Dare to be first.

University of Delaware

Center for

BIOMEDICAL ENGINEERING RESEARCH

ANNUAL REPORT

Vol. 3

January 2012

www.cber.udel.edu

MESSAGE FROM THE DIRECTOR

JILL HIGGINSON

We are proud to highlight the activities of the interdisciplinary members of the Center for Biomedical Engineering Research in the past year.

Thank you for your interest in the Center for Biomedical Engineering Research (CBER). In this third edition of the Annual Report, we provide details on the research programs of individual faculty members who conduct cutting-edge research at nano, micro and macro scales for the understanding and treatment of stroke, osteoarthritis, osteoporosis, cerebral palsy, and other disease processes. We also highlight new research initiatives, welcome new faculty to the University of Delaware, celebrate innovative activities that bring biomechanics to the local community, and identify opportunities for collaborative partnerships with clinical affiliates.

I invite you to explore our webpage (www.cber.udel.edu), attend the annual research symposium (mark your calendars for April 23, 2012), visit the labs, or contact our faculty about research opportunities. Please contact me or any of our affiliated faculty to discuss academic options or collaborative research ideas.

Best wishes for another successful and productive year!

Jill Higginson

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.

In this issue...

CONTENT DIRECTION: Jill Higginson, Elaine Nelson
DESIGN & LAYOUT: College of Engineering Communications Group
PHOTOGRAPHY: Office of Communications & Marketing
PRINTING: University Printing

www.cber.udel.edu

BIOMECHANICS RESEARCH

Biomedical engineering pioneer Van. C. Mow addresses symposium

Long before biomedical engineering was popular, Van C. Mow was fascinated with how soft tissue functions in the human body.

Mow, a former World War II Chinese refugee and biomedical engineering pioneer, shared how early adversity and adaptability led to his success in orthopedic biomedical engineering May 13 at the 8th annual Biomechanics Research Symposium at the University of Delaware. The event was organized and hosted by UD's Center for Biomedical Engineering Research (CBER).

Mow, who is the Stanley Dicker Professor and chair of the Department of Biomedical Engineering at Columbia University, delivered the event's keynote address to more than 120 attendees.

The talk, entitled "A Smorgasbord of Delectable Morsels: A Personal Odyssey to Biomedical Engineering," detailed Mow's unusual path from developing anti-submarine sonar to pioneering theories that would completely transform paradigms regarding soft tissue and joint biomechanics.

In a novel thermodynamics mixture approach, Mow's work views articular cartilage and other hydrated, charged soft tissues as composites in three separate phases, taking into account the effects of forces such as friction, pressure and electrical charges. His theories provide a base for further research in biomechanics and rank among the most highly cited references in bioengineering literature.

"My story is one of courage to overcome challenges, both personally and professionally," Mow explained. His work has had important impact on the development of biomedical engineering, particularly in shaping biomechanics in America today.

Poster sessions and podium presentations following Mow's talk detailed UD graduate research in such areas as bone, cell and cartilage; gait training and stroke; imaging methods and modeling; motor control; and osteoarthritis.

Judges from the UD faculty identified the top two presenters in each category with awards sponsored by the Delaware Rehabilitation Institute.

Article by Katie Galgano

www.udel.edu/udaily/2011/may/biomechanics-mow-051811.html

SAVE THE DATE

CBER RESEARCH SYMPOSIUM
MONDAY, APRIL 23, 2012

Keynote lecture by
DR. DARRYL D'LIMA

Visit
WWW.CBER.UDEL.EDU
for more information

PODIUM PRESENTATIONS

Amit Katiyar, "Modeling Subharmonic Response from Contrast Microbubbles for Noninvasive Blood Pressure Measurement."

Sarah Yerkes McCoy, "XYLOSYLTRANSFERASE1 as a Potential Biomarker for Osteoarthritis Progression."

POSTERS

Vincent Baro, "Biomechanical Responses of Meniscus to Contact Loading."

Maria Bellumori, "Improvements in the Rate of Force Development-Scaling Factor Following a High Speed-Low Resistance Cycling Exercise Program."

BABIES, START YOUR ENGINES

Toy ride-on cars provide mobility and sociability to kids with disabilities

Most university researchers find their collaborators at other academic institutions. Cole Galloway finds his at Toys "R" Us.

Best known for his "babies driving robots" research, Galloway has recently turned to off-the-shelf toy racecars to provide mobility to children who can't crawl or walk, empowering them to be part of the action at home, in the daycare center, or on the playground.

An associate professor in the Department of Physical Therapy at the University of Delaware, Galloway has long focused the research in his lab on improving the odds for kids whose mental, social and emotional development is delayed because of their physical inability to explore their environment. With collaborator Sunil Agrawal, a mechanical engineering professor at UD, Galloway has created robotic devices that enable children as young as six months to "drive," providing them with an unprecedented ability to navigate on their own.

But as successful as the program has been, Galloway gets phone calls and emails from parents and clinicians across the U.S. and even in other countries wanting to buy the devices. He has to tell them they can't.

"Development of the devices has moved at the speed of research," Galloway says. "We're continuously advancing the technology, but it hasn't been commercialized yet."

Enter some new team members you might recognize: Barbie, Mater, and Lightning McQueen.

"Using these cars in our project helps to normalize the therapeutic experience for children with limited mobility," Galloway says. "The other kids are pushing in, wanting to know when they can have a turn."

He points out that the low-tech isn't replacing the high-tech but complementing it. "There's a lot of trial and error in research," Galloway says. "We really don't know where we're going here. By modifying off-the-shelf toy cars that cost $150 or $200 each, we can make a lot of mistakes and learn a lot about the ideal configurations and features of mobility devices for kids this age."

Visitors to UD's Early Learning Center, which serves as Galloway's test track, will notice that while the cars are the real deal from the toy store, they have some added features—roll bars made out of PVC pipe, sling seats made from soft fabric, harnesses fashioned from mesh and plastic, and a specialized console over the steering wheel.

Galloway and his team adapt each car to the needs of the child who is currently using it. One of his newest team members is David Glanzman, a rising junior at Strath Haven High School in Wallingford, Pa., who participated in a research internship program sponsored by UD's Engineering Outreach Office this summer.

The sixteen-year-old engineered some of the adaptations to Mater so that it would meet the needs of 19-month-old Brenden, who has cerebral palsy. With plans to pursue a career in electrical engineering, Glanzman gained valuable insight into what happens when engineering meets kids.

"In electrical engineering, you have problems with defined solutions," he says. "It's different with pediatrics. Kids are dynamic, and they change over time—you have to be creative to adapt to that." Glanzman is finishing out his summer project by helping Galloway to develop some tracking features for the cars so that they can be sent home with kids and still provide the researchers with data.

"We make sure to stay within the manufacturers' intent, which is to use these cars as toys," he says. "We don't alter their use, and we don't alter the safety factors built into the cars."

The next step is to determine how many of the high-tech advances that have been incorporated into the robotic devices developed in Agrawal's lab at UD can be added to the low-tech platform, including for example, indoor and outdoor GPS.

Galloway says that recent developments in the commercial toy car industry have opened the door for his team's therapeutic use of the vehicles. Until a few years ago, for example, the cars were not recommended for children under age three. Now, some of the smaller ones can be used by children as young as 12 months. Also, some cars come with the ability for a parent to provide remote control.

Galloway also emphasizes that in both the low- and high-tech realms of his research, the use of mobility devices never replaces efforts to develop a child's own ability to walk and run. "We're actually finding that providing mobility with these fun cars helps develop the mental drive for kids to learn to walk," he says.

He himself never stops looking for creative ways to help individual children while also seeking avenues to spread the message and the technology to parents and clinicians. One idea he is currently exploring is to pilot a summer racecar camp. The research team would outfit the campers with cars, have them spend a week at the camp learning to drive, and then send the kids and cars home. The children's progress would be monitored for the next six to nine months.

"Fun is the key here—it unlocks brain development," Galloway says. "When your main goal is providing socialization for infants and toddlers, you can't ask for better collaborators than Barbie and Mater."

Article by Diane Kukich

www.udel.edu/udaily/2012/sep/galloway-mobility-092311.html

DHSA ORTHOPAEDIC RESEARCH

Clinical Teaching Collaborations Highlighted

Clinical and research collaborations between the University of Delaware Department of Physical Therapy and members of the Christiana Care Department of Orthopaedics were highlighted at the third annual Delaware Orthopaedic Symposium on Saturday, Oct. 23.

The symposium brought together researchers and practitioners from all of the Delaware Health Sciences Alliance (DHSA) partners -- the University of Delaware, Christiana Care Health Systems (CCHS), Thomas Jefferson University (TJU) and Nemours/A.I. duPont Hospital for Children -- as well as several other regional orthopaedic care providers.

Held at Christiana Care's John H. Ammon Medical Education Center, the symposium featured educational tracks on orthopaedic surgery, orthopaedic medicine, and physical therapy and rehabilitation.

According to course director Brian Galinat, M.D., chairman of the Department of Orthopaedic Surgery at CCHS and Assistant Professor of orthopaedic surgery at TJU, the symposium had a strong focus on evidence-based care and outcomes and on multidisciplinary management of musculoskeletal conditions.

Four UD presenters from the Department of Physical Therapy gave session talks highlighting ongoing research and clinical teaching collaborations within the DHSA.

Tara Manal, director of UD's Physical Therapy Clinics and associate professor, taught the CCHS primary care sports medicine residents, sharing a talk entitled "Clinical Decision-Making for Management of Lower Back Pain" with those in the orthopaedic medicine track.

Lynn Snyder-Mackler, Alumni Distinguished Professor, and Gregory Hicks, Assistant Professor, presented their community collaborative research findings in "Critical Decision-Making after ACL Injuries and Lower Back Pain in Active Older Adults."

Joseph Zeni, Assistant Professor, and Steve Rombach, director of Christiana Care Physical Therapy PLUS, gave a talk entitled "Community Application of Delaware Osteoarthritis Profile" and presented preliminary outcomes of their collaboration with total knee replacement surgeons in CCHS's Comprehensive Joint Replacement Center.

"We were pleased to showcase Delaware's world-class orthopedic rehabilitation research and practice in our own backyard," Snyder-Mackler said.

The event was sponsored by the Medical Society of Delaware jointly with the Delaware Society of Orthopedic Surgeons and the Christina Care Department of Orthopedic surgery. Additional sponsors included Pro Physical Therapy, Christiana Care Physical Therapy PLUS, and DePuy Orthopedics.

Attendees included orthopaedic surgeons, primary care physicians, orthopaedic physician assistants, nurses, physical therapists and other health care professionals.

In addition to the session talks, UD researchers presented nine research posters on topics including lower back pain, running injuries, knee replacement, and shoulder pain:

Article by Diane Kukich

www.udel.edu/udaily/2011/nov/dhsa-orthopaedic research110510.html

FORCE FEEDBACK JOYSTICKS

Infants using mobile robots avoid obstacles

Sunil K. Agrawal, professor in the Department of Mechanical Engineering at the University of Delaware, is co-author of a paper that explores how infants can be trained to avoid obstacles using mobile robots with force feedback joysticks.

Co-authors of the paper include Cole Galloway, associate professor in the Department of Physical Therapy, and graduate students Christina Ragonesi and Chen Xi. This work is funded by grants from the National Institutes of Health and the National Science Foundation.

Agrawal's paper, entitled "Training Toddlers Seated on Mobile Robots to Drive Indoors Amidst Obstacles," will appear in a summer issue of IEEE's Transactions on Neural Systems and Rehabilitation Engineering journal. The paper is currently available for electronic review and download as part of the IEEE Xplore digital library.

"This is a landmark study where a group of infants were trained to drive mobile robots within an environment simulating clutter within the workspace," says Agrawal. "The technology and algorithms were developed in my laboratory by doctoral student Xi Chen and tested at UD's Early Learning Center, with the results displaying overwhelming support that this "assist-as-needed approach" yields faster learning than a conventional joystick."

The paper explains that mobility is a causal factor in development. In typically-developing infants, for example, the onset of crawling and walking has long been associated with developmental changes in perception, cognition and socialization. Infants born with significant mobility impairments often experience developmental delays due to lack of environmental interaction.

Previous studies by Agrawal and his research team have shown that, with several months of training, infants can learn to drive directly to a goal using a conventional joystick mounted on a mobility device. Higher-level skills needed to navigate around obstacles or turns, however, are not learned in the same time frame.

The algorithms developed by Agrawal's research team employ haptic rendering -- or sensory touch -- to speed learning in this young population by creating a force field on the joystick. If the child steers the joystick outside a force tunnel centered on the desired direction, the driver experiences a force bias on the hand. This feedback provides helpful sensory cues that quickly train young drivers.

During the study, ten typically-developing toddlers with an average age of 30 months were trained to drive a robot within an obstacle course. A toddler unable to walk independently due to spina bifida was also taught. Results on robot position and travel time were recorded, as well as the number of obstacle collisions.

The group study results indicated that the force field algorithm helped very young children learn to navigate and avoid obstacles faster, more accurately and with greater safety. The results from the child with spina bifida showed positive effects during practice with a child with mobility impairments. Study subjects were retested one week after training and early measures indicate the toddlers retained the learned behaviors at least one week following training.

"In the future, we hope to extend this novel application of technology and training to allow young children with special needs to explore and acquire other functional skills using power mobility devices in real environments such as their home or classroom," concludes Agrawal.

