

# Modern biophysical view of electromagnetic processes of the phenomenon of life of living biological systems as a promising basis for the development of complex medicine: towards the concept of Bioelectronic Medicine

Ganna Nevoit<sup>1</sup>, Olena Filiunova<sup>2</sup>, Maksim Potyazhenko<sup>3</sup>, Ozar Minser<sup>4</sup>,  
Inga Arune Bumbylte<sup>5</sup>, Alfonsas Vainoras<sup>6</sup>

<sup>1,5</sup>Department of Nefrology, Lithuanian University of Health Sciences, Kaunas, Lithuania

<sup>1,3</sup>Department of Internal Medicine and Emergency Medicine, Poltava State Medical University, Poltava, Ukraine

<sup>2</sup>Preventive Medicine Center of Genesis Center LLC, Kyiv, Ukraine

<sup>4</sup>Department of Fundamental Disciplines and Informatics, Shupyk National Healthcare University of Ukraine, Kyiv, Ukraine

<sup>6</sup>Laboratory of Automation of Cardiology Research of the Institute of Cardiology, Lithuanian University of Health Sciences, Kaunas, Lithuania

<sup>6</sup>Corresponding author

**E-mail:** <sup>1</sup>anevoiyt@gmail.com, <sup>2</sup>filyunoval@gmail.com, <sup>3</sup>umsainua@ukr.net, <sup>4</sup>o.mintser@gmail.com, <sup>5</sup>ingabumbylte@gmail.com, <sup>6</sup>alfavain@gmail.com

Received 12 December 2023; accepted 28 December 2023; published online 28 December 2023  
DOI <https://doi.org/10.21595/chs.2023.23867>



Copyright © 2023 Ganna Nevoit, et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

**Abstract.** The publication of the results of a theoretical study on the conceptualization of Bioelectronic Medicine continues a series of articles on the role of electromagnetic processes in the implementation of the phenomenon of life. The authors, based on modern biophysical fundamental knowledge about the structure and functioning of the human body at the micro level of its structure (nanolevel and deeper) and the concepts of the Magnetochemical theory of metabolism, developed the main ideological concepts of the scientific direction “Bioelectronic Medicine” as a component for the further development of complex medicine. General scientific methods and theoretical methods were used in this theoretical study. The result of this theoretical research was the extrapolation of modern biophysical fundamental data on the structure of the microcosm of matter to medical knowledge about humans. It is proposed to call the resulting scientific direction the term “Bioelectronic medicine”. A conceptualization of the obtained fundamental ideas was made, three basic concepts and seven main aspects of “Bioelectronic Medicine” were formulated.

**Keywords:** bioelectronic medicine, complex medicine, magnetochemical theory of metabolism, quantum level, phenomenon of life, medical progress.

*Whatever nature has in store for mankind, unpleasant as it may be, men must accept, for ignorance is never better than knowledge*

*Enrico Fermi*

## 1. Introduction

In the name of further development and progress, the medical scientific paradigm must constantly evolve. Medicine is a transdisciplinary field that is constantly updated with the latest knowledge from other scientific fields.

Therefore, a priori, for the sake of the triumph of scientific truth in the future, medical scientists must constantly generate new ideas, develop and implement them in the practical field of healthcare. The presence of scientific progress in medicine tomorrow must be laid down today. However, in addition to the standard need for progress, there are many unresolved medical

problems. Many of these problems are global. For example, the pandemic of chronic Non-communicable diseases continues [1], [2] and today existing traditional medical approaches cannot completely heal any chronic disease of internal organs. There are problems of antibiotic resistance [3]-[5], comorbidity and multimorbidity [6]-[8], polypharmacy and side effects of drugs [9]-[12], aging of humanity [13]-[15], etc. All this requires the search for new promising approaches to solving them. Accordingly, further progress in medicine is simply necessary. Therefore, the search and development of new paradigms is relevant.

New ways for the further development of medicine already exist. Basic science has undergone dramatic changes over the past 50 years. They were based on transformations of ideas about the structure of the atom. After the principles of wave-particle dualism became understood (namely, that every particle is both a corpuscle and a wave), classical mechanics could not adequately describe how the Universe works. It was replaced by quantum mechanics. Now the entire scientific world recognizes the corpuscular-wave electromagnetic model of the structure of the atom - the so-called "Standard Model" of the structure of the atom [16]-[18]. Other fundamental sciences have changed in connection with the advent of quantum physics: Quantum chemistry [19], [20], physical quantum biology [21], [22], and many scientific branches studying the microworld and electromagnetic processes (for example, nanobiology, nanochemistry, magnetobiology) [23]-[26], etc. appeared. These scientific transformations are a challenge for modern medical science and require further progress from it in the research direction. This new fundamental knowledge can become the basis for a paradigmatic transformation of modern existing medical worldviews.

In order to contribute to the promotion of new ideas in medical science, the aim of the theoretical study was to develop basic ideological concepts based on modern biophysical fundamental knowledge about the structure and functioning of the human body at the micro level of its structure (nanolevel and deeper) and the concepts of the Magnetochemical theory of metabolism scientific direction "Bioelectronic Medicine" as a component for the further development of integrated medicine.

## 2. Materials and methods

The theoretical study was carried out by an interdisciplinary team from three universities:

1) Poltava State Medical University (23, Shevchenko St., 36011, Poltava, Ukraine), the cooperation coordinator is the Head of the Department of Internal Medicine and Emergency Medicine prof., DM M.M. Potyazhenko;

2) Lithuanian University of Health Sciences (9, A. Mickevičius St., LT-44307, Kaunas, Lithuania) according to the memorandum of support dated May 12, 2022, the cooperation coordinator is Head of Nephrology Department, prof., DM I.A. Bumblyte;

3) Shupyk National Healthcare University of Ukraine (9, Dorogozhytska St., 04112, Kiev, Ukraine), the cooperation coordinator is the Head of the Department of Fundamental Disciplines and Informatics, prof., DM O.P. Mintser.

It is a subset of research work of the Department of Internal Medicine and Emergency Medicine of Poltava State Medical University (23, Shevchenko St., 36011, Poltava, Ukraine) on "Development of algorithms and technologies for implementing a Healthy Lifestyle in patients with Noncommunicable Diseases based on the study of functional status" (state registration number 0121U108237: UDC 613 616-056-06: 616.1 / 9-03).

General scientific methods (dismemberment and integration of elements of the studied system, imaginary experiment, logical, historical research, analysis, induction, deduction and synthesis of knowledge) and theoretical methods (method of constructing theory, logical methods and rules of normative nature) were used in this theoretical study.

## 3. Results and discussion

The result of this theoretical research was the extrapolation of modern biophysical fundamental

data on the structure of the microcosm of matter to medical knowledge about humans. We called this scientific direction the term “Bioelectronic medicine”. A conceptualization of the obtained fundamental ideas was made, three basic concepts and seven main aspects of “Bioelectronic Medicine” were formulated. A brief rationale for these ideas can be described as follows.

Now in medical science there are prerequisites for the transition from the atomic-molecular level of understanding the structure of tissues and metabolism of substances to the quantum level, that is, to the subatomic and deeper to  $10^{-44}$  nm. This is so because quite clear scientific data have been formed about the structure of matter at the micro level [27]-[35]. In the article [36] a description of the structure of the microcosm of the human body was conceptualized. The main idea of this description is that when considering matter on a scale of  $10^{-19}$ - $10^{-13}$  cm, there are no longer atoms familiar to the human imagination of matter. For example, on this scale, the atomic nucleus can be conventionally described as a rotating electromagnetic rod, which consists of neutrons and protons. On a scale of  $10^{-28}$ - $10^{-35}$  cm, matter can be described in the form of ring wave processes and this corresponds to the physical description of bosons, etc. Thus, in the nanoworld, all matter is the energy of movement of electromagnetic waves of the internal environment. All these ideas that at the micro level all the atoms of the world are built from bosons and fermions, which are essentially electromagnetic field structures - that is, electromagnetic fields or, simply put, energy in its various qualitative representations, are described by fundamental science in the Standard Model of structure atom [16], [17], [37]-[39]. A simple and logical conclusion suggests itself: since the human body is formed by atoms, it turns out that at the micro level it is also formed by conglomerates of electromagnetic energy... In other words, all living biological organisms, including the human body, have an electromagnetic structure. They consist of resonating electromagnetic wave field oscillator structures and are united by electromagnetic field interactions. Therefore, they can be represented in the frequency-wave model in the form of resulting interference electromagnetic wave packets, at the nodes of which there are atoms. At the same time, atoms are a source of wave generation, which determines the presence of wave characteristics of structures at the macrolevel of organization [28], [40]-[46]. This became the basis of the first basic concept for the development of the ideas of “Bioelectronic Medicine”:

*Concept No. 1. The entire human body (like the matter of the whole world) is formed by bosons and fermions, that is, electromagnetic energy.*

*Concept Thesis: The human body is formed by energy.*

Thus, medicine receives a new, paradigm-transforming approach to looking at the human body: previously doctors understood that the entire body is built from molecules and atoms, but now it is clear that the human body is formed by electromagnetic field structures or, simply put, energy. And this concept radically deepens, expands and changes modern biological ideas about the levels of structural organization of the human body (Fig. 1).

