Magnetic resonance processes in organs and tissues with exogenous bioresonance therapy

M.Yu. Gotovsky
Center for Intelligent Medical Systems "IMEDIS" (Moscow)

Magnetic resonance processes in organs and tissues during exogenous bioresonance therapy

M.Yu. Gotovskiy
C enter of intellectual medical systems "IMEDIS" (Moscow, Russia)

SUMMARY

The article discusses one of the mechanisms of the biological action of exogenous bioresonance therapy, which is realized in a therapeutic effect through the mechanical transformation of alternating magnetic fields in the body. The discussed magnetic resonance effect is due to the presence in organs and tissues of magnetic nanoparticles of biogenic and technogenic origin, as well as the presence of mechanosensitive ion channels in cell membranes.

Key words: exogenous bioresonance therapy, mechanism of actionexogenous bioresonance therapy, biogenic and technogenic magnetic nanoparticles, mechanosensitive ion channels of cell membranes.

RESUME

One of mechanisms of exogenous bioresonance therapy biological action which is realized by means of mechanical transformation of alternating magnetic fields in the organism is considered in the article. The effect under consideration is realized due to the presence of magnetic nanoparticles of biogenic and technogenic origin as well as presence of mechanosensitive ion channels in cell membranes.

Keywords: exogenous bioresonance therapy, biogenic and technogenic magnetic nanoparticles, mechanosensitive ion channels in cell membranes.

INTRODUCTION

Therapeutic using their own electrical signals the human body, which has now firmly established itself as an effective non-invasive method of treatment, dates back to the 1970s. The founder of this method is considered the German physician F. Morell (1921-1990), who suggested the existence of two types of electrical oscillations in the body: physiological and pathological.

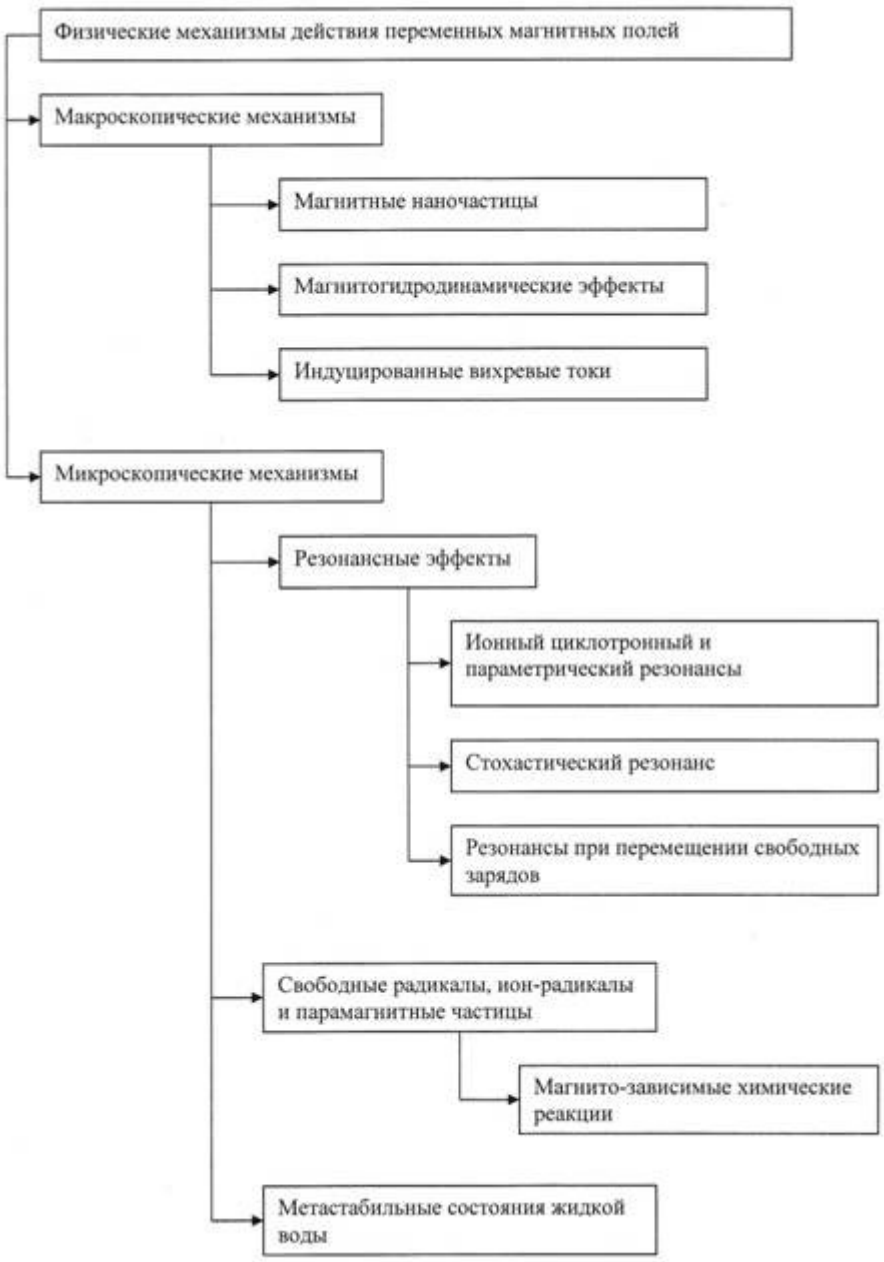
F. Morell realized his idea of inverting and eliminating pathological fluctuations in a therapeutic device, which he began to develop together with the engineer E. Rasche (1946–2010). Then, in 1977, they, together with the biophysicist L. Mersmann (1949-2004), created a filter to separate physiological from pathological fluctuations [1]. Somewhat later E. Rasche and W. Ludwig (1927-2004) instead of the L. Mersmann filter developed a very similar

