



13th Key Symposium 2016: Bioelectronic Medicine — Technology Targeting Molecular Mechanisms

September 21 - 23, 2016

The New York Academy of Sciences

Presented By: [The Feinstein Institute for Medical Research](#), the [Royal Swedish Academy of Sciences](#), the [Journal of Internal Medicine](#), and The New York Academy of Sciences

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- **Early Bird Deadline:**
August 22, 2016
- **Poster Abstract Deadline:**
July 29, 2016
- [Add to Outlook/Google/iCal](#)

Technology is changing the world and bioelectronic medicine is at the forefront of this technological revolution. The pharmaceutical industry's history is based on therapies that target molecular mechanisms, yet these therapies are expensive, difficult to administer, often toxic, and may be accompanied by lethal side effects. **Bioelectronic medicine — the convergence of molecular medicine; neuroscience and biology; and electronics and computing to develop cures — may change the future of therapies for a wide variety of diseases.** This groundbreaking discipline is aimed at **interfacing electronics with nerves to specifically target the biological processes underlying disease.** Bioelectronic medicine is now at the epicenter of where healthcare, technology, and science converge. A unique moment exists to characterize the **challenges and opportunities** facing the future of this scientific domain.

The Key Symposium 2016: Bioelectronic Medicine — Technology Targeting Molecular Mechanisms, will convene thought leaders who have the potential to explore, define, and create this new field. Session topics include: **Defining Circuits, Cell Biology and Cancer, Molecular Sensing, Clinical Updates, Brain Interfaces, Processing the Future, and Funding the Field.** By harnessing the power of technology spanning disciplines from microfluidics to **computer processing to molecular technology**, we step closer to the promise of bioelectronic medicine — to naturally reproduce a drug's therapeutic reaction by **mobilizing the body's natural reflexes to develop effective, safe and economical alternatives to pills and injectables.**

Call for Poster Abstracts

The deadline for abstract submission is **Friday, July 29, 2016**. For complete abstract instructions, please send an e-mail to BioelectronicMedicine@nyas.org with "Abstract Information" in the subject line. There is no need to type a message; instructions will be forwarded automatically. Please call 212.298.8648 with any questions.

Dinner Boat Cruise

There will be a **complimentary dinner boat cruise** around New York City for symposium attendees on **Thursday, September 22, 2016**, departing at **6:00 PM**. To attend the dinner boat cruise, this social event option must be selected during the registration process.

The final day to register and select this option is **September 6, 2016**.

Registration Pricing

	Before 08/22/2016	After 08/22/2016	Onsite
Member	\$350	\$400	\$450
Member (Student / Postdoc / Resident /	\$150	\$200	\$250

Fellow)

Nonmember (Academia)	\$450	\$500	\$550
Nonmember (Corporate)	\$900	\$1,000	\$1,100
Nonmember (Non-profit)	\$450	\$500	\$550
Nonmember (Student / Postdoc / Fellow)	\$200	\$250	\$300

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Agenda

* *Presentation times are subject to change.*

Wednesday, September 21, 2016

5:00 PM	Registration and Poster Set-Up
5:30 PM	Welcome Remarks Jan Andersson, MD, PhD, <i>Journal of Internal Medicine</i> Kevin J. Tracey, MD, The Feinstein Institute for Medical Research Representative, The New York Academy of Sciences
5:45 PM	Networking Reception and Poster Session

8:00 PM

End of Symposium Day 1**Thursday, September 22, 2016**

7:45 AM

Registration and Continental Breakfast

8:30 AM

Welcome RemarksJan Andersson, MD, PhD, *Journal of Internal Medicine*Kevin J. Tracey, MD, The Feinstein Institute for Medical Research
Representative, The New York Academy of Sciences**Session I: Defining Circuits**

8:45 AM

Mapping Reflexes in Immunity

Kevin J. Tracey, MD, The Feinstein Institute for Medical Research

9:15 AM

Somatosensory Neurons in Bacterial Detection and Host Defense

Isaac Chiu, PhD, Harvard Medical School

9:45 AM

Optical Tools for Analyzing and Repairing Complex Biological Systems

Ed Boyden, PhD, Massachusetts Institute of Technology

10:15 AM

Networking Coffee Break**Session II: Clinical Updates**

10:45 AM

Restoring the Balance of the Autonomic Nervous System in Rheumatoid Arthritis: From Preclinical Models to Patients

