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IN THIS ISSUE...

LETTER FROM THE BEMS PRESIDENT

BY JEFFREY CARSON

Although it seems like yesterday that I stepped off the plane from the June meeting in Seoul Korea, the autumn season is now upon us. And with autumn comes lots of work. Course materials need to be whipped into shape as university and college classes resume, grant applications have to be written to beat the Fall deadlines, and research work from the summer needs to be written up and sent off for review.

In addition to all of these tasks, we need to take some time to plan for next year. Dr Joachim Schüz and I are in the technical program planning stages for the Halifax meeting and would like to hear from you. Although we have attempted to incorporate ideas from the Meeting Quality Reports from previous years (which are based on the electronic meeting survey that should have arrived in your inbox), I am sure that many of you have ideas for new technical and plenary session topics. So, please feel free to send your ideas.

We are also in the midst of upgrading our website with new and improved services to better serve our members. We are planning to launch this Fall and would like your input here as well. In the next Newsletter, I will provide a detailed article on the new website, which describes its new features, how it will differ from our existing website, and a brief history on how the project started and came to fruition.

In the meantime, we are looking for content that can be placed on the new website. If you have BEMS-related pictures and are willing to provide the Society permission to use them in perpetuity, then please send them to us with short descriptive captions. Also, we are looking for interesting graphics that can be incorporated into elements on the site, e.g. backgrounds, buttons, etc. If you have colorful images (e.g. such as 3D-rendered datasets), then please send us a sample. You never know it, could end up built into the homepage for all to see.

Sincerely,

Jeffrey Carson

President, The Bioelectromagnetics Society
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2010 Student Awards for Best Presentations

Each year, we honor those students whose work won an award at the annual meeting by publishing a short description of their work and the context in which it has evolved.

This year, Andrew Wood, chair of the Awards Committee announced the following awards in Seoul, Korea:

First Place Platform (Oral) Presentation Award – Joseph James Morrissey Memorial Award

- **Michael Corbacio** of Lawson Health Research Institute and the University of Western Ontario (London, Ontario, Canada)

(with coauthors S. Brown, S. Dubois, J. Weller, A. Aeuter, D. Goulet, J. Lambrozo, M. Plante, M. Souques, Frank Prato, Alex Thomas, and A. G. Legros)

for his work entitled

"Effects of a 60Hz, 3000 MicroTesla Magnetic Field on Human Cognitive Processing"

First Place Poster Award – Curtis Carl Johnson Memorial Award

- **Steven M. Kennedy** of the University of Wisconsin (Madison, WI, USA)

(with coauthors Zhen Ji, Nicole B. Rockweiler, Adam R. Hahn, John H. Sooske, and Susan C. Hagness)

for his work entitled

"A Locally Constrained Surface Tension Model Based on Cortical Anchoring Predicts Stable Electropore Development"

2nd Place Platform (Oral) Presentation Award

- **Henning Hintzsche** of the University of Wuerzburg (Germany)

(with coauthor Helga Stopper)

for his work entitled

"Mobile Phone Radiation Does Not Induce Micronuclei in Buccal Mucosa Cells"

2nd Place Poster Award

- **Mary Redmayne** of the Victoria University of Wellington (New Zealand)

for her work entitled

"Adolescent Cell Phone and Cordless Phone Exposure and User-Habits"

3rd Place Platform (Oral) Presentation Award

- **Christian Beyer** of ETH (Zürich, Switzerland)

(with coauthors Ilian Jelesarov, Philipp Christen, and Jürg Fröhlich)

for his work entitled

"Thermosensor Protein GrpE of Heat Shock Protein Hsp70 System as Target for High-Frequency Electromagnetic Fields"

<u>3rd Place Poster Award</u>

- **Christian Beyer** of ETH (Zürich, Switzerland)

(with coauthor Jürg Fröhlich)

for his work entitled

"Novel in vitro PEMF exposure system for a large number of cell dishes"

<u>4th Place Platform (Oral) Presentation Award</u>

- **Sonja Huclova** of the Swiss Federal Institute of Technology (Zürich, Switzerland)

(with coauthor Jürg Fröhlich)

for her work entitled

"Simulation of bulk dielectric parameters of cell suspensions"

<u>4th Place Poster Award</u>

- **Yu-Hsuan Wu** of the University of Southern California (Los Angeles, USA)

(with coauthors Martin Gundersen and P. Thomas Vernier)

for her work entitled

"Monitoring real-time intracellular responses to nanoelectropulses"

MICHAEL CORBACIO - 2010 FIRST PLACE PLATFORM (JOSEPH JAMES MORRISSEY MEMORIAL) AWARD

At the 32nd Annual BEMS Meeting in Seoul, South Korea, Michael presented his research on the possible cognitive effects in humans from magnetic field exposure. Specifically, Michael tested healthy volunteers in a high intensity magnetic field (3000 μT) at the same frequency as the North American power-line distribution system (60 Hz). The research complements previous studies conducted by the BEMS group at Lawson Health Research Institute in London, Ontario, Canada by transitioning focus from physiological effects to cognitive effects of magnetic exposure.

