

VLADIMIR VERNADSKY : COSMOS, EARTH, LIFE, MAN, REASON—FROM BIOSPHERE TO NOOSPHERE

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Keywords: cosmos, biosphere, noosphere, naturalist, planetary cosmic synthesis, anthropocosmos, biocosmos.

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Summary

Vladimir Vernadsky was a natural researcher, a thinker, a public and political figure, a founder of modern Earth sciences complex, a founder of a scientific school, and an organizer of many large research institutions. Vernadsky's ideas played a considerable role in the development of scientific understanding of the earth. He produced a great deal of original thinking about the biosphere and its evolution into the noosphere—one of his central natural–scientific and philosophical interests. Vernadsky's doctrine about the interaction of nature and society was a stimulus for modern ecological consciousness. He developed traditions of Russian cosmism based on idea of internal unity of humanity and the Cosmos.

In Vernadsky's scientific and philosophical work, one may identify the following cardinal realities investigated by him during all his life: cosmic, terrestrial or planetary, living, human, rational or spiritual. In his main works Vernadsky speaks simultaneously as a cosmographer, a geologist and a geographer, a biologist, a historian and a sociologist, a humanitarian and a psychologist, as well as a theorist of scientific reason.

The biocosmic views of Vernadsky consist in his doctrine about living matter, in the biogeochemistry, and in the biosphere concept. In their totality, these views cover the three sections of the biological realities: macro-, micro- and mega-cosmos. The anthropocosmic views of Vernadsky are expressed in his understanding of man as geocosmic, planetary force, in his understanding of the evolution of society as a global-historical regular process with its natural foundations. A process in which, besides people's masses, the individual and personal principle plays an important and even increasing part. The bio- and anthropocosmic ideas of Vernadsky make up an integral scientific-philosophical system. Its core is the conception of the transition of the biosphere into the noosphere as a qualitatively new stage.

The biosphere is an integral bioinert system established in its equilibrium, self-organizing, and self-sustained under a certain stable regime. Human civilization continues to develop after the spontaneous laws of nature, and is being more and more transformed into a destructive principle directed to the destroying of the biosphere. This transformation creates a real threat for the existence of the mankind as such. Now—Vernadsky noted—an urgent necessity arose to change the whole paradigm of the system “biosphere–man.”

The destroying reason directed to the Evil should make way for the building and creating reason directed to the Good of nature and man. This would only be possible (Vernadsky affirmed) if the conscious one would replace the spontaneous development, and if the collective (directed to the Good) reason of the mankind would prevail in the biosphere, owing to which the biosphere would become oriented to the transition into the noosphere.

For such transition, according to Vernadsky, the necessary conditions are: the complete and final exclusion of wars out of the life of society; the human settlement all over the terrestrial surface of the Earth; the development and improvement of the means of communication and exchange; the development of an economic, political, cultural cooperation between peoples; the discovery of the new power sources; the liquidation of the racial oppression; the elimination of any hostility of the national and religious

ground; the liquidation of hunger, starvation, destitution, heavy diseases, epidemics; the conservation of the nature of the Earth; the rational renewal and development of the biosphere. An especially great significance (for the transition to the noosphere) Vernadsky attached to the eradication of the big and small wars—organized mass murders, as he used to call them. This eradication would be, according to him, the first real manifestation of the noosphere.

According to Vernadsky, there exist the following moving factors of the transition to the noosphere: scientific reason; the activities of the eminent personalities; the creativity of the people's masses; the development of all forms of the material and spiritual culture, as well as of the national education, at the humanist foundations. Vernadsky firmly believed that the mankind might solve the difficult problems standing on its way to the noosphere. Therefore one may look at the future with optimism.

1. A Russian Genius

An unsurpassed researcher of nature, a thinker–encyclopedist, a humanist, a great authority in the field of earth science, a founder of a number of new sciences and scientific branches, an organizer of science and the head of a scientific school, an educational specialist, a public and political figure, a historian, and a publicist. Vladimir Ivanovich Vernadsky was a prominent representative of Russian scientific and philosophical thought of the late nineteenth and the first half of the twentieth centuries. His name is rightly held among such luminaries as M. V. Lomonosov and D. I. Mendeleev.

From his youth to the end of his life, Vernadsky's attitude to the world arose and developed as a result of two main factors: his private scientific creativity, which formed the main business of his life, and the difficulties he encountered in his personal life. Vernadsky was not alone here. It was by no means unusual for Russian intellectuals of this period to lead very troubled lives.