an electronic device for amplifying signals and their spectral filtering [2]. In 1978 F. Morell first described the principle of therapeutic application of the separation of pathological from physiological fluctuations, which was named MORA therapy as an abbreviation of the names of the inventors of the "MO" method - Morell and "RA" - Rasche [3]. Subsequently, on the basis of this method, H. Brügemann developed a device connected to a computer, the use of which for therapeutic purposes was called "bioresonance therapy" [4].

In parallel with the use of natural electrical oscillations for therapeutic purposes according to F. Morell, later called endogenous bioresonance therapy (BRT), W. Ludwig developed a method of therapeutic use of variable magnetic fields of low frequency and intensity [5]. The proposed method consisted in the use of induction coils (solenoids) for local action on a particular area of the body with an alternating magnetic field with a fundamental frequency of 10 Hz with a variation in the range from 4 to 12 Hz. W. Ludwig assumed that this would implement a selective (resonant) effect on various organs and tissues (which are mainly in a pathological state), without affecting others, as it happens in the BRT method [6, 7]. In this case, the therapeutic effect was achieved using low-intensity magnetic fields. [eight]. Later, the capabilities of the W. Ludwig method were expanded by using magnetic fields of higher frequencies (up to 500 Hz). Data on the therapeutic significance of magnetic fields in this range were obtained empirically based on the results of electropuncture testing and the observed clinical effect. Later, this method was called exogenous BRT.

The mechanism of therapeutic action of both endogenous and exogenous BRT, despite the difference in the nature of the acting factor (electric oscillations and alternating magnetic fields), is based on stochastic resonance [9]. Stochastic resonance in endogenous BRT consists in overcoming the threshold and implementing a response in the process of amplifying the magnitude of the influencing (therapeutic) signal as a result of energy input from broadband noise. In the case of exogenous BRT, the leading role is also played by stochastic resonance as a result of synchronous modulation of the potential of controlled ion channels of membranes, induced by external alternating magnetic fields.

The understanding of the mechanisms of interaction of variable magnetic fields of low intensity (Fig. 1) with biological media has recently expanded significantly [10, 11].



Rice. 1. Physical mechanisms of action of alternating magnetic fields

In particular, the processes of interaction of alternating magnetic fields with biological objects are not limited only to the induction of currents in the medium, but there is another way - transformation into mechanical vibrations [12]. Thus, in the mechanism of exogenous BRT, among others, it became possible to consider the magnetic resonance (mechanical) component under the action of external alternating magnetic fields. Such an approach can be considered quite adequate, since all vital processes to one degree or another are accompanied by mechanical phenomena occurring both at the level of the whole organism and in organs and tissues. Studies on the presence in organs and tissues

magnetic nanoparticles and the existence of mechanosensitive ion channels of cell membranes made it possible to analyze and substantiate the role of mechanical transformations of alternating magnetic fields in organs and tissues during exogenous BRT, which we considered earlier [9].