Paul-Peter Tak, MD, PhD, Academic Medical Centre, University of Amsterdam

- 11:15 AM *The Cholinergic Anti-inflammatory Pathway in the Gut: From Bench to Bedside*
Guy E. Boeckxstaens, MD, PhD, University Hospital Leuven
- 11:45 AM *Vagus Nerve Stimulation in Inflammatory Bowel Disease*
Bruno Bonaz, MD, PhD, Grenoble Faculty of Medicine and Hospital; Grenoble Institute of Neuroscience

12:15 PM **Networking Lunch**

Session III: Brain Interfaces

- 1:30 PM *Cracking the Neural Code, Treating Paralysis, and the Future of Bioelectronic Medicine*
Chad E. Bouton, MD, PhD, Northwell Health, The Feinstein Institute for Medical Research
- 2:00 PM *Sequencing the Connectome*
Anthony Zador, MD, PhD, Cold Spring Harbor Laboratory

Session IV: Molecular Sensing

- 2:30 PM *Towards Paper-based Point of Care Affinity Proteomics*
Helene Svahn, PhD, Royal Institute of Technology
- 3:00 PM **Networking Coffee Break**
- 3:30 PM *Interrogating Neural Function with Optoelectronic and Magnetic Materials*
Polina Anikeeva, PhD, Massachusetts Institute of Technology
- 4:00 PM *Real-time Biosensors for Continuously Measuring Specific Biomolecules In Vivo*
H. Tom Soh, PhD, Stanford University

4:30 PM *Organic Bioelectronics in Neuroscience and Infection*
Agneta Richter-Dahlfors, PhD, Karolinska Institutet

5:00 PM **Closing Remarks**

5:10 PM **End of Symposium Day 2**

6:00 PM Dinner Boat Cruise Around New York City
Advance Registration Required

Friday, September 23, 2016

8:00 AM **Continental Breakfast**

Session V: Cell Biology & Cancer

8:30 AM *Metabolic Adaptation in Cancer Cells*
Tak W. Mak, PhD, Campbell Family Institute for Breast Cancer Research at Princess Margaret Cancer Centre, University Health Network

9:00 AM *Tumor Treating Fields - A Novel Cancer Therapy Utilizing Alternating Electric Fields*
William Doyle, SB, MBA, Novocure

9:30 AM *Remote Control of Neural Activity in an Electromagnetic Field*
Jeffrey Friedman, MD, PhD, The Rockefeller University; Howard Hughes Medical Institute

10:00 AM **Networking Coffee Break**

Session VI: Processing the Future

- 10:30 AM *Organic Bioelectronics and Electronic Plants*
Magnus Berggren, MSc, PhD, Linköping University
- 11:00 AM *Symmetries and Abstraction of Information from Vagal Nerve Recordings*
Patrick Lincoln, PhD, SRI International
- 11:30 AM *Title to Be Determined*
Peder Olofsson, MD, PhD, Karolinska Institutet
- 12:00 PM **Networking Lunch**

Session VII: Funding the Field

- 1:00 PM *National Institute of Neurological Disorders and Stroke and NIH Initiatives for Funding Research in Bioelectronic Medicine*
Nick Langhals, PhD, National Institute of Neurological Disorders and Stroke, U.S. National Institutes of Health
- 1:30 PM *The Neurophysiology and Emerging Technologies of the Defense Advanced Research Projects Agency's ElectRx Program*
Doug Weber, PhD, U.S. Defense Advanced Research Projects Administration
- 2:00 PM *Title to Be Determined*
Gene Civillico, PhD, U.S. National Institutes of Health
- 2:30 PM **Closing Remarks**

2:45 PM

Symposium Ends**Speakers****Featuring****Peder Olofsson, MD, PhD**

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[website](#)**Scientific Organizing Committee****Melanie Brickman Borchard, PhD, MSc**

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Kevin J. Tracey, MD

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Speakers**Polina Anikeeva, PhD**Massachusetts Institute of Technology
[website](#)**Magnus Berggren, MSc, PhD**Linköping University
[website](#)**Guy E. Boeckxstaens, MD, PhD**University Hospital Leuven
[website](#)**Bruno Bonaz, MD, PhD**

