

ORIGINAL ARTICLE

Biofield Science and Healing: History, Terminology, and Concepts

Beverly Rubik, PhD; David Muehsam, PhD; Richard Hammerschlag, PhD; Shamini Jain, PhD



Content designated
as open access

Citation

Global Adv Health Med.
2015;4(suppl):8-14.
DOI: 10.7453/
gahmj.2015.038.suppl

Correspondence

Beverly Rubik, PhD
brubik@earthlink.net

Key Words

Biofield,
bioelectromagnetics,
biological field,
electromagnetic fields,
energy medicine,
healing

Disclosures

The authors completed the ICMJE Form for Disclosure of Potential Conflicts of Interest and disclosed the following: Dr Rubik is a board member of and consultant for the Institute for Frontier Science; Dr Muehsam is a consultant for Rio Grande Neurosciences; and Dr Jain received a grant from Westreich Foundation—all outside the submitted work. Dr Hammerschlag had no conflicts to disclose.

Author Affiliations

Institute for Frontier Science, Oakland, California; Integrative Health Studies, California Institute of Integral Studies, San Francisco; College of Mind-Body Medicine, Saybrook University, Oakland, California; Energy Medicine University, Sausalito, California (Dr Rubik). Visual Institute of Developmental Arts and Sciences, National Institute of Biostructures and Biosystems, Bologna, Italy (Dr Muehsam). The Institute for Integrative Health, Baltimore, Maryland; Oregon College of Oriental Medicine, Portland (Dr Hammerschlag). Department of Psychiatry and Center for Integrative Medicine, University of California, San Diego; Consciousness and Healing Initiative, San Diego (Dr Jain).

ABSTRACT

Biofield science is an emerging field of study that aims to provide a scientific foundation for understanding the complex homeodynamic regulation of living systems. By furthering our scientific knowledge of the biofield, we arrive at a better understanding of the foundations of biology as well as the phenomena that have been described as “energy medicine.” Energy medicine, the application of extremely low-level signals to the body, including energy healer interventions and bioelectromagnetic device-based therapies, is incomprehensible from the dominant biomedical paradigm of “life as chemistry.” The biofield or biological field, a complex organizing energy field engaged in the generation, maintenance, and regulation of biological homeodynamics, is a useful concept that provides the rudiments of a scientific foundation for energy medicine and thereby advances the research and practice of it. An overview on the biofield is presented in this paper, with a focus on the history of the concept, related terminology, key scientific concepts, and the value of the biofield perspective for informing future research.

INTRODUCTION

Medicine is in transition. Conventional biomedicine is giving way to an expanded, integrative medical model that emphasizes healthcare as well as illness care, treats people not just diseases, and incorporates multiple therapeutic approaches, old and new, to offer patients greater choice.¹ This emerging model questions the dominant biomedical paradigm of molecular reductionism that focuses on genes, proteins encoded by genes, and molecules synthesized by proteins and that is based

on an inherent belief that complex systems can be understood by identifying their components. By contrast, an integrative model of health and medicine appreciates the complexity of our biology, which can give rise to emergent phenomena that are not, in general, predictive from isolated parts. Such a model also views healthcare from several perspectives beyond the molecular approach, including what has been called energy medicine.² Advances in biophysics, biology, psychology, and the developing fields of mind-body research such as psychoneuroimmunology and psychosocial genomics have helped substantially to form a foundation for this expanded integrative medical model.

In addition to biochemical signals, the idea that living systems generate and respond to energy fields as integral aspects of physiological regulation reflects a convergence of several disparate paths. Numerous spiritual traditions describe modes and pathways of energy within and surrounding the physical body (Jain et al, 2015, this issue). Many complementary and alternative medicine (CAM) therapies utilize variants of “laying-on-of-hands” and other minimally invasive procedures to improve endogenous energy flows. Moreover, Western biomedicine routinely examines electrical fields from the heart (via electrocardiogram [ECG]) and brain (via electroencephalogram [EEG]) as indices of clinical pathology. Furthermore, contemporary cell biology and biophysics provide evidence that endogenous electromagnetic and other types of fields play active roles in development, tissue repair, and an array of homeodynamic processes.³⁻⁵

The term *biofield* fills the need for a unifying concept to bridge traditional and contemporary explanatory models of energy medicine and provides a common language for aspects of both clinical practice and scientific research that focus on energy fields of the body. This paper summarizes the recent origins of the biofield concept and describes the levels of scale for which the term has been applied, from biophotons and cell membranes to whole organisms to Gaia and the *Tao*. Working definitions of *biofield* and related terms are offered with the proviso that such descriptions are and should be based in the cultural and scientific vantage points of the observers and may not always be completely comparable. In this light, in their descriptions of “the biofield,” a Tibetan Buddhist, a neurologist, a Reiki practitioner, a cell biologist, and a physicist (classical or quantum) enrich us all and bring us closer to a complete understanding of this emerging concept.