BIOGENIC MAGNETITE IN ORGANS AND TISSUESThe concept of "biogenic magnetite" to some extent explains the sensitivity to the geomagnetic field of some bacteria, fish, birds and higher animals by the presence of accumulations of iron oxide in their tissues - biomineralization. Biomineralization is a combination of biochemical processes, as a result of which mineral inclusions are formed in living organisms. Among such inclusions, particular attention has been drawn to inorganic iron compounds or biogenic magnetite - particles with ferromagnetic properties [13]. The most common magnetic inclusions are mainly composed of magnetite compounds (Fe_3O_4) or greigite (Fe_3S_4), which accumulate inside cells in the form of particles (ferromagnetic crystals) with a diameter of 30 to 120 nm - magnetosomes [14]. For the first time, the presence of biogenic magnetite was noted in bacteria and multicellular organisms, and in 1981 JL Kirschvink discovered the presence of magnetite compounds in the brain of primates [15]. The discovered crystals of magnetite in animals within the same biological species are the same in size. Magnetometric and morphological studies of tissues have shown that in some animals, for example, in monkeys, magnetite inclusions are found in the adrenal glands, cerebellum, midbrain, and corpus callosum [16]. The largest number of crystals of biogenic magnetite was found in the human brain, where 1 g of tissue accounts for at least 5×10^6 magnetite crystals ranging in size from 10 to 200 nm, which are evenly distributed in the cerebellum, basal ganglia, and midbrain [17]. According to RR Baker, the homing reaction of a person (orientation and navigation) is explained by the presence of biogenic magnetite in the brain tissues, thus being the sixth sense [18]. At the same time, the presence of magnetite crystals in the human brain does not allow one to assert unambiguously about any selective sensitivity to external geomagnetic fields.

However, one cannot exclude the possibility of the participation of biogenic magnetite crystals in the implementation of the effect of external alternating magnetic fields through magnetoacoustic effects. The magnetic moments of all atoms of ferromagnets are oriented in parallel, as a result of which the magnitude of the magnetic moment of the crystal is equal to the sum of all magnetic moments of the atoms. Ferromagnetic crystals respond to changes in the external magnetic field to a greater extent than diamagnetic or paramagnetic materials of the same volume.

Crystals of magnetite located in tissues are, in principle, capable of responding to changes in the magnitude of magnetic fields in two ways. One of the proposed mechanisms is that biogenic magnetite present in body tissues can absorb field energy through magnetoacoustic resonance. The energy of interaction of magnetite crystals with an external magnetic field from 10^3

to 10^7 times greater than the value of thermal energy kT (k is the Boltzmann constant, T - absolute temperature) of the body at normal temperature. In principle, magnetosomes are capable of responding in a resonant manner to an alternating magnetic field through magnetoacoustic resonance, in which the field energy is converted into mechanical vibrations in the same frequency range [12]. The combination of magnetite particles into unidirectional chains allows us to consider them as a structure that responds with resonance to an alternating magnetic field of a lower frequency than single crystals, thus providing a greater broadband interaction. Another mechanism is determined by the fact that magnetite is distributed in the body in the form of formations much less than one micrometer in size, in connection with which it was suggested that each of the set N crystals can be a kind of "receiver" of an alternating magnetic field [17].

Stochastic resonance of magnetic nanoparticles is also considered as one of the mechanisms of the biological action of low-frequency magnetic fields, which is determined by the averaged orientation of magnetosomes [19, 20]. One of the signs of stochastic resonance is the presence of a region in which the signal-to-noise ratio paradoxically increases with increasing temperature.

It is assumed that conformational vibrations of macromolecules in the process of enzymatic catalysis are accompanied by the appearance of elastic mechanical waves propagating in the environment in the frequency range from 0.001 Hz to 1.6 kHz and above [21]. The theoretical assessment allows us to consider the possibility of synchronization and delaying of the oscillation frequency of macromolecules induced by an external magnetic field, mechanical waves and thereby cause biological effects.