Grenoble Faculty of Medicine and Hospital; Grenoble Institute of Neuroscience

Chad BoutonThe Feinstein Institute for Medical Research
[website](#)**Ed Boyden, PhD**Massachusetts Institute of Technology
[website](#)

Isaac Chiu, PhD

Harvard Medical School
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**Abstracts****Somatosensory Neurons in Bacterial Detection and Host Defense**

Isaac Chiu, PhD, Department of Microbiology and Immunobiology, Division of Immunology, Harvard Medical School

The somatosensory nervous system densely innervates peripheral barrier tissues including skin, gut, and respiratory tract. Pain is mediated by a subset of somatosensory neurons termed nociceptors, which are able to respond to harmful / noxious stimuli. Two thousand years ago, Celsus defined pain as a major symptom of inflammation. It is increasingly clear that nociceptor neurons not only produce pain, but also play an active role in modulating the immune responses that accompany pain. Our laboratory is interested in determining the role of nociceptor neurons in infection, inflammation, and host defense. We find that nociceptors are able to directly respond to bacterial pathogens and their molecular mediators to induce ionic influx, generate action potentials, and produce pain-like behavior in mice. In turn, these neurons release neuropeptides, which play a role in modulating cytokine production and immune recruitment. Specific ablation of nociceptors or silencing their activity affects the ability of the host to combat bacterial infections in the skin and respiratory tract. Therefore, the peripheral somatosensory nervous system is integrated into host defense by their ability to detect pathogenic dangers and modulate inflammation.

Coauthors: Pankaj Baral, PhD¹, Kimbria Mills, BS¹, Felipe Ribeiro, MSc¹, Yan Zhou, MD¹, Clifford J. Woolf²

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Optical Tools for Analyzing and Repairing Complex Biological Systems

Ed Boyden, PhD, Department of Biological Engineering, Department of Brain and Cognitive Sciences, Media Lab and McGovern Institute, Massachusetts Institute of Technology

To enable the understanding and repair of complex biological systems such as the brain, we are creating novel optical tools that enable molecular-resolution maps of large scale systems, as well as technologies for observing and controlling high-speed physiological dynamics in such systems. First, we have developed a method for imaging large 3-D specimens with nanoscale precision, by embedding them in a swellable polymer, homogenizing their mechanical properties, and exposing them to water, which causes them to expand isotropically several fold. This method, which we call expansion microscopy (ExM), enables scalable, inexpensive diffraction-limited microscopes to do large-volume nanoscopy. Second, we have collaboratively developed strategies to image fast physiological processes in 3-D with millisecond precision, and are using them to acquire neural activity maps throughout small organisms. Third, we have collaboratively developed nanotechnological and robotic methods to record high-speed electrical events with single cell resolution in living mammalian brain. Finally, we have developed a set of genetically-encoded reagents, known as optogenetic tools, that when expressed in specific neurons, enable their electrical activities to be precisely driven or silenced in response to millisecond timescale pulses of light. In this way we aim to enable the systematic

mapping, dynamical observation, and control of complex biological systems like the brain.

Restoring the Balance of the Autonomic Nervous System in Rheumatoid Arthritis: From Preclinical Models to Patients

Paul-Peter Tak, MD, PhD, Academic Medical Centre, University of Amsterdam

We have found lower parasympathetic activity in established rheumatoid arthritis (RA) patients compared to healthy controls, but also in subjects at risk of developing RA (AR). Resting heart rate (RHR), reflecting the balance between sympathetic and parasympathetic activity, was significantly higher in AR individuals who subsequently developed arthritis. AR subjects with RHR ≥ 70 bpm demonstrated lower levels of the nicotinic acetylcholine receptor type 7 ($\alpha 7$ nAChR) on peripheral monocytes than subjects with RHR < 70 bpm. It is tempting to speculate that this might be explained by activity of the sympathetic nervous system or hypothalamic–pituitary–adrenal axis if the two autonomic branches counterbalance each other.

By screening an adenoviral short hairpin RNA library, we discovered that knockdown of the $\alpha 7$ nAChR in RA fibroblast-like synoviocytes results in an increased production of mediators of inflammation and degradation. The $\alpha 7$ nAChR is intimately involved in the cholinergic anti-inflammatory pathway (CAP). We could show that treatment with $\alpha 7$ nAChR agonists improved arthritis in animal models of RA. Accordingly, stimulation of the CAP by vagus nerve stimulation improved experimental arthritis. Conversely, we found aggravation of arthritis activity in $\alpha 7$ nAChR-knockout mice.