The second paradigm-transforming approach to thinking about the functioning of the human body comes from the first concept and from modern biophysical knowledge that the chemistry between all atoms and molecules is a secondary phenomenon of electromagnetism [28]:

*Concept No. 2. All metabolic chemical reactions are a secondary result of electromagnetic interactions between atoms and subatomic structures.*

*Concept Thesis: Chemistry is a secondary phenomenon of electromagnetism.*

This is so because the existence of molecules is based on quantum mechanical principles of structural organization [28], [44]-[46]:

1) A molecule as a material manifestation of matter and a fundamental structural and functional component of the micro-level organization of a living biological system of any level of complexity, including the human body, consists of atoms that are complexes of field structures.

2) In a molecule, atoms are interconnected by electromagnetic wave fields, the source of which is the atoms themselves, participating in chemical interaction and self-organization.

3) In a molecule, a chemical bond between atoms is the result of the interaction of electromagnetic wave fields of atoms and can be a covalent bond (sharing electrons) or a polar bond (sharing electrons).

4) Model-wise, any molecule can be represented in the form of electromagnetic wave packets, at the nodes of which there are atoms that are the source of wave generation; in this case, electromagnetic wave packets turn out to be the result of interference of radiation from all atoms of the molecule of a biological system.

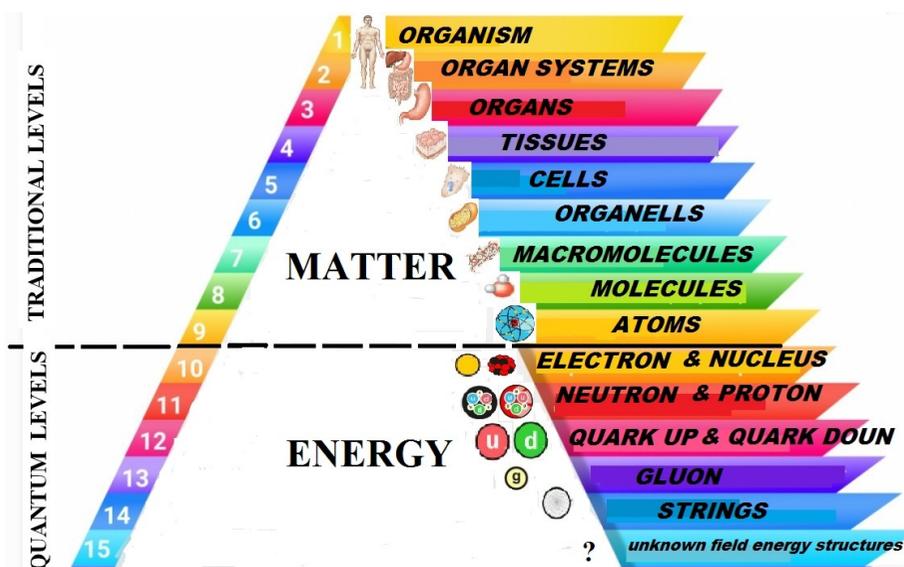


Fig. 1. Graphic representation of the structural levels of organization of the human body, considering modern fundamental biophysical knowledge

5) The geometry of molecules is determined by the quantum mechanical characteristics of the atoms that form it and in the ground, state corresponds to the minimum total energy and, accordingly, the maximum total energy of all chemical bonds.

6) A real molecule consists of resonating electromagnetic wave field structures (according to the principle of superposition of Dirac states), that is, it does not have a specific structure, but is formed solely as a result of continuous resonance - the electromagnetic superposition of many different atomic structures.

7) A molecule has energy characteristics determined by the electromagnetic parameters of the atoms that form it, which include the energy of rotation of electrons, the energy of vibration and rotation of the nuclei of each atom that forms it, with a different contribution of each type of energy to the total energy of the molecule; in this case, each energy component is quantized.

8) The molecule can be in the ground or excited electronic state, classified depending on the total spin of the molecule and obeys the rules of electronic transitions, which have different probabilities.

9) Molecules of biological systems have individual quantum mechanical characteristics due to the special composition of atoms (carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), sulfur (S)), biopolymer structure most molecules have significant molecular weight and molecular length and have various options for possible states of structural organization in space.

10) In a molecule, the state of an electron is described using a wave model based on the Schrödinger equation, which is called a molecular orbital and includes localized  $\sigma$ -orbitals, localized and delocalized  $\pi$ -orbitals, n-orbitals; At the same time, there are significant difficulties

in their adequate calculation, since taking into account interelectron repulsion there is no possibility to separate variables in one coordinate system, which predetermines the use of approximate methods in determining the shape of molecular orbitals (scientific ideas about the shape of molecules are relatively conventional).

Thus, it has been scientifically proven that all reactions between atoms and molecules are an exchange of electromagnetic energy and are determined by the primary energy state of atoms and their subatomic components.

This knowledge is generally accepted and known, but at this stage, in our opinion, it is not sufficiently used in the interpretation of modern biomedical research.

If we scientifically realize that the human body at the micro level of its structure is a conglomerate of electromagnetic fields (it is only the limitation of our senses that prevents us from seeing this scientifically proven fact with our own eyes) and all biochemical reactions are not just a connection of atoms, but energy interactions and energy exchange between various electromagnetic field structures, which we conventionally call atoms, examining them under a microscope, again we get a fundamentally different scientific view of the human body. And this scientific fact becomes the starting point for further opportunities to describe the course of physiological and pathological processes in the human body at the micro level. This creates theoretical prerequisites for deepening medical knowledge and describing the so-called “quantum pathogenesis” of diseases of internal organs. We display this in this aspect:

*Aspect No. 1. Now the pathogenesis of diseases has been theoretically worked out at the molecular level, but now there is a scientific opportunity to describe it more deeply at the micro level - that is, to create a description of the quantum pathogenesis of diseases of internal organs.  
Thesis of the aspect: There is quantum pathogenesis.*

Understanding the quantum mechanical mechanisms of the energetic functioning of biopolymers in the body of a living person, knowledge of the fundamental quantum principles of their organization in cells and the role of electromagnetic components in the processes of metabolism of substances are definitely the next step in the development of fundamental medical science. And this is the next promising and important stage in deepening the fundamental aspects of the pathogenesis of diseases of internal organs.

All pharmacological agents are also created from atoms, i.e. they are also conglomerates of electromagnetic energy and have certain electromagnetic characteristics, which determine their ability to react biochemically in the body. As we already know, the biochemical response of pharmacological agents in the body is the result of electromagnetic interaction between the field structures of the atoms of the pharmacological agent and the field structures of the atoms of the human body when considering the event at the nanoscale and deeper.

Further development of science in this direction may lead to the development of so-called “quantum pharmacology.” This became the basis for *Aspect No. 2*:

*Aspect No. 2. Now there is a scientific opportunity to create a new branch of pharmacology - quantum pharmacology.  
Thesis of the aspect: There is quantum pharmacology.*

The biopolymer molecule in its structural characteristics is the same both under *in vivo* and *in vitro* conditions. But in terms of their functional parameters, being in a living biological system, the molecules of biopolymers *in vitro* and *in vivo* are categorically different - they are alive in a living organism. Therefore, it has long been scientifically clear that the basis of the phenomenon of life should be associated with the peculiarities of the flow of micro-level energy processes and, as has now become obvious, due to quantum-mechanical differences in the energy characteristics of the atoms that form it due to the presence of biochemical and control flows of solitons/energy in biological polymers. That is, the phenomenon of life of biopolymer molecules is associated

with the occurrence of magnetochemical processes inside them. In the Magnetochemical theory of metabolism [44,45,46], it was conceptualized that the basis of the phenomenon of biological life of living systems at the microlevel is the transition of coherent energy/solitons from biopolymer chains to chains of crystalline energy-intensive water structures combined with biopolymers by hydrogen bonds, with the formation of long-existing biopolymers-water structures capable of receiving energy of any kind, converting it into a coherent form and transporting it, including along water chains, to molecular objects remote from the biopolymer. Energy processes at the molecular level occur on biopolymers in living biological systems, including humans, in the energy self-localization mode and in the transportation mode. This is so because the life of molecules is based on quantum mechanical principles of structural organization and functioning [28], [31], [32], [44]-[46]:

1) The fundamental quantum mechanical difference between the functioning of polymer biomolecules of living systems from molecules of inanimate matter is their ability to convert unorganized (thermal, chemical, etc.) energy into a coherent form and its intermolecular transfer due to a system of delocalized  $\pi$ -electrons (quantum-Mulliken mechanical model).

2) Delocalization of  $\pi$ -electrons in the molecular systems of living organisms is an important and fundamental quantum-mechanical feature of ensuring the energy cycle in the Universe (including the model of the “electronic circuit of life”) and the phenomenon of biological life; This is why all the most important biomolecules are partially or fully connected systems.

