A new interdisciplinary program in Medicine and Engineering at USC
I am delighted to introduce you to an innovative program at the University of Southern California that integrates training in both medicine and engineering. The program seeks to create new technologies and practices to advance patient care and promote health.

The Keck School of Medicine of USC and the USC Viterbi School of Engineering have created a collaborative program called the Health, Technology and Engineering Program or HTE@USC. A select group of medical students enrolled in this program will be more than just expert consumers of future technology: they will be innovators who create future technology.

Through HTE@USC, these outstanding students will start creating this technology during their medical school career. Their medical training will foster not only personal growth and learning, but also the development of new ideas and technologies that will immediately benefit patients.

I am particularly proud that through this program, the Keck School of Medicine also is contributing to the education of our engineering colleagues. I look forward to showing these students how physicians think, how we work with patients, and how to be effective partners in current and future projects. Project-focused collaboration will ensure that future physicians and engineers graduating from the HTE@USC program will be versed in the languages of both disciplines and emerge with an ability to work together to solve real medical problems rapidly.

In my own career, it took several years to master the engineering skills behind my successful work in ophthalmic laser technology. Collaboration was crucial. In addition to facilitating patents and publications related to the technology, early collaboration was the foundation for productive relationships and new projects that followed. Similarly, in the HTE@USC program, you will be learning and working in interdisciplinary teams starting from day one of your medical training, fast-tracking your career with fruitful collaboration from the beginning.

Exciting educational opportunities await you in our HTE@USC program and cutting-edge career paths will follow. I look forward to welcoming our new class of students into this exciting, challenging, and tremendously important program.

Carmen A. Puliafito, MD, MBA
May S. and John Hooval Dean's Chair in Medicine
The Viterbi School of Engineering has engaged in many external strategic partnerships. Within USC, there is an equally important need to promote training in interdisciplinary research that will embed doctoral-level engineers where they will apply their talent. In particular, many engineers will be active in healthcare settings.

Early immersion in healthcare delivery settings combined with training alongside medical students in collaboration will ensure that engineers develop the cultural awareness that will maximize their contribution in these settings. Trainees and graduates of our programs – even biomedical engineering – often rely on serendipity to link with colleagues and to develop professional relationships with medical doctors. Some have found their way into this arena to become champions of innovation through medical device invention, development and commercialization.

By connecting with the Keck School of Medicine, the Viterbi School of Engineering will develop a new process to co-train engineers with doctors and greatly increase the number of such champions graduating from USC. The Heath, Technology and Engineering Program (HTE@USC) will link labs and faculty across both schools. Through interdisciplinary collaboration focused on developing solutions to real medical problems during graduate school, this select group of Viterbi students will become leaders and entrepreneurs much sooner in their careers.

As members of small groups of like-minded doctors in training, engineering graduates of this program will play significant roles in continuous technology development attuned to patient needs. The relationships which are forged between engineering and medical students who share a passion for applied research focused on improving patient care through technological advancement will greatly amplify their combined output.

Yannis C. Yortsos, PhD
Z.A. Kaprielian Chair in Engineering
Chester Dolley Professor
The USC Viterbi School of Engineering and the USC Keck School of Medicine are proud to announce a new joint interdisciplinary division. Health, Technology and Engineering (HTE@USC) will augment the training of select doctors and engineers through project-focused collaboration resulting in the most effective and efficient solutions to real-world healthcare problems. HTE@USC is part of a larger USC effort to promote rapid advances in healthcare through research and education. The education program will combine the essentials of medicine with advanced engineering and scientific technologies so that both engineering and medical graduates will have experience as innovators. Students will learn and use patient-centered design and research approaches required to address the healthcare needs of all patients, including those from traditionally underserved populations.

The research program will embed students as active members of interdisciplinary teams linking researchers at both the Keck and Viterbi Schools. This will happen through projects, symposia and other events designed to broker new ties within USC and with external partners. The range and depth of current research activities and the collegial network of partners will make it possible for HTE@USC students to apply their talent to address a wide range of medical issues. HTE@USC student project groups will be matched with research mentors exploring related areas where languages of engineering, science and medicine all contribute to highly creative and productive interdisciplinary environments.

