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Magneto-electrochemical theory of metabolism: electromagnetic communication of cells and the role of the extracellular matrix

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A fragment of the results of a theoretical analytical systematisation of existing scientific data on the electromagnetic mechanisms of cellular signaling is presented. This is a continuation of the theoretical development of the magneto-electrochemical theory of metabolism (2019–2025). The aim of the theoretical research was to create a concept of electromagnetic communication of cells, to deepen fundamental knowledge, and to find new promising approaches to solving the problem of chronic noncommunicable diseases. General scientific methods of system analysis of literature review were applied in the study, which resulted in a working promising model of the concept of electromagnetic cellular communication. The article is focused on biophotonic signaling and the role of the extracellular matrix in its implementation. The research shows that the concept of biophoton signaling is a promising working model for scientific discussion and for further study into the role of electromagnetic fields in the phenomenon of biological cell life *in vivo*. The state of the extracellular matrix is an important biological aspect for the implementation of the phenomena of life and health and the quantum pathogenesis of noncommunicable diseases.

Keywords: noncommunicable diseases, extracellular matrix, biophotons, biophoton signaling, electromagnetic cell communication

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INTRODUCTION

According to the World Health Organisation, chronic noncommunicable diseases (NCDs) have created a global pandemic (WHO, 2024; The Lancet, 2022; Kostova et al., 2021). NCDs are a big medical and social problem and an obstacle to the further economic development of humankind (WHO, 2024; Kundu, Chakraborty, 2023; Andrade et al., 2023; Hambleton et al., 2023). Over the past few decades, world science and the international community have been making efforts to solve them. However, no results have been achieved yet. As NCDs continue to be a challenge for global science and medicine (NCD Alliance, 2024; Noncommunicable Diseases Countdown 2030 collaborators, 2020; Gassner et al., 2022; Mikkelsen et al., 2019), the search for new approaches to solving the problem of NCDs is relevant.

If the problem remains unresolved for a long time, it is worth considering it from a different angle. A new direction for finding solutions to NCDs is further study of fundamental issues of organising the functioning of the human body and other biological organisms at the micro level with a scientist using the latest knowledge of biophysics. This is so because over the past fifty years a significant breakthrough in fundamental science has been achieved in knowledge about the structure of the micro level of matter and insight into the essence of the subatomic world. Based on the Standard Model (Wells, 2020; Paganini, 2023; Hübsch, 2023), this fundamentally new knowledge about the structure of matter is reflected in such new fields as quantum physics (Davies, 2010; Rae, 2004; Schrödinger, 1992), quantum chemistry (Cao et al., 2019; Gupta, 2016), and quantum biology (Marais et al., 2018; Graham et al., 2011). They became a scientific challenge for medical scientists as they required further extrapolation into the medical science. For this purpose, a theoretical study was started to conceptualise the role of electromagnetic fields in the functioning of living organisms and humans. The results obtained became the basis for the conceptualisation of the magneto electrochemical theory of metabolism. Scientific publication of its concepts began in 2019 (Mintser et al., 2021; Mintser et al., 2022; Mintser et al., 2023). Results were published on the participation in electromagnetic processes of the implementation of the phenomenon of biological life of water (Nevoit et al., 2022), cell membranes (Nevoit et al., 2022), biophotons (Nevoit et al., 2023). Prospects for the study of electromagnetic parameters in medicine (Mintser et al., 2020; Nevoit et al., 2021; Nevoit et al., 2020) and in research (Nevoit et al. 2024; Nevoit et al. 2020; Nevoit et al., 2024; Mintser et al., 2019) have been described. Further systematisation and analysis of modern scientific knowledge required the creation of new models of knowledge concepts about the role of electromagnetic communication at the cellular level and at the level of tissues of the bodily organs. A deep understanding of the fundamental mechanisms of these processes can help find new causes, new pathogenetic mechanisms, and new therapeutic targets in the treatment and prevention of NCDs, which can help solve their problem in the future and reduce the burden of NCDs on humanity.

Therefore, to deepen the fundamental knowledge of the pathogenesis of NCDs, the aim of this theoretical study was to systematise knowledge about electromagnetic processes at the cellular level and create a promising concept of electromagnetic communication of cells.