Ninety-nine participants completed the double-blind protocol consisting of two sessions. The first session establishes a baseline for anxiety, depression and intelligence through the participants' performance on the Beck Anxiety Inventory, Beck Depression Inventory- II, and the Weschler Adult Intelligence Scale. There is no magnetic field exposure for the first session. The second session includes two blocks of testing with a 30 minute resting period before each testing block. Each testing block consists of the same sequence of psychometric tests: Digit Symbol Coding, Block Design, Arithmetic, Digit Span, Trail Making Parts A and B, Stroop, Mental Rotation and Fitts' Task.

Each participant is randomly placed in one of three groups: control group (no exposure), exposure for the first half of the session, or exposure for the final half of the session. The magnetic field exposure lasts for 1 hour and is centered at the level of the participants' head. The project is currently reaching the end and the results will be submitted for publication next month.

This study is a major part of Michael's research based Master's Degree in Medical Biophysics at the University of Western Ontario, and it will be the object of his defense to be held this term. It directly relates to other studies involved in setting the safety standards for workers in extremely low frequency magnetic field areas as overseen by his supervisors Dr. Alexandre Legros and Dr. Alex Thomas. The outcome of this study will promote future research regarding the ELF magnetic field safety in the overall population and will be used to positively influence the scientific community by setting the tone for the quality of future studies.

CORRECTION: JOSEPH JAMES MORRISSEY STUDENT AWARD

In the May - June 2010 BEMS newsletter, Ken Joyner was incorrectly referred to as a Motorola representative and Motorola was incorrectly described as the sponsor of the Joseph James Morrissey Memorial Award.

In fact, the Mobile Manufacturers Forum (MMF), an international association of telecommunications equipment manufacturers with an interest in mobile or wireless communication, is the sponsor of that award. Ken, who serves as MMF Chairman, is shown here with Joe Morrissey's widow and son in Seoul, Korea as they prepare to make the first of five annual student awards sponsored by MMF in memory of Dr. Morrissey. Since February 2009, Ken is no longer with Motorola. He is now Executive Technical Advisor, Standards and Technology Enabling, DMC R&D Center, Samsung Electronics CO., LTD.

We regret the error.

STEVEN M. KENNEDY - 2010 FIRST PLACE POSTER (CURTIS CARL JOHNSON) AWARD

Research Background and Agenda:

I'm currently wrapping up my graduate studies at the University of Wisconsin as National Institutes of Health, Ruth L. Kirschstein National Research Service Award (NRSA) Fellow and a University of Wisconsin Stem Cell and Regenerative Medicine (SCRM) Cluster Faculty Interdisciplinary Bioengineering Fellow. I have the pleasure of being advised by three faculty members whose affiliations span the Departments of Electrical and Computer Engineering, Biomedical Engineering, Materials Science and Engineering, and Pharmacology.

My research interests primarily underpin the overarching notion that there are many underutilized, yet powerful ways in which electromagnetic phenomena may be exploited in the area of tissue engineering and in regenerative medicine at large. Tissue engineering involves the development and repair of tissues and organs using stem cells and other precursory, non-tissue-specific cell types. Using these immature cells to develop and repair tissues involves a complex interplay of molecular-cellular and cellular-cellular interactions that must be orchestrated with a high degree of temporal and spatial precision. Generally speaking, these cells need to be told what to do in time and space if they are to successfully mature from a group of non-tissue-specific cell types into complex, functional tissues (which are characterized by a high level of spatial complexity with multiple cell types working in concert). The inability to spatiotemporally control cell behaviors has stymied researchers' ability to grow and repair more complex tissues and organs.

The research projects I have pursued as a graduate student and plan to pursue as a postdoctoral fellow involve the development of electromagnetically inspired technologies that enable the control over cell behaviors in a manner pertinent in the context of regenerative medicine. This research thrust lies at the intersection of my graduate advisors' respective research foci: Prof. John Booske who investigates high power, high frequency electromagnetic applications, Prof. William Murphy whose has expertise in stem cell bioengineering, tissue engineering and drug delivery materials, and Prof. Susan Hagness whose work primarily focuses on developing bioelectromagnetic diagnostics and therapeutics. The potential novelty in using electromagnetic energy to direct the maturation of stem and precursory cells into functional tissues lies in just a few fundamental guiding principles: electromagnetic energy (1) can be innocuous if administered properly, (2) has predictable penetrative properties in materials, (3) can be readily controlled in time and space, (4) lends itself naturally to implementation at the micro-scale, and finally (5) can exert an influence on virtually any biologically relevant molecule, natural or synthetic (i.e., all biologically relevant molecules either have charged domains or exhibit some degree of electronegativity).

Current (Graduate) Projects:

As a graduate student I have pursued three projects that underpin my overarching research theme. These projects and their promising results underscore the need for future research on the application of electromagnetics in regenerative medicine:

First, my thesis project aims to achieve highly efficient, non-mutagenic, regulated gene and drug delivery through electrical stimulation at both the macro- and micro-environmental scales. The hypothesis guiding this research is that the co-localization of charged molecules to the plasma membrane will modify the membrane potential in a manner contributing to electroporation. The electromechanical forces required for electroporation are traditionally achieved by exposing cells to a macro-scaled pulsed electric field (PEF). However, I have demonstrated that electric fields emanating from cationic peptides dramatically reduce the electric field required for electroporative delivery of molecules to cells. In some cases, cationic peptides eliminate the need for the application of a macro-scaled E-field). Because the co-localization of peptides and cells can be precisely controlled in 3D tissue engineering scaffolding materials, this electroporative technique may afford the ability to spatially regulate the delivery of behavior-modulatory molecules (i.e., genes and drugs) to cells. This is very promising in that spatially regulated gene and drug delivery results in spatially controlled cell behaviors, which is required in successful engineering of complex tissues.

