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Chapter 3

K. E. Tsiolkovsky and His Contribution to Space Life Sciences*

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Brief Description of the Life and Work of K. E. Tsiolkovsky

Konstantin E. Tsiolkovsky was born on September 17, 1857, in the village of Izhevskoye in Russia. His father Edward I. Tsiolkovsky was a forester.

K. E. Tsiolkovsky's elementary education was a home one. When the boy was ten years old he had gone through severe scarlatina complicated by hypacusis.

His hearing deficiency prevented him from attending secondary and higher schools and relegated him to self-education. The natural sciences attracted his particular attention but in the mid-1870s he was absorbed by the ideas of aërostation and conquering space.

The archives of the Russian Academy of Sciences contain the records made by K. E. Tsiolkovsky in 1878, namely, "Astronomic drawings" involving studies of the physics of free space, and the behavior of physical bodies and artificial satellites of the Earth in space.

At the same time, he constructed a centrifuge and conducted insect and chicken experiments with the purpose of determining their tolerance to the effects of acceleration.

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In 1879, when Tsiolkovsky was 22 years old he passed the exit examination which gave him the right to teach and instruct physics and mathematics in secondary schools, and starting in 1880, he worked as a teacher in the town of Borovsk.

In 1881, he prepared and sent to the Russian Physico-chemical Society in St. Petersburg his 2 first scientific papers dedicated to the theory of gases and biomechanics, and became a member of this scientific society.

By 1883 he had prepared the detailed manuscript "Free space," which is the original summary of numerous subsequent theoretical treatises by Tsiolkovsky dedicated to space exploration and the creation of spacecraft. In this work a conceptual sketch of a spacecraft is first presented (See Figure 1).

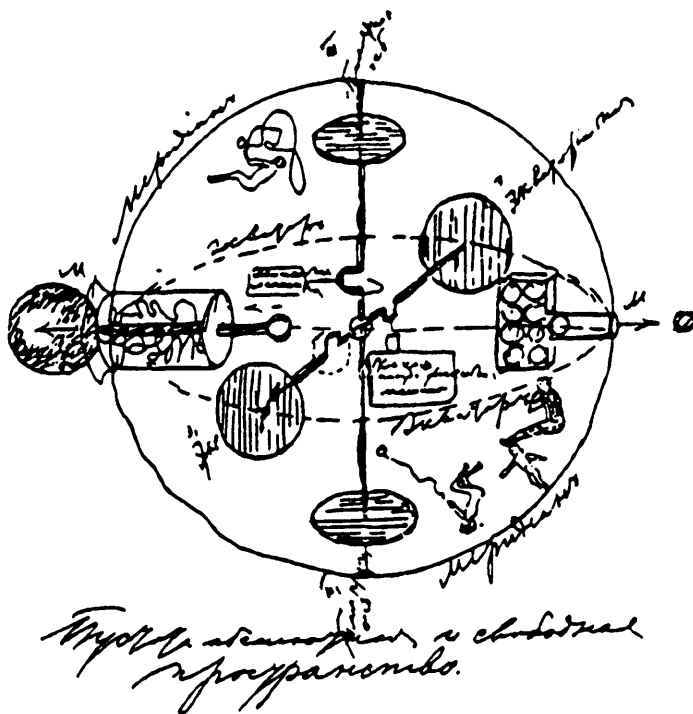


Figure 1 Sketch of K. E. Tsiolkovsky's Spacecraft (1883).

In 1892, Tsiolkovsky moved to Kaluga, where he continued working as a teacher, bought a private house, and equipped the workshop for his future studies.

He continued conducting theoretical and experimental investigations on aero- and hydrodynamics, took an active interest in the problems of aeronautics (air balloons, dirigibles, and aircraft), and of course in astronautics.

In the period from 1891 to 1903 he published 35 papers dedicated to these problems. Among them there are studies on hydrodynamics (1891), the "Metallic dirigible aerostat" (1892-1893), the scientific story "On the Moon" (1893), the "Aeroplane or bird-like (aviation) flying vehicle" (1894), etc.

In 1903, Tsiolkovsky published "The study of the Universe by jet devices," the first paper in world literature dedicated to the theoretical substantiation of realizing interplanetary missions with the help of a jet-propelled rocket-vehicle. (*Scientific Review*, St. Petersburg, 1903, No. 5, pp. 45-75) Further development of these ideas by Tsiolkovsky can be found in publications issued in 1911-1912, 1914 and 1926.