MATERIALS AND METHODS

This theoretical study was a fragment of the educational and scientific project 'Bioelectronic medicine or a different look at medicine', which was carried out under the research topic 'Development of algorithms and technologies for implementing a healthy lifestyle in patients with NCDs based on the study of the functional status' (state registration number 0121U108237) at the Department of Internal Medicine and Emergency Medicine of the Poltava Educational and Scientific Institute of Postgraduate Education State Medical University. Scientists from

the Shupyk National Healthcare University of Ukraine (Kyiv, Ukraine), the Lithuanian University of Health Sciences (Kaunas, Lithuania), and the Kherson State University (Ivano-Frankivsk region, Ukraine) participated in the study under scientific cooperation agreements. General scientific methods of system analysis (dismemberment and integration of elements of the system studied, imaginary experiment, logical, historical research, analysis, induction, deduction and synthesis of knowledge, theory construction method, logical methods, and rules of normative nature) were used.

RESULTS

The system analysis performed resulted in the development of a promising working model of the concept of electromagnetic communication of cells. Central to the concept is the modern knowledge of the role of biophotons/ultraweak photon emission (UPE) in the transfer of energy and information (Paolis et al., 2024; Tong et al., 2024; Nevoit et al., 2023). Therefore, to solve this problem, the concept of biophoton signaling was introduced. Proposed by us, this term unites all processes of intracellular and intercellular electromagnetic communication caused by the transfer of energy and information due to biophotonic mechanisms and with their participation. Biophotons are energy carriers of information in the cell and outside it, that is, they are the basis of electromagnetic biophoton signaling. The concept of biophoton signaling at the cell level is part of the concept of biological medical theory, which could describe the substrate and mechanisms of transmission of electromagnetic communication at the level of organs, organ systems, and the body as a whole (Nevoit et al., 2024).

Schematical representation and description of the concept of biophoton signaling at the cellular level is given in Fig. 1.

According to the presented promising scheme of the model, biophoton signaling in a cell is realised at five conditional levels:

1) the cell nucleus level;

2) the mitochondria level;

3) the level of intracellular matrix and cell membranes;

4) the level of the outer cell membrane;

5) the level of intercellular space and extracellular interaction.

1–2. Biophoton signaling at the level of the cell nucleus and mitochondria. It has been scientifically established that biophotons carry information, and 75% of biophotons in a cell are generated in the molecules of deoxyribonucleic acid (DNA) (Nevoit et al., 2023; Levin, 2021; Levin, 2014; Popp, 2006; Van Wijk, 2001; Scalletta et al., 2001; Popp et al., 1984). The arrangement of bases in DNA provides suitable conditions for the emission of biophotons (Popp et al., 1989; Popp, 2005). The spiral-shaped genetic material in DNA functions like a biological laser (Nevoit et al., 2023; Mintser, et al., 2021; Popp, 2005; Popp et al., 1989). DNA in the nucleus is a storage system for biophotons and a source of forced or spontaneous coherent emission due to its spatial conformation. DNA receives energy in the cell from nutrients in the form of photons (Nevoit et al., 2023; Popp, 2005; Popp et al., 1989). Photons exist in DNA in a Bose-Einstein condensate state. The information density of DNA is 1·109 higher than that of any technical solution known to date (Madl, 2006; Burgos et al., 2017). This leads to a phenomenon that is called the Bose-Einstein condensate. The essence of this is that photons are captured in a 'cryo-trap', compacted, and 'frozen' in time. The stored photons ensure the stability of the DNA molecule. There is a scientific opinion that the 97.98% of inactive human DNA, together with the 'frozen' energy of biophotons, play a key role in organising the 2.02% of genetically expressed DNA. An electromagnetic coherent cell-biological state is established in DNA in the form of a Bose-Einstein condensate, in which photons of the same frequency and phase are aligned with each other. Thus, the range of interaction increases from the microscopic to include macroscopic entities, including cells, organs, and entire organisms (Madl, 2006; Bischof, 1995). This confirms the ideas of Herbert Fröhlich about the biophotonic mechanism of action

