ENGINEERING
Momentum
Across Disciplines. Across the World® // SPRING 2015

Drones:
Wave of the future or nuisance?

Washington University in St. Louis

Snapshot //

WashU students enjoy spring weather in the Quad.

WUSTL PHOTO

In this issue //

SPRING 2015

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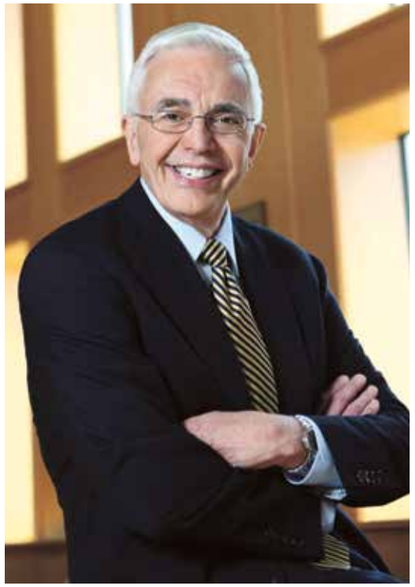


Dear friends,

It has been a privilege and honor to lead the School of Engineering & Applied Science during the past five years, and I am extremely proud of the considerable progress that we have accomplished together. Since 2010, we have welcomed one-third of the current 90 tenured and tenure-track faculty — including two new department chairs — who are all recognized among the very best engineering scholars in the world. We also increased student enrollment by 20 percent, creating the school's largest-ever undergraduate and graduate classes, and launched 16 new undergraduate and graduate academic programs. In addition, we improved diversity among students, faculty and staff, strengthened research programs in all departments and significantly expanded the school's facilities when we opened Stephen F. & Camilla T. Brauer Hall and Preston M. Green Hall. With plans underway for Henry A. & Elvira H. Jubel Hall, I am confident these state-of-the-art facilities will continue to attract truly outstanding faculty and students.

I am particularly pleased with the school's transformation into a fast-growing entrepreneurial engineering school. From the Discovery Competition, which we launched in 2011, to new courses and student organizations, along with enhanced alumni mentor and startup community relationships, our faculty and students are developing new products, solutions and companies at a rapid pace.

Of course, none of these achievements would have been possible without the unwavering commitment from the chancellor, provost and others in the upper administration; the dedication to excellence by the faculty and staff; and the steadfast support of alumni, parents and friends. Thousands of you have contributed countless hours as volunteers and have donated more than $94 million so far during the *Leading Together* campaign that helped us turn a strategic vision into reality. The work needs to continue for the school to reach the next level of achievement and visibility, but thanks to you, the future is bright, and I know it will shine even brighter during the years ahead with Aaron Bobick as dean and with your continued support.

Sincerely,

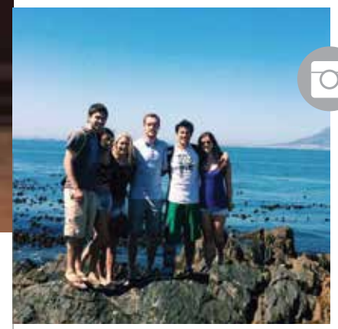
Ralph Quatrano, PhD
Spencer T. Olin Professor & Dean
rsq@wustl.edu

SOCIAL MEDIA BUZZ #wustlengineers

WUSTL PHOTO

Mae Jemison, MD, the first African-American woman in space, spoke to students Feb. 28 about her experience as a NASA astronaut.

Congrats to our new McKelvey Scholars, selected for their academic achievements, leadership ability and potential to make significant contributions to undergraduate research. Each will be conducting research with a faculty member in engineering, medicine or the sciences.



WashU Engineers studying abroad in Cape Town, South Africa

Rubik's Cube world champion and #WUSTLengineer **Kevin Hays** solves puzzle in 15 seconds while in a shark tank!

National Engineers Week

Feb. 22-28, 2015

Engineering students test their skills out making sculptures with butter and other hands-on activities.

Aaron Bobick, PhD, professor and founding chair of the School of Interactive Computing at the Georgia Institute of Technology, has been appointed dean of the School of Engineering & Applied Science at Washington University in St. Louis effective July 1.

DEVON HILL

LEADING THE WAY

Aaron Bobick, PhD, takes reins as dean July 1

Written by **JULIE HAIL FLORY**

Bobick will succeed Ralph S. Quatrano, PhD, who has served as dean since 2010 and announced last fall that he would be stepping down at the end of the 2014-15 academic year.