In 1918, he began to publish the fantastic story "Beyond the Earth," describing travel into interplanetary space, the spacecraft structure, crew training, and many other issues representing Tsiolkovsky's concepts regarding medical support for space missions (the complete edition of the story was published in 1920).

In 1921, when K. Tsiolkovsky was sixty-four he retired from his teaching position but continued his usual intensive creative activity. The problems of astronautics had always been the center of the scientist's creative power, but now he extended further. In addition to astronautics he was keenly interested in the issues of philosophy and natural sciences, in particular, biology and ecology.

Tsiolkovsky died in 1935 and was buried in Kaluga. He had left an enormous printed and archival scientific legacy and succeeded in attracting his contemporaries and followers by his faith and enthusiasm.

The Role and Significance of Konstantin E. Tsiolkovsky in the Process of Creating Astronautics

The idea of creating a jet-propelled (rocket) flying vehicle goes back several centuries. There were many suggestions over that period of time. In the 19th century alone they exceeded 30 in number. The honor of the first rigorous treatment of the solution of this problem must go to Tsiolkovsky.

In his 1883 work "Free space" he pointed to the possibility of using the reactive principle for flying in gravity-free environments. In 1896-1897, he first derived the formula of rocket movement, and in 1903 he published the first of the known theoretical works on astronautics: "Study of outer space using reactive devices in which the possibility of a space mission through the use of a liquid-propellant rocket is substantiated and the main formulae to calculate it are presented."

In the subsequent parts of "Study" published in 1911-1912 Tsiolkovsky refined the theory of the rocket, made an analysis of the problems associated with creating a spacecraft, and outlined his views relating to the perspectives and the ways of space development for mankind.

Significant contributions to the development of astronautics were also made by R. Esnault-Pelterie (1913-1928), R. H. Goddard (1919) and H. Oberth (1923). Each of the afore-mentioned scientists followed their own path; as this

took place, each of them, individually and collectively, have contributed to stabilizing and developing astronautics.

In practice, Goddard pioneered in developing rocket technology; he created and launched the first liquid-propellant rocket in 1929. Thus, the work of many scientists in Russia, France, Germany, the U.S., and Austria in the 20th century laid a strong scientific foundation for the successful development of astronautics.

Among these famous scientists and engineers Konstantin E Tsiolkovsky is the most prominent. He was not only the first scientist to lay the theoretical foundations for future space missions, but also studied in detail many problems related to the life and activity of man in space.

The Contribution of K. E. Tsiolkovsky to the Statement of the Problems of Life Space Sciences

Elaborating the problems of astronautics, Tsiolkovsky constantly thought about the place and role of man in the development of space. Despite his self-education, he had an encyclopedic knowledge, and the biological sciences were of great importance: At the initial stage of his studies he was greatly disturbed by the tolerance of living organisms to acceleration after launch. Apparently, he was the first investigator to conduct experiments on insects and chickens with the aim of determining their tolerances to acceleration.

In the fantastic story "Beyond the Earth," the first 10 chapters were written by Tsiolkovsky in 1896. He identified the broad spectrum of problems associated with manned space missions which at present are within the competence of space medicine.

Thus, discussing tolerance to the increase of acceleration (estimated value of 10 g), he proposed to use an immersive system for the crews.

In his works the methods for regenerating the spacecraft cabin air, for arranging the food and water supplies, and for utilizing human waste are discussed and substantiated. Considerable study is given to the issues concerning the spacecraft's interior, and the complex of questions concerned with people living and working in the environment of space.

It is difficult to name the problems referring to the competence of modern space biology and medicine which were not treated by Tsiolkovsky. Perhaps now only 2 problems could be named. They are the problem of radiation danger in the environment of space, and the need for realizing preventive procedures to protect astronauts from the effect of weightlessness.

Tsiolkovsky took quite an optimistic view of the effect of microgravity on human beings, although he indicated that in cases when it is required it is not difficult to create "artificial gravity" by spacecraft rotation.

As regards the problem of space radiation, the existence of radiation belts around the Earth and space radiation dangers were unknown. Tsiolkovsky's ideas concerning extravehicular operations of human beings should be also mentioned. He described in detail the spacesuits which might be used in the future and the ways of locomotion in space.

Much attention in his papers is given to creating "space hothouses" as the way of life-support of human beings in spacecraft. And finally it should be mentioned that Tsiolkovsky was also interested in the selection and training of space crews.