Terry Sanger, MD, PhD
Academic Director, HTE@USC

Overall program concept and design, curriculum development, cross-faculty networking, inter-institutional relations, research symposia planning, clinical and research mentor recruitment.

I am very excited to be able to create this program at USC. I personally feel very strongly about the richness of the combination of Engineering and Medicine. My background includes an MD from the Harvard-MIT Health Sciences and Technology program, PhD from the MIT department of Electrical Engineering and Computer Science, postdoctoral research at the NASA Jet propulsion laboratory and MIT, and clinical fellowships at Los Angeles County Medical Center Department of Pediatrics, Boston Children’s Hospital Department of Child Neurology, and the Toronto Western Hospital Division of Movement Disorders. In my research, I use engineering methods every day in the study and treatment of children with movement disorders.

Medicine and Engineering have two very different and unique methods of reasoning. Medicine is based on close observation and pattern-matching, and doctors use the concept of differential diagnosis to guide decision-making with multiple possible plans of action. Engineering is based on finding detailed solutions to carefully-specified problems, and engineers use quantitative methods to help break problems down into components that can be solved efficiently and reliably.

When we bring together expertise in Engineering and Medicine, we unite two languages, two ways of thinking and two types of skills that, together, provide great force to improve healthcare and the lives of patients. I look forward to working with you and learning from the new ideas you will bring.
The complexity of modern medicine makes it difficult for individual engineers, scientists or clinicians to move new technological or methodological advances all the way from concept to implementation and widespread application. The journey from bench to bedside is rarely straightforward and HTE@USC will teach the necessary steps and diverse expertise that are required along the way. Interdisciplinary collaboration is essential throughout the journey. The initial steps for each HTE@USC project group will include the identification of a problem that is both important and solvable. Solution-oriented designs will then be prototyped, refined and tested. Medical students and engineering students will work together to design pilot clinical trials to demonstrate comparative effectiveness. Good ideas can falter at any point in the winding journey from bench to bedside, and HTE@USC students will learn about both the successes and potential failures of medical technology development. Design teams will learn to anticipate and avoid future problems from the initial stages and iterations of design and prototyping.

As part of its education mission, HTE@USC offers a unique training program that provides hands-on, practical, real-world, case-based experience in medical technology and process improvement. The interdisciplinary approach of HTE@USC will inspire your creativity, enable your ingenuity and enhance the foresight you’ll need to spot and evaluate market demand. You will graduate as a valued member of a design team focused on healthcare innovation fully prepared to take on new challenges ahead.

George Tolomiczenko, PhD, MPH, MBA
Administrative Director, HTE@USC

Program and curriculum development, coordination of student and faculty recruitment, setting and monitoring program priorities and performance standards, marketing and communications, financial management and fundraising.

Experience as a clinician, researcher, teacher and administrator informs the multifaceted role I have with HTE@USC. After an undergraduate degree at Caltech, I earned a doctorate in clinical psychology at Boston University and a master’s in public health at Harvard. As both a scientist and clinician working at medical institutions, my focus shifted to public health and policy issues involving homelessness and mental illness. I am now returning to LA from Toronto where I worked on technology-enabled approaches to healthcare management.

My work building research capacity was broadened in Canada to include directorships in technology-based regional economic development, medical research funding and non-profit organizations. I have always been devoted to creating and funding programs and partnerships enabling research, knowledge translation and chronic disease management. I have done this through energizing interactions with students, faculty, staff and clinical personnel in a variety of settings. I am thrilled to be part of HTE@USC’s leadership team redesigning medical and graduate engineering education to train front-line innovators. We’ll make sure that HTE@USC graduates will be leaders among interdisciplinary thinkers and inventors in healthcare.