"I could not be more pleased that our search for the next dean of the School of Engineering & Applied Science has led us to Aaron Bobick," Chancellor Mark S. Wrighton said. "His many accomplishments as an educator and an innovator in his field make him extremely well suited for this position. I have no doubt he will bring an insightful and creative approach to our work in this critical academic arena.

"I also am deeply grateful to Ralph Quatrano for his years of service," Wrighton added. "It is thanks in large part to his strong leadership during the past several years that the school is poised to reach new heights in research and engineering education."

"After talking with the faculty, chairs, deans, the provost and chancellor, it is clear to me that the School of Engineering & Applied Science is rapidly expanding its scope and impact, with a strong emphasis on excellence in both education and research," Bobick said. "I cannot imagine a more attractive opportunity than becoming its dean. I look forward to our continued growth in influence — not only on the university, but also on the country and around the globe, from both the innovations we produce and the student leaders we graduate."

> "I look forward to our continued growth in influence — not only on the university, but also on the country and around the globe, from both the innovations we produce and the student leaders we graduate."
>
> — AARON BOBICK, PHD

A member of the Georgia Tech faculty since 1999, Bobick's research primarily focuses on action recognition by computer vision, an area in which he was a pioneer. He has recently extended his research to robot perception for human-robot collaboration. Bobick served as director of the

1981

Earns Bachelor's of Science degrees from Massachusetts Institute of Technology in Mathematics and Computer Science

1987

Completes doctorate from Massachusetts Institute of Technology in Cognitive Science

1992

Joins the MIT Media Laboratory faculty where he led the Media Lab DARPA VSAM project as well as a Dynamic Scene Analysis effort funded by the CIA

1999

Joins the faculty at Georgia Tech as Director of the GVU Center (formerly the Graphics, Visualization and Usability Center)

2005

Georgia Tech's School of Interactive Computing is created with Bobick as the founding chair

2014

Elected Fellow of the Institute of Electrical and Electronics Engineers (IEEE)

Georgia Tech Graphics, Visualization and Usability Center, an internationally known research center in computer vision, graphics, ubiquitous computing and human-computer interaction.

He also originated and helped develop Georgia Tech's computational media bachelor's degree program, which attracted some 300 majors within its first five years, and developed a variety of new courses that were introduced to the university's curriculum between 2000 and 2014.

> "His remarkable success as an administrator set him apart within an exceptionally strong pool of candidates. I am highly confident in his ability to set the tone, build momentum and lead the School of Engineering & Applied Science into its next chapter."
>
> — HOLDEN THORP, PHD

"In addition to his distinguished academic record, Aaron Bobick is also a great leader," said Provost Holden Thorp, PhD. "His remarkable success as an administrator set him apart within an exceptionally strong pool of candidates. I am highly confident in his ability to set the tone, build momentum and lead the School of Engineering & Applied Science into its next chapter."

Wrighton and Thorp also expressed their appreciation to the search committee, which was chaired by Mahendra Gupta, PhD, dean of the Olin Business School and the Geraldine J. and Robert L. Virgil Professor of Accounting and Management.

"We have made tremendous progress over the last five years with attracting extremely talented students, faculty and key leaders as department chairs," Quatrano says. "I am convinced that as dean, Aaron Bobick will not only continue the school's momentum and take it to the next level of national and international visibility and recognition, but with his expertise and background in data and computer science, will ensure its major role in interdisciplinary work on and off campus."

Bobick is a graduate of the Massachusetts Institute of Technology (MIT), where he earned bachelor's degrees in mathematics and computer science and a doctorate in cognitive science. Prior to joining the Georgia Tech faculty, he served as a member of the MIT Media Laboratory faculty, where he led the Media Lab Defense Advanced Research Projects Agency (DARPA) Video Surveillance and Monitoring Project, as well as its Dynamic Scene Analysis research effort.

He also has served as a senior area chair for numerous international computer vision conferences and as program chair for the Institute of Electrical and Electronics Engineers (IEEE) Conference on Computer Vision and Pattern Recognition. He has founded a variety of successful startup companies, is a distinguished scientist of the Association for Computing Machinery and was elected a Fellow of the IEEE in 2014.

Clockwise from left: Aaron Bobick greets School of Engineering & Applied Science faculty and staff March 13; Bobick talking with Barbara Schaal, PhD, dean of Arts & Sciences and William Tate, PhD, dean of the Graduate School of Arts & Sciences and vice provost for graduate education; Bobick and his wife, Denise.

