a radius of 50 light years because of the working of thousands of television stations (TV broadcasting is done in the decimetric waveband and can easily penetrate the earth's ionosphere; only longer radio waves are reflected back towards the earth's surface). In future, technology will make feasible sending probes to constellations in the galaxy and even manned missions to the nearer stars, though such trips would necessarily be very long ones: 'crew changes' would be made in the form of changing generations on board an enormous, well-planned out colony ship.

But the difficulty and distance of an interstellar voyage impels us to draw one highly optimistic socio-philosophical conclusion concerning contact between civilisations in the Universe. Mankind has not yet reached a level in its development of science and engineering where it would dare to organise an interstellar flight. It is not impossible, however, that there are civilisations in the Universe which have already reached so high a level and could make an interstellar journey, visiting, for instance, our earth. However, only a civilisation highly developed in the social sense as well, could obtain to such a high level in science and engineering. It would have to be a truly intelligent and humane civilisation, one which, in human language, is called a communist civilisation, from interaction with which we may expect nothing but peaceful co-operation, and the useful exchange of spiritual, cultural, and scientific information. Any alien civilisation with an antagonistic, divided society will simply be unable to find either the means or the ideas for so great a venture.

Here an analogy with man's distant past suggests itself–when people's first form of social organisation was primitive communism. Back then, mankind could not afford the 'luxury' of being socially divided. Its weak forces sufficed to secure its natural existence only by being unified. But will not people in essence really be needing this same thing, although on an immeasurably higher scientific, engineering, production, and social level, when they grapple with natural forces of astronomical dimensions and cosmogonic power?

But let us return to the problem of contact. Some people believe that were we to make contact with a far more advanced civilisation than ours we would benefit to the same extent as a Neanderthal man who, by some miracle, turned up in our society, i.e., mankind would be able to take a great leap forward. This seems rather unlikely, however, because mankind has its own traditions, routes of development, and, most of all, its own potentialities. Too great a leap might prove too taxing to mankind both materially and physiologically. All the same, it would likely be the most spectacular event in human history, essentially the beginning of a new history–that of the civilisations of the Universe fusing into a single 'inter-civilisation'. Philosophically, it would be a new, as yet unknown to us step in developing the social form of material movement.

So, it turns out, several conclusions about the world-view, philosophy, and sociology of space civilisations without having encountered one can be made. We can use as a reference what we know from the natural science of astronomy and the technical one of space exploration (and its practice) and the social sciences about man.

It remains for us to try answering the question why recent astronomy, even with the aid of our space programmes, has so far not located a single sign of intelligent (or any other kind) of life in the Universe. We cannot today repeat Blaise Pascal's words on the silence of the expanses of space, but by paraphrasing him, each of us could exclaim that the eternal silence of the *intelligent* Universe frightens me!

And yet there is perhaps no reason for fright. We can cite at least two considerations by scientists concerning the silence of the 'intelligent Universe'. One of them was voiced in Tallinn in 1981 by K. K. Rebane, President of the Estonian SSR Academy of Sciences at the All-Union Symposium on Extraterrestrial Civilisations. He thinks that neither our civilisation nor any other in the Universe should have to unfailingly attempt to send powerful signals into space to let other centres of intelligence know of one's existence. Even radio contact, to say nothing of interstellar expeditions, requires tremendous expenditures of energy, putting an additional strain on the sphere of habitation of the given civilisation.[1] Thus we see that even in what is today a hypothetical sphere of possible goals such as establishing contact with alien civilisations our current ecological problems and considerations make themselves known. We may further suppose these to hold not only for man on earth, but also for civilisations bringing nature under their domain somewhere in the distant corners of the Universe.

V. S. Troitsky, a radio astronomer from the city of Gorky and a corresponding member of the USSR Academy of Sciences, has formulated the second consideration, or more properly, hypothesis. He thinks that life, and consequently intelligence, arose about

[1] K. K. Rebane, 'Signalling between Civilisations and Environmental Protection'.– In: *The Search for Intelligent Life in the Universe. Theses of the Papers of the All-Union Symposium, 7-13 December, 1981, Tallinn, Estonian SSR*, Tallinn, 1981, pp. 13-14.

one and the same time throughout the metagalaxy, or, at the least, in our galaxy. It is not out of the question that human civilisation on the planet earth, making wide use of engineering to enter space, is one (if not the only one) 'super-civilisation', with all the other points of intelligent life still at a stage corresponding to our early, pre-historic society.[1]

We began this chapter with the character of Aelite from Alexei Tolstoy's novel of the same name. And in conclusion we discover that it is most likely Aelita resides not in some alien civilised world, but right on our own planet and is perhaps being dreamt of by creatures from far away worlds just now beginning their intelligent history. This circumstance does not liberate man from 'space loneliness', but does impel us to take another look at man's prospects and at the very phenomenon of the human being, who will have to be ever more active and creative in the Universe's evolution.

[1] V. S. Troitsky, 'The Quest for Extraterrestrial Civilisations: A New Strategy'.—In: *Zemlya i Vselennaya*, 1983, No. 6, pp. 48-52.

Chapter Eight

Anti-Finalism

The term 'anti-finalism' refers to that philosophical concept, that view of the world which asserts that human society and the human race is capable of continuing eternally in time. The opposing view is referred to as 'finalism', which predicts the inevitable death of mankind either as a result of genetic senility, or the 'natural' end of the planet earth and all life existing on it, or else the destruction of human civilisation as the result of a nuclear war. Thus the finalists assert that death is inherent not only in the individual as a specific living organism, but also in the human race in toto, whose end is sometimes called, in contrast to the death of individuals, the 'second death', an expression taken from the Revelation of St. John the Divine (The Holy Bible, Ch. 21. 8).

It may seem that, excepting the problem of preserving peace on earth, the other propositions are so abstract and refer to an event so distant in time that they are of little interest today, even at the theoretical level. However, this is not so. If they are based on the powerlessness of men in the face of natural processes, even though this powerlessness is to be understood only as ultimate powerlessness, and even more if they are based on the view that man has certain in-built defects, in particular social defects, that lead to his extinction, then such propositions are unquestionably damaging in the moral sense, as they sanction, as it were, all the negative aspects in the development of mankind today. More than this, such a position is inaccurate scientifically, as we hope to show hereafter.

We will begin by examining a third proposition (in addition to the viewpoints of K. K. Rebane and V. S. Troitsky), a proposition which is sometimes put forward to explain the silence of other supposed intelligences in the Universe, about which we did not speak in the previous chapter. This idea was presented at the first International Conference on Communication with Extraterrestrial Intelligence (CETI), held in Byurakan, Armenia, in 1971 by the American astronomer Sebastian von Hoerner. In his opinion, the civilisations of the cosmos, including, of course, human civilisation, simply do not have time to develop their scientific, technological and production potential sufficiently to establish contact with each other. They each perish before that moment is reached.

On the basis of this view, Hoerner produced a short but fatal formula: 'Nothing lasts forever.' As such, this formula can scarcely provoke objection, for it is wholly dialectical and echoes the quotation from Goethe's *Faust* cited by Engels: 'All that comes into being deserves to perish.'[1] In the history of human society, this formula found expression in the sequence of socio-economic formations, in the development, florescence and decline of specific civilisations and cultures. It was and remains an expression of social *progress*. However, as used by Hoerner it means physical death, the extinction of each centre of intelligence wherever it may emerge within the Universe; civilisations emerge and perish like stars, having, however, covered all the stages of their predetermined history immeasurably more quickly than any star. Among the factors leading to this, in his opinion, inevitable end of any civilisation he lists

[1] Frederick Engels, *Dialectics of Nature*, Progress Publishers, Moscow, 1974, p. 35.

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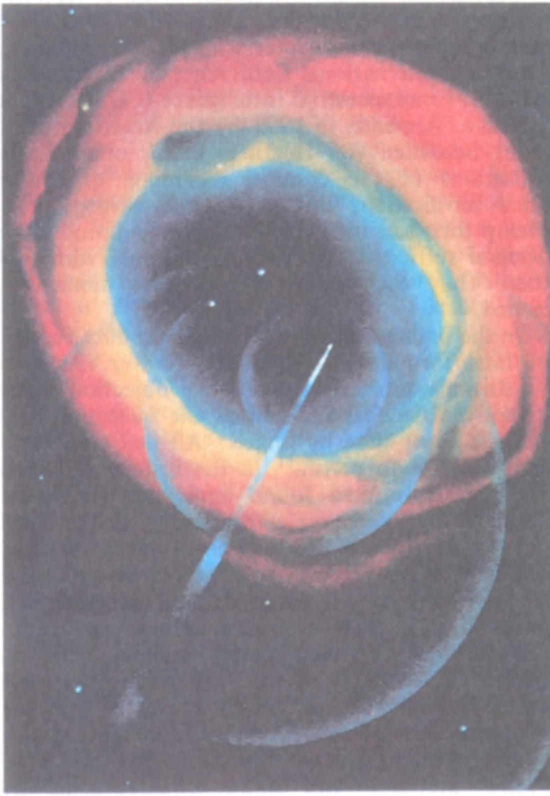

A planetary nebula

total thermonuclear war, the pollution of the environment and the exhaustion of natural resources, genetic degeneration, and the gradual but irreversible extinction of the species. Finally, there is also a total 'change of interest' in life which he assumes to occur in any intellectually overdeveloped and satiated civilisation.[1]

There is another, cosmological argument put forward not by Hoerner, but by other supporters of finalism. This is the modern concept of an oscillating Universe. According to this concept, after the present expanding phase of our metagalaxy, the period during which the galaxies 'rush away' from each other, there comes a phase of contraction. This irreversible process of a return to the 'cosmic egg' must inevitably destroy all the presently existing forms of the motion of matter, including social matter.

All of the above arguments, each of which is partial in character and which is based either on a natural scientific or a sociological concept, can be opposed by the following, equally partial arguments.

Senility, genetic degeneration and the extinction of the species do, indeed, take place as one of the laws of biological development. However, man is not merely a biological, but a bio-social being, and in this, one might say, lies the salvation of the species. Man is, in principle, capable of guiding his own biological evolution, and that of other species. Indeed, he is already doing so, beginning with the domestication of animals and the cultivation of crops, and on to penetration into the secrets of the genetic code. The fact of being a social organism is not merely a feature characterising the species, but also one that

[1] *Communication with Extraterrestrial Intelligence (CETI)*, The MIT Press, Cambridge, Massachusetts, and London, England, 1973, pp. 173-176.

places it a rung higher than any other biological form of the motion of matter. Nor is this simply a philosophical assertion (well-known and to be found in textbooks), but an assertion that is daily confirmed in man's social practice, including the management of biological processes.

It seems to us that the present nature of the relationship between the natural environment and civilisation of the planet earth–a civilisation divided socially into two opposing systems – is only the prehistory of intelligent and harmonious interaction between society and nature (as it is the prehistory of society itself). Even now more and more people are coming to realise that this 'prehistory' brings with it not only potential (the threat of a world-wide war) but also actual losses in the form of ecological, raw material, and energy crises which are all the less permissable as civilisation is moving into the global and cosmic stage of its interaction with the environment. Thus human history–in the full and real meaning of this term–lies not behind us but in front of us. It would be, to say the least, illogical to speak of the social prehistory of mankind, as we are now living it, and also speak at the same time of the completion of human biological history, already supposedly menaced by genetic degeneration.

Undoubtedly, there do exist dangers within society that directly menace civilisation with destruction, first and foremost destruction in a universal thermonuclear catastrophe which is capable not only of destroying civilisation, but all life on earth, thereby snapping the evolutionary thread on the planet where life has reached the level of intelligence. Even such dubious phenomena as a 'change of interest' in one's own existence have, regrettably, had their prototypes in history, most recently in the case of mass suicide by about a thousand members of the

American religious sect, 'The People's Temple', in Johnstown, Guyana, in 1978.

Nonetheless, potential and actual phenomena of this kind are pathological, and not the normal pattern of development either of society or individuals. There is absolutely no basis for deriving any laws from them.

