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Dear Colleagues,

The Institute for Engineering in Medicine (IEM) at the University of Minnesota is an interdisciplinary research organization strengthening efforts between the disciplines of engineering and medicine. IEM seeks to provide solutions and collaborative opportunities to the regional medical device industry.

We have over 270 affiliated researchers from more than 63 departments across the University of Minnesota working in one or more of our five research theme areas:

- Cardiovascular Engineering
- Neuroengineering
- Cellular and Molecular Bioengineering
- Medical and Biological Imaging
- Medical Devices

Our mission is to provide engineering solutions to medical problems.

I was recently appointed as the director of IEM and my mission is to chart the best possible course for the future for IEM.

In this report you will find features on our IEM Center activities and opportunities, which were also discussed during the recent IEM Annual Conference and Retreat (ACR) on Sept. 24. In particular, IEM will focus some of the IEM seed grants directly within the Centers. As in the past, IEM will also use some seed grants to build industrial collaborations and new faculty initiatives and working group grants (i.e. not associated with a specific Center). You will also find highlights of exciting IEM member research that has taken place in the past year. We look forward to your continued interest and support. Please contact us at iem@umn.edu with ideas you have that can improve what we do. Together, we will continue to make a difference in tomorrow’s medicine and healthcare through engineering innovation.

Sincerely,

John C. Bischof, Ph.D.
Director,
Institute for Engineering in Medicine
Organization

IEM hosts seven research centers and organizes its members’ research into five themes. Most IEM members are from departments in the University of Minnesota’s Academic Health Center or College of Science and Engineering. As an organization dedicated to building partnerships with a wide variety of medical, clinical, and engineering professionals, IEM highly values the involvement of scientific and industrial advisors from outside the University.
MISSION

The Institute for Engineering in Medicine (IEM) at the University of Minnesota serves as a catalyst for facilitating multidisciplinary collaborations in research and education between the Academic Health Center and the College of Science and Engineering, in addition to fostering collaborations with the medical technology industry. Our mission is to advance healthcare through research partnerships between engineering and medicine involving academia and industry. This is truly where medicine meets technology for tomorrow’s innovations.

VISION

As health care costs continue to rise exponentially and the world’s population ages, innovative and transformative approaches are needed now more than ever to deliver high-quality, safe and cost-effective care. IEM will champion the application of engineering technologies to generate innovative approaches for better treatment and management of a wide range of disorders. IEM members will develop programs that combine scientific advances with medical knowledge to improve the diagnosis, treatment, and prevention of diseases that affect our society.

IEM integrates expertise in engineering technology, basic sciences, biological and medical sciences, and the social aspects of health care. The position of IEM within the University—along with the University’s strong relationship with the Minnesota state government, support of the public, and presence amidst the heart of the world’s medical device industry—provides a unique environment for integrating new technologies into clinical practice and patient care. IEM is positioned to advance multi-disciplinary engineering solutions for all types of health care, and will foster innovations from basic science and discovery with translations to patient care, technological commercialization, and societal impact.
The Fifth Annual IEM Conference and Retreat took place on November 6, 2017, at the McNamara Alumni Center, attracting a crowd of 400+ participants. This year the IEM Annual Conference and Retreat was unique from those held in previous years as it focused upon generating more research collaborations, both among faculty members and between faculty members and industry. To accomplish this, the event was structured differently, having a condensed day between 11:30 am and 4:30 pm, with Plenary Talks held over the lunch hour, followed by a poster session and opportunity for collaboration during panel discussions.

**An approach to university collaboration in engineered biomaterials through 3M’s corporate research laboratory**

Greg Anderson  
Vice President, Corporate Research Lab  
3M Company

**Marrying the best of industry with the best of academia to enable breakthrough science, technologies and commercialization**

Dr. Sebastian Eriksson Giwa  
Cofounder of Elevian, Sylvatica Biotech, Ossium Health and the Organ Preservation Alliance

**Translation through early stage collaboration**

Dr. David M. Knapp  
Vice President of Corporate Research  
Boston Scientific Corporation

The afternoon consisted of panel discussions on industry collaboration, grant funding and entrepreneurship, and Collaborative Incubation "Genius Bars," at which faculty met to discuss the pursuit of research opportunities in IEM thematic areas and learned about the resources of IEM-affiliated centers. The panel discussions this year highlighted current activity in the areas of: UM Center Grants (U54, P41, P50, NSF etc), Large Company Partnerships (Medtronic, BSCI, 3M, Optum), Entrepreneurship, and a Student Career Panel. The poster session featured 100 posters and represented over 20 different departments. At the conclusion of the event, there were 18 poster awards given.

This year’s event served as an exceptional opportunity for IEM Member faculty to learn about a variety of research funding sources and methods from senior faculty, University funding and commercialization services, and from industry, including leading medical technology companies. In addition, it served as a singular gathering point for a variety of faculty with synergistic research interests in bringing engineering approaches to medical problems.
Since 2001, the annual Design of Medical Devices (DMD) Conference has hosted world-class medical device designers, researchers, and manufacturers from academia, government, and industry in what has become the largest medical device conference in the world. Conference participants discuss recent breakthroughs in medical device design and production over the course of the four-day event, with topics spanning numerous branches of medical device use, including 3D printing, prosthetics, and surgical robots. Presented by the Earl E. Bakken Medical Devices Center, IEM is able to exhibit the leadership of the University of Minnesota in the flourishing medical device community as well as raise funds to support medical device education at the University.

In its 17th year, the Design of Medical Devices Conference hosted almost 1200 attendees from 17 countries around the world. Over 150 speakers were invited to present during the conference and 108 paper submissions were accepted to be published in 2019 Proceedings of the Design of Medical Devices Conference in the ASME Digital Collection. DMD is proud to have 51 sponsors from industry and academia supporting the University’s medical device program.

A key aspect of this year’s event was its Emerging Technology Forum: "Digital Health." The forum experts included: Greg Anthony, Mayo Clinic; Peter Fitzgerald, Stanford University; Angie Franks, Central Logic; Ken Hoyme, Boston Scientific Corporation; Jodi Hubler, Lemhi Ventures; Jayant Parthasarathy, UnitedHealth Group; Bakul Patel, US Food & Drug Administration.