PHOTOS BY DEVON HILL

Drones: Wave of the future or nuisance?

Written by **BETH MILLER**

To those who remember watching the 1960s futuristic cartoon "The Jetsons," using unmanned aerial vehicles, or drones, to make package or pizza deliveries, to monitor crops or vineyards or to take video from new perspectives may seem like an idea whose time has come. But with that idea comes many 21st-century concerns, including privacy, liability, regulations and the most basic — how they work.

Faculty in the School of Engineering & Applied Science at Washington University in St. Louis are working to address these issues, since the low cost and accessibility of drones is leading them to become more common in some conventional and unconventional uses.

Watch Humberto Gonzalez, PhD, and Raj Jain, PhD, fly drones on the WashU campus: http://bit.ly/1HrRu0S

Drones: What are they?

Unmanned aerial vehicles or unmanned aerial systems, commonly known as drones or quad rotors, are smaller aircraft that can be used where it is too difficult, too risky or too expensive for a manned aircraft to fly. Ranging from $50 to millions of dollars, these aircraft run on short-lived batteries and generally cannot fly nearly as high as manned vehicles. They can be equipped with navigational equipment, such as a GPS, and sensors to read external conditions such as temperature, moisture and density, and often have cameras aboard to send back photos and videos to those controlling them. The U.S. government already is using drones to manage federal lands, monitor wildfires, conduct scientific research, monitor borders, support law enforcement and to train the military.

While there is a human operator controlling drones commercially available to the public, it's not quite like operating a remote-control airplane. Drones are programmed with highly complex computer code to transmit data gathered by the sensors and cameras.

Taking the challenge

In his lab, Humberto Gonzalez, PhD, assistant professor in the Department of Electrical & Systems Engineering, is using drones as a platform to study controlling systems, such as smart homes or hydroelectric power plants. While it is difficult to test for problems in a hydroelectric power plant because of its scope and size, testing sensors, new code and algorithms in drones is easier and less expensive, and the outcome can be applied to larger systems, even to autonomous cars, Gonzalez says.

"In the particular case of autonomous vehicles like drones and cars, it's very interesting for people like me because there is a place to do the things I like to do, which is work with theoretical problems, take them, write the code and make them work in real life," he says.

Gonzalez and his team are working to make drones that fly indoors without bumping into walls, the ceiling or people. They buy drones from a toy store or online, flush out the code inside the drone and load in new code that they have written.

Why would someone want to fly drones indoors? Flying indoors presents more challenges than flying outdoors, Gonzalez says.

"If we're going to make this completely autonomous, at the very least, we want it not to crash into the ceiling and walls," he says. "We want to have a high degree of certainty that the code we wrote and the mathematical algorithms that we are using will not make it crash into the ceiling. We want to do most of the work before we even turn it on."

Regulations and liability

In addition to flying drones indoors, Gonzalez is also interested in the liability and regulatory issues associated with drones.

"Liability is the biggest question out there," he says. "The liability problem is completely open, and everyone is trying to say, 'We can manage all of this, and we know what we're doing.'"

For example: A real estate agent purchases a drone with a camera to take photographs of homes he or she is selling. The agent turns it on, it flies over the home and takes some photos. But something goes awry, and the drone falls and crashes through the windshield of a car in the neighbor's driveway. Who is responsible for the damage: the agent, for making an error in operation while in control of the drone, or the drone manufacturer for a potential error in the code that may have caused it to crash?

Neil Richards, professor of law in the Washington University School of Law, says it's important that engineers not allow concerns about liability to cloud the development of drone technology.

"We might want to have the questions of privacy cloud the development, or at least shape the development, of the deployment of the technology in ways that respect commitments to privacy, but mere legal uncertainty shouldn't be something that stands in the way of developing these things," says Richards, who also teaches in the Henry Edwin Sever Institute in the School of Engineering & Applied Science. "We're living in a time when lots of new things are possible that weren't possible before. The law is necessarily going to lag, because we don't want to regulate everything prospectively, but wait until cases come up and we see problems before we deal with these things."

Drone manufacturers could attempt to escape liability through writing a contract with its human supervisor.

"Companies can give you a contract that says, 'You can fly this drone within certain conditions — no rain, no wind. If you meet all of those conditions, and the battery is charged, the drone will never crash,'" Gonzalez says.

While that may sound outlandish, that's a similar contract that commercial airplane manufacturers have with airlines and that state motor vehicle departments have with drivers when they issue a driver's license.

