Robert Barker/CU

Linking Engineering, Life Sciences, & Clinical Practice

Cornell's Biomedical Engineering

Bridging the Miles for Innovations in Medical Technology

Biomedical engineering is an inherently interdisciplinary field linking engineering with the life sciences and clinical practice. Cornell formed the Department of Biomedical Engineering (BME) in 2004 with the distinct mission of providing a physical and intellectual home for such an interdisciplinary effort at Cornell. These connections enable medical schools to provide innovative educational approaches to their students and to succeed in "translational research," the process by which laboratory discoveries are developed into technologies that help patients.

A persistent challenge to this mission at Cornell is the geographic separation of Weill Cornell Medical College (WCMC) in Manhattan and the College of Engineering in Ithaca. We are committed, however, to bridging the 230 miles that separate the colleges and the distinct cultures of engineers and clinicians, and we are succeeding at it, because we must. WCMC and BME need each other to succeed at the highest levels in achieving new solutions to human health problems and patient care. The top 10 medical schools in the United States, with one exception, are associated with a top-ranked BME department. The converse is also true: top-ranked BME departments almost always have an affiliation with a strong medical college. Cornell's campus-to-campus connection is critical for innovative research and the appropriate education of our students.

Orthopedic Implants, a Shining Model

A cornerstone of the BME mission is the commitment to the ideal that all BME faculty research has a tangible human health connection. This relationship with practicing clinicians at WCMC is a natural fit for the BME faculty, and we are proud that currently all of our faculty have joint research projects with WCMC faculty.

A shining, long-standing example of such an effort is the collaboration between Donald L. Bartel, Mechanical and Aerospace Engineering/BME and Timothy M. Wright at the Hospital for Special Surgery (HSS), which houses the orthopedics faculty of WCMC. In this collaboration that has spanned almost 30 years, Bartel and Wright have applied traditional methods of mechanical analysis to understanding the function of orthopedic implants. Using finite element modeling approaches to understand stress distributions in such devices, Bartel and Wright identified reasons that implants fail and ways to design more robust implants. They transformed the way hip and knee implants are designed. An estimated 500,000 people have

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David Putnam, Biomedical Engineering

Provided

Donald Bartel, Mechanical & Aerospace Engineering, Emeritus

Provided

Timothy Wright, Orthopaedics, WCMC

FASCINATING

- An estimated 500,000 people have implants that were designed using analysis techniques developed by Bartel and Wright.
- BME-WCMC collaborators:
  - Design living meniscus and intervertebral disc implants based on data obtained from MRI and CT scans.
  - Study the use of stem cells for engineering blood vessels in vitro.
  - Recreate the conditions that transform cancer stem cells into glioblastoma.
  - Develop microfabricated catheters for testing drugs that protect the brain from damage during stroke.
- Funding for six additional seed grants was made available to attendees of BME-Surgery's July 2007 retreat through the generosity of alumni James C. Morgan, ME '60, MBA '63 and Rebecca Morgan, HE '60 combined with matching funds from the Department of Surgery.

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From Tissue Engineering to Epilepsy, Stroke, and Cancer

Following the Bartel-Wright model for intercampus interaction, recent collaborations between BME and WCMC faculty focus on the next generation of implants made by using a process known as tissue engineering. Lawrence J. Bonassar, BME, works with Wright, Suzanne Maher, Applied Biomechanics in Surgery, WCMC, and Roger Hartl, Neurological Surgery, WCMC, to design living meniscus and intervertebral disc implants based on data obtained from MRI and CT scans. Using related techniques Cynthia A. Reinhart-King, BME, and Thomas N. Sato, Cell and Development Biology, WCMC, study the use of stem cells for engineering blood vessels in vitro. Claudia Fischbach-Teschl, BME, and John A. Boockvar, Neurological Surgery, WCMC, recreate conditions that transform cancer stem cells into glioblastoma, a particularly aggressive type of brain tumor.

Another collaborative focus is the development of surgical tools and techniques. David A. Putnam, BME, and Dix P. Poppas, Urology, WCMC, develop biomaterials to prevent the formation of adhesions that are common complications of intestinal surgery. Chris B. Schaffer, BME, and Theodore H. Schwartz, Neurological Surgery, WCMC, are creating a laser scalpel to treat epilepsy. Minah Suh, Neurological Surgery, WCMC, Peter Doerschuk, BME, and Schwartz are working to improve surgical planning for the treatment of epilepsy and to understand the mechanisms underlying the spread of seizures.