A BRIEF HISTORY OF THE TERM *BIOFIELD*

The term *biofield* was proposed in 1992 by an ad hoc committee of CAM practitioners and researchers convened by the newly established Office of Alternative Medicine (OAM) at the US National Institutes of Health (NIH). The committee was one of several meetings as part of an NIH/OAM-hosted conference in Chantilly, Virginia, to inform the OAM as it established its program priorities and initiatives. The committee had a dual focus on “manual medicine”—consisting of structural and manipulative approaches such as chiropractic, classical osteopathy, and massage—and “energetic therapies” such as Reiki, Therapeutic Touch, and external *qigong*. Most of the latter group of healing modalities were founded on a concept of a vital force, although each has its own explanatory model and terminology that reflect a particular cultural context. The committee sought to bring unity to the diversity of energetic practices by creating a term that would be amenable to the scientific and broader healthcare communities. Such a term was also needed to describe a central organizing biological field that healers were detecting and interacting with in their practice. The term *biofield* was coined for these purposes with the hope that it would be generic and malleable enough to fit differing explanatory models of therapy.

The committee defined biofield as “a massless field, not necessarily electromagnetic, that surrounds and permeates living bodies and affects the body.”⁶ Subsequently, one committee member succeeded in getting the term *biofield* accepted as a Medical Subject Heading (MeSH term) at the National Library of Medicine so that it became an official search term for scholars to locate peer-reviewed literature. Further, the committee sought to consolidate the diverse modes of energetic healing under the single term *biofield therapies*, which was also accepted by the NIH. An additional realization was that both diagnostics and therapeutics may be involved in these biofield modalities. Subsequently, a round of frontier medicine research grants in biofield science was funded by the National Center for Complementary and Alternative Medicine, the successor to the OAM.

Simultaneously, another of the 1992 ad hoc committees advising the OAM categorized “distant healing” or “distant healing intention”—remote healing over a distance performed through intention and/or intercessory prayer—as a mind-body modality. Thus, energy healing that was performed locally by healers directly on patients, which had been termed biofield therapy, was separated from distant healing due to this initial categorization. A rationale for this separation between local and distant healing was that they may operate by different modes of action. Whereas local or proximal energy healing might involve electromagnetic fields (EMFs) that diminish over distance by an inverse square law, the same fields are unlikely to be involved in healing across large distances. However, local and distant healing are commonly

performed by the same practitioner, such as in Reiki, which poses a conundrum.

HISTORY OF EARLY BIOLOGICAL FIELD CONCEPTS

Since antiquity, there have been 2 opposing views on the nature of life. Democritus, who coined the word *atom*, maintained that everything, including organisms, is reducible to its constituents, while Aristotle held that life processes are autonomous and organisms are integral wholes. These 2 viewpoints remain today, with the biochemical view of life represented by molecular reductionism and a holistic view that embraces a field concept of life.

In science, the notion of a vital force or *élan vital* dates back to the 1600s. In vitalism, living matter was believed to involve a life force: a metaphysical entity intrinsic to life that renders it alive. This force was initially considered immeasurable and outside the scope of science. Yet discoveries of bioelectricity challenged the notion that this force was immeasurable. By 1850, experimental electrophysiology had replaced the notion of vital force with electricity, effectively banishing vitalism from biological science.⁷

Nevertheless, many contemporary CAM practitioners continue to use terms from non-Western explanatory models and medical systems to evoke a vital force or vital energy. For example, there is *qi* (chi) in Chinese medicine, *ki* in Japanese medicine, *prana* in Ayurveda, and similar terms in other traditions of indigenous medicine. These descriptions of life energy originated from metaphysical considerations of the nature of consciousness and its interaction with mental, emotional, and physical systems (Jain et al, 2015, this issue) and were based on first-person observations by adept spiritual practitioners. In the modern age, the notion of a universal life energy is nearly ubiquitously employed by energy healing practitioners, who often describe energy coming from their hands and other parts of the body. These same practitioners report utilizing energy awareness not only to sense imbalances in patients’ energy fields but to regulate energy flow and release energy blockages perceived to be impeding the healing process. Most traditional healing practices maintain that disease starts with an energetic imbalance such as a blockage or other irregularity in the energy flow through the body. Modern CAM systems such as chiropractic,⁸ homeopathy,⁹ and classical osteopathy¹⁰ are also founded on principles of a vital force. Therapeutics in these practices involves restoring or rebalancing the vital force to promote healing.

The scientific concept of force, however, is very much in the physical realm, whereas the vital force at the basis of many CAM therapies is considered by mainstream science to be a metaphysical concept. Force, as well as field and energy, are fundamentals of physical theory. Force refers to any interaction that tends to change the motion of an object. The concept of a field from physics refers to a spatially distributed nonmaterial element that is able to impart a force upon

an object within it. Therefore, a field cannot be detected directly but only through its action upon a suitable probe—for example, a charge in an electric field. Contemporary physics holds that there are only 4 types of force operating throughout nature: gravity, electromagnetism, and the strong and weak nuclear forces, the latter 2 having a range limited to the atomic nucleus. A particular form of energy (defined in physics as the ability to do work: ie, to move a particle through a distance) is associated with each force: for example, electric, magnetic, and electromagnetic energies are associated with the electromagnetic force, which is most important in living systems. The concept of the biofield as proposed herein is firmly grounded in science, although other putative fields, as yet unknown to science, may also be involved.