2. A Brief Life Story

2.1 Beginning of the Path: 1863–1890

Vladimir Vernadsky was born on 12 March 1863, in St. Petersburg, the capital of the Russian Empire, to the family of an economist, Professor I. V. Vernadsky. In 1868 the family moved to Kharkov, where in 1873 Vladimir entered the first class of the local school.

In 1875 the Vernadskys made a large educational foreign tour, lasting several months. During this tour Vladimir visited Vienna, Prague, Venice, Milan, Geneva, Zurich, Leipzig, Dresden, Berlin, and other cities of Europe. The tour greatly impressed Vernadsky and it was to remain etched into his memory.

In 1876 the Vernadskys returned to St. Petersburg, where Vladimir continued his studies in school. His leaning toward natural sciences had become apparent by the completion

of his schooling and in 1881 he entered the first year of the Department of Natural Physics and Mathematics at St. Petersburg University.

The years of studies at the university greatly influenced Vernadsky, as he frequently recollected later. At that time St. Petersburg University was gleaming with a constellation of the most prominent names of Russian science. Foremost there was a chemist, D. I. Mendeleev, and a soil scientist, V. V. Dokuchaev. Vernadsky became their disciple and for all his life retained grateful memories of them and other university teachers. At the university the fields of Vernadsky's scientific interests became defined. These were: soil science, mineralogy, crystallography and also common *philosophy*—dealing with the problems of natural science and humanities.

At the university Vernadsky became friends with many students of different departments, several of whom later became prominent scientists, and public and cultural figures who were to play an important role in Russian history. At the same time Vernadsky too emerged as a Russian intellectual—a liberal convinced of his opposition to the authoritarian regime of the autocracy.

In 1885 Vernadsky graduated from St. Petersburg University but he remained there as a curator of a mineralogical collection. In 1886 Vernadsky married N. E. Starickaya, who became his faithful partner and helper for the next 56 years of their life together. Soon the couple bore a son, George.

In 1887 Vernadsky passed an examination to receive a master's degree in mineralogy, geology and chemistry, and in the following years, the university gave him an official journey abroad in recognition of his professorial status.

From 1888 to 1890 Vernadsky worked with the problems of crystallography and mineralogy in the chief scientific centers of Paris, Naples and Munich, and he took part in the International Geological Congress in London. He struck up acquaintances with many European natural scientists, and the works of Vernadsky became widely published abroad, mostly in French scientific journals.

Toward the completion of his official foreign tour, Vernadsky was offered a post at Moscow University, which he was happy to accept.

2.2 Laying of Foundation: 1890–1911

The autumn of 1890 saw the start of a very productive twenty years of Vernadsky's life, beginning at Moscow University. At this time he laid the foundation of his future creative path as a scientist, an educational specialist, an organizer of science, and a public and political figure. In 1898 the Vernadskys' married life was marked by a happy event. Their daughter Nina was born.

At Moscow University, Vernadsky gave lectures on mineralogy and crystallography, and he soon advanced from Senior Lecturer to Professor. Defending his master's degree and doctoral thesis, he gained followers, the number of which continuously increased.

He became a member of the Russian Academy of Science and many national and international scientific societies and organizations.

The international prominence of Vernadsky was on the increase. His writings were widely published abroad. He made several visits to European countries, taking part in International Geological Congresses in St. Petersburg, Paris, Vienna, and the Congress of the British Association of Science in Dublin.

Under Vernadsky's leadership, there were soil, geological–mineralogical and also radium expeditions to the far reaches of the territory of the Russian Empire, including the Urals, the Caucasus, Crimea, Kerch, Taman; Tambov, Poltava provinces, and Fergana. On his own initiative at the Russian Academy of Sciences the Permanent Radium Committee was created, under the chairmanship of Vernadsky.

In the early 1900s, Vernadsky actively joined in the fight for civil liberties in Russia and became a prominent figure in opposition to many Russian intellectuals—professors and lecturers of high educational institutions and scientists of the Academy of Sciences. The result of his participation was his election at the end of 1905 into the staff of the Central Committee of the Constitutional-Democratic Party, the main political organization of Russian liberals. His hard-hitting articles and essays on the topics of the day attracted the attention of the Russian people.