Another project I have pursued during my graduate training was the development of a low-energy, voltage-controlled approach for the deposition and impregnation of bone-like mineral on polymeric orthopedic implant materials. Contemporary orthopedic mineralization approaches that are capable of impregnating biologically relevant molecules within mineral layers (such as anti-inflammatory drugs or osteogenic growth factors which are meant to enhance orthopedic implant performance) have been limited to the use of materials with charged surface chemistries. I have developed a new approach that is independent of materials surface chemistry. This approach uses an electric potential to induce a surface charge, upon which, bone-like mineral will nucleate and grown when incubated in a solution electrolytically similar to blood plasma (i.e., modified simulated body fluid). I have demonstrated this new approach through the successful deposition of hydroxyapitite on poly(ethylene) substrates (a material that is very difficult to mineralize despite being inexpensive, physically ideal for orthopedic implantation, and FDA approved for surgical implantation). This voltage-controlled approach also holds exciting possibilities in creating general drug delivery implant materials with dynamic drug release profiles.

Another project I have pursued as a graduate student involves the electrophoretic placement of condensed plasmid DNAs, and/or growth factors in tissue engineering materials, such as poly(ethylene glycol) (PEG) hydrogels. PEG hydrogels have been used to encapsulate stem cells, creating viable three-dimensional cultures. These 3D polymeric PEG hydrogel stem cell cultures serve as appropriate "scaffolds," upon which, tissue and organs may be constructed. However, development of tissues and organs from stem cells requires the spatiotemporal control over the behavior and interaction of these encapsulated cells. Precisely positioning behavior-modifying molecules (like plasmids and growth factors) within these PEG scaffolds using electric fields, may prove to be a viable approach to controlling the maturation of tissues from stem cells. I have developed a electro-bioreactor capable of electrophoretically pulling molecules through PEG hydrogels while maintaining culture temperature, culture medium composition, pH, and stem cell viability.

Future (Postdoctoral) Projects:

Many of my interests involve biomaterials, stem cell biology and implementation of technologies within cellular microenvironments. Because I have yet to receive formal training in these research areas (my background is primarily biophysics), I felt it necessary to receive training in a laboratory that focuses in these areas. I will be beginning my postdoctoral research at the recently formed Wyss Institute for Biologically Inspired Engineering at Harvard University's School of Engineering and Applied Science (http://wyss.harvard.edu/) this fall in the laboratory of Prof. David Mooney. There, I believe I will have the resources to conduct high-risk, exploratory research at the interface of biophysics, biomaterials and biology, strengthen my background in the above-prescribed areas, and interact with and learn from a disciplinarily diverse group of scientists and engineers.

In addition to a continuation of some of my graduate research topics, there are two exciting projects that I may be pursuing. One of which is the development of electrically, magnetically, electro-thermally, and ultrasonically responsive drug delivery implant materials. In contrast to orally or intravenously administered drugs, implantable drug delivery materials allow sustained and localized drug delivery. This is vital in a number of current and immerging medical and therapies. For instance, sustained delivery of drugs locally to dysfunctional dopaminergic neurons could lead to cures for Parkinson's disease. Likewise, sustained delivery of drugs locally to dysfunctional insulin-producing beta cells in the pancreas could be an important treatment for class I diabetes. In other medical treatments, it may be important to administered drugs not only locally, but in a temporally dynamic manner (i.e., not sustained, but with precise temporal control). It is then desirable to implant a material, and remotely and innocuously "trigger" the release of a drug from that material. Thus, development of materials that encapsulate drugs, and degrade in response to electrical, magnetic, thermal, and/or ultrasonic stimuli will be an exciting and utilizable technology.

Finally, in relation to my doctoral thesis work, another project I may pursue involves the use, again, of charged peptides for modulating membrane potentials. In this proposed work, however, the goal is not to more efficiently electroporate cells, but rather regulate the differentiation of stem cells by controlling intracellular signaling pathways associated with membrane hyperpolarization and depolarization. For instance, the differentiation of human mesenchymal stem cells (hMSCs) down adipogenic (fat forming) and osteogenic (bone forming) lineages has been recently linked to membrane potential. If we are able to directly control membrane potential, through the co-localization of charged molecules, this would be an important addition to the technological tool chest required for successfully engineering tissues.

HENNING HINTZSCHE - 2010 SECOND PLACE PLATFORM AWARD

(Henning Hintzsche (L) is shown here accepting his award from Awards Committee Chair Andrew Wood (R))

The work I was honored to present at the 2010 Annual Meeting of The Bioelectromagnetics Society in Seoul was initiated from two directions:

The first is the topic of my PhD-thesis. I am investigating the putative genotoxic effects on different cell types caused by non-ionizing electromagnetic radiation. Specifically we look at the influence of different frequencies in the terahertz region, ranging from 0.1 THz to 10 THz. This area of research is a new field, and only very little results have been published so far, especially at higher frequencies. This is why a lot of preliminary work had to be done before expositions could start. In the course of these preparations we also conducted expositions with the same cells at lower frequencies, namely 900 MHz. Thus I became interested in the very controversial question of whether mobile phone radiation is able to cause genotoxic effects.