The concept of a biological field first arose in embryology as an underlying informational template to explain the developmental process. The Ukranian histologist Alexander Gurwitsch, PhD, coined the term *morphogenetic field* to describe the highly coherent and dynamic process that appeared to be guiding development of the unfolding embryo as well as biological regeneration. Gurwitsch also discovered mitogenetic radiation, ultraviolet light emission during cell division in onion roots.¹¹ From 1900 to 1950, other prominent developmental biologists including Hans Driesch, Paul Weiss, and others worked from this same perspective.¹² Weiss, who discovered that the morphogenetic field was unchanged if he removed portions of embryonic tissue, proposed that the biological field was a holistic property of the entire organism.¹² These early embryologists formed the concept of a morphogenetic field guiding development but did not determine its physical basis.

SCALABILITY OF THE BIOFIELD CONCEPT

The biofield concept soon gained traction and was extended from an entity “that surrounds and permeates living bodies” to include a more extensive variety of endogenous phenomena generated by living bodies. It has also been “scaled-up” to test its fit to macrolevel concepts including Gaia, a model of our planet as a complex, self-regulatory system. Thus, at this point in time, the concept of “biofield” may be better considered in its plural form of “biofields.” From this perspective, the term may continue to be usefully applied across a broad range of disciplines, in manners both evidence-based and speculative, including biophysics, cell biology, therapeutics, and ecology.

One line of research on endogenous biofields followed from the early discovery by Gurwitsch, as mentioned above, of ultraviolet light emission during cell division. Recent studies have reported evidence for a variety of biophoton-mediated regulatory processes, including cell-cell communication, cell-cell orientation sensing, secretion of regulatory neurotransmitters, modulation of respiratory activity in white blood cells, and accelerated seed germination.¹³ These findings, as

well as results of research correlating biophoton emission with human physiology, suggest the existence of coherent biophoton fields that play fundamental roles in intercellular signaling^{13,14} and human health.¹⁵

More generally, a wide variety of bioelectromagnetic activities has been identified, often associated with interaction energies substantially below that of thermal noise, which produce clinically significant effects, including enhancement of growth, wound repair, regeneration, and the reduction of pain and inflammation.^{3,16-18} In addition, field-like phenomena appear to contribute to the underlying principles of biological organization, including embryonic development and the coordinated maintenance of biological structure and function. For example, regenerative healing of whole limbs in animals such as salamanders has been shown to involve EMFs,¹⁹ and limb regeneration in higher animals has also been stimulated by means of externally applied EMFs.²⁰ More recently, the patterning of arrays of cell membrane resting potentials has been shown to play key roles in directing stem cell behavior during embryogenesis and in complex organ regeneration.^{21,22}

The biofield, or information associated with it stemming from multicellular electrical activity, is also the basis of a decades-old clinical tool most commonly in the form of the ECG (the detector of electrical wave forms generated by synchronous activity of heart muscle cells) and EEG (the detector of wave forms reflecting summative spontaneous or evoked electrical activity of neuronal arrays). While the ECG and EEG are readily detected from the body surface, the heart's magnetic field, generated by moving electric charges associated with electrical activity, can be recorded up to several feet from the body surface via a magnetocardiogram.²³ Magnetic fields produced by the heart appear to carry information that may be detectable by other persons or animals.²⁴ An example of the informational potential (bioeffectiveness) of these heart fields is cardiac-induced entrainment (or frequency locking) detected when the R-waves of one subject's ECG become precisely synchronized with the onset of EEG alpha waves of another subject at a distance up to 5 feet.²⁵

At the interpersonal level, the biofield concept encompasses a large body of research on the effects of biofield therapies, as practiced both locally with the practitioner in the same room as the patient (Jain et al, 2015, this issue), animals, or cell cultures (Gronowicz et al, 2015, this issue), and nonlocally, which includes distant mental interaction with living systems, as well as intercessory prayer and distant healing (Radin et al, 2015, this issue). Studies with biofield therapies in clinical settings reflect the propensity of certain practitioners and schools of healing to perform therapy with hands on and/or hands off the body,²⁶ therapeutic touch, and healing touch which raise questions about the physical effects of touch itself on biofield interactions and outcomes. However, recent reviews examin-

ing nontouch biofield therapies also report significant changes in outcome measures, suggesting that effects of biofield therapies on outcomes may not be ascribed only to effects of physical touch,^{27,28} and an explanation in terms of quantum entanglement or other nonlocal causes may be needed.²⁹

Biofield interactions also extend from molecular to planetary levels. At the molecular level, the term biofield may even be invoked to explain fundamental properties of individual molecules by considering them as “ordered electromagnetic structures.”⁵ The argument can be made that molecular interactions, such as between hormone and receptor, are those usually described at close range—eg, ionic, hydrophobic, and aromatic pi-electron interactions. Such properties, however, do not explain how molecular partners attain proximity to each other; the necessary preludes to docking are unlikely to occur via simple diffusion and Brownian motion.³⁰ Rather, one proposal is a “resonant recognition model” in which molecules are attracted to their targets by a form of electromagnetic resonance,³⁰ which clearly falls within the biofield rubric. At the planetary level, there is increasing evidence that the biofield concept can include effects of geocosmic fields on human health and behavior: for example, solar storms that significantly perturb the geomagnetic field correlate with increased rates and mortality from myocardial infarction.^{31,32}

HISTORY OF BIOFIELD SCIENTIFIC STUDIES

Early biofield studies were motivated in part by the many CAM modalities that appear to involve energy and/or informational fields and are broadly known as “energy medicine.” These include energy healing, homeopathy, acupuncture, magnet therapy, bioelectromagnetic therapies, electrodermal therapy, and applied kinesiology, among others. Some of these modalities involve novel ways of obtaining useful information from the body’s energy field as well as applying energy fields therapeutically.