Article by Karen B. Roberts

www.udel.edu/udaily/2011/mar/joysticks-infants-robots-030911.html

OSTEOARTHRITIS

Osteoarthritis (OA) is a major public health issue causing chronic disability worldwide in the increasingly aging population.

Characterized by loss of articular cartilage and degeneration of other joint tissues, this disorder falls behind other skeletal diseases such as osteoporosis and rheumatoid arthritis in available treatments. This is mainly because little is known about the underlying mechanisms and thus effective therapeutic targets are lacking.

Although multiple factors such as genetics and obesity may contribute to OA initiation and progression, biomechanical factors likely contribute to abnormal mechanical loading of the joint, affecting all the surrounding tissues including cartilage, bone and muscle.

The OA research efforts at the University of Delaware are led by Thomas Buchanan, George W. Laird Professor and director of the newly founded Delaware Rehabilitation Institute. Through the Center of Biomedical Research Excellence (COBRE), an $11 million five-year research program funded by the National Institute of Health, Professors Thomas Buchanan, Jill Higginson, Liyun Wang, Lucas Lu, David Burris, Kurt Manal, and Chris Price in the ME department have focused on illuminating the mechanisms by which biomechanical factors regulate the joint functions at the molecular, cellular, tissue, joint and whole body levels. They are also developing novel intervention methods in preventing or deterring OA.

At the molecular and cellular levels, Professor Lucas Lu is investigating how mechanical forces influence chondrocyte functions using microscopy techniques, nanotechnology and computer modeling. As the sole cell type embedded in cartilage, chondrocytes are responsible in maintaining the composition and structure of the cartilage tissues under daily and physical activities. Lu is utilizing a novel micro-patterned 3D system to culture the chondrocytes. Compared with the commonly used 2D culture disk system, this 3D system not only better maintains the cell phenotype, but also allows easy quantification of attachment forces that the cells insert to their surrounding matrix. Lu aims to systematically investigate the cellular signaling and gene expression under various degrees of mechanical stimulation. He hopes that his efforts will uncover new therapeutic interventions to treat OA at the cellular and molecular levels.

At the tissue level, Professor David Burris is investigating how local tissue structural damage influences cartilage tribological efficacy. Healthy cartilage provides extremely low friction coefficients and wear-free sliding over decades of continuous use. This amazing property is lost in OA cartilage. He hypothesizes that local structural damage can impede lubrication and induce additional stresses which cause additional damage.

To date, Burris has developed a custom microtribometer; demonstrated sustained fluid pressurization and lubrication for bovine cartilage in phosphate buffered saline over prolonged periods of testing with contact radii down to 100 μm; and developed in-situ methods for measuring the contact area and interstitial fluid pressure. He is actively developing strategies to study the degradation response to the mechanical stresses of sliding contacts.

Also at the tissue and preclinical level, Professors Liyun Wang and Chris Price are investigating how altered joint loading followed after joint injuries such as ACL rupture and meniscus tear induces the initiation progression of OA. They hypothesize that the highly viscularized subchondral bone compartment, which is capable of quick tissue turnover and remodeling upon mechanical alteration, is mechanically and biochemically coupled with the overlaying cartilage. Excess bone remodeling provides a vicious feedback leading to cartilage degradation. They aim to stop this loop by inhibiting bone turnover right after joint injury. The two have tested the efficacy of zoledronate in a preclinical mouse model. They found that injection of zoledronate twice a week for three months significantly suppressed the cartilage degradation seen in the non-treated animals after surgical destabilization of the joints. The mechanisms on the drug's effects on bone and cartilage are being studied with high-resolution CT imaging and immunochemistry. The window of opportunity of this early intervention will also be studied. If successful, the study will help develop a promising treatment option (inhibiting excess bone remodeling) for joint injury induced OA using an FDA approved agent or similar drugs.

At the clinical level, Professor Jill Higginson investigates muscle forces and coordination strategies during walking in individuals with age-related osteoarthritis of the knee through a combination of MRI, gait analysis, electromyography and biomechanical modeling and simulation. The goal of this longitudinal study is to relate changes in biomechanical loading at the knee to changes in tibio-femoral cartilage geometry as OA progresses. Healthy individuals and those with signs of knee osteoarthritis were recruited to participate in clinical exams, strength tests, walking analysis and knee imaging. They found that individuals with knee OA reduce walking speed to reduce joint loads and exhibit decreased knee excursion with increased stiffness regardless of speed. Imaging data indicates that individuals without OA have a significant correlation between knee flexion angle and contact area, while the OA subjects did not. OA subjects exhibited greater articular cartilage contact area than the healthy controls at all flexion angles considered. Musculoskeletal simulations are used to determine contribution of muscles to knee contact forces. They found similar initial peak knee contact forces (KCF) among groups and decreased second peaks of KCF in subjects with increasing OA severity. Higginson hopes the data will be used to develop guidelines and non-surgical interventions to prevent or deter OA progression.

Also at the clinical level, Professors Thomas Buchanan and Kurt Manal are studying the neuromuscular strategies seen in patients with various joint impairments to develop physical intervention in reducing compressive forces at the knees. They hypothesize that the mechanical failure of cartilage due to high compressive forces at the knee can be secondary to other knee problems that alter the mechanical structure of the knee, such as ligament injuries, meniscal tears or other traumatic injuries. By combining imaging and modeling, patient-specific dynamic loading models are developed. They study the ways patients with different types of impaired knees deal with mechanical loads that have been shown to lead to osteoarthritis. They are currently developing a new approach to treating these patients, in collaboration with physical therapists, based on reduction of the knee compressive forces. In this new approach, real-time feedback is provided to the subjects about the medial and lateral compartment compressive loads at the knee joint during gait. If successful, an effective physical treatment option will be developed for OA patients.

Overall, the ME faculty are actively pursuing a better understanding of OA from a variety of angles and are working to develop novel and effective treatments of OA from bench to clinical setting and from the molecular to the whole body levels

By Liyun Wang, Associate Professor, written for the 2011 Mechanical Engineering News Magazine.

UD AWARDED $19.5M DOD GRANT

Orthopedic rehabilitation clinic consortium benefits wounded soldiers

A team of researchers led by the University of Delaware has been awarded a five-year, $19.5 million grant from the Department of Defense to establish evidence-based orthopaedic rehabilitation care that optimizes the ability of soldiers with musculoskeletal injuries to function in everyday life.

The award was made through DOD's Office of Congressionally Directed Medical Research Programs to the BADER Consortium, which brings together military training facilities, academic researchers and rehabilitation institutes. Steven Stanhope, professor in UD's Department of Kinesiology and Applied Physiology, is principal investigator and will serve as consortium director.

BADER is an acronym for "Bridging Advanced Developments for Exceptional Rehabilitation." Typifying exceptional function following injury, Royal Air Force fighter pilot Sir Douglas Bader lost both legs in a plane crash but went on to shoot down 22 German planes and attempt multiple escapes as a POW during World War II.

Stanhope explains that improvements in body armor and emergency care have resulted in soldiers of the Iraq and Afghanistan wars surviving injuries in much greater numbers than those in previous wars. However, this has led to a significant increase in severe orthopedic injuries caused by high-velocity weapons and explosive devices.

Despite extensive medical services and limb salvage procedures, many of these injuries result in significantly impaired musculoskeletal structures and limb amputations.

"Our goal is to see every wounded warrior living a full and engaging life without boundaries -- just like Sir Bader," says Stanhope, who has a joint appointment in UD's Department of Mechanical Engineering and whose research specialty is biomechanics.

Initial clinical rehabilitation studies will focus on bone health, balance and stability, optimal walking and training to run. Work under the consortium will also include graduate training of military personnel in rehabilitation research through UD's interdisciplinary Biomechanics and Movement Science (BIOMS) program.

"This is a tremendous grant that opens up new opportunities for collaboration with the U.S. Army at APG in nearby Maryland," says David Weir, director of UD's Office of Economic Innovation and Partnerships. "And it falls in what is truly a 'sweet spot' for us -- the convergence of rehabilitation science, advanced materials with functional capabilities, and physical therapy clinical practice. This award and the work that it enables have the potential to lay the foundation for a collaboration with the Army at our Science and Technology Campus on the former Chrysler site."

At UD, the consortium will catalyze interdisciplinary collaborations between the colleges of Health Sciences and Engineering, as well as with the Center for Composite Materials and the Delaware Rehabilitation Institute.

Other partners in the BADER Consortium include Spaulding/Harvard Rehabilitation Hospital in Boston; the University of Texas at Austin; Christiana Care Health System; the Mayo Clinic in Phoenix, Ariz.; the Naval Medical Center in Portsmouth, Va.; the Naval Medical Center in San Diego; San Antonio Military Medical Center; Walter Reed Army Medical Center in Washington, D.C.; C-Motion, Inc. in Germantown, Md., and the University of Michigan.

Irene Davis, a faculty member at Harvard Medical School, and Ken Kaufman, professor of biomedical engineering at the Mayo Clinic, are co-principal investigators in the consortium. Davis, who retired from UD in 2010 after spending 21 years on the faculty in the Department of Physical Therapy, will be director of research for the consortium. Kaufman will serve as director of BADER's scientific core.

Article by Diane Kukich

www.udel.edu/udaily/2011/mar/orthopaedic-rehabilitation-031411.html

UDRF grants

University of Delaware Research Foundation awards six projects

The University of Delaware Research Foundation (UDRF), a nonprofit organization supporting fundamental research in all fields of science at UD, has awarded six strategic initiative grants for collaborative research in the life and health sciences, energy and the environment -- areas emphasized in the University's Path to Prominence.

Each project is led by at least one early-career faculty member working with one tenured faculty member, who serves as a mentor. Each grant totals $45,000-$55,000, which includes $5,000 in matching funds from both the provost's office and the lead faculty member's dean.

"The University of Delaware Research Foundation plays an important role in supporting high-priority, high-quality research at UD," said Mark Barteau, senior vice provost for research and strategic initiatives. "The strategic initiative grants not only advance major areas of research emphasis, but they help early career faculty gain valuable insight from experienced researchers in areas ranging from student mentoring to proposal development, further building a culture of research excellence at UD."

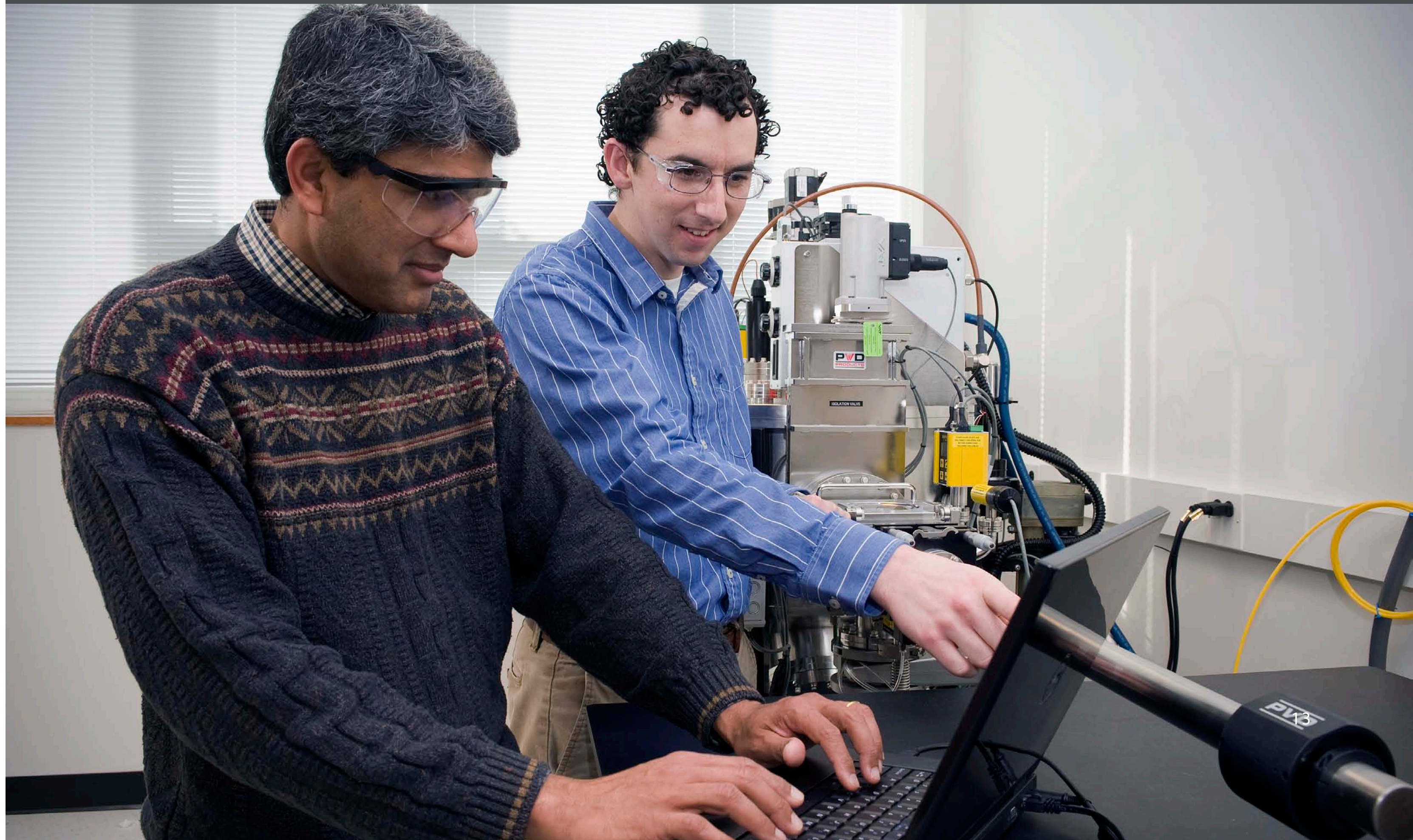
The UDRF grants will support the following two out of six research projects:

Although improved gait and mobility are key desired outcomes of Parkinson's disease treatments, currently there is no "gold standard" assessment that provides a direct measure of gait and mobility in a real-life setting, making it difficult to assess the real impact of treatments. Ingrid Pretzer-Aboff, Assistant Professor of nursing, and Sunil Agrawal, professor of mechanical engineering, hope to fill that void. They will develop and test an electronic sensor-enabled insole for evaluating gait and mobility in individuals with Parkinson's disease.