As regards the cosmological argument based on the contraction of the Universe, we will not examine this in any detail. According to this theory this contraction will begin only billions of years hence. By then the continually evolving social form of the motion of matter will no doubt have become such a powerful factor in the evolution of the Universe that it will be able to avert negative trends in the latter. We are inclined to accept–if not factually, then methodologically–the following bold hypothesis (more accurately, formulation of the problem) put forward by N. S. Kardashev: 'Today we may even ask whether the expansion of the visible Universe is the result of the deliberate action of some super-civilisation.'[1] It is, of course, difficult to say, at the moment, what the actual facts are, but in principle the possibility of the evolution of the Universe being guided by a super-civilisation cannot be rejected on any philosophical grounds.

In addition to this 'socio-cosmological' argument, which may appear somewhat abstract and speculative, we can offer in support of anti-finalism other, 'socio-astronautical' arguments which are far more concrete and closer to us in time-scale. The part played by modern applied astronautics in resolving the problems related to the interaction of society and the natural

[1] L. M. Gindilis et al., *Extraterrestrial Civilisations. Problems of Interstellar Contacts*, Moscow, 1969, p. 48 (in Russian).

environment, the possibility of the industrialisation of space and, at the same time, of establishing an ecological balance on earth (that is, all the things we discussed in earlier chapters) constitute, in terms of the issue we are now looking at, a means of ensuring the permanence of the earth, which will remain for an indefinite period into the future the home of mankind; human civilisation, while becoming a cosmic civilisation, will nonetheless continue to be a planetary civilisation.

It should be said at this point that the idea of unifying the cosmic and planetary aspects of human activity belongs to Tsiolkovsky. When he said, 'Our planet is the cradle of intelligence, but one cannot live forever in the cradle', he was not posing an alternative—either the earth, or the cosmos. It is indeed true that he was of the opinion that life in the 'ether', in artificial constructions in space, would be more comfortable than life on earth, where man is bound by 'the chains of gravity'. Now, however, we know that 'the chains of weightlessness' are also heavy to bear. He also believed that the expansion of mankind into space with the help of numerous 'space colonies' would free men from the risk of cosmic catastrophes and accidents, from dependence on our sun, which must eventually expend its energy, making life on earth impossible. With the help of rockets, wrote Tsiolkovsky, the men of the future will 'reach other stars and will use their fresh energy in place of their own dying sun'.[1]

This prognosis and plan for the future was the scientist's tribute to his day. He was educated in the spirit of the natural sciences of the 19th century,

[1] K. E. Tsiolkovsky, *The Intellect of the Cosmos and the Intellect of Its Beings*, Archives of the USSR Academy of Sciences, collection 55, list 1, article 500, p. 3.

which posited that, after a few million years, the solar system would come to an end, the sun would die and earth grow cold. Engels, too, immediately after the quotation from *Faust* which we have already cited, went on to describe how 'the human race, crowding more and more about the equator, will finally no longer find even there enough heat for life'.[1] Now the predicted 'lifespan' of the sun is estimated to be many thousands of millions of years.

Nonetheless, despite the considerable spread of natural-scientific and astronomical 'finalism' in the last century, Tsiolkovsky never believed that man's move out into space would merely be the consequence of the impossibility of life on earth. On the contrary, he frequently spoke about the rational transformation of the natural environment on earth, of the development of the earth by the use of intelligence. People, he asserted, 'will change the surface of the earth, its oceans, atmosphere, vegetation, and themselves. They will control the climate and will be the masters within the confines of the solar system as well as on the earth itself.'[2]

It might be useful here to define more clearly what we mean when we say that man will move out into space. What is meant in this context is not an equivalent to the Biblical 'exodus', with men abandoning the earth because of ecological pollution and the exhaustion of its natural resources. On the contrary, the conquering of space and, in the future, of other heavenly bodies, means not a change in the natural objects of exploitation, but the increase and accumulation of the natural resources used by men, the humanisation of the Universe, its increasing inclusion

[1] Frederick Engels, *Dialectics of Nature*, op. cit., p. 36.
[2] K. E. Tsiolkovsky, *The Intellect of the Cosmos and the Intellect of Its Beings*, op.cit., p. 3.

within the social form of the motion of matter. In doing this, men will have no need to leave the earth, unless they create artificial planets or artificial biospheres on natural heavenly bodies which are clearly better suited for habitation than our own natural planet and its biosphere.

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A Planet in the nebula I C 443

Does it therefore follow that the creation of such a 'permanent' earth, its increasing rather than diminishing importance for man in the space age, brings into question the whole 'cosmic philosophy' of Tsiolkovsky? Not at all! As we have seen, Tsiolkovsky foresaw and welcomed future progress in the interaction of society and the natural environment not only in space, but also on the earth. These were for him, it is true, simply two parallel developments. The concept of the combination of both was only possible in the light of the most recent astronautical practice and its concrete perspectives.

Such are the 'partial' arguments in support of anti-finalism. However, what we now have is not merely the sum of these 'partial' arguments. Together they represent, in our opinion, a fundamental argument, namely: there are no factors built into either mankind or individual men as social beings which make the end of human society and the human species inevitable at any point in the future, however remote. This is the radical difference between Homo sapiens and every other form of life on earth, and indeed, the earth as a whole which, being an individual body within the cosmos, is unquestionably historical and transitory. Man and the earth are bound together by innumerable bonds, but in their essential nature they are distinct and independent. This independence is not the tragedy of separation (as many foreign techno-ecologists are inclined to think), but the prerequisite for the optimistic conclusion that man is more powerful and more long-lived than the earth.

Thanks to his creative nature, man is immortal. The limits of his activity are set only by the laws of nature—we repeat, the *laws*, and not merely the *forces* of nature, which in principle he can always overcome. 'The more universal man (or the animal) is,' wrote Marx, 'the more universal is the sphere of inorganic nature on which he lives.'[1] The move towards universality increasingly distinguishes man from the

[1] Karl Marx and Frederick Engels, *Collected Works*, Vol. 3, Progress Publishers, Moscow, 1975, p. 275.

rest of life on earth, where biological species, on the contrary, by virtue of their narrow specialisation, find themselves in an evolutionary blind alley. This move to universality brings man closer to the Universe.

Let us repeat in this connection certain trivial yet, in this context, relevant points: man is the only living organism on this planet to have imitated the processes involved in splitting and synthesising the nucleus, processes which are essentially cosmic in nature and which do not occur naturally on the surface of the earth; man is also the only living being on the earth to have gone beyond the confines of the earth with the help of rocket technology and astronautics. 'Immortal' man who, perhaps only intuitively, yet correctly has termed himself the 'microcosm' since the days of antiquity, is ultimately commensurate not with the transitory earth, but with the eternal Universe, with the 'macrocosm'. Time and again we have the proof that Homo sapiens is also, in a certain way, Homo cosmicus–Cosmic man.

The finalism of the past–and it was represented by the French materialists of the 18th century, and the famous utopian socialist Charles Fourier–and also the majority of the natural scientists of the last century and the early 20th century, as well as the philosopher and science-fiction writer Herbert Wells, predicted, either in the distant or the near future, a 'descending branch' in the evolution not only of life on earth, but also in society, although it is impossible to imagine exactly how this lengthy process of total 'social regression' would finally end. History knows periods of decline in civilisations and societies, for example, the decline of Hellenic culture, the fall of the Roman Empire and the Indian civilisations of South America. However, the main line in the evolution of man has always been an ascending line, progress in the social, scientific, technological, cultural and ethical spheres. A general and continuing backward direction is unthinkable for a social organism, for it means death.

And now there appear not only social, but also scientific and technological grounds for denying an inevitable 'descending line' in the development of society. It would be hard to overestimate the philosophical and socio-psychological importance of this statement, which renders possible super-long-term prognosis for social development and also enriches the very concept of progress.

When the natural environment comes into the sphere of human activity, it develops not only, and not primarily, according to the laws of its own development, which indeed does usually divide into periods of rise and fall, but according to the laws of human progress, that is, moving steadily from the simple to the complex, from the less rational to the more rational. Today, the habitat of man is the whole earth, which everywhere bears the marks of human activity. In practice, this activity often brings with it ecological and other crises. However, taken as a whole, the earth is being 'humanised', and therefore is becoming an ever more suitable and stable home for man. We earlier compared the earth to a spacecraft. Now we must add that man is not only the pilot, but also the one who continually redesigns the craft.

The arrival of man at a cosmic level of activity, the beginning of the process of the humanisation of the Universe, transforms the concept of progress into a cosmological, 'Universe-forming' factor. Moreover, among many other factors, this factor is, by its very nature and function, a creative and not a destructive factor.

The cosmology of the recent past put before man the disturbing picture of a universal development which was called the theory of 'the thermal death' of the Universe. The proponents of this theory asserted that the Universe is governed by the second law of thermodynamics—a law which states that the physical world moves towards thermal equilibrium, the attainment of which brings an end to all development, all physical processes; such is the universal law of entropy—simplification, equilibrium, rest.

Social progress, the essential nature of the rational principle in the Universe, contradicts this law of entropy; that is why it is called the anti-entropic factor—the factor of development, creativity, useful complexity and diversity, of the accumulation of energy and information. In the highest form of its motion, matter opposes itself, its own destructive and simplifying tendencies. That is the cosmic function of civilisation, culture and intellect.

It seems to us that it is precisely in this function that the activity of communist civilisation will express itself, that communist civilisation whose process of formation has already begun, and which is being built on the foundations of Marxism-Leninism—the most influential philosophy in the entire history of world civilisation, the philosophy of social optimism. Thus, if one were, so to speak, to look at the communist ideal from a cosmic vantage point, then it appears as a *natural law*, sensed and actualised by men in the difficult ideological and political battles on the planet earth.

The concept of anti-finalism, although it deals with the super-long-term prospects for the existence and development of civilisation, is not thereby without immediate orientational and practical, and even ethical importance. One might quote here an extremely interesting statement by Tsiolkovsky: 'Man is ruled by the crude egoism of the brevity of his life on earth: take what you can – there is no better law than that. Even worse, this view of the earth has now been spread by the philosophers to the whole Universe. The practical sages (positivists), at least, ignored it as being either non-existent or irrelevant to the earth.'[1] Tsiolkovsky quite clearly 'linked' the finalism he was berating with positivism, that deliberately 'earthly' philosophy, and simultaneously pointed to its ethical unattractiveness. We believe that finalism is indeed unacceptable both philosophically and ethically. Anti-finalism, however, becomes a working, operative, hypothesis offering a programme of action for modern man, the only proper postulate worthy of Homo sapiens.

We will now move from civilisation as seen from a cosmic point of view to the individual as seen from that same point of view. This will be a continuation of the anti-finalism theme, but now as regards the individual, his world outlook in the space age, the new features that astronomical knowledge and space-age practice have revealed.

[1] K. E. Tsiolkovsky, *The Need for a Cosmic Viewpoint*, Archives of the USSR Academy of Sciences, collection 555, list 1, article 532, p. 1.

Chapter Nine

The 'High Frontier' of the Individual

The expression 'the high frontier' first appeared in American socio-philosophical literature and futurology dealing with the phenomenon of astronautics and its prospects. This was a tribute to the tradition of so-called 'frontierism', the search for new, 'final' frontiers for expansion and the colonisation of new lands and spaces from the expanses of the Far West to the conquering of the earth's atmosphere, the World Ocean and, today, outer space.

Let us say straight away that the concept of frontierism is extremely ambivalent. On the one hand, it dates back to the age-old desire for discovery and the expansion of the human habitat, including his intellectual habitat: opening up physical horizons is always accompanied by the opening up of intellectual and emotional horizons, developing and enriching the human personality. The voyage of Odysseus sung by Homer goes back into the distant past. Dramatic discoveries of the earth resulted from the voyages of Christopher Colombus, Ferdinand Magellan and Vasco da Gama in the 15th and 16th centuries, and the Russian expeditions in the 17th century led by Semyon Dezhnev, Erofei Khabarov and Vladimir Atlasov, which led to the Asian coasts of two oceans—the Pacific and the Arctic. By the beginning of the space age there was not a corner of the earth unknown to man. The journey into space became a new Odyssey, expanding the world of man to truly astronomical dimensions.

