2008 - 2009
Annual Report

Center for Biomedical Engineering Research

University of Delaware | College of Engineering

Mission Statement

The Center for Biomedical Engineering Research, CBER, is an interdisciplinary center whose mission is to provide engineering science and clinical technology to reduce the impact of disease on the everyday life of individuals. It was created to provide an appropriate forum and infrastructure to promote the interaction of biomedical researchers from the university and the medical community. As such, CBER serves as a research umbrella under which investigators from a variety of fields can work together.

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Director's Notes

Welcome to the first CBER annual report. This is an exciting time for research in biomedical engineering! As you will see, within our center, we have witnessed continued success of multidisciplinary research efforts consistent with our mission. Involvement in the center has increased to 37 faculty extending beyond mechanical engineering and representing biology, physical therapy, health, nursing and exercise science, and fashion and apparel studies! Plus we have added a staff assistant to facilitate communication among members and management of the eight funded projects currently underway. We have fostered student involvement and leadership in center activities such as the biweekly journal club and the upcoming research symposium.

With the development of the Delaware Health Sciences Alliance and Delaware Rehabilitation Institute recently announced by UD President Patrick Harker, we are facing renewed growth in size, space and research directions. Furthermore, we eagerly anticipate new opportunities offered by stimulus funding under the American Recovery and Reinvestment Act to support collaborative efforts in novel research directions.

Thank you for your continued interest and participation in the Center for Biomedical Engineering Research. I invite you to explore our updated webpages (www.cber.udel.edu) and encourage you to consider innovative research directions and potential collaborations as we embrace the initiatives of the new administration.

Jill Higginson

Assistant Professor, Mechanical Engineering
Director, Center for Biomedical Engineering Research (CBER)

COBRE for Women in Science and Engineering on Osteoarthritis

The University of Delaware has been awarded $11 million from the National Institutes of Health for leading-edge, "translational" research on osteoarthritis that includes a unique mentoring program to foster the development of women biomedical researchers at UD.

The grant, led by Thomas Buchanan, professor and chairperson of the Department of Mechanical Engineering, is the second five-year award to UD's Center for Biomedical Engineering Research from NIH's Centers of Biomedical Research Excellence Program. The center received a $6.4 million grant in 2002.

The wearing down of cartilage, the natural cushion between the bones and joints, causes osteoarthritis, the most common form of arthritis. The disease typically affects the knees, hips, back and hands.

According to Buchanan, the latest grant will enable UD to continue building the infrastructure and expertise to address the mechanisms of osteoarthritis, its prevention and treatment by examining the disease from the integrated perspectives of tissue mechanics, biomechanics, physical therapy and clinical intervention.

The program will involve 14 faculty in three of UD's seven colleges, including the departments of biological sciences and physical therapy in the College of Arts and Sciences, mechanical engineering in the College of Engineering, and health, nutrition and exercise sciences in the College of Health Sciences. Researchers from Alfred I. duPont Hospital for Children and the Kessler Medical Rehabilitation Research and Education Corporation will serve as collaborators.

"What we have at UD that's really unique is a collection of people to address osteoarthritis across multiple levels, which is what translational medicine is all about," Buchanan said.

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"We have people who can look at the proteins that are important to the healing of cartilage, for example, to people who can create biomechanical models showing the movement of bones and joints, to people who can conduct the clinical studies critical to the development of therapies. We can span lots of disciplines, which is what's exciting here," Buchanan noted.

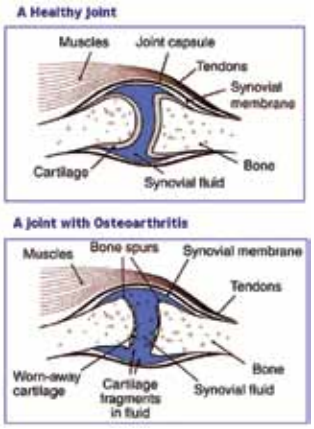
Buchanan said the program's focus on mentoring women in science and engineering evolved after the request for research proposals was circulated at UD. Women faculty submitted the top-five research proposals.

"We wanted to find ways to use this program as an opportunity to promote their role," he noted.

Nationally, women continue to be underrepresented in the academic ranks of science, technology, engineering and mathematics. At UD, the percentages of all tenured/tenure-track women faculty are 17 percent in the natural sciences and 10 percent in engineering, according to Buchanan.

"Mechanical engineering, for example, traditionally has been a male discipline although many of our new faculty are women," Buchanan said of the UD department he chairs. "Our goal is to find good faculty mentors and start working with these new hires to see the discipline change. We need better mentoring to help with the process."

The grant's chief components, Buchanan said, are to create a core facility for mentoring women in science and engineering, to establish a new lab focusing on cytomechanics, or cell mechanics, and to advance five integrated research projects in osteoarthritis.



L. Pamela Cook, professor of mathematical sciences, associate dean of engineering and chairperson of UD's Commission on the Status of Women, is assisting with the development of a strong internal networking and support system for women faculty in science and engineering. Professional development workshops, establishment of a faculty ombudswoman and University-wide presentations on gender issues, including promotion and tenure, are being planned.