3) Each of two or more autonomous systems of  $\pi$ -electrons of a living biological molecule can exhibit spectral independence and simultaneously interact with other molecules; in this case, the interaction of  $\pi$ -electron systems inside a molecule is due to the migration of energy along it, that is, the transfer of energy between various functional groups of this molecule, which is considered as quantum mechanical features of intramolecular and intermolecular transfer of energy and charge.

4) The ability for intramolecular and intermolecular transfer of energy and charge is determined by the intrinsic quantum mechanical features of the structure of biopolymers of living biological systems and is their fundamental distinctive property.

5) Energy conversion processes in the molecules of living biological systems are accompanied by the phenomenon of photon/electron emission, which is caused by various mechanisms of occurrence (with stimulation - secondary luminescence/photon emission; without stimulation - intrinsic luminescence/photon emission, etc.), is a special case energy transfer, has distinctive features in different cell ultrastructures (and, accordingly, in different tissues, organs, parts of the body), most characteristic of molecular structures containing complex proteins with chromoform coenzyme groups.

6) The fundamental difference between living biological systems is the presence of deterministic self-organization of their molecules through the implementation of information-energy processes of intramolecular and intermolecular energy transfers due to the exciton-phonon/soliton mechanism of conversion of chemical energy of adenosine triphosphate by biopolymers into coherent energy with subsequent transmission in the form of a soliton/biosoliton/electrosoliton along the chain biopolymer.

7) The soliton mechanism of energy transfer along a chain of biopolymers turns out to be the electromagnetic basis of the phenomenon of life in living biological systems, and all biopolymers of a living organism, which have a specific structure and contain anharmonic atomic groups in their chains, convert chemical (possibly another type) energy that excites their vibrations, into coherent energy/solitons, which are further transported along the chains of the biopolymer, providing its chemical interactions and mechanical movement.

Now the well-known definition of Friedrich Engels that “life is the mode of existence of protein bodies” can be expanded to the level of modern biophysical knowledge. “Life is a way of electromagnetic existence of protein bodies,” since the phenomenon of biological life is completely determined by magnetochemical processes at the molecular level: there are no energy

processes - there is no life. This became the basis for *Aspect No. 3*:

*Aspect No. 3. Medicine now has the opportunity to convey to every doctor and scientist the biophysical essence of the phenomenon of life as an electromagnetic process.*

*Thesis of the aspect: Life is an electromagnetic process.*

During the conceptualization of the Magnetochemical theory of metabolism, it was established that the phenomenon of biological life at the micro level is due to the fact that water in the human body is in an organized state of quantum-mechanical connectivity. In a living organism, the constant supply of coherent energy from biopolymers to water molecules transforms water into a single structure in the form of energy-intensive crystals. This deprives water of the fluidity familiar to the human imagination and allows it to have unique quantum mechanical properties necessary to ensure the phenomenon of life in living biological organisms. The phenomenon of biological death occurs when, due to the cessation of metabolic processes, coherent energy ceases to move along the chains of biopolymers. The lack of supply of coherent energy to the organized energy-intensive fractal crystal structure of water leads to its degradation and the transition of water into an unbound state of an aqueous solution. This is another aspect that explains how, at the molecular level, bioenergetic processes in living biological organisms are determined by magnetoelectric interactions. Therefore, according to the concepts of the Magnetochemical theory of metabolism, the following features of the stages of energy transformation at the microlevel of the structure of the tissues of the human body were identified to ensure the phenomenon of life [28], [44]-[46]:

1) The chemical energy of adenosine triphosphate on biopolymers is transformed into a coherent form of electromagnetic energy - a soliton.

2) Then this converted coherent electromagnetic energy in the form of solitons is transmitted along the biopolymer chain; and this ensures the "life" of this biopolymer, determining its mechanical and biochemical activity.

3) This coherent electromagnetic energy (solitons) can move from biopolymer molecules to adjacent water molecules; in this case, water is organized into an energy-intensive polarized crystalline structured water system, which transmits energy further without loss, that is, it performs the function of remote non-chemical energy transfer (remote energy-informational communication) to distant biopolymers and this ensures the implementation of interaction processes between biopolymers of the entire human body (Theory of collective processes N. Gall).

4) Electromagnetic resonant-frequency interactions between molecules is a universal physical mechanism that ensures selectivity of interaction between biopolymers and the implementation of the mechanism of energy-informational soliton communication between them; this is what makes molecules "alive", linking them in a single organism into one functional whole.

5) The constant collective energetic soliton interaction of biopolymers is a fundamental difference between the behavior of biopolymers in vivo in a normally functioning and living biological organism, in contrast to biopolymers in solution in vitro.

It is important to note that now knowledge of the basics of the flow of electromagnetic processes in tissues at the micro level gives rise to the understanding that the vital activity and functioning of living biological systems in the corridor of the physiological norm, conventionally called "health" in medicine, is completely determined by the magnetoelectric support of the molecules of its body. Now the phenomena of life and health acquire new, quantum characteristics of their conceptual apparatus, and this reflects the following aspect of "Bioelectronic Medicine":

*Aspect No. 4. Thanks to the understanding of the biophysical electromagnetic essence of the phenomenon of life, it became possible to convey to every doctor what the phenomena of health and disease are from a biophysical point of view.*

*Thesis of the aspect: Health is the normal course of electromagnetic metabolic processes; disease is their violation.*

Accordingly, disease is logically considered as a violation of the magnetoelectric state of bimolecular structures, death is their complete absence, and the human body is one of the forms of magnetoelectrochemical organization of biological matter on Earth.

*Aspect No. 5. Medicine has the opportunity to convey to every doctor and scientist the idea that from a biophysical point of view there is a phenomenon of disease and biological death.*

*Thesis of the aspect: Biological death is the cessation of electromagnetic metabolic processes.*

The life of a biological system is a process of magnetoelectric activation of its biomolecules, which triggers and ensures their biochemical activity (channelization of coherent energy - biochemical soliton flow) and ensures structural integrity in their collective [molecules] interaction of the whole organism (transport of solitons through water-energized structures - control soliton flow).

From the perspective of Bioelectronic Medicine, the phenomenon of biological death is caused by a change in the quantum mechanical energy characteristics of molecules and atoms in the tissues of the human body due to the cessation of the flow of coherent electromagnetic energy through biopolymers and organized aqueous crystalline structures. This leads to the disappearance of the energy-informational soliton connection between biopolymers and to the disintegration of energy-intensive water crystalline structures. As a result of this, the gradual disintegration of biopolymers begins, water begins to behave as a solvent, that is, the processes of biological disintegration of the human body begin.

Having identified these aspects, we can ask the most sacred questions for medicine. What is the practical significance of "Bioelectronic Medicine" as a component of Integrated Medicine? How can the application of scientific principles of Bioelectronic Medicine contribute to the treatment of patients? What therapeutic and preventive approach can be created from a quantum point of view for the treatment of diseases of internal organs?

When performing a theoretical study, it was found that the development and use of a frequency-wave model of the structure of the human body is of great importance for the further development of the medical paradigm in the direction of "Bioelectronic Medicine". Answers to the questions posed can be found by developing this model of the structural organization of the human body.

It has now been completely scientifically proven and clear that according to the Concept of Wave-Frequency Duality, each atom is a particle and a wave at the same time [32], [47], [48]. That is, from the point of view of physics, any atom can be described as a particle with size and mass, and as a wave process with wave/frequency parameters - for example, vibration frequency in hertz. Therefore, according to this universal law, all atoms have wave characteristics and have a constant vibration frequency in hertz. At the atomic and subatomic levels, the physical basis for the vibrational movements of an atom is the phenomenon of precession of atomic nuclei. Nuclear precession is a characteristic, specific constant frequency of rotation for the nucleus of an atom of each substance. Based on the known frequency of precession of nuclei, it is possible to determine the composition of the human body, the presence of certain substances, types of cells and tissues, and processes in it. According to modern scientific approaches, the precession of atomic nuclei can be established as follows: it is necessary to irradiate the nuclei of atoms with radio waves, constantly changing the frequency until it coincides with the frequency of precession of the nuclei - in this case a resonance (Nuclear Magnetic Resonance (NMR)) will arise, which will be recorded measuring instrument [49]-[52]. This principle has made it possible to scientifically establish the frequency properties of most known microorganisms, chemicals, tissues and functioning processes of the organs of the human body. This is so because the frequency characteristics of atoms add up to the frequency characteristics of molecules. In turn, the frequency characteristics of molecules form the total frequency characteristics of tissues and processes in them. Since this law is universal, the frequency principle of describing tissues and organs is valid for the entire

human body. Therefore, in the human body, each hierarchical level of its structure can be described in terms of their frequency-wave characteristics. That is, according to the law of frequency-wave dualism, the human body can be described in the frequency-wave model of its structure. And this is another paradigmatically transforming concept of “Bioelectronic Medicine”:

*Concept No. 3. The human body can be represented in a frequency-wave model of its structure.*

*Concept Thesis: There is a particle-wave model of the structure of the human body.*

This has experimental confirmation. It has been established that living cells of the body generate biological electromagnetic fields in the ultraviolet and visible range of the spectrum, as well as in the frequency range below the terahertz range [28], [29], [53]-[60]. The scientific literature describes specific frequency characteristics of the functioning of human organs. The most studied are the frequency characteristics of the brain and heart. Thus, neurons of the brain, depending on the level of the functional state of the human body, generate frequencies: Delta frequency – 0.3-4 Hz, Theta frequency – 4-8 Hz, Alpha frequency – 9-13 Hz, Beta frequency – 13-30 Hz, Gamma frequency – 30 Hz and above [61]-[64]. The heart generates electromagnetic radiation in the frequency range from 0.04 to 0.4 Hz according to spectral analysis of heart rate variability: High Frequency – 0.15-0.4 Hz, Low Frequency – 0.15-0.04 Hz, Very Low Frequency – 0.04-0.003 Hz, Ultra Low Frequency - less than 0.003 Hz. In total, this frequency spectrum forms the total electromagnetic power of the heart - Total Power [65]-[69].

