

Bioelectrodynamics

A New Patient Care Strategy for Nursing, Health, and Wellness

■ Marcy C. Purnell, MSN, FNP-C ■ Michael A. Whitt, PhD

Bioelectrodynamics is an interdisciplinary subject that offers a pathway for nursing to develop a new patient care strategy in health care. The application of bioenergy to living organisms has the potential to advance medical science in the areas of prevention, cancer, wound care, pain, and many other chronic diseases. **KEY WORDS:** *bioelectrodynamics, bioenergy, health, holistic, physics* *Holist Nurs Pract* 2015;00(00):1-6

The study of bioelectrodynamics is an interdisciplinary subject that has exhibited a rebirth in medical science. Bioelectrodynamics seeks to understand and reveal the important roles that electromagnetism plays in biology and the biophysical function of all living organisms.¹ The existence of electrical signals in plants, animals, and humans was discovered more than 2 centuries ago.² These electrical signals play important roles in the development, physiology, regeneration, and pathology of cells.³ Many scientists and health care professionals view these phenomena to be the result of some action rather than the mediator of cell physiology.

In the 1990s, the development of molecular and cellular tools, with the addition of microsystems and nanotechnology, has allowed us to see the

comprehensive link between cell biology and bioelectricity.⁴ In Western medicine, we currently utilize electromagnetic signals both in diagnostics and in the treatment of chronic disease in a *limited* fashion. The electrocardiogram and the electroencephalogram are widely used to record dynamic extracellular electrical signals of the heart and the brain. These are used to detect the health of the individual as well as the endpoint of life in a dying individual. Also, electrical stimulation devices that target *specific* cell types such as cardiac pacemakers, defibrillators, bone growth stimulators, and TENS units are currently used for treatment. Scientists appear to accept these dynamic electrical signals but reject the little known and understood coexisting steady electrical signals of most other nonexcitable cells.

Many electrical-based therapies in the past were considered bogus and acquired a bad reputation that was linked to quackery. Western medicine currently embraces the investigation and alteration of the chemical signaling side of the cell through research on and use of pharmaceuticals, whereas Eastern medicine has its roots in electromagnetic field therapies that are holistic in nature and that address the electromagnetic signaling side of the cell/organism. This review examines how an understanding of electromagnetism and the utilization of bioelectrodynamics can promote health and wellness in a holistic fashion. Examples from the scientific literature give credence to the role that understanding and utilizing electromagnetism can play in treating and addressing health and wellness⁵ and as such provides a unique opportunity for advanced nursing practice to utilize these techniques

Author Affiliations: University of Memphis, Loewenberg School of Nursing, Memphis, Tennessee (Ms Purnell); and Department of Microbiology, Immunology and Biochemistry, The University of Tennessee Health Science Center, Memphis (Ms Purnell and Dr Whitt).

The ongoing research referred to in this review has been funded by University of Memphis, 2013 Faculty Grant Award; Hal and Alma Reagan Fellowship Award 2014 from The University of Tennessee Health Science Center; University of Tennessee, Department of Immunology, Microbiology and Biochemistry Chair Funds; and Southern Nursing Research Society and Council for Advancement of Nursing Science 2014 Dissertation Award.

On February 11, 2015, there was a provisional patent, titled "Bioelectrodynamics Modulation Method," filed with the United States Patent and Trademark Office in Alexandria, Virginia. The inventors are Marcy C. Purnell and Michael A. Whitt. The assignee is University of Tennessee Research Foundation.

Correspondence: Marcy C. Purnell, MSN, FNP-C, University of Memphis, Loewenberg School of Nursing, 100 Billy Mac Jones Bldg, Office 210, Memphis, TN 38153 (mpurnell@memphis.edu).

DOI: 10.1097/HNP.0000000000000129

for patient care. An examination of both quantum and Newtonian physics will also be explored to show the links between quantum theory and Eastern medicine, as well as the links between Newtonian physics and Western medicine. We also discuss the application of *veritable* versus *putative* energy fields (biofields). Because of the holistic nature of bioelectrodynamics, which is actually based on concepts linked to quantum theory, a potential new frontier of energy medicine could be developed from future research endeavors by nurses and interdisciplinary teams.