Women faculty are directing the grant's five research projects. Two are led by senior faculty, who also are helping to mentor the junior faculty in charge of the remaining projects.

Mary C. Farach-Carson, professor of biological sciences and director of UD's Center for Translational Cancer Research, and Catherine Kirn-Safran, research assistant professor of biological sciences, are leading a team to define the structural and functional roles of the biomolecule perlecan in cartilage biology. The biomolecule's heparan sulfate chains are believed to be critical to the maintenance of cartilage in adults and the regrowth of damaged cartilage.

Liyun Wang, assistant professor of mechanical engineering, is exploring the pathway of communication between bone and cartilage. Experiments have shown that bone cells from osteoarthritic patients can cause cartilage to break down. Wang is combining lab techniques with mathematical modeling to characterize the movement of molecules through bones in normal and osteoarthritic joints.

Lynn Snyder-Mackler, Alumni Distinguished Professor of Physical Therapy and director of the Graduate Program in Biomechanics and Movement Sciences at UD, is leading a research team to determine if rehabilitation that normalizes quadriceps strength between the limbs after total knee replacement--one of the most common surgeries in the U.S.-- will ultimately decrease the progression of osteoarthritis of the hip and knee.

Jill Higginson, assistant professor of mechanical engineering, is investigating the muscle forces and coordination strategies used during walking in individuals with age-related osteoarthritis of the knee. A combination of MRI, gait analysis, electromyography and biomechanical modeling and simulation will be employed to determine the most effective nonsurgical interventions.

Katherine Rudolph, assistant professor of physical therapy, is working to understand how quadriceps strength, knee stiffness, proprioception and instability contribute to osteoarthritis of the knee. The study will help researchers understand the strategies that can be used to improve knee function without further joint damage and aid in developing screening tools to identify patients who will benefit from rehabilitation programs.

-Reprinted from UDaily *(NIH P20-RR16458, PI: Thomas Buchanan)*

These scientists and engineers, photographed in UD's Motion Analysis Lab, are leading the University's osteoarthritis research, funded by the National Institutes of Health. From left, Mary C. Farach-Carson, Thomas Buchanan, Katherine Rudolph, Jill Higginson, Liyun Wang, Lynn Snyder-Mackler and Catherine Kirn-Safran. *Article by Tracey Bryant | Photo by Kathy F. Atkinson*

Solute Transport of the Bone Lacunar-Canalicular System

Osteocytes, the most numerous cells in bone, are critical for bone health and bone quality. They are essential for bone to sense and adapt to mechanical stimuli and to remodel damaged tissue. Since osteocytes are completely encased in mineralized bone matrix, their survival and function are entirely dependent on transport of solutes (metabolites, growth factors, cytokines, and other signaling molecules) through the lacunar-canalicular system (LCS, Fig. 1). Despite advances in delineating transport pathways in bone, little is known about the mechanisms involved in moving biological molecules to and from osteocytes in vivo. This reflects a lack of methods available to study these questions under real-time conditions in living animals. To this end, we recently developed a new imaging method based on Fluorescence Recovery After Photobleaching (FRAP) that allows measurement of solute movement in the bone LCS in situ and in real-time (Wang et al.,2005. Proc Natl Acad Sci 102:11911, Fig. 2).

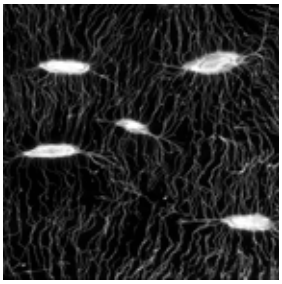


Fig. 1. Confocal image of osteocyte lacunae and canaliculi

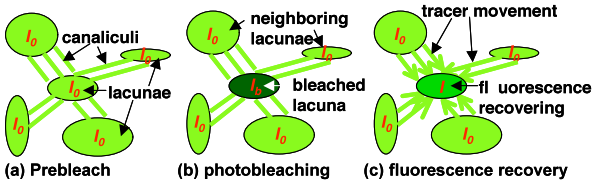


Fig. 2. Schematic of real-time measurement of molecular movement through the lacunar-canalicular system using FRAP. (a) A tracer-filled lacuna was imaged prior to photobleaching. (b)The chosen lacuna was then photobleached using strong laser illumination. (3) Due to tracer movement through the canaliculi, the fluorescence intensity in the photobleached lacuna was recovered and recorded using a confocal microscope.

We propose to use this novel approach in combination with mathematical / computational modeling to fully characterize diffusion and convection in bone. To test the hypothesis that convection due to mechanical loading is the primary mechanism for moving large molecules in the LCS, we will first quantify the baseline diffusive transport of solutes of various sizes in post-mortem bones. Convective transport driven by blood pressure and mechanical loading will be subsequently measured in live animals. These studies will delineate the transport mechanisms that are essential for osteocyte viability and bone mechano-transduction, and provide new insights into mass transport in other biological and engineered systems (e.g., tissue engineering scaffolds). Detailed knowledge of how molecules move within bone will help define molecular parameters such as hydrodynamic radii and half-life times for new drugs so that they can be delivered effectively into bone to treat diseases such as osteoporosis and arthritis. Our specific aims are: 1) to determine how solute diffusion in the bone LCS depends on the solute's molecular weight; 2) to determine how solute transport in the bone LCS is affected by vascular pressure; 3) to determine how solute transport in the bone LCS is affected by mechanical loading.