At the beginning of 1911 dramatic events took place. In protest against constraint of academic liberties, Vernadsky tendered his resignation, and, with a large group of professors and lecturers, left Moscow and moved to St. Petersburg.

2.3 On the Rise: 1911–1926

Henceforth, Vernadsky stopped teaching; his research and political activity was carried out in the Russian capital and was concentrated in the Academy of Sciences.

From 1911 to 1914 Vernadsky continued to lead expeditions to various regions of Russia in order to find and study radioactive minerals, He journeyed through many countries of Europe (France, Austria, Czechoslovakia), where he was associated with research and experiments with radium. In 1913, with a group of colleagues and disciples, he went to Canada and the USA, taking part in the International Geological Congress in Toronto.

The lack of knowledge on the natural resources of Russia was revealed after the beginning of the First World War, when the military authorities began to experience a lack of raw materials. In 1915, with a group of scientists, Vernadsky organized and headed the Commission on Research into Natural and Productive Forces of Russia. This Commission was attached to the Academy of Sciences.

During the war of 1914–1918, little by little, Vernadsky reached a turning point in his academic life. He got down to general and intensive researching of the frontier between biology, geology, chemistry and the problems of living matter and the biosphere. These investigations determined the focus of his scientific energy until the end of his life.

The February Revolution of 1917 provided Vernadsky with aspirations and expectations of propitious changes. He was a part of The Provisional Government as the head of the Agricultural Scientific Committee of the Ministry of Agriculture, and he also became Deputy Minister for Public Education.

The October Revolution of 1917 interrupted Vernadsky's work in these posts. He was not in support of the uprising and opposed much of what was going on. This led, at the end of 1917, to him moving to the Ukraine. In 1918 Vernadsky, with the aid of other scientists in Kiev including some of his committed disciples, established the Ukraine Academy of Sciences, and was elected its first president.

In 1919 in the Ukraine and in southern Russia, in the harsh prevailing conditions of the civil war, Vernadsky busied himself with the work of the Ukraine Academy of Science. He co-operated with many Ukrainian scientists and heads of higher educational establishments, of a range of political persuasions. In Crimea he was taken seriously ill with typhus and only narrowly escaped death.

In 1920 Vernadsky moved to Simferopol, where he was elected the Rector of Tavria University. In 1922 he returned to Petrograd (formerly St. Petersburg), where he played a major part in establishing the Radium Institute, of which he became the first Director. On his initiative the institute was attached to the Academy of Sciences. The Committee on the History of Science, Philosophy and Engineering was also established, with Vernadsky as its Chairman.

From 1922 until 1926 Vernadsky was based in France, promoting official scientific collaboration. In Paris he gave lectures on geochemistry, carried out experimental investigations in the Museum of Natural History, and in the Radium Institute. In 1924 his book "Geochemistry" was published in French for the first time. Subsequent editions with new material were published in Russia, and later in other countries.

2.4 New Horizons: 1926–1941

In 1926 Vernadsky returned to Leningrad. It was in the same year that his classic book 'Biosphere' was published. He had been working on it while abroad.

From 1927 to 1936 he repeatedly visited many countries in Europe, giving many memorable addresses and lectures on the problems of geochemistry, biogeochemistry, radiology, and his doctrine on the biosphere. His scientific and philosophical research in these fields achieved him wide fame in the international scientific community.

In 1928 in Leningrad, the Biogeochemical Laboratory of the Academy of Sciences was created under Vernadsky's leadership. Among the several dozen research workers, employed in the Laboratory, the most part were Vernadsky's students and disciples. In 1935 the Laboratory moved to Moscow, with Vernadsky and most of the research staff.

In 1937, for the last time, Vernadsky presented himself to a large-scale international forum of scientists. At the International Geological Congress in Moscow, his address was devoted to the day-to-day problems of radiology. In the following year he

organized and led the work of the Committee on Meteorites, of the Soviet Academy of Sciences.

In 1939, as part of a reorganization of the Academy of Sciences, Vernadsky was confirmed as a key staff member of three different departments: Geology and Geography; Chemistry; Physics–Mathematical Sciences. There was no precedent for this in the history of the Academy. In the same year Vernadsky was confirmed as Honorary Director of the Radium Institute. He persuaded the Academy of Sciences, and then the relevant government bodies, to intensify the search for radioactive ores within the territory of the USSR. He was able to present convincing evidence on the practical possibilities of using atomic energy.