Joshua Zide, Assistant Professor of materials science and engineering, and Ajay Prasad, professor of mechanical engineering, will demonstrate a novel application of thermoelectrics, which convert heat to electricity, to provide energy in inaccessible locales where other technologies are not viable. The researchers seek to model, optimize and demonstrate a system in which fluctuations in ambient temperature can be exploited to generate electrical energy.

Article by Tracey Bryant

www.udel.edu/udaily/2012/dec/research-foundation-120911.html



WILDLY POPULAR MAJOR

Biomedical engineering enrollment maxed out in second year

Until last year, Nick Campagnola wanted to pursue a career in cancer research or oncology. But when he learned about the new biomedical engineering degree program at the University of Delaware, he quickly changed his mind.

"Biomedical engineering allows me all the opportunities of a traditional science degree while simultaneously opening up career options in engineering disciplines, says the junior. Now, I stand out to graduate programs, medical schools and potential employers because of my major."

Biomedical engineering is an emerging field that applies fundamental engineering principles to the study of biology, medicine, behavior and health. U.S. Department of Labor statistics cites the career specialty as the fastest-growing occupation, with jobs in the field expected to grow by 72 percent by 2018.

Campagnola is among a growing number of UD undergraduate students clamoring to declare biomedical engineering as a major, in hopes of becoming the next generation of leaders and innovators bridging the gaps between medicine, engineering and biomedical research.

Student enrollment in the UD program, which was launched fall 2010 with 18 declared students, grew by 194 percent in its first semester and by 511 percent over one year. Today the program boasts 110 incoming freshmen and sophomores and a wait list for entry into the newly restricted major. One-third of these students are female, with another third enrolled in the Honors Program. Forty percent of the students are Delaware residents.

"The program's early success demonstrates how needed the major was and its tremendous growth potential," said program director Dawn Elliott, who joined UD Sept. 1. Elliot succeeded Jill Higginson, associate professor in mechanical engineering, who helped develop and launch the undergraduate program and who continues as its associate director.

The biomedical engineering program may also have a positive economic impact for the state, according to recent comments from President Patrick T. Harker.

"High-wage, high-skill jobs simply won't come to Delaware without the infrastructure to support them and without workers trained for them. Critical industry partnerships will not happen without our equal investment—investment in capital projects like the Science and Technology Campus and the Interdisciplinary Science and Engineering Lab, and in programs that fill emerging marketplace needs, like our undergraduate biomedical engineering program, whose enrollment has maxed out in only its second year. These investments don't diminish our land-grant commitment; they reinforce it," Harker said.

The four-year curriculum is dense with basic science and engineering courses, including topics such as biomaterials, signals and systems, biomechanics and biochemistry. This cross-disciplinary training enables students to become, in a way, multilingual – fluent in biology, as well as math and engineering – skill sets that can be practically applied in many fields.

"The way biomedical engineering applies engineering principles to help health is critical across a wide spectrum, particularly with the aging population – for orthopedic issues, musculoskeletal issues, but also Alzheimer's disease and the electrical circuitry related to understanding how the brain works," added Elliott.

A biomechanical engineer by training, Elliott spent 12 years in the University of Pennsylvania's Department of Orthopaedic Surgery. Internationally known, her research focused on lower back pain and osteoarthritis, studying how and why the intervertebral spine breaks down with aging and developing and testing therapeutics used in treatment. She will continue this research at UD through ongoing collaborations with her UPenn peers and new partnerships with her UD colleagues.

"Dawn's strong research program in orthopedic biomechanics and her interest in disc degeneration and material properties of spine components complements research already occurring on our campus," said Babatunde A. Ogunnaike, interim dean of the College of Engineering. "Her sterling intellectual reputation, academic vision and boundless energy make Dawn that rare architect-and-builder needed to help the college elevate this important program to national recognition, while meeting growing student and industry demands."

The first order of business, said Elliott, is to establish a biomedical engineering doctoral program, followed by a master's degree program that will both attract talented faculty and provide needed research infrastructure.

Dawn Elliott

"Biomedical engineering has the potential to impact human health, but at a more fundamental level, there is also opportunity to increase global understanding of the science of human health," remarked Elliott. "My role is to foster connections across all disciplines and integrate the biomedical engineering research already occurring on campus under one program."

"I envision our faculty bringing engineering directly to bear on the medical arena through translational, patient-oriented research that touches the patients who come through the Science and Technology Campus. Additionally, I foresee fundamental research continuing on the main campus, enabling students to gain both the academic skills and research experiences they need to pursue the careers they want."

Article by Karen B. Roberts

www.udel.edu/udaily/2012/sep/biomedical-engineering-091911.html

DELAWARE REHABILITATION INSTITUTE HOLDS INAUGURAL SYMPOSIUM

The Delaware Rehabilitation Institute (DRI) was officially launched on Feb. 24, 2011, with a one-day research symposium at the University of Delaware's Clayton Hall.

According to Thomas Buchanan, DRI director and George W. Laird Professor of Mechanical Engineering, the new institute builds on a strong history of rehabilitation research and practice in Delaware, bringing together academic investigators, clinical scientists and clinicians to enable breakthrough findings to be taken from the laboratory to the clinic.

After the audience viewed a brief video highlighting several DRI research projects, Delaware Gov. Jack Markell delivered brief opening remarks. He referred to DRI as "a big deal for Delaware."

"Cooperation is one of the things we do well in Delaware," he said, "and it's great for me as governor to see this kind of cooperation and achievement. To see it come to life and to see the positive impact on people from little kids to world-class athletes and everyone in between -- that's what it's all about."

Markell noted that UD has received substantial funding from the National Institutes of Health -- support that may be at risk with budget cuts. "It's important that all of us care about these kinds of investments and innovations," he said, "and that we speak up."

He also pointed out that there are very few centers across the country taking the holistic, comprehensive approach to rehabilitation adopted in Delaware.

Mark Barteau, senior vice provost for research and strategic initiatives at UD, said that DRI is the fourth in a series of institutes established over the past 12 years on the foundation of existing strengths at UD. The other three are the Delaware Biotechnology Institute, the UD Energy Institute and the Delaware Environmental Institute.

"With the formation of this new institute," he said, "we've strapped another engine on the rocket that is UD's Path to Prominence™."

Kathleen Matt, dean of the UD College of Health Sciences, pointed to the tremendous potential offered by a clinical and translational science institute like DRI.

"It's one thing to study mechanisms of disease," she said, "but then what do you do with that knowledge bank? Universities have traditionally been responsible for developing the knowledge, but we are at a time when that's not enough. We need to be able to translate it into applications that will have an immediate impact."

UD Provost Tom Apple said that UD's vision for the future of health sciences is, in many ways, aligned with the NIH Roadmap for Medical Research: To transform the way research is conducted and speed the movement of scientific discoveries from bench to bedside.

"The University of Delaware is the ideal setting for translational research, and DRI is an excellent example of how we can enhance our efforts of cross-campus research collaborations to really make a difference in people's lives," he said. "In this living laboratory, we can shorten the time and distance from discovery to delivery. We can go from bench to bedside and back again, continually refining research, practice and technology."

The event also included research overviews from UD faculty on stroke, osteoarthritis, childhood obesity, biomedical engineering, rehabilitation robots for infants and ACL injuries. Other sessions covered work being done by researchers at UD's partner institutions in the Delaware Health Sciences Alliance, as well as at other organizations in Delaware and beyond.

In addition, more than 20 research teams presented posters highlighting their ongoing work.

For more information about DRI, visit the website at www.udel.edu/dri.

Article by Diane Kukich

www.udel.edu/udaily/2011/feb/Delaware-Rehabilitation-Institute022811.html

UD ATHLETIC TRAINING HOSTS STUDENTS FROM CONRAD

Sixty students from the Henry C. Conrad Schools of Science got a crash course in athletic training research techniques and clinical practice during a visit to the University of Delaware on Wednesday, March 2, as part of National Athletic Training Month.

Conrad is a grade 6-12 magnet program focusing on biotechnology and allied health. The 10th through 12th graders who visited UD are currently taking courses in sports medicine and exercise science.

Three doctoral students in the interdisciplinary Biomechanics and Movement Science (BIOMS) program at UD -- Kathy Liu, Alan Needle and Laura Miller -- demonstrated research techniques including musculoskeletal ultrasound, joint stiffness testing and biomechanical motion analysis in UD's Human Performance Laboratory.

Miller outfitted Ronald S., who plays tennis and football at Conrad, with reflective markers, identifying each anatomical location as she worked. She then asked him to mimic an activity from each of his two sports.

The rest of the students crowded around the computer screen, which showed stick-figure Ronald simulating a tennis serve and a football move. Pointing at the image, Miller said, "Once we know the position of his markers, we can calculate velocity, mass, and forces. Biomechanics is all about physics."

"This technology allows us to see how an athlete moves and then take that one step further to develop an intervention," she added. "Our focus in athletic training is on preventing injury and finding ways to keep athletes healthy."

In the Bob Carpenter Center training room, graduate assistant athletic trainer Craig Oates explained the RICE — rest, ice, compression, elevation — strategy for treatment of

acute injuries and then showed the young students a cold compression boot, which combines all four functions in one device. He demonstrated it first on Conrad student Kelvin M. and then on injured UD basketball player Sarah Acker.

"It will become uncomfortable for her after the first few minutes," Oates explained, "but it's essential to get started with this treatment as soon after injury as possible. Tonight, we'll tape her so that she doesn't wake up tomorrow with her leg looking like a grapefruit."

Article by Diane Kukich

www.udel.edu/udaily/2011/mar/athletic-training-030811.html

UNLEASHING LEARNING

Engineering outreach helps high school students try careers on for size

Deciding what major to pursue in college can seem overwhelming when you are a junior or senior in high school. That's what makes the University of Delaware College of Engineering's outreach programs so inviting – the opportunity to try a career on for size.

In a unique hands-on program, young women dabbled for a day in the exciting worlds of bioengineering and orthopedics at Conrad Schools of the Science. They performed mock orthopedic surgeries and biomechanics experiments with UD graduate students, undergraduate students and faculty.

"What surprised me most about this program was how interesting these job options were," confided one teenage girl. Another expressed intrigue about "how closely biomedical engineers work with doctors in developing more successful strategies" to treat disease.

PARTICIPATING UD FACULTY MEMBERS INCLUDED:

- •Lynn Synder-Mackler, Alumni Distinguished Professor of Physical Therapy
- •Jill Higginson, Associate Professor of Mechanical Engineering
- •Jenni Buckley, Assistant Professor of Mechanical Engineering
- •Martha Murray, UD Mechanical Engineering alumna and orthopedic surgeon

Students at Conrad Schools of Science learn about the worlds of bioengineering and orthopedics during a hands-on program.

"We believe that early outreach and mentoring are critical to inspiring women to become leaders in engineering and other STEM-related fields," said Jenni Buckley, Assistant Professor of mechanical engineering and co-founder of The Perry Outreach program, which coordinated the outreach. The program aims to encourage young women to pursue careers in science, particularly mechanical engineering and orthopedic surgery, two fields in which women are traditionally underrepresented.

Hosted by UD and Red Clay Consolidated School District, the program attracted more than 30 students from nine area high schools in Delaware and Pennsylvania.

Buckley said she plans to expand the Perry Outreach program's infrastructure and curriculum over the next year with a recently acquired grant for $100,000 from Chevron Energy Solutions. This year's event at Conrad was sponsored in part by Stryker Corporation.

Article by Karen B. Roberts

www.udel.edu/udaily/2012/aug/perry-engineering-outreach-082511.html

APS FELLOW

Prof honored for pioneering fluid mechanics research

Lian-Ping Wang, professor of mechanical engineering at the University of Delaware, has been elected a fellow of the American Physical Society (APS).

Designation as an APS Fellow places Wang among the top one-half of one percent of APS members, an elite appointment that recognizes his pioneering research on the theory and computation of turbulent particle-laden flows and their application to engineering and environmental processes. He will be recognized during the APS Division of Fluid Dynamics annual meeting in Baltimore this November.

"Lian-Ping's work in computational fluid mechanics has contributed significantly to the understanding of environmentally important topics such as droplet growth in clouds and the transport of nano-particles in soil," noted Anette M. Karlsson, professor and chair of the Department of Mechanical Engineering.

Wang's work involves the creation of advanced simulation tools to study and predict physical processes at small scales, and the development of statistical descriptions of these processes that enable scientists to better formulate large-scale models. His research focuses on diverse environmental processes that show potential in perfecting existing prediction methods and reducing uncertainties in weather and climate models.

A critical step towards solving the global warming debate is understanding the microphysical development of clouds, said Wang. His group uses rigorous computer simulations to quantify how air turbulence can enhance the collision rate of droplets in atmospheric clouds. Their pioneering research in this area contributes to the improved accuracy of large-scale models used to predict weather phenomena and climate changes.

