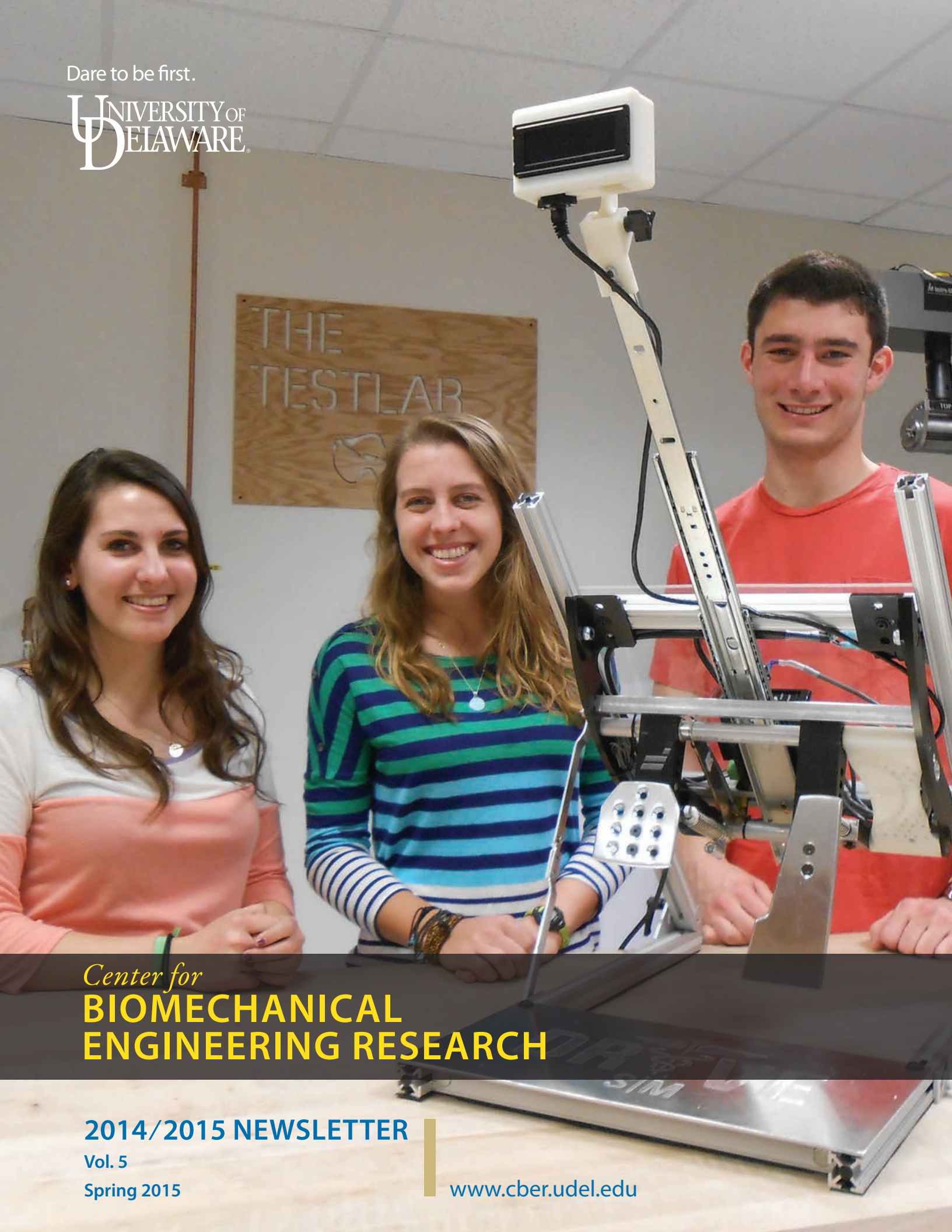


Dare to be first.



Center for
**BIOMECHANICAL
ENGINEERING RESEARCH**

2014/2015 NEWSLETTER

Vol. 5

Spring 2015

www.cber.udel.edu

Center for BIOMECHANICAL ENGINEERING RESEARCH

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MISSION STATEMENT

The Center for Biomechanical Engineering Research, CBER, is an interdisciplinary center with the mission is to provide engineering science and clinical technology to reduce the impact of disease on the everyday life of individuals. CBER was created to provide an appropriate forum and infrastructure to promote the interaction of biomechanical researchers from the university and the medical communities.

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Message from the Director

MICHAEL H. SANTARE, PH.D.

Director, Center for Biomechanical Engineering Research

Professor, Mechanical Engineering, Biomechanics and Movement Science, Biomedical Engineering

A lot is happening at CBER. One of the most exciting developments is our increased commitment to developing closer collaborations with industry.

Toward this goal, we have gotten more involved in biomechanical product design and development. For example, CBER faculty are guiding student design class projects—you'll read about several of them in this report. In the near future, we plan to get involved in helping transfer some of these innovations past the early technology readiness levels and bring them closer to commercialization.

In addition, we have established an Industrial Advisory Board to advise CBER on ways that, working together with industry, we can increase our impact. The board had its inaugural meeting in May 2014, and I look forward to continuing to work with the members going forward.

Other ways that CBER plans to interact with industry are through collaborative materials testing, musculoskeletal modeling, device design, gait analysis, in vitro and in vivo studies, and so on. State-of-the-art labs are located across campus including new facilities for testing human subjects at the Science Technology and Applied Research (STAR) campus.

We are also continuing our successful outreach and education programs. We held the eleventh annual CBER day in May and the twelfth annual is planned for May 8, 2015. We are also entering our third year of the SURF summer undergraduate research fellows program. You can read more about these events in the newsletter, as well.

I hope you enjoy reading about our work and welcome your input on our future direction.



A handwritten signature in blue ink, which appears to read 'Michael Santare'.

Cover photo: First State Orthopaedics Senior Design Team **Mara Gluck**, **Kelsey Devlin** and **Austin Crouse** with their DriveSim model. Read more about Senior Design on pages 14 and 15.

www.cber.udel.edu

AWARDS AND RECOGNITION

FOR CBER RESEARCHERS

Lu receives Rising Star Award for Work in Osteoarthritis Prevention

X. Lucas Lu, assistant professor of mechanical engineering at the University of Delaware, was presented with the Rising Star Award by the Biomedical Engineering Society (BMES).