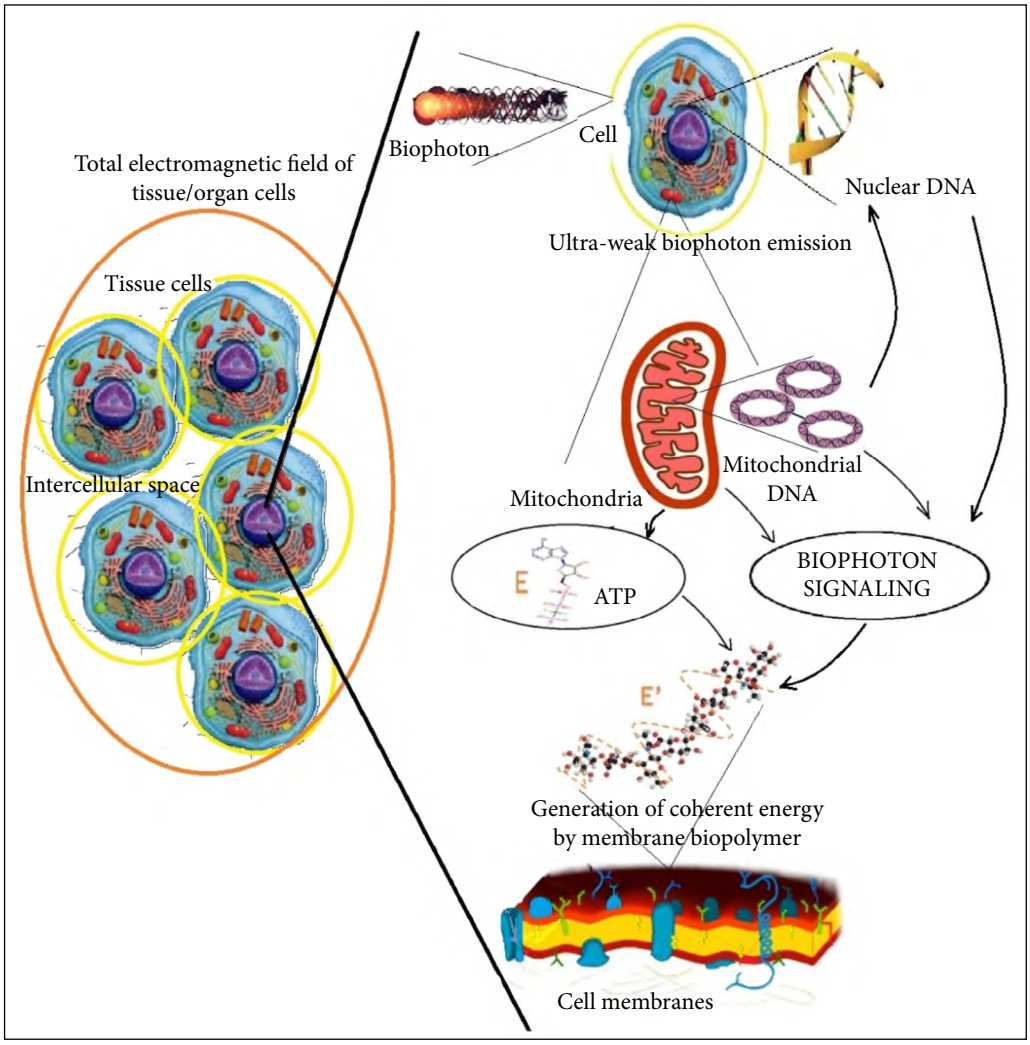

Fig. 1. Perspective scheme of the model of the concept of biophoton signaling at the cellular level

Note: E is the incoherent energy that comes to biopolymers from the universal chemical carrier – the ATP molecule; E' is the coherent energy, which is formed by the oscillatory activity of biopolymers; the yellow circle around the cell is a symbolic representation of the UPE phenomenon; the dotted curve is a symbolic representation of the processes of oscillation of biopolymers.

of DNA, which were presented in science back in the 1950s (Popp, 2006; Popp, Beloussov, 2003; Hyland, 2000; Chang et al., 1998). DNA unwinding during replication causes activation of biophoton emission (Popp et al., 1992; Popp, 2005; Rattemeyer et al., 1981). This has complex mechanisms that continue to be studied. In biological systems, an excited electron-hole pair, or exciton, can travel long distances within the system before releasing energy by emitting a photon. The formation of excitons and their propagation are involved in basic energy transformations and biocommunications. (Bischof, 1995; Van Wijk, 2001). Generation can occur due to the luminescent properties of nucleotides during their cooperative behaviour in DNA and due to the constant supply of energy through metabolic processes (Popp et al., 1992). In general, it should be noted that if the frequency of the vibrational charge is high and approaches the optical part of the spectrum of the electromagnetic field, then

the generated electromagnetic waves begin to exhibit corpuscular properties and form particles of light – biophotons. From the perspective of modern science, biophotons can be considered as gauge bosons, providing at the cell level electromagnetic mechanisms for transmitting information from nuclear DNA to mitochondria in the form of standing waves/Davydov solitons with a wavelength of >1 μm to 0 and energy <0.5 eV to 0. The spectrum of their radiation coincides with the region of the electromagnetic spectrum of the Sun and is significantly lower than the levels of ionization and excitation energies of atoms and molecules. UPE has a range of energy values: 1.67–3.41 eV in all biological organisms and in the human body (Nevoit et al., 2023). DNA is found in the cell nucleus and mitochondria. This is important because mitochondrial DNA also emits biophotons and determines biophotonic mechanisms of intracellular and intercellular signaling. At the same time, the DNA content in mitochondria is very significant due to the fact that normally each cell can contain up to several thousand mitochondria.

