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AND EVOLUTION**

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## **СОВРЕМЕННЫЕ ПРОБЛЕМЫ ГЕНЕТИКИ, РАДИОБИОЛОГИИ, РАДИОЭКОЛОГИИ И ЭВОЛЮЦИИ**

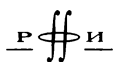
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# LIVING MATTER AND BIOSPHEROLOGY<sup>†</sup>

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**Abstract** - Without question, biospherology is primarily a Russian discipline, as its appearance is closely related to Russian scientists such as V.V. Dokuchaev, V.I. Vernadsky, and N.W. Timofeeff-Ressovsky. The role of V.I. Vernadsky, a student of the founder of genetic pedology, V.V. Dokuchaev, in its creation is especially great, for he discovered the phenomenon of living matter which forms the biosphere. With his theory of living matter, he was also the first in the history of science to place life in its proper position in the general picture of the universe and discovered fundamental laws which control geochemical activities of living matter in the biosphere. In the first half of the previous century V.I. Vernadsky founded a vitally important science for the future of mankind that we have named biospherology. N.W. Timofeeff-Ressovsky, even as a young scientist, correctly assessed the importance of V. Vernadsky's ideas on biospherology. Timofeeff-Ressovsky was the first scientist to re-establish Vernadsky's forgotten discipline of the biosphere. He left us a short but very persuasive program with his report called "The Biosphere and Mankind." It is now possible to include this program in any national or international program for "Sustainable Development."

Keywords: Biosphere, Living Matter

## 1. Introduction

As the title of my paper implies I will speak about "living matter" and the science that is called "biospherology".

In December 1977, I sent an article titled "On V.I. Vernadsky Biospherology" from France to the editorial office of "Zhurnal Obshchei Biologii" (Journal of General Biology) of the Academy of Sciences of the USSR. In that article I was the first to write about the fact that the doctrine of

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<sup>†</sup> Radiation Risk Estimates in Normal and Emergency Situations / Eds. A.A. Cigna and M.Durante. Springer, 2006. P.35-46.

living matter and biosphere created by V.I. Vernadsky in the twenties and thirties had become an independent science about three decades after the author's death, which can be called *biospherology*.

After almost three years of written controversy with my opponent, now deceased, corresponding member of the Academy of Sciences of the USSR N.B. Vassoevitch, the article was published in the above-mentioned journal in the mid-1980s.\*

Today I deal with the origin of the doctrine about living matter and biospherology as a real science and will speak about the importance of V.V. Dokuchaev's, V.I. Vernadsky's and N.W. Timofeeff-Ressovsky's ideas in the development of this science.

## **2. The doctrine of living matter and origin of biospherology**

At the end of the 19th century a man began his scientific research in Russia, generalised the observations of a number of eminent scientists of Europe, and offered the mankind a teaching that can be treated today as a science of the third millennium.

I refer to Vladimir Ivanovich Vernadsky (1867-1945) and his teaching about living matter and the biosphere – about biospherology (Guegamian, 1980, 1981).

It is not common in the history of any science for both the teaching and ideas developed by one scholar to become eventually an independent science. V.I. Vernadsky's teaching about living matter and the biosphere is one of such lucky exceptions.

In 1931, V.I. Vernadsky wrote in his diary: "My concepts rein is yet to come". He was right. In fact it took decades for the global scientific community to understand and appreciate the importance of Vernadsky's work. In my view, the following stages can be outlined during the development of biospherology in Russia:

- 1) Development of V.V. Dokuchaev's doctrine of the soil as a special natural body, during whose genesis the role of living organisms is dominant;
- 2) Living matter as planetary matter, discovered by V.I. Vernadsky, and
- 3) General teaching on the biosphere developed by V.I. Vernadsky.

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\* About this polemic see: A.N. Tjurjukanov, V.M. Feodorov "N.W. Timofeeff-Ressovsky: Thoughts on Biosphere", M., 1996, pp. 263-267.