“Laying on of hands” is one of the oldest, most ubiquitous forms of healing known to humankind, apparently having emerged independently among ancient cultures worldwide. The father of modern Western medicine, Hippocrates, referred to it as “the force which flows from many people’s hands.”³³ There are a growing number of studies on this and other related biofield healing modalities (as indicated in other articles in this journal issue) demonstrating a spectrum of beneficial results from the psychological and behavioral levels down to clinically relevant biomarkers.^{26,34-36} Another area is bioelectromagnetic medicine, where it has now been demonstrated that nonthermal EMFs, often with interaction energies substantially below that of thermal noise, produce a wide variety of clinically significant effects, including enhancement of growth, wound repair, regeneration, and the reduction of pain and inflammation.^{3,16-18,37,38}

In addition, the underlying principles of biological

organization, including embryonic development and the coordinated maintenance of biological structure and function, are beginning to be better understood, with evidence suggesting that field-like phenomena underlie many of these processes as described earlier.

Field effects have also been invoked as explanations of a large body of research on human intention effects and nonlocality.³⁹ Recent reports with relevance to CAM practices include effects on cultured cells,⁴⁰ seed germination,⁴¹ and distant healing of surgical wounds.⁴² Further, several studies have reported EEG correlations between isolated human subjects⁴³⁻⁴⁷ with in vitro corroboration using neurons adhering to printed circuit boards.⁴⁸ Experiments performed with shielding suggest that some of these results are not mediated by EMFs,^{43,48} perhaps suggesting a role for quantum entanglement or another nonlocal process.²⁹ Such phenomena, which clearly call for scientific explanations at levels of organization beyond the molecular realm, may be explained by a common model of biofield effects.

Concepts of sentience, mind, and consciousness have also evolved from the mechanistic approach of biochemical neuroscience to a field-oriented approach. The application of quantum theory to these concepts has led to several proposals of the body-mind as a macroscopic quantum system.⁴⁹⁻⁵² While the predictive power of these models is as yet unclear, there is increasing experimental evidence showing quantum signaling, communication, and conductivity in the cytoskeletal network of microtubules,^{53,54} and the electric fields generated by synchronized oscillations of microtubules have been demonstrated to play key roles in the regulation of cell division and chromosome folding and transcription.⁵⁵⁻⁵⁶ Similarly, it has been proposed that the acupuncture system and the patterning of cell resting potentials described above^{19,21} act through the continuum of liquid crystalline collagen fibers that make up the bulk of the connective tissues.⁵⁷ In this model, supported by evidence from biochemistry, cell biology, biophysics, and neurophysiology, the collagen matrix provides pathways for rapid intercommunication throughout the body, enabling the organism’s mind-body to function as a coherent whole.^{57,58} Together, these results describe the mind-body as an interconnected system in which electromagnetic and quantum interactions act through field-coherent oscillatory activity to regulate biological processes and mediate interactions correlated with sentience and mental activity.^{57,59,60}

BIOFIELD AS A CONVEYOR OF INFORMATION

As a regulator and mediator of biological interactions, the biofield appears intimately connected with information delivery within the organism. The biofield thus holds and conveys information that is vital for biocommunication and bioregulation. Here it must be said that the concept of information in biology is nothing new; it is already used successfully to explain

numerous molecular mechanisms in molecular biology, such as information encoded in DNA, hormone-receptor interactions, enzyme-substrate interactions, and many other forms of molecular recognition, as well as in ECG and EEG data. Further, many of these well-understood mechanisms may also be thought of as biofield interactions because information itself is often an emergent property of dynamical interactions that cannot be meaningfully understood from a reductionist viewpoint. At the cellular and subcellular levels, oscillatory behaviors emerge from negative feedback loops and coupled positive and negative feedback loops⁶¹ and result from stochastic, nonlinear biological mechanisms interacting with the fluctuating environment.⁶² For example, the emergence of phase-synchrony across large numbers of cells in circadian cooperative systems is the result of nonlinear coupling of oscillators across the cellular and multicellular levels.^{63,64} Similarly, electrically phase-coupled systems in neuronal networks give rise to cooperative behaviors across large numbers of neurons.⁶⁵

The concept of biofield regulation offers a shift from a mechanical, chemistry-based view of biology to an information-based view. Unlike machines, living organisms have an immense network of internal and external interconnections across which information flows to modulate life functions. The continuous exchange of information in living systems to maintain their integrity is astounding. Furthermore, new relationships along with new information exchanges emerge at higher levels of organization in life, forming new wholes. The biofield may be considered one such multilevel organizational concept in which information flows within and between the various levels of the organism. A wealth of information exchange, much like a “conversation” between the elements of these various levels of order—the “whispering” between cells and other units of life—is critical to sustaining life and promoting healing. The biofield may be considered to be the language of life.

