

Prof. Vladimir Voeikov

## Vernadsky's Concept of Living Substance, with Emphasis on the Fundamental Role of Water in its Existence, Properties, and Development

*This is the edited transcript of the presentation of Vladimir Voeikov to Panel I, "Vernadsky's Revolution in Science and Thought," of the Schiller Institute's Nov. 12, 2022, Conference, "The Physical Economy of the Noösphere: Reviving the Heritage of Vladimir Vernadsky." Dr. Voeikov is a professor in the Faculty of Biology at the Lomonosov Moscow State University. Subheads have been added.*

*The full conference video is [available](#) on the Schiller Institute website.*

Dear Colleagues,

It is my great pleasure and honor for me to participate in this remarkable meeting devoted to reviving the name, ideas, heritage, and mission of the great Russian-



Schiller Institute

Prof. Vladimir Voeikov

Ukrainian scientist Vladimir Ivanovich Vernadsky. I am very thankful to Mr. William Jones for the invitation to present a talk here.

I got acquainted with Vernadsky's works many decades ago when I was a post-graduate student in the Faculty of Biology at Moscow University. From my reading, I understood that the biology at that time, even modern biology, nearly completely ignores Vernadsky's teaching about living substance as the primordial entity, the engine of the development of the universe.

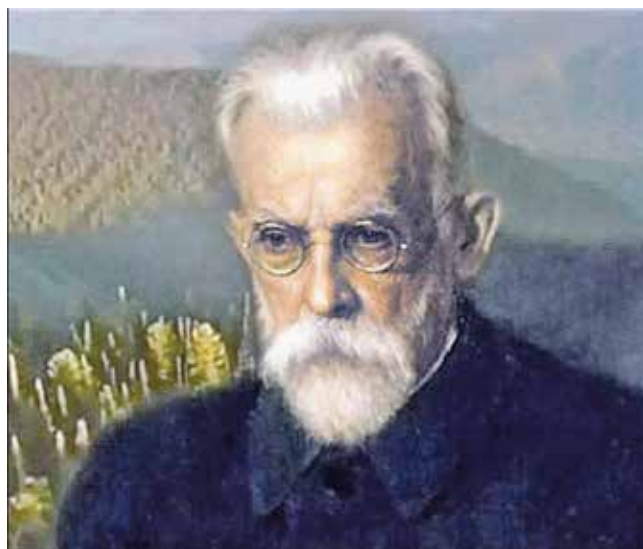
Since that time, I have worked on many projects, but I have continued to keep in mind Vernadsky's assertion that something is wrong with the scientific understanding/conception of living matter.

Only about two decades ago, I began to realize that water is the mother of all life, as Albert Szent-Györgyi insisted, while biology practically ignored this. I remembered that Vernadsky also assigned water a central role in the biosphere, so I suspected that real (natural) water may be the essence of animated states of matter, and that the funds developing research in water science may help to promote Vernadsky's overall teaching of living matter.

That is why, in this message that I suggest to your attention, I'll try to synthesize Vernadsky's concept of "living substance," and modern ideas about the functional role of water in life.

I titled my presentation, "Vernadsky's Concept of Living Substance, with Emphasis on the Fundamental Role of Water in its Existence, Properties, and Development."

Living matter was a very important notion for Vernadsky. In 1920, he wrote in his diary:



Vladimir Ivanovich Vernadsky



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“The Cosmos is unthinkable without matter, energy, and space. But can it exist as we know it without life?” —Vladimir Vernadsky

I began to realize clearly that I was destined to tell humanity something new about living matter, and that this is my vocation, my duty, which I must carry out, as a prophet who feels a voice within himself calling him to action.

In 1922, he wrote a small brochure, titled “The Beginning and Eternity of Life.” In his brochure, he was talking about most important questions for biology and for the universe in general:

- The Cosmos is unthinkable without matter, energy, and space. But can it exist as we know it without life?

He named *thinkable mechanisms* of the emergence of life, which were discussed at that time:

- *Abiogenesis (Archeogenesis)*—that all living things originate from dead matter.
- *Heterogenesis*—that all living things originated both from inorganic (dead) matter, and remnants of living things.

But, he insisted that these mechanisms were just hypotheses that had never been proven. Maybe they are right, maybe they are wrong, but what we knew for sure at that time about such great facts, he called an “*empirical generalization*.”

- *Biogenesis*—that “All living beings come from living beings.”

Vernadsky reminded us that it was the Italian naturalist, Francesco Redi (1626-1697), who proclaimed that principle, “*omne vivum ex vivo*.”