V.V. Dokuchaev's teaching of soil as a specific natural body was undoubtedly one of those great works that determine the development of scientific thoughts for many generations.

Was there anyone who could be the precursor of another fundamental teaching – the teaching of the biosphere developed by his disciple V.I. Vernadsky?

It was obvious to B.B. Polynov, one of the leading Russian soil scientists and follower of Dokuchaev's ideas, (Polinov, 1956) that “the great ideas on which Vernadsky's biogeochemistry is based were the direct and powerful development of those by Dokuchaev.” One can hardly find arguments against the statement of B.B. Polynov.

“Dokuchaev determined soil as the compound body that was the result of interaction between climate, nature of rock subjacent, organised world, life existing in it and on it, the relief”, wrote Vernadsky in 1904 (Vernadsky, 1992).

When he wrote these words he had not realised fully the importance of living matter in the evolution of the earth's crust and in the formation of the earth's soil cover. He subsequently dedicated the rest of his life to this concept. He could not find answers to questions he had at that time. For example, he wrote: “It is not clear where it is necessary to outline the soil bottom boundary, the difference between soils and friable products of some chemical erosion on the Earth is not clear either” (Vernadsky, 1992).

In search of the answer Vernadsky then turned to mineralogy, his speciality. He believed that “in order to have knowledge about soils it is necessary to study mineralogy carefully and in detail, i.e., to study properties, genesis, minerals changes and changes of its components” (Vernadsky, 1992). At that time, however, he understood the differences in the following and believed that “solid products have special physical state in soil... They are permanently dressed and processed by organised living matter; they are indissolubly mixed with products of dying down behaviour and vital functions” (Vernadsky, 1992; emphasis added by the author).

The previous phrase can be considered the beginning of Vernadsky's great ideas in biogeochemistry and hence, it must be admitted that Vernadsky had realised the importance of living matter, biogeochemistry and his teaching of the biosphere through the Pedology, with the help of his teacher V.V. Dokuchaev's concepts of soil as a special natural body, the formation of which is determined by climate, the texture of rocks, relief and, of course, by “the organised world, the life existing in it and on it”.

Certainly, his famous teacher influenced young Vernadsky but in my opinion, it would be erroneous to say that Vernadsky had paid special attention to the vital factor in soil formation process because of the help or instruction of V.V. Dokuchaev. Most likely, he achieved it by himself.

The interesting point is that V.V. Dokuchaev saw that V.I. Vernadsky was an extraordinary student. Otherwise he would not have directed the following words to his 24-years old student: “Dear Vladimir Ivanovich, I kindly ask you just to outline your point of view concerning saline soil on a sheet of letter-paper for me” (quotation from Sitnik K.M., Apanovitch E.M. and Stoyko C.M., 1988).

There is no doubt then that in his very first works Vernadsky had already noticed the role of a biological factor in the soil formation process, but it took him a quarter of a century to develop and formulate his concept about the living matter.

### 3. “Living Matter”

The concept of living matter is doubtlessly the cornerstone of Vernadsky’s biospherology. It is consequently strange but in the literature about the scientist’s work which is quite extensive, this concept has not been discussed enough, except some works (Aksionov, 1997; Guegamian, 1980, 1981; Kaznachejev, 1989; Mirzoyan, 1994; Lapo, 1977, 1987; Moiseev, 1994; Nazarov, 1988; Sitnik K.M. et al., 1988).

Nevertheless, it is my strong conviction that the “living matter” concept developed by basis of the genius Vernadsky is fundamental for science and mankind and will continue to be the study of many scientific researchers to come.

V.I. Vernadsky began his methodical work on living matter in 1916 in the Ukraine and continued working on it for nearly 30 years, i.e., for the rest of his life. He himself understood the importance of his ideas and in 1918 noted in his diary: “I’m working well on the living matter. Many new ideas in understanding of nature... I’m trying to criticise myself and my research: I acknowledge that the nature has never been considered this way” (Vernadsky, 1997).