Biofield information can manifest beyond mechanistic concepts; bioelectromagnetic medicine presents another example of the informational aspect of biofield interactions. The concept of “electromagnetic bioinformation” was advanced by Fritz-Albert Popp^{49,66} to describe findings that biophotons and other extremely low-level energy transactions in bioelectromagnetics below the thermal noise limit could induce biological effects. In addition to the above-mentioned weak EMF effects, a large body of literature has demonstrated the existence of nonthermal EMF resonance interactions.^{16,67-69} Bioeffects often occur only for particular frequencies, amplitudes, or waveforms, and the precise location of resonances is in general determined by the characteristics of the EMF/biological target system, which can vary with changes in state of health, disease, or injury.⁷⁰ Entrainment of physiological functions such as EEG and ECG with external fields²⁵ may be also seen as induced synchronization, which constitutes a

flow of information from an external field to the body. Furthermore, other elements of the biofield may carry information important for medical diagnostics, beyond the EEG and ECG, that provide useful medical information and suggest new modes of treatment via informational medicine. Indeed, information offers a unifying concept in the *modus operandi* of CAM and integrative medical modalities.^{71,72}

While information is exchanged across multiple levels of order in living systems, perhaps the most definitive information flow in humans is from the “top down,” from intention to the material body, to affect health and promote healing with conscious intention, purpose, context, and meaning. Information may thus be seen to mediate or serve as a bridge between mind and body: for example, in mind-body modalities, intent to heal, etc.

Typically, information is thought to be carried by either energy or matter. However, Bell’s Theorem (quantum nonlocality) supports observations of instantaneous interaction between entangled states.⁷³⁻⁷⁵ The quantum potential function conveys active information everywhere,⁷⁶⁻⁷⁸ as does the morphogenetic field,⁷⁹ with no diminution over distance. Information may thus be everywhere instantaneously, but it is active only where it is specifically directed—for example, by conscious intent—and may be considered intelligent information, producing a very specific response only where it is intended. Thus, information itself may be considered causal even though it does not always have a physical carrier.⁸⁰

TOWARD AN EVOLVING DEFINITION OF BIOFIELD

As described above, the biofield has evolved into a multiscale concept that offers a broader context for understanding biological regulation and information flow than does the currently dominant molecular paradigm of biological systems. As such, a biofield, whether at the level of biophotons, patterns of cell membrane resting potentials, EEG of brain, ECG of heart, or the synchronous movements of birds in flight, can succinctly be described as an organizing influence distributed over space and time. While biofields have most often been described as electromagnetic in nature,^{81,82} there have been several proposals of biofields involving quantum information flow.^{5,29,83} In their organizing capacity, it seems more useful to speak of biofields in terms of their homeodynamic activities than as individual entities: ie, to describe what they do rather than what they are. As presented earlier, the concept of a field from physics refers to a nonmaterial element that interacts with an object and a field cannot be detected directly but only through its action upon a probe. Thus, biofield interactions can influence and be influenced by a variety of biological pathways including biochemical, cellular, and neurological processes as they modulate activity and information flow across multiple levels of living systems. At this stage, the biofield may be considered as a

“massless” or information-based organizing principle in accordance with the original definition proposed by the 1992 NIH advisory committee.⁶

Finally, it is of interest to reflect again on the relation of the biofield concept to *energy medicine*, a term especially in vogue in the latter part of the 20th century. While biofields play a substantive role in guiding health processes, here they are conceived as playing a broader regulatory and informational role in biology than solely as a form of medical intervention as implied by energy medicine. The term *biofield therapy*, which involves healer-based interactions with biofields both within and around living systems,^{84,85} best captures this aspect of healing beyond limited implication of medicine as a treatment for illness.

CONCLUSIONS AND FUTURE PROSPECTS

The biofield concept, emerging initially from vitalist perspectives, offers an increasingly useful approach to explain a variety of physiological phenomena. Its applicability continues to evolve in terms of empirical inquiry. Endogenous biofield interactions with environmental, geocosmic, and other exogenous fields provide the rudiments of a scientific foundation for a holistic view of life and a *modus operandi* for numerous CAM modalities. The family of energy healing practices that have been widely practiced since antiquity, now called biofield therapies, may involve biocommunication and/or energy transfer through the biofield. While the biofield concept is a useful construct to guide new research on energy healing and other CAM modalities, it is also a requisite for a better understanding of contemporary developments in biophysics and biology. Moreover, information connected with the biofield may serve as a bridge between mind and body, which is fundamental to understanding mind-body interactions.

The biofield is also an important metaphor to guide further research. There are numerous examples from the history of science where metaphor and analogy have been key elements in the construction of successful theories. The use of metaphor in science is especially appropriate and critical for success in the exploratory phase of investigation when detailed descriptions and theories are unavailable. Metaphors provide foundational material for forming hypotheses, conducting studies, and eventually elucidating testable theories. Scientific metaphors can be key elements for posing truly novel questions, which upon experimental testing, advance our knowledge and understanding. The concept of the biofield, while still in its nascent stages, may well serve this purpose as biology moves from a local, chemistry-based model to an interconnected, information-based viewpoint. Further investigations in biofield science and healing, especially those involving multidisciplinary collaborations—including clinical and preclinical trials, physiology, biophysics, device technology, and theoretical and philosophical models—will guide the way to a new paradigm in biology and medicine.