MAGNETIC NANOPARTICLES OF MAN-GENERAL ORIGIN IN ORGANS AND TISSUE

Recently, it has been established that the number of polluting constituents of the atmosphere of large cities includes nanoparticles ranging in size from nanometers to several micrometers with a concentration of up to 10^7 particles in 1 cm^3 air [22]. Sources of such nanoparticles, including magnetic ones, are emissions from power plants, industrial plants, and exhaust from car engines [23–25]. Due to their small size, the most likely route for nanoparticles to enter the body is inhalation, although the possibility of their entry through the gastrointestinal tract cannot be ruled out. It is worth mentioning the results of studies of the founder of the magnetocardiography method D. Cohen, who, together with co-authors, when studying the remanent magnetization of various human organs, found the highest value in the lungs [26]. Thus, the results of these studies back in the 1970s clearly indicated the inhalation route of the entry of magnetic nanoparticles into the body, which is currently considered the main one.

Recently, it has become relevant to study the problem of pathogenic

mineralization as a result of technogenic pollution of the environment, along with the natural content of magnetite particles in the body. The intake of technogenic magnetic nanoparticles into the human body, which increases with age, in combination with biogenic magnetite contained in organs and tissues, can disrupt cellular homeostasis and cause the development of pathologies [27, 28]. Magnetic nanoparticles have been found in the tissues of the cardiovascular system and the human brain, since they have the ability to penetrate the blood-brain barrier, which can lead to the development of some neurodegenerative diseases, including Alzheimer's disease [29–31]. It can be assumed that magnetic nanoparticles predominantly accumulate in pathologically altered organs, which, to some extent, is the cause of the onset of diseases [32]. The study of the dynamics of the natural biodistribution of magnetic iron nanoparticles after oral and parenteral administration to laboratory animals showed the nature of their distribution in the body [33, 34]. It was found that the characteristics of nanoparticles affect not only their natural distribution in the body, but also a certain tropism to specific tissues and organs. Man-made magnetic nanoparticles, like biogenic magnetite particles, are capable of interacting with low-frequency alternating magnetic fields, both with natural and man-made fields. The nature of the interaction allows nanoparticles to modulate the main nervous processes (excitation and inhibition) in the central nervous system [35]. A similar process can also be realized through magnetoacoustic resonance and conversion into mechanical vibrations. It is quite possible that the recently noted increased meteosensitivity may be associated with the accumulation of technogenic magnetic nanoparticles in the body, leading to unfavorable reactions to changes in the Earth's geomagnetic field.

At the same time, it is necessary to take into account the fact that the propagation of mechanical vibrations in biological tissues heterogeneous in their mass with elastic properties and structural organization, characterized by a low figure of merit, leads to a very significant attenuation [36]. In this regard, the mechanism of transformation of mechanical vibrations into signals that are realized in cells through mechanosensitive membrane channels should be considered.

MECHANOSENSITIVE ION CHANNELS OF CELLULAR MEMBRANES

Mechanosensitivity as a reception and transformation of mechanical vibrations is a property of not only specialized receptor structures, but also represents a universal principle that applies to almost all cells of the body [37]. Mechanical stimuli are converted into intracellular signals through mechanosensitive ion channels, which are activated upon deformation (stretching or contraction) of the cell membrane [38]. Mechanosensitive membrane ion channels are found not only in excitable cells, but also in those whose function is not associated with perception.

stimuli, for example, blood erythrocytes, epithelial cells, etc. [39, 40]. Depending on the level of the acting mechanical stimulus, the mechanosensitive channel is activated, as a result of which electrical and / or chemical intracellular signals appear in the cell, causing further biological effects [40]. Cana priori to assert that as a resultmechanical action in the cell, a response is realized, which consists of two components - fast and slow. A fast response is characteristic of excitable cells, such as neurons or nerve fibers, and occurs as a local or spreading excitation. The slow component is metabolic and is associated with the modulating effect of the active transport of Na ions+ and K+ on the energy of the cell [41, 42]. In essence, the slow component can be considered as one of the elements of the mechanochemical regulation of cellular metabolism, which is also involved in developmental processes [43, 44]. There is every reason to believe that the resonance response of both biogenic and technogenic magnetic nanoparticles in the form of mechanical vibrations under the action of an alternating low-frequency magnetic field is perceived by mechanosensitive ion channels of membranes, being converted into intracellular signals in two components. Thus, the fast component in nerve fibers during exogenous BRT can be considered as a transformation of the frequency of an alternating magnetic field into a propagating nervous excitement. Based on the magnitude of the period of absolute refractoriness for a nerve fiber, on average, of the order of 0.4–2 ms, it can be assumed that that the frequency of transformation of mechanical vibrations of magnetic nanoparticles into nerve impulses will be in the range from 500 to 2500 Hz. It is also impossible to exclude the possibility of expanding the range of transformable frequencies of an alternating magnetic field with exogenous BRT to a lower frequency region, which is determined by the type of nerve fiber and the physiological function it performs. The slow component of intracellular signals from mechanosensitive channels under the action of mechanical vibrations of magnetic nanoparticles, which is associated with the energy of the cell, with exogenous BRT forms not nervous, but rather humoral regulation and can contribute to the formation of a more stable therapeutic effect. On the other hand, recently it has been shown that it is possible to control biochemical reactions under conditionsin vitro through the application of an externalmagnetic field with a frequency of 50 Hz [45]. As a result, nanomechanical action is realized using magnetic nanoparticles in combination with biological macromolecules. Nanomechanical control of biochemical reactions using external magnetic fields is fundamentally different from other methods both in selectivity and locality, and in the greater potential for control at the level of individual biological macromolecules [46].