The resonant frequency for the heart is 1 Hertz, for the stomach it is 2-3 Hz [70], [71], for the intestines it is 2-4 Hz [72], [73]. Peristaltic contractions of the intestine occur in such ranges as Three frequency modes are available for auscultation: bell (20-200 Hz), diaphragm (100-500 Hz), and extended range (20-1000 Hz) [74], [75]. The operating frequency of kidney function is the range of 6-8 Hz [76], etc.

The question arises, what is the practical significance of the frequency-wave model of the structure of the human body? Why is it needed in complex medicine? The answer is obvious: if we know that life is an electromagnetic process, the metabolism of chemical reactions is the result of electromagnetic processes, disease is a violation of electromagnetic processes, death is their cessation, then the frequency-wave component of cell functioning is an objective physical parameter of this measure of the electromagnetic phenomenon of functioning tissue cells of the human body. Knowing the normal frequency of functioning of cells or an organ, the doctor can objectively, from a scientific point of view, with the appropriate equipment, assess this condition for the organ. This gives scientific theoretical validity to use frequency parameters of the functioning of tissues and organs for diagnostics. This is the next aspect of “Bioelectronic Medicine”:

*Aspect No. 6. The frequency-wave characteristic of an atom, cell, tissue, organ, process (etc., according to the hierarchical level of the structure of the human body) is an objective physical parameter that can be a diagnostic criterion in “Bioelectronic Medicine”.*

*Thesis of the aspect: The frequency of functioning of a biological object is a diagnostic criterion.*

This principle has already found, to a certain extent, its practical implementation in traditional medicine as the physical basis of the nuclear magnetic resonance method [52], [77]. In 1952, Felix Bloch and Edward Mills Purcell (USA) received the Nobel Prize in Physics for the discovery of the phenomenon of nuclear magnetic resonance [78]. In 2003, Paul C. Lauterbur (USA) and Sir Peter Mansfield (UK) received the Nobel Prize in Physiology or Medicine for the development of the diagnostic method of magnetic resonance imaging [79]. However, the ideas from this aspect of Bioelectronic Medicine can be used more widely in practical healthcare. After all, it turns out that according to modern scientific views, substances (for example, trace elements, vitamins,

hormones, etc.), types of cells and tissues (for example, microorganisms, cancer cells, etc.), metabolic processes in the human body can be verified by the total frequency component of their own metabolic processes using special diagnostic equipment that allows recording the phenomenon of resonance [52], [80]. It is quite logical to conclude that each healthy tissue and each healthy organ is characterized by a set of natural frequencies of their normal functioning. These frequency components are of fundamental physiological importance, since they are a component of intercellular signaling and electromagnetic communication between tissues *in vivo* [36], [42], [81]-[84]. Apparently, at different structural levels of the organization of the human body, frequency-wave processes become more complex and are an information component.

Heart rhythm is an example that confirms at the organism level the correctness of the logic of these conclusions. So, heart rate is a systemic information process for the body, the wave vibrations of which carry information about the state of the body. Assessment of heart rate variability is a scientifically proven valid diagnostic criterion for the functional state of the whole organism and an established predictor for the diagnosis of sudden cardiac death [68], [85]-[87]. With pathology, the frequency components of the heart rhythm change. This can be confirmed and clinically assessed by analyzing the electrocardiogram using spectral analysis of a short recording of heart rate variability [65]-[69].

Thus, medicine currently has the opportunity to go further: analyze the frequency components of the work of organs and consider the information received as a component. And this is a fundamentally new look at the functional state of organs, which allows us to objectively assess the fundamental electromagnetic processes of organ functioning. And to assess the basic electromagnetic processes of cells means to assess the tissue level of metabolism in them intravitaly. This is very important for practical healthcare, since it opens up the possibility of rapid non-invasive early diagnosis of pathology of internal organs in a family doctor's office. This is so because when pathological conditions occur in cells, there will be a deviation from the frequency spectrum of their normal functioning. This deviation can be recorded using wave-frequency diagnostic techniques and become an additional objective diagnostic criterion [88]-[90]. According to the literature data available to us, over the past 100 years, a large layer of scientific and practical data has been accumulated on various methods of frequency-wave diagnostics. For example, the scientific results of the Electro-Acupuncture method according to Voll, Electro-Dermal Screening (EDS) or Meridian Stress Assessment (MSA) (author German doctor Dr. Reinhard Voll, MD) now deserve modern analysis from the perspective of bioelectronic medicine [91]-[94]. Of significant scientific interest are Nakatani Diagnostic (Ryodoraku) (author Japanese Japan prof. Yoshio Nakatani) [95], studies by Royal Raymond Rife [88], [96], etc. These data require further study, systemic analysis and integration into comprehensive medicine, subject to their validity. The results of these studies can receive a new modern interpretation after their systematic analysis through the prism of modern biophysical knowledge.

All of the above can be of great practical value for the diagnosis of infectious diseases. It is common knowledge that the human body consists of 30 trillion cells. At the same time, the human body contains 40-50 trillion cells of other microorganisms that are not related to the human body itself and are called the Microbiome. It has now been proven that the composition of the microbiome determines key life processes of the human body: from the processes of digestion and assimilation of food to complex immune responses and influence on higher nervous activity of a person [97], [98]. But there are also pathogens in the human body. Therefore, in the future, the widespread introduction of wave-frequency diagnostic methods into healthcare could simplify their diagnosis. Therefore, studies to determine the radiation spectrum of microorganisms [88]-[100] deserve attention, further analysis and use in complex treatment to overcome the problems of antibiotic resistance and increase the effectiveness of traditional antibacterial therapy.

Does Bioelectronic Medicine have any therapeutic potential? The answer to this question is very important for the further progress of therapeutic approaches in medicine.

Quantum mechanisms of normal functioning of membranes and organelles of organ cells are determined by the energy state of electrons in the atoms of their molecules. The electromagnetic

component is the result of the vital activity of cells and the component of intercellular communication - intercellular signaling [30], [84], [101]-[103]. Electromagnetic intercellular signaling links cells together into a single functional whole. Disruption of the process of electromagnetic signaling between cells leads to dysfunction of the tissue and organ. A doctor, using appropriate equipment for electromagnetic influence, can technically help change the frequency of functioning of organ tissues, normalizing it. This will lead to clinical improvement in the patient. This is the next and most important theoretical aspect of "Bioelectronic Medicine":

*Aspect No. 7. The wave-frequency characteristic of an atom, cell, tissue, organ, process is an objective parameter for subsequent treatment in Bioelectronic Medicine.*

*Thesis of the aspect: The frequency of functioning of a biological object is a therapeutic target.*

This aspect has also long had its practical confirmation in healthcare and various techniques have been successfully used in the treatment of patients with pain [104]-[107], rheumatological diseases [107]-[110], depression [61], [111]-[113], etc.

Now, from the position of the frequency-wave model of the body structure, a number of therapeutic methods of alternative medicine, such as treatment with singing bowls, music therapy, color therapy, magnetotherapy, light therapy, etc., can be scientifically explained.

In this theoretical study, we made an attempt to summarize previously disparate clinical areas with modern biophysical views to form a single holistic concept of "Bioelectronic Medicine" and the progress of medicine in general. It turns out that from the perspective of quantum approaches, the health of organ tissues depends on the energy state of the electrons of the atoms of their molecules. The electron is a carrier of energy and therefore it is conventionally understood as the final therapeutic medical goal in the process of treating a patient. Correction of the energy state of electrons of atoms in the tissues of the human body *in vivo* is the main theoretical principle of treating any disease. Therefore, the concept of "Bioelectronic medicine" arose in the scientific literature. Although the correctness of this term can of course be disputed. For example, it is known that the elementary carrier of the electromagnetic field is the photon. Therefore, theoretically, it would be quite acceptable to use the concept of "Biophotonic medicine". But the term "Bioelectronic medicine" already exists in the scientific literature [26], [114]-[117], is understandable to a wide range of scientists, and it is also quite logical. Therefore, it was chosen in the course of this study. The use of this term at the present stage will allow us to sufficiently correctly understand and be correctly understood in the modern world of world science and quantum approaches in medicine.