You can reach me through HTE@USC.edu.
case-based instruction, project-focused learning

An innovative program that teaches collaboration

To prepare motivated Keck medical students to be successful innovators equipped with new technology and demonstrated methodological skills, we have created a program that involves close collaboration at all stages with students and faculty in the Viterbi School. Our vision is that graduates of this new educational program will be experts in collaboration. Through interdisciplinary teamwork, graduates will be able to identify and solve the most important healthcare problems more rapidly and more effectively than has previously been possible.

First and foremost, medical students in this program must become excellent clinicians with a strong devotion to the humanism that guides and inspires all medical work, both clinical and engineering. Medical students enrolled in the HTE@USC program will therefore complete all components of their medical training along with their non-HTE peers at the Keck School of Medicine. During the first-year Introduction to Clinical Medicine (ICM) course, HTE@USC medical students will be joined by PhD students from Viterbi enrolled concurrently in the HTE@USC program. Team learning with graduate engineering students will be enhanced by their different perspective on the medical history and physical examination.

In addition to changes in the first year of ICM for medical HTE@USC students, two additional courses will be required for all HTE@USC students. “Topics in Health Technology and Engineering” is a seminar course that will discuss opportunities for innovation and lessons learned from successful and unsuccessful attempts to solve particular medical problems. Through this seminar, students will gain experience with the identification of important medical challenges and critical analysis of potential solutions. Group exercises within these two courses will be aimed at building effective design-team experience that will sustain participation in student group projects throughout their training.

The following summary lists the full requirements for becoming a graduate of the HTE@USC program in more detail.

**Topics in HTE:** A two-year lecture course that covers multiple topics affecting the successful development of collaborative projects. Topics will include techniques for collaboration and brainstorming, principles of design, ethics, regulatory controls on research and device development, intellectual property, creation of a business plan, strategies for approaching potential manufacturers, technology transfer, distribution, legal issues, licensing, and medical reimbursement. The course will be taught by faculty from several different schools at USC, including the Gould School of Law and the Marshall School of Business.

**Case Studies in HTE:** A one-year seminar course with in-depth analyses of specific healthcare problems and the factors that contribute to successful technological solutions. Under the close supervision of faculty from both Keck and Viterbi, students will
Case-based instruction, project-focused learning

**YEAR 1**
- Core Principles
- PPM
- Groups: Introduction to Clinical Medicine
- Class: Topics in HTE
- Projects: needs/opportunities analysis
  - Project: design

**YEAR 2**
- Organ Systems
- PPM
- ICM
- Class: Topics in HTE
- Case Studies in HTE
- Projects: initial prototype and dry testing

**YEAR 3**
- Year 3 Clerkships
- Projects: design refinement and preliminary human subject testing

**YEAR 4**
- MS program at Viterbi (encouraged but not required)
  - Year 4 Clerkships

**YEAR 5**
- Projects: design revision, ongoing human subjects testing, commercialization
Michael Khoo, PhD
HTE Academic Liaison
Viterbi School of Engineering

Dr. Khoo is an active researcher whose interests include the modeling of cardiorespiratory control during sleep, autonomic-metabolic interactions in obesity, and non-invasive physiological monitoring. As a Professor of Biomedical Engineering and Pediatrics and former Chair of the Biomedical Engineering Department, he has helped build the bridges that will allow HTE@USC to connect with the diverse engineering and science labs across a growing number of USC graduate programs. As a mentor and a leader of engineers embedded in a variety of settings, Dr. Khoo draws on his extensive experience to shape the curriculum from the engineering side. His continued involvement with the program will assure that the bridges linking labs and people between these disciplines will facilitate exciting new developments to improve health and healthcare services.
discuss examples of successful and unsuccessful examples of technological devices for healthcare. Discussion will include elements from design and prototyping, through regulatory, research and development, technology transfer, manufacture, marketing, and reimbursement. Invited speakers from small and large corporations will discuss their personal experiences and the decisions that were made in their teams.

Elective Block: During year 4, Keck students will take a 4-8 week elective working either in a laboratory at Viterbi or in an industry laboratory. Faculty will assist students with selection of an appropriate elective. In some cases, the elective time will be used to pursue additional testing or development of the health technology project.