Lu received the award for his lecture titled “Bisphosphonate Prevents Post-Traumatic Osteoarthritis by Promoting the Spontaneous Calcium Signaling in Chondrocytes,” in which he discussed a new drug for the prevention of osteoarthritis after joint injuries.

A respected researcher in the biomedical engineering industry, Lu’s research interests include soft tissue biomechanics,



X. Lucas Lu in his research lab with his research assistant, Ph.D. candidate [Miri Park](#).

joint lubrication, solid mechanics and the involvement of bone marrow in cartilage repair. His recent research has focused on post-traumatic osteoarthritis treatment and the effects of weight bearing rehabilitation after microfracture surgery.

Lu holds joint appointments in the Biomedical Engineering Program and the Biomechanics and Movement Science Program.

Elliott Awarded NIH Funding to Support Tissue Engineering Research

Nature is a master materials engineer. Wood, shells, leaves, skin and bone have all inspired man-made materials for applications ranging from car hoods and tennis racquets to adhesives and artificial limbs.

Biomedical engineering has made great strides in recent years as researchers create “tissue engineered constructs,” known as TECs, in the laboratory by combining cells, materials and biochemical factors to meet the required mechanical and structural properties of native tissue for proper functioning.

But mimicking nature is not a simple task.

Despite much work directed at TECs for load-bearing applications—for example, tendons, ligaments, spine and cartilage—researchers have yet to design a clinically applied construct with the right mechanical properties to function in the hostile environments encountered by these tissues.

Dawn Elliott, professor and director of biomedical engineering at the University of Delaware, believes that “reverse engineering nature” could provide new insights into the structure-function relationships of native tissue. This summer, the National Institutes of Health awarded her a \$1.8 million grant to explore the concept.

She hopes the work will pave the way for new TECs that mimic nature at the cellular level.

“We’re trying to understand what’s going on from the viewpoint of the cell,” Elliott says. “What does the cell see? Although we imagine the tissue as a highly organized composite, we know that at the cellular level, the structure is messy and disorganized, but it obviously works. If we can learn more about how it works and why it works, we can use that knowledge to design better engineered replacements.”



Dawn Elliott at work with **John Delucca**, a biomedical engineering doctoral student.

Elliott, continued from previous page

She is working with co-principal investigator Rob Mauck, associate professor of orthopedic surgery and bioengineering at the University of Pennsylvania, and **Randy Duncan**, professor in UD's Department of Biological Sciences, on the grant.

Elliott, whose specialty is biomechanics, and Mauck, an expert in tissue engineering, have collaborated on NIH-funded research for the past several years. Duncan brings knowledge of

mechanotransduction, the processes through which cells sense and respond to mechanical stimuli.

Over the past 12 years, Elliott and Mauck have successfully engineered new intervertebral disc tissue

using aligned electrospun polymers, disc cells, and stem cells to create a tissue that matches nature's function in the spine.

With that research transitioned to the Veterans

Administration and currently funded by the Department of Defense, the team is now focused on developing a better understanding of cellular-level functioning.

"We believe that our design approach for load-bearing fiber-reinforced tissues—focusing on mechanics first—can ultimately be extended to other orthopedic and cardiovascular tissue applications."

DAWN ELLIOTT,
PROFESSOR AND DIRECTOR OF BIOMEDICAL ENGINEERING

NIH Grant Advances Nohe's Research on Osteoarthritis-Fighting Peptide

Anja Nohe calls osteoporosis “a significant disease and a silent disease,” afflicting some 10 million Americans and leading to more deaths—from osteoporosis-related fractures—among women in the U.S. than breast and ovarian cancer combined. The condition weakens the bones and becomes increasingly common with age, especially in women.

“A person often doesn’t think about osteoporosis until she has a fracture—and a fracture doesn’t even have to come from a fall,” said Nohe, assistant professor of biological sciences.

“Once you realize that you have it, it’s only somewhat treatable.”

Nohe and her research team are working with a specific peptide—peptides are chains of two or more amino acids—that she developed. In early tests, the peptide appears promising for attacking osteoporosis on two fronts, by reducing the loss of bone that occurs with the disease and by simultaneously creating new bone.

The National Institutes of Health recently awarded Nohe a five-year, \$1.65 million grant to support her work in conducting further research on the peptide.

“You have cells that eat up the bone and cells that build up new bones,” Nohe said, explaining that current osteoporosis treatments target only one or the other of those mechanisms and that they also can have serious side effects. “We wondered: Can we develop something that does both—something that activates the bone-forming cells and slows down the bone-eating cells?”

Low bone-mineral density leads to 1.5 million fractures a year, at a cost of about \$19 billion and with a dramatic effect on the patients’ quality of life.

The peptide, she said, seems to accomplish that goal, by inducing bone formation while reducing the reabsorption of existing bone tissue. In her NIH grant application, she noted that low bone-mineral density

leads to 1.5 million fractures a year, at a cost of about \$19 billion and with a dramatic effect on the patients’ quality of life.

“New treatments for osteoporosis are desperately needed,” she wrote.

Nohe and her research team are now using a mouse model as they seek to better understand how the peptide works, with the hope that they can eventually use that knowledge to move into clinical trials of the potential treatment.