Studying this problem, Vernadsky came to several empirical generalizations for living matter (living substance), as put forth in the Introduction to his book, *The Biosphere*, published in Prague in 1926:

- Life did not originate from stagnant (inert) matter;
- There have never been lifeless epochs on the planet;
- The current living matter is connected with the previous one, so all life is unified in its basic properties;
- Its chemical effect on the environment has always been the same;
- There were no big changes in the quantity (rather than quality) of living matter, and therefore in number of atoms captured by it;
- Living matter “works” on solar energy, *chiefly*.

I have stressed here the word “*chiefly*,” to indicate that living matter may work not only from solar energy.

I have already used a couple of terms, “living matter,” and “living substance.” What is the difference between these two terms? I have translated the Russian term “*Живая Материя*” (“*Zhivaya Materiya*”) as “Living Matter” in some cases, and “Living substance” in other cases. Here is the citation from Vernadsky:

I will call Living Matter the totality of living organisms, expressed in weight, in chemical composition, in measures of energy, and in the nature of space (special geometry).

Living Matter is more or less continuously distributed on the Earth’s surface. It forms a thin but continuous cover on it, in which it concentrates the free chemical energy generated by it from the energy of the Sun.

This layer, the Earth’s shell, is the *Biosphere*. It represents one of the most characteristic features of the organization of our planet.

Only living organisms constituted the Biosphere, the special form of being of chemical elements, in which what we have called “Living Substance” (or “Animated Matter”) is present.

This is the definition of “Living Matter,” which I’ll use further on. But, what is “Living Substance”? “Living Substance” is a special form of being of chemical elements, or animated matter, of which all living organisms are constituted in the Biosphere.

What are the special properties of “Living Substances”? He asks this question in his work, “The Beginning and Eternity of Life.” There he writes:

There is some fundamental difference between living substance (animated matter) and dead matter. This difference should be due to some kind of difference of matter and/or energy in a living organism, compared with those forms of matter that are studied in physics and chemistry, in ordinary inert, stagnant, lifeless matter....

It also indicates the insufficiency of our usual ideas about matter and energy, derived from the study of stagnant nature, to explain all the processes of life.

Already in the 1920s and 1930s, Vernadsky emphasized that

from the point of view of our usual physical representations, this “animated matter” would have the property and character of not only conventional matter, but also of energy.

### Erwin Simonovich Bauer

Now, I would like to shift from a discussion about Vladimir Vernadsky, to his contemporary, also a great scientist to my mind: Erwin Simonovich Bauer (1890-



Erwin Simonovich Bauer (1890-1938) suggested a general theory of living substance.

1938), who also worked in the 1920s and 1930s in Soviet Russia.

Bauer wanted to understand what the “living state of matter” represents, and went into much more details than Vladimir Vernadsky. In his book, *Theoretical Biology*, published in Leningrad and Moscow in 1935, he suggested a general theory of living substance, based on three principles, or “axioms,” as he called them. Or, using the terminology of Vernadsky, “empirical generalizations.”

*Principle No. 1.* The Principle of Stable Non-equilibrium provides us with the essence of living systems. According to this principle, all, and only living systems, are never at equilibrium. At the expense of their free energy (i.e., energy that can be used for the performance of work), they ceaselessly perform work against equilibrium, demanded by the physical and chemical laws appropriate to the actual external conditions.

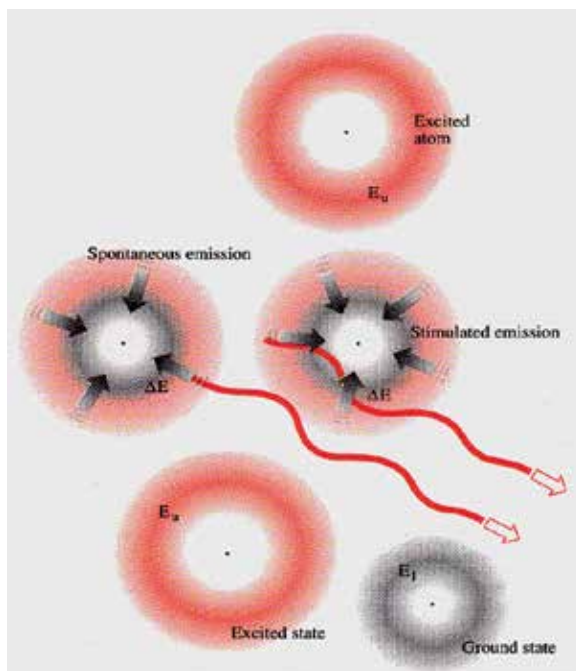
expense of their free energy (i.e., energy that can be used for the performance of work), they ceaselessly perform work against equilibrium, demanded by the physical and chemical laws appropriate to the actual external conditions.

In other, simpler words: Living systems, unlike inanimate things, persistently perform work to stay alive.

What is the essence of the matter in living systems which perform this work? This, then, is the second principle formulated by Bauer. According to him:

*Principle No. 2.* A stable, non-equilibrium (excited state) is exhibited at all levels of a living system organization, including the molecular one.