The second initiation came from human volunteer studies previously conducted within our group. Here, the effect of diseases and of different medications on genomic instability was investigated. The main sample types that were looked at were blood lymphocytes and buccal mucosa cells. Again genotoxic events were monitored and evaluated.

The idea for the presented work was to combine these two approaches and to look at human samples of volunteers and see whether genomic instability is affected by the use of mobile phones.

We recruited more than 130 individuals and took samples of buccal mucosa cells. The advantage of buccal cells is that sampling is quick, cheap and easy and participation rates among the study subjects is higher than e.g. blood withdrawal because sampling is more comfortable. After several washing and centrifugation steps, cells were brought onto microscopy slides and stained with a tubulin-antibody and chromomycin A3, the latter being a DNA-specific stain, the first making the cytoplasm visible. Evaluation was performed using the micronucleus test. This method detects genotoxic events caused by aneugenic and clastogenic agents. Subsequently we checked whether there is a correlation between micronucleus frequency and mobile phone use habits. These data were retrieved from the individuals by questionnaires that were filled out directly after sampling.

There was no correlation between the micronucleus frequency and the time which people used the mobile phone per day or week. Also other data related to mobile phone use like the overall time which participants have been using the a mobile phone or handset usage did not have any influence on the number of micronuclei. Furthermore, individual parameters like sex, age, smoking or drinking habits did not affects micronucleus frequencies. To demonstrate the effectiveness of the test to pick up genomic damage we included four patients receiving (ionizing) radiation therapy. Here we saw a huge increase of micronuclei. This shows that the micronucleus test is a suitable procedure to monitor genotoxic events.

For detailed information see:

Hintzsche, H. and Stopper, H. (2010). "Micronucleus frequency in buccal mucosa cells of mobile phone uses." Toxicol Lett 193(1): 124-130.

MARY REDMAYNE - 2010 SECOND PLACE POSTER AWARD

Mary Redmayne is studying for a PhD in New Zealand. At this year's BEMS meeting, she presented some results from a cross-sectional survey of adolescent wireless phone use undertaken with year 7/8 students in the Wellington Region. The survey collected a broad range of data on user-habits of the 373 participants, and self-reports on sleep-related factors. The accuracy of their texting estimation was also presented. A census of schools catering to this age-group in the region was also taken to establish what rules the schools had regarding cellphones and their use. Examination of both datasets has allowed an analysis of the effectiveness of rules and offers a clear picture of the extent of phone use by this age-group throughout the week, including at school and at night.

The second stage of Mary's PhD will be an examination of issues under discussion internationally regarding bio-effects of RF exposures typically encountered, and what evidence there is, if any, to indicate that these may impact adversely on health. Is the call for precaution from some quarters warranted scientifically, or just emotionally? How should these affect policy-setting? As well as a literature review, the issues to be examined will include the following along with the scientific-reasoning, drivers and substance underlying each:

- international Standard-setting and the push for harmonisation;
- the extent to which RF Standards cater for current technological capabilities;
- the range of advice being given regarding young people's exposure to RF and their use of wireless phones;
- proposed 'non-thermal' mechanisms and evidence for micro-thermal effects.

Results will be analysed with regard to policy-setting. Is there a sufficient level of risk for it to guide policy on children's use of and exposure to RF technology? How is the risk/ benefit balance to be weighed?

Mary's research advisors reflect the unique nature of her study. They are experts with a range of relevant skills, making them well-placed to support her broad topic. Professor Euan Smith is a geophysicist in the School of Geography, Environment and Earth Sciences at Victoria University of Wellington, where Mary is based. His research involves the physics of earthquakes and analysis of hazard and risk – Wellington lies on a major fault in the Pacific 'ring of fire'. Professor Michael Abramson is Deputy Head of the Department of Epidemiology and Preventive Medicine at Monash University, Melbourne, Australia. He recently led the MoRPhEUS study examining cognitive effects of adolescent wireless phone use. Mary worked in Melbourne analysing some data from this study for a few weeks in early

2009, and has subsequently co-published a paper in the Journal of Environmental Monitoring as lead author. Dr Sean Weaver is a specialist in environmental management and a Senior Associate with the Institute of Policy Studies at Victoria University of Wellington. His graduate research was in biology/botany.

CHRISTIAN BEYER - 2010 THIRD PLACE PLATFORM AND POSTER AWARDS

Christian Beyer is working towards a PhD degree in the 'Group for Electromagnetics in Medicine and Biology' hosted by the Laboratory for Electromagnetic Fields and Microwave Electronics at the ETH Zurich (www.bioc.uzh.ch). This group, headed by Dr. Jürg Fröhlich, conducts research toward applications of electromagnetic and optical principles in medical technology as well as in biomedical research. Various projects are run in close collaboration with academia and industry, covering magnetic resonance technology, optical spectroscopy, bioimpedance spectroscopy, wireless technologies for health care as well as risk assessment of electromagnetic fields. Regarding bioelectromagnetics, different projects including the potential effects of electromagnetic fields on biomolecular structures and cells as well as contributions to exposure assessment for epidemiological studies are conducted.

