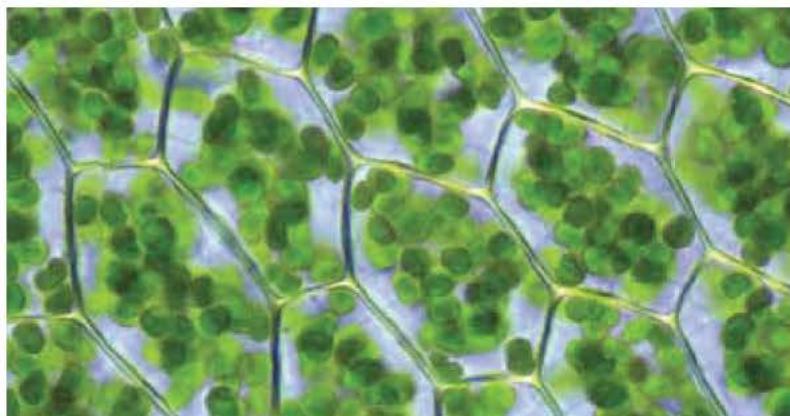
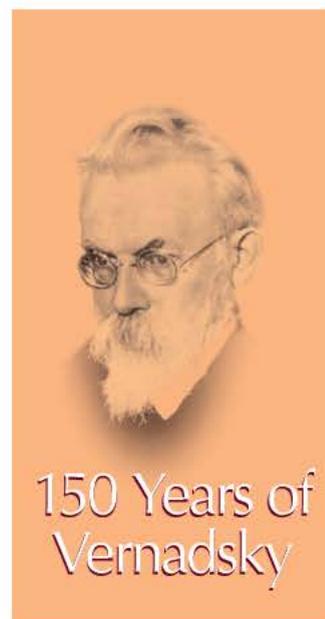


# Vladimir Ivanovich Vernadsky:



Kristian Peters/creative commons

*Plant cells of the moss Plagiomnium affine, showing visible chloroplasts.*



## The Science of The Biosphere and Astrobiology

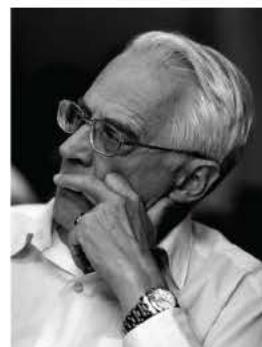
by Academician M. Ya. Marov

The figure of the renowned Russian scientist Vladimir Ivanovich Vernadsky must be included in the category of remarkable phenomena of the 20th century. The native talent and inquisitive mind of this naturalist, combined with his truly encyclopedic knowledge, enabled him to delve, in his multifaceted activity, into a whole array of scientific fields and to leave deep traces in all of them. Moreover, by rethinking natural phenomena, and drawing philosophical generalizations

from them, he laid the foundations for new areas of contemporary knowledge. He made an immense contribution to geochemistry and to the study of the history of the chemical elements in the Earth's crust, to mineralogy and to the study of the Earth's water cycle, as well as to the study of the nature of symmetry and of time. He laid the foundations of radiochemistry as one of the major fields in the development of nuclear power. He was the first to investigate the crucial problem of the close relationship

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*A more comprehensive treatment of Vernadsky's contributions to the science of the biosphere and astrobiology by Academician Marov will appear in the Summer issue of 21st Century Science & Technology.*





**Figure 1**

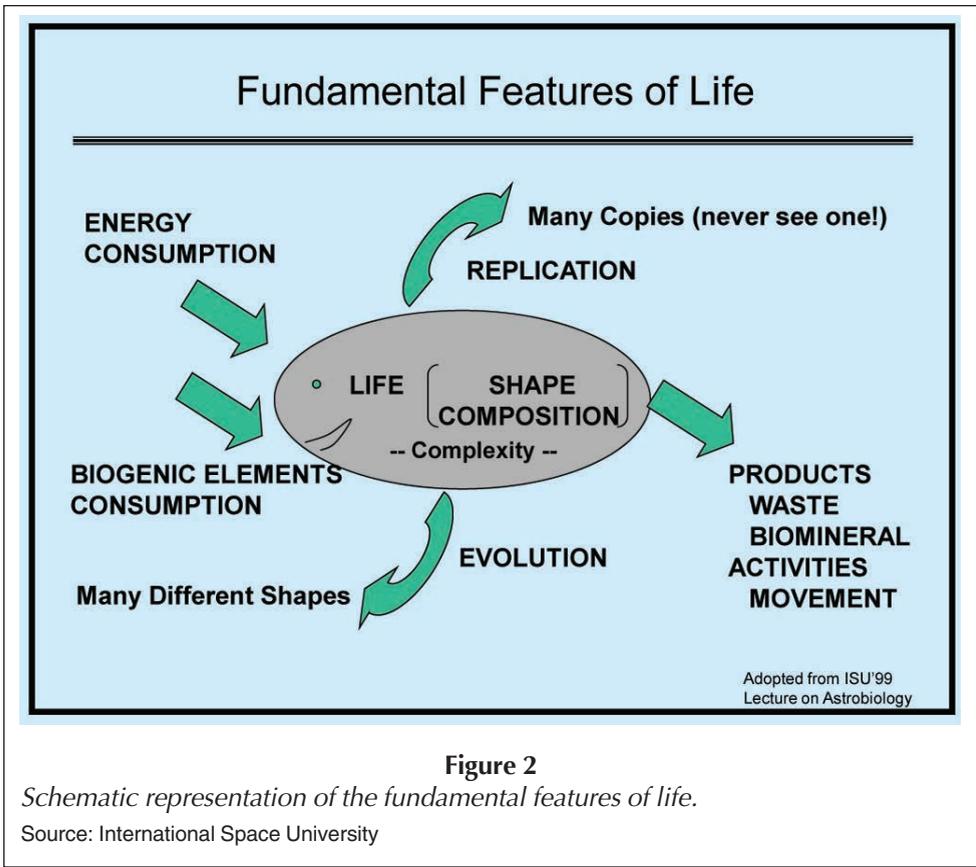
*Schematic view of the Solar System and planetary nebula to be left behind after the Sun (a G2 star with the lifetime about 10 billion years) exhausts its nuclear fuel, approximately five billion years from now, according to Encyclopedia of Astronomy and Astrophysics (2002).*