On the other hand, however, frontierism, as it is now understood in the West, paved the way for colonialism, and those who made these discoveries were followed by the 'conquistadores', which in Spanish

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Photon starships

means 'the conquerors'–conquerors of other peoples and destroyers of their cultures. The present 'cosmic frontierism' in the American space programme, both in its present practice and in its long-term plans, also bears the stamp of aggression, as is shown by the militarisation of space, which is now the leading trend in the activity of NASA.

We have already referred to the fact that the earth, thanks to the operation of numerous tele-transmittors, would appear a highly unusual planet to any hypothetical extraterrestrial observer. However, our planet would also prove highly unusual in yet another respect. To this day there is strontium and cesium decay as a result of nuclear explosions in the atmosphere, under water and on land. These only ended in 1963, with the signing of an international treaty prohibiting nuclear tests in these natural media (and in space). Yet the film of radio-active products from these previous explosions continues to form a glowing halo around the earth.

This second aspect of frontierism is inhuman and destructive; in the broad cosmological and philosophical understanding of the term it further intensifies entropy instead of countering it. Yet countering entropy is, as we have already said, the universal essence of intelligence and intelligent activity. Therefore, in speaking of the 'high frontier' of the development of the individual, we will, of course, have in mind not this second aspect, but the original, undistorted aspect—the aspect of discovery and cognition, accompanied by the improvement of men's moral and aesthetic qualities.

If one agrees that the desire for knowledge, discovery and achievement is one of the most important qualities of man, then we must inevitably turn to the concept of the individual in our attempts to provide a satisfactory answer to the 'question of the century' – why should man move into space?

This question has many answers, and we have already looked at most of them. Space is explored for immediate economic reasons. It is explored in order to develop fundamental scientific research in the fields of astronomy, astrophysics and planetology. It is explored with a view to creating in the future extra-terrestrial industrial-energy complexes. It is explored in order to satisfy the cosmic 'curiosity' of man, who looks for life and intelligence of extraterrestrial origin in order, in making contact with such life and intelligence, to understand his own nature better.

The multitude of answers reflects the multifaceted nature of astronautics. Yet let us concentrate on the main point. Intelligence has taken out into 'dead' space the most complex living organism found on the earth–man. This fact, easily formulated yet of enormous importance, encourages us to take a new look at the human individual, at the role and potential of this phenomenon, unique to the earth, and to seek the link between the human personality and the Universe.

It might seem that the reality of astronautics, the daily work of space crews and daily operation of space apparatus as they carry out their concrete and daily tasks would remove the aura of mystery and enigma that has always surrounded the cosmos. 'Any mythology,' wrote Marx, 'subdues, dominates and fashions the forces of nature in the imagination and through the imagination; it therefore disappears when real domination over these forces is established.'[1] In this sense, the space age of mankind marks the end of the myth of Icarus. However, it marks the realisation of the human personality, that personality whose germ first appeared in antiquity.

The aspirations of Icarus have accompanied men throughout their entire history. They were expressed in a striving to what might have seemed the impossible. The visible world, even the invisible world conceived of only in the mind, must become the tangible world. When Magellan, by his voyage around the world, experimentally confirmed that the earth is

[1] Karl Marx and Frederick Engels, *Collected Works*, Vol. 28, Progress Publishers, Moscow, 1986, p. 44.

round, as had been posited theoretically in the geocentric picture of the world drawn by Aristotle and Ptolemy, this discovery did not serve to underpin the idea of the finiteness of the globe, but of its unboundedness. Magellan had not found the 'edge' of the world, and thus it could be explored and explored again. When the Montgolfier brothers released a huge paper sphere filled with heated air, this opened up before men new expanses they could visit, new areas of activity, even habitation, and there immediately followed wholesale enthusiasm for ballooning. A few months later, people went up in a balloon. For a whole century air balloons sailed through the skies above lands little and large until they were replaced by the aeroplane.

Magellan, the Montgolfiers and other discoverers vastly expanded man's external, and therefore also his inner world. And if we recognise a direct dependence between the expansion of the external world and the inner world, then that inner world is now undergoing an unprecedented expansion, as unprecedented in its qualities and dimensions as is the space beyond the earth into which men are now penetrating.

It would no doubt be useful to distinguish two aspects in the exploration of the Universe: on the one hand we explore space in the interests of science, technology, and production, even improving certain aspects of our daily lives (for example, television and weather forecasting with the help of satellites); on the other hand, we explore space on the, so to speak, 'individual' (more accurately, personal) level, for we are satisfying the desire for discovery, for knowledge, we are satisfying the creative-transformative attitude to the world, all of which are inherent in human nature. It was therefore not surprising that Tsiolkovsky, speaking of the future exploration of space by men, of 'heaps of grain and vast power' that exploration of space would bring humanity, went on to add: ...there is no limit to the improvement of the personal—the individual.'[1]

For thousands of years the world of man was the earth, and for the most part that sufficed him. However, even in the early decades of the 20th century, the economic activity of men on the earth became comparable in its dimensions with global natural processes. The 'practical infinity' of the earth has gone irreversibly into the past. It is during this period that there appears the concept of the 'noösphere' (from the ancient Greek 'noos'—intelligence), the 'intelligent layer' of the earth comparable with the geological layers. 'The noösphere is a new geological phenomenon on our planet,' wrote Vernadsky. 'In that sphere man becomes the main geological force.'[2]

This new situation has brought with it problems that concern not only a few scientists, but millions of people. These problems include protection of the environment, the economy of non-renewable mineral resources, the battle against pollution of the atmosphere and the waters, the regulation of population growth, the elimination of the hunger and malnutrition which affect the majority of the inhabitants of the earth.

In looking for ways to overcome the ecological crisis, the crisis in man's natural environment, certain Western sociologists, philosophers, economists and ecologists see the exploration of space as virtually the single largest obstacle to the resolution of problems on earth: astronautics is seen as distracting men away from the real problems and orientating them in the

[1] K. E. Tsiolkovsky, *Cosmic Philosophy*, Archives of the USSR Academy of Sciences, collection 555, list 1, article 535, p. 23.

[2] V. I. Vernadsky, *The Biosphere. Selected Works on Biochemistry*, op. cit., p. 356.

wrong, and even a dangerous, direction. The American biologist and anthropologist Loren Eiseley, for example, wrote that the earth 'is the one complete island of being. The rest, including man, are in some degree fragmented and illusory'.[1] Man, having emerged on the earth, continued Eiseley, is adapted in mind and body only to the earth. The cosmic 'Odyssey' is dangerous, as it may lead to the dissolution and disappearance of mankind.

At first glance this might appear a perfectly rational argument. Indeed, the cosmic 'Odyssey' must preserve Odysseus himself–mankind. However, practical astronautics, far from contradicting the needs of the earth, corresponds to them entirely, as we have pointed out more than once. To this we can add that astronautics is an excellent way of 'educating' men in the 'spirit of earth'. Only about 200 astronauts have actually seen our blue and white planet against the harsh blackness of space. The rest of those 'left behind' on earth saw only photographs and film-shots of the earth as seen from space. Yet this was sufficient to create an enormous psychological impression which has played an important role in causing millions of people to see the earth in a new light and call for a rational and concerned approach to it. Cosmonaut Vitaly Sevastyanov was asked: 'Do you think that the move out into space has affected men's way of thinking?' He answered: 'Yes, I do. For example, we already knew that men cut down more trees than they cultivate, but that knowledge was somewhat abstract. Then we went up hundreds of kilometres above the surface of the earth and saw the bald patches on the green skin of the planet–and only then did we understand what it means.'

[1] Loren Eiseley, *The Unexpected Universe*, Harcourt, Brace and World, Inc., New York, 1969, p. 148.

Let us look at things in an even broader aspect—in this case, 'broader than the earth'. If one were to thwart man's continual desire for discovery and knowledge, if one were even only to 'change direction' by running down advanced scientific and technological programmes (for example, in the physics of microparticles, plasma processes, controlled thermonuclear reaction, and also in astronautics itself which, in addition to its other benefits, opens up wide possibilities in the areas just mentioned), then this would cause an irreversible shift in the psychology and personality of men, which would inevitably lead to the degeneration of mankind first in the social, and then in the biological sense.

Let us imagine the following scenario: space research is halted for the reasons given in the middle of the last century by the positivist Auguste Comte that further astronomical studies should be abandoned as being of no benefit to mankind; this view is then 'extended' to include fundamental research into natural processes occurring in space: shorn of their basis, applied research is 'simplified'; not only does Icarus cease to be a hero, but Prometheus is criticised for having been so unwise as to provide men with fire. From here it is but a step to that 'low frontier' beyond which men cease to be men.

In learning about the world, in penetrating the mysteries of nature and existence, in arriving at new summits of knowledge, man moulds his own personality. Astronautics combines a literal 'ascent' (the ascent into orbit) with an ascent to a new level of thought and feeling, and it is these thoughts and feelings which constitute personality. Odysseus would not have been Odysseus without his voyage.

The pioneers of space travel are and will always be people of courage and experience, resolute and highly disciplined, people with civic maturity—that is,

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Landing on the planet of the Blue Sun

people who have matured as personalities. However, they will not come to constitute some kind of human 'elite'. Some authors virtually 'biologise' the profession of astronaut. Stephen Dole, an American space biologist who works for the Rand Corporation, expressed his ideas on the profession of astronaut in the future, when it will cease to be something exceptional and become, if not a mass phenomenon, nonetheless a very ordinary one. He wrote: 'Each stage in the progress of man as he starhops into new unexplored regions of the Galaxy will be accompanied by an important kind of distillation process.

'Always, those volunteering for the next expedition into the unknown will tend to be adventurous, self-reliant, inquisitive, courageous, and hardy pioneers, while those selected to go will be chosen on the basis of good health, high professional competence, emotional stability, reliability of judgment, and so on. In the main, these characteristics will be passed on to their descendents, so that a kind of selection process will take place, with those at the frontier of the wave through the Galaxy always representing some of the best qualities of mankind, and leaving all of mankind with those qualities.'[1]

Dole is correct on the whole in his picture of those who explore space, but wholly incorrect in his reasoning. The 'selection process' does not operate in human society as it does among animals, where, as a result of the harsh battle for survival, the weak perish. In human society, the best qualities of individuals become, in time, accessible to all. The mankind of the future—in space, on the earth, on other heavenly bodies—will possess the main qualities now possessed by those who explore space, just as today the majority of us are familiar with and under-

[1] Stephen H. Dole, Isaac Asimov, *Planets for Man*, Methuen and Co Ltd., London, 1965, p. 225.

stand the ideas of Copernicus, Bruno, Tsiolkovsky—those 'great solitaries' of their day.

The cosmic expansion of man has yet another specific feature which is directly relevant to the future destiny of the human personality. Is it possible to imagine the settlement of space as a new variant of Robinson Crusoe, when not so very numerous human groups begin to live autonomously on heavenly bodies and in open space without experiencing a constant technical, material and spiritual need for communication with the earth and each other? Robinson Crusoe lived for 28 years on an uninhabited island without losing his humanity because he was the literary hero of Daniel Defoe, that is, a fictional character. The actual prototypes of Robinson Crusoe had, over periods far shorter than 28 years, spent in similar situations, lost both their human appearance and their human language. It is very likely that intellectual and spiritual degeneration await small groups in space if they wish to 'separate themselves' from the rest of mankind, and then Eiseley will prove correct in warning us against the possible dangers of the exploration of space for the human personality.

Yes, strictly speaking, such a danger exists. Individualism, the alienation of the individual is a serious illness in the modern world of capitalism, and this illness is often projected onto space. That is why foreign science fiction abounds with stories of space pirates, adventurists and gangsters. The Frenchman Marc Sabathier-Levêque, whose poem *Oratiorio pour la nuit de Noël* attracted the attention of such major physicists as Robert Oppenheimer, depicts the space and other similar progress of mankind as a kind of chaotic oscillation of 'the human protoplasm' which periodically destroys and disperses itself. Such a picture evokes in the author a burning desire to 'return to my bacterial origins'.