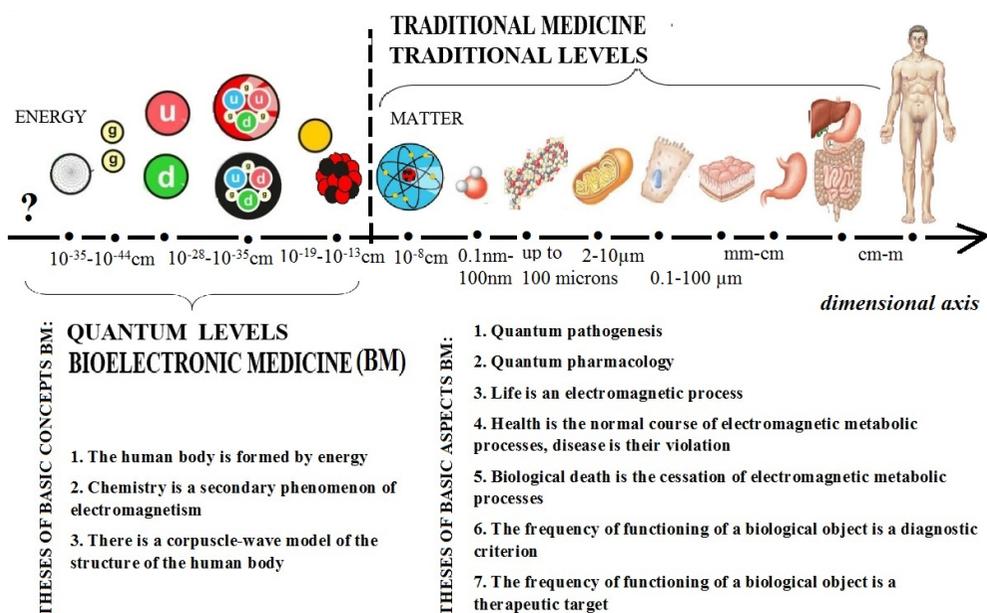
#### 4. Conclusions

1) A new layer of fundamental knowledge in quantum physics has formed the latest trend "Bioelectronic Medicine" for the development of medical science and medical education, which should be actively used by modern medical scientists.

2) "Bioelectronic medicine" is a scientific direction that includes all the fundamental knowledge of the structure and functioning of the human body at the micro level, the further development and use of human treatment taking into account and using this data.

3) Bioelectronic medicine is a new branch of medical knowledge that can organically complement traditional medicine, contribute to medical progress and the formation of a unified universe of medical knowledge in the form of Complex Medicine in the future.

4) The developed basic concepts and aspects of Bioelectronic Medicine in the form of abstracts are presented in Fig. 2, indicating the levels of theoretical concepts of traditional medicine and bioelectronic medicine on the dimensional axis of the structural levels of the organization of the human body.



**Fig. 2.** Diagram of the dimensional axis of the structural levels of the organization of the human body, indicating the levels of theoretical concepts of traditional medicine and bioelectronic medicine, as well as theses of the main basic concepts and aspects of bioelectronic medicine developed in the theoretical study

## Acknowledgements

The authors have not disclosed any funding.

## Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

## Author contributions

Conceptualization, Ganna Nevoit, Inga Bumblyte, Maksim Potyazhenko, Ozar Minser and Alfonsas Vainoras; Data curation, Inga Bumblyte; Investigation, Ganna Nevoit and Olena Filiunova; Methodology, Inga Bumblyte, Ozar Minser and Alfonsas Vainoras; Project administration, Alfonsas Vainoras; Resources, Inga Bumblyte; Supervision, Inga Bumblyte, Maksim Potyazhenko, Ozar Minser and Alfonsas Vainoras; Visualization, Ganna Nevoit; Writing – original draft, Ganna Nevoit and Olena Filiunova; Writing – review & editing, Inga Bumblyte, Maksim Potyazhenko, Ozar Minser and Alfonsas Vainoras.

## Conflict of interest

The authors declare that they have no conflict of interest.

## Ethics statement

The results of the theoretical study, which are presented in the manuscript of the article, were obtained based on the analysis fundamental knowledge. No studies have been conducted on humans or animals. It is a fragment research work of the Department of Internal Medicine and Emergency Medicine Poltava State Medical University (Ukraine, Shevchenko St., 23, 36001) state registration number 0121U108237: UDC 613 616-056-06: 616.1 / 9-03 and completed jointly with

the Lithuanian University of Health Sciences (A. Mickiavičiūsa St., 9, LT-44307, Kaunas, Lithuania) according to the memorandum of support dated May 12, 2022.

This research work has ethical approval. (Ethic Committee Name: Commission on Ethical Issues of Biomedical Ethics of Poltava State Medical University, Approval Code: 202, Approval Date: 24/02/2022).

## References

- [1] The Lancet, “Non-communicable diseases: what now?,” *The Lancet*, Vol. 399, No. 10331, p. 1201, Mar. 2022, [https://doi.org/10.1016/s0140-6736\(22\)00567-0](https://doi.org/10.1016/s0140-6736(22)00567-0)
- [2] D. Kostova, P. Richter, G. van Vliet, M. Mahar, and R. L. Moolenaar, “The role of noncommunicable diseases in the pursuit of global health security,” *Health Security*, Vol. 19, No. 3, pp. 288–301, Jun. 2021, <https://doi.org/10.1089/hs.2020.0121>
- [3] D. Chinemerem Nwobodo et al., “Antibiotic resistance: The challenges and some emerging strategies for tackling a global menace,” *Journal of Clinical Laboratory Analysis*, Vol. 36, No. 9, Aug. 2022, <https://doi.org/10.1002/jcla.24655>
- [4] “Antibiotics resistance.” World Health Organization, <https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance> (accessed 2023).
- [5] C. J. L. Murray et al., “Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis,” *The Lancet*, Vol. 399, No. 10325, pp. 629–655, Feb. 2022, [https://doi.org/10.1016/s0140-6736\(21\)02724-0](https://doi.org/10.1016/s0140-6736(21)02724-0)
- [6] M. Adan, C. Gillies, F. Tyrer, and K. Khunti, “The multimorbidity epidemic: challenges for real-world research,” *Primary Health Care Research and Development*, Vol. 21, p. e6, Mar. 2020, <https://doi.org/10.1017/s146342361900094x>
- [7] C. J. M. Whitty et al., “Rising to the challenge of multimorbidity,” *BMJ*, Vol. 368, p. l6964, Jan. 2020, <https://doi.org/10.1136/bmj.l6964>
- [8] J. Pearson-Stuttard, M. Ezzati, and E. W. Gregg, “Multimorbidity—a defining challenge for health systems,” *The Lancet Public Health*, Vol. 4, No. 12, pp. e599–e600, Dec. 2019, [https://doi.org/10.1016/s2468-2667\(19\)30222-1](https://doi.org/10.1016/s2468-2667(19)30222-1)
- [9] Anne D. Halli-Tierney, Catherine Scarbrough, and Dana Carroll, “Polypharmacy: evaluating risks and deprescribing,” *American Family Physician*, Vol. 100, No. 1, pp. 32–38, Jul. 2019.
- [10] L. Ye et al., “Factors associated with polypharmacy and the high risk of medication-related problems among older community-dwelling adults in European countries: a longitudinal study,” *BMC Geriatrics*, Vol. 22, No. 1, pp. 1–13, Nov. 2022, <https://doi.org/10.1186/s12877-022-03536-z>
- [11] N. Sultan and D. Swinglehurst, “Living with polypharmacy: a narrative interview study with older Pakistanis in East London,” *BMC Geriatrics*, Vol. 23, No. 1, pp. 1–12, Nov. 2023, <https://doi.org/10.1186/s12877-023-04392-1>
- [12] V. M. Bobirev et al., *Side Effects of Medications*. Ukraine: Nova knyga, 2023.
- [13] Kirkwood and T. B. L., “The most pressing problem of our age,” *BMJ*, Vol. 326, No. 7402, pp. 1297–1299, Jun. 2003, <https://doi.org/10.1136/bmj.326.7402.1297>
- [14] M. V. Blagosklonny, “Disease or not, aging is easily treatable,” *Aging*, Vol. 10, No. 11, pp. 3067–3078, Nov. 2018, <https://doi.org/10.18632/aging.101647>
- [15] M. Keshavarz, K. Xie, K. Schaaf, D. Bano, and D. Ehninger, “Targeting the “hallmarks of aging” to slow aging and treat age-related disease: fact or fiction?,” *Molecular Psychiatry*, Vol. 28, No. 1, pp. 242–255, Jul. 2022, <https://doi.org/10.1038/s41380-022-01680-x>
- [16] J. D. Wells, *SpringerBriefs in Physics*. Cham: Springer International Publishing, 2020, <https://doi.org/10.1007/978-3-030-38204-9>
- [17] P. Paganini, *Fundamentals of Particle Physics: Understanding the Standard Model*. Cambridge University Press, 2023.
- [18] T. Hübsch, *Advanced Concepts in Particle and Field Theory*. Cambridge University Press, 2015, <https://doi.org/10.1017/cbo9781316160725>
- [19] Y. Cao et al., “Quantum chemistry in the age of quantum computing,” *Chemical Reviews*, Vol. 119, No. 19, pp. 10856–10915, Oct. 2019, <https://doi.org/10.1021/acs.chemrev.8b00803>
- [20] V. P. Gupta, *Principles and Applications of Quantum Chemistry*. Academic Press, 2016.
- [21] A. Marais et al., “The future of quantum biology,” *Journal of The Royal Society Interface*, Vol. 15, No. 148, p. 20180640, Nov. 2018, <https://doi.org/10.1098/rsif.2018.0640>

