AT THE NEXUS OF SCIENCE, TECHNOLOGY AND HEALTH

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In his first six months at Binghamton University, President Harvey G. Stenger has articulated his strategic goals to enhance the academic excellence of our campus and become a premier public university in the United States. I am excited by his vision and enthused by the many ways in which the Watson School's existing strengths and areas of growth will support his plans for progress and advancement in the years to come.

The Watson School has always been dedicated to providing students, both graduate and undergraduate, with an outstanding education. We look beyond our borders to engage with universities abroad that provide global opportunities for our faculty and students. We also continue to prioritize recruitment of world-class faculty, who are able to seamlessly blend research and scholarship with excellent teaching skills, to enrich the many facets of our students’ academic experience.

Our newest faculty include Assistant Professor of Bioengineering Gretchen Mahler, whose novel in vitro cell culture models — see page 14 — have applications in areas including wound care, cardiac fibrosis and cancer. Faculty like Mahler open doors for collaboration across the University and with external scholarly and industry partners, bringing recognition to the Watson School while providing invaluable educational and research experiences for our students.

We’ve dedicated this issue of the Watson Review to showcasing the many ties our school has with the broad discipline we call healthcare. Our research collaborations within the field pervade every one of our departments, harness the expertise of a significant number of our faculty and help to jump-start a popular and rewarding career track for our students and alumni.

The Watson School has also made strides in areas such as cyber security, complex systems, energy-efficient electronic systems and electronics packaging, among others. And our flourishing research in smart energy has positioned our engineers and computer scientists at the core of an exciting and challenging endeavor — Binghamton’s NYSUNY 2020 plan.

The plan will improve the student: faculty ratio and provide students with effective academic and research support while bolstering the region’s economy and enhancing renewable energy research in New York state. Furthermore, the plan centers in part on a new Smart Energy Research and Development Facility at the Innovative Technologies Complex. The initiative will address vital areas such as solar and thermoelectric energy harvesting, energy storage, efficiency in electronic systems and sensor development for energy resource management.

With our engineering and computer science faculty already active leaders in relevant research areas including inexpensive, flexible and lightweight solar panels; super-capacitor systems; lightweight sensors; and data centers and electronic systems that reduce energy consumption without compromising performance, we will improve our position as leaders in renewable and responsible energy research.

As always, the Watson School embraces these new challenges, opportunities and developments, and will look for ways to enhance our support of Binghamton University, our community and society as a whole.

Krishnaswami "Hari" Srihari
Dean and Distinguished Professor,
Thomas J. Watson School of Engineering and Applied Science
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E-mail the editor at watson@binghamton.edu
Binghamton University signed a memorandum of understanding in December 2011 with the University of Maryland Eastern Shore (UMES), one of the 11 universities in the University System of Maryland. The esteemed, historically black university is located in Princess Anne, Md.

Watson School Dean and Distinguished Professor Krishnaswami “Hari” Szhari and partners from UMES have begun identifying areas of mutual interest that include adapting Binghamton’s best practices for working with industry at UMES, providing summer experiences and industry internships for UMES students at Binghamton and helping UMES students transition to graduate programs at the University and within the Watson School.

“This academic partnership has evolved into a strong multifaceted relationship that includes a variety of efforts, from graduate student recruitment to summer research opportunities for UMES students, collaborations with industry, and faculty academic and research collaborations and exchanges,” Szhari said. “Binghamton University and the Watson School’s partnership with the University of Maryland Eastern Shore is an invaluable opportunity to partner on initiatives that draw on the strengths of each institution while moving both campuses toward one goal — academic excellence.”

Faculty and staff of Binghamton University and the University of Maryland Eastern Shore pave the way for a new partnership during a visit to campus in March.

NEW EXECUTIVE MASTER’S IN HEALTH SYSTEMS OFFERED IN NYC, BEGINNING APRIL 2013

The 12-month executive master of science in health systems is designed to provide working professionals with a bachelor’s degree in any field and the opportunity to gain advanced knowledge and skills for modeling, analyzing and designing healthcare delivery systems and processes. Classes will be held Saturdays from 8:30 a.m. to 5 p.m. at the SUNY Global Center in midtown Manhattan.

For more information, visit binghamton.edu/emshs-nyc
LOCKEED MARTIN AND BINGHAMTON TO DEVELOP SIMULATED EMERGENCY DEPARTMENT

Faculty in the Department of Systems Science and Industrial Engineering received a one-year $300,000 grant in November 2011 as part of a collaboration with Lockheed Martin to develop a simulated emergency department (ED). Associate Professor Mohammad Khasawneh, Dean and Distinguished Professor Krishnaswami “Hari” Srihari and Director for Industrial Outreach Cheryl Monachino are leading this effort.

Lockheed Martin, a leader in information technology and systems engineering — and the largest provider of IT services, systems integration and training to the U.S. government — is applying its expertise in simulator technology and systems modeling to the development of integrated clinical environments. These virtual worlds will provide a safe, reproducible training tool for physicians, nurses and other medical personnel, much like a cockpit simulator provides true-to-life training for pilots.

The ED integrated clinical environment will be used to conduct studies that get at the root cause of issues such as false alarms, never events, medication errors and slow or difficult diagnostics to enable mitigation. This environment will also enable the study and evaluation of various process improvement recommendations.

Device interoperability and information systems communication are critical to systems. In hospitals, for example, patient data is gathered by an information system that pulls from multiple devices. These varying devices can assign differing time stamps for the same patient procedure or lab results. Such differences lead to significant challenges when using this data to monitor a patient or predict patient outcomes.

The Binghamton team is working closely with Dr. Robert Szczerba, Lockheed Martin’s director for global healthcare initiatives, his colleagues, Rick Crist, Steve Czarnecki, David Garrison and others from the company on this effort.