Mitochondria are an important organelle for energy production and they make up to 10% of the dry mass of the cell (Nevoit et al., 2024; Casanova et al., 2023; Schon, 2006). Thus, it becomes logical and clear that it is nuclear DNA and mitochondrial DNA that are the main sources of UPE/biophoton signaling. It is logical that a somatic cell, depending on the type of tissue, contains one nucleus, but may contain a different number of mitochondria. Therefore, the quantitative contribution of cells of different tissues to biophoton signaling should differ.

3–4. Biophoton signaling at the level of intracellular matrix, cell membranes. What is the further path of emitted biophotons in a cell *in vivo*? Based on a systematic scientific analysis, it was found that biopolymers of membrane structures are the next stage of biophotonic signaling. Biopolymers receive electromagnetic information from the cell nucleus and mitochondria in the form of biophotons and, based on it, create the parameters of the coherent energy they generate. It can be described in this way (Mintser et al., 2021; Mintser et al., 2023): the generally accepted concept has become the understanding that electrons are transferred by the adenosine triphosphate (ATP) molecule to the biopolymer, move along its chain and, moving from one reaction participant to another, support various endergic biochemical reactions.

The energy migration model is called 'Davydov soliton' (Dauxois, Peyrard, 2006; Bolterauer, 1990; Christiansen et al., 1990). Conceptualising existing knowledge, it can be described as follows: the biophysical mechanism of electron transfer along a chain of biopolymers is an exciton-phonon mechanism for converting the chemical energy of ATP by biopolymers into coherent energy, followed by transmission in the form of a soliton along the biopolymer chain. The physical essence of the mechanism of energy transfer directly through the chains of biopolymers is that the biopolymer converts the incoherent energy of its chemical carrier, the ATP molecule, into a coherent form. This makes it possible for the biopolymer not to waste energy on thermal processes but to transport it non-radiatively further along its chains. In this case, the biopolymer acts as an oscillator-transformer of energy, carrying out coherent transformation of energy thanks to the quantum-mechanical features of the structure of its primary chains, which were formed at the stage of chemical evolution.

It is noteworthy and logical that the physical model of energy transfer was proven by the Soviet scientist Alexander Davydov using a model of the collagen protein. Collagen is a filamentous protein, the content of which is up to 25% of the total amount of protein in a living organism, which is most concentrated in the connective tissue and intercellular space/matrix. Collagen has a length of about 300 nm and a molecular weight of about 285 kDa, with a tertiary structure of the molecule in the form of a right-handed helix, twisted from three polypeptide left-handed alpha helices (Wu et al., 2023; Rahman et al., 2024). This allowed Davydov to consider a fragment of the configuration of this molecule as a one-dimensional chain of dipoles accessible to mathematical

description. The ATP molecule is a universal energy carrier of the body; it provides energy *in vivo* for most energy-dependent reactions and consists of three parts: a nucleic base (adenine), sugar (ribose), and a chain of phosphate groups (Dunn, Grider, 2023). Davydov proved that the energy transferred to collagen by the ATP molecule caused excitation and vibrations of its chain. The amide I groups involved in the excitation, which due to the rigidity of the C=O double bond are capable of only longitudinal vibrations, strain the structure of the molecule within this bond. This local lattice distortion acts as a potential well that localises the vibrational energy and prevents its dispersion. Processes of collective excitation in a one-dimensional chain of dipole peptide groups of mass M are located along the z axis at nodes. In such a chain, the vibrational energy of longitudinal C=O oscillators (amide I), with the help of phonon bonds (vibration bonds of the crystal lattice), acts on neighbouring atomic groups and changes the structure of the chain within C=O. This change causes energy to be captured by the amide I group, preventing further energy dispersion. This phenomenon was called the energy self-channelling effect. The emergence of self-channelisation of energy is associated with a violation of rigidity in the biopolymer chain. 'Flexible' bonds between peptide groups in the C-N, C-C chain determine the minimum values of its longitudinal elasticity æ, while large χ provide for significant interaction between amide I vibrations and phonons. Obtaining a solution for an optical soliton (a soliton that is formed when light or another quantum of an electromagnetic field is absorbed) is the next result of the development of Davydov's theory, which took into account quantum fluctuations of the equilibrium positions of molecules and their thermal vibrations relative to new equilibrium positions. It has been established that in this case, a quasiparticle, which is an electron with a local deformation surrounding it – an electrosoliton – moves from the molecular chain. The stability of the electrosoliton is due to the mutual compensation of the effects of nonlinearity and dispersion in the molecular chain and is most manifested in soft one-dimensional chains of peptide groups in proteins. Always moving at a speed lower than the speed of longitudinal sound, the electric soliton does not emit phonons, that is, it does not lose its energy (Davydov, Alexander, 1982; Davydov, 1977; Davydov, 1974; Davydov, 1973; Nevoit et al., 2022).