(NIH: R01-AR054385, PI: Liyun Wang)

Liyun Wang, UD assistant professor of mechanical engineering, views osteocytes (bone cells) in her lab, as graduate students Wen Li and Xiaozhou Zhou examine the magnified images in the background.

Muscle Morphology, Strength and Compensatory Strategies Following Stroke

Stroke afflicts more than 700,000 Americans each year and often results in muscle weakness which impairs performance of activities of daily living. The relationship between altered muscle force-generating capacity, activation and coordination during walking after stroke is unclear. By coupling experiments with computer simulations, we will identify factors that limit walking speed following stroke in order to assist rehabilitation professionals in designing treatment interventions that address the specific impairments of an individual subject. Current simulations described in the literature predict muscle function using generic musculoskeletal properties. To better influence clinical decision-making, specific models reflecting subject size and individual muscle deficits are needed.

In a five-year, $1.6 million study funded by the National Institutes of Health, Dr. Higginson is leading a team of investigators to develop subject-specific simulations of post-stroke gait based on parameters that reflect changes in muscle morphology in the hemiparetic population. This multi-disciplinary study involves collaborators Stuart Binder-Macleod and Darcy Reisman from Physical Therapy as well as Thomas Buchanan from Mechanical Engineering. With the assistance of Nils Hakansson (post-doctoral fellow) and three graduate students, data is derived from MRI, strength testing, electromyography, twitch interpolation and gait analysis to accurately identify limitations and compensatory strategies used by individual stroke survivors.

Collaboration with the Simbios National Center for Biomedical Computation facilitates implementation and augmentation of an open-source simulation toolkit (www.simtk.org). Results will be posted and shared with biomechanists around the world to enhance the utility of muscle-actuated simulations in a clinical setting.

(NIH: R01-NS055383, PI: Jill Higginson)

Robotic Exoskeletons, FES, and Biomechanics: Treating Movement Disorders

A multidisciplinary research team from the University of Delaware departments of Mechanical Engineering and Physical Therapy has been awarded a five-year, $3 million grant from the National Institutes of Health (NIH) to continue a study on the treatment of movement disorders. The grant was awarded under NIH's Bioengineering Research Partnerships (BRP) program.

Led by Sunil Agrawal, professor of mechanical engineering, the team includes John Scholz, professor of physical therapy; Stuart Binder-Macleod, Edward L. Ratledge Professor of Physical Therapy; and Jill Higginson, assistant professor of mechanical engineering.

The project will focus on developing and testing novel rehabilitation solutions, including un-motorized and motorized exoskeletons for gait training of stroke and other motor-impaired patients.

Agrawal emphasizes the extent of the problem: "Some 700,000 people suffer strokes every year," he says, "and there are already two to three million survivors suffering the after-effects of stroke."

"It has a big impact on a person's life," adds Scholz. "Stroke not only affects many aspects of daily living but also can trigger further problems -- for example, bad balance can lead to a fall and a broken hip. Improved emergency care has led to more stroke victims being saved, but many are severely impaired."

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The initial BRP grant, awarded in 2002 and led by Thomas Buchanan, professor of mechanical engineering and deputy dean of the College of Engineering, enabled the researchers to develop robotic prototypes and demonstrate the feasibility of the treatment approach through limited testing with human subjects. Significant progress was also made in the development of biomechanical models to predict muscle deficiencies during normal and abnormal gait.

"The competitively renewed grant will focus on new developments in robotic exoskeletons, embedded with a variety of position and force sensors to enable further testing," Agrawal says, "as well as modification of the two robotic exoskeletal devices developed during the initial research."

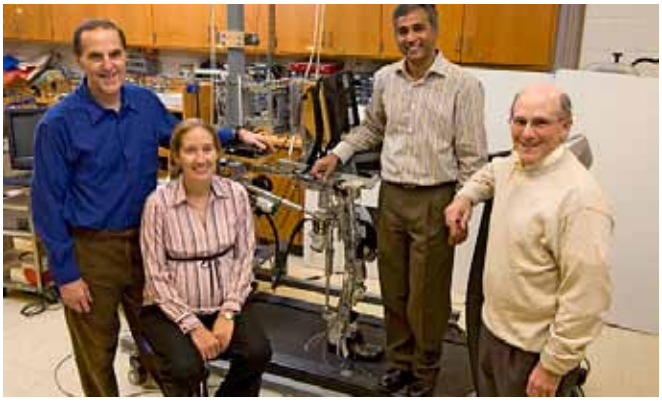
The first is a simple un-motorized device, known as a gravity-balancing orthosis (GBO), which increases range of motion in impaired individuals by removing gravity from the joints. The second, an active leg exoskeleton (ALEX), is equipped with servo motors and a controller to apply forces on the leg to not only improve its motion but also maximize learning, or retraining of the brain.