Junior Christopher Toney II, front, is among the first Parris Foundation STEM Summer Research Fellows. He is working with Ron Miles, associate dean for research and distinguished professor of mechanical engineering. Toney, an electrical engineering student, comes to Binghamton through a partnership with the University of Maryland Eastern Shore.

FACULTY HIRES

AARON CARPENTER
Assistant Professor of Electrical and Computer Engineering
Research interests: chip-multiprocessors, on-chip interconnect networks, computer architecture/microarchitecture, VLSI design, and use and integration of emerging technology in microprocessor design

PAUL CHIAROT
Assistant Professor of Mechanical Engineering
Research interests: advanced manufacturing using continuous ink jet technology and electrospray deposition, electrospray engines for microsatellite propulsion, microfluidic devices for high-throughput single cell studies, and point-of-care bio-sensing using miniaturized ion mobility spectrometry

ZHANPENG JIN
Assistant Professor of Electrical and Computer Engineering
Research interests: medical cyber physical systems and instrumentation, sensor-enabled embedded systems, reconfigurable computing, hardware system (FPGA/SoC/VLSI/ASIC) and electronic device design, neural networks and neuromorphic systems, computer architecture and microprocessors

GRETCIEN MAHLER
Assistant Professor of Bioengineering
Research interests: in vitro and in silico toxicology and pharmacology, microfluidic models of organs and tissues, endothelial and epithelial cell biology and pathophysiology

TING ZHU
Assistant Professor of Computer Science
Research interests: power electronics, renewable and sustainable energies, energy transmission and storage, power systems, cyber-physical systems, mobile systems, embedded systems, distributed systems, operating systems, wireless and sensor networks, network management, network protocols, social networks, security, AI, bioinformatics, controls, databases/data mining, modeling, software engineering, and VLSI design
CHRISTINA ABATE ’12 AWARDED FIRST PLACE AT 2012 EMERGING RESEARCHERS NATIONAL CONFERENCE

In the summer of 2011, mechanical engineering major Christina Abate traveled to Honduras with other Binghamton University students to build a water sanitation and distribution system for a rural community. As a senior, she became the project manager for the second phase of the operation: developing a way to get rid of the dirty water now that clean water is coming in. Safety concerns in the region prevented Abate and her team from returning to Honduras, but they plan to complete the project by sending their translated designs to contacts in the country.

“Our goal is to complete the project without going there, which I think is even harder,” she said. “You have to be extremely detailed in everything you do.”

Abate used the Honduras work as the foundation of a research project called “Sustainable Engineering in Research Education and Practice.” She examined the Honduras operation and determined what aspects are sustainable and where improvements could take place. In February, Abate not only presented her research at the 2012 Emerging Researchers National Conference in Atlanta, but she won first place in the oral presentation category for mathematics and science education.

IBERDROLA GIFT TO BOOST HANDS-ON EDUCATION FOR GRADUATING SENIORS

The Watson School received a $100,000 gift in April from the Iberdrola USA Foundation to enhance the senior capstone design experience. The funding will support a range of projects focused on energy and the environment. “The real-world skills students gain from the capstone courses are precisely the skills needed in the utility business going forward as we partner with government, educational institutions and vendors to implement technology and provide services that will help improve the quality of life for our customers,” said Robert D. Kump ’83, chief executive officer of Iberdrola USA, NYSEG’s parent company, and a Binghamton University graduate.

Alumnus Robert D. Kump ’83, chief executive officer of Iberdrola USA, at Binghamton’s Energy Innovation Day.
UHS TURNS TO WATSON SCHOOL EXPERTS FOR LEAN SIX SIGMA TRAINING

Last fall, Mohammad Khasawneh, associate professor of systems science and industrial engineering, conducted a Lean Six Sigma “green belt” training course for 24 employees of UHS, a not-for-profit hospital and healthcare system serving Binghamton and the Southern Tier.

Six Sigma is a business-management strategy that seeks to improve quality by identifying and removing the causes of defects, as well as minimizing process variability. It uses a set of quality-management methods and creates an infrastructure of experts within the organization. For example, a “green belt” participates in improvement projects under the guidance of a “black belt.” When Six Sigma is combined with “lean” improvement methodologies, which address process flow and waste, it’s called “Lean Six Sigma.”

According to Srikanth Poranki, PhD ’10, improvement administrator of UHS Quality and Patient Safety Services, UHS chose Binghamton University to provide the training after reviewing a number of options. “Binghamton University offered the best value for our money,” he said.

Students met once a week for eight weeks. Topics included continuous process improvement in healthcare; the impact that waste and variation have on improvement efforts; Lean thinking and Six Sigma, and their importance in achieving and sustaining continuous process improvement; and the five-phase framework for Six Sigma (define, measure, analyze, improve, control). Students also received a refresher course on statistical analysis. Games and group exercises were used to explain various concepts; several case studies and examples were also presented.

“Dr. Khasawneh and his group did a terrific job with the training,” Poranki said. “They knew many of the students had been out of school for years, so they did not put them in a room and lecture at them for eight hours. They used simulations, games and videos, so the training was interactive.”

Students must take an exam at the end of the course and work on at least one Lean Six Sigma project within a year to earn green belt certification. Poranki said all the students passed and most are already working on improvement projects.

“The students worked very hard and received all the support needed from their leadership at UHS,” noted Khasawneh. “That’s a key to ensure success, and I am extremely satisfied with the outcome.”

SAMMAKIA HONORED

Bahgat Sammakia, distinguished professor of mechanical engineering and interim vice president for research, was presented with the 2012 THERMI Award at the SEMI THERM 2012 Conference in March. The THERMI Award recognizes Sammakia’s contributions to critical thermal issues that relate to the performance of semiconductor devices and systems.