between the activity of man and living organisms, on one side, and geological processes, on the other; this investigation provided the basis for his concept of the biosphere. He is also credited with investigations into the history of the foremost branches of science and of methods for the compilation of scientific knowledge. He was the first chairman of the Commission on the History of Science, which was created by the Soviet Academy of Sciences in 1921 and reorganized in 1932 as the Institute of the History of the Natural Sciences and Technology. He was a passionate publicist, whose articles expressed his anxiety and concern for the interests of the nation and the world.

Here we are able to touch briefly upon only one aspect of the tremendous legacy of V.I. Vernadsky, namely, his teachings on the biosphere, a science which embraces a grand retrospective survey of the Earth's evolution—one that is closely and fundamentally connected with its cosmic surroundings and life's origin. This field of investigation, which extends far beyond the bounds of the Solar System and has undergone vigorous development during

the last decades, borders directly upon astrobiology and the broad array of current problems embraced by that science.

Astrobiology is one of the most fundamental areas of contemporary natural science. It is directly connected with both biology and astronomy, in that it investigates not only the essential problems of the origin of life, and of its physical and chemical basis and properties, but also examines basic notions concerning the chemical evolution of matter and the possibilities for the genesis of life under a variety of conditions of the natural environment and on different bodies in the Universe. The tremendous progress in molecular biology, genetics, and biochemistry, which has led to the deciphering of the genome, together with the investigations in astronomy, astrophysics, and space science, which have made possible the detailed study of the bodies of the Solar System and the discovery of planetary systems beyond the Solar System, as well as an understanding of their genesis, have placed this inter-disciplinary field of study on a new scientific basis. In that connection, it is extremely important to examine



of scientific knowledge is connected not only with the quantitative expansion of our picture of the Universe, but also with its qualitative transformation through man's refining of his methods of empirical observation and deepening of his mathematical and logical analysis. As man does this, he brings to that picture, including to outer-space phenomena and to deep inside the planet, the knowledge he has formed from studying himself, living nature, and his native biosphere." And further, he writes: "At present, man has direct scientific knowledge only of the biosphere, and of himself and the living organisms in it—he knows scientifically only the thin outer envelope of the planet, and all of his knowledge is connected to it. The domains both

the relationship of astrobiology with geochemistry, that is, with the migration of chemical elements on the planet and the problem of the appearance of life, which Vernadsky viewed as directly connected to the origin of the biosphere. In a broader sense, one could well refer to an interrelationship of the evolution of the upper envelopes of the planet with the concept of biogeochemistry, which Vernadsky introduced, and, when it comes to studying the evolution of chemical elements in cosmic space, also with cosmochemistry (astrochemistry).

In the chapter entitled "Geochemistry and the Study of Life," written in 1911 and published as part of his fundamental work *The Life-Permeated Envelope of Our Planet*, Vernadsky writes: "Scientific knowledge is entirely imbued with formulations derived from scientific notions about man and living nature, of which man is an inseparable part, and about the living environment around him, i.e., that part of the planet, which we call the biosphere... Basing himself on this knowledge, man advances scientifically into areas of the visible Cosmos unfamiliar to him or into the deeper, inaccessible layers of the planet he inhabits. This scientific knowledge has never been comparable, either in depth or in its diversity of phenomena, with what is revealed to man in his study of himself and the environment he lives in. The progress

above and below that thin envelope remain inaccessible to him. Cosmic phenomena above him are reflected in his sense organs, and in the creation of the biosphere, a special part of the planet produced by the influence of cosmic phenomena—by forces outside the planet. The biosphere is that vehicle, through which man studies the Cosmos."

These are words of profound meaning, which identify numerous problems of the world around us and its evolution. Vernadsky gave insight into the appearance of geochemical function and its diversity, caused by the different morphological classes of living organisms responsible for cyclic mass-exchange processes. This is also closely related with the problem of whether the source of life's origin was biogenic or abiogenic, to which Vernadsky paid much attention.

In a longer contribution, to be published in the Summer 2013 issue of *21st Century Science & Technology*, we will discuss these problems in more detail, utilizing Vernadsky's basic concept of the biosphere as one of the geospheres of our planet and as the key paradigm for the biogeochemical processes in our natural surroundings. Taking this into consideration, we will then attempt to approach the question of the origin of life from the standpoint of modern astrobiology.