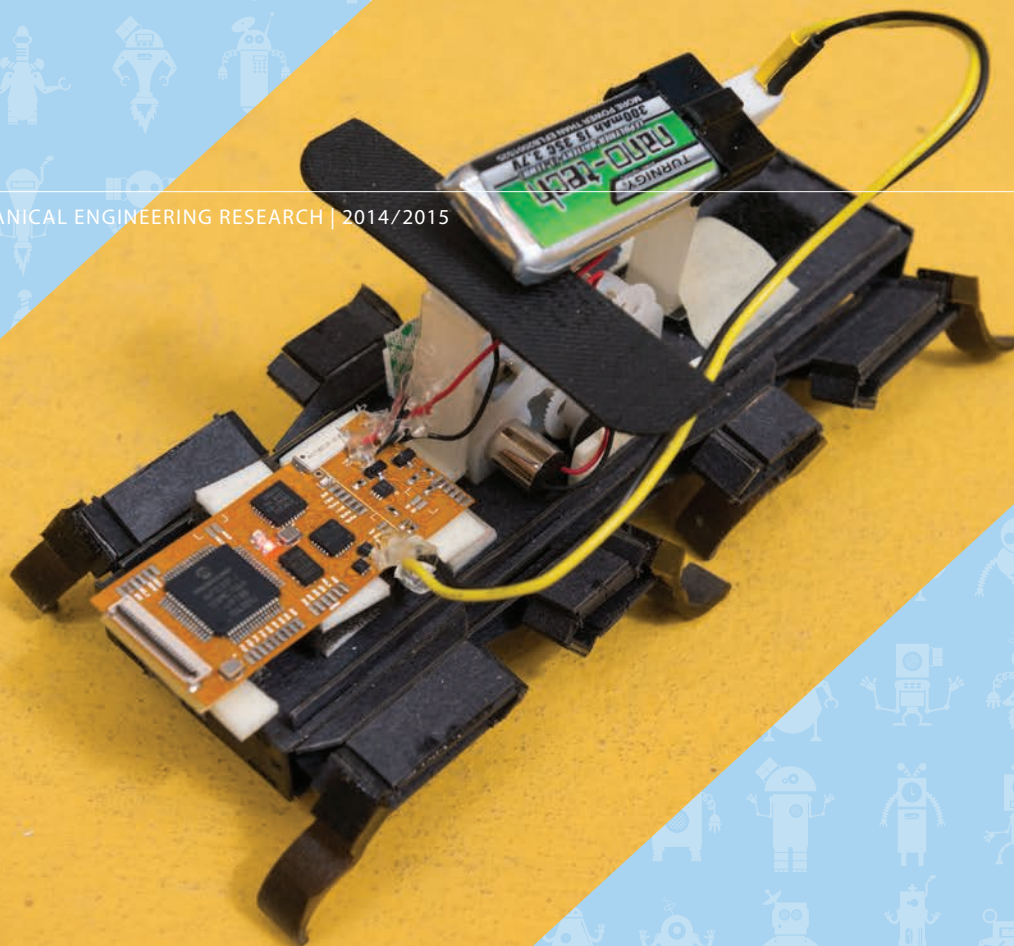
At UD, her team includes doctoral student **Hemanth Akkiraju** and research associate and lab manager **Jeremy Bonor**. She credited both of them—as well as colleagues at the Jackson Laboratory in Bar Harbor, University of Maine and Maine Medical Research Institute, where she began working with the peptide—with providing invaluable help in her research.

Additionally, she said, the bone research group at UD helped her expand her expertise in bone biology. A chemist by training, who later specialized in biophysics and cell biology, Nohe relied on UD bone group **Randall Duncan**, professor and chairperson of biological sciences and professor of mechanical engineering and her mentor and investigator on the grant; **Liyun Wang**, associate professor of mechanical engineering; **Christopher Price**, assistant professor of biomedical engineering; and **Robert Sikes**, associate professor of biological sciences, as she developed her knowledge of bone biology and her research techniques.

“I couldn’t have done this work without the right collaborators,” she said.



Osteoporosis researchers (from left) Anja Nohe, Jeremy Bonor and Hemanth Akkiraju examine samples of bone and cells, which will be analyzed to measure bone thickness and growth.



Poulakakis Receives NSF Award to Develop Planning Strategies for Animal-Inspired Robots



Ioannis Poulakakis, assistant professor of mechanical engineering at the University of Delaware, received the prestigious Faculty Early Career Development Award from the National Science Foundation to support his robotics research.

Poulakakis is investigating ways to regulate the cyclic motion of legged robots so that they can perform tasks such as surveillance or exploration, jobs previously reserved for wheeled systems.

“Planning a robot’s movements to achieve real-life tasks—such as exploration or search and rescue missions—is a key problem in robotics. When it comes to legged robots, we know what controls can generate reliable locomotion, but how these controls are linked with higher level mission objectives is not well-explored,” Poulakakis said.

When searching for inspiration, Poulakakis looked to nature.

“Animals move purposefully. Foraging for food, pursuing a prey, fleeing an environment, these are all examples of high-level animal behaviors planned to achieve a goal,” he said.

He is particularly interested in the way an animal’s limbs move during locomotion—a choreographed, cyclic motion that combines complex muscular planning, momentum and agility.

“Steering a legged robot’s dynamic, or constantly changing, movements is challenging because its fundamental task is to remain upright and in motion,” he explained. This basic constraint can limit things like traveling speed, mobility and maneuverability, which can interfere with the robot’s ability to accomplish tasks where reasoning is required.

“We need to provide the necessary robotics science and technology to create dexterous, highly-mobile legged robots that can autonomously plan actions in human-centric environments,” Poulakakis said.



Algorithms help robots sense, plan and act. Many established algorithms separately address high-level (mission planning) and low-level (locomotion stability) objectives; but, when it comes to dynamically moving legged robots, none integrate the two.

Poulakakis is working to develop real-time planning algorithms that can bridge the gap between a robot's platform controls and higher-level motion planning objectives. If successful, this research will bring highly mobile and versatile robot platforms like legged machines closer to real-life applications in industry, agriculture and emergency response. For example, in supply chain management systems legged robots could help companies rapidly reconfigure their production or assembly lines to adapt to changes in demand or new product designs.

He will work with robots of different types and sizes, ranging from slow moving palm-sized crawlers weighing mere ounces to rapid runners including bipeds and quadrupeds weighing hundreds of pounds.

Similar to their counterparts in nature, small and large legged robots operate differently, enabling the researchers to study the effect of scale on their approach. In particular, they will concentrate on a 150 pound quadruped's capacity to walk, trot and bound in an uncertain environment and a 1.3 ounce octoroach's ability to navigate in tightly constrained spaces while crawling and running.



Ioannis Poulakakis (center), with research team members **Konstantinos Karydis** (left) and **Xin Liu**.

NSF GRANT HELPS BURRIS ELUCIDATE SCALING EFFECTS IN FRICTION

Friction helps us light fires in the wilderness, stop our cars at red lights and run on pavement without slipping. It affects everything from cellular interactions to seismic activity.

"Friction governs the operating limitations, durability, energy consumption, and control of virtually all machines, including those with important implications for health care, economic prosperity, and national security," said **David Burris**, associate professor of mechanical engineering at the University of Delaware.