The coherent energy created by vibrations of biopolymers, which already has information content from DNA, must be transmitted further in the cell. It was found in the course of a systematic scientific analysis that the electromagnetic coherent biophonic flux/solitons can be transmitted in two main ways (Fig. 2).

Two fundamental discoveries of the 20th century underlie the formulation of this scientific idea. The first discovery was the establishment of the possibility of a soliton transitioning into water without loss of energy thanks to a theoretical solution to the problem for an anharmonic polymer in an electret medium by the Italian scientist Emilio Del Giudice in 1985 (Del Giudice E et al., 2010; Nevoit et al., 2022). The second discovery, made by the Soviet scientist Nikolay A. Bulienkov in the 1980s, was the establishment of the fact and biophysical mechanisms of fractal crystallisation of water in the form of a 31/21 spiral in condensed matter physics (Zheligovskaya, Bulienkov, 2021; Bulienkov, Zheligovskaya, 2017; Bulienkov, Zheligovskaya, 2006; Bulienkov, Zheligovskaya, 2013; Nevoit et al., 2022). Subsequently, these results were generalised in works on collective processes in cells by the Soviet physicist Lidia N. Gall (Mintser et al., 2021).

According to the results of the conceptualisation of the magneto-electrochemical theory of metabolism (2019–2025), the first way of transmitting biophoton signaling is the possibility of transferring the flow of electromagnetic coherent biophoton energy/solitons from biopolymers of membrane structures to water molecules. It has been established that under the influence of this energy flow, water molecules are structured into energy-intensive liquid crystals, which have the shape of a 31/21 spiral (Zheligovskaya, Bulienkov, 2021; Bulienkov,