The researchers will test these devices with additional features and functionality, including functional electrical stimulation (FES) and motorized control of the ankle. They will also compare the GBO and ALEX with a traditional gait training approach known as body-weight-supported treadmill training. The subject pool for the new study will consist of 30 stroke patients.

A third aspect of the new project is to use gait analysis, biomechanics, FES models, and sensors on the exoskeleton to develop a screening tool for use in determining whether a subject's gait can be improved.

"There is growing awareness that new technologies can make a major contribution to quality of life," Scholz says. "Stroke centers are very interested in these devices and would provide an excellent setting for further testing on larger numbers of people."

-Reprinted from UDaily *(NIH R01-HD038582, PI: Sunil Agrawal)*



UD researchers working on the treatment of movement disorders are, from left, John Scholz, Jill Higginson, Sunil Agrawal and Stuart Binder-Macleod.

Article by Diane Kukich | Photo by Kathy F. Atkinson

Effects of Bisphosphonate Treatment on Osteoarthritic Knees

A. ABSTRACT - We propose to investigate a promising treatment for delaying the progress of osteoarthritis (OA). OA is a degenerative joint disease that affects millions of people and is the leading cause of disability in adults over 45 years-old. A growing body of evidence suggests that increased subchondral bone turnover is present even before focal cartilage damage occurs. Inhibition of bone turnover appears to be a promising regimen to fight the prevalent OA conditions. Bisphosphonates, the FDA-approved antiresorptive drugs, have been successfully used to treat osteoporosis. Although initial preliminary studies demonstrate their benefits in OA, the mechanisms of how and why bisphosphonates affect joint function are not clear.

In this study, we will test the hypothesis that (i) an increase of communication between subchondral bone and cartilage results in transport of bone-derived catabolic factors into the overlaying cartilage, leading to the progression of OA, and (ii) bisphosphonate treatment inhibits the release of the bone-derived factors and thus slows down the OA progression. Combining our expertise in animal model, bioimaging (Wang), and nanoindentation (Karlsson), we will examine the characteristics of signal transport and mechanical stiffness in normal and OA knees receiving either bisphosphonate or placebo. This research addresses the fundamental issue of the interplay between bone remodeling and OA progression, and most importantly, tests the efficacy and mechanism of a promising treatment for OA. We plan to use the data to apply funding from NIH, NSF, and Arthritis Foundations. This research has high impact on Life and Health Sciences, one of the focus areas in UD's Strategic Plan.

B. RESEARCH PLAN

B.1. Background

Osteoarthritis (OA), as an organ-level failure of synovial joints, is characterized by loss of articular cartilage and abnormality in other tissues including bone (Fig. 1). Articular cartilage and bone are essential for normal joint functions, playing complementary roles during locomotion. The softer articular cartilage is responsible for joint lubrication and load distribution, while the stiffer subchondral bone serves as a major load bearing component and a supporting mattress for articular cartilage. Whether subchondral bone provides nutrients/signaling to articular cartilage in mature joints is a long-time puzzle. The dominant view is that the bone-cartilage interface (calcified cartilage) is impermeable barrier separating articular cartilage and subchondral bone [1].

However, utilizing an advanced imaging technique (fluorescence loss induced by photobleaching, FLIP), we were able to demonstrate a direct transport between these two tissues and the transport rate was surprisingly fast for biological molecules [2]. This finding, for the first time, provides convincing scientific support for a new OA treatment method. This method focuses on treating abnormality of subchondral bone, instead of articular

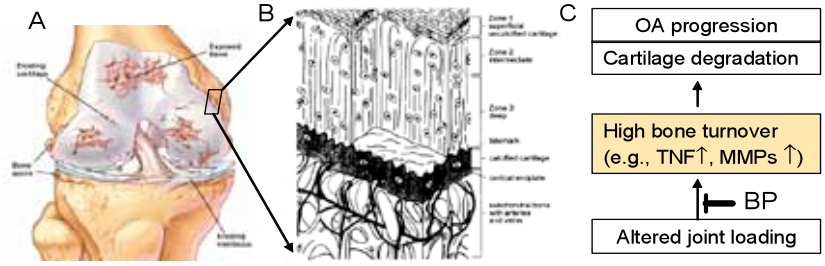


Fig. 1. (A) Osteoarthritic knee (B) Articular cartilage, subchondrial bone, and sandwiched calcified cartilage (C) Proposed mechanisms of bisphosphonates in treating OA by inhibiting transport of bone-derived factors.

cartilage itself. In contrast to cartilage that lacks of vasculature, bone is highly vascularized, making it respond to insults (such as altered loading patterns) more rapidly. In fact, clinical observations indicate an abnormal high turnover in bone before any cartilage abnormality shows up [3].Therefore, subchondral bone is a logic choice for early interventions since it can respond to pharmaceutical interventions more rapidly.

The working hypothesis for this new OA treatment is illustrated in Fig. 1C. Typically, altered loading such as in ACL injuries triggers the normal bone remodeling process and releases many factors such as tumor necrosis factor (TNF) and matrix metalloproteinases (MMPs) in the bone compartment. With a permeable interface between bone and cartilage, these factors penetrate into articular cartilage, inducing catabolic responses of chondrocyts that eventually cause cartilage degradation. If an inhibitor is applied early on to suppress the bone remodeling process, it may delay or abolish the degenerative process. Bishposphonates, a class of FDA approved drugs for treating osteoporosis, have been shown to be effective to suppress the bone loss and release of the catabolic factors. In this one-year proposal, we will test the efficacy of BP in a well-established OA model and its acting mechanisms.