NEWTONIAN VERSUS QUANTUM PHYSICS

Prior to the beginning of the 20th century, science embraced Newtonian physics as the basis for life processes.⁶ Concepts based in Newtonian physics refer to the organizational structure of matter in which the smallest known particle, the atom, consists of protons, neutrons, and electrons that orbit a nucleus much as the planets orbit the sun in our solar system. Western practitioners believed that all things could be divided into parts of the whole. The reliance on particle theory led to the belief that if you could affect one particle or pathway of the cell/atom that has gone awry, health could be restored. This became the basis for the pharmaceutical industry explosion where the development of a small molecule (medication) that affected a specific cell signaling pathway normally controlled by the binding of hormones, cytokines, growth factors, ions, messengers, etc, to their cognate receptors would correct a specific health problem.

With a greater understanding of our physical world, the concept of quantum physics provided an alternative view for how energy and health are related. Chinese practitioners first recognized this relationship thousands of years ago.⁷ They realized that when the energy fields of an organism are strong and vibrant, the organism remains healthy; when it is weakened or disturbed, it becomes vulnerable to sickness and eventually death. A few years after the turn of the 20th century, scientists began to explore the relationship between energy and matter, which ushered in the era of quantum physics. Concepts of energy fields are grounded in quantum physics and how they can be utilized to affect the physiology and health of living organisms. Quantum physicists suggested that "atoms" or matter are actually energy fields that are constantly spinning, moving, or vibrating.^{6,8,9} The concept that

energy and matter are one in the same was recognized and described by Max Planck, who is considered the father of quantum theory.¹⁰ He stated that energy E is equal to a constant (h) multiplied by its frequency (ν) or $E = h\nu$. Therefore, it is impossible to separate living organisms into energy and matter since they are actually coexistent. It stands to reason that we should seriously consider and not ignore the role that energy and its associated energy fields can play in affecting living matter (organisms) since energy and matter are considered inseparable in quantum theory.

These 2 schools of thought were running in parallel until around the turn of the 20th century; energetic medicine that is grounded in the study of energy fields was abandoned for pharmaceutical therapy, which has predominated medical practice used today. Bioelectrodynamics recognizes that living organisms are energetic beings. It does not separate us into the sum of our parts. We each have individuality that is based in the makeup of our subatomic particles, but there is a commonality that resides on the energy frequency side of our makeup. In bioelectrodynamics, we view our bodies as vibrating fields of energy. While our individual DNA sequence defines the constituent physical properties of our bodies, there is also a unique frequency or pattern of energy that makes us each individuals.¹¹

The universe, environment, organism, and individual cells are an integration of interdependent energy fields. For example, we receive energy from the sun as well as the earth's electromagnetic fields. We also are affected by the energy field of other organisms around us.¹² The flow of energy and information in the quantum world is holistic, meaning the whole being and not one specific chemical pathway is involved in the energy ebb and flow. Since Newtonian physics divides living organisms into individual cells and targets their cell signaling pathways through the use of chemical energy (medications), this creates a series of interconnected events that can lead to unwanted side effects. In a very simple example, when an antibiotic is given to a patient to fight infections, this foreign chemical has to be processed by the body's liver/gastrointestinal tract or kidney cells. This can lead to organ stress due to the assumption that the antibiotic is working in a specific or linear fashion. Linear can be explained with regard to how the pharmaceutical targets/affects one cell process/pathway and not the whole organism. For example, with the administration of a β -lactam antibiotic, the pathway that is affected is cell wall

mucopeptide synthesis of the invading/pathogenic bacterium. This affects the ability of the bacterium to maintain integrity of the cell wall, thereby causing cell lysis or death. Since our normal flora and health depend on “good” bacteria that manufacture their cell walls in the same manner as the pathogenic bacteria, unwanted side effects such as *Candida* overgrowth and gastrointestinal dysfunction occur, as the normal flora that are necessary for bodily processes are also harmed.