Keynote speakers included: Jazmín Aguado-Sierra, Barcelona Supercomputing Center; George Church, Harvard University; Michael Coyle, Medtronic, Inc.; Paul Howard, US Food & Drug Administration; Jesse Roitenberg, Stratasys.

**DMD CHINA**

The second DMD China Conference, held from December 10th to 12th in Beijing, was a significant success, with close to 500 participants representing the medical technology industry, including Chinese-based business units and scientists from the U.S. and China. Topics presented included two live surgeries, global harmonization of regulatory pathways, medical device innovation, virtual and augmented reality, 3D printing, including biologics, and computer modeling and simulation. Keynotes were delivered by senior personnel from Medtronic, 3M, Abbott, Boston Scientific, Johnson & Johnson, the China FDA, and Tsinghua University. Other speakers included IEM Member Dr. Gwenyth Fischer, Assistant Professor of Pediatrics, IEM Industrial Fellow Dr. David M. Knapp, V.P. of R&D at Boston Scientific, and Randy Schiestl, IEM Industrial Advisory Board Member and Vice President of R&D and Global Technology at Boston Scientific. "Attendance, content and messaging were very strong for our international audience of 450+ participants," says Mr. Schiestl. "We are proud to play a role in partnering with the University of Minnesota on all global DMD conferences." The conference was established by its Chair, Dr. Arthur G. Erdman, IEM Executive Committee Member and Director of the Earl E. Bakken Medical Devices Center, as an extension of the Design of Medical Devices Conference, held annually at the University of Minnesota in April.
The 6th Minnesota Neuromodulation Symposium, organized by the Institute for Engineering in Medicine (IEM) and MnDRIVE Brain Conditions, was held on April 12-13, 2018. Neuromodulation is a rapidly growing field, encompassing a wide spectrum of implantable and non-invasive approaches for the treatment of neurological and psychiatric disorders.

The Symposium brought together over 460 scientists, engineers, clinicians, industrial practitioners and entrepreneurs to discuss challenges and opportunities in neuromodulation. The program consisted of plenary presentations by leaders in academia, industry and government and over 100 poster presentations to exchange ideas in this exciting field. An award ceremony concluded the event with travel and poster awardees being recognized.

The meeting was organized and sponsored by IEM with major co-sponsors Abbott, MnDRIVE Brain Conditions, and Medtronic. Other sponsors were Heraeus, Rogue Research Inc., NIRX, Boston Scientific, Bio-Techne, Brain Vision LLC., RCRI, ReShape Lifesciences, Evergreen Medical Technologies, Jali Medical, Magstim, and the Institute of Science and Technology for Brain Inspired Intelligence at Fudan University, China.
IEM Distinguished Seminar Series

In 2017-2018, IEM established the new IEM Distinguished Seminar Series. Based on feedback from the IEM Executive Committee, IEM will reduce the number of speakers for the recent academic year and focus on bringing in thought leaders from around the world to provide insight into diverse research areas.

IEM invited three distinguished speakers who are doing cutting-edge work at the intersection of the medical and engineering fields and whose work has broad appeal to our members. These high-caliber speakers have made significant original or leadership contributions to the field of engineering in medicine.

“Model-based design of novel therapies for heart disease.”

Jeffrey Holmes, M.D., Ph.D., F.A.H.A.
Professor of Biomedical Engineering and Medicine
Director, Center for Engineering in Medicine
University of Virginia

Jeff Holmes is a Professor of Biomedical Engineering and Medicine at the University of Virginia. He obtained his B.S. in Biomedical Engineering from the Johns Hopkins University in 1989, his Ph.D. in Bioengineering from the University of California, San Diego in 1995, and his M.D. from the University of California San Diego in 1998. His first faculty position was at Columbia University, where he helped found and build a new Biomedical Engineering department from 1999 to 2007. In 2007, Dr. Holmes moved to the University of Virginia, where he heads the Cardiac Biomechanics Group. His laboratory studies the interactions between mechanics, function, and growth and remodeling in the heart, using a combination of computational and experimental models. His research has been funded by the NIH, NSF, the American Heart Association, the Whitaker Foundation, the Coulter Foundation, the Hartwell Foundation, and the Allen Foundation. Dr. Holmes was awarded the Y.C. Fung Young Investigator Award in 2005 and the American Heart Association Established Investigator Award in 2006. He is a Fellow of the American Heart Association, the American Institute for Medical and Biological Engineering (AIMBE), and the American Society of Mechanical Engineers. Dr. Holmes has taught a wide range of undergraduate and graduate courses including Computational BME, Fluid Biomechanics, Cardiac Mechanics, Soft Tissue Mechanics, Advanced Quantitative Physiology, Engineering Physiology, Biomedical Innovation, and Ethics for Biomedical Engineers. He currently serves as the founding Director of the Center for Engineering in Medicine at the University of Virginia.
“Personalized treatment planning in pediatric cardiology: methodological developments and clinical application.”

Alison Marsden, Ph.D.
Associate Professor Departments of Pediatrics and Bioengineering, and by courtesy of Mechanical Engineering, Institute for Computational and Mathematical Engineering, Vera Moulton Wall Center Faculty Scholar, Stanford University

Alison Marsden is an associate professor and Wall Center scholar in the Departments of Pediatrics, Bioengineering, and, by courtesy, Mechanical Engineering at Stanford University. From 2007-2015, she was a faculty member in the Mechanical and Aerospace Engineering Department at the University of California San Diego. She received her Ph.D. in Mechanical Engineering from Stanford in 2005 working with Prof. Parviz Moin. She was a postdoctoral fellow at Stanford University in Bioengineering and Pediatric Cardiology from 2005-07 working with Charles Taylor and Jeffrey Feinstein. She was the recipient of a Burroughs Wellcome Fund Career Award in 2007, an NSF CAREER award in 2011, and she is fellow of the American Institute for Medical and Biological Engineering. She received the UCSD graduate student association faculty mentor award in 2014 and MAE department teaching award at UCSD in 2015. She has published over 90 peer reviewed journal papers and has received funding from the NSF, NIH, and several private foundations. She is currently on the editorial boards of several leading journals in biomechanics. Her work focuses on the development of numerical methods for cardiovascular blood flow simulation, medical device design, application of optimization to large-scale fluid mechanics simulations, application of engineering tools to impact patient care in cardiovascular surgery, and congenital heart disease.