Better to say it now: from the molecular level to the biospheric, or probably the level of the universe. We



Bauer’s Third Principle of Living Substance: The structure of matter in an excited state differs from the structure of the same matter in the equilibrium (ground) state.



return to the molecular and cellular level. Bauer states:

*Principle No. 3.* The structure of matter in an excited state differs from the structure of the same matter in the equilibrium (ground) state.

All the work performed by a living system is produced at the expense of structural energy—energy of excited structural elements of the system.

Principle #1 tells us the essence of living systems. I remind you that this was written in 1935, but it is talking about the laser state of living matter. Living matter is continuously being pumped by energy, and when the structural energy is released, it is “free energy,” which is capable of performing work.

Unfortunately, I do not have time to go deeper into Bauer’s Theory of the Living State, but I would like to say that Bauer managed to deduce from his basic [three] principles, all manifestations of the Living State, including metabolism, growth and development, reproduction, excitability, ability to perform external work, aging and apoptosis, and cellular complexity.

Hower, Bauer did not (and could not) specify the *nature of living matter* able to persist in a stable non-equilibrium state. Neither did he suggest a convincing mechanism of living matter’s ability to convert low-grade chemical energy of food, into high-grade structural energy (energy of excitation).

### Back to Vernadsky, and ‘Living Substance’

When we are talking about real living matter, or better to return to the term “living substance,” what is the major chemical constituent of living substance? We’re now coming back to Vernadsky.

In his [3-volume] *History of Natural Waters*, [published sequentially 1933-1936], he wrote:

Water occupies a unique place in the history of our planet. There is no natural body that could compare with it in its influence on the course of the main geological processes....

All the natural substances—minerals, rocks, living bodies are permeated and covered by it, due to its properties....

[I]t is omnipresent in the upper part of the planet ... and also in its deepest parts....

It plays an exceptional role in the phenomena of life. At least 2/3 by weight of all living matter

of the planet, of all organisms, consists of liquid water; for many aquatic organisms, it is more than 99.5% by weight.

As the French biologist Emil du Bois-Reymond (1818-1896) correctly said, “*La vie est de l’eau animée*” (Life is animate water).

I would like to add that water is omnipresent in the universe. In the last 10-15 years, it has been demonstrated that water is the third, by abundance, substance in the universe, after helium and hydrogen.



Courtesy of Vladimir Voeikov

*Water is omnipresent—the third most abundant substance in the universe.*

Here are some examples of Living Water. There are some jellyfish which consist, by weight, of 99.9% water. All the bio-organic matter which we so carefully study, constitutes only 0.1%. This Living Water lives in what is supposed to be much less living, or, if you want, inanimate water, sea water, which is much more dirty than the water which constitutes the body of a jellyfish.

Contrary to the generally accepted view that water is in equilibrium with the environment unless it is affected by an external force, natural waters are *never* in equilibrium. They permanently reside in the far-from-equilibrium state—the state of stable non-equilibrium! (to use Erwin Bauer’s terminology).

Due to this property, waters are capable of self-organization, and may serve as the source of high-density energy. We know this; we’ve seen it very often that self-organized water, for example in tornados—by the way, the clouds are also self-organized water—may sometimes be stronger than steel—not in the form of

solid water, but in a special form of dynamic water—water as a process.

Atmospheric water is a source of electricity. Vernadsky also emphasized that water may be the source of a *tremendous* quantity of electricity.

Now, water is itself a fuel. It may burn. This was first discovered 220 years ago, but then forgotten, then rediscovered by the end of the 19th Century, and again it was forgotten. In the 21st Century, it was demonstrated (in 2007) by the American inventor John

Kanzius and proved by Professor Rustum Roy (in 2009) from University of Pennsylvania, that salted seawater may burn under irradiation of radio waves [13.56 MHz, 200-400 Watt—ed.], and the temperature of the flames under such radio waves may reach 1,500° C, meaning that this water under the action of radio waves may split into hydrogen and oxygen. The hydrogen will burn in the presence of oxygen.

From these and many other observations, it follows that:

- Electrons in water may be at a much higher state of excitation than what is usually considered.
- A rather low energy of excitation is needed to make them free, and when they stick to oxygen, burning may be observed.

Very recent studies of natural (“real”) water may explain why it behaves so.

### Gerald H. Pollack

I would say that the real pioneer in this work, who is leading work in this area, is Professor Gerald H. Pollack, who will give his lecture in Panel 2 of this conference.