So, from the human personality to bacteria! Such themes and appeals can scarcely encourage us as forecasts of the future. They are certainly of no use whatsoever as working hypotheses about the future exploration of space. We ourselves build our own future, basing ourselves on the main historical trends of our activity. These trends are perfectly clear. Already all major undertakings in space require the combined efforts of experts in various countries. Already now international teams are forming in space. Such is the reality of the space age. Labour and intercourse in labour made men men. The exploration and settlement of space constitute an unprecedented process. If some nurse the individualistic dream of cosmic 'harbours' isolated from the rest of mankind, then they forget that large-scale undertakings in space, the effective use of the energy, gravitational and other advantages of space, are only possible on the basis of large teams supported, in the final analysis, by the experience, technology and information possessed by the whole of mankind. Thus the more significant and longer-term the work and life of man in space, the more collective and international that work and life must be.

The differences in this new natural environment will cause an unusual expansion in the human world of sensations and interests, but it will be a human world—a world of contacts, of mutual aid and cultural intercourse which will lead, amongst other things, to an unparalleled development and useful diversification of what we term the human personality.

Such a diversification, the result of astronautics, is already quietly taking place within us now. Space technology is being used to resolve highly complex ergonomic problems (ergonomics is the study of the labour process with man's participation) of the relationship between man and the machine. Here the man-machine system functions in almost pure form. Sometimes the name used for this system provokes anxiety. Does it mean that man is merely a machine?

Before answering this question (and our answer will, of couse, be negative), let us recall that in the 18th century the French philosopher Julien Offroy de Lamettrie published an essay entitled *The Human Machine*, in which he asserted that man is indeed similar to a machine in that all his mental and physical activities can be reduced to mechanisms. Thus Lamettrie belonged to the school of mechanical materialism, which has long since been replaced by dialectical materialism. However, the name of Lamettrie is once again being remembered in the age of the scientific and technological revolution, and most frequently with anxiety lest his unscientific–from a modern point of view–understanding of man nonetheless proves to be true. In this age of the scientific and technological revolution, machines are becoming ever more complex. They not only work, they also 'think' (computers, microprocessors). A modern space station could be termed a concentration of mechanical complexity and multi-functionality. However, this does not mean that man resembles a machine. On the contrary, it is the machine that is coming more and more to resemble man, the ideal which it can never actually achieve (just as man, and only man was the measure and embodiment of all natural forces in the days of ancient mythology).

Dreaming cyberneticians and, in their wake, certain science-fiction writers, understanding very well that the human brain cannot be simulated by any 'intelligent' machine, suggested a fantastic combination of the machine and man, and called this symbiosis 'the cyborg' (the combination of a cybernetic device with a living organism). The cyborg takes from man only the brain, nourished by all the necessary liquids, while the rest is replaced by mechanisms. Such a cyborg, they argue, would be perfectly suited for very long space voyages to other stars and galaxies. Well, perhaps such cyborgs might indeed reach other stars and galaxies, but nonetheless the cyborg is not a man. Humanity requires emotions, feelings, sensations, the world of men and nature. A cyborg (but not thus called and without any related concept of astronautics) was presented at the beginning of the 19th century in the novel by Mary Shelley entitled *Frankenstein or the Modern Prometheus*, which people today are also recalling. In the story, the artificially created intelligent being revenges himself for his tragedy—the fact that he does not resemble humanity. (It is worth noting that this story could serve as a warning to those enthusiastic supporters of gene technology who talk about creating 'new men' by manipulation of the genetic code.)

However, let us return to astronautics. Astronautics in no way turns man into a machine. If that were so, it would be easier to limit research and the exploration of space to exclusively automated devices. Indeed, in the history of astronautics, the path to the stars was always opened up by automatons, which were always the first. However, it is worth repeating again in this context that these automatons are designed and controlled by men. No automated device has the perceptive, observational or selective ability of men, the ability to take quick and clear decisions, the ability to evaluate and generalise—in short, all those abilities which are intrinsic to men and which will never be possessed by any machine or mechanism.

However, in principle the 'vocation' of the machine is not to damage man but to assist him. As for that whole complex of space technology which we call astronautics, it is capable of helping to create

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A probe for interstellar flights

that personality which eliminates the contradiction between the 'humane' and the 'technical' (a contradiction which dates back to the ancient attitude of the slave-owner to the labour of the slave, the 'technical' fulfiller of his will), and which harmoniously combine exact knowledge with fundamental spiritual qualities. This, in particular, is the way in which the beneficial complexification of the personality expresses itself in the age of astronautics and the scientific and technological revolution in general.

Before the beginning of the space age, and even in the early years of space exploration, much was said about the possible compatibility of man and space, the compatibility of a being rooted in the earth and wholly biological, and space, the kingdom of the inorganic and the unclear. There existed an attitude which may be described by paraphrasing the words of the New Testament, 'Render therefore unto Caesar the things that are Caesar's; and unto God the things that are God's' (Matth., 22. 21) to read: 'Render unto man that which is of the earth, and to technology the things of space'. After all, man does not penetrate physically into the microworld, but studies it by using microscopes and other devices. Thus, it was argued, we should behave with regard to the macroworld of outer space. The inorganic world of space is more suited to metal and plastic.

It was no accident that we chose just now to quote from the Gospel of St. Matthew. Sometimes, alongside technology, there is a tendency to try to use as an intermediary between man and space (in philosophical speculations concerning astronautics, published in large numbers in the West), God himself—or more accurately, a special 'cosmic religion' which is supposed to help the astronaut to orientate himself in this unknown world, and which will combine the latest data of science with the postulates of traditional faith. St. Christopher, the patron of travellers, has already become one of the symbolic emblems on the equipment used by American astronauts.

So we have various mediators. Let us examine them. Such mediators have always existed in the relationship between man and nature. Deity was used for this role in the days when men were still ignorant (and is sometimes still used for this role today for the same reason). This role was also accorded to technology, which man used, to speak metaphorically, as his sword and shield in his relationship to nature. Outer space is also 'nature', but a nature which requires further improvement in man's technological equipment as he penetrates into it. That technology is still his shield—the reliable shield of the spacecraft, the space station, the spacesuit. It is also his sword, not in the military sense, but in the sense of his tool of cognition and transformation. (We repeat once again that the militarisation of space can be spoken of only as a pathological deviation from the essence of the space age, as, indeed, militarisation in general is a pathology affecting all the ages of human history.)

However, a mediator remains a mediator, and in that sense always plays a secondary role. The first role goes to men. As soon as we speak of the exploration of space, it opens up truly 'cosmic' possibilities for the development of the human personality. This new world of natural phenomena, new forms of overcoming its resistance and co-operating with it, its adaptation to human needs, all this will lead to the formation of an essentially new personality. However, astronauts or the inhabitants of space settlements will nonetheless remain fully human. As for those who continue to live on the earth, they will acquire the necessary cosmic outlook, which can only help to form a new view of the earth and assist its improvement.

Chapter Ten

The Cosmic World of Culture

We cannot think of world of the human mind apart from the world of culture, where 'culture' refers to a broad spectrum of human feelings and thoughts ranging from 'the meaning of life' to aesthetics. This chapter, therefore, is a continuation of the previous one (in which we cited certain examples and illustrations from literature). We will try to show how cosmic motifs have penetrated into every form of art, from fiction to industrial design.

From time immemorial, outer space has attracted the attention not only of philosophers, but also of poets, artists and architects. The rock paintings drawn by primitive man depicted cosmic objects–the sun, the moon, the stars. These are not, in our opinion, proof that beings from other planets visited the earth in the distant past (as believe the supporters of paleocontact). They served as a set of practical instructions–primitive calendars used in agriculture (the opinion–in our view correct–of archeologists and ethnographers.) But they were also works of art expressing awe for the splendour of the Universe. This same awe was expressed in the religious architecture of the religions of the world. Awe before the heavens was not 'dictated by the heavens'. In his own creations man can only express the human and the humanised. Nor was it only awe that was being expressed here. They also expressed a human striving: the upward-soaring Gothic cathedral can indeed be described as 'rocket-like'.

But we will begin straight away with a later period, with the cosmic tradition in Russian literature, for we believe that it was here that this tradition manifested itself most clearly, containing within itself not a little of the heuristic, the instructive and the original.

Mikhail Lomonosov was full of awe and amazement at the splendour of the Universe: '...The abyss opened, full of stars ...' About a hundred years later Fyodor Tyutchev saw the earth as if from outer space in his imagination: '...and we float, surrounded on all sides by the blazing abyss.'

'The blazing abyss...' And he is talking about the black sky punctured here and there by the stars! Out in space, the rays of the sun lay a carpet over the stars, but the sky seems black. The Russian poet anticipated the visual sensations of the astronauts.

There were insights that penetrated even further. Take the lines from Pushkin's poem *The Prophet:*

I heard the trembling of the skies,
The flight of angels in the height,
The glide of creatures in the ocean,
And vines inertly growing in the dale.

If one sets aside the archaic terms and the metaphorical nature of some of the images, such as the flight of angels, then one is left with an integrated view of the world in its true proportions, the unity of the terrestrial and the cosmic, what one might call the cosmic nature of the earthly, that is, that which is now becoming the normal perception by men of the world around them. The 'trembling of the skies' reflects far more accurately the modern picture of the Universe that Pascal's 'eternal silence'.

The playwright Sukhovo-Kobylin, that same playwright who, as we mentioned in the first chapter, formulated *The Teaching of the Universe*, was full of admiration for ... the bicycle, because he believed that this new, more rapid means of transport would have consequences for the biological evolution of men, who might even, finally, evolve wings. Despite the naive fantasy of Sukhovo-Kobylin's prediction, it should be noted that this was the first time that 'cosmic' thought had based itself on the actual achievements of human technology, and not on the simple, age-old contemplation of the starry sky.

The first artist of the word–the first one to 'see' the Universe–was, in fact, Tsiolkovsky. He was not only a theoretician and experimentalist, but also a science-fiction writer. Moreover, in his science fiction he was also philosopher able to predict future reality with subtle accuracy (the essays *Visions of Earth and Sky, Beyond the Earth, Living Beings in Space* and others). Tsiolkovsky wrote, for example, that on the moon, which has a gravitational force six times less than that of the earth, the best way to move about is by jumping, pushing oneself away from the surface with both feet simultaneously. Neil Armstrong, the first man to step onto the moon, gave a report at one of the congresses of the International Astronautical Federation in which he described his own experience of moving about on the moon–a description that coincided exactly with that of Tsiolkovsky.

The first manned space flights also saw the first literary articles and essays about space, and the publication of books such as *There Is a Flame!* and *Pathway to the Universe* by Yuri Gagarin, *Angle of Attack* by Georgi Beregovoi, *Diary above the Clouds* by Vitaly Sevastyanov, *People and Space* by Vladimir Shatalov... These works, written by astronauts, contain priceless first-hand information, often recorded in the log-book in the first few moments following the experience itself, information about a world new to men, about completely novel cosmic-

A. Leonov, A. Sokolov

Towards new worlds

earthly living conditions aboard spaceships and orbiting stations. 'Our sleeping quarters remind me a little bit of a beehive (in a forest) to which the bees return. The same small holes into which we sail when it is time to sleep, and out of which we sail when reveille sounds.' That was what Vladislav Volkov[1] wrote in the log-book, and this unexpected yet so accurate comparison would probably never occur to any 'earth-bound' science-fiction writer. Volkov never had the time to write a book. He gave his life for cosmonautics, as did the other members of the crew aboard the space station *Salyut-1*.