HTE Project: The project will run throughout the time enrolled in the program. During the first year, HTE@USC students will identify a list of medical needs and opportunities and each will belong to a project group around a particular problem. All project groups will consist of two students from Keck and two students from Viterbi. During the summer between the first and second year of the program, project groups will start to develop plans for prototypes and assess challenges to manufacture, distribution, and clinical use. Appropriate laboratories at Keck and Viterbi will be identified. During the second to fourth years, project groups will continue to work together under close faculty supervision to develop and test prototypes or candidate methods, obtain preliminary clinical data, and work toward development of commercializable products, methods, or systems. We anticipate that the projects will form the core of the PhD students' theses, and the medical students will be closely involved with testing, usability determination, and needs assessment throughout the second through fourth years of their training. Students will be closely mentored by faculty from both Keck and Viterbi, and as part of their projects they are likely to be involved in more than one laboratory. Projects are intended to solve real unmet healthcare needs, and groups are expected to file preliminary patents or submit descriptive manuscripts by the end of their training, with the intent that commercialization will be

Allan Abbott, MD
HTE Academic Liaison
Keck School of Medicine

Dr. Abbott currently heads the Curriculum Office at Keck and was an architect of the redesign of the medical school curriculum intended to better integrate medical and basic science subjects. The redesigned curriculum also facilitates the integration of the hybrid curriculum for medical and graduate engineering students HTE@USC offers. Dr. Abbott is a family and sports medicine physician with interests in disease prevention and best practices in teaching medicine. His involvement with HTE@USC complements his focus on practice needs of individual physicians for structured continuing medical education. HTE@USC training will establish an early foundation for life-long learning for medical and engineering students aiming to innovate through interdisciplinary collaboration.
“Opportunity at the Intersection”

Excerpts from the President’s Special Address to the Health Sciences, August 25, 2010

C. L. Max Nikias, President, University of Southern California

The very laws of physics limit the growth of conventional electronics. But because of electronics, forces are gathering in such a way that this century is poised to be the Age of Medicine and Biology.

We can hope for breakthroughs in these areas—which will open up entire new sectors of the global economy. It is here that we will see the fastest-growing industries of this century. New technology can reshape medicine—with applications in drug delivery and patient care. We can see new therapeutic products unlike anything to date. And we can see new ideas move from the bench to the bedside—faster and more intelligently than ever.

So the leaders of the future will be universities that generate research and innovation in these areas, through cross-disciplinary approaches that generate intellectual friction and intellectual sparks; intellectual friction and sparks between medicine, and engineering, and biology, and chemistry, as well as pharmacy, and dentistry. Take any combination you like!

There are already many heroes and heroines in USC’s efforts to build disciplinary bridges. These are stars who have been willing to set aside traditional measures of academic prestige in order to be a part of teams that can make a difference.

SUMMARY OF THE MEDICAL PROGRAM

Students will be selected from the entering KSOM class from those completing two supplementary essays and interview(s) coordinated with their KSOM application.

Required coursework for medical school.

- Introduction to Clinical Medicine HTE@USC (special section with engineers, year 1)
- Case Studies in HTE (year 2)
- Topics in HTE (years 1 and 2 given at University Park Campus)
- Encouraged to apply for a 5th year to participate in VSoE laboratory research
- Engineering or Industry elective block (year 4)

Upon graduation from HTE@USC, you will be uniquely prepared to create new devices and methods to improve the health of patients. You will also have begun lifelong relationships with a select group of engineering students and faculty who will be your contacts and collaborators for future projects. Our graduates will look at healthcare with critical eyes, always thinking of ways to make processes and devices better. Most importantly, you will have the practical experience to know how to work with teams of experts to accomplish this, so that your career will have magnified impact on patients throughout the world who will benefit from the technologies and methods you develop.
EXAMPLES OF POSSIBLE PROJECTS

1. **A wearable pulse oximeter** that provides continuous outpatient data on the status of children with congenital heart disease.

2. **A tablet-based hospital information system** that allows instant communication between different teams of physicians caring for a patient.

3. **Software for bedside monitors** that incorporates information on a patient’s diagnosis in order to provide reliable alerts of concerning cardiac or respiratory rhythms.