Starting from 2003, Pollack demonstrated more and more convincingly that [in] a water phase adjacent to hydrophilic surfaces, or, better to say, in water that is near the hydrophilic surfaces, there forms a very thick layer of water making it different from bulk water in physical and chemical properties. These thick layers of water which are formed near the hydrophilic surfaces constitutes a particular phase state of water—neither



WKYC.com (NBC-TV HD3)

*Pennsylvania engineer and inventor John Kanzius used radio waves to split the water molecule in a salt solution into its hydrogen and oxygen, igniting it to burn at 1,500°C, May 28, 2007.*

liquid, nor solid, nor vapor. It is liquid-crystalline, quasi-polymeric, coherent water. As a matter of fact, as there are a tremendous quantity of hydrophilic surfaces in all living organisms, a tremendous quantity of biological water should have these properties—properties of “Exclusion Zone” water, as named by Pollack.

### EZ Water

I will now concentrate on one very important property Pollack discovered. This Exclusion Zone (EZ) water is negatively charged; it is rich in

quasi-free electrons, unlike bulk water, which is rich in protons and is positively charged. So, there is an electrical potential difference between these two waters.

EZ water may be the source of electrons. A high oxygen concentration is always present in EZ water. These electrons may stick to oxygen, which means that the oxygen is reduced, and water is oxidized. It’s a kind of water burning, and water burning generates free energy.

About a decade ago, we discovered that bicarbonates ( $\text{HCO}_3^-$ ), which are always present in real (natural) waters, catalyze water burning.

The unique property of water is that the products of its oxidation with oxygen are, again, water molecules and oxygen:  $[2\text{H}_2\text{O} + \text{O}_2 \rightarrow \rightarrow \rightarrow \rightarrow \text{O}_2 + 2\text{H}_2\text{O} + \text{hv}]$ . This is a unique reaction in which reagents and products are chemically the same. Energy is obtained from destruction of structured water and conversion into chaotic water. Free energy is released, due to an increase in entropy.

It could burn completely, completely converting into chaotic water. Again, Pollack discovered that radiation, especially infrared light, (“warmth,”) promotes regeneration of structured water from disorganized water molecules.

So, water can perform work, by increasing entropy and, due to low density, environmental energy from infrared (and probably other parts of the radiation spectrum), there is a *continuous* regeneration. Water, in this sense, is a converter of the dissipated energy in the environment into high-density free energy.

## Unique Properties of Aqueous Systems

We can now summarize the unique properties of aqueous systems:

- Aqueous systems are capable of self-organization into holistic units.
- They may extract low-density energy (energy of “warmth”) from their environment and convert it into high-density free energy.
- They may serve as the source of coherent photonic (phononic) radiation.
- All these properties endow to them the capacity to receive resonant EM (electromagnetic) and other oscillatory impulses from the environment and actively react to them.

From this it follows that the properties of aqueous systems are characteristic of the living state of matter, and water, as we know, is the fundamental component and energizer of living matter.

But, there is a question, to which there is no answer today: Do we know anything about the origin of water, or its “creation,” or is it as eternal as life, as according to V.I. Vernadsky? In other words, there is a kind of [imaginative conception] that water and life are indivisible. As life, according to Vernadsky, didn’t originate, so we can say now that water, also, did not originate.

*Cnacubo* (“*Spasibo*”). Thank you very much for your attention.

## BOOK REVIEW

# The Secret World of Water

by Liona Fan-Chiang

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### The Fourth Phase of Water

by Gerald H. Pollack  
Ebner and Sons Publishers, Seattle, 2013. 358 pages.

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*This book review first appeared in 21st Century Science & Technology magazine, Fall-Winter 2013, p. 66, and is being reprinted with the permission of the editor.*

Water is not something that most people spend much time thinking about, and due to the nature of science today—to specialize, molecularize, and concentrate on minute details—most people assume that there is not much that a layman can wonder about water that hasn’t already been explained. In his new book, *The Fourth Phase of Water*, Dr. Pollack challenges this notion, pointing out both that since water is all around us, we tend not to see it as phenomenal, and that since the focus throughout the Twentieth Century has shifted from looking for fundamental laws, to detailing consequences of assumedly known laws, basics can go long

unchallenged. “If currently accepted orthodox principles of science cannot readily explain everyday observations, then I am prepared to declare that the emperor has no clothes,” Pollack declares in his Preface.

*The Fourth Phase of Water* is the latest in a series of books on the subject, including *Cells, Gels and the Engines of Life* (2001), *Water and the Cell* (2006), and *Phase Transitions in Cell Biology* (2008), in which Pollack and his collaborators reveal the results of their many years of research on the unique, and previously unexplained, properties of water. This book’s composition is paradox driven, meaning that there are no attempts to explain something unless the reader is first presented with something unexplained.

In that sense, although the book may look and feel like a textbook, it is not composed as one, keeping the reader’s mind hypothesizing and engaged. For example, Chapter 1, titled “Surrounded by Mysteries,” begins by listing fifteen everyday observations, such as gelatin desserts composed of 95% water but not leaking, and warmer water freezing faster than cold water, and asks you to try to explain them. He follows