Gonzalez says there is no such contract — yet — for autonomous vehicles and drones, because the technology is still in its early stages.

"This is a highly mathematical problem that involves understanding what a quad rotor is capable of doing. We are studying the mathematical description of the dynamics of the quad rotor. Given the types of maneuvers the helicopter can do, which ones are safe and which are unsafe, given the data from the sensors?"

Security and safety

New proposed guidelines released by the Federal Aviation Administration Feb. 15 require unmanned aircraft to have an operator who has passed a test at an FAA-approved testing center and has obtained an unmanned aircraft operator certificate. In addition, operators would have to report any accident that results in injury or property damage to the FAA within 10 days, and drones must remain in the line of sight of the operator, which limits their use for delivery purposes.

One of the biggest concerns about the use of drones is their potential to interfere with commercial air traffic. Drone operators are required to notify an airport if they plan to fly within five miles of it. However, in late 2014, the FAA released that pilots and controllers had reported about 150 incidents of drones flying near aircraft or near misses to date that year.

Air traffic control towers are responsible to manage commercial air traffic in a certain area around each tower. If two planes are approaching each other, it's the tower's responsibility to prevent the crash. Will we need a control tower for drones?

"Probably not, because it defeats the purpose of speed," Gonzalez says. "But if you have drones that are flying around, how do you control them? What if there is a drone traffic jam?"

Neil Richards

DEVON HILL

Gonzalez says these are questions that will have to be answered as drones become used more frequently.

The U.S. military has been using drones for surveillance in foreign conflicts, and the U.S. Department of Homeland Security and U.S. Customs and Border Protection have been using drones to monitor activity on the nation's borders. US CBP has the largest U.S. drone fleet of its kind outside of the military. But there has been considerable criticism of both programs from many groups, including the American Civil Liberties Union (ACLU), which argues that drones limit privacy and personal liberties.

Police departments, such as the St. Louis Metropolitan Police Department, have advocated for the use of drones to assist them in watching over large crowds or to help chase a suspect. While some police departments are using drones, the implementation nationwide has been slow due to privacy and safety concerns.

"Do we want to have particular rules for police drones, particularly weaponized drones with teargas or missiles or plastic flechette guns to control crowds, and do we want to have particular procedures in place before police will deploy a drone against civilians in the U.S.?" Richards asks. "These are things that we want to work out soon rather than after the fact. We're going to need to strike some balances between police effectiveness and civil liberties and between the ability to use drones to look at the world and people's rights of privacy against being spied on."

Other applications

Raj Jain, PhD

Raj Jain, PhD, professor of computer science & engineering, is working on other applications for drones in his lab. Jain's group is working on a project called Cellular System for Emergency and Disaster Relief, based on the concept that natural disasters can compromise ground-based communication infrastructure, making it difficult for victims to contact safety personnel and for those personnel to communicate warnings. Under their proposal, unmanned aerial vehicles could be used to provide cellular access to users with standard mobile phones, improving communication during times of crisis.

"Ninety-six percent of the world has cell phones," Jain says. "When there is any emergency, such as a hurricane or other natural disaster, cell towers are useless, and that is the time everyone wants to call someone."

In addition, Jain says drones with sensors, which cost about $700, can be sent up for many other applications, including in forests to detect wildfires, temperature and carbon dioxide; in oil and gas exploration; wildlife and environmental monitoring; and in agriculture, in which sensors can be placed in crops to detect moisture levels or temperature.

Scaled-down drones

The WashU chapter of the American Society of Mechanical Engineers (ASME) has built a drone able to carry a camera and also works with palm-sized Hubsan X4 quadcopters, or microcopters, which are lightweight at only an ounce or two. The quadcopters, which operate by remote control similar to a model airplane, are a simple way to provide access to the technology, says Will Andersen, president of the ASME chapter and a senior majoring in mechanical engineering through the Dual Degree program.

While the quadcopters are inexpensive at about $40 each, they are unable to carry any weight other than the lithium battery used to power them, which lasts about 15 minutes before needing to be recharged.

Andersen says engineering students are very interested in working with the quadcopters and the drone, with about 40 students attending a recent event that allowed them to fly the quadcopters.

Ian Smith, a University College student majoring in global leadership & management and vice president of ASME, owns and built a mid-sized drone that can carry a Go-Pro camera. The team is able to make replacement parts for it using a 3-D printer.

In working with the quadcopters and drone, the team has two goals, Andersen says.