Christian's research interests include the investigation of potential effects of electromagnetic fields on bio molecular structures and cells, the characterisation of dielectric properties of cells and its numerically modelling.

The first mechanism orientated study presented at the BEMS 2010 in Seoul, South Korea, is an investigation on potential effects of uniform electromagnetic fields on the conformational equilibrium of thermosensor protein GrpE of the Hsp70 chaperone system of Escherichia coli. The project is carried out in collaboration with the Department of Biochemistry at the University of Zurich, bringing together engineers and biologists. The experimental set-up for the exposure of the protein solution to electromagnetic fields (EMF) has been constructed in the workshop at ETH and installed in the circular dichroism (CD) spectropolarimeter of the Department of Biochemistry at the University of Zurich(2), where also experiments and evaluations are carried out by collaborators of both institutions.

Measurement results of different hypothesis driven protocols are shown using a novel exposure setup, where the point of observation becomes identical with the potential electromagnetic field interaction site in space and time. By examining GrpE, that undergoes completely reversible thermal transitions, thermal and non-thermal effects of electromagnetic fields should be distinguishable due to the different time scale of immediate EMF effects and delayed thermal effects. The measurement results obtained so far suggest that GrpE's conformational equilibrium is insensitive to weak harmonic and GSM modulated electromagnetic fields.

Future work will focus on investigating potential direct effects of RF and ELF electromagnetic field exposure on GrpE's conformation and the kinetics of its change. If a potential effect is observed, the threshold in terms of the magnitude of the electromagnetic field can be obtained together with the frequency ranges where it occurs.

The aim of the second project presented at BEMS 2010 is to design a novel in vitro exposure system allowing for the investigation of potential effects of pulsed electromagnetic fields (PEMF) on osteoblast like cells in a large number of cell dishes simultaneously. The sham controlled system fitting in a standard incubator is optimised for high magnetic flux density field uniformity over a wide frequency range whilst maximising the exposure volume. Measurement results of vibrational acceleration of cell dishes caused by the currents in the coils are shown. Thus special attention was given to minimize mechanical vibration leading to biological reactions in mechano-sensitive cell lines, like osteoblast cell.

Future work will concentrate on investigating potential enhancing effects of PEMF exposure on mechano-sensitive cells like osteoblasts and myoblasts.

SONJA HUCLOVA - 2010 FOURTH PLACE PLATFORM AWARD

Sonya's work arose from a collaboration with an industrial partner (Solianis Monitoring AG) dedicated to non-invasive glucose monitoring. One of the tracks in order to improve the performance of the glucose sensor effectively measuring skin impedance consisted of modelling the sensor-skin system. However, this task turned out to be challenging.

In the operating frequency range of the sensor, from approx. 1 to 100 MHz the behaviour not only of skin, but biological tissue in general is mainly dictated by the shorting of the thin, almost insulating cell membrane. In the following, the basic idea was to consider tissue as quasi-periodic and calculate its dielectric properties on the scale of a unit cell. In the simplest case the unit cell consists of a single biological cell embedded in extracellular medium. On the microscopic scale the cell is exposed to a homogeneous electric field in all three spatial directions. Since an inhomogeneous field applied on the macroscopic scale is still approximately homogeneous on the microscopic cellular scale, the dielectric parameters (a tensor in general) of the unit cell are said to represent the properties of the tissue as a bulk material. Consequently, the properties of different tissue types, such as in the example of the skin can be accounted for in a macroscopic model.

The results of the work presented at the BEMS 2010 in Seoul focused on the actual ability to numerically model dielectric properties of cell suspensions taking cell shape and high volume fractions occurring especially in tissue into account. The second task was to investigate to which extent the effective dielectric properties can be approximated by analytical expressions such as the Maxwell-Garnett formula or even just the dielectric parameters of the extracellular medium. It was shown that especially in the low MHz region approximations should be applied with care. Besides of the use for the presented application the availability of reliable models would help to close the gap for dosimetry data in the MHz range since compared to ELF or HF this part of the EM spectrum has only been paid limited attention so far.

Among the improvement and validation of the tissue model for skin impedance measurements and extension by including electro-thermal interaction the goals of the underlying work are even more general. The question is to which extent microscopic physiological changes can be measured on a macroscopic scale. As the 'Group for Electromagnetics in Medicine and Biology' is involved into applications covering a wide frequency range from LF to optical, therefore our overall aim is to develop appropriate models for the interactions with EM fields and biological tissue at any scale and frequency.

Yu-Hsuan Wu - 2010 Fourth Place Poster Award

I have been studying nanoelectropulse-induced cell responses for few years and the effects on mitochondria reported here is part of this picture.

Theoretically, electric pulses with different pulsewidths should affect different regions of cells. In fact, the literature reports a lot of studies on how the plasma membrane permeability changes with different pulsing parameters. There are also reports on the impact of such pulses on some subcellular effects including nucleus fragmentation, calcium release. In my poster, we report that the electric pulses in the few nanosecond range can affect not only the outside plasma membrane of cells but also intracellular organelles.