REFERENCES

1. Maizes V, Rakei D, Niemiec C. Integrative medicine and patient-centered care. *Explore (NY)*. 2009;5(5):277-89.
2. Cassidy CM. What does it mean to practice an energy medicine? *J Altern Complement Med*. 2004;10(1):79-81.
3. Funk RH, Monsees T, Ozkucur N. Electromagnetic effects—from cell biology to medicine. *Prog Histochem Cytochem*. 2009;43(4):177-264.
4. Movaffaghi Z, Farsi M. Biofield therapies: biophysical basis and biological regulations? *Complement Ther Clin Pr*. 2009;15(1):35-7.
5. Bischof M, Del Giudice E. Communication and the emergence of collective behavior in living organisms: a quantum approach. *Mol Biol Int*. 2013;2013:987549.
6. Rubik B, Pavek R, Greene E, Laurence D, Ward R, Al E. Manual healing methods. In: Rubik B, et al, eds. *Alternative medicine: expanding medical horizons: a report to the National Institutes of Health on alternative medical systems and practices in the United States (NIH Publication)*. Washington, DC: US Government Printing Office; 1995:113-57.
7. Bischof M. Vitalistic and mechanistic concepts in the history of bioelectromagnetics. In: Belousov L, Popp F, eds. *Biophotonic: non-equilibrium and coherent systems in biophysics, biology, and biotechnology*. Proceedings of International Alexander Gurwitsch Conference, Sept 28-Oct 2, 1994. Moscow: Bioinform Services; 1995:3-14.
8. Senzou SA. Chiropractic and energy medicine: a shared history. *J Chiropr Humanit*. 2008;27-54.
9. Hahnemann S. *Organon of medicine*. 6th ed. Germany: WF Wakeman; 1833.
10. Northrup GW. *Osteopathic medicine: an american reformation*. Chicago: American Osteopathic Association; 1966.
11. Belousov L V, Opitz JM, Gilbert SF. Life of Alexander G. Gurwitsch and his relevant contribution to the theory of morphogenetic fields. *Int J Dev Biol*. 1997;41(6):771-7; comment 778-9.
12. Jerman I, Krasovec R, Leskovic RT. Deep significance of the field concept in contemporary biomedical sciences. *Electromagn Biol Med*. 2009;28(1):61-70.
13. Van Wijk R. Bio-photons and bio-communication. *J Sci Explor*. 2001;15(2):183-97.
14. Popp FA, Chang JJ. The physical background and the informational character of biophoton emission. In: Chang JJ, Popp FA, eds. *Biophotons*. Dordrecht, The Netherlands: Kluwer; 1998:238-50.
15. Ives J, van Wijk E, Bat N, et al. Ultra-weak photon emission as a non-invasive health assessment: a systematic review. *PLoS One*. 2014;9(2):e87401.
16. Brain interactions with weak electric and magnetic fields. *Neurosci Res Prog Bull*. 1977;15(1):1-129.
17. Shupak N. Therapeutic uses of pulsed magnetic-field exposure: A review. *Radio Sci Bull*. 2003 Dec;307:9-32.
18. Funk RH, Monsees TK. Effects of electromagnetic fields on cells: physiological and therapeutic approaches and molecular mechanisms of interaction. A review. *Cells Tissues Organs*. 2006;182(2):59-78.
19. Becker RO. The bioelectric factors in amphibian-limb regeneration. *J Bone Joint Surg Am*. 1961;43-A:643-56.
20. Becker RO. Stimulation of partial limb regeneration in rats. *Nature*. 1972 Jan 14;235(5333):109-11.
21. Levin M. Endogenous bioelectrical networks store non-genetic patterning information during development and regeneration. *J Physiol*. 2014;592(Pt 11):2295-305.
22. Adams DS, Tseng AS, Levin M. Light-activation of the Archaerhodopsin H(+) pump reverses age-dependent loss of vertebrate regeneration: sparking system-level controls in vivo. *Biol Open*. 2013;2(3):306-13.
23. Steinhoff U, Schnabel A, Burghoff M, et al. Spatial distribution of cardiac magnetic vector fields acquired from 3120 SQUID positions. *Neuro Clin Neurophysiol*. 2004 Nov 30; 2004:59.
24. McCraty R, Atkinson M, Tomasiño D, Bradley RT. The coherent heart, heart-brain interactions, psychophysiological coherence, and the emergence of system-wide order. *Integr Rev*. 2009;5(2):110-115.
25. McCraty R. The energetic heart: Bioelectromagnetic communication within and between people. In: Rosch PJ, Markov MS, eds. *Bioelectromagnetic Medicine*. New York: Marcel Dekker; 2005:511-30.
26. Jain S, Mills PJP. Biofield therapies: helpful or full of hype? A best evidence synthesis. *Int J Behav Med*. 2010;17(1):1-16.
27. Hammerschlag R, Marx BLB, Aickin M, Marx A. Nontouch biofield therapy: a systematic review of human randomized controlled trials reporting use of only nonphysical contact treatment. *J Altern Complement Med*. 2014;20(12):881-92.
28. Roe CA, Sonnex C, Roxburgh EC. Two meta-analyses of noncontact healing studies. *Explore (NY)*. 2015;11(1):11-23.
29. Thaheld FH. An interdisciplinary approach to certain fundamental issues in the fields of physics and biology: towards a unified theory. *Biosystems*. 2005;80(1):41-56.
30. Cosic I, Pirogova E, Vojisavljevic V, Fang Q. Electro-magnetic properties of biomolecules. *FME Transact*. 2006;34(2):71-80.
31. Halberg F, Cornélissen G, Otsuka K, et al; the International BIOCOS Study