Drawing on Cornell's longstanding strengths in nanobiotechnology and drug delivery, another focus comes to the forefront. William L. Olbricht, BME, and Y. Pierre Gobin, Neurological Surgery, WCMC, develop microfabricated catheters for testing drugs that protect the brain from damage during stroke. Michael L. Shuler and David A. Putnam, BME, and Susan C. Pannullo, Neurological Surgery, WCMC, work on a new treatment for malignant gliomas using novel materials for delivery of chemotherapeutic agents that can be customized to individual patients based on MRI scans.

Expanding Connections and Expertise

To complement the efforts of individual faculty in developing collaborative research projects, BME has created relationships on an institutional level with departments at WCMC. The primary catalyst for these relationships is a series of retreats that bring BME and WCMC faculty together. We held the first retreat in Ithaca in July 2006 for BME and the Department of Neurological Surgery. Subsequently, we held joint retreats in January 2007 in Manhattan and in June 2007 in Ithaca. Fifteen joint research projects in the areas of brain tumors, epilepsy, vascular disease, and cellular therapy have resulted from these meetings. Our most recent retreat served in part as a planning vehicle for a training grant proposal in neural engineering, which offers an opportunity to jointly mentor graduate students and postdoctoral fellows in this exciting area of research.

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We also enhanced our relationship with the Department of Surgery through a joint retreat. In July 2007 more than 40 physicians, surgeons, and scientists from the surgery department came to Ithaca to discuss topics such as instrumentation development, drug delivery, and tissue regeneration. We identified a number of important areas of synergy between the two departments, and collaborations from this retreat are still evolving. An important catalyst for maximizing the efficiency of these retreats has been the university-sponsored seed grant program. In 2004, 2005, and 2006, calls were issued for proposals that bridge the Ithaca and Manhattan campuses. BME has been tremendously successful in competing for these grants. Ninety percent of the awards involved faculty who are members of the BME department or graduate field, reflecting the natural synergy

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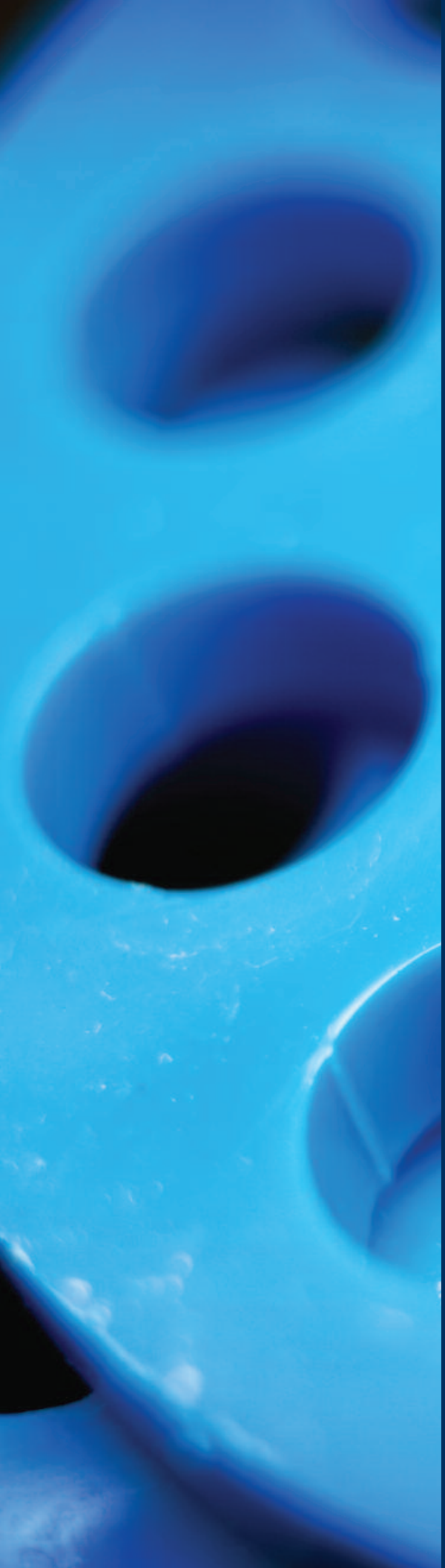
Michael Shuler
Biomedical Engineering

Frank DiMeo

Larry Bonassar
Biomedical Engineering



Tissue Engineering in Bonassar's Lab


Omotunde Babalola


Jason Gleghorn


(l.) Robby Bowles


Natalie Galley

Graduate student Omotunde M. Babalola studies stem cell differentiation, specifically mechanically differentiated stem cells within a polymer construct for osteochondral tissue engineering. Current treatment options for repair of osteochondral defects mostly address only the cartilage portion of the defect and not the bone, in which case, the repair tissue does not integrate well with the underlying subchondral bone. Tissue engineering provides very useful tools to assist in reconstructing replacement tissue. Babalola's research is in collaboration with Alan J. Nixon and Lisa A. Fortier, Clinical Sciences.