“From fundamentals to bedside: unraveling the systems properties of health and disease.”

Andre Levchenko, Eng.Sc.D.
John C. Malone Professor of Biomedical Engineering
Yale University

Andre Levchenko, John C. Malone Professor of Biomedical Engineering, combines experimental results with computational models to learn about the interactions within protein and cells networks in healthy and disease states. Levchenko, who joined the Yale faculty in 2013, is engaged in multi-disciplinary research to define molecular and cellular interactions from single-cell to multi-cell levels. In addition to his endowed post, Levchenko was also appointed as the inaugural director of the Yale Systems Biology Institute.
Research at IEM is focused around five core themes that aim to understand the mechanisms of disease and develop engineering solutions for these problems. True to the interdisciplinary nature of the Institute, many IEM-sponsored research projects combine one or more of these themes, and many members regularly conduct cross-theme research. The Institute is also fortunate to run six unique centers and labs which provide faculty, students, and industrial partners with resources for conducting research.

CARDIOVASCULAR ENGINEERING
Theme Co-Chairs: Victor Barocas, Ph.D., and Paul Iaizzo, Ph.D.

The major goal of the Cardiovascular Engineering theme is to address the global public health challenge of cardiovascular diseases by studying the heart at the gene, cell, tissue, and whole-organ levels. Research teams also develop novel imaging and sensing modalities to study the mechanisms of cardiovascular functions and guide engineering solutions for clinical diagnosis and management.

CELLULAR AND MOLECULAR BIOENGINEERING
Theme Co-Chairs: Kalpna Gupta, Ph.D., and David Odde, Ph.D.

The Cellular and Molecular Bioengineering theme has the research goal of developing therapeutic strategies at the cellular level to halt disease and promote regenerative healing. Building upon genome sequencing projects, theme researchers apply modeling and advanced instrumentation to understand how molecular parts form functioning systems that enable cells to execute specific disease-related tasks and use these models to design novel therapeutic strategies.


Image: Cellular traction force dynamics. A neuron (green) uses myosin motors to pull on the deformable substrate to which it is adhered. Red fluorescent nanoparticles embedded in the gel revealed load-and-fail dynamics as predicted by a stochastic motor-clutch model. From “Traction dynamics of filopodia on compliant substrates.” Science. Volume 322, pp. 1687-1691, by Chan CE and Odde DJ.
**MEDICAL AND BIOLOGICAL IMAGING**

Theme Co-Chairs: Wei Chen, Ph.D., and Stephen Engel, Ph.D.

This theme's major research goal is to strengthen the role of imaging in support of biomedical research and clinical translation. Researchers pursue this goal by integrating and sharing a large variety of state-of-the-art imaging approaches and fostering interdisciplinary collaborations among basic science, bioengineering, and clinical researchers in academia and the biomedical industry. Researchers in this theme also develop grant proposals to procure state and federal funding for interdisciplinary imaging research. Imaging technologies available include MRI, in vivo MRS, PET, CT, ultrasound, optical imaging, and cellular and electrophysiological imaging.


**MEDICAL DEVICES**

Theme Co-Chairs: Arthur Erdman, Ph.D., and Christy Haynes, Ph.D.

The goal of the Medical Devices theme is to develop devices and technologies that aid in the diagnosis, treatment, and management of various diseases. Emphasis is placed on engineering innovations that address unmet medical needs. For more information on this research theme, see the description of the Medical Device Center.

![Image: Researchers at the Medical Devices Center using high-resolution 3D visualization and virtual prototyping.](image)

**NEUROENGINEERING**

Theme Chair: Kelvin Lim, M.D., and Tay Netoff, Ph.D.

The goal of the Neuroengineering theme is to develop multi-level solutions that involve the operation of whole neural systems. IEM researchers in this theme focus on developing methods to detect, image, interface with, and modulate brain and nervous system disorders. They also focus on developing non-invasive methods for understanding and healing the brain.

![Image: Illustration of a novel noninvasive brain-computer interface that can control the flight of a virtual helicopter in 3-D virtual space at the University of Minnesota campus from “thoughts” sensed over the scalp of human subjects. Work published in PLoS ONE (Doud et al) and featured by ABC News.](image)
The mission of the Biopreservation Core Resource (BioCoR), led by Allison Hubel of the Department of Mechanical Engineering, is to advance the science, technology and practice of preservation. Over the past several years, BioCoR has developed methods for streamlining protocol development and optimization and applies those approaches to accelerate development of improved preservation protocols for high-value products.

Over the past year, BioCoR has provided short online courses in biopreservation, complete with course notes: “Preservation of Cellular Therapies” and “Preservation of Molecular, Cellular, and Tissue Biospecimens.” It also managed a Hematology Workforce Training grant that funded students (generally at or above the graduate level) to study blood preservation technologies.

BioCoR also promoted the 2017 Organ Banking Summit at Harvard Medical School. This event brought together leading scientists and engineers, as well as other key stakeholders from government, industry, academia, and the nonprofit sector, to address the challenge of banking organs and large tissue systems for transplantation, research, regenerative medicine, and other applications. Participants outlined new and emerging research strategies that can overcome the remaining scientific sub-challenges in organ banking, benefiting millions of patients each year worldwide.

For 2018-19, BioCoR will continue to offer short courses and looks forward to publishing Allison Hubel’s new book, Preservation of Cells: A Practical Manual (Wiley Blackwell), which grew out of the short courses that BioCoR has offered over the past decade. The book will 1) clearly explain the reasons behind every step in the development of a preservation protocol, and 2) provide sample protocols for preservation, thawing, and shipping of cells.
The Cancer Animal Core (CAC) Lab is a research core for IEM faculty and local industry to engage more readily in cancer research with animals. Since it was established in 2014, CAC has run pilot and long-term projects using cancer models that were already in operation within the core, dramatically reducing the time for academic and industry researchers with limited experience using animals in cancer research. CAC also serves as a hub for IEM members seeking collaborative research and shared resources.