- Group. Cross-spectrally coherent ~10.5- and 21-year biological and physical cycles, magnetic storms and myocardial infarctions. *Neuro Endocrinol Lett.* 2000;21(3):233-58.
32. Stoupe E. The effect of geomagnetic activity on cardiovascular parameters. *Biomed Pharmacother.* 2002;56 Suppl 2:247s-56s.
 33. Schiegl H. *Healing magnetism.* Freiburg, Germany: Herman Verlag KG; 1983.
 34. Lutendorf SK, Mullen-Houser E, Russell D, et al. Preservation of immune function in cervical cancer patients during chemoradiation using a novel integrative approach. *Brain Behav Immun.* 2010;24(8):1231-40.
 35. Friedman RS, Burg MM, Miles P, Lee F, Lampert R. Effects of Reiki on autonomic activity early after acute coronary syndrome. *J Am Coll Cardiol.* 2010;56(12):995-6.
 36. Jain S, Pavlik D, Distefan J, et al. Complementary medicine for fatigue and cortisol variability in breast cancer survivors. *Cancer.* 2012;118(3):777-87.
 37. Rubik B, Walleczek J, Liboff A, Hazelwood C, Becker R. Bioelectromagnetics Applications in Medicine. In: Rubik B, Al. E (11-member editorial review board), eds. *Alternative Medicine: Expanding Medical Horizons: A Report to the National Institutes of Health on Alternative Medical Systems and Practices in the United States.* Washington, DC: US Government Printing Office; 1995:45-65.
 38. Muehsam D, Ventura C. Life rhythm as a symphony of oscillatory patterns: electromagnetic energy and sound vibration modulates gene expression for biological signaling and healing. *Glob Adv Heal Med.* 2014;3(2):40-56.
 39. Radin D, Nelson R. Meta-analysis of mind-matter interaction experiments: 1959-2000. In: *Healing*, ed. London: Harcourt Health Sciences; 2003:39-48.
 40. Radin D, Yount G. Effects of healing intention on cultured cells and truly random events. *J Altern Complement Med.* 2004;10(1):103-12.
 41. Creath K, Schwartz GE. Measuring effects of music, noise, and healing energy using a seed germination bioassay. *J Altern Complement Med.* 2004;10(1):13-22.
 42. Schlitz M, Hopf HW, Eskenazi L, Vieten C, Radin D. Distant healing of surgical wounds: an exploratory study. *Explore (NY).* 2012;8(4):223-30.
 43. Wackermann J, Seiter C, Keibel H, Walach H. Correlations between brain electrical activities of two spatially separated human subjects. *Neurosci Lett.* 2003;336(1):60-4.
 44. Radin DI. Event-related electroencephalographic correlations between isolated human subjects. *J Altern Complement Med.* 2004;10(2):315-23.
 45. Richards TL, Kozak L, Johnson LC, Standish LJ. Replicable functional magnetic resonance imaging evidence of correlated brain signals between physically and sensory isolated subjects. *J Altern Complement Med.* 2005;11(6):955-63.
 46. Standish LJ, Johnson LC, Kozak L, Richards T. Evidence of correlated functional magnetic resonance imaging signals between distant human brains. *Altern Ther Health Med.* 2003;9(1):128, 122-5.
 47. Standish LJ, Kozak L, Johnson LC, Richards T. Electroencephalographic evidence of correlated event-related signals between the brains of spatially and sensory isolated human subjects. *J Altern Complement Med.* 2004;10(2):307-14.
 48. Pizzi R, Fantasia A, Gelain F, Rossetti D, Vescovi A. Non-local correlations between separated neuronal networks. *Proc SPIE.* 2004;5436:107-17.
 49. Popp F. *Electromagnetic Bio-Information.* Baltimore, MD: Urban und Schwarzenberg; 1989.
 50. Hameroff SR. Quantum coherence in microtubules: A neural basis for emergent consciousness? *J Conscious Stud.* 1994;1(1):91-118.
 51. Ho MW, Popp FA, Warnke U, eds. *Bioelectrodynamics and Biocommunication.* London: World Scientific; 1994.
 52. Stapp HP. *Mind, Matter and Quantum Mechanics.* Berlin, Heidelberg: Springer Verlag; 2009.
 53. Hameroff S, Nip A, Porter M, Tuszynski J. Conduction pathways in microtubules, biological quantum computation, and consciousness. *Biosystems.* 2002;64(1-3):149-68.
 54. Havelka D, Cifra M, Kučera O, Pokorný J, Vrba J. High-frequency electric field and radiation characteristics of cellular microtubule network. *J Theor Biol.* 2011;286(1):31-40.
 55. Zhao Y, Zhan Q. Electric fields generated by synchronized oscillations of microtubules, centrosomes and chromosomes regulate the dynamics of mitosis and meiosis. *Theor Biol Med Model.* 2012 Jul 2;9:26.