As one delves into the metabolic processes of the cell, it does not take long to realize the complicated and multidimensional nature of the cell and how quickly changes are occurring in multiple pathways simultaneously.¹³ Energy medicine can enhance all biological processes that are necessary for and are the basis of life. Electromagnetic energy fields are absorbed by all excitable and nonexcitable cells in the organism and affect, and actually enhance, multiple pathways at the same time in a tertiary or nonlinear fashion. Tertiary means the application addresses 3 different phenomena at 1 time.¹⁴

Bioelectrodynamics utilizes an electrical energy source that affects not only the organism but also the field immediately surrounding the organism. So, the tertiary interaction of these 3 components—(1) energy source, (2) environment, and (3) the organism—is involved in the process of bioelectrodynamics. The energy source can consist of regulated electrical current (AC [alternating current] or DC [direct current]) delivered through a specifically designed power pack, or it can consist of natural sources that emit electrical fields such as lightning, sunlight, cosmic radiation, or other man-made devices such as cellular phones, microwaves, electrical power lines, televisions, as well as other living organisms or surrounding objects. The environment is the immediate area surrounding the organism (cell or individual) such as the extracellular matrix of the cell as well as the energy field surrounding the organism (person). If electromagnetic fields generated by the energy source, the organism/cell, and the environmental field interact either positively or negatively, this has the ability to affect physiologic processes of the living organism in a quantum or tertiary fashion.^{14,15} When energy emanates from an appropriate source that is beneficial to the living organism, this energy becomes bioenergy and will be utilized and absorbed by the whole organism with no processing needed, thereby no side effects. Multiple cell signaling pathways of the whole organism will be

affected by the external energy source and the environment. In other words, our bodies operate in a holistic, quantum energetic fashion where pathways of energy are interconnected in a tertiary fashion. For example, all humans can take energy emanating from the sun (energy source) and absorb them into their bodies (organism) to manufacture vitamin D, a natural steroid hormone. This hormone is necessary for the health of every living cell. If time in the sun is not abused over long periods to cause burning, this energy is absorbed and incorporated into the body to fuel physiologic processes. The energy fields of the sun are interacting with the energy fields of the environment (field surrounding the organism as well as the extracellular matrix) and the living organism (including the intracellular matrix). There is generally no stress on the living organism with appropriate exposure, and vitamin D is manufactured for use by the organism.

VERITABLE VERSUS PUTATIVE ENERGY FIELDS

The National Center for Complementary and Integrative Health has divided energy medicine into *veritable* applications, or those that can be measured for diagnosis and treatment, and *putative* applications (biofields), or those that have defied measurement by lack of reproducibility.¹⁶ Eastern medicine applications have historically been considered putative by involving a health care practitioner and a client, with the practitioner addressing the electromagnetic fields of the whole living organism through such methods as acupuncture, reflexology, massage, healing touch, Reiki, etc. Putative energy fields have been the most controversial of the alternative energy medicine practices, but they are gaining popularity in not only the American marketplace but also several academic medical centers. Now, 85% of medical schools in the United States offer elective courses in these alternative health practices.¹⁶

Recent veritable research shows that addressing the electromagnetic fields of an organism has remarkable effects on the health of living organisms.¹⁷ Also, it is known that organisms must process environmental electromagnetic signaling to survive and these signals are indeed now measurable with recent advances in medical science.¹² The speed of an electromagnetic energy signal is 186 000 miles per second, and the speed of a chemical reaction is less than 1 cm per

second.⁶ This shows how much more efficient a holistic electromagnetic signal operates that is based in quantum theory versus a chemical signal that is based in Newtonian theory. These new measurement tools and the development of veritable energy medicine applications will hopefully help provide significance and reproducibility that will offer credible and valid research and allow for an increase in these applications in Western medicine. We now explore the recent research of energy and electromagnetic fields that are currently being used to treat disease and promote health in order to give credibility to addressing life and health with quantum physics.

REVIEW OF CURRENT ENERGY MEDICINE RESEARCH

To illustrate the idea behind organisms having their own energy field, if one were to take a voltage meter and place it in the hands of an individual, a measurement of the voltage that is being emitted from the individual can be made. This will vary between individuals, as well as within the same individual as his or her state of health changes. Just as voltage potential can be measured from the electromagnetic signals coming off the whole organism, we can also measure transmembrane potential (V_{mem}) on the membrane of cells and this phenomenon results from differential ion concentrations across the cell membrane.^{18,19}