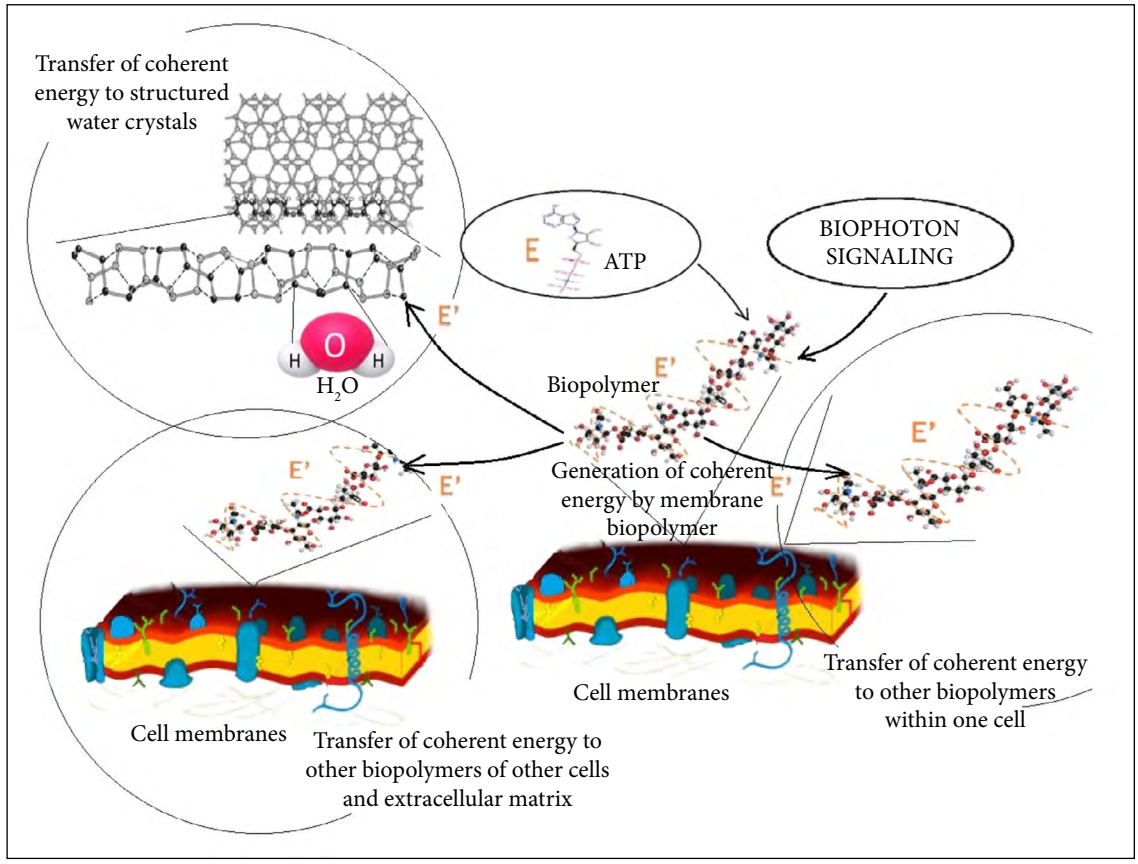

Fig. 2. Scheme of further transfer of coherent energy with a biophoton signal

Note: E is the incoherent energy that comes to biopolymers from the universal chemical carrier – the ATP molecule; E' is coherent energy, which is formed by the oscillatory activity of biopolymers; the dotted curve is a symbolic representation of the processes of oscillation of biopolymers.

Zheligovskaya, 2017; Bulienkov, Zheligovskaya, 2006; Bulienkov, Zheligovskaya, 2013; Mintser et al., 2021; Nevoit et al., 2022). At the same time, water loses its fluidity and acquires special properties of electrical conductivity, which explain the presence of biological anomalies in water in vivo and allow flows of coherent energy to flow through the water structures of the cellular and intercellular spaces without loss (Del Giudice et al., 2010; Mintser et al., 2021, 2023). Thus, the biophysical role of water in the human body is also explained by its participation in the transmission of electromagnetic biophoton signaling at the cellular level.

The second way is the possible transfer of energy and information by biophotons to the biopolymers of membrane structures of other cells. On the one hand, collagen has semiconductor properties and transmits an electromagnetic signal (Giraud-Guille, 1989; Davydov, Alexander, 1982; Davydov, 1977; Davydov, 1974; Davydov, 1973). On the other hand, according to modern biophysical concepts, cell membrane lipoproteins are found in membranes in a state of liquid crystals (Blanco-Fernández et al., 2023; Adwan et al., 2024; Mintser et al., 2023; Mintser et al., 2021; Nevoit et al., 2022). This also creates conditions for the transmission of electromagnetic signals in cell membranes.

5. Biophoton signaling at the level of extracellular space and intercellular interaction. It is important to understand that the coherent energy formed by biopolymers receives information content from the DNA of the cell thanks

to biophotonic signaling and forms the electromagnetic field of the cell (biological morphogenetic field). We are talking about the individual electromagnetic field of the cell. Thanks to this, the total electromagnetic radiation of energy of each cell of the body has a certain level of an energy and information component. In this case, the overall level of energy that the cell will emit will be determined by the intensity of its generation by membrane structures. This, in turn, will be predetermined by the intensity of general metabolic processes in the cell (ATP production, ion and electrolyte exchange, etc.). The energy generated by membrane structures becomes the carrier of the information component. This information component comes to it from biophotons, which are emitted from the nucleus and mitochondria of the cell are capable of changing the vibrational processes in this energy, imputing to it the corresponding information about metabolic processes that they received from DNA.

Cells in the body *in vivo* are conditionally isolated and must constantly communicate with each other in order to adequately perform the functions of the tissue of the organ to which they belong. But how does an individual somatic cell learn about its functions in the process of its ontogenesis? What initially forms and supports the features of its morphological development? Why do somatic cells that initially have the same genome exhibit fundamentally different scenarios of differentiation and morphological development depending on their localisation? What else affects them if the composition of blood and lymph is approximately the same throughout the body? What else influences them if the impulses from the central nervous system and the autonomic nervous system are also approximately the same in individual segments of the body? Answers to these questions can be obtained through knowledge of the function of biophotons and the role of biophoton signaling.

The coherent energy created by vibrations of biopolymers, which already has information content from DNA, must be transmitted further between cells in the tissues of the human body. In the course of a systematic scientific analysis, it was found that the electromagnetic coherent biophoton flow/solitons can be transmitted in two main ways, which are similar to the transmission paths inside the cell: through the transition of the electromagnetic coherent biophoton energy/soliton flow to liquid crystalline energy-intensive water structures of the 31/21 spiral and to membrane biopolymer structures of other cells and matrix. This creates the conditions for the transmission of an electromagnetic signal through tight junctions between cells in tissues. However, when considering the structure of tissues of the whole organism, it is clear that different tissues/membrane biopolymers of different types of cells have different quantum mechanical structures and can generate and conduct electromagnetic signals in different ways. Modern biophysical knowledge (Langevin, 2006; Bordoni, Simonelli, 2018; Bordoni et al., 2018; Binhi, Rubin, 2022) allows us to consider the connective tissue of the body as a morphological substrate that can carry out adequate translation of the electromagnetic signal flow throughout the body. This is justified by the fact that the features of the histomorphological structure of connective tissue cells allow them to be semiconductors and, under certain conditions, also effectively transmit an electromagnetic signal between cells.