CAC provides four key services for cancer researchers: 1) cell culture, 2) basic small animal study, 3) small animal cancer models, and 4) DSFC (dorsal skin fold chamber) models. It also provides educational exposure to graduate students engaged in cancer-related research and opportunities for undergraduates or master’s students seeking projects besides coursework.

CAC is directed by John Bischof, with post-doctoral researcher Qi Shao (from the Department of Mechanical Engineering) managing day-to-day operations.

Since 2014, CAC has supported work that has resulted in 15 peer-reviewed publications and at least several further research projects supported by government and industry.

For 2018-19, CAC plans to better market its services with the University, the local medical community, and even to companies and researchers outside the Twin Cities. One particular goal is to generate more preliminary data for researchers that will qualify them for larger government- and industry-sponsored research grants. Another is to expand services for the rapidly growing field of immunotherapy-based cancer treatment.
The Center for Neuroengineering (CNE) is a campus-wide research center to promote interdisciplinary research and training in the field of neuroengineering. It was founded by Bin He in 2008 and is now led by Dr. Tay Netoff, a professor in the Department of Biomedical Engineering. CNE is both a center of IEM and a center of the Medical School’s Institute for Translational Neuroscience. Participating faculty come from various departments including those in biomedical sciences, engineering, and physical sciences.

The mission of CNE is to advance neuroengineering research, foster collaborations between neuroscience and engineering faculty at the University and with industrial partners, and training the next generation of leaders in this exciting field.

2017-18 has been a year of considerable change at CNE. First, the Center bid farewell to founder Bin He and welcomed the new leadership of Tay Netoff. This has meant reorganizing the approach to the annual Neuromodulation Symposium, making plans for recruiting new faculty to participate in the Center, updating the CNE website, and reorganizing CNE’s research space.

Key highlights of 2017-18:
• The Neuroengineering seminar has been made into a course that students can take for credit that counts towards a Neuroengineering minor.
• David Redish, professor of neuroscience, was awarded a Computational Neuroscience T32 training grant. While this training grant was not a direct initiative of CNE, it involves many CNE members and will support students who participate in CNE.
• The sixth Minnesota Neuromodulation Symposium brought together more than 500 scientists, engineers, clinicians, industry representatives, and entrepreneurs to discuss challenges and opportunities in neuromodulation.
The Earl E. Bakken Medical Devices Center (Bakken MDC) at the University of Minnesota is an interdisciplinary program that combines basic research, applied and translational research, education and training, and outreach and public engagement, all related to medical devices.

In July 2017, the Medical Devices Center was renamed in honor of UMN Alumnus and Medtronic, Inc. co-Founder Earl E. Bakken. “The Medical Devices Center wouldn’t be possible without the foundation Earl Bakken built in Minnesota,” said Arthur Erdman, Ph.D., director of Bakken MDC. “Having his name officially associated with our center is an honor, and we are committed to continuing to live up to his charge.”

2017-18 had an impressive group of Innovation Fellows (see p. 30). As with previous years, the Innovation Fellows spent their first few weeks in a series of Educational Rotations presented by thought leaders in the College of Science and Engineering, Medical School, Academic Health Center, law firms, surrounding med-tech industry, venture capitalists, and angel investors. They then spent several weeks in a period of Clinical Immersion, where they put on scrubs and stood in the periphery of operating rooms and clinics and observed MDs, nurses, and associated technicians at work. From that point, they worked together and with faculty collaborators to accelerate the development of prototypes.

2017-18 also saw another attendance record for the Design of Medical Devices (DMD) conference, and plans are underway for a third DMD in China and a new DMD in Europe.

In the next year, Bakken MDC will focus on expanding its marketing and collaborative reach outside of Minnesota, enlarging its portfolio of federally-funded research projects, involving more faculty in Bakken MDC research, enhancing its educational offerings, and expanding its base of funding.
The mission of the Tissue Mechanics Laboratory (TML) is to provide specialized instruments and methods to characterize the mechanical properties of soft biological materials, provide quantitative loads to living tissues, foster research in these areas, and provide a resource for the University community and industrial partners.

The key instruments of TML include 1) a Nanolndenter XP microprobe system, 2) a Microbionix testing system, and 3) a Planar biaxial testing system.

Robert Tranquillo, Ph.D., Department Head
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In 1997, Paul A. Iaizzo founded the Visible Heart® Laboratory (VHL) in collaboration with Medtronic to study reanimated large mammalian hearts (including human hearts) under simulated physiological conditions. Since then, the VHL has grown into a unique and robust place to perform translational research, from tissue studies to whole organ investigations. The VHL also maintains a 3D printing lab with more than a dozen printers that are used for creating models of human hearts for educational and clinical pursuits, as well as an ever-growing human heart library that can be utilized by students, academics, clinicians, and medical device designers. It is also worth noting that VHL’s multiple research collaborations with Medtronic makes it the home of the University’s largest industrial partnership.

2017-18 did not see any new initiatives at VHL, but a steady expansion of its existing work. Hundreds of new images (including videos) were added to the one-of-a-kind Atlas of Human Cardiac Anatomy, for example, and its 3D printers were busier than ever making new models for a wide range of academic and industrial researchers.

Over the next year, VHL plans to expand its 3D printing capabilities, its educational offerings, and the number of research collaborations aimed at securing funds for large, multi-investigator projects.
3D Printing Core

Mission Statement

IEM’s 3D Printing Core is an interdisciplinary organization that aims to use segmentation, digital design, and additive manufacturing to provide patient-specific, three-dimensional anatomical models to clinicians and researchers at the U of M. Led by Professor William Durfee, a longtime IEM member and the Director of Design Education in the Department of Mechanical Engineering, the 3D Printing Core works closely with the Medical Devices Center and the Visible Heart Lab to implement its mission.

The 3D Printing Core, led by Will Durfee of the Department of Mechanical Engineering, is an interdisciplinary resource that aims to bring the benefits of additive manufacturing and three-dimensional medical modeling to the University of Minnesota clinical community. The Core specializes in the use of segmentation, digital design, and additive manufacturing to provide 3D-printed renderings of medical scans to University of Minnesota clinicians.