Mitochondria, an important organelle inside cells, plays a crucial role in apoptosis. It releases several apopotosis-inducing factors into the cytoplasm, presumably through the mitochondrial permeability transition pore (MTP). We believe that if we could manipulate the mitochondria to release the apoptosis-inducing factor and actually induce apoptosis, the process could become part of a cancer therapy regime. However, people have not shown any evidence of the nanoelectropulse-induced MTP opening before.

Starting from this point, we investigated whether we could manipulate the MTP opening by applying proper pulsing condition. In our study, we looked the mitochondrial membrane permeability changes with 4 ns electric pulses. We used three different methods to identify the location and permeability of mitochondria. Our positive results suggest that we are making the mitochondrial membrane more permeable under certain pulsing conditions. These results suggest one more approach to treating cancer by manipulating the MTP with nanelectropulses to induce apoptosis.

In the next year with this project, I hope to monitor the time scale at which MTP forms and connect the nanoelectropulse-induced MTP to apoptosis.

LETTERS FROM BEMS MEMBERS: Perhaps a Way Forward to Study Fundamental Biological Processes with EMF

By Carl Blackman

A recent paper by Focke et al. published in Mutation Research 2010, Vol 683(1-2), pp 74-83, should be of substantial interest to the Bioelectromagnetics community.

The paper, entitled "DNA fragmentation in human fibroblasts under extremely low frequency electromagnetic field exposure," directly and thoroughly addresses issues about reproducibility and plausibility on this subject that have been debated for many years. The authors' approach was to perform replication of the Ivanscits et al. publications in Mutation Research 2002, Vol 519, pp 1-13 and Intl Arch Occup Environ Health 2003, Vol 76, pp 431-436. The authors' goals were to explore issues associated with this phenomenon in depth to determine if claims have validity and under what conditions they can be repeatably reproduced, and ultimately to discover processes and conditions that could guide mechanistic explorations.

The authors raised the following fundamental questions and obtained answers:

1) Is it the electric or the magnetic field that causes the effect?

The result showed that it is the magnetic field; similar magnetic field dependencies were shown by Blackman et al., FASEBJ 7:801, 1993 and BEMS 14:273, 1993.

2) Is cell proliferation needed for the effect to occur?

The result shows that proliferating cells are needed.

3) Is apoptosis involved in the DNA fragmentation?

The results showed a slight component (about 1-2 % of the DNA damage) is due to apoptosis.

4) Is oxidative damage of DNA bases the fundamental cause?

The results show that oxidative damage does not seem to be a causal component in DNA fragmentation. Other, secondary questions of interested to the BEMS readers, such as cell type and physiological state, were asked and answered.

Conclusions from this study include:

1. Results clearly define the conditions under which reproducible ELF-EMF-induced DNA fragmentation can be detected.
2. Results do not appear to be artifacts of the technique or procedures, as has been previously alleged.
3. Results provide an explicit platform from which biological studies can be launched to more fully define:
   a. exposure conditions, including parameters such as (1) intensity, (2) pulse repetition rate, (3) frequency and (4) static magnetic field intensity and orientation to alternating field, and
   b. biological processes, including dependence on (1) cell type, (2) physiological status with respect to differentiation or perturbation from the homeostatic condition, and (3) co-insult with chemical, nutritional and biological agents.
4. Future studies with this methodology may be able to contribute to (1) improve fundamental understanding of biological processes, (2) identify exposure conditions that may be useful in medical applications, and (3) identify conditions to avoid in general population exposure scenarios.

LETTERS FROM BEMS MEMBERS: DOSIMETRY (AND, AGAIN, DOSIMETRY!)

[Editor's note: This article, submitted by BEMS member ***Marko Markov****, raises some important and intriguing questions. We invite comments from other readers to be published in future issues of the newsletter on a space available basis.]*

The Bioelectromagnetics Society (BEMS) was created more than 30 years ago with the purpose of integrating the knowledge and experience of biologists, physicists, engineers, clinicians in developing a new scientific area. Shortly after that, the journal *Bioelectromagnetics* was established. It is now in it's 29th year. Thirty years is long enough for the Society and Journal to mature. It is time that both BEMS and the Journal establish criteria for conducting and publishing studies in the basic science research and clinical applications of electromagnetic fields.

The fundamental question for engineers, scientists and clinicians is to identify the biochemical and biophysical conditions under which electromagnetic fields (EMF) are recognized by cells in ways that modulate cell and tissue functions. It is also important for the scientific and medical communities to recognize that different magnetic fields applied to different tissues can cause different effects.

Clinical applications and associated research should begin with medical diagnostics. Ideally, physicists and engineers would work towards designing an exposure system in a way that focuses the required magnetic flux density directly at the target tissue(s). Unfortunately, in most cases, the clinical trial starts with a different question: "what field is available?" Then the clinician applies common sense and his/her experience and intuition in constructing the remaining protocol of the trial. Dosimetry and analysis of the signal parameters remain, in appropriately, out of the official protocol of the experiment.