Eight years later, in 1924, he wrote from Paris to B.L. Lychkov and made these clarifications: “I think that my ideas about the living matter make the understanding of nature fresh and significant, and logical presentation of these ideas cannot yet be considered a science but a “teaching” in the scientific scheme that has not been completely discussed yet. Anyway, the teaching of the living matter is a specific comprehension form of both life and the environment. The results are significant” (Kirzhaev, 1979).

I would like to remind you that these words belong to a venerable scholar who possessed encyclopaedic knowledge and definitely knew the material.

The questions arise:

1 - Why did Vernadsky believe that the teaching of living matter was a “*specific form of environment comprehension?*” and

2 - What did he mean by saying that “*the results are significant?*”?

Before answering these questions, it should be mentioned that Vernadsky was the first to consider life and living organisms as planetary and cosmic phenomenon. Furthermore, V.I. Vernadsky left the complete scientific characteristics of the living matter. He defined the functions, essential properties and differences of living matter from the “inert” (Vernadsky’s term) natural bodies of the biosphere.

J.B. Lamarck had the theory in the same sense (Guegamian, 1981) but it was only the beginning of such an approach and Vernadsky could accurately and completely define the place of life in Cosmos. He was the first to understand that all the living organisms on the Earth should be considered as an integrated system, a formation of all organisms, which is very important for the existence of the earth’s crust. Vernadskiy showed that the life plays a completely unique role in space, that it has its “own” space, named for the planet the Earth the biosphere. According to Vernadsky’s words, it is a cosmic phenomenon in the form of a “natural body” – living matter that can be expressed in numbers by its chemical composition, weight and energy. But I would like to mention, however, that Vernadsky’s notion of living matter underwent some changes. Sometimes it can be difficult to find accurate or specific definitions to understand his statements on this notion. Various explanations of the same words, epithets and phrases have been used from the 1920s to the end of his life. This causes various interpretations of his ideas and thoughts.

I think it is, therefore, more advisable not to base these on all Vernadsky’s statements about living matter but to refer to his last book where, according to his own words, he reviewed his scientific activities (Vernadsky, 1965, p. 245). I refer to his monograph “The Chemical Structure of the Earth Biosphere and Its Surroundings.”

From memoirs, letters and other documents, it seems that Vernadsky had been working on this book from 1935 to the end of his life; he did not finish it. He often spoke of this work as “the main book” of his life. After Vernadsky’s death his close colleagues and followers edited the book and it was published for the first time in 1965. It is difficult to overestimate the heuristic importance of the scientist’s thoughts expressed in this book. Of course, I cannot now analyse this outstanding work of V.I. Vernadsky, but dwell on living matter, which is of interest to us. In my opinion, chapters XIX and XX of the book are the quintessence of all whatever Vernadsky wrote about living matter. There V.I. Vernadsky defined living matter “both as biological envelopes that are indissolubly tied up with its environment of biosphere and as a powerful



geologic factor that forms its integral” (ibid, p. 290). Yet, you can ask me: what is so great about, at first sight, the simple fact that there is a special natural body called “living matter” on the Earth and consequently in the Cosmos? In fact, it was known before Vernadsky’s discovery, was it not?

Of course it was known, but having evaluated life as a significant feature of the Universe, V.I. Vernadsky was the first to discover the fundamental laws that control the geochemical activities of living organisms in the biosphere. He understood and explained the mechanism, and the laws of function of that definitely unique cosmic system. That is what is very special about his teaching about living matter. Vernadsky presented the laws discovered by him in the form of his own biogeochemical concepts\* mentioned above as biosphere postulates of V.I. Vernadsky (Guegamian, 1981).