The 3D Printing Core partners extensively with IEM’s Bakken MDC and Visible Heart® Lab to develop efficient and accurate ways to print new specimens. It also combines technical talent with educational opportunities by incorporating over 20 students in multiple projects. Importantly, these students represent seven departments at the University, including two in the College of Liberal Arts.

In the past year, the 3D Printing Core has worked with University and industry researchers and clinicians to print a number of unique models: a full brain, high-precision mandibular teeth, experimental dental implants, ribs, and others.

For 2018-19, the Core aims to expand its educational offerings and equipment in order to meet the ever-growing demand for 3D models from researchers in medical and non-medical fields. The Core also aims to develop strong educational materials about 3D printing, especially for patients for whom 3D models are a key aspect of their treatment.

Mechanical Engineering students take measurements to 3D print an attachment to an injured green sea turtle’s shell.
IEM Seed Funding Program

The IEM Seed Grant program awards selected multidisciplinary groups of investigators to seek program/center/group external block funding, with the goal of making major contributions in significant medical and health research using engineering approaches.

Proposals can be in any area of engineering that is related to biomedicine and health, with the expectation that the research aims to strengthen University of Minnesota capabilities in addressing significant biomedical and health problems using engineering approaches. Proposals in IEM thematic areas of Cardiovascular, Neural, Cancer, Regenerative Medicine and Transplantation, and Medical Devices research are encouraged, but all areas are considered. The proposals must address a major biomedical problem with a multidisciplinary approach, including a balanced group of investigators from AHC, CSE and other colleges who have demonstrated track records of conducting externally funded biomedical research.

IEM funding is not intended to replace external funding for research, but rather to help develop strong external proposals, produce pilot data through collaboration for new external funding, or provide the basis for establishing a national center or program. As such, a detailed plan should be provided on how the proposed faculty group will work together, what specific external funding opportunities will be addressed, and why and how the IEM seed funding will facilitate achieving the goal. Group proposals, if funded, may be renewed for a second year, contingent upon demonstrated progress. Recipients of group grants may be called upon to present their progress at the next IEM Annual Conference and Retreat. PIs of awarded group grants will also be expected to serve on a new committee chaired by Associate Director David Odde to create a leadership community that provides critical feedback and mutual support in sharing of strategies/best practices among IEM group grant awardees.

Faculty Seed Grants Awarded (by Fiscal Year)

2005 – 9 Awarded (total: $508,401)
2006 – 18 Awarded (total: $617,871)
2007 – 14 Awarded (total: $562,335)
2008 – 19 Awarded (total: $1,494,707)
2009 – 21 Awarded (total: $1,312,647)
2010 – 4 Awarded (total: $200,000)
2011 – 11 Awarded (total: $278,727)
2012 – 18 Awarded (total: $487,968)
2013 – 11 Awarded (total: $452,399)
2014 – 12 Awarded (total: $342,960)
2015 – 25 Awarded (total: $479,431)
2016 – 14 Awarded (total: $434,716)
2017 – 11 Awarded (total: $480,000)
2018 - 10 Awarded (total: $375,000)
Seed Grants Blossom Into Research Centers

IEM seed grants help researchers “sprout” a new idea, and sometimes those seedlings blossom into large, pioneering research centers that promise to change the face of medicine.

Here are three University of Minnesota research centers that started as IEM seed grants:

**Physical Science in Oncology Center (PSOC)**
http://psoc.umn.edu

**Director:** David Odde, IEM Associate Director
“The laws that drove Newton’s apples to the ground should also drive the migration of cancer cells.” That’s the unspoken motto of PSOC, a National Cancer Institute research center aiming to unravel the cellular and molecular mechanisms of cancer migration and design new clinical tools to shut down cancer pathways.

**Udall Center of Excellence for Parkinson’s Disease Research**
http://udall.umn.edu

**Director:** Jerrold Vitek, IEM Member
Named for former U.S. Congressman Morris K. Udall of Arizona, who fought a long battle with Parkinson’s, the University of Minnesota’s Udall Center aims to define the changes in brain circuitry that underlie Parkinson’s disease and use this information to develop novel deep brain stimulation therapeutic approaches.

**Cannabinoid-based Therapy and Approaches to Quantify Pain in Sickle Cell Disease**

**Director:** Kalpna Gupta, IEM Member
This Center, which began in 2013, has made significant progress determining causes and treatments for pain associated with sickle-cell disease. Research published by Center scientists is also helping quantify pain associated with other diseases.

“We need to strive for reliable treatments for the millions of people suffering from this painful genetic disease. Moreover, objective quantification of pain is a major unmet need in treating pain.”

Kalpa Gupta

“Deep brain stimulation is a proven treatment for Parkinson’s, but we need to learn a lot more to maximize its effectiveness for the millions of Parkinson’s sufferers worldwide.”

Jerrold Vitek
WALTER BARNES LANG FELLOWSHIP RECIPIENTS

Each year, IEM is proud to offer the Walter Barnes Lang Fellowship, which supports travel for research presentations. Recipients of the award are graduate students at the University of Minnesota who are engaged in study and research related to engineering in medicine and who are advised by IEM members. Applicants are evaluated on several criteria, including their record of academic achievement, the quality of their research plan, their demonstrated commitment to engineering in medicine, and demonstrated leadership strengths.

INTERDISCIPLINARY DOCTORAL FELLOWSHIP

The Interdisciplinary Doctoral Fellowship (IDF) is awarded to outstanding graduate students who have interdisciplinary dissertation topics and who would benefit from interaction with faculty at one of the University’s research centers or institutes. IEM is proud to be one of the host institutions for the Graduate School’s IDF and offer additional funds to support professional development as well as a space to accommodate the needs of IDF research projects.