MCAA STUDENT CHAPTER FORMS

The Department of Mechanical Engineering has established a Mechanical Contractors Association of America student chapter. Sponsored by the Southern Tier of New York MCA, it will be the first MCAA student chapter in New York state. James Pitarresi, distinguished teaching professor and ME chair, serves as the faculty advisor.

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Signal

Micro system detects the wavelength of disease
Suppose you are sick enough to go to an emergency room. A physician examines you and decides that some blood tests are warranted. A phlebotomist draws the blood and sends it to a lab for testing. The results won’t be known for some time, however, so all the ER staff can do is try to make you comfortable while you are feeling progressively worse.

David Klotzkin, an associate professor of electrical and computer engineering, thinks that’s not good enough. He and a colleague, Ian Papautsky, associate professor of electrical engineering and director of the University of Cincinnati’s BioMicrosystems Lab and its Micro/Nano Fabrication Engineering Research Center, have developed a technology to not only accelerate testing, but enhance it in a number of other ways.

Klotzkin is an expert on the properties of light. Much of his research has focused intensely on photonics — the science of photons, elementary light particles — since 1998, when he earned his PhD in electrical engineering at the University of Michigan.

As a senior engineer at Lasertron Inc., a manufacturer of photonics components, he developed high-speed laser modulation equipment used in multiplexing — the combining of multiple message signals or data streams, such as many television channels or telephone conversations that share a single cable to maximize the use of an expensive resource.

As an American Society for Engineering Education summer faculty fellow at the Naval Research Laboratory in Washington, D.C., in 2007, he designed circuits that are essential for free-space optical communications. This low-power, high-data-volume alternative to conventional radio frequency communications, with both military and civilian applications, is quickly evolving thanks to improved laser technology and compact optical systems.

Klotzkin was an associate professor in the University of Cincinnati’s Electrical and Computer Engineering and Computer Science Department from 2002 to 2008. That’s when he began collaborating with Papautsky. At the time he was involved in research on organic light emitters, thin films of organic matter on glass that emit light when exposed to an energy source to excite their electrons.

Papautsky, a fellow faculty member, was studying microfluidics, the science of how fluids behave when they are manipulated in tiny spaces. He is a leader in development of what’s called “lab-on-a-chip.” Analogous to microelectronics, in which multiple functions are integrated on a single tiny device, lab-on-a-chip takes advantage of engineers’ increasing knowledge of microscale mechanics. It integrates several laboratory tests on a single tiny chip, and the advantages quickly become apparent when one considers what the technology makes possible. With a single inexpensive, disposable lab-on-a-chip, it may be possible to conduct — in the
field — different tests that, not so long ago, had to be conducted individually in a laboratory remote from where the sample was acquired. It’s also possible to perform those tests simultaneously and quickly, using samples as small as a millionth of a liter.

“In the microfluidics community, we’ve had this idea of small, disposable platforms that could be used for many different tests for a long time,” Papautsky says.

Klotzkin helped him find the way. Since different materials emit different light waves, it is possible to use light to detect the presence of disease-causing microorganisms such as viruses and bacteria.

“Fluorescence is one of the most commonly used analytic techniques in the biosciences,” Klotzkin explains. Here’s how it works in the typical microfluidic immunoassay: Regardless of what is being tested — bacteria, viruses or some other type of organic molecules — fluorescently labeled antibodies are used to tag it. An excitation light stimulates the dye to fluoresce. The wavelength of the fluorescence — essentially the “fingerprint” of the disease-causing agent — is observed through a filter that suppresses the excitation light.

There was a problem, though. “There was no way to conveniently build filters into the micro system,” Klotzkin says. Consequently, the detector signal emitted by the dye was inevitably overwhelmed by the excitation light.

That is, until he and Papautsky found a simple solution. Using polarizers, they were able to isolate the excitation light from the detector. While the excitation light is polarized, the fluorescence from the dye is emitted with random polarization. Then, when a second polarizer is positioned 90 degrees from the first, the intensity of the excitation light is dramatically reduced as it crosses the two polarizers.

“This solution works with any combination of excitation and emission light,” says Klotzkin, “even if two signals overlap in wavelength.”

Klotzkin and Papautsky published their first paper on their solution in 2007. The following year, Klotzkin joined the Binghamton faculty. Since then, they have continued to collaborate on lab-on-a-chip models that employ the polarized light approach. They’ve demonstrated the efficacy of this technique with what Papautsky calls “low-hanging fruit,” miniature and portable oxygen sensors for firefighters. Labs-on-a-chip for blood analyses are next.

“We are working toward the goal of putting a ‘lab’ in everyone’s office,” Klotzkin says, “and putting fluorescence in a microchip is one step toward that. More than half of emergency room patients require at least one blood test. With this technology they can get results immediately, from a much smaller volume of blood. Rather than send a vial of blood out to a lab, the doctor can put a drop of blood into a microfluidic system and analyze it instantly.”

Not only do labs-on-a-chip produce potentially life-saving results more quickly, they can perform several tests simultaneously. With patents pending, the engineers’ work may be about to pay off.

“There was a lot of excitement about the lab-on-a-chip idea back in the early 2000s,” says Papautsky, “but then a number of start-ups failed and investors pulled back. Things got even worse when the economy went into recession.” Now that the economy is rebounding, the two inventors’ concept could result in a new product in the near future.
There are smart phone apps to tell us if a movie is a blockbuster or a flop, if a restaurant is two stars or five, and if it’s T-shirt weather before we roll out of bed. And if we can’t remember when our bills are due every month, we have to-do lists, calendars and reminders for that as well. Yet we believe — and often expect — our doctors to know and remember everything when, in fact, they need to know far more information than they could ever memorize.