These data supported exploration of vagus nerve stimulation in RA patients. We found that an implantable vagus nerve stimulating device inhibited monocyte TNF production in RA. Clinical signs and symptoms were significantly improved, even in patients with therapy-resistant disease. Together, these data support the notion that implanted nerve stimulating devices may become a useful treatment alternative for patients with RA and other immune-mediated inflammatory disorders.

The Cholinergic Anti-inflammatory Pathway in the Gut: From Bench to Bedside

Guy E. Boeckxstaens, MD, PhD, Division of Gastroenterology, Translational Research Center for Gastrointestinal Disorders, KU Leuven, University Hospital Leuven, Leuven, Belgium

The gastrointestinal tract is continuously exposed to vast amounts of foreign antigens, mainly of dietary and bacterial origin. Although the intestinal mucosa creates a tight barrier against intraluminal proteins and bacteria, it remains very vulnerable to pathogens, obviating the need for an efficient defense mechanism. Conversely, innocent microorganisms such as commensal bacteria or food antigens should be recognized as harmless to avoid unnecessary inflammation and collateral tissue damage, a mechanism referred to as oral tolerance. The balance between activation of the immune system versus tolerance therefore should be tightly regulated to maintain immune homeostasis not only to prevent chronic inflammation and tissue damage, but also to prevent lethal infection or uncontrolled growth of tumor cells. We recently showed that the enteric nervous system, to a large extent driven by the vagus nerve, exerts an important immune-modulatory role via interaction with CX3CR1^{high} macrophages. In a murine model of postoperative ileus, vagus nerve stimulation prevented manipulation-induced intestinal inflammation and resulted in faster postoperative recovery. *In situ* Ca²⁺ imaging revealed dampening of macrophage activation by nicotine and electrical field stimulation, an effect mediated by $\alpha 7$ nicotinic acetylcholine receptors. This anti-inflammatory effect of vagus nerve stimulation was further shown in models of colitis and food allergy, further showing the therapeutic potential of this pathway. Currently, several clinical studies are evaluating the therapeutic effect of vagus nerve stimulation in inflammatory bowel disease and in patients undergoing surgery. To what extent the bench data are indeed translated to the bedside will hopefully become evident soon.

Vagus Nerve Stimulation in Inflammatory Bowel Disease

Bruno Bonaz, MD, PhD, University Clinic of Hepato-Gastroenterology, Grenoble Faculty of Medicine and Hospital; and University Grenoble Alpes, Grenoble Institute of Neuroscience, Inserm, Grenoble, France

Inflammatory bowel disease [IBD; Crohn's disease (CD) and ulcerative colitis] affect an estimated 1.5 million Americans and 2.2 million people in Europe. The pathophysiology of IBD is multifactorial involving immunologic, genetic, infectious, and environmental factors. Medical treatment does not cure IBD but is only suspensive. Anti-tumor necrosis factor (TNF) therapies are the gold standard in the treatment of IBD but are not devoid of adverse events and 20% to 40% of IBD patients are not compliant with their treatment. Thus, a treatment targeting TNF using an intrinsic anti-TNF pathway, with few side effects, devoid of the problem of compliance, and cheaper than biologicals (i.e., anti-TNF) should be of interest.

The vagus nerve (VN) has anti-inflammatory properties through its afferents (hypothalamic–pituitary–adrenal axis) and efferents (cholinergic anti-inflammatory pathway: anti-TNF effect). Thus, VN stimulation (VNS), as a non-drug therapy, could be of interest in IBD. We have reported that vagal tone is blunted in CD patients and is associated with a high plasmatic TNF level. We have shown that VNS improves colitis in rats and we recently reported a six month follow-up pilot study of chronic VNS in seven patients with active CD. VNS was feasible and well-tolerated in all patients. Among the seven patients, two were removed from the study at three months for clinical worsening and five evolved toward clinical, biological, and endoscopic remission with a restored vagal tone. These results provide the first

evidence that VNS is feasible and appears as an interesting tool in the treatment of active CD.