- [22] G. R. Fleming, G. D. Scholes, and Y.-C. Cheng, "Quantum effects in biology," *Procedia Chemistry*, Vol. 3, No. 1, pp. 38–57, Jan. 2011, <https://doi.org/10.1016/j.proche.2011.08.011>
- [23] V. N. Binhi and A. B. Rubin, "Theoretical Concepts in Magnetobiology after 40 Years of Research," *Cells*, Vol. 11, No. 2, p. 274, Jan. 2022, <https://doi.org/10.3390/cells11020274>
- [24] S. Sindhvani and W. C. W. Chan, "Nanotechnology for modern medicine: next step towards clinical translation," *Journal of Internal Medicine*, Vol. 290, No. 3, pp. 486–498, Mar. 2021, <https://doi.org/10.1111/joim.13254>
- [25] O. P. Minser, M. M. Potiazhenko, and G. V. Nevoit, "Evaluation of the human bioelectromagnetic field in medicine: the development of methodology and prospects are at the present scientific stage," *Wiadomości Lekarskie*, Vol. 72, No. 5, pp. 1117–1121, Jan. 2019, <https://doi.org/10.36740/wlek201905231>
- [26] S. Gibney, J. M. Hicks, A. Robinson, A. Jain, P. Sanjuan-Alberte, and F. J. Rawson, "Toward nanobioelectronic medicine: Unlocking new applications using nanotechnology," *WIREs Nanomedicine and Nanobiotechnology*, Vol. 13, No. 3, Jan. 2021, <https://doi.org/10.1002/wnan.1693>
- [27] K. A. Peacock, *The Quantum Revolution*. Greenwood: Publishing Group, 2008.
- [28] O. P. Minser, M. M. Potyazhenko, and G. V. Nevoit, *Magnetochemical Theory of Metabolism. Volume 1 Conceptualization*. (in Ukraine), Kyiv-Poltava: Interservice, 2021.
- [29] Erwin Schrödinger, *What is Life? The Physical Aspect of the Living Cell*. Cambridge: University Press, 1944.
- [30] H. Frohlich and F. Kremer, *Coherent Excitations in Biological Systems*. Berlin: Springer-Verlag, 1985.
- [31] K. Yamanouchi, *Quantum Mechanics of Molecular Structures*. Berlin, Heidelberg: Springer Berlin Heidelberg, 2012, <https://doi.org/10.1007/978-3-642-32381-2>
- [32] J. Mehra, "Quantum Mechanics and the explanation of life: the inclusion of human consciousness in quantum physics recognizes mind as the primary reality: will a new science arise that can harmonize quantum physics and biology?," *American Scientist*, Vol. 61, No. 6, pp. 722–728, 2021.
- [33] K. M. Merz, "Using quantum mechanical approaches to study biological systems," *Accounts of Chemical Research*, Vol. 47, No. 9, pp. 2804–2811, Sep. 2014, <https://doi.org/10.1021/ar5001023>
- [34] *Encyclopedia of Physical Science and Technology*. Elsevier, 2001.
- [35] O. P. Mintser, V. V. Semenets, M. Potiazhenko, P. Podpruzhnykov, and G. V. Nevoit, "The study of the electromagnetic component of the human body as a diagnostic indicator in the examination of patients with non-communicable diseases: problem statement," *Wiadomości Lekarskie*, Vol. 73, No. 6, pp. 1279–1283, Jan. 2020, <https://doi.org/10.36740/wlek202006139>
- [36] G. Nevoit, I. A. Bumblyte, M. Potyazhenko, O. Minser, and A. Vainoras, "Modern biophysical view of electromagnetic processes of the phenomenon of life of living biological systems as a promising basis for the development of complex medicine: the role of biophotons," *Journal of Complexity in Health Sciences*, Vol. 6, No. 1, pp. 1–15, Jun. 2023, <https://doi.org/10.21595/chs.2023.23443>
- [37] M. K. Gaillard, P. D. Grannis, and F. J. Sciulli, "The standard model of particle physics," *Reviews of Modern Physics*, Vol. 71, No. 2, 1999.
- [38] B. C. Chauhan, M. Picariello, J. Pulido, and E. Torrente-Lujan, "Quark-lepton complementarity, neutrino and standard model data predict ( $\theta_{13} \text{PMNS} = 9+1-2$ )," *European Physical Journal*, No. 3, pp. 573–578, 2007.
- [39] B. Carithers and P. Grannis, "Discovery of the top quark," *Beam Line*, Vol. 25, No. 3, pp. 4–16, 1995.
- [40] M. Cifra, J. Pokorný, D. Havelka, and O. Kučera, "Electric field generated by axial longitudinal vibration modes of microtubule," *Biosystems*, Vol. 100, No. 2, pp. 122–131, May 2010, <https://doi.org/10.1016/j.biosystems.2010.02.007>
- [41] Davies and P. C. W., "Does quantum mechanics play a non-trivial role in life?," *Biosystems*, Vol. 78, No. 1-3, pp. 69–79, Dec. 2004, <https://doi.org/10.1016/j.biosystems.2004.07.001>
- [42] R. K. Adair, "Vibrational resonances in biological systems at microwave frequencies," *Biophysical Journal*, Vol. 82, No. 3, pp. 1147–1152, Mar. 2002, [https://doi.org/10.1016/s0006-3495\(02\)75473-8](https://doi.org/10.1016/s0006-3495(02)75473-8)
- [43] G. Nevoit, I. A. Bumblyte, M. Potyazhenko, and O. Minser, "Modern biophysical view of electromagnetic processes of the phenomenon of life of living biological systems as a promising basis for the development of complex medicine: the role of cell membranes," *Journal of Complexity in Health Sciences*, Vol. 5, No. 1, pp. 22–34, Jun. 2022, <https://doi.org/10.21595/chs.2022.22787>
- [44] O. P. Mintser, M. Potiazhenko, A. L. Vainoras, I. B. Bumblyte, and G. V. Nevoit, "Informational analytical representations of the magneto-electrochemical theory of metabolism, life and health," *Ukrainian Journal of Medicine, Biology and Sports*, Vol. 7, No. 5, pp. 232–246, Nov. 2022, <https://doi.org/10.26693/jmbs07.05.232>