BY ASHLEY R. SMITH

Advancing a decision support system to improve physician practice and patient outcomes
Joshua Steinberg, MD, a family physician at Wilson Hospital in Binghamton, is humble enough to affirm that this information deluge is a very real challenge within the medical profession.

As Steinberg explains, it’s inevitable for questions to arise over the course of a day that a physician cannot answer on the spot. They typically involve uncertainty related to a diagnosis and treatment strategies — such as the precise dose of a medicine or what imaging study can rule out a kidney stone. Studies have shown that while doctors are quick to turn to textbooks and colleagues for support, they usually spend less than two minutes seeking an answer. And therefore, some questions go temporarily unanswered.

No worries, though. They're not rolling the dice with your health. "Maybe we order an extra test, or refer you to a specialist," Steinberg explains. "Or sometimes we have a general idea, or there's not a precise answer."

He's the first to admit that is not the best practice for good patient care. "We've all had those times when we have five patients in rooms grumbling that they've been waiting for 40 minutes to see the doctor," Steinberg says. "And there's no time to go read a chapter in a textbook."

Acutely aware of his needs in certain topics, Steinberg adopted the traditional practice of keeping pocket manuals and guides on hand.

When the Palm Pilot debuted, he became a self-proclaimed power user and was able to make a few apps for personal use. Then the iPhone arrived. UHS, General and Wilson hospitals went all-in, developing custom software to plug into the hospitals’ patient information system. Soon, every physician, every resident and every student would have a hand-held device.

Steinberg redirected his attention, but unlike with the Palm Pilot, there's no simple kit for constructing iPhone software. "After buying three different books — one literally called iPhone Application Development for Dummies — I was convinced I couldn't write a lick of it myself," Steinberg says. So he made a cold call to the Department of Computer Science at Binghamton University.

He met with computer science faculty including Associate Professor Madhusudhan Govindaraju. While iPhone programming is not part of the Watson School curriculum, they decided to give the partnership a shot.

"We teach students the foundations of computer science, programming, software and hardware," Govindaraju says. "They are proficient in some programming languages, best practices in software development and how to apply the concepts they have learned to developing applications for a smart phone."

But just as Steinberg had learned, the students couldn’t rely on picking up a book to learn exactly what to do. The iPhone environment evolves quickly, with Apple releasing new operating systems and new versions of the parameter framework every few months to a year.

To create a truly useful app, Alter also had to address the intricacies of healthcare human-computer interaction.

"The target users of these tools are people with very little time who need to see data instantaneously," Govindaraju says. "We need to figure out their attention span, how it affects them, their time and their way of doing things. It needs to be an aid to them at the point of care without requiring that they follow it exactly."

What are all the questions that should happen," Alter explains. He — like those students who have followed — read blogs, scoured websites and interacted with other programmers to learn the latest recommended API and methodology to use with the Objective C language for developing interesting features for the iPhone application. "Once I amassed enough knowledge, I wrote some simple code, did testing and played around," he says. "After a month or so of learning, I broke the project into model—view—controller (a common design pattern for user-interface development — think model = HTML, view = CSS and controller = browser). Then I broke down the code I would need to write, and after a few tries it started coming together."

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What are all the questions that should
be asked? What does the decision-tree look like? Does the patient have X or does the patient have Y and, if so, then what should be asked or what procedure should be performed?

Done correctly, the applications are a decision-support system at the point of care to prevent errors. Providing quick answers, easily and effectively, in 10 to 30 seconds, gets the doctor back to the patient.

Alter, now a second-year medical student at Ross University School of Medicine on the island of Dominica, West Indies, sees firsthand the benefits of his undergraduate work. “Patients get the right care, at the right time, with lower costs, fewer tests and a more thorough understanding of their ailment. The doctors have a better grasp of the ailment, too, so they can treat the patient better, more quickly and more effectively,” he explains. However, there are potential drawbacks to having a phone in-hand at all times. “If you are checking your iPhone, you’re not fully listening to the patient, and it could make things more difficult,” Alter says.

Steinberg and the Watson School have created nine apps thus far that meet three criteria: topics that are recurrent, complex and high-stakes.

A topic that meets all the elements is the blood thinner Warfarin. “This is probably one of the most dangerous medicines in common use besides chemotherapy, and I went the first decade of my career not being particularly good or confident in the management of this medicine,” Steinberg says. “Thin the blood so that a patient doesn’t get blood clots, but don’t make it too thin or else they’ll start bleeding, never stop, and die.”

The Warafin Guide app, written for all types of healthcare providers, answers common questions such as, how do I treat with Warfarin after a first deep-vein thrombosis (a blood clot, most commonly in the legs)? Or, when do I give vitamin K to reverse Warfarin anticoagulation and at what dose?

“For us, it’s a great educational experience for our students,” Govindaraju says. “Students are working on real projects and seeing what it means to interact with a real client. They’re able to put this on their résumé, and some are getting interview calls and subsequently jobs because of it.”

Jonathan Alter ’10
Medical student at Ross University School of Medicine, Dominica, West Indies

“M y two best friends as a freshman convinced me to join Harpur’s Ferry and become an EMT. I enjoyed my time as an EMT but I knew that I could, and should, do more.

I decided to study computer science. But medicine is my calling – I would spend my days at the bedside in lieu of a cubicle. I like the idea of learning every day for my entire life. I like that I get to interact with people every day. And, that I work as part of a team and as an individual.

My CS classes and lab work taught me how to effectively and methodically analyze a problem. In my medical studies, some elements of my education are simple memorization of facts and numbers. But generally, each disease or symptom can also be broken down into smaller pieces to show a grander picture.