In 1940, on Vernadsky's initiative, within the Academy a Committee was established to investigate the problems of uranium, involving many prominent Soviet specialists. Vernadsky was appointed Deputy Chairman.

Vernadsky embarked on a great project to summarize and integrate the results of his many years of scientific and philosophical research. He referred to this as his life's work, his legacy for future generations. Work on the book dragged on for several years, during which period the title of the book was repeatedly changed and made more precise. The final version was entitled *The Chemical Structure of the Biosphere of the Earth and its Surroundings*.

Meanwhile, another project of Vernadsky's had been underway for many years. This was to write a book in the form of a monograph or a series of essays under the title 'Philosophical Thoughts of a Naturalist'. This ambition was realized in part in the form of a large-scale Introduction to his book 'Chemical Structure of the Biosphere of the Earth and its Surroundings'. The Introduction was called 'Scientific Thought as Planetary Phenomena'.

From the late 1930s, Vernadsky settled down to selection of material for an autobiographical book that was to be entitled *Experience and Great Deal of Thinking*. This occupied him for several years, until 1944, but he never had time to complete his book of memoirs, about which he had dreamed for so long.

2.5 Completion of a Course: 1941–1945

The attack by Germany on the USSR in June 1941 found Vernadsky in an academic sanatorium "Uzkoe" in the environs of Moscow. From that moment to the end of the life he was certain of the ultimate victory of the USSR and its allies, and the inevitable downfall of fascism on a world scale.

In July 1941, along with a large group of scientists, he was evacuated to a health resort called Borovoe in Siberia, to the North of Kazakhstan. He succeeded in moving to Borovoe a considerable part of his archives.

At the end of the same year the Biogeochemical Laboratory and the Radium Institute moved to Kazakhstan. Vernadsky remained as Director of both organizations, and he

maintained regular communication with their staff, by correspondence and private contacts.

At Borovoe Vernadsky continued intensive research work, mainly on the book *Chemical Structure of the Biosphere of the Earth and its Surroundings*, and he finished the series of articles and essays entitled *About Geological Envelopes of the Earth as a Planet, Thoughts of a Naturalist on the Organization of Slavonic Scientific Work against a Background of World Science, About the Geological Importance of Symmetry*, several works about the noosphere, and various other publications.

In February of 1943 Vernadsky suffered a major blow. His wife Natalia Egorovna died at Borovoe. In the spring of that year, in recognition of Vernadsky's eightieth birthday, the Biogeochemical Laboratory was renamed the "V. I. Vernadsky Laboratory of Biogeochemical Problems" of the Academy of Science of the USSR. Today it is known as the V. I. Vernadsky Institute of Geochemistry and Analytic Chemistry of the Russian Academy of Science.

On 8 August 8 1943 Vernadsky returned from Borovoe to Moscow, where he continued his research and scientific pursuits.

At the end of December 1944 Vernadsky was taken seriously ill, and on 6th January 1945 he died, at the end of the 82nd year of his life. On 9 January, after civil funeral rites at the Conference Hall of the Presidium of the Academy of Science, Vladimir Ivanovich was buried in Novodevich Cemetery in Moscow.

3. A Person

3.1 Value Orientation

As a man—a scientist, a thinker, and a socially active person—Vernadsky went through a long and complex way of evolution. In spite of all the difficulties he faced during his life he remained faithful to a solid unquestionable legacy. Owing to this he firmly conserved such qualities as purposefulness, self-discipline, determination, and steadfastness in critical situations. Highly inquisitive and sensitive, he repeatedly tested himself in the pursuit of goals concerned with protection, consolidation and progress of the spiritual values of culture.

Vernadsky maintained that cosmic reason was and remains to be personified in the earth in the man-made values of science, philosophy and art. Therefore, *the highest aim* of every thinking and responsible man is to apply his inclinations and abilities for implementing these values. Vernadsky regarded this to be a particular duty of scientists, philosophers, writers, and poets, as the *banner-carriers of consciousness, leading the onward march of humanity*.

Undoubtedly ascribing himself to the category of a spiritual standard-bearer, Vernadsky noted that cataclysms repeatedly occurred in Russia in the form of spontaneous riots, uprisings, and revolutions should not automatically be fought against but are to be—as far as it is possible—*closely related to the development of culture, science, and*

education. In the latter, Vernadsky saw his *highest moral duty*. He maintained that he should live and work in the name of the eternal values of science and culture. They are the very foundation of life. Everything else is mainly froth, which sooner or later comes to naught.