"Although we sense friction at the macroscale, it's known to originate at the atomic scale," he said. "The scientific roots of this subject date back to



us to measure friction at practical size-scales, it tells us almost nothing about the responsible phenomena, nor does it provide any insight into the design of new low friction materials.

"Although we understand that friction originates at the atomic scale, we lack the tools needed to quantitatively study how these interactions contribute to the generation of machine friction," he said.

Burris and his research team have developed two key technologies to enable this project. The first is a method to reliably calibrate and quantitatively measure atomic-scale

friction using atomic force microscopy. The second is a microtribometer that can bridge measurements from the atomic scale to those from the macroscale.

"Our aim now is to stitch these length scales together by carefully controlling material, load, probe radius, and speed in the gap between the atomic and macro size scales," Burris said.

"By making simple observations of friction across length scales, we hope to quantitatively link the friction we observe every day to its fundamental origins."

"Our long-term goal is to produce a testable theory of interfacial friction that our materials scientist collaborators can use to design materials and engineer interfaces for improved frictional control."

DAVID BURRIS,
ASSISTANT PROFESSOR OF MECHANICAL ENGINEERING

Leonardo da Vinci, but our understanding of how these fundamental atomic-scale interactions contribute to everyday friction remains poor."

Burris hopes to fill that basic gap in knowledge with a \$300,000 grant from the National Science Foundation that will support a controlled study of interfacial friction from the atomic scale to the practical scale. The results will be used to develop a testable model of frictional scaling, which is needed to inform materials design and surface engineering efforts for friction control applications.

An expert in tribology, or the scientific study of friction, Burris explains that although traditional tribometry allows

BUCHANAN NAMED ASB FELLOW

Thomas Buchanan, director of the Delaware Rehabilitation Institute, Laird Professor of Mechanical Engineering, and professor of biomedical engineering and biomechanics & movement science, was elected Fellow in the American Society of Biomechanics.





OU EARNS NSF GRANT

Yvonne Ou's National Science Foundation proposal, "Inverse problems for poroelastic composites with application in bone health monitoring," was ranked at the top tier of funded awards and highly valued by a NSF-Division of Mathematical

Sciences Inverse Problems panel for its originality. Ou's latest NSF grant continues her previous ARRA-NSF-Math. Biology funding for investigating the cancellous bone properties as two-phase composites. This three-year award brings \$207,000 to UD, with part funding opportunities for a graduate student and the summer support of students in the Research Experience for Undergraduates program.

HEALTHCARE THEATRE DEVICE TAKES FIRST-PLACE IN INTERNATIONAL TECHNOLOGY INNOVATION COMPETITION

A device that provides realistic training for the care of tracheostomy patients, known as SimuTrach, was selected as the first-place technology innovation winner by the 15th International Meeting on Simulation in Healthcare (IMSH 2015) Scientific Content Committee, which referred to the UD student-designed and fabricated overlay system as "exceptional work."

SimuTrach is an overlay worn by actors playing the role of patients in simulation training through UD's Healthcare Theatre Program, which helps health care professionals develop communication and treatment skills through interactive scenarios presented by simulated performers.

Students **Brad Biggs**, **Devon Bond** and **Nick Campagnola** (biomedical engineering), along with **Ed Doll** and **Nate Hott** (mechanical engineering), developed the first SimuTrach prototype in a mechanical engineering design class taught by **Jenni Buckley**, assistant professor of mechanical engineering, at the request of nursing instructor and Healthcare Theatre co-founder **Amy Cowperthwait**. **Francis Rivera** (electrical engineering) later joined the team.

They further developed the device through First Step, a program in the College of Health Sciences designed to promote innovation and entrepreneurship among undergraduates. The project received the first-place award in First Step, where additional funding and mentoring will facilitate taking the project to the next level.

SimuTrach has also been adopted into the Office of Economic Innovation and Partnerships' Spin In program, which matches entrepreneurs developing innovative early-stage technology with a team of UD business students to further develop both the technology and the marketing strategy.

Cowperthwait presented the work at the IMSH 2015 in New Orleans in January.



SimuTrach, displayed here at the 2014 Health Sciences First Step competition at the University of Delaware, was recently selected as the first-place technology innovation winner by the 15th International Meeting on Simulation in Healthcare Scientific Content Committee.

SAVE THE DATE

12TH ANNUAL
CBER BIOMECHANICS
RESEARCH SYMPOSIUM
FRIDAY, MAY 8, 2015
ON UD'S STAR CAMPUS

Visit
WWW.CBER.UDEL.EDU
for more information



2014 symposium guest speaker Alberto Esquenazi (left) with Michael Santare, professor of mechanical engineering and director of UD's Center for Biomechanical Engineering Research.

2014 WINNERS

Podium presentations

Ashutosh Khandha – "Peak Medial Compartment Contact Forces (PMCCF) in the Knee After Anterior Cruciate Ligament Reconstruction (ACLR) – 5 Year Follow Up."

Axel Moore – "Systematic Variation of Material and Tribological Properties of Cartilage in the Bovine Stifle Joint."

Posters

Miri Park – "The Effect of Delayed Loading on In Vitro Microfracture Model."

Stephen Suydam – "Semitendinosus Tendon Elasticity Recovery Post ACL Reconstruction."

MossRehab's Esquenazi Headlines 2014 Event

Highlights role of problem solving, patient-centered research

The Center for Biomechanical Engineering Research (CBER)'s annual research symposium is the opportunity for regional Industry professionals, University of Delaware faculty and students to come together and advance a collective vision for the field of biomechanics.

The 2014 event showcased the impact of biomechanics on rehabilitation medicine, with keynote address by Alberto Esquenazi, John Otto Haas Professor, chair of the Department of Physical Medicine and Rehabilitation at MossRehab and director of the Sheerr Gait and Motion Analysis Laboratory.

Esquenazi detailed the early history of biomechanical engineering and discussed improvements and innovations that have advanced the field, such as innovative surgeries for injuries and improved prostheses for amputees. He also covered limitations of current biomechanical medicine and showcased several new methods for rehabilitation

treatment, including robotic-assisted systems, such as LOKOMAT and ReWalk.