IEM CAREER DEVELOPMENT AWARDS

The Institute for Engineering in Medicine’s Faculty Career Development Awards honor highly promising IEM junior faculty by supporting their research activities. Award winners receive $30,000 over the course of three years to continue advancing their respective research initiatives.
Clinical Immersion Program

Expect the unexpected. That has become a common theme among participants in IEM’s Clinical Immersion Program. While most medical procedures have standard processes, the patients and their circumstances can vary significantly. Percutaneous Coronary Intervention (PCI), for example, is a common procedure performed by cardiologists in the United States, but during a heart attack doctors need to work quickly in a high-stress situation to place the catheter tube inside the blocked artery. The diversity of treatment factors and their implications for the design and application of medical devices is part of what makes the Clinical Immersion Program a key element in the development of engineers and other professionals in the medical technology industry.

Participating companies send groups of employees to spend five days at the University of Minnesota Medical Center, during which they view numerous medical procedures, learn from a variety of clinicians, go on patient rounds, and attend physician conferences.

“We learned about all aspects of surgery operations, and the residents did a fantastic job of explaining quite a bit of the technical aspects, and we feel much smarter for it.”

– 3M Participant

IMMERSION PROGRAMMING

The Clinical Immersion Program began with a focus on general surgery in 2015, then expanded to include cardiology and neurosurgery in the spring and fall of 2016, respectively. At its most basic level, the program includes observations of procedures, direct and in-depth interaction with clinicians, patient rounding, and physician conferences. By nature, however, each program focus provides an entirely unique experience to participating groups. The general surgery immersions are hosted and led by surgical residents and include a large variety of surgical procedures, such as cardiac, thoracic, colorectal, urological, oncological, and transplantation. Interventional cardiologists host the cardiology immersions, which include some procedures performed in the surgery operating rooms, such as transcatheter aortic valve replacements (TAVR), but are primarily focused on interventional and electrophysiological procedures, which occur in the hospital’s Cath Lab. The neurosurgery immersions, by contrast, are more classroom-oriented, with participants attending neuroanatomy trainings and lectures on procedures that are delivered by neurosurgeons, in addition to observations of those procedures.

Surgery Immersion participants having lunch with residents.
COMMUNITY TIES

The program is the brainchild of IEM Associate Director for Education and Outreach, Paul Iaizzo, who identified the value of industry professionals gaining exposure to the very environments in which their devices are used so that they can develop a better understanding of the needs of clinicians and their patients. “Everyone has the same goal, but industry and academic groups come at problems from different angles,” says Dr. Iaizzo, “and of course they’re all really smart people with a ton of knowledge about medical devices, so when they spend structured and unstructured time together, all kinds of new and surprising things happen.” Moreover, most of the attendance fees for the program are used to fund training for residents and fellows in the participating departments.

2017-2018 PROGRAM HIGHLIGHTS

Led by IEM Assistant Director Ken Rosen, the program has hosted more than 200 participants from eight companies in its first three years. With its strong reputation for delivering high-quality learning, the Clinical Immersion Program is becoming a well-known professional development tool and for medical technology companies. In addition to its core, week-long programs in surgery, cardiology and neurosurgery, more customized immersions have been developed and staged for companies focused on specific innovation efforts, both in those traditional clinical areas and in others. “As medical device companies expand beyond their traditional cardiovascular, structural heart and neuromodulation businesses, we are developing and delivering immersion experiences in other clinical areas to meet these specific needs,” says Rosen.

“The last week was really beneficial for me. I had some observing experiences before but never this close. The physician interaction in Cath Lab and Round and many discussions will surely motivate us and bring new aspiration for the continued invention of new medical devices.”

– Boston Scientific Participant
Melena Bellin

Dr. Melena D. Bellin, Associate Professor of Pediatrics, is leading the University of Minnesota’s arm of a study to test an off-the-shelf islet cell transplant treatment for Type 1 diabetes patients who lack the ability to produce their own islet cells needed for the production of insulin. Type 1 diabetes affects approximately 1.25 million adults in the U.S.

Gert Bronfort and Roni Evans

Dr. Gert Bronfort, Research Professor, and Dr. Roni L. Evans, Research Associate Professor, each in the Integrative Health & Wellbeing Research Program, are leading a large study that seeks to find non-pharmaceutical alternatives to opioids for preventing chronic lower back pain. They are studying treatments like spinal manipulation therapies and supported self-management as ways to reduce chronic pain and surgeries.

Nathaniel Helwig

Dr. Nathaniel E. Helwig, Assistant Professor of Psychology and Statistics, was a collaborator on a project aimed at determining the elements of “successful smile.” A total of 802 participants evaluated computer-generated 3D images of human faces and rated the smiles on those faces by their effectiveness, genuineness, pleasantness and perceived emotional intent. The results of the study have broad applications in facial reanimation surgery, rehabilitation, computer graphics, and psychology.
Jürgen Konczak
Dr. Jürgen Konczak, Professor and Director of the School of Kinesiology, is investigating the commercial potential of a robotic system for neurological rehabilitation that has been tested on more than 300 human users. The system allows patients to have unrestricted movement and can be used to rehabilitate patients recovering from stroke and those with Parkinson’s disease, dystonia, and traumatic brain injuries.

Michael Kyba
Dr. Michael Kyba, Professor of Pediatrics, is the principal investigator of a team that successfully developed a mouse model for facioscapulohumeral muscular dystrophy, a disease that affects approximately 38,000 people in the U.S. and for which there is no approved treatment. Producing mice with the disease is a key step toward testing therapies that can treat it.

Hubert Lim
Dr. Hubert H. Lim, Associate Professor of Biomedical Engineering and Institute for Translational Neuroscience Scholar, is piloting a clinical trial that uses noninvasive ultrasound focused on the spleen to treat rheumatoid arthritis. Lim is also studying the use of ultrasound to treat inflammation disorders.
Michael McAlpine

Dr. Michael C. McAlpine, Benjamin Mayhugh Associate Professor of Mechanical Engineering, has demonstrated the first successful 3D printing of electronics onto skin. The printing is made possible by a continuous tracking process that accounts for small movements and a curing process that occurs at room temperature. When they are no longer needed, the electronics can be easily peeled off by tweezers or washed off with water.

Walter Low

Dr. Walter C. Low, Professor of Neurosurgery, is investigating the use of the Zika virus to attack brain tumors. This is an outgrowth of Low’s discovery that brain tumor stem cells share the same receptors as neural stem cells, which are susceptible to the Zika virus.