It is important to note that the extracellular matrix plays a significant role in the transmission of electromagnetic signals. This is a separate problematic issue of the transfer of electromagnetic energy/biophotonic signaling between cells, because the quantum mechanical parameters of the structural components of the extracellular matrix predetermine the parameters of further transmission of the electromagnetic signal from the cells.

Histologically, the extracellular matrix/mesenchyme is a complex comprising a branched three-dimensional network of connective tissue fibres of collagen, elastin, proteoglycans and glycosaminoglycans, surrounded by interstitial fluid (Karamanos et al., 2021; Theocharis et al., 2019; Theocharis et al., 2016). Biophysical mechanisms of matrix functioning are reflected in the works of many scientists (Karamanos et

al., 2021; Theocharis et al., 2019; Theocharis et al., 2016; Sinatra et al., 2017; Oschman, 2007). Conceptualising existing knowledge, the following important aspects of electromagnetic signaling in the matrix can be identified:

– The interstitial fluid contains clustered water structures in the form of structured water in the form of energetic liquid crystals in a dynamic state (Mintser et al., 2021). This is an important way for transmitting an electromagnetic signal without losses in the form of solitons along chains of water crystals.

– Connective tissue fibres in combination with energy-intensive liquid crystalline structured water systems have semiconductor properties and provide communicative transfer of electromagnetic energy and information at the cellular level.

– There is an electrical potential in the extracellular matrix. The resting electrical potential of the extracellular matrix is 240 nV. The electrical potential of the extracellular matrix changes under the influence of changes in the acid-base balance of the environment, oxidative stress, inflammation, and the effect of medications and chemical agents on it.

Electric charge plays an important role in the transfer of electron flows in the matrix. For example, proteoglycans have a negative electrical charge. Therefore, positively charged toxin molecules are attracted to the matrix structure and are fixed due to electrical binding (Koolman, 2005). Toxins can be trapped in the network structure of proteoglycans and glycosaminoglycans at the matrix level and the toxins will alter their quantum mechanical properties. If the amount of trapped toxins increases significantly, they can (physically and chemically) prevent any beneficial substances from reaching the cells (Oschman, 2009; Oschman, 2007), etc. Therefore, such physical parameters of biophotonic signaling as the spectral density of the signal, the total signal power, and signal attenuation will depend on the conductivity of its components. It is logical that the more molecules that are 'atypical' for the normal state (exotoxins, endotoxins, excess ions, infectious agents, heavy metals, etc.) in the extracellular matrix, the more this will change the process of electromagnetic communication of cells. On the one hand, excessive accumulation of chemicals in the matrix will aggressively affect the energy-intensive crystalline structures of water, destroying them and thereby worsening the conductivity of energy through them. On the other hand, many chemicals can change the quantum mechanical properties of collagen fibres and also impair the conduction of electromagnetic signals through them. Of course, the slowing of lymph flow in the intercellular space and lymphatic capillaries, inflammatory processes, and allergic processes in tissues create a complex of pathological effects on the local conduction of electromagnetic impulses. Therefore, the state of the intercellular matrix must be considered as an important aspect of the quantum pathogenesis of NCDs as well.

DISCUSSION

Issues of intercellular communication are an important aspect of the scientific understanding of the functioning of tissues and organs. It is necessary to understand exactly how tissues and organs function in the body *in vivo* both under normal conditions and in pathology. It is already absolutely obvious that today, the chemical paradigm of metabolism is no longer able to explain all aspects of cellular metabolism and the high degree of coordination of the simultaneous occurrence of a great variety of chemical reactions in the cell. Modern biophysical knowledge has supplemented these ideas with knowledge about the influence of electromagnetic fields on the reactivity and behaviour of molecules in the cell. However, for further development and extrapolation of this knowledge into medicine, it was necessary to create a working biological theoretical concept that could logically systematise and present a description of the role and consistent participation of these electromagnetic processes in cellular metabolism. Therefore, a working concept of a model of biophotonic signaling at the cellular level was developed and presented in the results of a theoretical study.