Wang's research group also studies nano-particle transport in ground soil. They are developing a revolutionary bottom-up simulation tool to help scientists predict the passage and retention of nano-particles in soil. This work is literally "groundbreaking," as little is known about the progression of these particles and their effect on the environment.

Article by Gabriella Chiera

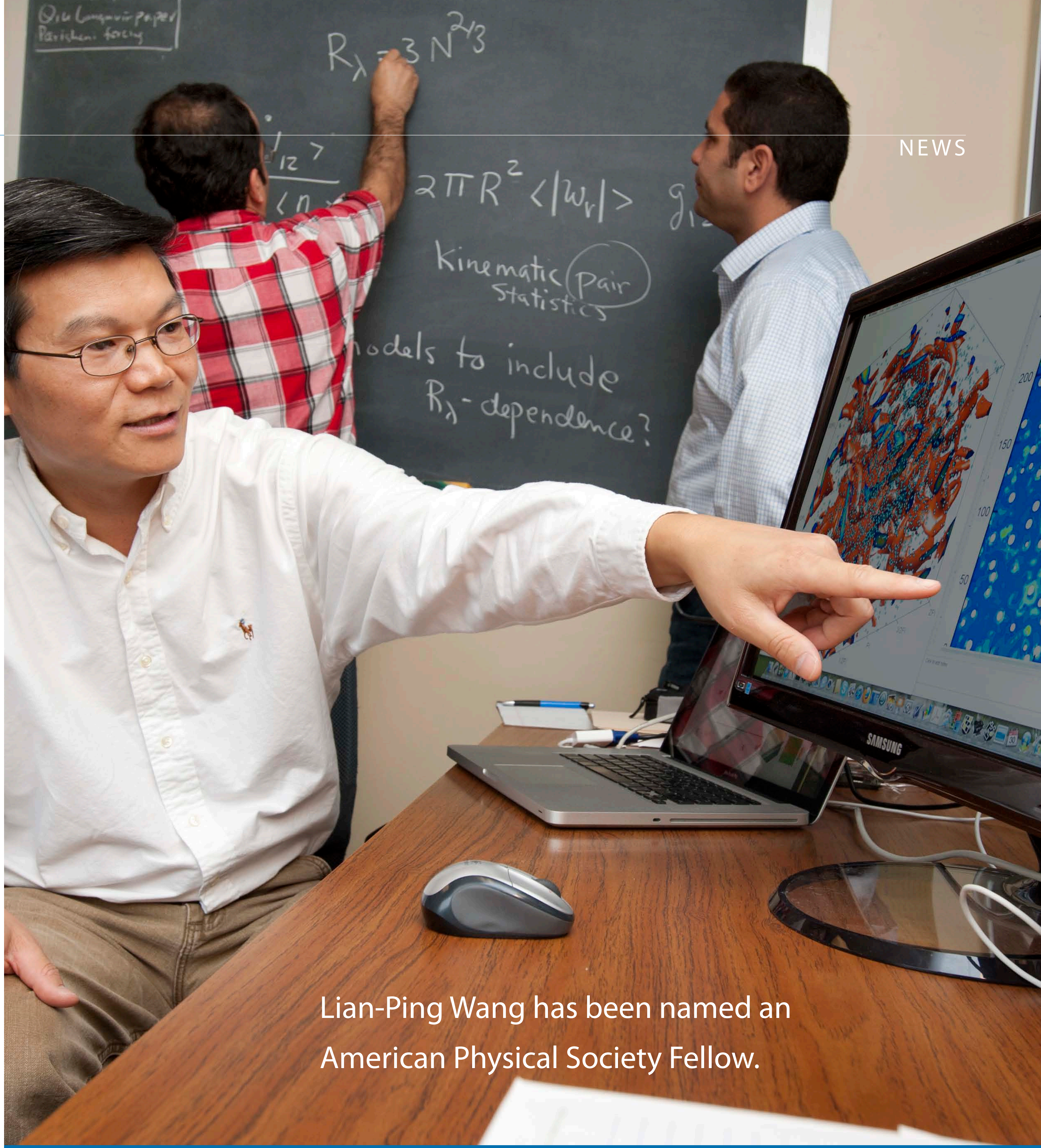
www.udel.edu/udaily/2012/oct/wang-aps-fellow-100711.html

About Lian-Ping Wang

Lian-Ping Wang joined UD in 1994. In addition to his duties in mechanical engineering, he is affiliated with the College of Earth, Ocean, and Environment and UD's Center for Critical Zone Research and Center for Study of Space Radiation Effects, as well as the National Center for Atmospheric Research and the Chinese Academy of Sciences.

Wang's research was listed among the top 50 most cited articles in the Atmospheric Research journal in 2010 and 2011. His career honors include the Distinguished Overseas Scholar Award from China, UD's Francis Alison Young Scholars Award and UD's junior-faculty Outstanding Teaching Award.

Wang received his bachelor's degree in engineering mechanics from Zhejiang University, China. He earned his doctoral degree in mechanical engineering from Washington State University.



Lian-Ping Wang has been named an American Physical Society Fellow.

STUDENT RECOGNITION

Ms. Nadia Lepori-Bui was selected to present her abstract as a podium presentation at the 2012 Orthopaedic Research Society-Annual meeting held in San Francisco, California this coming February.

Alan Needle, a second-year doctoral student in athletic training at the University of Delaware, recently won a research scholarship from the Eastern Athletic Trainers Association (EATA).

Advised by Charles "Buz" Swanik, associate professor in the Department of Kinesiology and Applied Physiology, Needle is conducting research aimed at determining the causes and potential treatment options for the management of joint injuries.

"Ankle sprains are the most common injury seen in athletic populations and physically active people," Needle says. "About 50 percent of patients who suffer an ankle sprain will have a repeated sprain or develop ankle instability. This occurs when patients have frequent sensations of the ankle 'giving way' or 'rolling' during activity."

The goal of Needle's work is to identify physiological factors that may cause these sensations of instability to develop. Specifically, he is looking at the relationship between the amount of extra motion the ankle has (laxity), the ability for the joint to sense changes in position and force (proprioception), and the strategies people use to optimize joint stiffness and react to sudden twisting motion at the ankle.

Article by Diane Kukich

www.udel.edu/udaily/2011/jan/athletic-training-research-012811.html

CURRICULUM

DEGREE PROGRAMS

PROGRAM	UNDER-GRADUATE	GRADUATE	WEBSITE
Applied Physiology		✓	www.udel.edu/kaap/
Biological Sciences	✓	✓	www.bio.udel.edu/
Biomechanics & Movement Sciences		✓	www.bmsc.udel.edu/
Biomedical Engineering	✓	✓	www.engr.udel.edu/biomed/
Bioresources Engineering	✓	✓	http://ag.udel.edu/breg/
Electrical & Computer Engineering	✓	✓	www.ece.udel.edu/
Exercise Science	✓	✓	www.udel.edu/kaap
Fashion & Apparel Studies	✓	✓	www.udel.edu/fash/
Materials Science & Engineering		✓	www.mseg.udel.edu/
Mechanical Engineering	✓	✓	www.me.udel.edu/
Neuroscience	✓		www.psych.udel.edu/undergraduate/
Physical Therapy		✓	www.udel.edu/PT/
Quantitative Biology	✓		www.udel.edu/qbio/

FACULTY RECOGNITION

Dr. Charles (Buz) Swanik was inducted into the Class of 2011 Mohawk's Distinguished Alumni Hall of Fame sponsored by the Mohawk Community Education Foundation at the Mohawk School System in Bessemer, Pennsylvania.

To read more about this honor please visit

www.mohawk.k12.pa.us/1871101112945610/site/default.asp

CBER WELCOMES NEW FACULTY

Yvonne Ou

1

Dr. Ou received her PhD in Applied Mathematics from UD in 2001. She was a Research Scientist working with the Computational Mathematics Group in Oak Ridge National Laboratory before returning to UD as a faculty member in 2011. Dr. Ou models biological systems at the interfaces between macro, micro and nano-scales by developing a mathematically consistent and computationally effective approach. Her main interest in mathematical biology focuses on bone and the study of how an Integral Representation Formula (IRF)-based dehomogenization can retrieve microstructural information from macroscopic measurement, hence bypassing the imaging process. To validate her results obtained by the dehomogenization approach, she and her collaborators have been working on computation of detailed field distribution in composite from μ-CT image data based on BEM-FMM method. Her other current project is on numerical computation of wave scattering by poroelastic materials such as cancellous bones. Her teaching interests include complex variables, partial differential equations and numerical methods for eigenvalue problems.

April Kloxin

2

Dr. Kloxin trained in Chemical Engineering with B.S. (2001) and M.S. (2004) degrees from North Carolina State University. Her doctoral work was completed at the University of Colorado under the direction of Kristi Anseth where she developed photodegradable hydrogels for controlling cell-material interactions. Her subsequent postdoctoral research utilized enzymatically degradable hydrogels and fundamental biological techniques to understand and direct alveoli development and skeletal muscle repair. In June 2011, Dr. Kloxin joined UD as an Assistant Professor with joint appointments in Chemical Engineering and Materials Science and Engineering.

Dr. Kloxin's research group seeks to understand important biological signals in tissue regeneration and disease using both a materials- and engineering-based approach. They design materials to mimic soft tissues, such as brain, muscle, and connective tissue, and whose properties can be modified at any location and time. These novel biomaterials are used as a flexible platform for cell culture to ask fundamental questions about how the environment surrounding a cell influences cell function and fate for tissue regeneration or disease progression. These findings will be utilized to develop better approaches for tissue repair or disease treatment towards improving human health.

Jenni Buckley

3

Dr. Buckley received a B.S. in Mechanical Engineering (2001) from the University of Delaware, and her MS (2004) and PhD (2006) in Mechanical Engineering from the University of California, Berkeley, where she worked on computational and experimental methods in spinal biomechanics. Since 2006, her research efforts have focused on the development and mechanical evaluation of medical devices, particularly orthopaedic, neurosurgical, and pediatric devices. In 2011, Dr. Buckley joined the faculty at the University of Delaware Department of Mechanical Engineering, where she teaches a range of courses as part of the undergraduate curriculum. She also serves as the Chief Scientific Officer for The Taylor Collaboration, an orthopaedic biomechanical testing laboratory, and Executive Director of The Perry Initiative, which sponsors outreach programs to inspire young women to pursue careers in Orthopaedic Surgery and Engineering.

Dawn Elliott

4

Dr. Elliott joined the University of Delaware in 2011 as Director and Professor of Biomedical Engineering. Previously, she was a professor in orthopedic surgery and in bioengineering at University of Pennsylvania from 1999-2011. Dr. Elliott was founding director of the structure-function biomechanics core center in the Penn Center for Musculoskeletal Disorders. She has a B.S. in mechanical engineering from the University of Michigan, M.S. in engineering mechanics from the University of Cincinnati, and a PhD in biomedical engineering from Duke University.

Dr. Elliott's research expertise includes the biomechanics of collagenous soft tissues and intervertebral disc function, degeneration and restoration. She uses in vivo models and MRI-based biomarkers of disc degeneration to study structure-function relationships in load-bearing fiber-reinforced tissues and joints, and the associated changes that occur during development, with degeneration and injury, and following therapeutic intervention. The Elliott lab works to develop and apply innovative, cutting edge technologies, including novel mechanical tests, rigorous mathematical models, and state-of-the-art magnetic resonance imaging and analyses.

Dr. Suresh Advani has research interests in materials and processing, rheology, fluid mechanics and heat transfer as applied to composite processing and alternate energy sources. He has co-authored over 200 journal articles and has contributed chapters to over twenty books. Advanced composite materials offer the potential to tailor component properties by selecting material ingredients and spatially controlling ingredient composition and configuration. Previous applications in biomechanics included the design of the stiffness modulus for a hip prosthesis to closely approximate the stiffness of the natural bone at the interface and the evaluation of strength, stiffness, fatigue and impact properties following manufacturing.

Dr. Advani is the George W. Laird Professor of Mechanical Engineering and has an affiliate appointment in Biomedical Engineering.

The Mechanical Systems Laboratory and rehabilitation robotics laboratory, directed by ***Dr. Sunil Agrawal***, focuses on robotics and control with emphasis on novel designs of robots and autonomous machines, computational algorithms using the theory of differential flatness, and devices for medical rehabilitation. Dr. Agrawal's published works include topics such as space robots, differentially flat systems, cable driven systems, robotic exoskeletons for gait training, and pediatric mobility devices. His research studies apply fundamentals of systems and control, robotics and optimization, mechanisms, and robotics and have enjoyed funding from the NSF, NIH, ARO, NIST and other sources for the last 20 years. Dr. Agrawal collaborates actively with investigators from the field of health science and engineering that includes Cole Galloway, John Scholz, Stuart Binder-Macleod, Jill Higginson, and others.

Dr. Agrawal is a Professor in Mechanical Engineering and Biomedical Engineering and holds a joint appointment in the interdisciplinary graduate program in Biomechanics and Movement Science.

In addition to his role as a practicing orthopaedic surgeon, ***Dr. Michael Axe*** actively participates in a variety of research projects pertaining to osteoarthritis, anterior cruciate ligament reconstruction and rehabilitation and total knee arthroplasty with collaborators from across campus. His special interests include sports-related injury, arthroscopic surgery, arthritis and fracture care. In addition, Dr. Axe co-hosts a local television program, Youth in Sports, which highlights outstanding young people and others who make a difference in the local community.