CONCLUSION

Analysis of the role and significance of mechanical transformation of alternating magnetic fields in organs and tissues during exogenous bioresonance therapy showed that

the leading role in these processes belongs to magnetic nanoparticles of biogenic and technogenic origin present in organs and tissues of the body as sources of mechanical vibrations. The receivers of such vibrations are mechanosensitive ion channels of cell membranes, the activation of which is converted in the cell into electrical and / or chemical signals that cause further biological effects. It can be assumed that magnetic fields during exogenous BRT selectively (in a resonant manner) react with magnetic nanoparticles accumulated in pathologically altered organs and tissues of the body, which is associated with a clinically justified choice of the frequency of the alternating field.

LITERATURE

1. Mersmann, L. Verfahren zur Untersuchung biologisch wirksamer elektromagnetischer Strahlungen von anorganischen und organischen Substanzen sowie deren komplexe Verbindungen bezüglich ihrer toxischen und nichttoxischen Quantität und Qualität ihrer Einwirkungen auf biologische Systeme wie Mineralien, Pinefliere - Application from Germany No. 2840114. MKI G01N21 / 00, G01N23 / 00, G01N27 / 22. Appl. 15.09.78. Publ. 05/29/80.

2. Rasche, E., Ludwig, W. Elektronikgerät zur Signal-verstärkung und Spektralfiltrierung für meteorologische, landwirtschaftliche und medizinische Anwendungen / E. Rasche, W. Ludwig. - Application of the Federal Republic of Germany No. 3114905. MKI G01R23 / 165. Appl. 04/13/81. Publ. 05/26/83.

3. Morell, F. Die MORA-Therapie - Therapie mit korpereigenen Schwingungen / F. Morell. - Friesenheim, Med-Tronic, 1978 .-- 181 s.

4. Brügemann, H. Bioresonanztherapie. Grundlagen und Praxis der weiterentwickelten Therapie mit patien-teneigenen Schwingungen nach Morell / H. Brügemann // Erfahrungsheilkunde. - 1989. - Bd. 38, H.3a. - S.162-167.

5. Ludwig, W. Die Debatte um die Magnetfeldtherapie aus der Sicht der Biophysik / W. Ludwig // Erfahrung-sheilkunde. - 1988. - Bd. 12, H.6. - S.735-739.

6. Ludwig, W. Die Grundlagen der Mora-Therapie / W. Ludwig // Erfahrungsheilkunde. - 1985. - Bd. 34, H.5. - S.668–672.

7. Ludwig, W. Die Bedeutung der Bio- und Umwelt-resonanz für die moderne Diagnostik und Therapie Ergebnisse der Grundlagenforschung medizinischer Biophysik / W. Ludwig // Erfahrungsheilkunde. - 1989. - Bd. 38, H.3a. - S.159-161.

8. Ludwig, W. Wie ist die Therapiewirkung mit schwachen elektromagnetischen Signalen erklärbar? / W. Ludwig // Erfahrungsheilkunde. - 1995. - Bd. 44, H.5. - S.353–355.

9. Gotovsky, M.Yu. Bioresonance therapy / M.Yu. Gotovsky, Yu.F. Perov, L.V. Chernetsov. 3rd ed. - M .: IMEDIS, 2019 .-- 256 p.