B.2. Preliminary Data

OA model: We have successfully replicated a mouse OA model, originally developed by Dr. Sonya Glasson in Wyeth. This is a mild OA model by destabilizing the medial meniscus (DMM) of mouse knee, which has been published in Nature [4]. The advantage of the DMM model over the typical ACL transaction model is that the DMM model is easy to operate, and exhibit a slower progress that allows one to test disease interventions. Based on our preliminary work, we find consistent damages to the medial joint (Fig. 2).

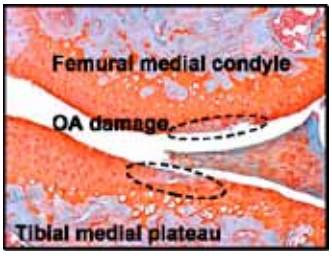


Fig. 2. OA knee joint in our DMM model

Novel imaging approach to study transport: To quantify the transport rate between subchondral bone and articular cartilage, we developed a novel approach combining FLIP and bi-spherical transport model. A representative tracer mimicking small signaling molecules was injected via tail vein into a live mouse. Once the tracer perfused the joint (20 min post injection), the joint was split open and studied under a laser scanning con-focal microscope. As a condrocyte was photobleached continuously with high laser power, the tracer movement from bone to calcified cartilage and within cartilage was simultaneously monitored, from the changes of their intensities the diffusivity (easiness of the tracer to diffuse) of the tracer was quantified using a mathematical model. The novelty of this method is that FLIP creates a higher driving force for solute flux that allows us to measure the slow transport rate in calcified tissues. We have successfully measured the permeability of a normal joint, with a mean diffusivity of 0.57 μm2/s within the calcified cartilage and 0.17 μm2/s between subchondral bone and calcified cartilage [2]. We will use this method to study transport in OA joint.

(Funded by UDRF, PI: Liyun Wang and Anette Karlsson)

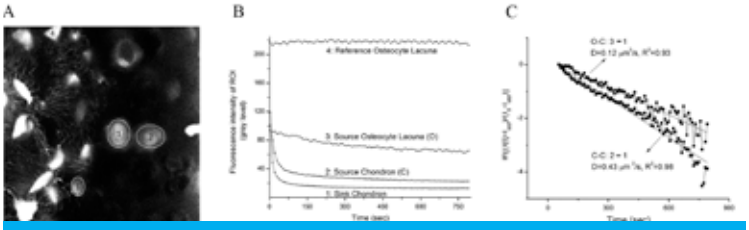


Fig. 3. Our novel FLIP approach to quantify extremely slow transport rate in mouse joint (A) chondrocytes (ROI: 1&2) and bone cells (ROI 3&4) in the joint. ROI1 was subjected to FLIP. (B) Intensity changes of ROIs (C) calculated diffusivity.

News Items

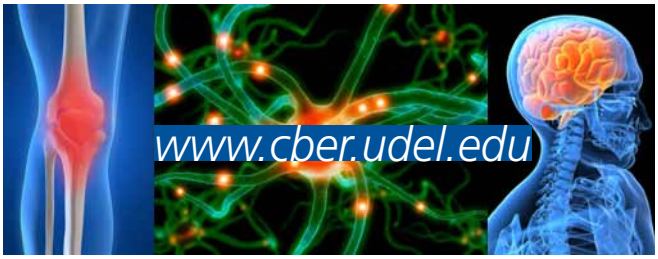
ADMINISTRATIVE CHANGES

Jill Higginson, PhD, was named Director of the Center for Biomedical Engineering Research effective July 1, 2008. She also serves as an Assistant Professor in Mechanical Engineering as well as the Biomechanics and Movement Science program. Dr. Kurt Manal, who served as Director for the previous four years, greatly expanded the CBER Research Symposia while the center grew substantially in research funding.

Elaine Nelson (nelson@udel.edu) became the first staff assistant for the Center for Biomedical Engineering Research in August 2008. She transferred to CBER from Occupational Health and Safety and provides assistance with CBER-related proposals, event planning, publications and so on. Her office is located in 201 Spencer Laboratory – *please stop by and say hello!*

WEBPAGE UPDATES

Check out our new look! In an effort to promote visibility of the Center for Biomedical Engineering Research, we have recently updated our webpage. We hope this will serve as a tool to highlight our research success stories and recruit students, sponsors and collaborators.
Any suggestions for improvement are welcome!



RESEARCH DAY

The 6th annual CBER Research Day, held on Friday, May 15, 2009, highlights the outstanding and varied biomechanics-related research taking place at the University of Delaware. Student researchers are eligible for awards for the best poster and podium presentations.