Dr. Axe is a board-certified orthopaedic surgeon for First State Orthopaedics, and maintains an appointment as Clinical Professor for the Department of Physical Therapy at the University of Delaware.

Dr. Thomas Buchanan is an expert in the development of mechanical models depicting how muscles generate forces and how such forces affect loads in cartilage and ligaments. This work has been applied to osteoarthritis, stroke and sports medicine and supported by over $25 million of NIH research grants. Current research activities include the study of muscle patterns and optimal rehabilitation strategies following reconstruction of the anterior cruciate ligament as well as subject-specific EMG-driven modeling of individuals with osteoarthritis and post-stroke hemiparesis. Other areas of interest include neural control of movement, patient-specific modeling using MRI and ultrasound, muscle mechanics. orthopaedics, radiology and neurology. In addition, Dr. Buchanan has served as Editor-in-Chief of the Journal of Applied Biomechanics and as President of the American Society of Biomechanics.

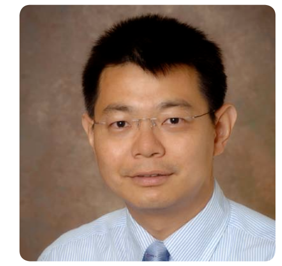
Dr. Buchanan is the George W. Laird Professor of Mechanical Engineering and the founding Director of the Delaware Rehabilitation Institute. He also holds appointments in Biomedical Engineering and the interdisciplinary graduate program in Biomechanics and Movement Science.

Electrical stimulation can have a profound effect on muscle performance and has been the focus of ***Dr. Stuart Binder-Macleod's*** research involving human and animal research models. Ongoing investigations funded by the NIH involve novel therapeutic interventions such as fast treadmill training and functional electrical stimulation (FES) to improve walking post-stroke and the use of robotic exoskeletons, FES, and biomechanical modeling to treat movement disorders. This has led to the pursuit of the design of a neural prosthesis for stroke ambulation and rehabilitation. He is also a collaborator on a study of muscle morphology, strength and compensatory strategies following stroke. Dr. Binder-Macleod serves as a faculty mentor for the Center for Biomedical Research Excellence (COBRE) for Women in Science and Engineering on Osteoarthritis, and Program Director on several training grants for physical and occupational therapists.

Dr. Binder-Macleod is the Edward L. Ratledge Professor & Chair of the Department of Physical Therapy with a joint appointment in the interdisciplinary graduate program in Biomechanics and Movement Science.

Dr. David Burris' research lies at the intersection of materials science and mechanical engineering in the area of materials tribology. Laboratory activities are diverse and include design of novel experimental techniques, development and characterization of nanocomposite and hierarchically structured materials, microscale and macroscale tribometry, wear modeling and life prediction. Dr. Burris' research efforts address the challenges of operation in extreme and remote environments; examples include space-flight, remote military missions, biological systems, internal combustion engines, high-power wind turbines and MEMS/NEMS. Specifically his research group is assessing the role of tissue structure-function coupling in the initiation and progression of osteoarthritis in a study funded by NIH. He also conducts in situ studies of cartilage microtribology to determine the roles of speed and contact area, performs functional characterization of normal and degraded bovine meniscus and fluid load support during localized indentation of cartilage with a spherical probe.

Dr. Burris is an Assistant Professor in Mechanical Engineering, Biomechanics and Movement Science, and Biomedical Engineering.

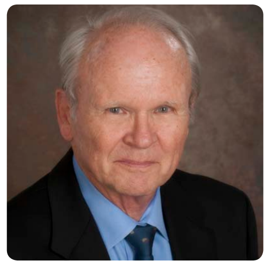


Dr. Huantian Cao has research interests encompassing sustainable textile and apparel design and production. He contributes to the innovation of protective clothing for agricultural, industrial, homeland security and military applications including the use of smart textiles. Currently, Dr. Cao's research group is investigating the development of apparel and footwear from renewable sources as well as localized production of apparel and accessories from agriculture-based materials. He is also exploring thermal and moisture comfort of textile and clothing using novel experimental paradigms.

Dr. Cao is an Associate Professor in the Department of Fashion and Apparel Studies at the University of Delaware.

The development of skeletal architecture and the maintenance of bone mass is dependent on the mechanical stresses and strains encountered throughout our lifetime. The focus of ***Dr. Randall Duncan's*** research group is to understand how mechanical signals are perceived by bone cells and converted into biochemical responses within the cell to promote bone formation. The objective of his lab is to define the role of ion channels in mechanically-induced increase in intracellular calcium and how the changes in channel activity influence the function of the cell. They also seek to determine how the cell can control the kinetics of these channels. Finally, they are using genetic manipulation to determine how mutation, overexpression and knockout of various components of the proposed mechanotransduction pathway alter the response of the skeleton to mechanical loading.

Dr. Randy Duncan is Professor and Chairperson of the Department of Biological Sciences with joint appointments in Biomechanics & Movement Science, Mechanical and Biomedical Engineering.



Dr. William Fagerstrom has expertise in manufacturing processes and systems, specifically in stress, vibration and machinery diagnostics to improve the health and reliability of the process machinery or product quality. He has served as an engineering consultant with DuPont, Gore and many other companies and is active in the Delaware Chapter of the Society of Manufacturing Engineers. An author, as well as teacher and trainer in both industrial and academic environments, Bill is currently an instructor for Senior Design in the Mechanical Engineering curriculum at UD as well as Manufacturing Processes & Systems, a course he developed. Dr. Fagerstrom also has a personal interest in the design and manufacturing of medical devices.

Dr. Fagerstrom, P.E. is a supplemental faculty member in Mechanical Engineering.

Dr. Cole Galloway's research focuses on motor behaviors of infants. He is especially interested in the interaction of neural, biomechanical, behavioral and environmental influences as infants learn to coordinate their early head, arm and leg behaviors for later skills such as reaching, sitting and walking.

Dr. Galloway is an Associate Professor in Physical Therapy and Biomechanics and Movement Science.

Dr. Robert Gilbert's research includes partial differential equations, homogenization and other asymptotic methods, poro-elastic, thermo-elastic, and visco-elastic problems, moving boundary problems, convexity, function-theoretic methods, and biomechanics. He is currently studying cancellous bone rigidity and modeling the osteoblastic cell. Dr. Gilbert is the founding editor of two mathematical journals including Applicable Analysis and Complex Variables, and serves as the Honorary President of The International Society for Analysis, its Applications and Computation (ISAAC).

Professor Gilbert, an applied analyst, is primarily known for his treatises on function theoretic methods applied to partial differential equations. As a research mathematician Dr. Gilbert has published 300 articles in professional journals and conference proceedings. Dr. Gilbert's current research efforts are in the areas of inverse problems, theory of plasto-elasticity, homogenization applied to biological mechanics, hemivariational inequalities, and the flow of viscous fluids.

Dr. Gilbert is a UNIDEL Professor in Mathematical Sciences.

In the Mechanical Design and Development Laboratory led by ***Dr. James Glancey***, research interests are in the application of solid mechanics, controls, sensors, solid modeling and electronics to a variety of problems. Goals include the development of new or improved products and automated processes, the forensics of product failures, as well as a better understanding of the underlying physics of many natural and man-made phenomena. Over the last ten years, a wide variety of research, teaching and outreach projects have been completed with the help of more than forty graduate and undergraduate students as well as partners from local and national industry and government agencies. Specific research projects are currently being conducted in the areas of automated composite modeling and manufacturing, the design of composite-based tools for improved biomechanical performance, and the mechanics of human falls.

Dr. Glancey is an Associate Professor in the Departments of Bioresources Engineering and Mechanical Engineering.

Dr. Gregory Hicks has expertise in the design of interventions for low back pain, rehabilitation strategies focused on trunk muscle function, and understanding factors that impact body composition and physical function in older adults. Ongoing studies examine the effectiveness of trunk muscle training, both volitionally and augmented by neuromuscular electrical stimulation, to reduce pain and improve functional capacity of older adults with chronic low back pain. Dr. Hicks is also conducting an investigation of the hip fracture consequences further by examining trajectories of change in bone strength, bone metabolism, muscle composition, hormones, and markers of inflammation following hip fracture, and by comparing these changes in men and women during the year following a hip fracture.

Dr. Hicks is an Assistant Professor in Physical Therapy and Biomechanics and Movement Science. He also maintains an Adjunct appointment in the Department of Epidemiology and Public Health at the University of Maryland School of Medicine.

The fundamental objective of the ***Dr. Jill Higginson's*** research group is to improve the understanding of muscle coordination in normal and pathological movement through coupled experimental and simulation studies. She uses a cause-and-effect framework to relate muscle impairments to gait deviations in order to develop a scientific rationale for therapeutic interventions. Current experiments involve three-dimensional kinematic and kinetic analysis and EMG recording during treadmill and overground gait. State-of-the-art modeling and optimization techniques are used to develop simulations based on experimental data. Ongoing research projects funded by the NIH are related to muscle deficits and subject-specific interventions for post-stroke hemiparetic gait as well as cartilage contact and compressive forces in progressive knee osteoarthritis.

Dr. Higginson is an Associate Professor in Mechanical Engineering with joint appointments in Biomedical Engineering and the interdisciplinary graduate program in Biomechanics and Movement Science. She serves as Director of the Center for Biomedical Engineering Research.

The central theme of ***Dr. Xinqiao Jia's*** research program is the design and synthesis of advanced biomaterials for the treatment of human diseases. Novel polymeric materials being developed in Dr. Jia's group include multifunctional, cross linkable micro- and nano-particles that are attractive drug delivery vehicles and synthetic extracellular matrices that resemble their natural counterparts structurally and functionally. The synthetic matrices, combined with defined mechanical cues and biological factors, create a three dimensional microenvironment for the engineering of healthy (vocal folds, salivary gland and cartilage) and pathological tissues (cancer). Dr. Jia's primary focus is on the synthesis of functional biomaterials for drug delivery and tissue engineering applications.

Dr. Jia is an Associate Professor in Materials Science and Engineering and Biomedical Engineering.

For more than 20 years, ***Dr. Michael Keefe's*** research objective has been to apply computer-aided engineering, solid modelling and system modelling. His current research involves the multi-scale interaction effects as one goes from filament to yarn to fabric. That fabric would then be used as an engineered material to support/carry loads; for example, a recent application has involved modelling with loading that is ballistic rather than quasi-static -and has the potential to impact the design of protection garments.

Dr. Keefe is an Associate Professor and Associate Chairman for Undergraduate Education in the Department of Mechanical Engineering.

Dr. Catherine Kirn-Safran is best known for her work on the study of the terminal differentiation of progenitor cells into cells producing an organized mineralized extracellular matrix (ECM) during murine embryonic development. This area of research includes the study of the mechanisms of cartilage (chondrogenesis), bone (osteogenesis), and tooth (odontogenesis) development.

Currently, Dr. Kirn-Safran is developing novel strategies to detect and slow osteoarthritis (OA) progression by using (normal and genetically engineered) cell lines and animal models of knee OA. Her approach requires the use of advanced analytical methods and imaging techniques to quantify molecular changes between normal and diseased tissue. Novel therapeutic methods for inhibiting cartilage degradation/stimulating cartilage repair are tested in preclinical animal models and will benefit a wide range of patients affected with chondral lesions.

Dr. Kirn-Safran is a research Assistant Professor in Biological Sciences, Biomechanics and Movement Science, and Biomedical Engineering.

Dr. X. Lucas Lu has a vast array of research interests that include soft tissue biomechanics, cartilage tissue engineering, cell biomechanics, theory, modeling and simulation of articular cartilage, bio-tribology of temporomandibular joint, cell force in chondrocytes, mixture theory for connective tissue, repair of cartilage lesion, and bone marrow involved cartilage repair.

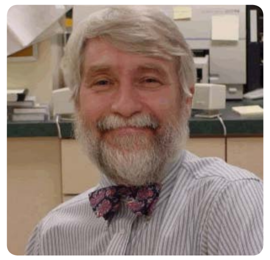
Dr. Lu is an Assistant Professor in Mechanical Engineering, Biomechanics and Movement Science, and Biomedical Engineering.

Dr. Samuel Lee's research interest is to improve the function of individuals with central nervous system injury through the application of electrical stimulation to activate paralyzed or weakened muscles. To this end, he is interested in the use of electrical stimulation as a tool to study the physiologic characteristics of muscle and the central and peripheral nervous systems; to be applied as a rehabilitative or training method to improve muscle function and strength; and as a method to produce functional movement (FES) of impaired muscles.

Dr. Lee is an Assistant Professor in Physical Therapy and Biomechanics and Movement Science.

Dr. Kurt Manal categorizes his research into musculoskeletal modeling, motion analysis and assistive technology. Muscle models can be used to compute the force generated by a muscle based on knowledge of the musculoskeletal geometry, the external forces acting on the skeleton, the joint kinematics and the muscle excitation or activation. We are currently using musculoskeletal models to estimate joint contact forces at the knee during everyday activities such as walking and going up & down stairs in healthy individuals and those with ACL injury or knee osteoarthritis. Dr. Manal has extensive experience with realtime tracking and feedback of motion analysis data and is developing the realtime capabilities of muscle force prediction. His interests in assistive technology are primarily concerned with human-computer interfaces and the design of software applications to enhance computer functionality.

Dr. Manal is a research Assistant Professor in Mechanical Engineering, Biomechanics and Movement Science, and Biomedical Engineering.