Current research shows that we have only scratched the surface on how we address the bioenergetic side of the body. We know that cell behavior is regulated by not only chemical gradients but also by bioelectric cues.¹² V_{mem} differences have been found in cancerous, injured, and proliferating cells.^{19,20} Cancerous, injured, and proliferating cells have a more depolarized membrane potential of approximately less than -30 mV, whereas noncancerous cells have a resting potential of more than -70 mV.¹⁹ Cells have been found to respond to different electromagnetic signals when undergoing division, migration, and differentiation.² Scientists have found that bioelectricity or electromagnetic fields involve the changing gradients of transmembrane potential, ion channel activity, and electromagnetic fields that are produced and sensed by nonexcitable cells in living organisms.^{20,21} Therefore, bioelectricity shows an effect well beyond excitable cells and has been shown to affect wound healing, cell migration, nerve growth,

limb regeneration, and cancer.^{3,22} Changes in transcription, after depolarization of the cell membrane, occur across multiple genes, and it appears that bioelectric cues or signals override chemical signals since human mesenchymal stem cells will not differentiate without hyperpolarization despite potent chemical inducers.²³

Bioelectric gradients have also been found to mediate signaling beyond cell-to-cell communication and actually appear to communicate throughout the whole organism and beyond.¹² This suggests that bioelectric cues are a very efficient medium for carrying information. For example, planarian flatworms can remarkably regenerate themselves from partial body fragments.²⁴ The partial body fragments require communication to control whether the regrowth occurs symmetrically or asymmetrically where one edge becomes a head or becomes a tail to grow the entire whole organism. The cells must be able to conduct long-range communication since gap junction (cell-cell) communication would not suffice for this high-level differentiation from the remaining partial body fragments.²⁵

It has been shown that electrical events tell the cells what to do; voltage changes not only have been found to be a sign of cancer but it appears also to determine whether or not cancer may develop.²⁰ A research group at Tufts University has also found that cells are regulated not only by their own internal voltage potential but also by their neighbors, as well as from the environment.¹² This finding opens the door for potential research in the areas of cancer, wound care, and any other disease process that can be attributed to a depolarized V_{mem} that leads to cell damage/inflammation/death.¹⁹ The 4 cardinal signs of inflammation are redness, swelling, heat, and pain; the fifth cardinal sign of inflammation is loss of function.²⁶ Since loss of function is thought to originate with inflammation of the cell, V_{mem} augmentation with bioelectromagnetic energy could offer a new treatment options for chronic disease. With regard to human trials, a single-group open-label phase I/II study was conducted to assess the safety and efficacy of intrabuccal administration of low levels of electromagnetic fields in patients with advanced hepatocellular carcinoma. They found that these treatments decreased tumor size and increased progression-free survival for more than 6 months in the participants.¹⁷

These in vitro experiments and in vivo human trials show potential for electromagnetic fields not only as

diagnostic tools but also as treatments of disease. Alternative medical practices have utilized the electromagnetic fields between the practitioner and the client.²⁷ Massage, reflexology, healing touch, Reiki, and acupuncture are reported to have beneficial effects on health and wellness of clients.²⁸⁻³¹ Many of these practices have not gained scientific credibility due to the lack of ability to conduct rigorous scientific trials and the putative applications with many of these treatments. The measurements that need to occur are often difficult to attain due to the lack of molecular and cellular tools that existed prior to the 1990s. Now that these tools have been developed and scientists are now quantifying on the cellular level the significant effects of electromagnetic fields and bioelectricity on living organisms, it is time to move these treatments forward with scientific rigor. Research on the mechanisms by which cells interact with bioelectrical signals, chemical gradients, and physical forces has begun to emerge in recent decades.^{32,33} Molecular analyses of the effects of bioelectricity may point us to a way we can understand the mechanisms that occur at the cellular level and lead us to biomedical transformations.

ROLE OF NURSING

Nursing is based on caring for the whole person in a holistic manner. Nursing has historically viewed the individual as a whole and that individuals can be greatly influenced by the environment. Grand theorist Martha Rogers' theory of the *Science of Unitary Human Beings* addresses the phenomenon of bioelectrodynamics.³⁴ The *unitary human being* is defined by Rogers as an irreducible and indivisible energy field that is identified by pattern (DNA signature field) and manifests characteristics that are specific to the whole that cannot be divided into parts (quantum theory). Rogers³⁵ describes the concepts of *environment* as an energy field that is identified by patterns (various environmental fields and biofields) and is integral with the human field. Rogers considered the *energy field* to be a fundamental unit of the living and the nonliving. Openness is the concept that explains that no boundaries exist that inhibit energy flow between fields and that the human field(s) and the environmental fields are constantly exchanging energy (in a tertiary fashion).