The keynote lecture delivered by Dr. Irving Shapiro, Professor of Orthopaedic Surgery, Biochemistry and Molecular Biology at Thomas Jefferson University is entitled "Molecular Engineering of Orthopaedic Implants: From Bench To Bedside." Dr. Shapiro's research interests include mechanisms of bone growth and repair, tissue engineering of the intervertebral disc, and creating bioactive surfaces for repair of fractured and infected bone. Details and the full program can be found online: www.cber.udel.edu

JOURNAL CLUBS

The OA Journal Club meets biweekly during the spring and fall semesters to read and discuss journal articles related to Osteoarthritis research. For more information regarding meeting times and locations please visit: www.cber.udel.edu/journal_club.htm

The ACL Journal Club will be starting in Spring 2009 and will be meeting monthly to read and discuss journal articles related to ACL research. For more information regarding meeting times and locations please visit: www.cber.udel.edu/ACL_journal_club.htm

WOMEN IN SCIENCE AND ENGINEERING (WISE)

WISE works to initiate and support programs intended to increase the recruitment and retention of tenure/tenure-track faculty women in fields related to science and engineering and to improve the representation of women at the highest academic and administrative ranks at the University. WISE hosts two Brown Bag Lunch Seminars during each of the spring and fall semesters.

SPRING COURSE OFFERED

Dr. Takashi Buma, Assistant Professor of Electrical Engineering, offers a course of interest to CBER students each spring. ELEG 679 (cross-listed as ELEG 479 for undergrads) is called *"Introduction to Medical Imaging Systems."* In this course, physics, instrumentation, system design, and image reconstruction algorithms will be covered for the following modalities: radiography, x-ray computed tomography (CT), single photon emission computed tomography (SPECT), positron emission tomography (PET), magnetic resonance imaging (MRI), and real-time ultrasound. PREREQ: Requires permission of instructor. *Check UDSIS for scheduling details.*

JOURNAL OF ORTHOPAEDIC RESEARCH FEATURES COVER IMAGE AND ARTICLE

The January 2009 Issue of the Journal of Orthopaedic Research contained the Oristian et al., article titled, *"Ribosomal Protein L29/HIP Deficiency Delays Osteogenesis and Increases Fragility of Adult Bone in Mice."* This issue also featured an image from the article on its cover. To view and read the article in its entirety, please visit: www3.interscience.wiley.com/journal/121544680/issue

STUDENTS RECOGNIZED FOR RESEARCH

The North American Congress on Biomechanics (NACOB), held in Ann Arbor, Michigan, gave the 2008 Delsys Recognition for Best EMG Presentation to Qi Shao and Dr. Thomas S. Buchanan for their work entitled *"An EMG-driven forward simulation of single support phase during gait."* The prize given this year to the winners of this award included a 2-Channel Begnoli EMG System with EMGworks Software, A/D card, a plaque and $500.

Laura G. Sloofman, a senior majoring in Quantitative Biology working under the direction of Dr. Catherine Kirn-Safran, won 1st place for her oral presentation in Sigma Xi Competition at the UD 2008 Summer Undergraduate Symposium (www.udel.edu/chem/white/HHMI3/Symp08/S08TalkSched.html) and 2nd place for her poster presentation at the University of Maryland 11th annual Undergraduate Research Symposium in the Chemical and Biological Sciences on Oct. 11, 2008 (www.udel.edu/udaily/2009/nov/undergrads110608.html) for her studies on the bone properties of mice lacking an element of the protein synthesis machinery.

William R. Thompson, a Ph.D. student member of the BIOMS program (www.bmsc.udel.edu/Descrip.htm) working under the direction of Dr. Farach-Carson, won three awards for his work on bone mechano-sensing cells:

1. University of Delaware Center for Biomedical Engineering Research Travel Award, 2008
2. University of Delaware Graduate Fellow Award, 2008
3. Foundation for Physical Therapy Florence P. Kendall Doctoral Scholarship, 2007

News Items

HYBRID ELASTOMERS BEING USED FOR VOCAL FOLD TISSUE ENGINEERING

The September 22, 2008 edition of C&EN Online (*Chemical & Engineering News)* highlighted the article titled *"Hybrid Polymers for Healing Voices."* Visit: http://pubs.acs.org/cen/science/86/8638sci2.html

The vocal fold tissue engineering effort at the University of Delaware was also featured during an interview with CNN.

THE BIOMECHANICS OF BABY-CARRYING

Evanna Singh, an undergrad researcher in the Department of Anthropology, has been conducting research to investigate the biomechanical effects of child-carrying practices and is looking at this subject from a biomedical point of view rather than evolutionary. Singh had been using the dual-belt treadmill in the biomechanics laboratory to investigate stance and gait changes is 20 female subjects. For more information on Singh's research please visit: www.udel.edu/udaily/2009/mar/babycarrying030309.html

TRABANT AWARD FOR WOMEN'S EQUITY

The 2008 E.A. Trabant Award for Women's Equity was awarded to Thomas Buchanan in recognition of his support for women's equity at UD. Buchanan has helped increase the number of tenure/tenure-track women in the College of Engineering, as well as improved the atmosphere for both female faculty and students.In 2007, the National Institutes of Health (NIH) awarded UD an $11 million grant for osteoarthritis research for which Buchanan coordinates the efforts of five women faculty on major research projects. To read the entire UDaily article please visit: www.udel.edu/PR/UDaily/2008/jun/award060508.html