As an amputee himself, Esquenazi understands that while technology advancements are important to the field, the need to incorporate user preferences into any device is equally important.

He noted that versatility and comfort are key features, and that simplicity isn't necessarily a bad thing. He asked biomechanical researchers to recognize not just what users need to do, but to also consider what they want to do.

The annual event features multiple talks by biomechanics experts, highlights ongoing student biomechanical research projects at the University of Delaware, and gives industry professionals a unique opportunity to tour UD's new Science, Technology and Advanced Research (STAR) Campus and discuss possible research collaborations with UD faculty and students.

"Great opportunity to connect with other researchers."

MIRI PARK,
DOCTORAL STUDENT, BIOMECHANICS AND
MOVEMENT SCIENCE

"The perfect platform for the students in my lab to present their work. This process is an opportunity for my students to learn how to prepare posters and podium slides, present and discuss their work with other students and professors. All enjoyed the symposium's friendly and professional atmosphere."

X. LUCAS LU,
ASSISTANT PROFESSOR, MECHANICAL ENGINEERING

"This event consistently provides an exciting and unique opportunity for Gore to witness firsthand the incredible depth and breadth of capabilities within CBER. Moreover, it fosters a stimulating environment for interaction among industry, research and academic partners. Congratulations to the Michael Santare and the CBER team for all their past, and future, success with this event."

GEORGE FOUTRAKIS,
W.L. GORE & ASSOCIATES

"I appreciated receiving feedback that offers a different perspective on my work."

AMY BUCHA,
GRADUATE STUDENT, MECHANICAL ENGINEERING

Young Investigator Hopes to Keep Marathoners Moving

Researcher understands that sitting on the sidelines is the worst kind of punishment for a runner.

"I know some marathon runners suffer from severe osteoarthritis and have had to give up running. As a marathon lover myself, I don't want it happen to me," said **Yilu Zhou**, a University of Delaware doctoral student in mechanical engineering who is investigating new treatments for post-traumatic osteoarthritis (PTOA).

Many athletes experience traumatic joint injuries throughout their careers. Although surgery can treat and correct these injuries, many patients eventually develop PTOA, a degenerative joint disease that affects more than 5 million Americans and can lead to complete loss of joint function.

Zhou is studying how zoledronic acid (ZA) protects cartilage from traumatic-damage induced degeneration.

A Food and Drug Administration-approved drug, ZA is a biophosphonate used to prevent skeletal fractures and bone loss in patients with cancer and osteoporosis. Zhou's research has also shown that the drug can inhibit cartilage degeneration.

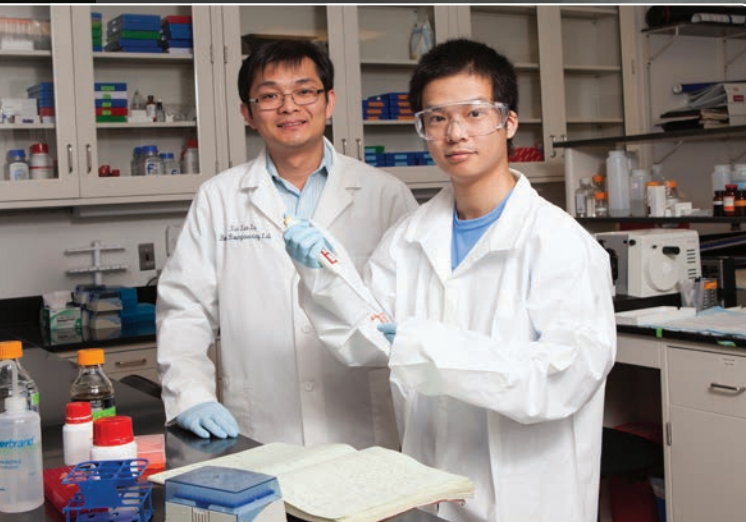
The American Society for Bone and Mineral Research selected Yilu Zhou for its Young Investigator Award for his work in osteoarthritis prevention research.

"Our experiments showed that treatment with ZA following trauma-induced damage enhances the biomechanical properties and biochemical content of tissue, preventing further deterioration of the cartilage," Zhou explained.

According to his thesis adviser **X. Lucas Lu**, assistant professor in the Department of Mechanical Engineering, Zhou's research findings "have attracted interest from many scientists and clinical investigators."

Zhou presented his research findings to an international audience of scientists and clinical investigators at the Bone Research Society's annual meeting in Sheffield, Yorkshire, United Kingdom, this past June.

"Once we understand how ZA works, we can identify other drugs that can target the same pathway with minimum side effects on the body, since there is concern that ZA could disrupt the natural metabolism of healthy bones in younger patients," explained Zhou, who was selected for a Young Investigator Award by the American Society for Bone and Mineral Research.



University of Delaware
mechanical engineering
graduate student Yilu Zhou
(right) with adviser X. Lucas Lu.

Six Spend Summer **SURF**ing

TOWARD BIOMECHANICS INVESTIGATION SUMMER UNDERGRADUATE RESEARCH FELLOWSHIPS

The Center for Biomechanical Engineering Research (CBER) and the Department of Mechanical Engineering joined forces to award Summer Undergraduate Research Fellowships (SURF) to six young biomechanics investigators. A committee including **Lucas Lu**, **Jill Higginson**, **Mike Santare** and **Elaine Nelson** selected fellowship recipients, planned events, conducted seminars and monitored student progress. Training was provided on “What to know before getting into a laboratory” and “Plotting a course and application for graduate schools.” Each participant hosted a lab tour featuring ongoing

research activities. Students conducted independent research projects (see details below), were responsible for literature review, experimental design, data collection and analysis, as well as presentation of results.

A highlight of the summer was the lab lunch at Kells Park, with invites extended to all undergrads in the participating labs.

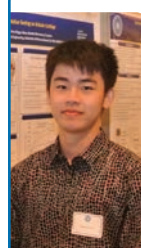
After 10 weeks of research and mentorship, each student presented his or her work at the Undergraduate Research Celebratory Symposium on August 14th.

This summer’s six CBER SURF recipients were:



Hunter Bachman: Mechanical Engineering (Advisors: *X. Lucas Lu & David Burris*)

Hunter quantified the effect of friction and lubrication on cartilage degeneration at the temporomandibular joint (TMJ) with a custom microtribometer.