"We want to introduce people to the technology and become comfortable with it, and we want to learn how and why the quadcopters work and the scope of how they can be used," he says.

Privacy

With drones now making films featured at public events such as the New York City Drone Film Festival, many have raised questions about privacy.

"Drones are their own thing, but by being digital network technologies, they raise all of the issues of computer security and digital privacy that Facebook or Google Glass or self-driving cars also raise," Richards says. "We can't let our fascination with the novelty and awesomeness of drones blind us to the fact that they raise really substantial issues, not just legal issues, but human issues about the way we use technologies, the way we design technologies, and the way these technologies fit into complex technological and human systems."

The future

Recently, Amazon.com has proposed delivering packages via drone 30 minutes after ordering. Amazon Prime Air's drones would have a 10-mile radius for delivery and would be able to carry about five pounds. However, the FAA's Feb. 15 guidelines prevent any object from being dropped from an unmanned vehicle. In late March, the FAA gave Amazon permission to perform tests of its delivery drone in the U.S.; however, Amazon is no longer testing that model. The company has applied to test a newer model as well as for a commercial drone exemption.

Gonzalez says while Amazon's proposed delivery by drone is technologically possible, there are still many unanswered questions and many different algorithms.

"Most of the algorithms are case by case," he says. "As a larger question, can we write algorithms in a general way so that the Amazons of the world can be certain whether or not they need a control tower for their drones? And if they do, which is very likely in my opinion, what kind of control tower? All of these are potential questions that are out there waiting to be answered."

Richards says although drones are new, they aren't operating in a law-free environment, much like the early Internet in the mid-1990s, and that's something engineers need to consider when designing them.

"We have FAA regulations that deal with flying things," he says. "We have criminal laws that stop people from committing a crime, whether they use a drone, a gun or a video camera to blackmail or inflict emotional distress. Drones are going to create a lot of new possibilities for good and for bad and new ways of doing things, both good and bad, and the law will have to be adjusted to deal with the possibilities that drones present."

Rohit V. Pappu, PhD (center) with members of his lab

“Some days I’m the teacher, some days they’re the teachers and some days we solve problems together.” — ROHIT PAPPU, PHD

RON KLEIN

POWER in NUMBERS

Written by **BETH MILLER**

While it takes a village to raise a child, it might also take one to develop a scientist – at least in the case of Rohit Pappu, PhD.

Pappu, who was installed as the Edward H. Murty Professor of Engineering in March, can name every researcher he’s ever worked with over the course of his education and career as a … well, that’s hard to define.

“Someone recently asked me, ‘What are you? Are you a biophysicist? A physicist? A chemist? A physical chemist? An engineer? A computational scientist?’” Pappu recalls. “I said, ‘Yes ... and no.’ I’m not a biologist, but I know some biology. No self-respecting physicists would include me in their group. I have these core anchors, and they happen to be a polyglot of things.”

Regardless of his title, Pappu studies intrinsically disordered proteins and their role in neurodegenerative disorders such as Huntington’s disease, Alzheimer’s disease and Parkinson’s disease as well as age-related protein misfolding and aggregation. He also heads the Center for Biological Systems Engineering.

Pappu’s path to the Department of Biomedical Engineering in the School of Engineering & Applied Science in 2001 may not have been traditional, but he learned something from everyone with whom he worked as a graduate student, a postdoctoral researcher and as a faculty member. Those teachers included Nobel Laureates, physicists and scientists from varied backgrounds, his father and grandfather, and his students and trainees.

Pappu with his wife, Natasha, (right) and daughter, Minerva.

“My wife is my hero number one and my daughter is my hero number two. They keep me on the straight and narrow and remind me of what’s important, but so do the people I work with. These are phenomenal people.”

— ROHIT PAPPU, PHD

After earning a bachelor’s degree in physics, mathematics and electronics from St. Joseph’s College in Bangalore, India, Pappu came to Tufts University in Boston intending to study nonlinear optics to stay in the family business — his father was a researcher and professor of nonlinear optics at the Indian Institute of Science. While doing research, he came across a problem pertaining to diffusion he couldn’t solve and asked advice from the late David Weaver, who gave Pappu a stack of papers to read.

“I admire people who appreciate baseball because I live in a parallel universe where I could go on about cricket for weeks on end.”

He noticed a common theme throughout — protein folding. He decided to write his doctoral thesis on developing computer simulation approaches to modeling aspects of the diffusion-collision model for protein folding.