Granted, I won’t be using what I learned in Theory of Computation anytime soon. But those skills to view or find a problem, understand the problem at its core, break it down and solve each piece so I can build it back up with a better solution — that is what CS at Binghamton taught me. And I can apply that to almost anything.”
Ronald Miller was only a freshman, but his search for a summer research project paid off in spades when Associate Professor of Bioengineering Jacques Beaumont connected him with Dr. Daniel Tso, director of research at SUNY Upstate Medical University's neurosurgical laboratories. During summer 2011, Miller joined Tso's team of NIH-funded researchers working to develop an early-detection protocol for debilitating retinal diseases that affect the sensitive tissue inside the eye.

"Right now, the only way to identify macular degeneration — or many other retinal diseases — is to already have it," Miller explains. "By then it's past certain points in treatment. This could be a way to detect it before the onset of the disease."

To develop a new method for assessing the health and function of the retina, Miller helped other lab staff present visual stimuli to normal mice and mice with specific genetic mutations. Miller collected retinal images from the stimulated mice with sensitive digital cameras. The images captured expected retinal activity in the normal mice, and showed expected deficits in retinal function in mice with the mutations. These mice, as Miller learned, are called "knockout mice" because certain genes are selectively removed prior to research — in this case, photoreceptor genes that affect retinal function.

Miller's interest in biomedical engineering grew during his first year in the Watson School. The research experience was a way to go beyond the classroom, forcing him to apply theory, find information and solve problems on his own. And he was able to experience the fast pace and steep learning curve of biomedical research early on in his college career. "You have to be more like an autodidact," he says. "Independent learning was a big part of successful research."

Miller rejoined Tso's team this summer to process the results in the mouse retinal research, readying the study for publication. He will also participate in the adaptation of the method for use in humans.
Kevin Buschle, left, and Eric Van Aernam create an all-terrain wheelchair for Sky Lake Buddies Camp. The wheelchair will transport campers ages 18 to 65 with a range of disabilities down a steep grass hill and over mud, sand and gravel to the camp’s waterfront.

Tasha Casagni builds a device that will enable a Binghamton biological sciences PhD student to better understand the way animals learn. The animal — such as a parrot — is asked to play a pattern recognition video game, and if completed correctly, is delivered a reward.

Aristo Wong, left, and Paul Knudsen build an inexpensive wheelchair lift using a winch and pulley system for the Southern Tier Independence Center. Lifts on the market today start around $5,000 while the raw materials for this model came in under $500. Professor and Undergraduate Program Director George Catalano looks on.
Breeding a

Bioengineering’s most recent hire targets cell behavior to understand critical health concerns

BY ASHLEY R. SMITH

The tissues and organs in the body aren’t just influenced by nutrients and blood flow, but by changes in internal pressure, strain and stresses. All of these add up to create a dynamic environment that challenges biomedical researchers.

“Problems in human health have always been the most interesting to try to solve,” says Gretchen Mahler, assistant professor of bioengineering. Her research looks at how biochemical signals and biomechanical forces influence the building blocks of our body during the development and progression of disease or in response to therapeutic drugs or chemicals. “Does the shear flow over an epithelial layer cause changes around a tumor, and can it cause the tumor to metastasize or trigger further genetic changes in the tumor that lead it to mutate more?” It’s the kind of question that Mahler has been working to answer for the better part of a decade.

Mahler joined the Watson School faculty in fall 2011. Her specialty is in vitro cell-culture models of organs and tissues — a tool that mimics what is happening in the body.

Her peanut-sized “body-on-a-chip” has chambers of living cells etched onto silicon. Liquids containing drugs are passed through tiny channels to determine how they interact with and are absorbed by human kidney, liver, bone marrow, lung and tumor cells.

This three-dimensional dynamic-culture environment is a biomedical niche with the potential to shed new light on disease.

In vivo (in the body) experiments — such as animal testing — provide the most accurate data on how a compound interacts with an organism. But, Mahler says, it’s difficult and sometimes impossible to tell how the compound interacts with individual organs, tissues and cells.
In silico (computational) methods provide a great deal of data on how a drug or toxin interacts with a human, but, she explains, “the model’s performance and biological relevance depend greatly on the accuracy of the parameters you put into the model.”

In vitro testing is the middle ground. It can replicate some of the cell-to-cell interactions that are not as easily studied in vivo or in silico. And the data collected in vitro can be applied to computational models to improve accuracy. Mahler’s “body-on-a-chip” microfluidic device is the groundwork for better compact modeling of human systems.

“By taking things and shrinking them, we use less reagent, which lowers the expense and enables us to do more testing, and more at one time,” Mahler says. “It also brings it to a physiological scale that’s more realistic in cell-to-fluid ratios.”

Though new to Binghamton, Mahler has an impressive toolbox of skills when it comes to bioengineering or biomedical engineering. As a Cornell graduate student she worked in microfabrication, microscopy and computer modeling. As a postdoc she moved on to microbiological techniques, microsurgery, and primary cell isolation and culture. Her studies ranged from nutrient absorption, drug absorption and interaction of toxic substances such as nanoparticles in the gastrointestinal tract, to working to understand how biochemical signals and biomechanical forces influence heart valvulogenesis and the development of heart-valve disease.

Across the board, the common thread was building in vitro models.

At Binghamton, Mahler is collaborating with researchers on several projects that include studying the role of biomechanical and biochemical forces on the development of heart-valve disease; studying the role of biomechanical forces and biochemical factors on cancer-associated fibroblast generation and cancer progression; minimizing soybean allergies with natural engineering by studying soybean protein transport through models of the gastrointestinal tract; and investigating the pharmacokinetics of pHLIP — a novel anti-cancer peptide developed by Assistant Professor of Chemistry Ming An.

The pHLIP (pronounced “flip”) project targets tumors based on acidity in order to alleviate common issues with toxicity to surrounding healthy tissues. If successful, the team will have made major strides in selective drug delivery.