4. **A handheld electroencephalograph** that can be used at the bedside to assess cortical function in the intensive care unit.

5. **Paperwork and workflow for more rapid triage** and processing of patients in the emergency room.

6. **A wheelchair** that facilitates safe transfers to and from the bed.
real-world knowledge
that changes the real world

INTERDISCIPLINARY MENTORING
On entry into HTE@USC, medical students will be assigned a primary mentor from among the faculty at the Keck school of medicine, and a secondary mentor from among the faculty at the Viterbi school of engineering. Mentors will work closely with students to ensure that they are meeting the requirements of the program and to provide additional help where necessary. Mentors will also provide guidance on the selection of design projects and other aspects of collaborative research. After the design teams have been formed and specific projects have been proposed, students will work within laboratories at Viterbi and Keck. The laboratory directors are faculty who will serve as additional mentors with specific domain knowledge related to the student’s research project.

PURSUING AN ADVANCED ENGINEERING DEGREE
Following graduation from the HTE@USC program, mentors will remain as important resources for guidance and advice.

MD students will enter the program at the time they start medical school (the beginning of the first year). MD students who are able to attend an additional year will be encouraged to do so between the 3rd and 4th years of the regular medical program. This would provide time to take engineering courses, work more intensively on their technology project, and explore additional laboratories or research groups. In some but not all cases students may be able to complete the requirements for an MS degree in an engineering field. Students within the Keck/Caltech MD-PhD program may participate in HTE@USC, but they will be expected to perform their PhD primarily in a laboratory within the Viterbi school of engineering at USC.
GRADUATES WILL BE LEADERS

We anticipate several potential career paths for graduates of this program:

- A full-time clinician who remains alert for potential innovations and knows how to contact the right people to start the development process,
- A leader of a clinical project group that actively identifies and develops new technology for healthcare,
- A leader of an industrial research and medical design group,
- An academic medical clinician-scientist whose laboratory develops new healthcare technology

After completing the HTE@USC program, students will have direct experience with the full process of device or method development in medical technology. Most importantly, they will have formed bonds with a group of like-minded medical students and engineers who will be their mentors, colleagues, and contacts for the rest of their lives. HTE@USC will eliminate barriers to collaborative projects and provide a clear path so that graduates know whom to contact, how to discuss their projects, how to work together, and how to plan from the beginning for a successful outcome.

Successful graduates will be provided with a certificate of completion of the requirements of the HTE@USC program. But more important than the certificate will be their experience with hands-on project development, and the tangible results of the project including patent applications and initial steps toward technology transfer.

APPLYING TO HTE@USC

Successful applicants to the MD program will have completed an undergraduate degree in Engineering, Applied Sciences, Mathematics, Physics, or Chemistry, and they must demonstrate a commitment to medicine and a devotion to the humanistic goal of caring for and improving the lives of patients. In addition to the regular components of an application to the Keck School of Medicine, applicants must complete two additional essays: (1) How do my goals after completion of medical school involve a combination of medicine and engineering, and (2) Describe a device or method you would like to develop, state why it is important and what potential impact it could have, give a brief description of an initial implementation, and state at least 3 major problems that must be overcome.

Applicants will be notified of entrance into HTE@USC at the same time as they receive notice of entrance into the Keck School of Medicine. It is possible to be admitted to Keck without being admitted to HTE@USC. It will not be possible to transfer into HTE@USC after starting medical training at Keck.

Interviews for admission into HTE@USC will be coordinated with the interview process of the Keck School of Medicine.

For further information, interested applicants should contact the HTE@USC office by phone.
Students admitted to the HTE@USC program will have access to a wide variety of research centers where expertise, facilities and other resources will enable them to design, build and test solutions. By plugging into and supporting the strong and successful collaborations that already exist or which have recently been formed between the Viterbi School of Engineering and the Keck School of Medicine, students will be able to tackle the real-world problems they identify and prioritize in clinical settings.