- [45] G. V. Nevoit, "Magneto-electrochemical concept of metabolism: postulates and main conclusions. Part 1.," (in Ukrainian), *Bulletin of the Ukrainian Medical Dental Academy*, Vol. 21, No. 1, pp. 203–209, Mar. 2021, <https://doi.org/10.31718/2077-1096.21.1.203>
- [46] O. P. Mintser, M. M. Potiazhenko, and G. V. Nevoit, "Informational analytical representations of the magneto-electrochemical theory of life and health," *Journal of Applied Interdisciplinary Research*, Vol. 2, No. Special Issue, pp. 72–79, Jan. 2023, <https://doi.org/10.25929/38d5-p759>
- [47] R. Nowak, *Theoretical Concepts of Quantum Mechanics*. Scitus Academics, 2012.
- [48] P. J. Shepherd, *A Course in Theoretical Physics*. Wiley, 2013, <https://doi.org/10.1002/9781118516911>
- [49] E. Butikov. "Precession and nutation of a gyroscope," <https://mriquestions.com/why-precession.html>.
- [50] A. Mohorič, G. Planinšič, M. Kos, A. Duh, and J. Stepišnik, "Magnetic resonance imaging system based on earth's magnetic field," *Instrumentation Science and Technology*, Vol. 32, No. 6, pp. 655–667, Dec. 2004, <https://doi.org/10.1081/ci-200037034>
- [51] S. A. Huettel, A. W. Song, and G. McCarthy, *Functional Magnetic Resonance Imaging*. Oxford University Press, 2014.
- [52] Jason A. Koutcher and C. Tyler Burt, "Principles of nuclear magnetic resonance," *Journal of Nuclear Medicine*, Vol. 25, No. 1, pp. 101–111, Jan. 1984.
- [53] Y.-S. Lee, *Principles of Terahertz Science and Technology*. New York: Springer, 2009, <https://doi.org/10.1007/978-0-387-09540-0>
- [54] G. J. Wilmink and J. E. Grundt, "Invited review article: current state of research on biological effects of terahertz radiation," *Journal of Infrared, Millimeter, and Terahertz Waves*, Vol. 32, No. 10, pp. 1074–1122, Jun. 2011, <https://doi.org/10.1007/s10762-011-9794-5>
- [55] H. Hintzsche and H. Stopper, "Effects of terahertz radiation on biological systems," *Critical Reviews in Environmental Science and Technology*, Vol. 42, No. 22, pp. 2408–2434, Jan. 2012, <https://doi.org/10.1080/10643389.2011.574206>
- [56] J. Son, *Terahertz Biomedical Science and Technology*. Boca Raton: CRC Press, 2014.
- [57] O. P. Cherkasova et al., "Cellular effects of terahertz waves," *Journal of Biomedical Optics*, Vol. 26, No. 9, p. 090902, Sep. 2021, <https://doi.org/10.1117/1.jbo.26.9.090902>
- [58] R. Vanwijk, "Bio-photons and Bio-communication," *Journal of Scientific Exploration*, Vol. 15, No. 2, pp. 183–197, 2001.
- [59] F.-A. Popp, K. H. Li, and Q. Gu, *Recent Advances in Biophoton Research and Its Applications*. Singapore: World Scientific Publishing, 1992, <https://doi.org/10.1142/1559>
- [60] H. J. Niggli, "Biophotons: ultraweak light impulses regulate life processes in aging," *Journal of Gerontology and Geriatric Research*, Vol. 3, No. 2, Jan. 2014, <https://doi.org/10.4172/2167-7182.1000143>
- [61] E. Basar and T. H. Bullock, *Induced Rhythms in the Brain*. Boston, MA: Birkhäuser Boston, 2012, <https://doi.org/10.1007/978-1-4757-1281-0>
- [62] G. Buzsáki and B. O. Watson, "Brain rhythms and neural syntax: implications for efficient coding of cognitive content and neuropsychiatric disease," *Dialogues in Clinical Neuroscience*, Vol. 14, No. 4, pp. 345–367, Dec. 2012, <https://doi.org/10.31887/dcms.2012.14.4/gbuzsaki>
- [63] G. Buzsáki, *Rhythms of the Brain*. Oxford University Press, 2006, <https://doi.org/10.1093/acprof:oso/9780195301069.001.0001>
- [64] J. Gross, "Magnetoencephalography in Cognitive Neuroscience: A Primer," *Neuron*, Vol. 104, No. 2, pp. 189–204, Oct. 2019, <https://doi.org/10.1016/j.neuron.2019.07.001>
- [65] G. V. Nevoit, Potiazhenko, P. Mintser, N. I. Ignatenko, and Y. Kabernik, "Bioelectrical impedance determining body composition and hardware-software recording of heart rate variability during an Objective Structured Clinical Examination as a diagnostic tool," *World of Medicine and Biology*, Vol. 16, No. 72, pp. 089–93, Jan. 2020, <https://doi.org/10.26724/2079-8334-2020-2-72-89-93>
- [66] G. V. Nevoit, Potiazhenko, P. Mintser, and L. Y. Babintseva, "Electro-photonic emission analysis and hardware-software recording of heart rate variability during an objective structured clinical examination," *World of Medicine and Biology*, Vol. 16, No. 74, pp. 107–111, Jan. 2020, <https://doi.org/10.26724/2079-8334-2020-4-74-107-111>
- [67] G. V. Nevoit, Potiazhenko, and P. Mintser, "Assessment of the functional types of body mobilization based on a dynamic analysis of spectral indicators of heart rate variability and their classification," *World of Medicine and Biology*, Vol. 16, No. 73, pp. 077–81, Jan. 2020, <https://doi.org/10.26724/2079-8334-2020-3-73-77-81>

- [68] O. P. Mintser, M. M. Potiazhenko, and G. V. Nevoit, "Short Recording of Heart Rate Variability in the Objective Structured Clinical Examination of the patients, textbook," (in Ukraine) in *Systemic Medicine*, Kyiv-Poltava: Intermedservice, 2022.
- [69] R. Castaldo, L. Montesinos, P. Melillo, C. James, and L. Pecchia, "Ultra-short term HRV features as surrogates of short term HRV: a case study on mental stress detection in real life," *BMC Medical Informatics and Decision Making*, Vol. 19, No. 1, pp. 1–13, Jan. 2019, <https://doi.org/10.1186/s12911-019-0742-y>
- [70] J. Chen, R. W. McCallum, and R. Richards, "Frequency components of the electrogastrogram and their correlations with gastrointestinal contractions in humans," *Medical and Biological Engineering and Computing*, Vol. 31, No. 1, pp. 60–67, Jan. 1993, <https://doi.org/10.1007/bf02446895>
- [71] P.L. Rhee et al., "Analysis of pacemaker activity in the human stomach," *The Journal of Physiology*, Vol. 589, No. 24, pp. 6105–6118, Dec. 2011, <https://doi.org/10.1113/jphysiol.2011.217497>
- [72] I. G. Khorbenko, *Sound, Ultrasound, Infrasound*. (in Russia), Moscow: Knowledge.
- [73] V. S. Lesovik, I. L. Pershina, and D. A. Degtyarev, "The role of architectural geonics in creating an architectural space," (in Russia), *IOP Conference Series: Materials Science and Engineering*, Vol. 463, p. 042060, Dec. 2018, <https://doi.org/10.1088/1757-899x/463/4/042060>
- [74] S. S. Ching, "Spectral analysis of bowel sounds in intestinal obstruction using an electronic stethoscope," *World Journal of Gastroenterology*, Vol. 18, No. 33, pp. 4585–4592, Jan. 2012, <https://doi.org/10.3748/wjg.v18.i33.4585>
- [75] X. Du et al., "A mathematical model of bowel sound generation," *The Journal of the Acoustical Society of America*, Vol. 144, No. 6, pp. EL485–EL491, Dec. 2018, <https://doi.org/10.1121/1.5080528>
- [76] Andrew M. Higgins, Michael J. Wolf, Russell E. N. Becker, and Khurshid R. Ghani, "How I do it: ureteroscopy and high-power holmium laser lithotripsy to treat renal stones," *The Canadian Journal of Urology*, Vol. 30, No. 3, pp. 11574–11582, Jun. 2023.
- [77] S. A. Huettel, A. W. Song, and G. McCarthy, "Functional magnetic resonance imaging," *Yale Journal of Biology and Medicine*, Vol. 88, No. 1, pp. 99–100, 2015.
- [78] "The Nobel Prize in Physics 1952." The Nobel Prize, <https://www.nobelprize.org/prizes/physics/1952/speedread/>.
- [79] "The Nobel Prize in Physiology or Medicine 2003." The Nobel Prize, <https://www.nobelprize.org/prizes/medicine/2003/summary/>
- [80] O. Filyunova, G. Nevoit, M. Potyazhenko, and A. Vainoras, "Bioelectronic Medicine for sports: justification of biophysical mechanisms and clinical feasibility of use," *Fitoterapiia. Chasopys – Phytotherapy*, Vol. 3, pp. 15–18, 2023.
- [81] M. Levin, G. Pezzulo, and J. M. Finkelstein, "Endogenous bioelectric signaling networks: exploiting voltage gradients for control of growth and form," *Annual Review of Biomedical Engineering*, Vol. 19, No. 1, pp. 353–387, Jun. 2017, <https://doi.org/10.1146/annurev-bioeng-071114-040647>
- [82] M. Levin, "Bioelectric signaling: Reprogrammable circuits underlying embryogenesis, regeneration, and cancer," *Cell*, Vol. 184, No. 8, pp. 1971–1989, Apr. 2021, <https://doi.org/10.1016/j.cell.2021.02.034>
- [83] M. Levin, "Endogenous bioelectrical networks store non-genetic patterning information during development and regeneration," *The Journal of Physiology*, Vol. 592, No. 11, pp. 2295–2305, May 2014, <https://doi.org/10.1113/jphysiol.2014.271940>
- [84] R. P. Bajpai, "Quantum coherence of biophotons and living systems," *Indian Journal of Experimental Biology*, Vol. 41, No. 5, pp. 514–527, May 2003.
- [85] S.-C. Fang, Y.-L. Wu, and P.-S. Tsai, "Heart rate variability and risk of all-cause death and cardiovascular events in patients with cardiovascular disease: a meta-analysis of cohort studies," *Biological Research for Nursing*, Vol. 22, No. 1, pp. 45–56, Sep. 2019, <https://doi.org/10.1177/1099800419877442>
- [86] F. Sessa et al., "Heart rate variability as predictive factor for sudden cardiac death," *Aging*, Vol. 10, No. 2, pp. 166–177, Feb. 2018, <https://doi.org/10.18632/aging.101386>
- [87] M. T. La Rovere et al., "Short-term heart rate variability strongly predicts sudden cardiac death in chronic heart failure patients," *Circulation*, Vol. 107, No. 4, pp. 565–570, Feb. 2003, <https://doi.org/10.1161/01.cir.0000047275.25795.17>
- [88] N. Sylver, *The Rife Handbook of Frequency Therapy and Holistic Health Hardcover*. Desert Gate, 2011.
- [89] C. Vértési, *Infectious Disease Treatment with Radio Frequency Resonance*. Washington: Alterra, 2004.