It is important to note that long before understanding the significance of the role of electromagnetic fields in the phenomenon of cell life and in cellular communication, many biologists and physicians argued about the great importance of the intercellular matrix in the processes of interaction between cells. For example, in 1855, the French histologist Claude Bernard outlined the fundamental role of the matrix for health. He was the first to introduce the concept of *le milieu interior* 'the internal environment of the body' and developed the idea that 'the quality of life of a cell is directly related to the purity of its environment, since this is the substance from which it receives its nutrition and energy, and also in which it deposits its waste' (EU Universalis. fr., 2024). Between 1926 and 1970, the German scientist Alfred Pischinger identified the connections of the extracellular matrix with the hormonal and autonomic nervous systems. The extracellular matrix is a component that participates in regulatory activity within the body (Hildebrandt, Czarnowski, 2017; Pischinger, 2007). The German doctor Hans-Heinrich Reckeweg discovered the influence of exogenous and endogenous toxins on the extracellular and the intracellular matrices. He found that disturbances in the functioning of the matrix lead to the emergence and progression of organ tissue pathology. Based on these ideas, Reckeweg developed the theory of homotoxicosis (1948–1955), which is of fundamental importance for medicine (Reckeweg, 1989). From the perspective of modern knowledge, this can be considered as a variant model of the occurrence of NCDs, which is based on the degree of disruption of biophoton signaling due to an acquired disruption of the functioning of the matrix. At the current point in scientific research, the American biophysicist James L. Oschman has contributed significantly to the substantiation of these theories (Oschman, 2009; Sinatra et al., 2017; Hammerschlag et al., 2015). The ideas of the concept of biophoton signaling presented in the article are based on and are consistent with the results of his scientific research. Oschman proved that proteins function as crystalline semiconductors, the deformation of the elements of connective tissue creates piezoelectricity, every cell is connected to every other cell at any moment, and they communicate with one another.

It is important to note that the concept introduced is based on already existing scientific knowledge; it complements the existing scientific paradigm of knowledge but does not deny it. This concept fits elegantly into all existing scientific models of the chemical interaction of substances in cells and explains the complex coordination of their metabolic transformation.

CONCLUSIONS

The fragment of the results of a theoretical analytical systematisation of existing scientific data on the electromagnetic mechanisms of cellular signaling presented in the article is the next scientific step in an attempt to study and describe intercellular communication, taking the role of biophotons into account. The concept of biophoton signaling is a promising working model for scientific discussion and for further study into the role of electromagnetic fields in the phenomenon of biological life of a cell *in vivo* and the human body as a whole. The state of the extracellular matrix must be considered as an important biological aspect for the implementation of the phenomena of life and health, the quantum pathogenesis of NCDs. Renewing the scientists' attention to the issue of intracellular electromagnetic signaling and extracellular electromagnetic signaling can open up new opportunities in studying the role of the intercellular and intracellular matrices in the pathogenesis of NCDs. Therefore, research in this direction should be continued.

Author contribution statement

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Visualisation: Ganna Nevoit;
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Writing (review and editing): Gediminas Jaruševičius, Ozar Mintser, Inga Arūnė Bumblytė, Maksim Potyazhenko, Alfonsas Vainoras.

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Conflicts of interest

The authors declare no conflict of interest.

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MAGNETOELEKTROCHEMINĖ METABOLIZMO TEORIJA: ELEKTROMAGNETINIS LĄSTELIŲ RYŠYS IR TARPLĄSTELINĖS MATRICOS VAIDMUO

Santrauka

Pateikiamas esamų mokslinių duomenų apie ląstelių signalizacijos elektromagnetinius mechanizmus teorinės analizės rezultatų fragmentas yra magnetoelektrocheminės metabolizmo teorijos (2019–2025) raidos tąsa. Teorinio tyrimo tikslas – sukurti ląstelių elektromagnetinės komunikacijos koncepciją, siekiant pagilinti fundamentalias žinias ir rasti naujus, perspektyvius lėtinių neinfekcinių ligų gydymo būdus. Straipsnyje pristatomas veikiantis elektromagnetinio ląstelių ryšio / biofotonų signalizacijos koncepcijos modelis ir tarpląstelinės matricos vaidmuo. Biofotonų signalizacijos koncepcija yra perspektyvi mokslinėms diskusijoms ir tolesniems elektromagnetinių laukų poveikio biologinėms ląstelėms *in vivo* tyrimams. Tarpląstelinės matricos būklė yra svarbus biologinis aspektas suprantant gyvybės ir sveikatos reiškinius bei neinfekcinių ligų kvantinę patogenezę.

Raktažodžiai: neinfekcinės ligos, biofotonai, tarpląstelinė matrica, biofotonų signalizacija, elektromagnetinis ląstelių ryšys