The selection of research centers below is a small sample of those that could potentially include HTE project groups. For HTE students, the focus will be on problem-specific projects to complete while mentored by leading faculty experts and working in concert with other USC resources aiming to bring ideas to market (including the Stevens Institute for Innovation (http://stevens.usc.edu/) and the Alfred E. Mann Institute for Biomedical Engineering (http://ami.usc.edu/)).

Beginning as an integrative program across two USC schools, HTE@USC will provide the skills and abilities so that our students will be able to form the best and most successful team of clinicians, engineers, and scientists for a particular job. With training to facilitate and accelerate collaboration, HTE@USC students and graduates will learn by example from their mentors and lead by example beginning at USC and continuing through productive careers.

USC-affiliated centers which have been enabled through interdisciplinary approaches include:

- **Bioelectronic Research Lab** >> http://bmes-erc.usc.edu/brl/
- **Center for Applied Molecular Medicine** >> http://camm.usc.edu/
- **Center for Autism Research in Engineering** >> http://care.usc.edu/
- **Biomimetic MicroElectronic Systems Engineering Research Center** >> http://bmes-erc.usc.edu/
- **Center for Vision Science and Technology** >> http://cvst.usc.edu/
- **Biomedical Imaging Research Lab** >> http://neuroimage.usc.edu/
- **Center for Body Computing** >> http://www.usccardiology.org/bodycomputing/index.html
- **Center for Neural Engineering** >> http://www.neural-prosthesis.com/index-7.html
- **Clinical and Translational Science Institute** >> http://www.labctsi.org/
- **Institute for Creative Technologies** >> http://ict.usc.edu/
- **Medical Device Development Facility** >> http://mddf.usc.edu/
- **Brain-Body Dynamics Lab** >> http://bbdl.usc.edu/
- **Pulsed Power Research Group** >> http://pulsedpower.usc.edu/
- **Signal Analysis and Interpretation Laboratory** >> http://sail.usc.edu/
- **Center for Robotics and Embedded Systems** >> http://cres.usc.edu/Home/
- **Zilkha Neurogenetic Institute** >> http://www.usc.edu/schools/medicine/research/institutes/zni/
Some HTE@USC research mentors

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<tr>
<th>Name</th>
<th>Position/Institute</th>
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<tbody>
<tr>
<td>Ellis Meng, PhD</td>
<td>Biomimetic Microelectronic Systems (BMES) and Biomedical Microsystems (BML)</td>
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<td>Yigal Arens, PhD</td>
<td>Intelligent Systems Division, Information Science Institute</td>
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<td>Pat Levitt, PhD</td>
<td>Zilkha Neurogenetic Institute</td>
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<td>Francisco Valero-Cuevas, PhD</td>
<td>Division of Biokinesiology and Physical Therapy</td>
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<td>Gerald E. Loeb, MD</td>
<td>Medical Device Development Facility</td>
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<td>Laurent Itti, PhD</td>
<td>iLab USC</td>
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<td>David B. Agus, MD</td>
<td>USC Westside Prostate Cancer Center</td>
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<td>Shrikanth (Shri) S. Narayanan, PhD</td>
<td>Signal Analysis and Interpretation Laboratory</td>
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<td>Shinyi Wu, PhD</td>
<td>Roybal Center for Health Policy Simulation</td>
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<td>Noah Malmstadt, PhD</td>
<td>Laboratory for biomimetic phase interfaces</td>
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<td>Leslie A. Saxon, MD</td>
<td>Center for Body Computing</td>
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<td>Norberto M. Grzywacz, PhD</td>
<td>USC Center for Vision Science and Technology</td>
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<td>Maja J Mataric, PhD</td>
<td>Center for Robotics and Embedded Systems</td>
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<td>Albert (Skip) Rizzo, PhD</td>
<td>Institute for Creative Technologies</td>
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<td>Theodore W. Berger, PhD</td>
<td>Biomimetic Microelectronic Systems (BMES), Biomedical Simulations Resource (BMSR), and Center for Neural Engineering (CNE labs)</td>
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<tr>
<td>Mark S. Humayun, MD</td>
<td>Bioelectric Research Lab</td>
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