They stated the following:

1. *The biogenic migration of the atoms of chemical components in the biosphere always tends toward the maximum of its manifestation;*
2. *The evolution of species throughout a geological time makes it possible to create certain existing types, which are stable in biosphere and tend to increase the atoms migration in biosphere.*

Vernadsky presented the basic functional characteristics of living matter with the help of these postulates. It follows from the first biosphere postulate that among other geospheres that are without life, where the chemical balance and “tranquillity” domain, life speeds up reactions in the biosphere and with the help of this disturbs the chemical inertness of the planet; that among other biogenic phenomena the biogenic migration of atoms is dominant in the biosphere. This phenomenon cannot be secondary because it “tends toward the maximum of its manifestation”.

The tendency of life to occupy the whole surface of the Earth, according to V.I. Vernadsky, is the statement of the first principle. At the same time he pointed out “vsjudnost” (omnipresence) of life, which can be achieved by “pressure”, “load” of life. Vernadsky supposed that the evolutionary process throughout the geological time has and keeps intensifying this “vsjudnost” (omnipresence) and load of life in the biosphere and that the acme of this process is the existence of *Homo sapiens faber* in biosphere.

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\* In 1928 V.I. Vernadsky (1992, pp. 134-145) stated the two mentioned “principles” but later (1965, p. 286) he added a third one and noted that this statement can be considered the third principle “in case there would be a need”. In fact Vernadsky offered more precise formulation of Charles Darwin’s theory of the possibility of densely populated existence during the past geological periods of the Earth.

V.I. Vernadsky distinguished among three types of biogenic migration of the atoms:

- 1 - For microscopic unicellular and microbes (For animalcular monadiforms and microbes);
- 2 - For multicellular organism and
- 3 - Biogenic migration of atoms of the third type that has become known to a man not long ago and which during our “Psychozoique” era of the history of the biosphere becomes dominant.

He thought that the first biogeochemical principle was a generalisation of the three types of migrations mentioned above and it demonstrated that “all living matter of the planet in the whole...is the source of an active free energy and can execute work” (Vernadsky, 1965, p. 267).

As for the second principle, V.I. Vernadsky offered the following additional clarifications: “According to the second biogeochemical principle, the evolution of living matter species has to follow a certain direction, which increases the biogenic migration of atoms in the biosphere, i.e., must be directed” (ibid, p. 272). As we can see, V.I. Vernadsky not only confirmed his statement in the first postulate concerning the significant importance of the phenomenon of biogenic migration of atoms in the biosphere functioning, but also provided an absolutely new and unexpected explanation of the evolution theory.

According to Vernadsky, the vital forms stable in biosphere (which is the same at Ch. Darwin as “best adapted”) are the forms that increase (i.e., intensify) biogenic migration of the atoms in the biosphere. In other words, the second postulate implies that in the struggle for existence those species that increase the biogenic migration of the atoms in biosphere can survive, and that the evolution of living matter has a tendency to accelerate biogenic migration and to intensify biogenic cycles of atoms in the biosphere. Thus, a logical conclusion: the ability of every species to “turn over” atoms in “organism-environment” system at any speed should be a principal biosphere feature of this species, should be its biosphere constant. Consequently, for the record of biogeochemical work of every species and of every living organism in the biosphere we must measure these constants. The results obtained will allow us not only to understand the mechanism of biosphere functioning, but also to select the best adapted species in the biosphere sense to create associations with the bioproductivity of the highest possible level.

That’s why, in my opinion, V.I. Vernadsky could believe, indeed, that, first, the teaching of living matter was “*specific form of environment understanding*” and, second, “*the results are significant*”.

And now I would like to add some more words concerning “significant results”.

#### 4. The energy of living matter

According to V.I. Vernadsky, living matter, together with its habitat, forms the upper Earth mantle – the biosphere, which is *energetically* tied to both the Universe and the lower strata of the planet. I emphasise the word “energetically” because this point has an exclusive place in the scientific work of V.I. Vernadsky. The issue of biosphere energy and the importance of living matter in this energy runs throughout the teaching of living matter and biospherology founded by him. V.I. Vernadsky believed that together with a human being (who is an integral part of living matter) there is no other such geological force on the Earth than living matter. At the beginning of the 1920s he reached a significant conclusion that “the study of lifecycle inconvertibility takes us to the sphere of science, which is in the process of formation and concerns the great aim of life and energy. This science is the domain field of the future, i.e., the future *energy of our planet*” (Vernadsky, 1994, p. 342). What exactly were his ideas about “future energy of our planet”? Let us deviate slightly from the subject of my report.