Xiaoyu (Dave) Gu: Mechanical Engineering (Advisor: *Liyun Wang*)

Dave mechanically tested mouse tibiae to determine whether perlecan serves as a mechano-sensor in healthy and porous bone.



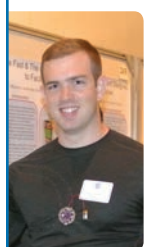
Michael Furr: Mechanical Engineering (Advisors: *X. Lucas Lu & Michael Santare*)

Michael performed indentation testing with different loading to model the biomechanical properties of cartilage. His long-term aim is to develop possible in vivo applications for indentation testing to help with early detection of osteoarthritis.



Thomas McDowell: Biomedical Engineering (Advisor: *David Burris*)

Thomas investigated the ability of biphasic hydrogels to mimic the mechanical and tribological properties of cartilage for use on joint replacement material.



Ben Greenspan: Mechanical Engineering (Advisor: *Cole Galloway*)

Ben created the Sparklesuit™ using state-of-the-art materials and technology to provide patients with impaired muscle function an easy and inexpensive method to determine whether muscles are active and to what extent their activity changes across time.



Maria Nicholson: Biomedical Engineering (Advisor: *Jill Higginson*)

Maria examined different modes of biofeedback while walking to determine whether audio or visual signals most effectively induced changes in reaction forces and swing time.

Senior Design Projects

First State Orthopaedics and Independence Prosthetics Orthotics Inc look to CBER for mobility-related prototypes

CBER is partnering with two local industry leaders—First State Orthopaedics and Independence Prosthetics & Orthotics, Inc., to bring ideas to market with the help

of UD students through the Senior Design class taught by Jenni Buckley, assistant professor of mechanical engineering.

First State Orthopaedics | Michael Axe, M.D.

Orthopaedic surgeon Michael Axe, M.D., of First State Orthopaedics, specializes in sports medicine, arthroscopic surgery and minimally invasive therapies for arthritis. His practice is sponsoring a project called “Driving simulator for post-operative rehabilitation and assessment, in which students will be charged with developing a simulator to assess whether an individual is capable of driving following lower limb surgery. Kurt Manal, assistant professor of mechanical engineering, served as faculty consultant for the team.

About the project

Driving an automobile requires operating two or three foot pedals (brake/gas or brake/gas/clutch). Orthopaedic surgical procedures on the ankle, knee, or hip (e.g., ACL repair or total knee replacement) affect the patient’s reaction time and ability to apply sufficient force to the pedals. Therefore, driving is prohibited or restricted during the post-operative (healing) period until the clinician discerns that the patient is strong enough to return to driving. The current clinical test for return-to-drive is rather subjective and involves moving the foot laterally 15 times (gas-to-brake) followed by a sit-to-stand maneuver. The goal of this project is to develop a cost-effective, easy-to-use device to simulate brake/gas control on an automobile. This system should provide quantitative data on a patient’s readiness to drive. The team is

tasked with creating a viable first generation prototype of this system.

Why this is important to FSO

The first generation prototype will be used in clinical trials to compare the diagnostic potential of the system to the clinical standard of care. If successful, FSO, as sponsor, will partner with the University of Delaware to commercialize this product. Potential end-users include orthopaedic and sports medicine practices, as well as physical therapy clinics.



Team FSO members **Rob Oblander, Kelsey Devlin, Austin Crouse** and **Maria Gluck** developed a device to simulate brake/gas control to offer quantitative data on a patient’s readiness to drive post surgery.

Independence Prosthetics & Orthotics (IPO), Inc., and CBER

John Horne is president and founder of Independence Prosthetics-Orthotics, Inc. (IPO), here in Newark, Del, a full-service provider of custom prosthetic and orthotic devices designed to enhance the mobility and quality of life of to limb-loss population. They are partnering with CBER to sponsor a Senior Design project known as "MagSockLock:" in which students will help them develop a first-generation prototype and manufacturing process for a magnetic socket lining system for lower-limb prostheses under the advisement of Dustyn Roberts, assistant professor of instruction in mechanical engineering, and Michael Santare, professor of mechanical engineering as faculty consultants.

About the project

Mobility has a direct and profound impact on quality of life. With greater mobility comes lower morbidity and

reduced overall healthcare costs. The key to restoring mobility after amputation is to provide effective prosthesis fixation with a comfortable socket that is easy to don and doff. Current technologies employ a shuttle-lock (pin), suction or vacuum to provide fixation forces and a soft liner to distribute the compressive contact forces between the socket and the residual limb. The team is tasked to develop an innovative socket system that uses magnetic forces to simultaneously provide fixation and distribute the contact pressure. Relative to current systems, this new system must reduce relative motion (i.e. pistoning and rotation), thereby increasing comfort and proprioception and reducing pain, fatigue and instability. This system must also decrease liner wear and, therefore, has the potential to reduce overall cost, as well.

Why this is important to IPO

IPO and CBER plan to use the first generation prototype in clinical trials to determine system efficacy. If successful, patent applications and production considerations will follow.



Joseph Boyce demonstrates Team IPO's prosthesis fixation socket system.



Team IPO members **Kyra Isaria, Brianna Gietter, Joseph Boyce** and **Kyle Bannon** developed this innovative prosthesis fixation socket system.

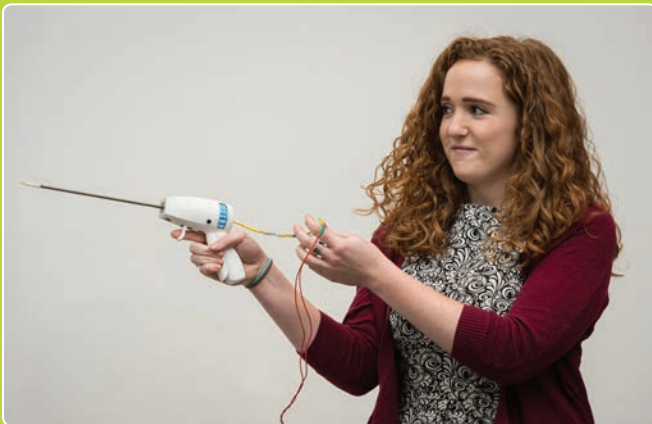
Interdisciplinary Projects Yield New Engineering Designs for Better Diagnostics, Treatment

Wearing sensory feedback devices created by Senior Design teams, actors in UD's Healthcare Theatre Program pose as patients to help students learn how to perform such skills as urinary catheter simulation, post-op chest tube assessment and care, defibrillation and intravenous needle insertion.