A review of magnetobiology and magnetotherapy studies (Markov MS (2004), Magnetic and electromagnetic field therapy: basic principles of application for pain relief. in: Rosch PJ and Markov MS (eds), *Bioelectromagnetic Medicine*, Marcel Dekker, NY, 251-264.) suggests that biological effects involve at least one of six distinct kinds of electromagnetic fields:

(1) static/permanent magnetic fields,

(2) low frequency sine waves,

(3) pulsed electromagnetic fields (PEMF),

(4) pulsed radiofrequency fields,

(5) high frequency electromagnetic fields,

(6) millimeter waves.

Devices that generate such fields have been designed and distributed in different countries, used for different purposes, applying different protocols. While it is difficult to create unifying criteria for all these groups, there are at least 10 parameters that need to be quantified in order to accurately and uniquely characterize these fields (Markov MS, What needs to be known about the therapy with static magnetic fields. *The Environmentalist*, 29: 169-176, 2009):

- Type of field
- Intensity or induction
- Spatial gradient (dB/dx)
- Temporary change (dB/dt)
- Frequency
- Pulse shape
- Component (electric or magnetic)
- Localization
- Duration of exposure
- Depth of penetration

Therefore, these must be part of the protocol given in any publication describing biological effects, or lack thereof, from electromagnetic fields. In support of my argument, I strongly recommend the first, and to the best of my knowledge the last, paper published in our journal on planning experiments and dosimetry (Valberg P., How to plan EMF experiments, *Bioelectromagnetics* 16:396-401, 1995).

In some cases, a dosimetry analysis of the electromagnetic signal might be seen in publications. It should be always remembered that the only valuable information in biological and clinical studies is dosimetry at the target site. The important dosimetry is related to the field seen by the biological system (I call this biophysical dosimetry).

There were many reasons for writing this note, but I want to focus on two key points: First, more than 75% of the papers on magnetobiology and magnetotherapy call this area of study "a controversial issue". I fundamentally disagree. It is our lack of critical details about dosimetry in our publications that creates the problem. One may open any journal in this area, especially Bioelectromagnetics, and see plenty of papers making claims that magnetic fields do or do not cause biological responses based only on careful characterization of the magnetic flux density. Even the authors of such statements would agree that their study shows nothing else but the fact that this magnetic field, applied on this biological object caused this result. From a scientific standpoint, there is no basis for further generalizing.

Here I want to remind my colleagues that a former President of BEMS, the late Andy Bassett, always talked about the possibility that selected magnetic fields initiate particular biological/clinical responses. I believe that, by regularly ignoring important distinctions related to the dosimetry of electromagnetic fields, The Bioelectromagnetics Society and the *Bioelectromagnetics* Journal have consistently failed to meet this basic criterion for scientific accuracy. It is time to do better.

I urge the organizers of future meetings, and the Editorial Board of the journal, not to accept submissions with overly general titles such as "Constant magnetic field of 300 Gauss causes changes in the metabolic activity . . ." At a minimum, the authors MUST demonstrate why exactly 300 Gauss was selected (eventually based upon previous studies). Otherwise, such a paper does not contribute seriously in advancing the science. Moreover, it contributes to "controversial issue" arguments that are ultimately harmful to the more scientifically honest research that many of our members are trying to do.

In addition, I urge every author to focus on more details to accurately and unambiguously document the actual experimental condition and dosimetry at the target site. As an example of the kind of work I am encouraging, see, for example, a recent paper from Frank Prato's laboratory in London, Ontario (Reddy SB, Weller J, Desjardins-Holmes D, Winters T, Lynn L, Prato FS, Prihoda TJ, Vijayalaxmi, Thomas AW, Micronuclei in the Blood and Bone Marrow Cells of Mice Exposed to Specific Complex Time-Varying Pulsed Magnetic Fields, *Bioelectromagnetics* 31:445-453, 2010) reporting changes in micronuclei in the blood and bone marrow cells of mice exposed to specific complex time-varying pulsed magnetic fields. Along with the precision one would expect in describing the biological system, this paper also included a remarkably accurate explanation of the electromagnetic component of the study protocol.

A few years ago, I was involved in a study (Colbert AP, Wahbeh H, Harling N, Connelly E, Schuffke HC, Forsten C, Gregory WL, Markov MS, Souder JJ, Elmer P, King V. Static magnetic field therapy: a critical review of treatment parameters, *eCAM* 1-7, doi:10.1093/ecam/nem131, 2007) that analyzed 56 published papers reporting the application of permanent magnets in clinical trials. Some of these papers were published in *Bioelectromagnetics*. In addition to six of the ten parameters listed above, four other clinically important parameters were added to the analysis. Surprisingly, only 2 of the 56 papers (< 4%) accurately reported the experimental conditions and study protocol according to our criteria.

In my opinion, our journal does not serve as the leader it should be in dosimetry related to bioelectromagnetics and magnetotherapy. Many of the recent articles published in the journal seem to confirm this opinion. We can't keep "comparing apples and oranges" or worse… apples and potatoes. Even though both are round and can be eaten, they are not the same thing. Neither are homogeneous and non-homogenous fields. To perform scientifically accurate experiments that can be reliably repeated, we need to know the full characteristics of the applied fields. In addition, the term "radiation" never applies to static magnetic field (homogeneous or not).