BUCHANAN NAMED FELLOW BY TWO PROFESSIONAL SOCIETIES

The American Institute for Medical & Biological Engineering (AIMBE) and the American Congress of Sports Medicine (ACSM) have both elected Thomas Buchanan as their newest fellow. AIMBE elects fellows based on their distinguished contributions to public health in research, industrial practice, education and innovation. ACSM combines scientific research, education, and practical applications of sports medicine and exercise science. To read more and view the Mechanical Engineering Newsletter (Winter 2009) see: www.me.udel.edu/News_Events/newsletters/ME%20winter%2009%20p6%202-25.pdf

Faculty

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Sunil K. Agrawal, Ph.D.

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Kenneth E. Barner, Ph.D.

Professor, Electrical and Computer Engineering, Biomechanics and Movement Science

www.ece.udel.edu/research/by-faculty.php?facid=83

Stuart Binder-Macleod, Ph.D., PT

Chairperson, Edward L. Ratledge Professor

Physical Therapy, Biomechanics and Movement Science

www.udel.edu/PT/About%20Us/People/binder.html

Thomas S. Buchanan, Ph.D.

Deputy Dean, College of Engineering

Professor, Mechanical Engineering, Biomechanics and Movement Science

http://research.me.udel.edu/buchanan/

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Recent Publications

Brown A.J., Alicknavitch M., D'Souza S.S., Daikoku T., Kirn-Safran C.B., Marchetti D., Carson D.D., Farach-Carson M.C. "Heparanase expression and activity influences chondrogenic and osteogenic processes during endochondral bone formation," *Bone*, 43:689-699 (2008).

Crabtree C.A., Higginson J.S. "Modeling neuromuscular effects of ankle foot orthoses (AFOs) in computer simulations of gait," *Gait and Posture*, 29(1): 65-70 (2009). http://dx.doi.org/10.1016/j.gaitpost.2008.06.004

Farach-Carson M.C., Brown A.J., Lynam M., Safran J.B., Carson D.D. "A novel peptide sequence in perlecan domain IV supports cell adhesion, spreading and FAK activation," *Matrix Biol*, 27:150-60 (2008).

Galloway J.C., Rhu J., Agrawal S. "Babies driving robots: Self-generated mobility in very young infants," *Journal of Intelligent Service Robotics*. DOI: 10.1007/s11370-007-0011-2 (2008).

Heathcock J., Lobo M., Galloway J.C. "Movement training advances the emergence of reaching in infants born less than 33 weeks gestational age," *Physical Therapy*, 88: 310-322 (2008).

Heathcock J., Galloway J.C. "Early Object Exploration with the Feet and the Effect of Movement Training in Infants born Preterm," *Physical Therapy*, (accepted, 2009).

Jha A.K., Hule R., Jiao T., Teller S., Clifton R. J., Duncan R. L., Pochan D. J., Jia X. "Structural Analysis and Mechanical Characterization of Hyaluronic Acid-Based Doubly Crosslinked Networks," *Macromolecules*, 42,537-546 (2009).

Jia X., Kiick K.L. "Designing Multicomponent Hybrid Hydrogels for Tissue Engineering," *Macromol. Biosci.*, 9,140-156 (2009).

Jiao T., Farran A., Jia X., Clifton R. J. "High Frequency Measurements of Viscoelastic Properties of Hydrogels for Vocal Fold Regeneration," *Exp. Mech.*, Online (DOI: 10.1007/s11340-008-9126-4) (2009). www.springerlink.com/content/ej2p738607648302

Kirn-Safran C.B. "Disruption of ribosomal protein Gene expression in eukaryotes: a class of mutations causing similar global growth defects with cellular variations," Book chapter on "Ribosomal Proteins," *Nova Science publishers*, Hauppauge, New York (in press).

Lee H.M., Galloway J.C. "Toy-oriented changes in early arm movements IV: The coordination of hand, shoulder and elbow," *Infant Behavior and Development*, 31:447-469 (2008).

Lobo M.A., Galloway J.C. "Postural and Object-Oriented Experiences Advance Early Reaching, Object Exploration, and Means–End Behavior," *Child Development*, 79(6): 1869-1890 (2008).

Lynch A., Lee H.M., Bhat A., Galloway J.C. "No Stable Arm Preference During the Pre-reaching Period: A comparison of right and left hand kinematics with and without a toy present," *Developmental Psychobiology*, 2008 50:390-8 (2008).

Lynch A., Galloway J.C. "Power Mobility Training for a 7-month-old Infant with Spina Bifida," *Pediatric Physical Therapy*, (accepted, 2009).

Ni C., Lia X., Chen Z., Li H.-Y., Jia X., Shah I., Xiao J.Q. "Oriented Polycrystalline Mesoporous Ceo2 With Enhanced Pore Integrity," *Micropor. Mesopor. Mat.*, 115, 247–252 (2008).