“When I went to college, I always had a medical slant and was thinking about being pre-med. But this is exactly where I want to be,” Mahler says. “Trying to solve problems in human health is not always specifically in the clinic.”

By studying how embryonic cells behave, Mahler may have a blueprint for directing adult cells away from disease and toward regeneration.

Shown here, embryonic heart valve endothelial cells (top) and adult valve endothelial cells (bottom) grow in a control medium and an inflammatory medium that triggers cell differentiation. Red and green stains help to identify cell transformations.
The Department of Bioengineering’s newest assistant professor, Gretchen Mahler, is quick to note that everything she needs to do her work, and to do it well, is here at Binghamton. That includes high-quality undergraduate and graduate students.

"The first year is a transition. I give students a list of projects I have available, they decide what they want to work on, and then they have to learn all the techniques in the lab," Mahler says.

Bioengineering senior Matthew Reiss is one of eight to join her team. As an undergraduate research assistant, Reiss will grow and care for a stock of sensitive kidney cells necessary for cancer drug testing. To prepare, he received hands-on training from Mahler that ranged from laboratory safety techniques to how to make solutions and sterilize them, and then how to grow and work with cells.

"We got the whole spectrum of how you treat cells — everything from growing cells to cryogenically freezing them. We purposely got to contaminate stuff so we could see what a bacterial infection looked like," Reiss says. "We learned the basics of how it’s done, why it’s done and then practiced it."

Bioengineering senior David Bassen is studying the interaction of therapeutic nanoparticles with heart-valve endothelial cells. Bassen is a Barry M. Goldwater Scholar.

Bioengineering junior Yehudah Pardo is working with cyanobacteria to develop biological solar cells.

Master of engineering student Qingfeng Cao is designing a microfluidic chamber for studying biological cell transformations.

Biomedical engineering master’s student Sara Mina is working with Cao to design and build a microfluidic chamber. Mina is also working with the endothelial and prostate cancer cells that will be grown and studied.

Biomedical engineering master’s student Frances Wallace is studying the absorption of soybean protein subunits through a model of the GI tract. The project will use natural plant enzymes to pre-digest soybean proteins with the hope that this pre-digestion will help minimize soybean allergies.

Biomedical engineering doctoral student Sudip Dahal is developing a microfluidic model of the heart valve to study the role of biochemical and biophysical factors on endothelial-to-mesenchymal transformation.

Biomedical engineering doctoral student Courtney Sakolish is developing a microfluidic device including kidney, liver, tumor and bone marrow cells to better understand the pharmacokinetics of pHLIP. Sakolish — a Clifford D. Clark Fellow — will develop and test two structures to grow an in vitro kidney most effectively.
ANSWERING THE “WHAT IF”

Systems scientists and industrial engineers harness the power of simulation to model better healthcare.

BY NATALIE BLANDO-GEORGE
Soon after Mohamed El-Sharo, MA ’09, PhD ’12, graduated in May with a doctorate in industrial and systems engineering from the Watson School, he left for Minnesota to start his career at the Mayo Clinic. He is among the hundreds of engineering graduates nationwide who are using their expertise in process and system improvement to make hospitals, HMOs, long-term care facilities, clinics and other healthcare-related organizations more efficient and effective.

“As a health-systems consultant, I am providing technical advice to the hospital departments and units to improve their performance,” says El-Sharo, who was advised during his doctoral studies by Mohammad Khasawneh and Sang Won Yoon, faculty members in the Department of Systems Science and Industrial Engineering (SSIE). “I chose the Mayo Clinic because it is one of the leading healthcare organizations in the world.”

Discrete-event simulation (DES) is among the many engineering tools El-Sharo is using to help the Mayo Clinic streamline its operations.

According to Sarah Lam, associate professor of SSIE, “Discrete-event simulation is a technique that enables the user to evaluate the efficiency of existing healthcare delivery systems, to ask ‘what if’ questions and to design new systems.”

DES can be used to predict the impact of changes in patient flow, to examine resource needs or to investigate complex relationships among different variables (such as rate of arrivals or service). This data enables healthcare managers to select alternatives that can be used to reconfigure existing systems, improve system performance or design, or plan new systems. “A simulation study allows you to test different scenarios, make mistakes and try new things without impacting patients or staff,” Lam explains. “That’s not always feasible in the real world.”

One of the greatest advantages of DES, Lam says, “is its ability to capture the randomness found in the real world.” Simulation studies can provide results in minutes or hours rather than months or years, and they enable organizations to assess various options without committing precious resources to them.

“With simulation, there is no need to interrupt processes or stop them to experiment with improvement suggestions,” El-Sharo adds. “Because healthcare processes are very sensitive and directly involve patient safety, simulation seems to be the best tool to analyze those sensitive processes.”

Watson School students learn DES in Lam’s undergraduate- and graduate-level simulation courses. All students taking these courses must complete a simulation project, through which they implement the steps involved in developing a simulation study and learn how to model the various systems in simulation software, including Arena and Simio.

Most simulation software has animation capability. SSIE Assistant Professor Sang Won Yoon says that is useful in helping healthcare personnel, who typically don’t have an engineering background, visualize different scenarios. “We can show them how their current system looks and then how it would look if they implemented a process change,” he notes. “It’s much easier for people to understand than a lot of jargon and statistics.”

Through the Watson Institute for Systems Excellence (WISE), Lam, Yoon and SSIE Associate Professor Mohammad Khasawneh work with students on projects for healthcare organizations with an eye toward improving efficiency, reducing costs and increasing patient satisfaction and safety. Previous studies that used DES have focused on streamlining hospital emergency department patient and process flow, increasing the use of a hospital’s dental clinic, optimizing chemotherapy chair usage at an ambulatory infusion center and reducing wait time within a hospital’s outpatient physical therapy department.
In addition to discrete-event simulation, researchers in SSIE use digital-human modeling and agent-based simulation methods. “Depending on the nature of the behavior of the people or the nature of the processes that take place, we have to decide what type of simulation to use,” Khasawneh says. “The nature of the system being studied determines the type of simulation that’s most appropriate for the specific objectives identified for maximum impact.”