Dr. Freeman Miller is a specialist in pediatric orthopedics focused on the care of children with physical disabilities due to brain abnormalities. The primary problems of many children in his practice have cerebral palsy, although there are many children with genetic conditions like familial spastic paraparesis, Retts syndrome, chromosomal abnormalities, who also are part of his practice.

Dr. Miller has done extensive research and lectured on the prevention and treatment of hip, spine, and foot deformities occurring in children with cerebral palsy. He is currently conducting a study of how the feet develop over time. Other research projects address evaluations of bone density and possible treatment options, spasticity in children with cerebral palsy, and the impact of general physiologic conditioning and activity levels in children with cerebral palsy.

Dr. Miller is an orthopedic surgeon and the co-director of the Cerebral Palsy Program at A.I. DuPont Institute.

Dr. Christopher Modlesky's research focus, in his Musculoskeletal Physiology Laboratory, is the study of the compromised musculoskeletal system in individuals with movement and genetic disorders, such as cerebral palsy, spinal cord injury and osteogenesis imperfecta. He uses imaging techniques, such as magnetic resonance imaging and dual-energy X-ray absorptiometry, to assess the quality and quantity of bone and muscle in these groups. He is also exploring the potential effectiveness of different mechanical loading treatments, such as low-magnitude vibration, in stimulating bone and muscle development and recovery. His lab works collaboratively with all members of the Delaware Health Sciences Alliance, which includes the AI duPont Hospital for Children, Christiana Care Health System and Thomas Jefferson University.

Dr. Modlesky is an Associate Professor in Kinesiology and Applied Physiology and Biomechanics and Movement Science.

Dr. Anja Nohe's laboratory focuses on the development of new therapeutics for bone diseases, especially osteoporosis. Currently she is investigating the effect and mechanism of mimetic peptides based on Bone Morphogeneitc Protein 2 (BMP) signaling on bone formation. Using novel imaging techniques she tries to visualize the delivery and target of these peptides to induce stem cell differentiation into bone forming cells (osteoblasts) and reduce fat cell differentiation (adipogenesis) within the bone marrow.

Dr. Nohe is an Assistant Professor in Biological Sciences and Biomedical Engineering.

Dr. Ioannis Poulakakis' current research interests are in the area of dynamics and control with application to bio-inspired robotic systems, specifically monopedal, bipedal and quadrupedal robots. In addition to his work in legged locomotion, he has recently started to investigate problems pertaining to the dynamics of collective decision making in multi-agent systems. Prior to working with legged robots and decision making, Dr. Poulakakis developed algorithms for path planning and obstacle avoidance for nonholonomic mobile manipulators.

Dr. Poulakakis is an Assistant Professor in Mechanical Engineering and Biomedical Engineering.

Dr. Ajay Prasad is an expert in developing optical diagnostic tools and applying them to flows of interest in basic and applied problems. In particular, he has contributed to the development of Particle Image Velocimetry, which is a laser/video-based flow measurement technique that provides instantaneous velocity data over extended domains with high accuracy. Dr. Prasad has applied this technique with anatomically accurate in-vitro models to understand flow and mixing in the human nasal passages, the bifurcating passages in the conducting region of the lung, and in the alveoli.

Dr. Prasad's other research interests lie in the area of clean energy including fuel cells, Li-ion batteries, wind and ocean current energy, and vehicle-to-grid technology. He is also interested in energy-efficient, solar-powered buildings.

Dr. Prasad is a Professor in Mechanical and Biomedical Engineering, Biomechanics & Movement Science, and he directs the UD Center for Fuel Cell Research as well as the UD Fuel Cell Bus Program.

Dr. Christopher Price's research focuses on the role that load-induced solute transport and fluid flow has on the development, maintenance, adaptation, and degeneration of both bone and cartilage, especially with respect to the disease etiology of osteoporosis and osteoarthritis. His current research includes investigations into the biology and mechanics of bone and cartilage adaptation, the direct quantification and modeling of fluid flow within healthy and diseased tissues, and the development of novel advanced imaging techniques for the investigation and solute/fluid transport in biological tissues. He is also exploring novel imaging-based functional markers of musculoskeletal degeneration and disease, and the development of rational, bio-mechanically inspired treatment and prevention paradigms for both bone loss and cartilage degeneration.

Dr. Price is a research Assistant Professor in Mechanical Engineering.

Dr. Darcy Reisman's lab has been investigating the movement deficits of persons with neurologic injury and the study of treatment interventions aimed at addressing those deficits. In addition, they have been studying basic movement coordination and the neurophysiologic and biomechanical processes underlying this coordination. In her ongoing study of neurobiological factors and motor learning following stroke, Dr. Reisman is examining the relationship between brain-derived neurotrophic factor (BDNF), which is involved in mediating cortical plasticity and learning, and motor learning in persons post-stroke compared to age- and gender-matched control subjects.

Dr. Reisman is an Assistant Professor in Physical Therapy and Biomechanics and Movement Science.

Dr. Todd Royer's research interests are biomechanics and energetics of gait, amputee locomotion, and knee osteoarthritis. His lab is currently investigating secondary disability of lower-extremity amputation (e.g., gait asymmetry, increased metabolic cost of locomotion, increased risk of joint degradation) and as well as a conservative in-shoe wedged orthotic treatment for knee osteoarthritis.

Dr. Royer is an Associate Professor in Kinesiology and Applied Physiology and Biomechanics and Movement Science.

Dr. Jim Richards has a long-standing interest in sports biomechanics and rehabilitation biomechanics. He maintains active collaborations with the Shriner's Hospital in Philadelphia and the AI duPont Hospital for Children in Wilmington, Delaware. Current research activities include the design of innovative modalities to measure scapular kinematics in healthy individuals and children with brachial plexus birth palsy. He has also contributed substantially to the understanding and application of biomechanics in elite figure skating. Recent papers have addressed the implications of unanticipated missteps in the elderly, shoulder function in collegiate baseball players, predicting success of rectus femoris transfer surgery in children with cerebral palsy and a range of other topics.

Dr. Richards is a Distinguished Professor of Kinesiology and Applied Physiology and Biomechanics and Movement Science.

The unifying theme to ***Dr. Michael Santare's*** research is the mechanics of complex material systems in which microstructure is a key element. Examples of these systems include composites, fuel cell membranes, biological tissues, functionally graded materials and damaged materials. He employs a combination of analytical, computational and experimental research techniques to develop models to predict the behavior of these materials to external loads. These models are then used to study the relationships between material parameters and mechanical response. In technological systems, this is critical information for engineering design, manufacturing and construction. In natural systems, the load-response behavior of materials is important for the understanding of natural phenomena such as fracture and orthopedic disease.

Dr. Santare is a Professor in Mechanical Engineering, Biomedical Engineering and Biomechanics and Movement Science.

Dr. John Scholz' laboratory investigates the effect of gait retraining using robotic exoskeletons on the recovery of walking in persons post-stroke (in collaboration with Agrawal, Binder-Macleod and Higginson), the development of upper extremity robotic training paradigms for arm function recovery post-stroke (collaboration with Agrawal), the effect of sensory information on the coordination of upright posture (collaboration with John Jeka, University of Maryland and Gregor Schöner, Rühr University, Germany), and mechanisms of joint and muscle coordination for upper limb function (collaborations with Mark Latash, Penn State, Gregor Schöner, Rühr University, Germany).

Dr. Scholz is a Professor in Physical Therapy and Biomechanics and Movement Science.

Dr. Erica Selva's research interests include the studies of signal transduction which have yielded a wealth of information about the molecules required to transmit signals from the cell surface to the nucleus. Yet it still remains unknown how a signaling pathway can be differentially modulated to yield unique outcomes from similar cellular contexts. Recently, it has become clear that glycosylation as well as other posttranslational events play a crucial role in the temporal and spatial regulation of signal transmission by altering extracellular receptor-ligand interactions. The objective of her research is to use Drosophila melanogaster as a model system to study the function of posttranslational changes during developmentally critical signaling events.

Dr. Selva is an Associate Professor in Biological Sciences.

Dr. Lynn Snyder-Mackler conducts research on sports-related knee and shoulder injuries. She concentrates her clinical practice and research in the areas of knee and shoulder rehabilitation, and electrical stimulation of muscle. She has authored many research publications in the areas of knee and shoulder rehabilitation and neuromuscular electrical stimulation and regularly speaks to national international audiences on these topics. She was named a Catherine Worthingham Fellow of the American Physical Therapy Association in 2003. Her research has won several major awards by helping patients and practitioners and answering critical questions in sports and orthopedic rehabilitation.

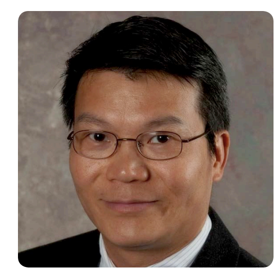
Dr. Snyder-Mackler is an Alumni Distinguished Professor in Physical Therapy and Biomechanics and Movement Science.

Dr. Steven Stanhope's research interests include biomechanics, orthopaedic rehabilitation, prosthetics, orthotics, and human movement analysis. A team of researchers led by the University of Delaware was awarded a five-year, $19.7 million grant from the Department of Defense to establish evidence-based orthopaedic rehabilitation care that optimizes the ability of soldiers with musculoskeletal injuries to function in everyday life. This award was made through DOD's Office of Congressionally Directed Medical Research Programs to the BADER Consortium, which brings together military training facilities, academic researchers and rehabilitation institutes. Dr. Stanhope is the principal investigator and consortium director.

Dr. Stanhope is a professor in Kinesiology and Applied Physiology, Mechanical Engineering, and Biomechanics and Movement Science.

Dr. Buz Swanik's primary research interests focus on the neuromechanical regulation of joint stiffness, in particular how certain sensorimotor or neuropsychological characteristics may lead to accidents and unintentional injury.

Dr. Swanik is an Associate Professor in Kinesiology and Applied Physiology. In 2011 he became the Director of the interdisciplinary graduate program in Biomechanics and Movement Science (BIOMS).



Dr. Lian-Ping Wang's work on modeling of flow through soil porous media and transport of colloids is relevant to transport through biological tissues. His research group is also developing a mesoscopic approach based on the lattice Boltzmann equation for complex and multiphase flows, which has the potential to be applied to biological systems. Current applications, however, are in environmental fluid systems.

Dr. Wang is a Professor in Mechanical Engineering and Biomedical Engineering.

Dr. Liyun Wang's current research focuses on biomechanics in musculoskeletal system, in particular fluid and solute transport in bone and cartilage. 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. She also seeks to understand the role of subchondral bone in the development of osteoarthritis (OA) due to aging and altered joint loading. Being a highly vascularized tissue, bone may respond to the altered joint loading rapidly by increasing bone turnover, which may in turn lead to changes in cartilage.

Several projects are being undertaken in Dr. Wang's laboratory (1) to investigate how solute diffusion and convection are modulated by the ultrastructures of the fluid pathway and mechanical stimuli in normal and diseased bones; (2) to develop novel imaging methods to quantify the interstitial fluid flow in bone and cartilage; (3) to use animal models to elucidate the etiology of OA.

Dr. Wang is an Associate Professor in Mechanical Engineering, Biomedical Engineering and Biomechanics and Movement Science.

Dr. Joseph Zeni, Jr.'s research includes investigations into the biomechanical factors that result in the progression of osteoarthritis and treatment interventions aimed at reducing disability associated with knee pathology. His particular interest is in altered movement patterns after total joint replacement and the relationship to disease progression in the non-operated limb. Currently, he is working on innovative and engaging physical therapy interventions to reduce movement asymmetry after total joint replacement and maximize long-term functional outcomes.

Dr. Zeni is an Assistant Professor in Physical Therapy and Biomechanics and Movement Science.