Rogers' grand theory addresses the individual as a whole and who is integral and connected with his or her

environment. These concepts align with those forming the basis of quantum theory perfectly and lay the groundwork for nursing to own a vast field of empirical research with regard to bioelectrodynamics. The rebirth of research in electromagnetic field therapies gives credence to Rogerian theory and opens a path for future nursing research. It is time for nursing to partner with interdisciplinary teams in order to continue moving the research of bioelectrodynamics forward for the benefit of humanity. We now discuss the research that is coming on the horizon that offers great promise for the future of new treatments of acute and chronic disease as well as promotion of health and wellness.

THE FUTURE OF NURSING PRACTICE

Besides the explosion of pharmaceutical therapies, the primary roadblocks for the implementation of bioelectrodynamics research and electromagnetic field therapies have been due to the personal nature of the interaction between a therapist/practitioner and a client and the lack of quantifiable outcomes following the therapy. The effects produced are often impossible to replicate to obtain scientific validity. Preliminary studies that utilize a bioenergy device and that use cellular and molecular techniques to determine the basis for the effects induced by the device are offering intriguing insights into how bioenergy affects cancer cell lines in culture.³⁶ Phase I safety trials with this device will commence soon, which will hopefully open the door for future research on bioelectrodynamics. It is believed that this bioenergy device augments the electromagnetic fields of living organisms and has potential through carefully planned clinical trials to bring valid energy medicine applications into Western medicine. The research on this device is currently being conducted by an interdisciplinary team of molecular biologists, nurses, biostatisticians, electrical engineers, and inventors.

The holistic nature of this research, which has its foundations in quantum physics, has great potential and should be viewed as a new frontier in which nursing can take the lead and pioneer as a future practice of energy medicine. Every living cell/organism responds to electromagnetic energy and therefore if done correctly and safely, the potential for life enhancement and health is immeasurable. For too long, scientists have perceived electromagnetic information as by-products of biological activities. We are now learning that cells maintain integrity and health by minute

molecular changes that involve both continual inter- and intracellular communications that convey not only chemical messages but also electromagnetic messages.

Since cell's V_{mem} drops in cancerous, injured, and proliferating cells, the normalization of this V_{mem} with electromagnetic fields shows great potential to positively affect inflammation and disease processes such as cancer, wound care, pain, hypertension, arthritis, Chronic obstructive pulmonary disease, asthma, and many other health issues.⁴ Western medicine has created an out-of-balance science because of its broad and encompassing emphasis on pharmaceutical therapy. It is time to bring the bioelectrical side of the cell into play with new holistic treatments that have their roots in Eastern medicine and quantum theory. Martha Rogers has laid an important foundation for the future of nursing research. Applications of energy medicine show great promise for teams of nurse scientists in partnership with many supporting disciplines and will offer a path to health and wellness that our society has yet to experience.

[AQ1]

REFERENCES

1. Zhou SA, Uesaka M. Bioelectrodynamics in living organisms. *Int J Eng Sci.* 2006;44(1):67-92.
2. McCaig CD, Song B, Rajnicek AM. Electrical dimensions in cell science. *J Cell Sci.* 2009;122(pt 23):4267-4276.
3. McCaig CD, Rajnicek AM, Song B, Zhao M. Controlling cell behavior electrically: current views and future potential. *Physiol Rev.* 2005;85(3):943-978.
4. Funk RH, Monsees T, Ozkucur N. Electromagnetic effects—from cell biology to medicine. *Prog Histochem Cytochem.* 2009;43(4):177-264.
5. Goodman R, Blank M. Insights into electromagnetic interaction mechanisms. *J Cellular Physiol.* 2002;192:16-22.
6. Lipton BH. *The Biology of Belief.* Carlsbad, CA: Hay House Inc; 2008.
7. Rubik B. Energy medicine and the unifying concept of information. *Altern Ther Health Med.* 1995;1:34-39.
8. Panagopoulos DJ, Messini N, Karabarbounis A, Philippetis AL, Margariis L. Mechanism for action of oscillating electric fields on cells. *Biochem Biophys Res Commun.* 2000;272(3):634-640.
9. Tseng A, Levin M. Cracking the bioelectric code: probing endogenous ionic controls of pattern formation. *Commun Integr Biol.* 2013;6(1):e22595.
10. Kuhn TS. *Black Body Theory and Quantum Discontinuity.* New York, NY: Oxford University Press; 1978.
11. Hackermuller L, Utenthaler S, Hornberger K, et al. Wave nature of biomolecules and fluorofullerenes. *Phys Rev Lett.* 2003;91(9):090408.
12. Levin M. Molecular bioelectricity: how endogenous voltage potential control cell behaviors and instruct pattern regulation in vivo. *Am Soc Cell Biol.* 2014;25:3835-3850.