The complex world of the astronaut and astronautics insistently demands the attention of professional writers and artists. Contemporary scientific discoveries in astronomy, astrophysics and astronautics are gradually exerting their influence over and reorientating science fiction and the science-fiction aspects of other, essentially realistic and 'earthly' literary and artistic works. Today the cosmic theme attracts the science-fiction writer, the utopian and the realist, not in terms of the natural sciences, nor in terms of technology, but in human terms. And it is natural that this should be so. In our day, the increasing complexity and specialisation of the natural and technical sciences mean that predictions and discoveries in these fields are the work of highly qualified specialists and collective bodies of scientists and engineers. The age of spontaneous insight is, we believe, passing into history. However, today as never before it is necessary to integrate science, technology and man, to develop the human and personal principles, humaneness, culture and art.

All of this finds expression in profound and monumental works. The Soviet writer Ivan Yefremov,

[1] *Salyut in the Orbit*, Moscow,1973, pp. 137, 139 (in Russian).

who resurrected the utopian literature in the best, the energetic and prophetic sense of the word 'utopia', sketched out in his book *Andromeda* a communist future in which men, having shaken off all alien accretions, begin their new history, combining a Hellenic sense of harmony with the technology of a developed cosmic civilisation. The novel *A Day Lasts Longer Than a Century* by another Soviet writer, Chinghiz Aitmatov, is rooted in reality. It is about the daily life of people working at a railway station in the remote steppeland of Kazakhstan (the novel has the subtitle *Station in the Steppe*). However, a science-fiction theme is woven into the text, and one, moreover, that is essentially tragic—failure of a contact between a socially divided, 'unprepared' humanity and an extraterrestrial civilisation that is both moral and 'open'.

This same theme of 'unpreparedness' is tackled directly in a Soviet film made in the 1970s and called 'The Silence of Doctor Ivens' (written and directed by Budimir Metalnikov, with Sergei Bondarchuk in the main role). A representative of a highly-advanced extraterrestrial civilisation, a woman capable of instantaneous motion through space and able to hypnotise hardened scoundrels and render them harmless, is shot dead by foreign detectives. Earthly evil (personified in representatives of the capitalist West) has proved the stronger. However, the struggle in defence of humanism, solidarity and intelligence is continued by Doctor Ivens, an inhabitant of the earth. And this is as it should be; we cannot hope to be saved by some advanced extraterrestrial civilisation. We must rely on our own strength, or else we may become victims of a mass psychosis, believing in 'flying saucers' that are allegedly watching human activity, disapprove of militarisation, and will save mankind at the last moment from nuclear self-destruction.

Since the end of last century, with the publication of *The War of the Worlds* by H. G. Wells, cosmic science fiction abroad has always been notable for this 'aggressive' tradition which unfavourably differs from the tradition which it is appropriate to call socialist—a line aimed at co-operation and solidarity, at overcoming intra-human antagonisms unworthy of the ideal which takes on the form either of highly developed extraterrestrial civilisations or a human civilisation of the future.

Higher, non-terrestrial intelligence is aggressive in its relationship with men. The Universe is hostile to mankind and implacable. Such is the idea which runs as a leitmotif through the majority of foreign science fiction, up to an including the superficially dazzling and expensive 'westerns' of the 1970s and 1980s—the film trilogy 'Star Wars', 'The Empire Strikes Back' and 'The Return of Jediah' produced by George Lucas. This trilogy telling the story of the battle waged by the young hero, Jediah, against evil forces in the Universe, and how he rescues a fair princess, has entranced many of those who have seen it, and 'laser swords' copied directly from the film have become a favourite toy with children. They never suspected how close this extravaganza was to reality: President Reagan's plans to militarise space have been nicknamed 'Star Wars', and, as part of these plans, American space Shuttles are beginning to test their 'laser swords' for a cosmic war to be waged not against 'extraterrestrial' evil, but against men, and, ultimately, against those same American film-goers and children whom we have just spoken of.

Why is the theme of 'aggression' so firmly rooted in Western science fiction? The literary form we are examining (in this instance, bourgeois) is socially and ideologically weighted to show the supposed innateness, insuperability and permanence of aggression in human society. It is a theory which promises that aggression and capitalism will reign for millions of years.

However, sometimes even bourgeois science fiction indirectly recognises the new social situation existing in the World. The American woman-writer Ursula Le Guin, in her novel *The Dispossessed. An Ambiguous Utopia*, describes two societies living on two different planets–a communist, non-authoritarian society on the barren planet of Anarres, and a decadent but wealthy capitalist society on the planet of Urras. The hero of the novel, a young physicist, tries to reconcile these two worlds. We have, of course, before us the usual theory of the convergence of two opposing social systems, here expressed in the form of science fiction. However, the attraction of this novel lies in the following: an entire planet under the control of decadent capitalism is not fiction–such was the earth until October 1917, until the socialist revolution in Russia; but an entire communist planet is something new in this science fiction, which usually supports the world of private property and alienation. This is indeed an ambiguous utopia!

In the 1930s, when Americans were thrown into a false alarm by radio broadcasts of Wells' story, Tsiolkovsky was writing his philosophical essays, in which there was not a single word to suggest that the intelligent creatures of the Universe might be aggressive to each other, this being excluded by the very concept of 'rational'. In his science-fiction story *Living Beings in the Universe* he described the co-operation and mutual aid of all 'solar systems' in which intelligence exists. Within our own solar system, the author envisaged direct contact, without people moving out into space: his 'necklace', a chain of space settlements, was linked by tube-corridors (the story *Beyond the Earth*). Despite a certain schematic abstractness in his pictures of cosmic society, Tsiolkovsky was able to perceive the direct link between man's exploration of space and human social progress.

Recently a great deal has been written and said about the link between space and society, between the universal and the social, a link furnished by culture, including art. Here we move from the sociological, moral and political aspects of the theme 'culture and space' to the socio-philosophical and purely philosophical aspects.

Both abroad and at home, attempts are being made to link certain phenomena of social consciousness, and in particular culture and art, with the natural phenomena of the Universe, to compare the laws governing the evolution of the Universe and detected by science with the laws governing the human view of the world, imaginative thought and the subconscious.

Such attempts might appear, at first glance, extravagant, but they are not altogether without their usefulness, particularly as the ancient belief in the unity of the Universe and man, in the macro- and microcosmos, is supported by modern cosmology.

Unfortunately, these attempts are sometimes founded upon pure speculation, often fundamentally idealistic and bordering on the mystical. For example, the American physicist Heinz Pagels suggests that the single 'cosmic code' is a kind of 'message' (from whom?) which governs not only natural processes in the Universe, but also socio-cultural processes in human society.[1]

Whether such a code exists (not, of course, in the form of a message from a non-material substratum,

[1] Heinz R. Pagels, *The Cosmic Code. Quantum Physics as the Language of Nature*, Simon and Shuster, New York, 1982, pp. 343-349.

that is, a god, but the one built-in by matter in itself) is difficult to say as yet. However, the existence of a genetic code related to the biological stage of the movement of matter is indisputable. Penetration into

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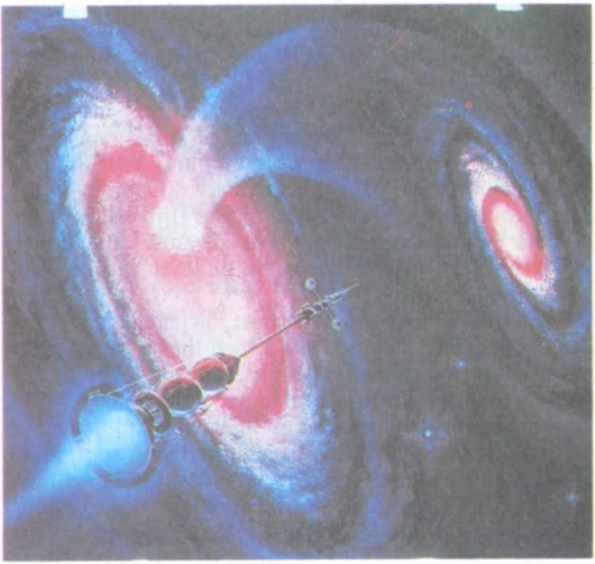

A starship on its way to a new galaxy

the secret of the genetic code which programmes the development of all life on earth may, perhaps, shed light on an even greater mystery—the emergence of the organic from the inorganic. We have already mentioned the fact that this process, according to the most recent data obtained by astrophysics and the planetology of the earth, clearly has its origins not only on the earth, but also beyond, in the Universe.

However, to believe that this genetic code (itself derived from the 'cosmic code') is responsible for programming the development of intelligence and culture on earth would be no less clearly a pseudo-scientific method of investigation into social processes, which have their own nature and their own laws—those same laws based on collective activity and the use of tools, of which we have already spoken, and which remove the mystery (and mysticism) surrounding the emergence of intelligent life.

In our opinion, the Soviet author Konstantin Kedrov, also far removed from science, in his essay *Book of the Stars*[1] suggests that the fairy tales of many peoples, and also certain works of fictional literature written more recently (for example, *The Death of Ivan Ilyich* by Lev Tolstoy) reveal a certain 'metacode', the decoding of which might enable us to explain much about ancient civilisations and, in the modern context, to form some theory concerning the unity of man and the Universe. Thus it is possible to assert that all the complexities of our existence and the diversity of our history, emotions, perception, etc., were programmed into the initial, 'galactic egg' which gave rise to our visible Universe, which is, in effect, precisely the suggestion put forward by the astrophysicist and corresponding member of the USSR Academy of Sciences, I. S. Shklovsky, in his pithy and interesting book, *The Universe, Life, Intelligence*, re-issued several times.[2] However, in philosophy this is called 'predetermination', 'providentialism', 'fatalism', which contradict materialism and Marxist dialectics.

[1] *Novy mir*, 1982, No. 2.

[2] I. S. Shklovsky, *The Universe. Life. Intelligence*, Moscow, 1973, p. 100 (in Russian).

The idea of a 'metacode' appeals to man's predilection for all that is mysterious and miraculous, just as he is also attracted to hypotheses such as that of paleo-contact, and fascinated by 'flying saucers'. However, in our opinion, all this serves to distract from the reality of cosmonautics and the space age. Man's penetration into new areas of the natural world and the mysteries of nature has often, in the history of the natural sciences, been accompanied by mystical interpretations. One need only remember the 'crisis of physics' and the idea of the 'disappearance of matter' at the beginning of this century, during the transition from classical physics to quantum mechanics and the physics of elementary particles. In his work *Materialism and Empirio-Criticism*, written about that time, Lenin quite literally 'defended' matter against attack by philosophical positivists and 'physical idealists'.

Something similar can be seen today. However, in modern science mysticism is quickly and effectively dealt with. Today it is science fiction, and indeed social psychology that lag behind. Today the science-fiction writers love to play with the paradoxes of time and space (travel backwards in time, multidimensional space, etc.). However, in the physical world, time cannot be reversed, and space is three-dimensional; is it not time to take these axioms into account–after all, no one writes any more about machines capable of perpetual motion!

Gradually we are freeing ourselves of our 'flying saucer' psychosis, which has already begun to bore. They litter our 'mental cosmos', just as abandoned space apparatus is littering the physical cosmos. When the world heard the TASS report on the first sputnik, the first declaration of the space age, which read: 'Artificial earth satellites will pave the way for journeys into space'–there was much that was still not clear. What and whom might we meet in space? Would there be anything out there? And if there was, how could space be made to serve the earth? Today outer space represents not only, and not so much the prospect of interplanetary travel and a meeting with fellow intelligences (the favourite theme of science fiction), nor an empirical verification of Einstein's theory of relativity (although such experiments, in embryonic form, are being carried out on automated space stations), with comparatively young astronauts returning to meet their ageing great-grandsons (though this is a well-worn subject in science fiction). Today the cosmos is our reality, the outlines of which it is time to sketch out, including by artistic means, as the space age is already thirty years old.

In literature–science fiction or realistic–it would be an error to limit the subject of outer space to extraterrestrial civilisations (even if this did not take the form of 'flying saucers'), or to the more extravagant aspects of time and space, intended to stagger common sense. Such an approach can easily become traditional through mental inertia. Real cosmonautics, its actual prospects for the future, are more fantastic than anything modern science fiction can offer, and, more importantly, far more productive in terms of artistic observation and prognosis than any superficial discussions of the Einsteinian space-time continuum or extraterrestrial intelligence. Such discussions are gradually becoming fruitless, for they are not supported by the empirical experience of astronomy and astronautics.