I want to conclude by returning to the title of my note: "Dosimetry and, again, dosimetry". I strongly believe that the journal *Bioelectromagnetics* has the duty to lead the scientific and clinical community in proper design, execution, and reporting of all relevant exposure conditions and dosimetry. Where appropriate, to maintain appropriate scientific standards, the Editorial Board should require that authors investigate a range of parameters in order to demonstrate the superiority of the selected magnetic field exposure, or at least to report the reasons for selecting the specific magnetic field chosen. This is also the role of reviewers: as members of BEMS, we should be focused on what is best for the science that is behind the formation of The Society in the first place. It is time for the Editorial Board to encourage the consistent publication of all the parameters that need to be characterized in every report of biological effects, or lack of effects, from electromagnetic fields. Reviewers must require that the authors follow this instruction before the papers are approved for publication. Otherwise, sloppy inattention to these critical details will lead to continued "controversial research" that will discredit the field in general and lead to the demise of BEMS.

NL 215: In Case You Missed It

Mark your calendars now: The 33rd Annual Meeting of The Bioelectromagnetics Society will be held June 12 - 17, 2011 in Halifax, Nova Scotia, Canada. The following year, the 34th Annual Meeting of The Bioelectromagnetics Society will be held in Brisbane, Australia (in 2012). The exact dates will be announced shortly.

The recently published 2010 WHO Research Agenda for Radiofrequency Fields is available on the World Health Organization's website (http://www.who.int/peh-emf/research/agenda/en/index.html).

A recent article in Science (13 August 2010, Vol. 329, No. 5993, pp. 830-834) describes flexible nanoscale field-effect transistors placed on the tip of a silicon nanowire to create three-dimensional localized bioprobes, in contrast to the planar designs of most previous work. Of particular interest, according to the abstract (http://www.sciencemag.org/cgi/content/full/329/5993/830?eaf), is that these nanoprobes can be modified with phospholipid bilayers to enter single cells to record intracellular potentials.

Dr Joachim Schüz, Vice President/President-Elect of BEMS, is now the head of the Environment section at the International Agency for Research on Cancer (IARC).

Calendar for NL 215

6th International Workshop on Biological Effects of Electromagnetic Fields (http://www.istanbul.edu.tr/6internatwshopbioeffemf/callforpaper.htm)

Date: 10-14 October, 2010

Location: Kefaluka Hotel, Akyariar, Bodrum, Turkey

MobiHealth 2010, International ICST Conference on Wireless Mobile Communication and Healthcare (http://www.mobihealth.name/)

Date: 18-20 October 2010

Location: Ayia Napa, Cyprus

Note: BEMS Journal editor, Jim Lin, is part of the steering committee for this meeting.

5th Course: "Medical Applications of Electromagnetic Fields" (http://www.ebea.org/ebea_school_2010.htm)

Date: 22-23 November 2010

Location: Erice (Sicily), Italy

Contact: Ferdinando Bersani

10th EBEA International Congress (biannual meeting of the European Bioelectromagnetic Association) (http://www.ebea.org/ebea_2011.htm)

Date: 21 - 24 February 2011

Location: Faculty of Engineering, University of Rome "La Sapienza"

Important dates: Abstract submission deadline is 1 November 2010, acceptance notification will be 15 December 2010

Contacts: Carmela Marino, EBEA President; Micaela Liberti, EBEA2011 Chair

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29th Progress in Electromagnetics Research Symposium (PIERS) (http://piers.org/piers2011Marrakesh/)

Date: March 20-23, 2011

Location: Marrakesh, MOROCCO

14th International Congress of Radiation Research (14th ICRR 2011)

(http://www.icrr2011.org/)

Date: August 28 - September 1, 2011

Location: Warsaw, Poland

Contact: Prof. Marek K. Janiak, MD, PhD, Chair, Organizing Committee via Ewa Nowosielska

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International Workshop on Electroporation-based Technology and Treatments (http://www.cliniporator.com/ect/first.asp?id=0)

Date: 13-19 November 2011

Location: Ljubljana, Slovenia

NEXT MEETINGS OF THE BIOELECTROMAGNETICS SOCIETY:

12 - 17 June 2011: Halifax, Nova Scotia

2012: Brisbane, Australia

2013: Joint meeting with EBEA (Location TBD)

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Please send new items for the calendar to news@bioelectromagnetics.org or bemsnewsletter@gmail.com

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The Bioelectromagnetics Society newsletter is published and distributed to all members of the Society. Institutions and libraries may subscribe to the newsletter at an annual cost of $85(USD).

The newsletter serves as a forum for ideas and discussion of issues related to bioelectromagnetics research. Contributions may include news items, meeting reports, short notes on research, book reviews, and relevant items of historical or other interest. All submissions must be signed. While it is understood that contributions by individual authors reflect the views of the contributor, the editor may require that contributing writers submit a statement of affiliation and/or disclosure of possible conflict of interest at the time an article is submitted for consideration. Advertisements included in the newsletter are not to be considered endorsed by the Society.

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or by surface mail to The Bioelectromagnetics Society, 2412 Cobblestone Way, Frederick, MD, 21702-2626 USA. BEMS newsletter editor, Janie Page, is an independent consultant in Oakland, CA. Tel: 415-937-1477.

For other Society business or information, contact Gloria Parsley, Executive Director, Tel: 301-663-4252, Fax: 301-694-4948. BEMS website: www.bioelectromagnetics.org

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