10. Bingi, V.N. Principles of electromagnetic biophysics / V.N. Bingi. - M .: FIZMATLIT, 2011 .-- 592 p.

11. Buchachenko, L.A. Magnetically Dependent Molecular and Chemical processes / L.A. Buchachenko // Advances in chemistry. - 2014. - T.83, № 1. - C.1-12.

12. Magnetite in human tissues: A mechanism for the biological effects of weak ELF

magnetic fields / JL Kirschvink [et al.] // Bioelectromagnetics. - 1992. - Vol. 27, Suppl. 1. - P.101-113.

13. Lowenstam, H.A., Kirshvink, D.L. Biomineralization of iron: geobiological approach // Biogenic magnetite and magnetoreception. New about biomagnetism: In 2 volumes. Vol. 1. / H.A. Lowenstam, D.L. Kirshvink; ed. J. Kirshvink, D. Jones, B. McFadden. - M .: Mir, 1989. - pp. 15–31.

14. Gorobets, SV, Gorobets, O.Yu. Functions of biogenic magnetic nanoparticles in organisms / SV Gorobets, O.Yu. Gorobets // Functional Materials. - 2012. - Vol.19, N.1. - P.18-26.

15. Kirschvink, JL Ferromagnetic crystals (magnetite?) In human tissue / JL Kirschvink // J. Exp. Biol. - 1981. - Vol. 92, N. 1. - P. 333–335.

16. Kirschvink, JL Magnetite biomineralization in the human brain / JL Kirschvink, A. Kobayashi-Kirschvink, BJ Woodford // Proc. Natl. Acad. Sci. USA. - 1992. - Vol.89, No. 8. - P.7683-7687.

17. Kirshvink, J.L. Particle size in magnetic magnetoreceptors / J.L. Kirshvink, M.M. Walker // Biogenic magnetite and magnetoreception. New about biomagnetism: In 2 volumes. Vol. 1. / Ed. J. Kirshvink, D. Jones, B. McFadden. - M .: Mir, 1989. - pp. 319–333.

18. Baker, RR Human Navigation and the Sixth Sense / RR Baker. - Hodder & Stoughton, London, 1981.183 p.

19. Bingi, V.N. Stochastic resonance of magnetosomes anchored in cytoskeleton / V.N. Bingi, D.S. Chernavsky // Biophysics. - 2005. - T.50, issue. 4. - P.684–688.

20. Bingi, V. Temperature factor and magnetic noise in conditions stochastic resonance of magnetosomes / V. Bingi, D. Chernavsky, A. Rubin // Biophysics. - 2006 .-- T. 51, issue 2. - pp. 274–277.

21. Shnol, S.E. Conformational vibrations of macromolecules / S.E. Shnol // Oscillatory processes in biological and chemical systems / Tr. All-Union. symp. on oscillatory processes in biological and chemical systems. - Moscow: Nauka, 1967. - pp. 22–41.

22. Air pollution and cardiovascular disease: A statement for healthcare professionals from the expert panel on population and prevention science of the American Heart Association / RD Brook [et al.] // Circulation. - 2004. - Vol.109, N.21. - P. 2655–2671.

23. Giere, R. Solid particulate matter in the atmosphere / R. Giere, X. Querol // Elements. - 2010. - Vol. 6, No. 4. - P.215–222.

24. Grobéty, B. Airborne particles in the urban environment / B. Grobéty [et al.] // Elements. - 2010. - Vol.6, N.4. - P.229-234.

25. Magiera, T. Magnetic particles in alkaline dusts from power and cement plants / T. Magiera, B. Cołuchowska, M. Jabłonska // Water Air Soil Pollut. - 2013. - Vol.224, No. 1: 1389.

26. Part I. Abnormal patterns and physiological varia-tions in magnetocardiograms / D. Cohen [et al.] // J. Electrocardiol. - 1976. - Vol.9, N.4. - P.398-409.

27. Skilled, I.Yu. The role of magnetosomes in impaired cellular homeostasis and development of pathology / I.Yu. Skilful, T.N. Popova // Biomedical chemistry. - 2010. - T. 56, No. 5. - pp. 530-539.