Digital-human modeling enables the user to simulate various work environments with biomechanically accurate “human” models and then measure the effects of different activities on the body. Khasawneh explains that you can determine the impact of various changes that can be made within the workplace to determine which will produce the most positive outcome on the human body from an ergonomics perspective. “The ability to perform digital-human modeling is important, since doing these assessments in real life is difficult, time consuming, inconvenient and costly,” Khasawneh says. “By doing this in a simulated environment with biomechanically accurate digital humans, we can quickly and easily test different kinds of ‘what if’ scenarios.”

Previous healthcare-related research projects that used digital-human modeling examined patient lifting protocols, the stresses sonographers endure during ultrasound procedures and the appropriate height for an operating room table for surgeons performing laparoscopic procedures. “Studies like these help improve workplace safety and productivity,” Khasawneh says. “They can also be used to reduce the risks associated with work-related musculoskeletal disorders (WMSDs), such as back injury and upper extremity disorders.”

With agent-based simulation, every simulated person is considered an “agent,” and that agent’s actions and interactions are studied. Agent-based simulation is currently being used to evaluate why people in rural areas sometimes bypass their local hospital to seek services in a larger city, even when those services are available locally — an issue that has a significant financial impact on the local hospital.

As healthcare costs continue to rise, healthcare organizations are under pressure to improve efficiencies, reduce costs and increase patient satisfaction. With its proven record of helping them do just that, simulation continues to be an invaluable tool in the healthcare field, and those skilled at its use remain in high demand. Just ask El-Sharo.

“Being proficient in using simulation modeling as a tool, I built an impressive résumé that helped me get job offers from many healthcare organizations,” he says. “This eventually led me to the Mayo Clinic.”
WaTS

Managed chaos

WHAT DOES IT TAKE TO MOVE 150 PATIENTS — THE YOUNGEST A MERE TWO HOURS OLD — TO A NEW FACILITY THREE MILES AWAY IN UNDER FOUR HOURS? TWENTY-FOUR AMBULANCES, OVER 175 NURSES, 100+ VOLUNTEERS AND 18 MONTHS OF PLANNING, PRACTICE AND PASSION.

Virtua’s Voorhees Hospital in south New Jersey was maxed out on space. Besides no land to expand on, retrofitting the building built in 1973 for tomorrow’s technology while concurrently improving workflow was not only challenging, but costly.

So Virtua decided to build a new $463 million, 680,000-square-foot campus that would enable them to transform their entire care system and create an environment to meet needs of patients and providers for decades to come.

In the midst of the venture was Tejas Gandhi, MS ’03, assistant vice president of management engineering and lean leader at Virtua, who led the process-driven hospital design. “Before pen went to paper, we looked at over 200 processes,” he says. “Ninety-nine percent of people come to work to do a good job. When there is an error, it’s because the system fails.”

Gandhi, who studied industrial and systems engineering at Binghamton, used patterns and hospital data to make educated, cost-saving decisions. “When the planners came back with 395 beds, we said we only needed 368. It’s less than 20 beds, but each bed costs us $2 million.”

Together, the engineers and architects infused art with science as the planning moved forward.

They removed barriers that were non-value add — spend a year in the shoes of a nurse at Virtua and you’ll have walked from Philadelphia to Atlanta. “It’s not about the walking, it’s about time spent away from patient care,” Gandhi explains.

They also removed opportunities for mistakes.

By identifying and isolating critical pathways, patients travel shorter distances for testing and procedures. And staffing models ironed out issues with flow for modification at the new location. For example, bathrooms are now located off the end of the patient bed instead of the head.

Also on Gandhi’s team were industrial and systems engineering alumni, Joshua Bosire, MS ’07, and Balagopal Gopakumar, MS ’08. As graduate research associates with the Watson Institute for Systems Excellence (WISE) working at Virtua, the duo built computer models and simulations critical to ensuring that hospital staff and volunteers understood move concepts before the full-scale drills. Virtua has since hired both full-time, and Gopakumar is also a part-time PhD student in the ISE program.

At the end of the big move day, Gandhi and his fellow Virtua colleagues were thrilled with how smoothly things went, and with their organization’s new home. “Working out scenarios ahead of time allowed staff to be on top of the process, and, most importantly, for our patients to feel at ease.”

Tejas Gandhi, MS ’03, assistant vice president of management engineering and lean leader at Virtua Voorhees Hospital, center, during move day.
Imagine having surgery without a surgeon present in the operating room. What if your surgeon were in another state or even another country? With robot-assisted remote surgery, that's exactly what can happen.

Remote surgery combines elements of robotics and state-of-the-art communication technology. With remote robotic surgery, physical distance between surgeons and patients is irrelevant, allowing patients to access the expertise of specialized surgeons around the globe from any hospital equipped with a surgical robot.

But remote robotic surgery has some challenges, says Mechanical Engineering Professor Frank Cardullo, MS ’72, a researcher in the field of man-machine systems. Before joining the Watson School, Cardullo spent years designing simulators for flight and aerospace.

Today, he is applying his expertise regarding perception and stimulation of visual and motion cues, and computational methods for real-time systems, to improve remote robotic surgeries and develop a simulator that will provide valuable true-to-life experience for surgeons.

“The tactile feedback surgeons get during traditional, ‘open’ surgery is missing with these remote robotic procedures, and that information is very useful,” explains Cardullo.