RECENT PUBLICATIONS

1. Agrawal, S.K., Chen, X., Ragonesi, C., Galloway, J.C. "A Novel Haptic Guidance for Learning Steering with Application to Special Needs Children", IEEE Transactions on Haptics. (In Press).
2. Alnahdi, A., Zeni, J., Snyder-Mackler, L. "Gait after unilateral total knee arthroplasty", Journal of Orthopaedic Research, 29(5): 647-52. doi: 10.1002/jor.21323. (2011).
3. Altman, A.R., Reisman, D.S., Higginson, J.S., I.S. Davis. "Comparison of split-belt and single-belt treadmill walking and the effects of accommodation", Gait and Posture. (In Press).
4. Barrios, J.A., Royer, T., Davis, I.S. "Dynamic versus radiographic alignment in relation to medial knee loading in symptomatic osteoarthritis", Journal of Applied Biomechanics. (In press).
5. Bhat, A., Galloway, J.C., Landra, B. "Current perspectives on motor functioning in infants and children with autism spectrum disorders", Physical Therapy, 91, (In press).
6. Bonnevie, E.D., Baro, V., Wang, L., Burris, D.L. "In-situ studies of cartilage microtribology: roles of speed and contact area", Tribology Letters, 41: 83-95 (2011).
7. Borthakur, A., Maurer, P.M., Fenty, M., Wang, C., Berger, R., Yoder, J.H., Balderston, R.A., Elliott, D.M. "T1r MRI and discography pressure as novel biomarkers for disc degeneration and low back pain", Spine, (In press).
8. Buchanan, J., Gilbert, R., Ou, M. "Wavelet decomposition of transmitted ultrasound wave through a 1-D muscle-bone system", Journal of Biomechanics, 44 (2): 352-358 (2011).
9. Buchanan, J., Gilbert, R., Ou, M. "Transfer functions for a one-dimensional fluid-poroelastic system subject to an ultrasonic pulse", Nonlinear analysis: Real World Applications, http: //dx.doi.org/10.1016/j.nonrwa.2011.02.00
10. Gilbert, R., Buchanan, J., Ou, M.Y. "Recovery of the parameters of cancellous bone by inversion of effective velocities, and transmission and reflection coefficients", Inverse Problems, (In press).
11. Butler, R.J., Barrios, J., Royer, T., Davis, I.S. "Frontal plane gait mechanics differ between individuals with medial and lateral knee osteoarthritis", Physical Therapy, 91(8), 1235-1243. (2011).
12. Chandrasekaran, V.C.S, Advani, S.G., Santare, M.H., "Influence of Resin Properties on Interlaminar Shear Strength of Glass/Epoxy/MWNT Hybrid Composites", Composites Part A, v. 42, #8, p. 1007-16, (2011).
13. Chandrasekaran, V.C.S., Santare, M.H., Krishnan, P., Advani, S.G., "Amino Functionalization of MWNTs and Their Effect on ILSS of Hybrid Nanocomposites", Composite Interfaces, v. 18, #4, p. 339-55, (2011).
14. Chen, X., Ragonesi, C., Galloway, J.C., Agrawal, S.K. "Training Toddlers Seated on Mobile Robots to Drive Indoors among Obstacles," IEEE Transactions on Neural Systems and Rehabilitation Engineering, Vol. 19, No. 3, 271-279. (2011).
15. Chhabra, S., Prasad, A.K. "Flow and particle dispersion in lung acini: Effect of geometric and dynamic parameters during synchronous ventilation", Journal of Fluids Engineering, 133:071001-1-10, (2011).
16. Choi, J.S., Zhao, L., Park, G.J., Agrawal, S.K., Colonay, R.L. "Enhancement of a Flapping Wing Using Path and Dynamic Topology Optimization", AIAA Journal. (In Press).
17. Cortes, D.H., Elliott, D.M. "Extra-fibrillar matrix mechanics of annulus fibrosus in tension and compression", Biomechanics and Modeling in Mechanobiology, (In press).
18. Costi, J.J., Freeman, B.J.C., Elliott, D.M. "Intervertebral disc properties: challenges for biodevices", Expert Reviews 8(3):357-76, (2011).
19. Crawford, R., Nathan, R., Wang, L., Wu, Q. "Experimental Study on the Lift Generation inside a Random Synthetic Porous Layer under Rapid Compaction", Experimental Thermal and Fluid Science, 36: 205-216. (2012).
20. DiSanto, T.J., Swanik, C.B., Swanik, K.A., & Straub, S.J. "Concurrent Validity of the Anterior Drawer Test and an Arthrometer in Evaluating Ankle Laxity", Athletic Training & Sports Health Care, Jan;. 3(1): 15-20 (2011).
21. Driscoll, T.P., Nerurkar, N.L., Jacobs, N.T., Elliott, D.M., Mauck, R.L. "Fiber angle and aspect ratio influence the shear mechanics of oriented electrospun nanofibrous scaffolds", Journal of the Mechanical Behavior of Biomedical Materials 4(8): 1627-36, (2011).
22. Dubey, V.N., Agrawal, S.K."Study of an upper-arm exo-skeleton for gravity balancing and minimization of transmitted forces", Proc. IMechE Vol. 225 Part H: J. Engineering in Medicine, 1025-1035. (2011).
23. Farran, A.J.E., Teller, S.S., Jia, F., Clifton, R.J., Duncan, R.L., Jia, X. "Design and Characterization of a Dynamic Vibrational Culture System", J. Tissue Eng Regen. M., (In press).
24. Fattah, A., Hajizadeh, K., Agrawal, S.K. "Gravity Balancing of a Human Leg Using an External Orthosis, "ASME Journal of Medical Devices, Vol. 5, 2011, 011002-(1-10).
25. Feitas, S.M.S.F., Gera, G., Scholz, J.P. "Trajectory timing variability of reach trajectories in left versus right hemisphere stroke", Brain Research. (In Press).

RECENT PUBLICATIONS

26. Gao, H., Li, H., Wang, L.P. "Lattice Boltzmann Simulation of Turbulent Flow Laden with Finite-Size Particles, Computers & Mathematics with Applications", doi:10.1016/j.camwa.2011.06.028 (2011).

27. Gomez-Gil, J., Ryu, J.C., Alonso-Garcia, S., Agrawal, S.K. "Control of an Agricultural Vehicle: Simulations and Experiments", ASBAE. (In Press).

28. Grabowski, W.W., Andrejczuk, M., Wang, L.-P. "Droplet growth in a bin warm-rain scheme with Twomey CCN activation", Atmospheric Research, 99, 290-301 (2011).

29. Greene, A.C., Zhu, J., Pochan, D.J., Jia, X., Kiick, K.L. "Poly (Acrylic Acid-b-Styrene) Amphiphilic Multiblock Copolymers as Building Blocks for the Assembly of Discrete Nanoparticles", Macromolecules, 44, 1942-1951. (2011).

30. Grieshaber, S.E., Nie, T., Yan, C., Zhong, S., Teller, S.S., Clifton, R.J., Pochan, D.J., Kiick, K.L., Jia, X. "Assembly Properties of Alanine-Rich, Lysine-Containing Peptide and the Formation of Peptide/Polymer Hybrid Hydrogels", Macromol. Chem. Phys., 212, 229-239. (2011).

31. Gutierrez, G.M., Knight, C.A., Swanik, C.B., Royer, T., Manal, K., Caulfield, B., Kaminski, T.W. "Examining Neuromuscular Control During Landings on a Supinating Platform in Persons With and Without Ankle Instability", Am J Sports Med., (In Press).

32. Gilbert, R., Guyenne, P., Ou, M.Y. "A quantitative ultrasound model of bone with blood as the interstitial fluid", Math. Comp. Modelling, (In press).

33. Gilbert, R., Hackl, K.,Ilic, S. "Application of a biphasic representative volume element to the simulation of wave propagation through cancellous bone", Journal of Computational Acoustics, 19, (2) 111138. (2011).

34. Hakansson, N.A., Kesar, T., Reisman, D., Binder-Macleod, S., Higginson, J.S. "Effects of FastFES gait training on mechanical recovery in post-stroke gait", Artificial Organs, 35(3): 217-20, 2011.

35. Hartigan, E.H., Zeni, J. Jr., Di Stasi, S., Axe, M.J., Snyder-Mackler, L. "Preoperative Predictors for Non-Copers to Pass Return to Sports Criteria After ACL Reconstruction", J Appl Biomech. (2011).

36. Henderson, C.E., Barrance, P.J., Higginson, J.S. "Comparison of MRI-based estimates of articular cartilage contact area in the tibiofemoral joint", Journal of Biomechanical Engineering, 133 (1). (2011).

37. Heo, S.J., Nerurkar, N.L., Baker, B.M., Shin, J.W., Elliott, D.M., Mauck, R.L. "Fiber stretch and reorientation modulates mesenchymal stem cell morphology and fibrous gene expression on oriented nanofibrous microenvironments", Annals of Biomedical Engineering, 39(11):2780-90, ** selected for cover art** (2011).

38. Higginson, J.S., Ramsay, J.W., Buchanan, T.S. "Hybrid models of the neuromusculoskeletal system improve subject-specificity", Proceedings of the Institution of Mechanical Engineers, Part H, Journal of Engineering in Medicine. (In Press).

39. Holmes, L., Cornes, M.J., Foldi, B., Miller, F., Dabney, K. "Clinical epidemiologic characterization of orthopaedic and neurological manifestations in children with leukodystrophies", J Pediatr Orthop. 31(5):587-93. (2011).

40. Hsu, W.-L., Scholz, J.P. "Motor abundance supports multi-tasking while standing", Human Movement Science, (In press).

41. Jacobs, N.T., Smith, L.J., Han, W.M., Morelli, J.D., Yoder, J.H., Elliott, D.M. "Effect of orientation and targeted extracellular matrix degradation on annulus fibrosus shear mechanical properties", Journal of the Mechanical Behavior of Biomedical Materials 4(8):1611-9, (2011).

42. Jha, A.K., Xu, X., Duncan, R.L., Jia, X. "Controlling the Adhesion and Differentiation of Mesenchymal Stem Cells Using Hyaluronic Acid-based, Doubly Crosslinked Networks", Biomaterials, 32, 2466-2478. (2011).

43. John, C., Anderson, F., Higginson, J., Delp, S. "Stabilization of walking by intrinsic muscle properties revealed in a three-dimensional muscle-driven simulation", Computer Methods in Biomechanics and Biomedical Engineering. (In Press).

44. Johnston, T.E., Modlesky, C.M., Betz, R.R., Lauer, R.T. "Muscle changes following cycling and/or electrical stimulation in pediatric spinal cord injury", Arch Phys Med Rehab. (In press).

45. Kesar, T.M., Binder-Macleod, S.A., Hicks, G.E., Reisman, D.S. "Minimal detectable change for gait variables collected during treadmill walking in individuals post-stroke", Gait Posture, 33(2): 314-317. (2011).

46. Kesar, T.M., Perumal, R., Reisman, D.S., Rudolph, K.S., Higginson, J.S., Binder-Macleod, S.A. "Combined effects of fast treadmill walking and functional electrical stimulation on post-stroke gait", Gait and Posture, 33 (2), pp. 309-313. (2011).

47. Khan, Z.A., Agrawal, S.K., "Optimal Hovering Kinematics of Flapping Wings for Micro Air Vehicles", AIAA Journal, Vol. 49, No. 2, 257-268. (2011).

48. Khan, Z.A., Agrawal, S.K. "Study of Biological Inspired Flapping Mechanism for Micro Air Vehicles", AIAA Journal, Vol. 49, No. 7, 1354-1365. (2011).

49. Krishna, O.D., Jha, A.K., Jia, X., Kiick, K.L. "Integrin-Mediated Adhesion and Proliferation of Human MSC Elicited by a Hydroxyproline-Lacking, Collagen-like Peptide", Biomaterials, 32, 6412-6424. (2011).

50. Kubinski, A.J., Higginson, J.S. "Strategies used during a challenging weighted walking task in healthy adults and individuals with knee osteoarthritis", Gait and Posture. (In Press).

51. Kusoglu, A., Karlsson, A.M., Santare, M.H. "Aspects of Fatigue Failure Mechanisms in Polymer Fuel Cells Membranes," Journal of Polymer Science: Part B: Polymer Physics, v. 49, #21, p. 1506-17, (2011).

52. Lake, S.P., Cortes, D.H., Kadlowec, J.A., Soslowsky, L.J., Elliott, D.M. "Evaluation of affine fiber kinematics in human supraspinatus tendon using quantitative projection plot analysis", Biomechanics and Modeling in Mechanobiology, (In press).

53. Lau, E., Lee, D., Li, J., Davies, J.E., Wu, Q., Wang, L., You, L. "Effect of low-magnitude, high-frequency vibration on osteogenic differentiation of rat mesenchymal stromal cells", J Orthopaedic Research, 29:1075-80. (2011).

54. Lazouskaya, V., Wang, L.P., Gao, H., Shi, X., Czymmek, K., Jin, Y. "Pore-scale investigation of colloid retention and mobilization in presence of dynamic air-water interface", Vadose Zone J., doi:10.2136/vzj2011.0003 (2011).

55. Li, L., Teller, S., Clifton, R.J., Jia, X., Kiick, K.L. "Tunable Mechanical Stability and Deformation Response of a Resilin-based Elastomer", Biomacromolecules, 12, 2302-2310. (2011).

56. Lobo, M.A., Galloway, J.C. "Enhanced Handling and Positioning in Early Infancy Advances Development Throughout the First Year", Child Development (In press).

57. Logan, S.W., Modlesky, C.M., Scrabis-Fletcher, K., Getchell, N.A. "The relationship between motor skill proficiency and body mass index in preschool children", Research Quarterly for Exercise & Sport, 82 (3): 44 2-8 (2011).

58. Lu, X.L., Huo, B., Chiang, V., Guo, X.E. "Osteocytic Network Is More Responsive in Calcium Signaling than Osteoblastic Network under Fluid Flow", Journal of Bone and Mineral Research, doi: 10.1002/jbmr.1474. (2011).

59. Lu, Z., Kim, C., Karlsson, A.M., Cross, J.C., Santare, M.H. "Effect of GDL Modulus and Land-Groove Geometry on Membrane Stresses in PEM Fuel Cells," Journal of Power Sources, v. 196, #10, p. 4646-54, (2011).

60. Maser, R.E., Kolm, P., Modlesky, C.M., Beck, T.J., Lanhard, M.J. "Hip strength in adults with type 1 diabetes is associated with age at onset of diabetes", J Clin Densitom, (In press).

61. Mattos, D., Park, E., Kuhl, J., Scholz, J.P., Latash, M.L. "Unpredictable elbow joint perturbation during reaching results in multijoint motor equivalencel", Journal of Neurophysiology, First published Online June 15, 2011; doi:10.1152/jn.00163.2011. (2011).

62. McClelland, J.A., Zeni, J.A., Haley, R., Snyder-Mackler, L. "Functional and Biomechanical Improvement in a Patient after Total Knee Arthroplasty: The Benefits of Symmetry Retraining", Journal of Orthopaedic and Sports Physical Therapy. (In Press).