V.I. Vernadsky was among the first to take over the radioactivity research with a view to use intra-atomic energy. There were few people at that time who believed in the possibility of such an opportunity, but Vernadsky delivered his report at the general meeting of the Academy of Sciences of Russia on December 29, 1910 and stated: “The phenomenon of radioactivity makes it possible for us to use energy sources, which are much more, millions of times, powerful than those that can be imagined by a man” (Vernadsky, 1997, p.13).

It is fascinating that in 1922 this eminent person already suspected the danger of nuclear energy and warned us about it: “We approach a great revolution in the life of the mankind, to which nothing experienced earlier can be compared. The time when a man will master atomic energy, a powerful source that will allow him to build up his life in accordance with his desire, is not far. It can happen within the coming years or it can happen in a century. But it is absolutely clear that it will have to happen. Will a man manage to make use of this power, to direct it to good purpose but not at self-destruction? Is a human mature enough to use the power that science will inevitably supply him?” (Vernadsky, 1989, pp. 331-332).

As for the energy of living matter, V.I. Vernadsky came to grips with this for the first time in Paris in 1924. First, he attempted to organise a biogeochemical laboratory but failed. He could only obtain a small subsidy from the Rosenthal Fund and thanks to this subsidy continued his activity in Paris. Vernadsky delivered a report on this work titled “Living Matter in the Biosphere” in 1925.

We read the following words in this document: “It is impossible to realise how important living matter is for the chemistry of the earth's crust, for the movement of chemical components in biosphere, if the geochemical energy of life is not measured” (Vernadsky, 1994, p. 557).

He decided to organise such work and after returning to his native land (1926) he tried, together with A.P. Vinogradoff, classify living organisms according to chemical composition, according to their weight and way of reproduction and finally, according to their biogeochemical energy. He accomplished a little but on the whole, it was a failure because he did not have the needed entire biometrics database. Nevertheless, V.I. Vernadsky was an optimist and wrote in his “book of life”: *“I have no doubt that there is time for everything and biologists will have to take into account a very important factor – biogeochemical energy in order to solve pure biological issues of both theoretical and applied importance”* (Vernadsky, 1965, p.298).

Unfortunately, nobody has yet taken this important factor into account.

## 5. Biospherology

In my archive there are faded press cuttings from two March issues of 1968 of a small-town newspaper called “Vperjod” (Forward), which was published in Obninsk. N.W. Timofeeff-Ressovsky’s lecture on “Biosphere and Mankind” read by him in February–March in 1967 in Moscow House of Scientists and in the Institute of Medical Radiology in Obninsk was published in this newspaper for the first time.

It is not incorrect to maintain this modest article, for the first time after Vernadsky’s death, Russian scientists turned to his teaching of biosphere. The article had been published several times while the author was alive and even after his death, nevertheless, nobody had paid attention to it.

For me among all of the published variants of this article, the most interesting one is that rewritten and expanded by the author, which was published in a journal called “Priroda” (Timofeeff-Ressovsky, 1970). The title of the article was “Biosphere and the Man” (the editors seem to change “mankind” into “man”, but, in my opinion, Timofeeff-Ressovsky preferred “biosphere and mankind”).

This article bears certain similarity to a well-known article of Vernadsky “Several Words about the Noosphere”. First, both articles were written for popular consumption. (It should be remembered that V.I. Vernadsky sent his papers to be published in “Pravda” newspaper, as well.) Second, in spite of the 23 years difference between them, the authors worried about the same thing - the destiny of humankind. And third, both articles are written in a manner of scientific testament.

V.I. Vernadsky wrote: “ *In the geological history of biosphere before the man enormous future is opened, if he understands this and does not use his mind and his labour for self-destruction* ”.