Oristian D.S., Sloofman L.G., Zhou X., Wang L., Farach-Carson M.C., Kirn-Safran C.B. "Ribosomal protein L29/HIP deficiency delays osteogenesis and increases fragility of adult bone in mice," *Journal of Orthopaedic Research*, 27:28-35 (2008). (Cover Image of Journal issue)

Pradhan S., Zhang C., Jia X., Carson D.D., Witt R., Farach-Carson M.C. "Perlecan domain IV peptide stimulates salivary gland cell assembly in vitro," *Tissue Engineering*, (2009), accepted.

Sahiner N., Jha A.K., Nguyen D., Jia X. "Fabrication and Characterization of Crosslinkable Hydrogel Particles Based on Hyaluronic Acid: Potential Application in Vocal Fold Regeneration," *J. Biomater. Sci. Polymer. Edn*, 19, 223-243 (2008).

Schmitt L.C., Fitzgerald G.K., Reisman A.S., Rudolph K.S. "Instability, Laxity, and Physical Function in Patients with Medial Knee Osteoarthritis," *Physical Therapy*, 88(12):1506-1516 (2008).

Schmitt L.C., Rudolph K.S. "Muscle Stabilization Strategies in People with Medial Knee Osteoarthritis: The Effect of Instability," *Journal of Orthopaedic Research*, 26(9):1180-5 (2008).

Tseng Y., Galloway J.C., Scholz J.P. "The organization of intra-limb and inter-limb synergies in response to different joint dynamics," *Experimental Brain Research*, DOI 10.1007/s00221-008-1616-1 (2008).

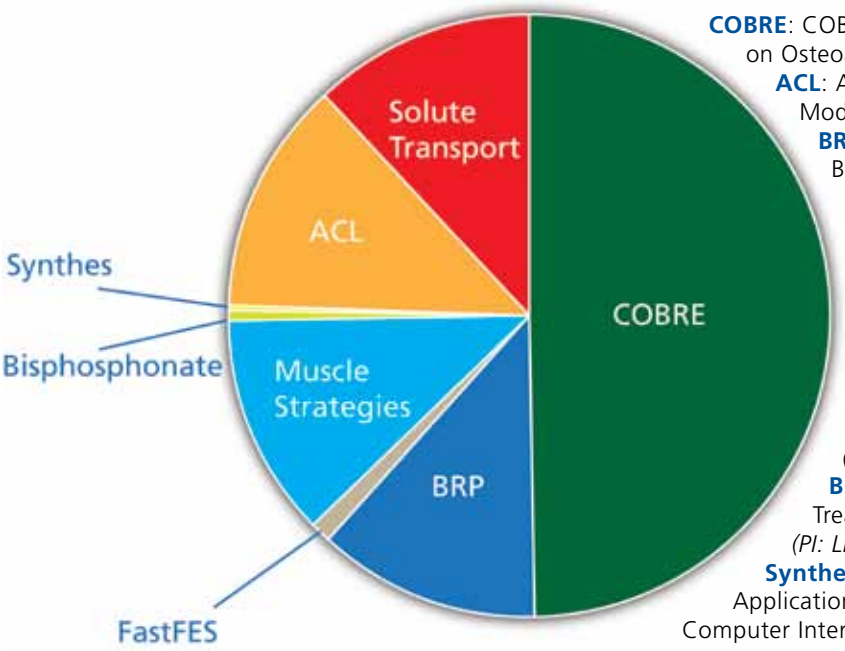
Xiao M., Higginson J. "Muscle function may depend on model selection in forward simulation of normal walking." *J Biomech*, 41: 3236-3242 (2008). http://dx.doi.org/10.1016/j.jbiomech.2008.08.008

Zeni Jr., J.A., Richards, J.G., Higginson, J.S. "Two simple methods for determining gait events during treadmill and overground walking using kinematic data," *Gait and Posture*, 27(4): 710-714, 2008.

Zifchock R.A., Davis I., Higginson J., Royer R. "Side-to-side differences in overuse running injury susceptibility: a retrospective study." *Human Movement Science*, 27: 888-902 (2008).

Zifchock R.A., Davis I., Higginson J., Royer R. "The Symmetry Angle: A Novel, Robust Method of Quantifying Asymmetry," *Gait and Posture*, 27(4): 622-627 (2008).

CBER Research Grants



COBRE: COBRE for Women in Science and Engineering on Osteoarthritis *(PI: Buchanan)*

ACL: ACL Injured Knee: MRI and Biomedical Modeling *(PI: Buchanan)*

BRP: Robotic Exoskeletons, FES, and Biomechanics: Treating Movement Disorders *(PI: Agrawal)*

Muscle Strategies: Muscle Morphology, Strength and Compensatory Strategies Following Stroke *(PI: Higginson)*

Solute Transport: Solute Transport in the Bone Lacunar-Canalicular System *(PI: Liyun Wang)*

FastFES: Fast Treadmill Training/Functional Electrical Stimulation to Improve Walking *(PI: Binder-Macleod)*

Bisphosphonate: Effects of Bisphosphonate Treatment on Osteoarthritic Knees *(PI: Liyun Wang)*

Synthes: High-Resolution RFID Tracking with Applications In Gesture Recognition And Human-Computer Interaction *(PI: Barner)*

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