Cracking the Neural Code, Treating Paralysis, and the Future of Bioelectronic Medicine

Chad E. Bouton, Northwell Health, The Feinstein Institute for Medical Research, Manhasset, New York

Bioelectronic Medicine is a field where devices are developed to treat a wide variety of conditions, including: paralysis, rheumatoid arthritis, diabetes, and even cancer. In paralysis, a "bioelectronic neural bypass" is being developed to circumvent disconnected pathways to reconnect the brain to the affected muscles. Intracortically-recorded signals can be decoded to produce information related to motion allowing primates and paralyzed humans to control computers and robotic arms through imagined movements. In a first-in-human clinical study, we have shown that intracortically-recorded signals can be linked in real-time to muscle activation to restore movement in a paralyzed human. We applied machine-learning algorithms to decode the neuronal activity and control stimulation of the participant's forearm muscles through a custom-built, high-resolution, neuromuscular electrical stimulation system. The participant achieved isolated finger movements and continuous cortical control of six different wrist and hand motions, and completed functional tasks relevant to daily living. The participant's motor impairment level improved from C5-C6 to a C7-T1 level unilaterally, giving him the abilities to grasp, manipulate, and release objects. This is the first demonstration of successful control of muscle contraction utilizing intracortically-recorded signals in a paralyzed human and has significant implications in advancing bioelectronic technology for people living with paralysis. Future work includes developing improved machine-learning algorithms and high-resolution implantable neural interface technology to support highly dexterous movement in hands and lower extremities. These methods are being adapted to deepen our understanding of neural coding in other parts of the nervous system to develop new ways to treat conditions.

Towards Paper-based Point of Care Affinity Proteomics

Helene Svahn, PhD, Royal Institute of Technology, Stockholm, Sweden

The Nanobiotechnology group at the Royal Institute of Technology consists of a multidisciplinary team of physicists, material scientists, biochemists, biotechnology engineers, and medical doctors with focus on developing novel experimental tools to the clinic and life sciences. One area of interest is enabling highly multiplexed bioanalytical rapid tests with the same or improved performance as conventional tests. Here, novel biosensor concepts, biofunctionalized nanomaterials, magnetic and ultrasonic force actuation, optical engineering, and microfluidics tools are combined to allow highly multiplexed detection, faster biosensor kinetics, controlled analyte transport, powerful nanoparticle-based reporters, signal amplification concepts, etc. The purpose of the research is to present convenient rapid tests that may be used in clinical labs or at the point of care to accurately detect or monitor disease for the benefit of patients as well as facilitating a more cost efficient decentralized health care system. Some of the group's current projects include: Developing a rapid multiplexed test for inflammatory responses in pediatric cancer patients in remission, Rapid test for differential diagnostics and management of children with suspected meningitis in Mbarara, Uganda, Rapid test for accurate upper respiratory infection diagnostics in children with fever and symptoms in a Swedish emergency medical context, Designing printer-free microarray platforms to enable rapid and reliable array construction for whole proteome analysis, Projects aiming to mitigate or solve fundamental problems in multiplexed immunoassays such as cross reactivity, limited dynamic range, and limited sensitivity using nanotechnology tools and microfluidics.

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Interrogating Neural Function with Optoelectronic and Magnetic Materials

Polina Anikeeva, PhD, Department of Materials Science and Engineering, Research Laboratory of Electronics, Massachusetts Institute of Technology

Our ability to understand the signaling complexity of the nervous system is currently limited by the lack of tools capable of multifunctional interfaces with neurons without causing a foreign body response. We have recently applied fiber-based and nanomagnetic approaches to monitoring and modulating neuronal function in the brain, spinal cord, and the periphery. Using fiber-drawing techniques we have produced multifunctional flexible probes for electrophysiological recording, optical stimulation, and delivery of pharmacological compounds and viral vectors into the brain and spinal cord. Furthermore, we have shown that these devices are suitable for guiding the repair of the damaged nerves. In parallel with the fiber-based platforms, we have been pursuing magnetic nanomaterials as transducers of wireless neuromodulation in deep tissue. Specifically, synthetic magnetic nanoparticles have been functionally coupled to heat-sensitive ion channels, allowing for magnetothermal neuromodulation with alternating magnetic fields.