We read in the work of N.W. Timofeeff-Ressovsky: “*Humanity will have to improve its rational mutual relationships [with the biosphere]. There is a danger for humanity of many difficulties in the near future without such rational mutual relationships.*”

In several pages of the most popular natural-science journal of the time of the Academy of Sciences of the USSR, N.W. Timofeeff-Ressovsky in his distinct manner posed the point, as he said, of the “problem № 1” of natural science of the present and of the near future."

The end of the article was written in a form of a real program – a testament for succeeding generations. I quote this short but very persuasive program since, in my opinion, it can be included in any national or international program of “Sustainable Development”. He wrote:

*“...I deem it expedient... to enumerate some (in some instances tightly bounded with each other and interacting) issues, which first of all should attract attention of researchers:*

*a) quantitative and semi-quantitative inventory of fauna and flora in land, aqueous and pedocenoses, definition of a biomass and connected to it biological productivity of various landscapes and regions of the world;*

*b) possible full studying of material and energy turnover in various biogeocenoses;*

*c) fundamental studying of cultivated biogeocenoses (agrocenosis);*

*d) work in the field of experimental biogeocenology in the open environment and on biocenoses samples;*

*e) impact assessment of economic and industrial activity of a man and development of rational principles of environment usage;*

*f) development of rationalisation principles of mutual relationships between developing economy of mankind and development of biological productivity of natural biogeocenoses;*

*g) experimental and theoretical study of the dynamic equilibrium and its dysfunction in biogeocenoses as the main task associated with understanding of biosphere structure and its biogeochemical operation and with melioration changes of its areas;*

*h) definition of mathematics and computer models for the process analysis running in populations and biogeocenoses, which is primarily connected with the problem of solving of dynamic equilibrium in living organisms associations;*

*i) development of approach to study of the problem of evolution in biogeocenose”.*

N.W. Timofeeff-Ressovsky concluded the article with the following words:

*“Vital necessity of mankind makes it absolutely inevitable and necessary to include “Problem No. 1” in the definite program of the natural science.”*

It is to be regretted that N.W. Timofeeff-Ressovsky for some reason did not resume his work “The Biosphere and Mankind” (he lived for 10 years after the article was published). Unfortunately, the representative of the USSR at the conference on biosphere organised by UNESCO in September 1968 in Paris was not N.W. Timofeeff-Ressovsky. To tell the truth, he was involved in the process of the report preparation, which was presented at the conference by the soviet delegation. Just thanks to that fact the report was made on the basis of Vernadsky’s teaching, but if N.W. Timofeeff-Ressovsky, whose opinion was more than highly respected, appeared in the world arena, he could play a key role in further development of biospherology of V.I. Vernadsky in the world.

## 6. Final remarks

In March 1920 V.I. Vernadsky wrote in his diary: “I’m clearly getting on to the fact that I have to tell mankind something new in my teaching about living matter and it is my mission, my obligation imposed on me, which I am to put into practice as a prophet who feels a voice within that encourages him to act. I felt a demon of Socrates inside me. Now I understand that this teaching can have the same influence as Darwin’s book...” (Vernadsky, 1997, p. 32).

V.I. Vernadsky fulfilled the “obligation imposed” on him and developed the teaching about living matter. Today everything is in the hands of mankind, particularly in the hands of those who shape the destiny of the biosphere.

Will all forces of people be directed at studying of living substance and biosphere?

Has man matured enough to be responsible for the future of the biosphere?

Even as long ago as 1922 V.I. Vernadsky demanded: “Will a human be able...?”

Forty-five years later N.W. Timofeeff-Ressovsky warned: “...there is danger for mankind of many difficulties in the near future.”

Only 40 years have passed since then but do our contemporaries understand that a global biosphere crisis is just around the corner and that it concerns the future of their children or, their grandchildren?

We can confidently maintain, unfortunately, that man does not understand, and, as George Hutchinson was right: humanity continues to shorten its life by millions of years.

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