"Using live actors and these simulation tools provides a superior learning experience for our students in a safe environment that doesn't compromise quality of care, says **Amy Cowperthwait**, coordinator of the simulation lab in UD's School of Nursing.

Supporting surgery and workplace ergonomics

One team created a minimally invasive vessel-sealing tool that incorporates an attachable extendable shaft and interchangeable tip sizes for use in laparoscopic surgery.



Other projects were aimed at solving workplace ergonomic issues. One team worked with VWR International to create Uncap'n It, a machine that caps and uncaps sterile vials, while another group collaborated with W.L. Gore & Associates to develop tooling for suture manufacture. The purpose of both devices is to eliminate the need for injury-producing repetitive movement on the part of lab technicians.

"Most of the teams on these projects are actually designing for or working with human subjects," says **Dustyn Roberts**, assistant professor of instruction in mechanical

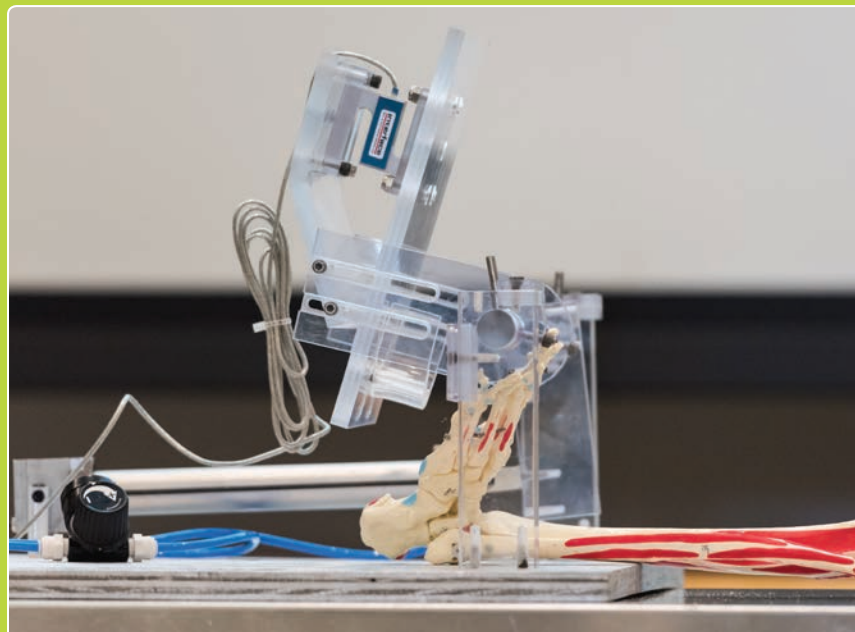
engineering. "One team even had their protocol approved by the IRB [Institutional Review Board] early in the semester, and they were able to run 30 subjects through their experimental protocol this fall."

Designs for everyone

One team worked with veterinary specialists at the University of Pennsylvania New Bolton Center on Active Hoof, worn by horses with restricted movement due to injury.



Other projects included hands-on K-12 workshops in orthopedics, a driving simulator for post-operative rehabilitation and assessment, a next-generation Quadcrew adaptive rower, an MRI-compatible dynamometer, and a magnetic suspension system for lower limb amputees that enables the user to attach and remove a prosthesis (see article, page 15).



Senior Design Teams Represent UD at Clinton Global Initiative

Four up-and-coming Blue Hen engineers represented the University of Delaware at the 2014 Clinton Global Initiative University (CGI U) in Phoenix this spring showcasing their adaptive rowing prototype that allows those with quadriplegia, paraplegia, hemiplegia, multiple sclerosis and paresis to operate a crew boat.

Robert Bryant (MEEG 2014), **Matthew Imm** and **Molly Wessel**, both biomedical engineering majors, planned, designed and developed the adaptive technology as part of their capstone senior design course under the advisement of **Jenni Buckley**, assistant professor.

Team QuadCrew is working with UD's Office of Economic Innovation and Partnerships to patent their design and are pursuing a licensing deal with a major rowing company.

The prototype features a propulsion system, an adaptive seat and a leg motion seat synchronizing system—all designed to fit in the shell of a standard crew boat. The team tested its design on the Wilmington Riverfront last winter with help from the UD women's rowing team.



Team QuadCrew members, left to right: Robert Bryant (ME), Sarah Masters (ME), Molly Wessel (BME), Matthew Imm (BME)

For their work on SimuCath, the urinary catheter simulation device, team members **Bimal Amin** and **Taylor Boyle** will represent CBER in the eighth annual Clinton Global Initiative University this March at the University of Miami.

The Clinton Global Initiative University brings together the next generation of global leaders from 30 universities and colleges to solve challenges in education, environment and climate change, peace and human rights, poverty alleviation and public health.

Collaborators represented a number of departments and schools across campus, including kinesiology and applied physiology, physical therapy, education, and fashion and apparel studies.

One senior design team worked on a FUNctional Fashion line created by **Michele Lobo**, assistant professor of physical therapy. Their project: a garment that children with arm movement impairments can inflate and deflate

to assist them in moving their arms so they can better explore, play and learn.

"It's really quite amazing what our students are able to accomplish over the course of a semester," said **Jenni Buckley**, assistant professor of mechanical engineering and lead professor for the interdisciplinary senior design course. "We've had sponsors come back to us and say that their teams have accomplished in four months what it takes them years to do. That's what we like to hear. We want our students to get their ideas out there."

Financial support for the projects was provided by industry, the College of Health Sciences and the Office of Economic Innovation and Partnerships.



Building Relationships with Industry Partners

Harnessing human potential

Body-weight-support technology supports rehabilitation, research, education

Four-year-old Maya loves playing Barnyard Bingo, but the game is work disguised as play for the little girl.