Science-fiction writers look into space. Astronautics looks at the earth. If the conquest and use of space constitute, in their own way, an extension of the earth (and certainly not the abandonment of the earth by a mankind which supposedly had to migrate into space in search of 'virgin lands'—the view of certain futurologists abroad frightened by their own ecological, raw material and demographic predictions), then it is also, simultaneously, the extension of the human world, the human horizon. The 'X-ray effect' can also be applied to the human ability to see the earth and mankind in a new light.

The onset of the space age brought with it a profound, if not directly obvious change in our perception and way of thinking. The photographs sent back from outer space revealed the face of the most unusual planet in our solar system, and perhaps in our galaxy—the planet earth, with its thin layer of biosphere, the sphere of life, suspended in the black emptiness of space. Astronomers had long been aware that the earth is tiny in comparison with such planetary giants as Jupiter, Saturn or Uranus, but now the epithet 'fragile' has been added to refer to our nonetheless reasonably solid planet.

This psychological 'turn around' is well illustrated and symbolised by the now familiar picture of the earth as seen from the moon. *The Crescent Earth* is the title of a short story by the Soviet writer Victor Stepanov, a story which, in its documentary, journalistic style, is a continuation of the books written by astronauts themselves. However, this story is about people—Gagarin, Armstrong, Leonov, Korolyov—and not about moonscapes. The moonscape with the crescent earth is merely a symbol, a sign of the times.

The sharpened sense of the genetic unity of Homo sapiens face to face with the Universe and, for the moment, alone within it, increases the need for social unity and turns it into a categorical imperative. Thus the world of earth comes face to face with the ideals of collectivism and this is certainly not taking place independently of astronautics. 'Cosmic' fictional literature, journalistic literature and science fiction, like all literature, stand at the 'meeting point' of aesthetics and ethics and must help foster the unity of mankind as an alternative to 'cosmic loneliness', if I

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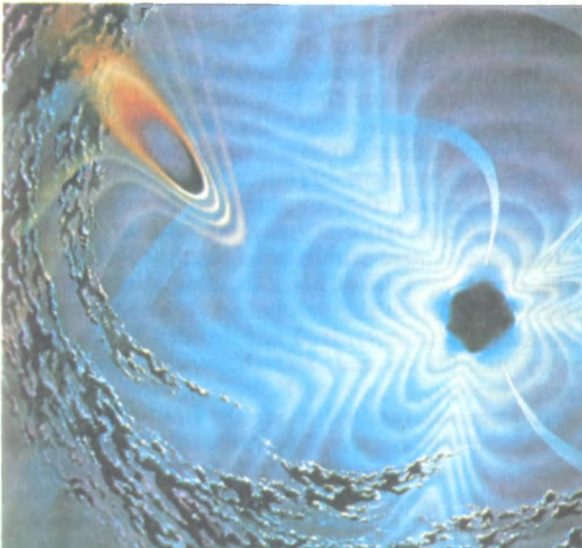

'Black Star'

may repeat once again this expression used by Bertrand Russell.

Let us now move on directly to aesthetics. Although the theme of space has long since become part of our aesthetic perception of reality as a result of the contemplation of the skies from the earth, this was not the 'Universe' in the proper sense of the term.

Rather it was 'the sky', that is, the projection of the Universe on our planet, an earthly 'cross-section' of that Universe. The emotional-aesthetic effect of the Universe could only have its full impact when man left the surface of the earth, when this customary 'projection' was upset. This began with Gagarin's exclamation: 'It's simply fantastic!'—the first human exclamation made in orbit.

Gagarin's flight was, as we all remember, described as 'a step into the unknown'. That 'unknown' included practically everything, and therefore also the effect of direct contact with outer space on the psyche and emotions of men. Some science-fiction writers imagined the returning astronauts as men alienated from everything on earth—as men who had established contact with outer space, but lost contact with their own fellows. Gagarin, after 180 minutes in space, proved that this was not so. So also have those astronauts who have lived and worked in space for many months on end, and those who had landed on the moon.

Gagarin was the first to see the fine shades of colouring in the earth's atmosphere during the transition from day to night, and he compared them to the colours used by the Russian painter Nikolai Roerich—a very 'cosmic' painter—on his canvasses. His work included several Himalayan landscapes. American astronauts noted that the craters and rocks on the moon, upon closer observation, have virtually no colour of their own, but are capable of assuming a wide range of colours and shades depending on the strength and direction of the sunlight. It has been suggested that primitive man did not distinguish between the green of steppeland and the green of the forest, between the blue of the sky and the blue of rivers, lakes and seas. Perhaps man's visual perception of the grey-brown rocks of Venus and Mars will undergo an evolution, and the landscapes of these planets will take on totally new colours and tones.

We have already spoken of the books written by astronauts, those literary-documentary sources of first-hand information written by authors who are simultaneously the heroes of their own works. There is also a painter-astronaut, Alexei Leonov, whose canvasses, be their theme reality or fantasy, always reveal the priceless and irreplaceable brushmarks of an eye-witness. This, too, begs a historical counterpart, although from more recent times: prior to the invention of photography, travellers sketched what they saw. The sketch and the painting still retain their importance, not only as works of art, but also as documents—for example, drawings by animal artists recording the external appearance and behaviour of animals. The same can be said of space. Let us recall that Leonov saw the sun with a 'kokoshnik' on before the camera filmed it. No doubt future space crews will include a talented painter.

The Universe is silent. However, if one considers the correlationship between the musical octave and the colours of the spectrum—a correspondence first used by the Russian composer Alexander Scryabin, then the airless, and hence silent Universe may cease to be silent for the world of music. There is also that part of the Universe which possesses an atmosphere, but it is difficult to anticipate the aesthetic effect of the sound of natural processes on Venus, Mars, Jupiter and other planets and certain of their satellites whose atmosphere is capable of transmitting sound. Whatever the case may be, the world of music may also be dramatically enriched with new sounds.

One might even—though today this can only be at the theoretical level—speak of ballet in conditions of weightlessness. What freedom of movement and what marvellous opportunities open up here for the development of this art form! Choreographers of the future will move into this area, and the choreographers of the present might well begin to reflect on it.

Astronautics also opens up extremely interesting prospects for architecture and town planning. Conditions in space permit new, hitherto impossible technical and aesthetic solutions. For example, on the basis of space stations, which already exist, one can raise fundamental questions about the nature and design of satellite cities—not in the suburban but in the cosmic sense of this term. Cities first emerged historically as the formation of units more independent of external factors than the caves and small settlements of primitive man. This trend in town planning has been seen in recent years in plans for new towns—buildings with their own microclimate and hothouses for the Soviet Far North. The city is moving into increasingly uninhabitable areas, and thus, at the same time, protects itself from the unpleasant and extreme effects of this environment. Thus man's move into space will not, in this sense, produce any surprises in the development of town planning, but will appear as a logical continuation of one of the trends within it.

But there will be that which is unique to space. The cosmonaut Konstantin Feoktistov once spoke of the 'swarm principle' of space construction: industrial plants, energy installations, residential complexes, hothouses, laboratories could 'float' freely very close to each other, forming a kind of cluster or 'swarm'. This principle would make it possible to eliminate reciprocal negative effects between buildings with a different purpose—interference, for example, between residential buildings, where it would be desirable to have some artificial gravitational pull achieved by causing the building to rotate on its own axis, and laboratories where the instruments require the total absence of any disturbance, protection against any vibrations, jolts, etc. At the same time, all the buildings are close to each other, facilitating communication between them. Roughly spherical in shape, spreading in all directions, without streets—such is the 'cluster city', as yet unknown in town planning and architecture on earth.

The cosmic space surrounding such cities will remain lifeless; here there will be no 'green belts'. Thus those inhabiting these cities will particularly feel the need for decorative architectural elements such as, for example, the column, which has a rich history in human culture and art. And, perhaps, new forms will be found, and new ways of creating aesthetically pleasing complexes which will 'eliminate' cosmic loneliness, emptiness, cold and darkness.

Already, thanks to an abundance of novel architectural solutions, cosmic technology is providing grounds for new aesthetic evaluations. Weightlessness and vacuum, basic characteristics of outer space, while imposing harsh demands in terms of durability and reliability, also permit great freedom of form, and the internal rationality of these forms is often more evident that in structures and mechanisms on earth.

In the conditions obtaining on the earth, we are not accustomed to scattered forms, to the fact of individual elements being placed far beyond the bounds of a given structure. Weight and wind and other phenomena of our planet dictate their own conditions. For example, on earth, only slowly-moving objects may have sharp angles (carriages and the first automobiles). Today, modern means of transport are invariably streamlined, with smoothly flowing lines (ships and airliners, modern cars). This has led to a corresponding conception of elegance, beauty and comfort. It is indicative that, before the space age, imaginary rockets and space apparatus were depicted just as streamlined and graceful as the latest aircraft.

However, practical experience in space has also left its mark. As soon as the nose cone of the spaceship is jettisoned as the craft goes into orbit, other laws, and a different aesthetic, come into play. The first sputnik had an ideal form–the sphere. Thus man took his first experimental step into space. Gradually our knowledge of the processes and conditions in space became more concrete, and so did the demands that men made on space. The range of tasks increased, the apparatus became more complex. The American lunar module and the Soviet 'moon buggy' were unexpected in their design from the point of view of traditional aesthetics. However, once the grid-like wheels of the 'moon buggy' had traced out a multikilometre track along the surface of the moon, and the antenna-like eyes of the television cameras offered a detailed picture of the area it had crossed, the sense of unexpectedness at the design disappeared, once again confirming that awareness of the rationality of a form assures it a corresponding aesthetic evaluation.

In this chapter we have attempted to review the socio-cultural and ethico-aesthetic effects of the cosmic age on men. We can see that, not only in the sphere of science and production technology, but also in culture and art, there is a slow but irreversible move away from a purely geocentric view of the world to a cosmic view of the world, and of man in that world. It is thus that Homo cosmicus is formed.

Chapter Eleven

The Universe versus Chaos

For the ancient Greeks, the concept of the 'cosmos' (Universe) means not only that which lay beyond the earth, but also order and harmony. The concept of the cosmos was set against the concept of chaos–disharmony and disorder. Quite unexpectedly this ancient philosophical concept is today becoming dangerously near to the truth. The Universe could become chaotic as a result of 'Star Wars' generated by men themselves. We are referring here to the militarisation of space, a topic mentioned earlier, but to which we now feel it necessary to devote an entire chapter: the militarisation of near space has begun to exert an excessively powerful influence on world astronautics.

When was it that the first call was sounded in the world for making outer space an arena of peaceful research and creation? Today one will hardly believe that it was in Russia at the end of the 18th century. But it was really so. In 1784 V. A. Levshin published a fantastic work entitled *The Latest Journey*, an article about the flight to the moon, a 'new India', first of some small apparatus and then a whole 'fleet' of them. 'This fleet,' Levshin wrote, 'would not be navigated by gold-lovers: only excellent minds would take off for enlightening purposes. The coasts of this new India would not be stained with blood as a result of thunderous furies falling onto them: that would be an army equipped solely with optical instruments, pens and paper.'[1]

From ancient times the Universe has attracted the attention of thinkers and scholars. Astronautics has made that Universe an object of interest for millions of people. In the early stages of the development of astronautics, people raised the question as to whether men needed to explore space, or whether they would do better to concentrate their efforts on problems closer to home. The obvious advantages and attractive prospects of exploiting space for the benefit of mankind resulted in a decision in favour of space exploration. However, this was merely the lull that preceded renewed and general concern– indeed, now, anxiety. In the mid-1980s everyone is aware of the plans to militarise space, and the steps to carry these plans through.