3.2 An Ideal of Personal Holiness

Undoubtedly this ideal was of the utmost important in Vernadsky's life. As early as 1886, Vernadsky formulated his vision of this ideal in a letter to his wife.

Vernadsky notes his intention always to follow this clearly recognized ideal of holy life that he understood first of all as life in accordance with truth. It is life without any discrepancy between word and belief; life filled with every possible help to one's neighbor, to all people. Life yielding best, honest, sublime fruit—as much as it will be possible—and causing little, indeed very little sorrow and suffering, so he could say dying that he made nobody unhappy, and that he might now be replaced by the workers equal with him – nay, better than he – to follow the same aim and ideal of devoting themselves to the Good.

The ideal of personal holiness emerged in Vernadsky's young years under the influence of the various factors and circumstances. Among them, one may reckon his friends from the Fraternity—a circle of the students of Peterbourg University. Other factors: books by L. N. Tolstoi and V. G. Korolenko, personal communication with them, cultural atmosphere, etc. This ideal explains many sides of Vernadsky's temper and life, including:

- Radical denial of violence and arbitrary rule in any manifestations.
- Categorical rejection of the principle “purpose justifies means.”
- Immutable respect to every man's rights, freedom, and dignity.
- Lack of any fear to conflict with the powers risking one's own well-being and safety, in the name of ideal.

For his life, Vernadsky wrote hundreds of reviews, petitions, and recommendations. Living in no luxury, he gave systematical and gratuitous money help to colleagues, students, relatives, and acquaintances. In the Czarist and especially Soviet years, he many times spoke in defense of those subject to repression, for amnesty, for abolition of death penalty. In the times of “Red Terror,” he was persecuted himself, and once was arrested and imprisoned by Cheka officials. During the 1930s, Cheka placed him in the list of hostile elements and even conspirators. Several personal dossiers were prepared on him, and it was almost through a miracle that he was rescued.

There are many respects in which Vernadsky resembles his contemporary and friend, Russian physiologist I. P. Pavlov.

3.3 Hygiene and Freedom of Thought

In Vernadsky's life and work, the Cosmic Reason undoubtedly revealed itself with the utmost force and adequacy. Vernadsky himself recognized that—with more or less

distinctness, but rather intuitively. In his letters and diaries he noted many times that for him, Thought is life, and that out of the constant work of Thought, his individual existence would lose its sense and even become impossible and superfluous.

According to his conviction, the predestination of Thought under its personal and cosmic aspects never comes without volitional effort supporting man's everyday struggle for *the hygiene of thought*.

And this is the most important thing in the life. Owing to the hygiene of thought, a man reaches an aspiration to harmony within him and with the world, becomes full of consciousness and sense of harmony. One should not become bogged down in the recollections of the evil made on or without purpose, one must not only think about the personal and petty affairs when one is surrounded with the great ideals and there is so much free area for wide, harmonious, and fine thought, when people perish and when a cruel fight is going on over the world for the dearest values of our personality.

It is thought alone cleaned from all that is petty and alien (Vernadsky noted). Thought risen over paltry ordinariness—that can be really *free*.

According to Vernadsky, the freedom of thought is the highest and eternal value. He was, so to say, obsessed with this idea for all his life. Any restriction laid upon thought always made him indignant and provoked him to a resolute protest.

Vernadsky's struggle against Soviet censorship (that of gendarmes, as he used to call it) was full of dramatic episodes. He always emphasized that the right for freedom of thought, for living without blinkers in one's eyes is for him the first and foremost right of an individual. He never could reconcile himself with the absence or infringement of this right. *The freedom is the foundation of all things* such is one of the last records in his diary.

3.4 On the Threshold of the End

The last years of his life were distressing. Senile indisposition grew more and more painful. The death of the wife made him feel lonely. Efforts to remove to the USA, to his children, failed. Still, Vernadsky was not left by *planetary optimism* so characteristic of him. As in his past years, he was looking at the inevitably approaching death calmly and without a shadow of fear. There is one of the last records in his diary when he accentuated his unbelief in immortality of soul, less still of personality. As to the body, it will disintegrate after death into atoms and their isotopes, in a natural way, like any other organism.

In the last years of his life, engrossed in his creative work just as before, Vernadsky went on taking his bearings—*the protective rules*, exactly observing the set up working routine.