Maya, who has cerebral palsy, can't walk on her own, but a unique harness system enables her to not only run and reach, but also cross a miniature bridge and trudge through "mud" as she plays Barnyard Bingo and other games with University of Delaware physical therapist **Tracy Stoner**.

The Health Sciences Complex at UD's Science, Technology and Advanced Research (STAR) Campus is home to a number of these devices, which are seeing increased use in research, rehabilitation and education.

More formally known as "fall-arrest and body-weight-support systems," the structures include track systems in the Delaware Physical Therapy Clinic, open-area support systems, such as the GoBabyGo Café, and portable units like the one in the GoBabyGo Lab and Design Studio at STAR, as well as a large body-weight-support system in the gym at UD's Early Learning Center.

All were custom designed and installed by EnlitenLLC, a small business in Newark, Del., started by UD alumnus **Ralph Cope** and his brother Steve. Enliten is a spinoff of Accudyne Systems, established in 1996 to create custom automation equipment to solve manufacturing challenges across a variety of industries.

"The harness systems enable us to challenge our patients while also keeping them safe," says **Darcy Reisman**, associate professor of physical therapy. "Also, from a teaching perspective, harnesses give



Maya navigates a step in the PT Clinic harness system as physical therapist Tracy Stoner offers her a Barnyard Bingo token.

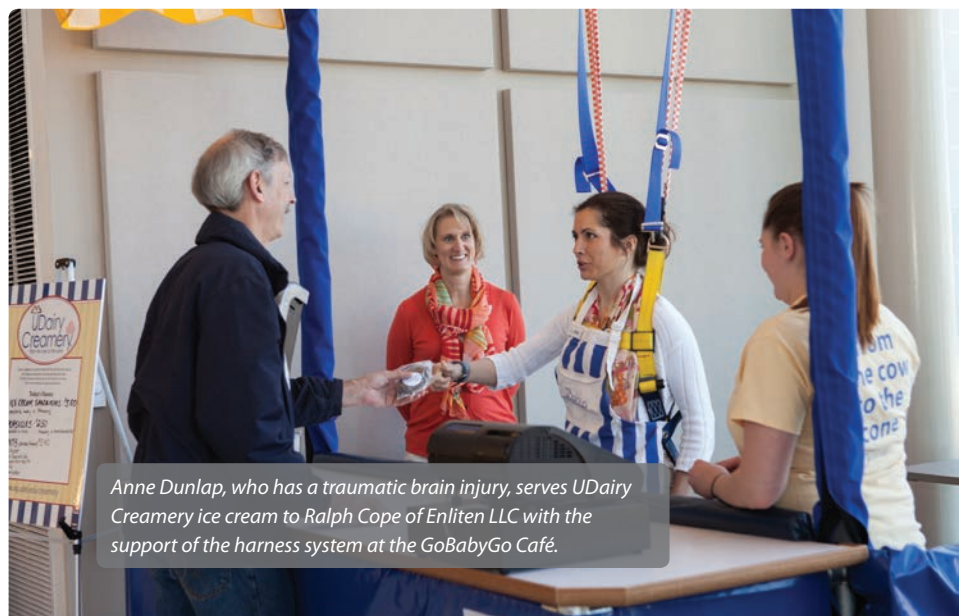
clinical instructors another layer of confidence and allow students to safely explore treatment options."

Reisman points out that many rehabilitation devices are designed for specific populations, but the Enliten harness systems serve everyone from toddlers and injured athletes to stroke survivors and people with traumatic brain injuries.

For Anne Dunlap, who was injured in a car accident at the age of 18, the harness in the GoBabyGo Café provides an opportunity to gain valuable

occupational and communication skills. Through a collaboration with the UDairy Creamery, which produces ice cream made with milk from the cows on the farm at the UD College of Agriculture and Natural Resources, Dunlap now sells ice cream at the GoBabyGo Café.

The carefully engineered system in the café enables Dunlap to move anywhere within the 50-square-foot structure. After her first test work session, she said to Cope, "Hey, Steve, can I have one of these in my house?"



Anne Dunlap, who has a traumatic brain injury, serves UDairy Creamery ice cream to Ralph Cope of Enliten LLC with the support of the harness system at the GoBabyGo Café.

ABOUT THE TECHNOLOGY

Key features of Enliten's portable mobility aids, open area support systems, and custom installations:

- ▶ The user is connected to the support structure with a strap that provides no lift when the user is moving, but catches the person if he or she starts to fall.
- ▶ A counterbalance or elastic connection between the user and the support structure provides a steady vertical force to reduce the load on the user's legs.
- ▶ Low-friction, lightweight "cars" provide support wherever the user roams with no need for electrical connections.
- ▶ A turntable enables the user to change direction with a twist of the wrist.
- ▶ With all support coming from overhead via soft links, users are free to interact with their surroundings with no interference. They can swing a bat, kick a ball, play Barnyard Bingo ... or serve ice cream.



PT student Amy Arundale demonstrates the use of the harness system in the PT Clinic for rehabilitation of a knee injury.

In one case, the harness actually helped clinicians save a life, when a research participant using a treadmill experienced a heart attack.

"The support system worked exactly as intended by preventing the patient from falling and incurring additional injuries until a team was able to reach him and administer CPR," said Cope.

For patients in the PT Clinic, the technology is a game changer. "One woman said to Reisman, "If only I could unhook this and attach it to a cloud."

For Cope, no request is out of bounds. "I'm finding new applications like the café very exciting and opening up new ways of thinking about therapy and social interaction in clinical, work, and home environments," he says.

Reisman says that working with Enliten has been a true partnership.

"We started with a problem, and they helped us develop a solution," she says. "They didn't just try to sell us a device and expect us to find a use for it. A number of national companies offer stock products, but we couldn't find anyone else that offered the custom support we have with Enliten."

"Working with Enliten has been a true partnership. We started with a problem, and they helped us develop a solution."

DARCY REISMAN,
ASSOCIATE PROFESSOR OF PHYSICAL THERAPY

And for little Maya, the harness is a game with a purpose.

"She's learning skills that will help her in her daily life as she gets older," said Stoner. "Her physical control has improved significantly with this approach—and she has a lot of fun doing it."



Stroke survivor Virginia Cottrell uses a harness for support as she walks on a treadmill under the guidance of researcher Kelly Danks.



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