Graduate student Jason P. Gleghorn studies tissue engineering, specifically meniscus replacement. Working with HSS, his focus is on evaluating and designing joint replacement materials for meniscal repair in order to determine the frictional properties of the repair material and the resulting biological changes to the surrounding cartilage in the joint.

Graduate student Robby Bowles researches implants for intervertebral discs. His focus is on developing tissue engineering strategies to treat back pain through the creation of biological intervertebral disc implants, specifically, the development of the anisotropic collagen architecture of the annulus fibrosus in order to create a disc that is mechanically functional. Bowles's research is in collaboration with Roger Hartl, Neurological Surgery, WCMC.

Graduate student Natalie K. Galley studies cartilage and friction: the protein that lubricates the joints.

Photos on this page: Frank DiMeo

between BME in Ithaca and the interests of the WCMC faculty. Funding for six additional seed grants was made available to attendees of BME-Surgery's July 2007 retreat through the generosity of alumni James C. Morgan, ME '60, MBA '63 and Rebecca Morgan, HE '60, combined with matching funds from the Department of Surgery. This funding ensures that the momentum for collaborations generated during the retreat will be sustained.

Neurological Surgery, WCMC, and Chris B. Schaffer, BME, laid the groundwork for their new course during the second BME-Neurological Surgery retreat. The course, BME 411–Science and Technology Approaches to Problems in Human Health, was offered for the first time in fall 2007. It is cotaught by WCMC faculty, who identify current medical problems and discuss treatment of problematic diseases, and Ithaca-based faculty, who present current research on developing new treatments that incorporate the latest advances in biological and technological tools. The course is open to juniors, seniors, and graduate students throughout Cornell, and with an enrollment of more than 150, it is one of the largest upper-level courses in the College of Engineering.

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Innovative Approaches to Intercampus Education

While making connections with clinical scientists is important for the success of current research efforts, exposing students to this interdisciplinary paradigm is crucial for the education of the future generation of scientists. Toward this end, the signature experience of the BME Ph.D. program is the clinical immersion term, in which all first-year BME doctoral students spend most of the first summer at WCMC.

These students shadow selected clinicians, observe surgery in the operating room, become accredited to work with patients and their records, and conduct a short-term clinical research project. They begin to experience the clinical environment so that the devices and treatment strategies they develop in their professional lives truly serve the medical needs of patients and physicians. While the initial two years of the program were funded by internal sources, in 2007 this program received a training grant from the National Institutes of Health (NIH) to support the program for five years. The grant, written by Yi Wang who has a joint appointment in Radiology at WCMC and BME, demonstrates that our peers consider this approach to education valuable. As an extension of the program, BME is currently investigating the feasibility of a WCMC term for mechanical engineering students who would bring their engineering design experience to the bedside.

Creating opportunities in the clinic works well for graduate students, but it is an obvious logistic challenge for undergraduates. In an effort to bridge this gap, Michael G. Kaplitt,

BME's Intercampus Research and Education Takes on Its Unique Challenge

The value of interdisciplinary research and education becomes more important year after year. Cornell is presented with a unique set of challenges in bringing its engineering and medical colleges together. BME's success in bridging the miles is manifest in collaborations between individual faculty in Ithaca and Manhattan, jointly planned events for BME and WCMC departments, and educational programs for BME students designed to maximize their exposure to the medical environment. It is clear from our tremendous success of the past few years that overcoming these challenges is well worth the effort. We look forward to intensifying these efforts in intercampus research and education and to reaping the benefits in the coming years for Cornell and for society.

Michael L. Shuler, Chair, Biomedical Engineering
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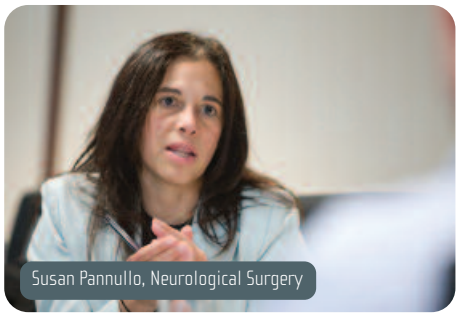

Susan Pannullo, Neurological Surgery

Frank DiMeo

(l.) Researcher Roisin Owens, (r.) Moonsoo Jin, Biomedical Engineering

BME ACADEMICS

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