4. Naturalist and Thinker

4.1 Basic Cognition Areas

Already from this preliminary description of Vernadsky as a naturalist, one may understand to which degree his work was organically interrelated with the basic problems of *world outlook*, of general world picture (indeed his work frequently included these problems). Beginning from his student years, his investigations included the following main realities that he studied during all his life. These realities are:

- Cosmic.
- Terrestrial or planetary.
- Animated.
- Human.
- Rational or spiritual.

It is by no chance that in his main works (books, essays, articles for more than 60 years—1882 to 1944—of his creative work) Vernadsky appears simultaneously as a cosmographer, a geologist and a geographer, a biologist, a humanitarian scholar and a sociologist, a historian, and a theorist of scientific reason. We particularly mean the following works (only the most important of them are listed below):

Ethics (1882); On forecasting weather (1882); On polymorphism as a general property of matter (1890); Genesis of minerals (1892); On scientific world outlook (1902); Essays on the history of the modern scientific world view (1903); Science progress and people's masses (1903); Cant and natural science (1904); Paragenesis of chemical elements in the Earth crust (1909); Present day problems in radium area (1910); On the gas exchange in the Earth crust (1912); From the history of ideas (1912); Letters on higher education in Russia (1913); International Association of Academies (1913); Higher school and scientific organizations (1913); On the study of natural productive forces of Russia (1915); War and science progress (1915); On the state network of research institutes (1916); The objectives of science with relation to state policy in Russia (1917); To the forming of the Ukraine Academy of Science (1918); Living matter (1920–1923); The beginning and eternity of life (1922); Biogeochemical essays (1922–1932); History of minerals of the Earth's crust (1923–1936); Autotrophy of mankind (1925); The biosphere (1926); Essays of geochemistry (1927–1934); About search of cosmic dust (1932); Scientific thought as a planetary phenomenon (1936–1938); Problems of meteoritics (1938); Goethe as a naturalist (1938); On “right” and “left” (1940); Chemical structure of the Earth biosphere and its surroundings (1940–1944); Naturalist's thought about organization of Slavic scientific work at the background of the world science (1942); On the states of space in the geological phenomena of the Earth as a planet (1942–1943); Biosphere and noosphere (1943); Mineralogy as appeared in Cosmos (1944).

4.2 New Sciences and Research Areas

Sciences, scientific concepts, and research areas in which Vernadsky participated may be divided into two groups. The first group consists of the areas created exclusively thanks to his efforts or is whose forming he participated immediately. These areas are:

- *Genetic mineralogy, which deals with the conditions, laws, and processes leading to the forming of certain minerals and their associations.*
- *Geochemistry—a science studying the chemical structure, distribution, and migration of chemical elements within the Earth crust and in the deeper layers. Geochemistry has become one of the theoretical foundations of the search for useful deposits.*
- *Radio geology, which deals with the natural transformations in the nuclei in the substance of the Earth as well as with their manifestation in geological processes. The data obtained by radio geology are the base of absolute geochronology.*
- *The doctrine of symmetry and dissymmetry as manifestations of the qualitatively different space–time states of the earthly and cosmic bodies and processes.*
- *The doctrine of living matter as the sum total of plants and animals and the most important geological factor of the Earth crust evolution.*
- *Biogeochemistry—a science dealing with the geochemical aspect of living organisms and their associations.*
- *The biosphere conception dealing with the upper envelope of the Earth imbued and transformed by life.*
- *The doctrine of the natural productive forces, both material and spiritual as the natural historic base of social development.*
- *The concept of mankind's autotrophy dealing with the conditions and prerequisites of man's independence from the natural nutrition sources, both vegetative and animal.*
- *The doctrine of science as a planetary phenomenon, as a leading factor of the evolution of mankind: a factor that determines the cosmic future of mankind.*
- *The conception of noosphere—a sphere of reason, the new evolutionary state of biosphere (under this state, rational human action becomes the decisive factor of biosphere development).*

All these sciences and research areas are qualitatively unequal, when one considers them in the context of their history: their past, present, and future. Among the items (1)–(11), one may identify the sciences and research areas whose formation process is already completed. Such are the items (1) to (3). Further on, there are sciences and research areas still in their youth period. Such are the items (4) to (7). Finally, items (8) to (11) are still not shaped distinctly. Their potentialities will become evident in the future.