Through the use of sophisticated signal-processing techniques, Cardullo is also working to mitigate the time delays introduced when you physically separate the surgeon and the surgical robot. The time it takes for the signal to travel to and from a communications satellite results in a time lag between the surgeon’s “command” and the robot’s response that can affect the surgeon’s performance and the outcome of the surgical procedure.

“During remote robotic surgery, you’re operating over long distances and through computers, so there is a communication delay that can be as much as two seconds.” And as he explains, in robotic surgery or any high-performance man-machine system, any delay greater than 50–75 milliseconds is problematic.

The Department of Systems Science and Industrial Engineering (SSIE) will offer a Pursuit of Operational Excellence event **OCTOBER 11-12** during Homecoming Weekend. Industry professionals, University professors and recent SSIE alumni will share their insights into the capabilities of industrial and systems engineering practice offered by the department and students. Particular emphasis will be on the fields of healthcare systems and electronics packaging.

For more information and to register, visit binghamton.edu/ssie/about/opex.
Could nanomaterials hold the answer to reversing the effects of UV radiation?

BY SHERRIE NEGREA
The link between sunlight and skin cancer is widely accepted — the absorption of ultraviolet radiation can damage skin cells. Exactly how the sun’s radiation breaks down the DNA within cells is a process that Changhong Ke, assistant professor of mechanical engineering, has spent the past six years trying to understand.

At first, Ke used an atomic force microscope with an extremely sharp tip to observe the single- or double-strand breaks that radiation causes in DNA molecules. More recently he has collaborated with Jie (Jayne) Wu, associate professor of electrical and computer engineering at the University of Tennessee, to use an electrical field to separate the DNA based on the impairment it has experienced.

“This can help us understand the damage caused by the radiation, and it can be used to study the repair of DNA,” Ke says. “You have to know how much damage occurred before you even consider repairing the DNA.”

Ke’s research on detecting DNA damage is one example of how he has integrated biology and physics with mechanical engineering at the nano level. While he is conducting foundational research, Ke says the tools he has developed to observe DNA molecules could be applied to evaluate new therapeutic drugs designed to rebuild impaired cells.

“Our tools can help determine how efficient the drug is,” Ke says. “If 50 percent of a cell’s DNA has been damaged and, after drug treatment, only 20 percent of the total DNA is still damaged, then the drug has fixed 60 percent of the damaged DNA.”

After earning a bachelor’s degree at Beijing Institute of Technology, Ke completed a doctoral degree in mechanical engineering at Northwestern University, where he focused on nanomechanics. It wasn’t until he began a post-doctoral fellowship at Duke University that he delved into biophysics, the study of the physical properties of biomolecular structures.

At Duke, Ke was part of a team of scientists who were the first to measure the force between the nucleotides in a single-stranded DNA molecule with an atomic force microscope. By quantifying a single strand of DNA, the Duke scientists could separate the effects of the two principal forces that characterize the double helix structures — the stacking force between base units along the length of the helix and the pairing force between opposing base units that form its rungs.

After arriving at Binghamton in 2007, Ke began a new area of research with many potential applications — nanotubes. These hollow structures form low-density, high-strength materials that can be used for tasks ranging from drug delivery to spacecraft development. When thousands of nanotubes are joined together, they’re still thinner than a single strand of hair.

In 2010, Ke was one of 43 researchers nationwide selected for the Air Force’s Young Investigator Research Program, which supports scientists and engineers who have received a PhD in the past five years and who show exceptional ability and promise for conducting basic research. With a grant of $120,000...
annually for three years, Ke is investigat-
ing whether nanotubes, formed from either carbon or boron nitride, could enable the Air Force to reduce the weight of vehicles such as fighter planes and spacecraft.

In another angle of this research, Ke is combining the carbon nanotubes with DNA molecules to create a hybrid material that may have therapeutic applications. Working with Assistant Professor of Mechanical Engineering Pong-Yu “Peter” Huang, Ke is attempting to determine how strong the bond is between the DNA and the nanotubes and, conversely, how much force is required to separate the two materials after they interact. That question will have a bearing on potential applications because once the DNA wraps around these nanotubes, the DNA can no longer perform its chemical functions and is rendered useless.

“If you use these as some sort of drug delivery agents for gene therapy, you want to know exactly what kinds of impact they have when these carbon nanotubes are injected into cells,” says Huang, who has been collaborating with Ke since 2010.

In his nanomechanics laboratory, Ke works with three graduate and two undergraduate students, often conducting research late into the night. One of his students, Meng Zheng, who received his PhD in mechanical engineering in May 2012, has published nine journal articles with Ke and given four presentations at national and international conferences.

What impressed Zheng in the four years he worked for Ke was his dedication and his attitude toward his research. “I learned a lot from his research skills — how to define a problem, how to analyze a problem and how to solve a problem,” Zheng says. “He’s also a kind-hearted person and he can motivate people. He’s the best professor I’ve had in my life.”
I want students to have the tools in their hands to solve problems.

– Joseph “Harry” Boyer, founder, chairman and chief technology officer of Innovation Associates, which has worked with the University’s Watson Institute for Systems Excellence (WISE).

Joseph “Harry” Boyer supports the Watson School

$250,000 TO THE WATSON SCHOOL EQUIPMENT ENDOWMENT

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BOLD BRILLIANT BINGHAMTON
THE CAMPAIGN FOR BINGHAMTON UNIVERSITY
Seven-year-old Ibny Xian prepares to launch his rocket with the help of Robert Dextre '12 and Watson School Dean and Distinguished Professor Krishnaswami “Hari” Srihari. Dextre, a graduate of mechanical engineering, interned at NASA and will attend the University of Alabama, Huntsville, this fall to pursue a PhD in aerospace engineering. The rocketry workshop was sponsored by the Society of Hispanic Professional Engineers.