Real-time Biosensors for Continuously Measuring Specific Biomolecules *In Vivo*

H. Tom Soh, PhD, Department of Electrical Engineering and Department of Radiology, Stanford University, Stanford, California, United States

A biosensor capable of continuously measuring specific molecules in the bloodstream *in vivo* would give clinicians a

valuable window into patients' health and their response to therapeutics. Unfortunately, continuous, real-time measurement is currently only possible for a handful of targets (i.e., glucose and oxygen) and existing platforms for continuous measurement are not generalizable for monitoring other biomolecules. Here, we will present a "universal" real-time biosensor technology capable of continuously tracking a wide range of circulating molecules in living animals. Our real-time biosensors require no exogenous reagents, operates at room temperature, and can be reconfigured to measure different target molecules by exchanging probes in a modular manner. To demonstrate the system's versatility, we will present real-time measurement of doxorubicin (a chemotherapeutic) and kanamycin (an antibiotic) in live rats with sub-minute temporal resolution. Finally, we will present the first real-time, closed loop feedback control of drug concentration in live animals using the real-time biosensor system and discuss potential applications of our technology.

Organic Bioelectronics in Neuroscience and Infection

Agneta Richter-Dahlfors, PhD, Karolinska Institutet, Stockholm, Sweden

Over the last decade, organic bioelectronics have become more popular and widely used in biological research and medicine. Organic bioelectronic devices are based on conductive polymers — materials that show great flexibility, optical transparency, as well as electrical and ionic conductivity. Further, they can be adapted and functionalized in a wide variety of ways thanks to organic chemistry methods. This combination of structural and functional flexibility makes them especially well-suited to applications in the medical field since it allows precise modeling of various attributes of cells and human tissues. This presentation will highlight a series of organic bioelectronic devices that function based on the principle of iontronics. Further, we will introduce a panel of active surfaces based on organic bioelectronics, which help to mimic dynamic biological environments and allow modulating cell behavior with high degrees of spatiotemporal control. Since self-controlled systems are the ultimate goal in bioelectronic interfaces aiming to alleviate pathological states, sensing applications based on organic bioelectronics are also included. The focus will be placed on specific applications of organic bioelectronics in neuroscience and infection.

Coauthor: Susanne Löffler, PhD, Karolinska Institutet, Stockholm, Sweden

Tumor Treating Fields — A Novel Cancer Therapy Utilizing Alternating Electric Fields

William F. Doyle, SB, MBA, Novocure Ltd., New York, New York, United States

Tumor Treating Fields (TTFields) is a novel cancer treatment modality utilizing 100–1000 kHz, electric fields to exert forces on charged intracellular proteins interrupting cell division and causing cancer cell death. Cell death occurs through multiple pathways including apoptosis, chromosome miss-segregation with subsequent reduced clonogenic potential of cellular progeny, and immunogenic cell death. TTFields has been shown to be frequency specific for different cell types, affording it a high therapeutic index. In 2015 the United States Food and Drug Administration approved TTFields for the treatment of newly diagnosed glioblastoma, the most common primary brain cancer, based on the results of a phase 3 clinical trial demonstrating significant improvements in progression-free and overall survival. Promising phase 2 clinical trial results have also been shown in non-small cell lung cancer (NSCLC) and pancreatic cancer. Ongoing clinical trials are being conducted in ovarian cancer, mesothelioma, and brain metastases from NSCLC. TTFields therapy requires tumor exposure to electric fields of 1–3 volts per centimeter for at least 18 hours per day for a period of up to 2 years. Exposure is accomplished with a portable electric field generator and transducer arrays attached to the skin surrounding the tumor region. These arrays are insulated by a high dielectric constant ($\epsilon > 5,000$), non-porous, Lead Magnesium Niobate – Lead Titanate (PMN-PT) ceramic layer to provide maximum electric field intensity while minimizing tissue damage at the sites of application. Device size and power consumption are minimized by utilizing novel digital signal generating technologies specifically designed to operate within the TTFields frequency and load ranges.