- [90] S. Dörfler, *Neue Lebenskraft durch Bioresonanz. Diagnose, Therapie, Lebensweise*. SIMONDO Gesundheitservice, 2002.
- [91] R. Voll, *Topographic Positions of the Measurement Points in Electro-Acupuncture, Textual and Illustrated Volume III*. Medizinisch Literarische Verlagsgesellschaft, 1977.
- [92] J. Scott-Morley and R. Voll, *The 850 EAV Measurement Points of the Meridians and Vessels including Secondary Vessels*. Germany: Medicina Biologica, 1983.
- [93] R. Voll, *Interrelations of Odontons and Tonsils to Organs, Fields of Disturbance, and Tissue Systems*. Medizinisch Literarische Verlagsgesellschaft, 1978.
- [94] R. Voll and H. Schuldt, *Medicina Biologica*. 1977.
- [95] M. Hyodo, "Introduction for Ryodoraku treatment," in *1st International Ryodoraku Congress*, 1988.
- [96] "Rife machine history," <https://www.bionuu.com/rife/>
- [97] E. Rackaityte and S. V. Lynch, "The human microbiome in the 21st century," *Nature Communications*, Vol. 11, No. 1, pp. 1–3, Oct. 2020, <https://doi.org/10.1038/s41467-020-18983-8>
- [98] L. K. Ursell, J. L. Metcalf, L. W. Parfrey, and R. Knight, "Defining the human microbiome," *Nutrition Reviews*, Vol. 70, No. suppl\_1, pp. S38–S44, Aug. 2012, <https://doi.org/10.1111/j.1753-4887.2012.00493.x>
- [99] H. R. Clark, *The Cure for All Diseases*. United States by New Century Press, 2011.
- [100] C. Vertesi, *The Use of Radiofrequency in the Medicine*. Budapest, 2010.
- [101] M. Cifra, J. Z. Fields, and A. Farhadi, "Electromagnetic cellular interactions," *Progress in Biophysics and Molecular Biology*, Vol. 105, No. 3, pp. 223–246, May 2011, <https://doi.org/10.1016/j.pbiomolbio.2010.07.003>
- [102] A. S. Davydov, "Solitons as energy carries in biological systems," *Studia Biophysica*, Vol. 62, No. 1, pp. 1–8, 1977, [https://doi.org/10.1007/978-3-662-08994-1\\_2.pdf](https://doi.org/10.1007/978-3-662-08994-1_2.pdf)
- [103] H. Fröhlich, "Long-range coherence and energy storage in biological systems," *International Journal of Quantum Chemistry*, Vol. 2, No. 5, pp. 641–649, Oct. 2004, <https://doi.org/10.1002/qua.560020505>
- [104] F. A. Abdulla, S. Alsaadi, M. Sadat-Ali, F. Alkhamis, H. Alkawaja, and S. Lo, "Effects of pulsed low-frequency magnetic field therapy on pain intensity in patients with musculoskeletal chronic low back pain: study protocol for a randomised double-blind placebo-controlled trial," *BMJ Open*, Vol. 9, No. 6, p. e024650, Jun. 2019, <https://doi.org/10.1136/bmjopen-2018-024650>
- [105] K. A. Alzayed and S. M. Alsaadi, "Efficacy of pulsed low-frequency magnetic field therapy on patients with chronic low back pain: a randomized double-blind placebo-controlled trial," *Asian Spine Journal*, Vol. 14, No. 1, pp. 33–42, Feb. 2020, <https://doi.org/10.31616/asj.2019.0043>
- [106] A. S. Arneja, A. Kotowich, D. Staley, R. Summers, and P. S. Tappia, "Electromagnetic fields in the treatment of chronic lower back pain in patients with degenerative disc disease," *Future Science OA*, Vol. 2, No. 1, Mar. 2016, <https://doi.org/10.4155/fsoa-2015-0019>
- [107] C. Wild, *Bioresonance Therapy for Allergies, Atopic Dermatitis, Non-Organic Gastrointestinal Complaints, Pain and Rheumatic Diseases: Systematic Review*. Vienna: Ludwig Boltzmann Gesellschaft GmbH, 2009.
- [108] G. Barassi, "Fibromyalgia and therapeutic integration: role of quantum medicine," *Journal of Biological Regulators and Homeostatic Agents*, Vol. 34, No. 3, pp. 1193–1197, Jun. 2020, <https://doi.org/10.23812/20-165-l-31>
- [109] A. Kanashiro, G. S. Bassi, F. Queiróz Cunha, and L. Ulloa, "From neuroimmunomodulation to bioelectronic treatment of rheumatoid arthritis," *Bioelectronics in Medicine*, Vol. 1, No. 2, pp. 151–165, May 2018, <https://doi.org/10.2217/bem-2018-0001>
- [110] A. Trofè et al., "Effect of pulsed electromagnetic fields (PEMFs) on muscular activation during cycling: a single-blind controlled pilot study," *Healthcare*, Vol. 11, No. 6, p. 922, Mar. 2023, <https://doi.org/10.3390/healthcare11060922>
- [111] C. K. Loo et al., "High (15 Hz) and low (1 Hz) frequency transcranial magnetic stimulation have different acute effects on regional cerebral blood flow in depressed patients," *Psychological Medicine*, Vol. 33, No. 6, pp. 997–1006, Jul. 2003, <https://doi.org/10.1017/s0033291703007955>
- [112] S. Rizvi and A. M. Khan, "Use of transcranial magnetic stimulation for depression," *Cureus*, Vol. 11, No. 5, May 2019, <https://doi.org/10.7759/cureus.4736>
- [113] Z. Nahas et al., "Safety and benefits of distance-adjusted prefrontal transcranial magnetic stimulation in depressed patients 55-75 years of age: a pilot study," *Depression and Anxiety*, Vol. 19, No. 4, pp. 249–256, Jan. 2004, <https://doi.org/10.1002/da.20015>
- [114] C. Sevencu, "Single-interface bioelectronic medicines-concept, clinical applications and preclinical data," *Journal of Neural Engineering*, Vol. 19, No. 3, p. 031001, Jun. 2022, <https://doi.org/10.1088/1741-2552/ac6e08>

- [115] P. Ganzer and G. Sharma, "Opportunities and challenges for developing closed-loop bioelectronic medicines," *Neural Regeneration Research*, Vol. 14, No. 1, p. 46, Jan. 2019, <https://doi.org/10.4103/1673-5374.243697>
- [116] P. S. Olofsson and K. J. Tracey, "Bioelectronic medicine: technology targeting molecular mechanisms for therapy," *Journal of Internal Medicine*, Vol. 282, No. 1, pp. 3–4, Jun. 2017, <https://doi.org/10.1111/joim.12624>
- [117] P. Sanjuan-Alberte, M. R. Alexander, R. J. M. Hague, and F. J. Rawson, "Electrochemically stimulating developments in bioelectronic medicine," *Bioelectronic Medicine*, Vol. 4, No. 1, pp. 1–7, Mar. 2018, <https://doi.org/10.1186/s42234-018-0001-z>



**Ganna Nevoit**, Ph.D., Associate Professor, Physician-therapist in the specialty "Therapy", Associate Professor of the Department of Internal Medicine and Emergency Medicine of the Poltava State Medical University (Ukraine), Assistant of Nephrology Department of the Lithuanian University of Health Sciences (Lithuania).



**Olena Filiunova**, Physician-therapist in the specialty "Therapy", Complex Medicine Specialist, Head of the Preventive Medicine Centre of Genesis Centre LLC (Ukraine).



**Maksim M. Potyazhenko**, MD, Professor, Physician-therapist in the specialty "Therapy", Head of the Department of Internal Medicine and Emergency Medicine of the Poltava State Medical University (Ukraine).



**Ozar P. Mintser**, MD, Professor, Honored Worker of Science and Technology of Ukraine, Honored Innovator of the Ukrainian SSR, Head of the Department of Fundamental Disciplines and Informatics of the Shupyk National Healthcare University of Ukraine.



**Inga Arune Bumblyte**, MD, Professor, Physician-therapist in the specialty "Nephrology", Head of Nephrology Department of the Lithuanian University of Health Sciences (Lithuania), President of Lithuanian Association of Nephrology, Dialysis and Transplantation.



**Alfonsas Vainoras**, MD, Professor, Cardiologist, Biophysicist, Senior Researcher of the Laboratory of Automation of Cardiology Research of the Institute of Cardiology of the Lithuanian University of Health Sciences (Lithuania).