Tim O’Brien

Dr. Timothy D. O’Brien, Professor of Veterinary Population Medicine, is leading a feasibility study to explore the safety and efficacy of cell products derived from brain organoids for transplantation as a treatment for Parkinson’s disease. This study is built on his lab’s pioneering generation of brain organoids from stem cells.
**Valerie Pierre**

Dr. Valerie C. Pierre, Associate Professor of Chemistry, is seeking to commercialize a 5-minute diagnostic test that can be used by consumers to detect urinary tract infections. These infections affect millions of Americans every year (mostly women), but current tests require 48 hours for conclusive results.

**Matthew Hunt and Elizabeth Pluhar**

Dr. G. Elizabeth Pluhar, Professor in the Department of Veterinary Clinical Sciences, and Dr. Matthew A. Hunt, Associate Professor in the Department of Neurosurgery, are collaborators on a new study on dogs with glioblastoma brain cancer that could lead to future applications for human patients with the disease. The treatment is a combination of surgery and breaking down tumor defenses against natural immune responses.
Dr. Kamil Ugurbil, Professor of Radiology-CMRR, performed the world’s first 10.5 Tesla MRI scan of a human in December 2017. The scan was significantly higher than standard 1.5 and 3 Tesla MRIs. Once it is further developed, the 10.5 Tesla magnetic field will provide unprecedented image clarity that will help scientists better understand the workings of the human body, especially the brain.

Dr. Jerrold L. Vitek, Professor and Chair of the Department of Neurology, served as a co-Principal Investigator for the U.S. study of the Vercise deep brain stimulation system that received FDA approval in 2017. The Vercise system, which was launched by Boston Scientific in 2012, is used to treat Parkinson’s disease patients by improving their waking hours and motor function.
Industial Fellows

With the unique positioning of the University of Minnesota at the center of a highly active medical device industry, the Institute established the Industrial Fellows program to optimize the knowledge and resources of University faculty, facilities, and clinical capabilities. More than an advisory group, the IEM Industrial Fellows help the Institute understand the needs of local industry and establish new University research partnerships with local medical companies. The Fellows have continued to play a vital role in building the highly successful Clinical Immersion Program, serving as ambassadors for employee recruiting initiatives within their respective organizations, and both speaking at and promoting numerous IEM-sponsored events, including the IEM Seminar Series and the MN Neuromodulation Symposium.

Class of 2018

Jesus A. Cabrera
Senior Principal Architect, Smiths Medical

Seb Giwa
Founder and Executive Chairman, Ossium Health

Mark Palmer
Senior Principal Scientist, Medtronic

Teresa A. Whitman
Senior Research Manager, Medtronic

Class of 2017

Sarah Ahlberg
Research Manager, Medtronic

Michael Eggen
Principal Scientist, Medtronic

Sean O’ Neil
VP of Enterprise Architecture, Optum

Patrick Park
Medical Director, 3M Critical and Chronic Care Solutions Division
Sponsored by IEM’s Medical Devices Center, the Innovation Fellows Program concentrates on developing medical devices for a broad variety of clinical areas. The goal is to train the next leaders in medical technology by fostering leadership and teaching risk management for medical devices to a group of postgraduate engineers, seasoned medical device professionals, bioscientists and physicians. The MDC guides the Innovation Fellows through the disciplined product development process, which includes understanding FDA requirements, insurance reimbursement, intellectual property, and business strategies, in addition to creativity techniques and prototyping.

**YASHEEN BRIJLAL**
Yasheen is from South Africa where he grew up in Durban and moved to Cape Town to do his Bachelor of Science degree in Electrical Engineering followed by a Masters in Medicine in Biomedical Engineering, both at the University of Cape Town. Yasheen is passionate about applying his biomedical engineering skills and abilities to make an impact in healthcare with a personal interest in developing medical devices that will ultimately address the unique challenges experienced in Africa.

**LYNDSEY CALVIN**
Lyndsey Calvin was born and raised in Seattle, Washington. She attended the University of Utah where she earned a Bachelor of Science in Exercise and Sport Science. While at the University of Utah, she interned for a local prosthetics and orthotics clinic as well as volunteering with Special Olympics Utah organizing fundraising events.

**AMY HOELSCHER**
Amy was born and raised in Minnesota. She completed her Bachelors of Science in Nursing as well as her Doctor of Nursing Practice in Health Innovation and Leadership at the University of Minnesota. Amy also completed a Health Care Design and Innovation Post-Baccalaureate Certificate and a Leadership in Health Information Technology for Health Professionals Certificate during her graduate studies and is a Certified Patient Experience Professional.

**KIERAN LEONG**
Dr. Kieran Leong is from Edmonton, Canada. He attended the University of Wisconsin-Madison for his undergraduate studies, earning bachelor degrees in medical microbiology and immunology and French. He then went on to medical school at Touro College in New York City. He then trained at Louisiana State University Health Science Center in New Orleans for his combined internal medicine/pediatrics residency and then pursued fellowship in pediatric cardiology at the University of Minnesota. His publications have helped to contribute to advancements in the areas of procedural cardiology.

**IBRAHIM YEKINNI**
Ibrahim was born and raised in Lagos, Nigeria. He attended the University of Lagos for Premedical studies in 2009 and moved on to receive his medical degree from the College of Medicine of the University of Lagos (2015).

During his undergraduate study at the University of Lagos, he co-founded a digital agency which helped small businesses get online at the time. Some of the success stories include a gadget store that increased orders from 50 to more than 2000 in a year and a platform that helped connect over a thousand medics during the first month of launch.
Membership

The Institute is comprised of over 270 faculty members who serve in 63 academic departments and divisions from nearly every college on the University of Minnesota - Twin Cities campus. Benefits of IEM membership include access to research funding provided by IEM, participation in organized research groups, assistance in developing contacts or collaborations within the University and with local industry, reduced costs for attendance at IEM-sponsored conferences and activities, and reduced costs for use of IEM-sponsored research centers. IEM members can also apply for support for presenting at conferences or symposia, use of IEM equipment or facilities, sponsorship of visiting scientists or lecturers, and graduate student research.