28. Giere, R. Magnetite in the human body: biogenic vs. anthropogenic / R. Giere // Proc. Natl. Acad. Sci. USA. - 2016. –Vol. 113, N.43. - P.11986-11987.

29. Lamanova, L.M. Methods for the detection of extracellular mineral grains in tissues of the cardiovascular system / L.M. Lamanova, N.N. Boroznovskaya // Siberian medical journal. - 2010. - T.25, No. 1. - P.78-83.

30. Magnetite pollution nanoparticles in the human brain / BA Maher [et al.] // Proc. Natl. Acad. Sci. USA. - 2016. –Vol. 113, N.39. - P.10797-10801.

31. Magnetic nanoparticles in the central nervous system: targeting principles, applications and safety issues / F. D'Agata [et al.] // Molecules. - 2018. - Vol.23, N.1: 23010009.

32. Gorobets, SV Physiological origin of biogenic magnetic nanoparticles in health and disease: from bacteria to humans / SV Gorobets, O.Yu. Gorobets, M. Koralewski // Int. J. Nanomedicine. - 2017. - Vol.12. - P.4371-4395.

33. Morphological changes in the internal organs of laboratory animals with a single injection of Fe nanoparticles / N.A. Navolokin [and others] // Izv. Saratov University. - 2011. - T.11. Ser. Physics, no. 2. - P.62–66.

34. Dynamics of natural biodistribution of magnetic nanoparticles, obtained by various methods, with their single administration to Wistar runoff rats / D.V. Korolev [et al.] // Translational Medicine. - 2016. - Vol. 3, No. 4. - P.56–65.

35. Progress in neuromodulation of the brain; a role for magnetic nanoparticles? / M. Roet [et al.] // Progr. Neurobiol. - 2019. - Vol.177. - P.1-14.

36. Romanov, S.N. Biological action of mechanical vibrations / S.N. Romanov. - L .: Nauka, 1983 .-- 208 p.

37. Mechanosensitivity and Mechanotransduction // Mechanosensitivity in Cells and Tissues. Vol.4. / A. Kamkin, I. Kiseleva eds. - Springer Science + Business Media BV, 2011 .-- 371 p.

38. Martinac, B. Mechanosensitive ion channels: molecules of mechanotransduction / B. Martinac // J. Cell. Sci. - 2004. - Vol. 117, pt. 12. - P.2449-2460.

39. Sackin, H. Mechanosensitive channels / H. Sackin // Annu. Rev. Physiol. - 1995. - Vol.57, N.1. - P.333–353.

40. Sachs, F. Mechanosensitive ion channels in nonspecialized cells / F. Sachs, CE Morris // Reviews of Physiology Biochemistry and Pharmacology. - Springer, Berlin, Heidelberg, 1998. - Vol. 132. - P.1–77.

41. Dittrich, F. Mechanism of ATP free-energy transfer and utilization in (Na, K) -ATPase transport function / F. Dittrich, R. Schön, KR Repke // Acta Biol. Med. Ger. - 1974. - Vol.33, N.1. - P. 17-25.

42. Skulachev, V.P. Energy of biological membranes / V.P. Skulachev. - M .: Science, 1989 .-- 564 p.

43. Ingber, DE The mechanochemical basis of cell and tissue regulation / DE Ingber // Mech. Chem. Biosyst. - 2004. - Vol.1, N.1. - P.53–68.

44. Farge, E. Mechanotransduction in development / E. Farge // Curr. Top. Dev. Biol. - 2011. - Vol.95. - P.243-265.

45. Single-domain magnetic nanoparticles as power generators for nanomechanical control of biochemical reactions by low-frequency

magnetic field / Yu.I. Golovin [and others] // Izvestiya RAN. Ser. physical. - 2013. - T.77, No. 11. - P.1621-1630.

46. Nanomechanical control of the properties of biological membranes with using rod-shaped nanoparticles in a super-low-frequency magnetic field / Yu.I. Golovin [et al.] // Technical Physics Letters. - 2015. - T.41, No. 9. - P.96-102.

Author's address
Ph.D. Gotovsky M.Yu., General Director of LLC "CIMS" IMEDIS "
info@imedis.ru

Gotovsky, M.Yu. Magnetic resonance processes in organs and tissues during exogenous bioresonance therapy / M.Yu. Gotovsky // Traditional medicine. - 2019. - No. 3 (58). - P.4-9.