4.3 Traditional Sciences and Research Areas

The second group includes sciences and research areas in whose creation Vernadsky did not participate immediately, but he contributed something (often something very valuable) to their shaping and development. Such are:

- Geometrical (mathematical) crystallography, crystallophysics, crystallochemistry;
- Theory of the structure of silicates;
- Soil science;

- Biological ecology;
- Study of regional specifics and local lore;
- History of natural water, oceanology, hydrology, hydrogeology, hydrochemistry;
- Theory of gas regime of the Earth;
- Radiology, radiochemistry;
- General (theoretical) geology and geography;
- General (theoretical) biology;
- Science of meteorites and of cosmic dust;
- Problems of cosmology;
- Cosmic chemistry;
- Cosmic biology;
- Study of the geological and cosmic role of humanity;
- History of Russian and world science;
- History of the emergence and development of scientific world view;
- Structure, logic and methodology of scientific knowledge;
- Sociology of science and problems of science organization;
- Psychology of creativity in science;
- Language of science.

4.4 Philosophical Creed

Vernadsky's philosophical views formed and developed during all his conscious life under immediate influence of his own research and personal experience as well as of studying social-historic practice of mankind and past and present state of science and philosophy in the West and the East. Vernadsky rejected all the attempts to label him as an idealist, a vitalist, a materialist, or a mechanist. In philosophy, he regarded himself a *realist* like D. I. Mendeleev. But in comparison with him, Vernadsky made one further step: he considered *life* (life substance) to be an eternal and imperishable substantial foundation of the Universe, along with matter (substance), power (force, movement), and spirit (mind, consciousness). The epochal meaning of this step begins only to be open during the recent years, in connection with the research of the tracks of extraterrestrial life.

Vernadsky as an organized unity considered the Universe. He also divided systems into mechanical and self-organizing, which anticipated some ideas of cybernetics and general theory of organization. Vernadsky denied the division of space and time into mutually independent units, but he regarded both space and time in their inner organic integrity. He maintained that three aspects of reality, mega-, micro- and macrocosmos, are mutually inter-conditioned and penetrate into one another. The basic properties of reality studied by us are its eternity, infiniteness, and inexhaustibility.

4.5 Life Drama

Owing to the originality of Vernadsky's interests, they cannot be placed within the routine working schemes of a rank-and-file natural scientist. Vernadsky repeatedly emphasized that the size and dimensions of the Earth, even of the solar system were becoming more and more narrow for a modern naturalist who seeks for a worldwide

cosmic interconnection. It is not mere chance that Vernadsky's basic works are characterized with a cosmic approach and the spirit of cosmic reality.

On the one hand, Vernadsky deeply recognized and experienced a kinship of his thought and the nature of the Earth. One ought not to be astonished at the poetic style of his works dealing with biosphere, life, and living nature. On the other hand, Vernadsky's thought tried to break through the cramped boundary of the Earth into the cosmic space. Vernadsky's reason oscillated between these two poles, with an aim to unite them, to show the cosmic principle in the Earth one and vice versa.

Still the "limit points" of this cognition swing were manifestly unequal: the equilibrium in the system "Earth–Cosmos" was displaced to the side of the Earth, which contradicted reality. This contradiction hardly worried Vernadsky; it became a problem omnipresent in all his works. The solutions of this problem could not be more than partial and relative and thus never satisfied Vernadsky to a full degree. It was the life drama of Vernadsky as a naturalist and thinker.

4.6 Mysticism

Vernadsky did not hope for any rational solution of this drama during his lifetime. From this his mystical trend, which was not casual, and often accompanied his scientific and philosophical work, giving it very peculiar overtones. Mystical intuition gave to Vernadsky a possibility for a deep feeling of the interconnection of the earthly and the cosmic; of the organic integrity of the World; of the unity of the I and the Universe.

Vernadsky's knowing of the Universe was not exclusively the external one, obtained through assimilating, processing, and generalizing enormous data files. He also recognized the reality from within, from his own personality. Even stimulus for such cognizing was often received from within, and only afterwards some "external mechanisms" became involved in the process. But even after this, that inner side of the process did not vanish or disappear: it withdrew into the background but constantly made itself be felt (though unseen) in Vernadsky's creative work.

Vernadsky himself repeatedly and in some surprise and perplexity noted this mysterious and obscure side of his soul. He only could ascertain that he was a mystic, according to his nature, and he frequently returned, in various forms, to this thought—especially in his diaries.

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