On March 23, 1983, President Reagan announced the American programme of 'Star Wars', which includes the development of such a 'super-weapon' as, for instance, an orbital X-ray laser installation actuated by a nuclear explosion and hitting targets in outer space, in the air and on land. To this day people remember the horrors of Hiroshima and Nagasaki onto which two atomic bombs were dropped in 1945. Today nuclear weapons, this sword of Damocles of the 20th century, for many decades now hanging over mankind, should 'merely' serve as a fuse for actuating a series of X-ray beams, the swords of Damocles of the 21st century, or the 'thunderous furies', to use the terminology of the 18th century.

Aggressive circles in the USA, the second space

[1] V. A. Levshin, 'The Latest Journey'.–In the book: *Interlocutor of Russian Literature Lovers*, Part XIII, St. Petersburg, 1784, p. 140 (in Russian).

power, have adopted a policy of transforming near space into a new, incomparably vast arena for the arms race and preparations for thermonuclear and 'X-ray' carnage. Such is the space Shuttle programme. The Pentagon's share in the American space pro-

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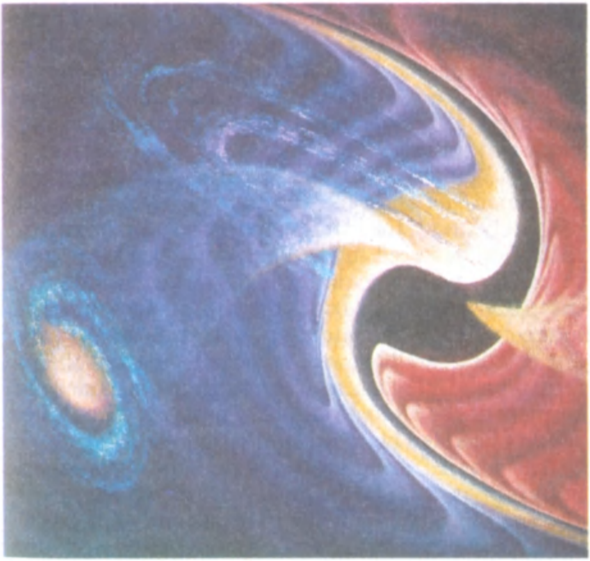

Neutrinos 'crossing' into an antiworld

gramme is constantly growing, and the Shuttles are revealing a tendency to turn from means of exploiting space for scientific and economic purposes into a new type of weapon. The 'High Frontier' project now being discussed in America at many levels, from the

Pentagon to the press, proposes that around 500 satellites be put into orbit in order to destroy apparatus put into space by the 'enemy', that is, the first space power.

The militarisation of space is delaying its industrialisation. The proud expression 'High Frontier', to which we have just referred and which symbolises the boundless striving of human genius, is now being basely transformed into a term for misanthropic plans. We understand the space age to be something integral, progressive and humane, and this is indeed essentially true. Militarisation is not the norm, but a sickness afflicting astronautics, which was born in peace and for peace.

Let us remember history. Aviation, having scarcely completed the stage of research and testing, was immediately used for military purposes (air bombardment first occurred in the First World War), and only thereafter did it acquire civilian uses (the middle of the 1920s). Astronautics, on the other hand, had intercontinental ballistic missiles as its technical base, but the first satellites were launched as part of the International Geophysical Year programme under the auspices of the United Nations. The dawn of the space age was heralded by the sign of peace.

The idea of using space for military purposes appeared, it is true, in the first years of the space age, and was formulated openly, in detail, and with 'knowledge of the matter in hand'. At the beginning of the 1960s Donald Brennan, a professor of mathematics at Massachusetts Institute of Technology, enumerated the following possible types of space weapons:

orbital atomic bombs which could 'land' at any place at any time, while the more powerful bombs could be exploded while still in orbit, devastating a wide area;

bomb strikes against the earth from lunar bases, which would make it difficult for the enemy to intercept the weapon carriers in flight;

orbiting interceptors to destroy or seize ballistic missiles and satellites launched by the enemy;

satellites for observation and espionage;

piloted spaceships and stations which could, and more reliably, carry out the last two tasks.[1]

Time disposed in different ways of these projects and predictions. In 1979, an international Agreement Governing the Activities of States on the Moon and Other Celestial Bodies was signed. A draft plan for this agreement had been put before the United Nations by the Soviet Union, and the agreement itself contains, amongst other things, a ban on the use of the moon for military purposes. The technological possibility of militarising the moon proved unrealisable—at least within the framework of international space law. There, far from the earth, the principle of peaceful co-habitation rules supreme. It may be far away—but it is an example to the earth! One can also not exclude the possibility that this Agreement explains why there had been such an indefinitely long moratorium on flights to the moon by American piloted craft following the completion of the *Apollo* programme, as the moon had become 'of no interest' to American strategists.

However, American intelligence satellites such as *Midas*, with infrared transmitters, and *Samos*, fitted with cameras, were already in orbit when Brennan's work was published. Here, it is true, one nuance must be borne in mind. The probing of the earth in infrared and other wavebands, and also high-resolution photography of the earth and other planets of the solar

[1] Donald G. Brennan, 'Arms and Arms Control' In: *Outer Space. Prospects for Man and Society*, Frederick A. Praeger Publishers, New York, 1968, pp. 145-177.

system, being carried out by both the USA and the USSR, also represent a peaceful and scientific development of astronautics, thus revealing the social ambivalence, the two-sidedness of the use of space technology, which is capable of serving both peaceful and military purposes.

This two-sidedness, peaceful and military, comprised within space technology, should not, however, deceive anyone into believing that technology constitutes a 'whole', and that therefore both these aspects are permissible. Long-term prediction of the nature of space militarisation and 'Star Wars' is still continuing in the West, and is now 'running ahead' into the 21st century. In such 'research', space technology appears as something purely military and terrifying in its destructive power. In 1979, for example, the American futurologist David Langford published a book entitled *War in 2080*[1] in which he drew an apocalyptic picture of battles between super-powerful and super-complex space constructions that were military robots in near-earth orbit and in outer space.

We can only hope that such a picture will remain science fiction, that the Soviet draft agreement, presented in 1981, which prohibits the deployment in space of any type of weapons, and also the draft agreement proposed by a group of socialist countries, including the USSR, which is a continuation of the first and prohibits the use of force in space and from space against the earth (both documents were approved by the UN General Assembly), will be adopted and, of course, observed. Pursuing the principles laid down in these two documents, the Soviet Union unilaterally declared a moratorium on the launching of anti-satellite weapons, and in 1984 it proposed

[1] David Langford, *War in 2080. The Future of Military Technology*, Westbridge Books, New York, 1979.

that the General Assembly discuss the question of using space for exclusively peaceful purposes, for the benefit of mankind. In 1985, the General Assembly adopted a resolution on preventing the arms race in space.

Nonetheless, the theoretical prospect of a space war between automations is encouraging certain experts in the West to draw rather curious conclusions. None other than Thomas Stafford, the commander of the American space crew in the joint *Soyuz-Apollo* space flight in 1975, who has now transferred to work in a military department, expressed the following idea: 'Under certain circumstances, space may be viewed as an attractive arena for a show of force... Conflict in space does not violate national boundaries, does not kill people and can provide a very visible show of determination at relatively modest cost.'[1]

This idea is willingly supported and developed in US political publications. A certain Alexis Gilliland, writing in *The Washington Post*, declared that '...it is theoretically possible to negotiate a surrender after losing [a space war]'.[2]

So what is the result of all of this? It is suggested that war can be 'removed' from men, who will take no direct part in the military operations, nor feel the impact on themselves of any direct consequences. A bloodless war of technology against technology is supposed to replace traditional warfare. A war of this kind, suggest its supporters, can lead to the capitulation of one of the sides, which has simply received the information on the result. Using formal logic, one can move on to a more radical theoreti-

[1] David Baker, *The Shape of Wars to Come. The Hidden Facts behind the Arms Race in Space*, Patrick Stephens Ltd., Cambridge, 1981, p. 174.

[2] *The Washington Post*, September 4, 1983.

cal conclusion, namely that such a cosmic war need not even begin, as the two sides, having evaluated the situation and their respective chances on the basis of information and prognosis, can move on immediately to 'talks on capitulation'.

Such speculative logic would appear to offer a long-sought alternative to war in general, which has become incompatible with the concept of civilisation and which can apparently now be replaced by a duel between mechanical 'knights'. This unique form of 'pacifism' is supported by some of the most fundamental achievements of the scientific and technological revolution—highly advanced automation and cybernetics, in this case, as applied in space technology.

In what, therefore, lies the false logic of this argument, intended to lull the vigilance of those who wish peace and are campaigning for it?

The idea of military operations engaged in solely by technological devices and not by people is simply a variant of technological fetishism, a phenomenon that today manifests itself not only in military doctrines concerning outer space. In the West, technological fetishism, or technological determinism, permeates concepts of social development as a whole, which is seen as developing not according to its own laws, but according to the laws governing the operation of technological systems. This same fetishism is to be found in the fantasies of those whose interest in cybernetics leads them to talk of 'robotic civilisation' supposedly capable of replacing the civilisation of living beings.

This technical manner of thinking, taken in general and also in its particular application to the subject of contemporary warfare, clashes with reality. Similar illusions were once entertained in connection with aviation. Battles of aeroplanes were depicted, thus removing war into the air. In actual fact, aviation became a third arm of the service, alongside the army and the navy, and merely served to increase the total destructive potential. Now war is supposedly 'being removed' into outer space. However, the militarisa-

A. Sokolov

Cosmic horse's head

tion of space technology would thereby simply turn it into yet another arm of the service complementing the other three.

No 'war of automatons or robots', including robots in space, could be thus restricted, can have a desirable outcome. In fact, such a war would mean the inevitable escalation of any space war to include the earth, to destroy manpower and civilisation itself by those very technological devices which, according to the supporters of the doctrine of a 'purely space war', are supposed to destroy only each other.

The term 'escalation' entered the military-strategic and political vocabulary at the time of American aggression in Indochina, and initially meant a dangerous expansion (or a deliberate encouragement of such an expansion by the aggressor) of a local war into a regional or even global conflict. This term is also applicable to the provocative proposition of a 'limited' nuclear war, a concept formulated in the Pentagon and taken up by foreign mass media. According to this concept, the resolution of such a nuclear conflict would not require the use of the whole arsenal of atomic and hydrogen weapons, whose number is such that they would destroy many times over the whole of mankind and all life on earth. However, any 'limited' nuclear war is fraught with the risk of escalation into a total, global conflict.

Now the term 'escalation' must be used when speaking of the possibility and probability of the escalation of a space war into an 'earth war'. Physically speaking, this means not so much an 'escalation' as the 'descent' onto the earth of death and destruction from that very 'High Frontier' where it is proposed to deploy rockets and bombs. However, in social and political terms, this is still 'escalation'.

This is why the Soviet Union and peace-loving forces around the world consider it their duty to debunk consistently any doctrine concerning an 'exclusively robotic war in space'. Such a war would not be limited simply to loss of metal and plastic. It would also lead to loss of life, to bloodshed, by virtue of the very dialectic of the development of modern warfare and the misanthropic aspiration of the modern aggressor.

Such is the real meaning of concepts and fantasies about space wars, which are, however, based on the actual militarisation of space. They function as a justification for the arms race and are aimed at demobilising the social forces which are calling for the rejection of war as a means of resolving political and social contradictions in the modern world. The campaign against 'Star Wars' is not an easy one, but it has already achieved successes: these include the international agreements on 'demilitarised zones' in space, zones such as celestial bodies, and also the increasing rejection by the mass of people of 'romantic' concepts of galactic warfare.