13. Barry P. It's the network, stupid. *Sci News.* 2008;173.
14. Skrinjar T, Walker S. *Q Mechanics.* Toowomba, Queensland, Australia: Terry J Skrinjar & Stven T Wilker; 1996.
15. Marsh R. A preliminary report on the new BEFE: bioelectric field enhancement. *Explore.* November 6, 2001;10.
16. Maret K. *Energy Medicine in the United States: Historical Roots and Current Status.* Loveland, CO: Foundation for Alternative and Integrative Medicine. www.dovehealthalliance.org. Published July 2009. Accessed March 2, 2015.
17. Zimmerman JW, Pennison MJ, Brezovich I, et al. Cancer cell proliferation is inhibited by specific modulation frequencies. *Br J Cancer.* 2012;106(2):307-313.
18. Cone CD. Variation of the transmembrane potential level as a basic mechanism of mitosis control. *Oncology.* 1970;4(6):438-470.
19. Yang M, Brackenbury WJ. Membrane potential and cancer progression. *Front Physiol.* 2013;4:185.
20. Lobikin M, Chernet B, Lobo D, Levin M. Resting potential, oncogene-induced tumorigenesis, and metastasis: the bioelectric basis of cancer in vivo. *Phys Biol.* 2012;9(6):065002.
21. Levin M. Large-scale biophysics: ion flows and regeneration. *Trends Cell Biol.* 2007;17(6):261-270.
22. Nishiyama M, von Schimmelmann MJ, Togashi K, Findley WM, Hong K. Membrane potential shifts caused by diffusible guidance signals direct growth-cone turning. *Nat Neurosci.* 2008;11:762-771.
23. Sundelacruz S, Levin M, Kaplan DL. Membrane potential controls adipogenic and osteogenic differentiation of mesenchymal stem cells. *PLoS One.* 2008;3:e3737.
24. Reddien PW, Sanchez Alvarado A. Fundamentals of planarian regeneration. *Annu Rev Cell Dev Biol.* 2004;20:725-757.
25. Marder E. Electrical synapses: rectification demystified. *Curr Biol.* 2009;19:R34-35.
26. Rather LJ. Disturbance of function (functio laesa): the legendary fifth cardinal sign of inflammation, added by Galen to the four cardinal signs of Celsus. *Bull N Y Acad Med.* 1971;47(3):303-322.
27. McMakin CR, Oschman JL. Visceral and somatic disorders: tissue softening with frequency-specific microcurrent. *J Altern Complement Med.* 2013;19(2):170-177.
28. Chen K. *Inhibitory Effects of Bio-Energy Therapies on Cancer Growth.* Baltimore, MD: Center for Integrative Medicine, University of Maryland School of Medicine; 2008.
29. Levin J, Mead L. *Bioenergy Healing: A Theoretical Model and Case Series.* *Explore.* 2008;4(3):201-209.
30. Mackey B. Massage therapy and reflexology awareness. *Nurs Clin North Am.* 2001;36(1):159-170.
31. Facco E, Liguori A, Filomena P, et al. Traditional acupuncture in migraine: a controlled randomized study. *Headache.* 2008;48:398-407.
32. Habal M. Effect of applied dc currents on experimental tumor growth in rats. *J Biomed Mater Res.* 1980;14(6):789-801.
33. David S, Absolom D, Smith C, Gams J, Herbert M. Effect of low level direct current on in vivo tumor growth in hamsters. *Cancer Res.* 1985;45:5625-5631.
34. Karnick PM. The Science of Unitary Human Beings continues to flourish. *Nurs Sci Q.* 2014;27(1):29.
35. Rogers ME. Nursing science and the space age. *Nurs Sci Q.* 1992;5: 27-34.
36. Purnell M, Cowan P, Whitt M. The effects of bioelectrodynamics on cancerous and noncancerous cells. <http://www.resourcecenter.net/images/SNRS/Files/2014/AnnMtg/AbstractProceedings/data/papers/E4-6.html>. Published February 15, 2014. Accessed March 2, 2015.

[AQ2]

[AQ3]

[AQ4]