**MEMBERSHIP BREAKDOWN**

IEM continues to grow and increase its engagement with faculty, students, clinicians, and professionals in industry and government. Consistent with previous years, the majority of this membership gain has come from the Medical School, with a substantial number of new members arriving from the College of Veterinary Medicine. Much of this growth indicates the increasing awareness of IEM among University clinicians and their interest in cross-disciplinary research collaborations.

While all members are required to be a part of one research theme, a majority of the membership of the Institute conducts research that spreads across more than one theme.

**MEMBERS BY COLLEGE**

<table>
<thead>
<tr>
<th>College</th>
<th>Members</th>
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<tbody>
<tr>
<td>Medical School</td>
<td>153</td>
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<tr>
<td>College of Science &amp; Engineering</td>
<td>74</td>
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<tr>
<td>College of Pharmacy</td>
<td>8</td>
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<tr>
<td>College of Veterinary Medicine</td>
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<td>School of Dentistry</td>
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<td>School of Public Health</td>
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<tr>
<td>College of Biological Sciences</td>
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<td>College of Liberal Arts</td>
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<tr>
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<td>CFANS</td>
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<td>College of Design</td>
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<tr>
<td>School of Nursing</td>
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Executive Committee

IEM’s Executive Committee is composed of eminent University of Minnesota faculty from the Academic Health Center and the College of Science and Engineering. Their passion for innovation and growth puts them in a unique position to promote the mission of IEM while actively contributing to research, education, clinical and industry needs, grant development, and technology transfer.

**John C. Bischof, Ph.D.**  
IEM Director; Distinguished McKnight University Professor of Mechanical Engineering

**Paul A. Iaizzo, Ph.D.**  
IEM Associate Director for Education and Outreach; Director of the Visible Heart® Laboratory; Professor of Surgery; Theme Co-Chair, Cardiovascular Engineering

**David Odde, Ph.D.**  
Theme Co-Chair, Cellular and Molecular Bioengineering; Professor of Biomedical Engineering

**Arthur G. Erdman, Ph.D.**  
Director, Medical Devices Center; Theme Co-Chair, Medical Devices; Richard C. Jordan Professor of Mechanical Engineering

**Wei Chen, Ph.D.**  
Theme Co-Chair, Medical and Biological Imaging; Professor of Radiology

**Stephen Engel, Ph.D.**  
Theme Co-Chair, Medical and Biomedical Imaging; Professor of Psychology

**Kalpna Gupta, Ph.D.**  
Theme Co-Chair, Cellular and Molecular Bioengineering; Professor of Medicine

**Christy Haynes, Ph.D.**  
Theme Co-Chair, Medical Devices; Professor of Chemistry

**Allison Hubel, Ph.D.**  
Director of the Biopreservation Core Resource; Professor of Mechanical Engineering

**Kelvin O. Lim, M.D.**  
Theme Co-Chair, Neuroengineering; Professor and Vice Chair for Research, Department of Psychiatry; Drs. T.J. and Ella M. Arneson Land Grant Chair in Human Behavior
Advisory Boards

IEM has two advisory boards that connect its members and the University with local and national organizations and provide direction for the Institute’s programs. Members of the Scientific Advisory Board are national leaders at academic institutions across the United States. The Industrial Advisory Board is comprised of industrial leaders in local biomedical companies.

**SCIENTIFIC ADVISORY BOARD**

- **Rashid Bashir, Ph.D.**
  Executive Associate Dean and Chief Diversity Officer, Carle Illinois College of Medicine

- **Warren Chan, Ph.D.**
  Professor (Cross Appointed), Institute of Biomaterials and Biomedical Engineering, University of Toronto

- **Amy E. Herr, Ph.D.**
  Lester John and Lynne Dewar Lloyd Distinguished Professor, Bioengineering, University of California Berkley

- **Mehmet Toner, Ph.D.**
  Helen Andrus Benedict Professor, Surgery, Massachusetts General Hospital and Harvard Medical School

**INDUSTRIAL ADVISORY BOARD**

- **J. Fernando Bazan, Ph.D.**
  CTO, Bio-Techne

- **Stephanie Board**
  Vice President, Research and Development, Abbott

- **Matthew M. Cooper, M.D.**
  Division Medical Officer, Medtronic

- **Sebastian Giera, Ph.D.**
  Co-founder of Ossian Health, Sylvatica Biotech, and the Organ Preservation Alliance

- **Tim Laske, Ph.D.**
  Vice President of Research and Business Development - A&R Solutions Medtronic

- **Kathleen Motzenbecker**
  Senior Vice President, The Medical Alley Association

- **Richard Olson**
  Vice President, Research and Development, Abbott

- **Sean O’Neil**
  Vice President, Enterprise Architecture Optum

- **Randy Schwab**
  Vice President, S&I&D, Global Technology Boston Scientific

- **Erik Scott, Ph.D.**
  Bakken Fellow, Technical Fellow, and Director of Advanced Development, Medtronic

- **Rhonda Robb**
  COO, Cardiovascular Systems, Inc.

- **Dale Wahlstrom**
  Founder and CEO, ACTJ, LLC Life Science Consulting

- **David M. Knapp, Ph.D.**
  Vice President, Research and Development, Boston Scientific
Institute for Engineering (IEM) uses Facebook, Twitter, and LinkedIn to interact with our IEM members, the University of Minnesota community, members of industry, and the scientific community.

To connect with IEM through social media:

Facebook: @Institute.for.Engineering.in.Medicine
Twitter: @UMNIEM
Instagram: @umnнием
LinkedIn: Institute for Engineering in Medicine - University of Minnesota

If you have any questions, please connect with iem at iem@umn.edu.

We look forward to engaging with you and your groups!
SUPPORT IEM

Research projects at the University of Minnesota that are funded by IEM’s grant programs have a proven record of making ground-breaking discoveries and generating continuing research grants. IEM relies on the generous contributions by organizations and individuals like yourself to support these pioneering research projects. Make a difference in the world of medical engineering by providing a tax-deductible gift to the Institute through our website.

If you would like to support the Institute in a different way or would like to make a donation for a specific cause, please contact us at the phone number or email address below.

Thank you!

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