Remote Control of Neural Activity in an Electromagnetic Field

Jeffrey Freidman, MD, PhD, The Rockefeller University, Howard Hughes Medical Institute, New York, New York, United States

Targeted, temporally regulated neural modulation using light or drugs has proven invaluable for determining the physiological roles of specific neural populations or circuits. Recently, we have developed an alternative method enabling non-invasive temporal activation or inhibition of neuronal activity using electromagnetic waves. We have used this method *in vivo* to control gene expression and to study the central nervous system control of glucose homeostasis and feeding in mice. Neuronal activation using radio waves or magnetic fields is achieved by co-expressing a GFP-tagged ferritin fusion protein tethered to the cation-conducting transient receptor potential vanilloid 1 (TRPV1) by a camelid anti-GFP antibody (anti-GFP–TRPV1). Neuronal inhibition via the same stimuli is achieved by mutating the TRPV1 pore, rendering the channel chloride-permeable. Acute activation of glucose-sensing neurons in the hypothalamus was found to increase plasma glucose and glucagon, lower insulin levels, and stimulate feeding; while inhibition reduced blood glucose, raised insulin levels, and suppressed feeding. These results suggest that pancreatic hormones function as an effector mechanism of central nervous system circuits controlling blood glucose and behavior. The method we developed allows neural regulation on a more rapid time scale than drugs and obviates the need for permanent implants. The transduction mechanism by which the electromagnetic wave gates TRPV1 has not been precisely defined with temperature, motion, and local voltage changes all potentially contributing.

Current studies focus on the application of the method to study a variety of biologic process in neurons and other cell types.

Organic Bioelectronics and Electronic Plants

Magnus Berggren, MSc, PhD, Laboratory of Organic Electronics, Linköping University, Linköping, Sweden

Organic electronics is explored as the signalling bridge between biological systems and electronics targeting new opportunities in diagnostics, therapy, and biotechnology. Using the coupled charge accumulation and ion exchange of conjugated polymer–polyelectrolyte systems different sensor and actuator devices have been developed. Included in circuits, these can simultaneously record and regulate physiology and functions at high spatiotemporal resolution. As artificial nervous systems, such circuits have successfully been applied, *in vivo*, to combat for example, pathological pain and epileptic seizures, in tissue and animal models. Applied to, and manufactured inside, the vascular systems of plants, e.g., *Rosa floribunda*, analogue and digital organic circuits have successfully been achieved, thus open up for new "green" energy technologies and electronic control over growth and production processes in living plants.

Coauthors: E. Gabrielsson¹, A. Jonsson¹, K. Tybrandt¹, D. Simon¹, E. Saitanidou¹, E. Gomez¹, R. Gabrielsson¹, Ove Nilsson², B. Meyersson³, G. Malliaras⁴, G. Gustafsson⁵, D. Nilsson⁵

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National Institute on Neurological Disorders and Stroke and National Institutes of Health Initiatives for Funding Research in Bioelectronic Medicine

Nick Langhals, PhD, National Institute on Neurological Disorders and Stroke, U.S. National Institutes of Health, Bethesda, Maryland, United States

The National Institutes of Health (NIH), and in particular, the National Institute of Neurological Disorders and Stroke (NINDS), are actively participating in several funding initiatives in the area of bioelectronic medicine and peripheral neuromodulation therapies. Active NIH efforts include "Stimulating Peripheral Activity to Relieve Conditions" (SPARC) as well as the "Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative." NINDS is also participating in several efforts focused around small molecule, biologic, and therapeutic devices. During this talk, I will present an overview of the efforts in this area as well as outline details of current funding opportunities for participating in this area of research.

The Neurophysiology and Emerging Technologies of the Defense Advanced Research Projects Agency's ElectRx Program

Doug Weber, PhD, Defense Advanced Research Projects Agency / Biological Technologies Office, Arlington, Virginia

To advance DARPA's mission to enable breakthrough technologies for National Security, the DARPA ElectRx program is funding efforts to unravel the neurophysiology governing inflammatory disease and post-traumatic stress disorder (PTSD) while simultaneously investing in disruptive neural interface and biosensor technologies. Combined, the DARPA ElectRx portfolio is driving towards an integrated solution for atraumatic, closed-loop neuromodulation to treat disease in humans. In this talk, Dr. Weber, program manager of ElectRx, will discuss the science, technology, and strategy that DARPA is undertaking to realize a vision where bioelectronic medicines are no longer therapies of last resort, but instead are recognized as effective, safe, and minimally invasive enough to use as frontline interventions.

Travel & Lodging

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