 56. Zhao Y, Zhan Q. Electric oscillation and coupling of chromatin regulate chromosome packaging and transcription in eukaryotic cells. *Theor Biol Med Model.* 2012 Jul 3;9:27.
 57. Ho MW, Knight DP. The acupuncture system and the liquid crystalline collagen fibers of the connective tissues. *Am J Chin Med.* 1998;26(3-4):251-63.
 58. Langevin HM. Connective tissue: a body-wide signaling network? *Med Hypotheses.* 2006;66(6):1074-77.
 59. Plankar M, Brežan S, Jerman I. The principle of coherence in multi-level brain information processing. *Prog Biophys Mol Biol.* 2013;111(1):8-29.
 60. Ho M-W. Illuminating water and life. *Entropy.* 2014;16(9):4874-91.
 61. Ferrell JE, Tsai TY-C, Yang Q. Modeling the cell cycle: why do certain circuits oscillate? *Cell.* 2011;144(6):874-85.
 62. Glass L. Synchronization and rhythmic processes in physiology. *Nature.* 2001;410(6825):277-84.
 63. Bordyugov G, Westermark P, Korenčič A, Bernard S, Herzel H. Mathematical modeling in chronobiology. *Handb Exp Pharmacol.* 2013;(217):335-57.
 64. Lara-Aparicio M, Barriga-Montoya C, Padilla-Longoria P, Fuentes-Pardo B. Modeling some properties of circadian rhythms. *Math Biosci Eng.* 2014;11(2):317-30.
 65. Dodla R, Wilson CJ. Interaction function of oscillating coupled neurons. *Phys Rev E Stat Nonlin Soft Matter Phys.* 2013;88(4):042704.
 66. Popp FA, Becker G, König H, Peschka W, eds. *Elektromagnetische Bioinformation.* Munich: Urban und Schwarzenberg; 1979.
 67. Zhadin MN. Review of Russian literature on biological action of DC and low-frequency AC magnetic fields. *Bioelectromagnetics.* 2001;22(1):27-45.
 68. Binhi VN, Rubin AB. Magnetobiology: the kT paradox and possible solutions. *Electromagn Biol Med.* 2007;26(1):45-62.
 69. Muehsam DJ, Pilla AA. A Lorentz model for weak magnetic field bioeffects: part II—secondary transduction mechanisms and measures of reactivity. *Bioelectromagnetics.* 2009;30(6):476-88.
 70. Muehsam DJ, Pilla AA. The sensitivity of cells and tissues to exogenous fields: effects of target system initial state. *Bioelectrochem Bioenerg.* 1999;48(1):35-42.
 71. Rubik B. Energy medicine and the unifying concept of information. *Altern Ther Health Med.* 1995;1(1):34-9.
 72. Rubik B. Information, energy, and the unpredictable whole. *Adv J Mind-Body Heal.* 1997;13(2):67-70.
 73. Einstein A, Podolsky B, Rosen N. Can quantum-mechanical description of physical reality be considered complete? *Phys Rev.* 1935 May 15;47:77-80.
 74. Bell JS. On the Einstein Podolsky Rosen paradox. *Physics (College Park Md).* 1964;1(3):195-200.
 75. Aspect A, Grangier P, Roger G. Experimental realization of Einstein-Podolsky-Rosen-Bohm Gedankenexperiment: A new violation of Bell's inequalities. *Phys Rev Lett.* 1982;49(2):91-4.
 76. Aharonov Y, Bohm D. Significance of electromagnetic potentials in the quantum theory. *Phys Rev.* 1959;115(3):485-91.
 77. Bohm D. *Wholeness and the Implicate Order.* London: Routledge and Kegan Paul; 1980.
 78. Noguchi A, Shikano Y, Toyoda K, Urabe S. Aharonov-Bohm effect in the tunnelling of a quantum rotor in a linear Paul trap. *Nat Commun.* 2014;5:3868.
 79. Sheldrake R. *A New Science of life: the hypothesis of formative causation.* London: Blond and Briggs; 1981.
 80. Walker SI, Davies PC. The algorithmic origins of life. *J R Soc Interface.* 2012 Dec 12;10(79):20120869.
 81. Rubik B. The biofield hypothesis: its biophysical basis and role in medicine. *J Altern Complement Med.* 2002;8(6):703-17.
 82. Hintz KJ, Yount GL, Kadar I, Schwartz G, Hammerschlag R, Lin S. Bioenergy definitions and research guidelines. *Altern Ther Heal Med.* 2003;9(3 Suppl):A13-A30.
 83. Rein G. Bioinformation within the biofield: beyond bioelectromagnetics. *J Altern Complement Med.* 2004;10(1):59-68.
 84. Warber SL, Cornelio D, Straughn J, Kile G. Biofield energy healing from the inside. *J Altern Complement Med.* 2004;10(6):1107-13.
 85. Levin M. The wisdom of the body: future techniques and approaches to morphogenetic fields in regenerative medicine, developmental biology and cancer. *Regen Med.* 2011;6(6):667-73.