Mention must also be made of another, broader aspect of the problem. The militarisation of space is the direct projection of imperialist practice and attitudes onto conveniently distant locations in space and conveniently distant periods in time. It is no accident that the plan to create 'islands in outer space' put forward by the American physicist Gerard O'Neil—to which we have already referred—a plan that is technically feasible, has nonetheless been criticised by more rationally-minded futurologists in the USA as threatening to take into outer space the aggressive nature of capitalism. Paul Csonka, a physicist at the University of Oregon, wrote that O'Neil's 'islands' would inevitably war against each other; someone would seize the ready-prepared islands belonging to someone else rather than construct his own, and use these captured 'islands' to settle his own 'surplus' population; wars might also occur because of the presence of profitable raw materials, for racial reasons, as a result of cultural conflicts, etc.; that is, Paul Csonka concluded significantly, everything would be just as it had been during the opening up of America, when there were wars among the Indians, the Spaniards, the English and the French.[1] Yes, any plans for the exploitation of outer space and its settlement by men, if they tacitly suppose the 'perpetual' existence of capitalism (and such are the predictions and computations of O'Neil, and of the majority of bourgeois physicists and sociologists who sketch out the future development of astronautics), must of necessity include the possibility of space wars of the most varied kind.

The militarisation of space in principle means the future militarisation of the Universe, and that is not, from the point of view of world outlook, a hyperbole. The theory of the militarisation of space, wittingly or unwittingly, presupposes that aggression and militarism constitute an inalienable, and indeed determining quality of human society. If, according to Marxist philosophers (and not only Marxist philosophers, but also other philosophical champions of humanism and peace), the community of the inhabitants of the planet earth is called upon to carry out a creative function within the Universe, then, according to the logic used by the theoreticians of militarisation, that community can also carry out a destructive function, getting equal in this respect to the natural forces of the Universe provoking cosmic catastrophes.

It would be appropriate here to recall the opinion of Tsiolkovsky as regards the essential nature of a cosmic civilisation, a position to which mankind is now aspiring. According to Tsiolkovsky, the exploration and use of space was incompatible with any aggressive purposes whatsoever. This scientist

[1] Paul L. Csonka, 'Space Colonisation: An Invitation to Disaster?', – In: *The Futurist*, Vol. XI, No. 5, October 1977, pp. 285-290.

excluded aggression, the absence of ethics from the very definition of intelligence. Destructive and immoral intentions make it impossible to explore and exploit space in any purposeful, long-term manner; long before it can do this, civilisation will itself have perished at its own hand. Therefore Tsiolkovsky did not limit himself to merely excluding the concept of evil from the definition of intelligence, but also called for an active struggle against the use of force and injustice. In his draft essay 'Non-resistance or Struggle', written in 1935, not long before his death, he asserted: 'We fight against harmful bacteria, harmful plants, harmful insects, rodents and predators. Not to fight means to perish. We fight against all aggressors who trespass on our labour or our freedom. Could it be otherwise? Free the hands of those who are inclined to use force and they will take the very shirt off your back.'[1] Angry words straight from the heart. They could be quoted today by all those who oppose the threat of 'Star Wars'.

Practical astronautics began, as has already been mentioned, within the framework of the first internationally-agreed measure, undertaken under the auspices of the United Nations, to study the natural environment on earth in order to improve life on this planet. These initial 'genetic' hallmarks of astronautics still remain the most important and the ones that determine its nature. They are embodied in the Soviet space programme—a programme for the planned and long-term study and exploitation of space in the interests of science and the economy, in the interests of social and cultural development; a programme free of elements introduced ad hoc or merely to attract

[1] Cited from: A. Terentyev, 'Thoughts on the Future. On the World Outlook of Tsiolkovsky'.—In: *Znamya* (Kaluga), September 18, 1984 (in Russian).

attention, as science is a stranger to both; a programme open to international co-operation and carrying out such co-operation: eleven states around the world take pride in having their own astronauts who have flown aboard *Soyuz* spacecraft and worked aboard *Salyut* space stations.

Those who do not believe this, who do not believe that Soviet astronautics is purposefully orientated on the future, we not only refer to the earlier chapters of this book, but also invite to look at the sky. There one may see, with the naked eye or with the help of binoculars, many devices launched into outer space. The majority of them have a peaceful, economic or cultural purpose. Who has launched the majority of them?

Astronautics in the name of peace and progress will continue to oppose astronautics in the name of militarism and war. The 'High Frontier' must be closed to weapons of any kind.

Chapter Twelve

The Shining Hour

'The Shining Hours of Mankind' was how Stefan Zweig described those turning points in the history of mankind which determined its course for a long time into the future. These include great discoveries in the natural sciences, social revolutions, and the inventions of individual genius which subsequently changed the life of people upon earth.

In 1968, the last speech by Yuri Gagarin was read out at the first UN Conference on Research and Peaceful Uses of Outer Space, held in Vienna (he was killed in an air crash that same year). In this speech Gagarin quite rightly included man's penetration into space among the 'shining hours of mankind'. The space age is sometimes referred to as an era, thus equating it with those tremendous changes which mark the geological and social history of our planet.

The 'shining hour' that rang out in 1957 with the call signs of the first satellite is a very special one. For the first time this metaphore ceased, in fact, to be purely a metaphore and became a literal truth. Mankind was indeed moving out to the stars, into the Universe.

In some respects this fact may even arouse trepidation. Now, of course, it is not that terror of which Blaise Pascal spoke with reference to the 'eternal silence' of the Universe. The Universe now speaks to us, through dynamic natural processes discovered by astronomy and astrophysics, and through human voices coming from aboard space stations and spaceships. Nor is this the terror of man's 'cosmic loneliness', referred to by Bertrand Russell. Yes, mankind is as yet still alone; it has not yet encountered extraterrestrial intelligence or extraterrestrial life. However the men of the space age have become convinced of their potential ability to spread life and intelligence through the Universe and to create in outer space—albeit, perhaps only in the remote future—extraterrestrial civilisations of terrestrial origin, new foci of intelligence and, perhaps, even new trends in the biological evolution of Homo sapiens among those who have left the planet earth.

This 'terror' is rather awe in the face of the tremendous and far-reaching consequences of man's entry into the space age, and in face of the 'end of the metaphore', similar to the 'end of mythology' insofar as it becomes reality, a point made by Karl Marx. We have entered upon the genuine and almost literal 'starry hour of mankind'.

It might seem that astronautics is a purely technological phenomenon heralding the possibility and the fact of sending technological devices, manned or automatic, into space. But it is not so. We have seen how the 'geneological tree' of astronautics branches out into philosophy, prognosis, sociology, psychology, human emotionality, ethics and aesthetics. Now there is a new, 'cosmic' angle to the old questions of man's place within the natural order, the social development of man himself, and, if one will, the 'meaning of life', as this most ancient of all questions comprises concepts of the non-entropy of the social form of the motion of matter, and of anti-finalism as guideline hypothesis concerning the development of the society that has arisen on earth.

The space age is, in principle, the age of optimism. It has so opened up men's horizons that those very horizons, insofar as they served as boundaries and limitations, have disappeared; this fact is reminiscent

A. Sokolov

Across time

of the round-the-world voyage by Magellan, who did not discover 'the edge of the world'. However, this absence of boundaries does not lead to confusion and disorientation, but to a sense and comprehension of the limitless possibilities of creation and discovery.

This work has been written in precisely that spirit, and supported by the concrete facts of astronautics. It has been in the main positive. However, from time to time one could hear the menacing refrain of aggression taken to the level of the Universe, the militarisation of space. We did not wish to develop this topic in detail, and indeed we would have preferred to avoid it altogether, but it is a part of life, which does not consist exclusively of positive elements. However, we believe that the positive will gain the upper hand over the negative, as it always has done ultimately in the history of mankind, and for this reason we wished to emphasise and underline precisely the positive aspects.

Astronautics is a global phenomenon. We have spoken mainly of the Soviet space programme, though we have also not ignored the achievements in this area of the USA, the second space power, historically speaking. This preference on our part is perfectly understandable: the author is himself a citizen of the first space power. However, this is not the only reason. It is our belief that the Soviet space programme most fully expresses the essence of the space age: planned and consistent research into and exploitation of space for peaceful purposes and for the benefit of mankind, the implementation of the principles of international co-operation and collectivism along this path, the logical and necessary dissemination of these principles, which are called upon to function in the area of the interaction between men and nature and between men and men.

The human space age promises to be a long one—

we may even hope that it will be endless. And not only hope, but act to make it so.

When we look up into the sky, we see only the past: the moon as it was just a second or so ago, the sun as it was eight minutes ago, the stars as they were tens or hundreds or thousands of years ago, and other galaxies as they were millions and thousands of millions of years ago. Such is the effect of the speed of light.

Perhaps, even at this moment, someone is looking through a powerful telescope and seeing the earth as it was before the appearance of man. But, perhaps, that 'someone' will 'find' the gold plate that is now moving beyond the boundaries of our solar system, and which contains a message from the inhabitants of the earth, sent into space in 1972 from the interplanetary station *Pioner-10*. This message contains a picture of a man and a woman in all their naked beauty. They are almost indistinguishable from the people who existed at the dawn of human history, and poetically represented in the image of Adam and Eve. But they are no longer Adam and Eve, for they are now able to launch this gold plate into the immeasurable distances of space.

This plate contains not a single bit of information about social problems and wars, both so plentiful in human history. Mankind wishes to appear at its best, united and intelligent, before this unknown addressee.

The plate also has a return address–information which will enable any intelligent recipient to find our planet among the myriads of stars. Let us hope he will find us, and not our past or the evening dusk that had gone.

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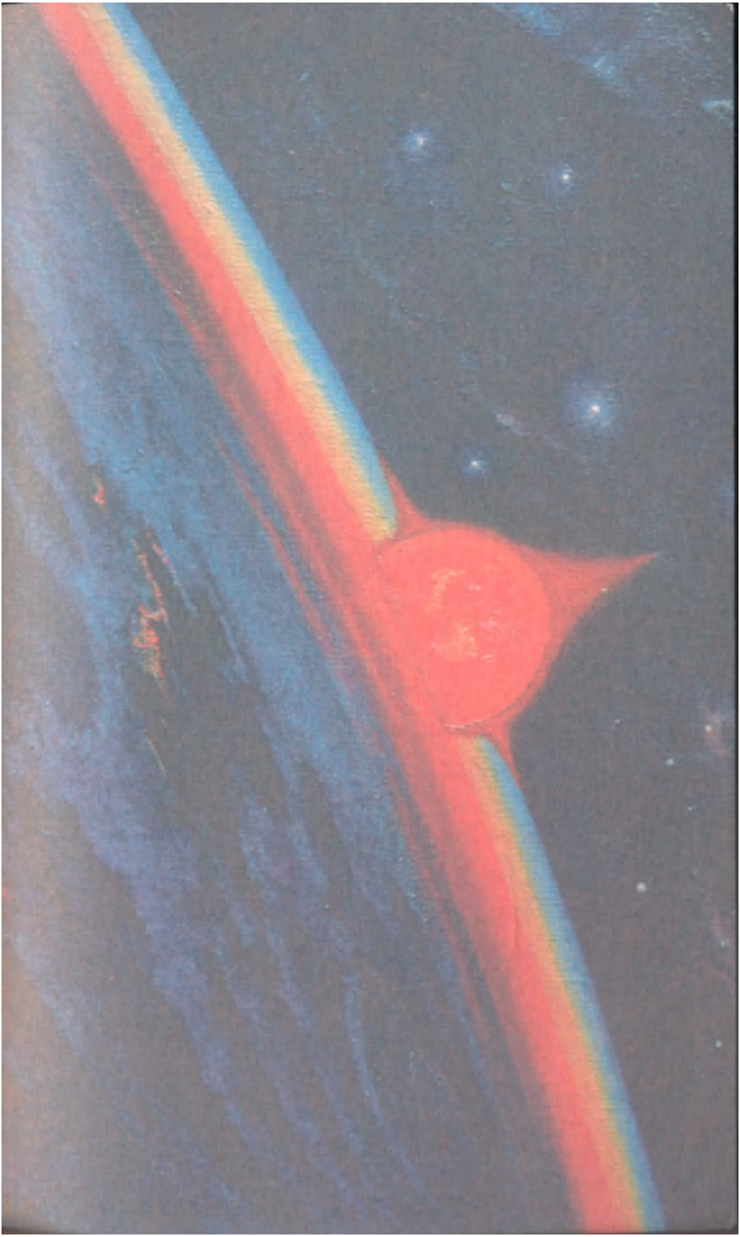

THE SPACE AGE

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