63. Miller, F. "The effects of continuous intrathecal baclofen infusion in non-ambulant children with cerebral palsy," Dev Med Child Neurol. 53(8):679-80. doi: 10.1111/j.1469-8749.2011.04026.x. (2011).

64. Modlesky, C.M., Bajaj, D., Kirby, J.T., Mulrooney, B.M., Rowe, D.A., Miller, F. "Sex differences in trabecular bone microarchitecture are not detected in pre and early pubertal children using magnetic resonance imaging", Bone. 49(5):1067-72. (2011).

65. Moffit, D.M., Swanik, C.B. "The association between athleticism, prenatal testosterone, and finger length", J Strength and Conditioning Res., April, 25 (4): 1085-1088 (2011).

66. Mustafa, S.K., Agrawal, S.K., "On the Force-Closure Analysis of n-DOF Cable-Driven Open Chains Based on Reciprocal Screw Theory", IEEE Transactions on Robotics. (2011).

67. Nazarian, D.G., Zeni, J. "Management of a pelvic mass following a worn uncemented total hip arthroplasty", J Arthroplasty. (2011).

68. Nerurkar, N.L., Han, W., Mauck, R.L., Elliott, D.M. "Homologous structure-function relationships between native fibrocartilage and tissue engineered from MSC-seeded nanofibrous scaffolds", Biomaterials 32(2):461-8, (2011).

69. Nerurkar, N.L., Mauck, R.L., Elliott, D.M. "Modeling interlamellar interactions in angle-ply biologic laminates for annulus fibrosus tissue engineering", Biomechanics and Modeling in Mechanobiology, (2011).

70. Nerurkar, N.L., Sen, S., Baker, B.M., Elliott, D.M., Mauck, R.L. "Dynamic culture enhances stem cell infiltration and modulates extracellular matrix production on aligned electrospun nanofibrous scaffolds", Acta Biomaterialia 7(2):485-91l, (2011).

71. O'Connell, G.D., Jacobs, N.T., Sen, S., Vresilovic, E.J., Elliott, D.M. "Axial creep loading and unloaded recovery of the human intervertebral disc and the effect of degeneration", Journal of the Mechanical Behavior of Biomedical Materials, 4(7): 933-42, (2011).

72. O'Connell, G.D., Malhotra, N.R., Vresilovic, E.J., Elliott, D.M. "The effect of nucleotomy and the dependence on degeneration of human intervertebral disc strain in axial compression", Spine, 36(21):1765-71, (2011).

RECENT PUBLICATIONS

73. O'Connell, G.D., Sen, S., Elliott, D.M. "Human annulus fibrosus matieral properties from biaxial testing and constitutive modeling are altered with degeneration", Biomechanics and Modeling in Mechanobiology, (In press).

74. O'Connell, G.D., Vresilovic, E.J., Elliott, D.M. "Human intervertebral disc internal strain in compression: the effect of disc region, loading position, and degeneration", Journal of Orthopaedic Research 29(4):547-55, (2011).

75. O'Reilly, R.C., Greywoode, J., Morlet, T., Miller, F., Henley, J., Church, C., Campbell, J., Beaman, J., Cox, A.M., Zwicky, E., Bean, C., Falcheck, S. "Comprehensive vestibular and balance testing in the dizzy pediatric population",Otolaryngol Head Neck Surg. ;144(2):142-8, (2011).

76. Oto, M., Thabet, A., Miller, F., Holmes, L. "Correlation between selective pedobarographic and radiographic measures in the assessment of surgically treated CTEV patients", Eklem Hastalik Cerrahisi. 22(3):145-8, (2011).

77. Pan, J., Wang, B., Wen, L., Zhou, X, Scherr, T., Yang, Y, Price, C., Wang, L. "Elevated cross-talk between subchondral bone and cartilage in osteoarthritic joints", Bone, (In press).

78. Gilbert, R., Panchenko, A., Barannyk, A. "Closure method for spatially averaged dynamics of particle chains", Nonlinear Anal. Real World Appl., 12, 1681–1697, (2011).

79. Gilbert, R., Panchenko, A.,Vasilic, A. "Homogenizing the acoustics of cancellous bone with an interstitial non-Newtonian fluid", Nonlinear Anal., 74, 1005–1018, (2011).

80. Price, C., Zhou, X., Li, W., Wang, L. "Real-time measurement of solute convection within the lacunar-canalicular system of mechanically loaded bone: direct evidence of load-induced fluid flow", J Bone Miner Res, 26:277-85, (2011).

81. Ramsay, J.W., Barrance, P.J., Buchanan, T.S., Higginson, J.S. "Paretic muscle atrophy and non-contractile tissue content in individual muscles of the post-stroke lower extremity", Journal of Biomechanics, 44 pp. 2741-2746, (2011).

82. Rawal, R., Miller, F., Modlesky, C.M. "Effect of a novel procedure for limiting motion on body composition and bone estimates by dual-energy X-ray absorptiometry in children", Journal of Pediatrics,159 (4): 691-4e2, (2011).

83. Riad, J., Modlesky, C.M., Gutierrez-Farewik, E.M., Broström, E. "Are muscle volume differences related to concentric work during walking in spastic hemiplegic cerebral palsy?" Clin Orthop Relat Res, (In press).

84. Rosa, B., Wang, L.P., Maxey, M.R., Grabowski, W.W. "An accurate model for aerodynamic interactions of cloud droplets", J. Comp. Phys., 230, 8109-8133 (2011).

85. Ryu, J.C., Agrawal, S.K., "Differential Flatness Based Robust Control of Mobile Robots in the Presence of Slip", International Journal of Robotics Research, Vol. 30, No. 4, 463-475. (2011).

86. Schoepflin, Z.R., Chen, X., Ragonesi, C.B., Galloway, J.C., Agrawal, S.K., "Design of a Novel Mobility Device Controlled by the Feet Motion of a Standing Child - A Feasibility Study", Medical & Biological Engineering & Computing. (In Press).

87. Scholz, J.P., Tseng, Y.W., Dwight, T., Lynch, J., Martin, V., Schöner, G. " Motor equivalence and self-motion induced by different movement speeds", Experimental Brain Research, 209: 319-332 (2011).

88. Schrank, E., Stanhope, S.J. "Dimensional accuracy of ankle-foot orthoses constructed by an automated fit customization and rapid manufacturing framework", Journal of Rehabilitation Research & Development, 48(1):31-42. (2011).

89. Senaran, H., Yilmaz, G., Nagai, M.K., Thacker, M., Dabney, K.W., Miller, F. "Subtalar fusion in cerebral palsy patients: results of a new technique using corticocancellous allograft", J Pediatr Orthop. 31(2):205-10. PMID:21307716 (2011).

90. Smith, L.J., Chiaro, J.A., Nerurkar, N.L., Cortes, D.H., Horava, S.D., Hebela, N.M., Mauck, R.L., Dodge, G.R., Elliott, D.M. "Nucleus pulposus cells synthesize a functional extracellular matrix and respond to inflammatory cytokine challenge following long term agarose culture", European Cells and Materials, 20;22:291-301, (2011).

91. Smith, L.J., Elliott, D.M. "Formation of lamellar cross bridges in the annulus fibrosus of the intervertebral disc is a consequence of vascular regression", Matrix Biology 30(4):267-74, (2011).

92. Smith, L.J., Nerurkar, N.L., Choi, K.S., Harfe, B.D., Elliott, D.M. "Degeneration and regeneration of the intervertebral disc: lessons learned from development", Dis Model Mech 4(1):31-41, (2011).

93. Sreenath, K., Park, H.W., Poulakakis, I., Grizzle, J.W. "A Compliant Hybrid Zero Dynamics Controller for Stable, Efficient and Fast Bipedal Walking on MABEL", International Journal of Robotics Research, Vol. 30, No. 9, pp. 1170--1193, (2011).

94. Srinivasan, P.P., McCoy, S.Y., Jha, A.K., Yang, W., Jia, X., Farach-Carson, M.C., Kirn-Safran, C.B. "Injectable Perlecan Domain 1-Hyaluronan Microgels Potentiate the Cartilage Repair Effect of BMP2 in a Murine Model of Early Osteoarthritis", Biomed. Mater., (In press).

95. Su, J.H., Xu, F., Lu, X.L., Lu, T.J. "Fluid flow induced calcium response in osteoblasts: mathematical modeling", Journal of Biomechanics, 44(11):2040-2046. (2011).

96. Swanik, C.B., Kim, A. "Neurocognitive factors of Injury Risk", Lower Extremity Review, September (2011).

97. Swanik, K..A., Huxel, K..C., Swanik, C.B. "Rotator Cuff Muscle Recruitment Strategies during Shoulder Rehabilitation Exercises", Journal of Sports Rehabilitation 20(4):471-8, (2011).

98. Tang, C.P., Miller, P.T., Krovi, V., Ryu, J.C., Agrawal, S.K., "Differential Flatness-based Planning and Control of a Wheeled Mobile Manipulator – Theory and Experiment", IEEE Transactions of Mechatronics, Vol. 16, No. 4, 768-772. (2011).

99. Temel, M., Rudolph, K., Agrawal, S.K., "Gait Recovery in Healthy Subjects: Perturbations to the Knee Motion with a Smart Knee Brace", Advanced Robotics, Vol. 25, No. 15, 1857-1877. (2011).

100. Thomas, S.J., Swanik, C.B., Higginson, J.S., Kaminski, T.W., Swanik, K.A., Bartolozzi, A.R., Abboud, J.A., Nazarian, L.N. "A bilateral comparison of posterior capsule thickness and its correlation with glenohumeral range of motion and scapular upward rotation in collegiate baseball players", J Shoulder Elbow Surg. Jul., 20(5):708-16 (2011).

101. Thomas, S.J., Swanik, C.B., Kaminski, T.W., Swanik, K.A., Higginson, J.S., Bartolozzi, A.R, Nazarian, L. "Humeral retroversion and its association with posterior capsule thickness in collegiate baseball players", Journal of Shoulder and Elbow Surgery. (In Press).

102. Thomas, S.J., Swanik, K.A., Swanik, C.B., Huxel, K.C., Kelly, J.D. "Change in Glenohumeral Rotation and Scapular Position After Competitive High School Baseball", Journal of Sport Rehabilitation, 19(2) (2011).

103. Thompson, W.R., Modla, S., Grindel, B.J., Czymmek, K.J., Kirn-Safran, C.B., Wang, L., Duncan, R.L., Farach-Carson, M.C. "Perlecan/HSPG2 Deficiency Alters the Pericellular Space of the Lacuno-Canalicular Network Surrounding Osteocytic Processes in Cortical Bone", Journal of Bone and Mineral Research, 26: 618-29 (2011).

104. Tong, Z., Sant, S., Khademhosseini, A., Jia, X. "Controlling the Fibroblastic Differentiation of Mesenchymal Stem Cell via the Combination of Fibrous Scaffolds and Connective Tissue Growth Factor", Tissue Eng Part A, 17, 2773-2785. (2011).

105. Twiss, J.L., Donnelly, C.J., Willis, D.E., Xu, M., Tep, C., Yoo, S.O., Schanen, N.C., Kirn-Safran, C.B., van Minnen, J., English, A., Yoon, S.O., Bassell, G.J., Jiang, C. "Limited availability of ZBP1 restricts axonal mRNA localization and nerve regeneration capacity", EMBO Journal, (In press).

106. Tyrell, C.M., Roos, M.S., Rudolph, K.S., Reisman, D.S. "Infuence of Systematic Increases in Treadmill Walking Speed on Gait Kinematics After Stroke", Physical Therapy, 91: 392-403. (2011).

107. Wang, X., Gurski, L.A., Zhong, S., Xu, X., Pochan, D.J, Farach-Carson, M.C., Jia, X. "Amphiphilic Block Co-polyesters Bearing Pendant Cyclic Ketal Groups as Nanocarriers for Controlled Release of Camptothecin", J. Biomat. Sci.-Polym. E, 22, 1275-1298. (2011).

108. Willis, D.E., Xu, M., Donnelly, C.J., Tep, C., Kendall, M., Erenstheyn, M., Schanen, N.C., Kirn-Safran, C.B., English, A., Yoon, S.O., Bassell, G.J., Twiss, J.L. "Axonal localization of transgene mRNA in mature PNS and CNS neurons", Journal of Neuroscience, (In press).

109. Wyszogrodzki, A.A., Grabowski, W.W., Wang, L.P. "Activation of cloud droplets in bin-microphysics simulation of shallow convection", Acta Geophysica, 59 (6), 1-16, DOI: 10.2478/s11600-011-0052-y (2011).

110. Xu, X., Jha, A.K., Duncan, R.L., Jia, X. "Heparin-Decorated, Hyaluronic Acid-Based Hydrogel Particles for the Controlled Release of Bone Morphogenetic Protein 2", Acta Biomater, 7, 3050-3059. (2011).

111. Zanotto, D., Rosati, G., Agrawal, S.K., "On the Design of Adaptive Cable Driven Systems" Journal of Mechanisms and Robotics, Transactions of the ASME, Vol. 3, No. 2, 021004-(1-13). (2011).

112. Zeni, Jr., J.A., Higginson, J.S. "Knee osteoarthritis affects the distribution of joint moments during gait", The Knee, 18(3): 156-9. (2011).

Center for Biomedical Engineering Research (CBER)
UNIVERSITY of DELAWARE
201 Spencer Laboratory
Newark, DE 19716

College of Engineering

Center for Biomedical Engineering Research (CBER)
(302) 831-3466
cber-info@udel.edu
www.cber.udel.edu