After earning a doctorate in theoretical and biological physics from Tufts, Pappu wanted to continue working on computer simulations through postdoctoral research with Martin Karplus, PhD, now the Theodore William Richards Professor of Chemistry, Emeritus, at Harvard University and a 2013 winner of the Nobel Prize in Chemistry. Karplus and Pappu’s thesis mentor, Weaver, had developed the diffusion-collision model for protein folding, which was the first analytical theory for protein folding mechanisms. But Karplus was headed to Strasbourg, France, and Pappu was determined to stay in the U.S.

“I was on a visa at the time, and I thought that coming back from Europe to get employment in the U.S. would be difficult,” Pappu says. “That was pure naiveté. I will never live that down.”

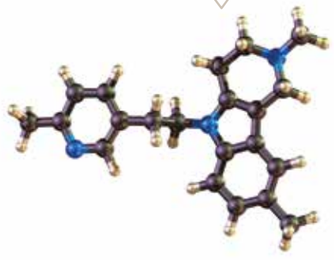
But saying no to the prospect of working with a future Nobel Prize winner didn’t destroy his career. Pappu came to St. Louis to visit his father, who was living here at the time, and met with Jay Ponder, PhD, who was an assistant professor in the Department of Biochemistry at the School of Medicine.

“We got on like a house on fire,” Pappu says. “It was four hours of the most stimulating conversation I’d ever had. I was determined to work with him.”

Another postdoctoral researcher who further shaped Pappu’s career came to work in Ponder’s lab at the same time. Enoch Huang, PhD, who had come from Stanford University, was attracted to Ponder’s lab for different reasons: Ponder had made important advances to the inverse folding problem. Given a sequence, one can either determine how that sequence folds, or given a fold, one can determine how many sequences will achieve that fold. Pappu’s conversations with Huang while working in Ponder’s lab began to catalyze his desire to work across disciplines.

The Center for Biological Systems Engineering (CBSE) expertly combines engineering, science and medicine to tackle the basis of complex diseases.

cbse.wustl.edu



“I started to notice that having to work on really hard biological problems, I was becoming a better physicist,” Pappu says.

With his eyes on a job in academia, Pappu wanted to get additional postdoc experience in a biophysics lab, so he went to Johns Hopkins University School of Medicine to work with another giant in the field, George Rose, PhD, professor of biophysics.

In Rose’s lab, Pappu focused on protein in its unfolded forms. This required an entirely different approach, and Pappu set out to learn all he could about polymer physics. Together, Rose and Pappu wrote two papers that uncovered a formalism for describing the conformational properties of unfolded proteins.

“One thing I did at Hopkins was read — up to 10 papers a day — and I would think,” he says. “I figured if I could keep indulging in the exposure, the language would sink in. I was a physicist muddling through biology, and eventually the light went on. That, to me, was the most shape-shifting period in my career.”

“It’s interesting that you can learn from people either because they teach you something and tell you exactly what to do, or you can learn from them because they know how to frame a problem, and they let you just be,” he says.

Yet another person would have influence on his life and career path just before he left Hopkins.

Keith Dunker, PhD, (now the director of the Center for Computational Biology and Bioinformatics; professor, Biochemistry and Molecular Biology and School of Informatics at Indiana University), gave a talk at Johns Hopkins. Dunker enlightened Pappu to the presence of proteins that have an intrinsic, sequence-encoded inability to fold into specific 3-D structures. Despite this inability, which suggests a negative connotation, these intrinsically disordered proteins are central to a variety of pathways that regulate several cellular decision-making circuits and outcomes. These proteins also are implicated in numerous complex diseases, including cancers, cardiovascular disorders and neurodegeneration.

Take an inside look at the research being done in the Pappu Lab: youtube.com/WUSTLEngineering

Dunker sent Pappu a review of his findings, and Pappu narrowed his focus on what he wanted to study as an independent investigator at Washington University. He has since focused on connecting the information encoded in sequences of intrinsically disordered proteins to their conformational properties and the functions controlled by these apparently unusual molecules. He also has focused on the deleterious aspects of intrinsically disordered proteins, namely, the molecular basis of neurodegeneration in diseases such as Huntington’s disease and Alzheimer’s disease. He has pursued these interests since joining Washington University in 2001 as an assistant professor in the Department of Biomedical Engineering.

While Pappu continued to collaborate with high-profile scientists at WashU, including Carl Frieden, PhD, professor of biochemistry and molecular biophysics at the School of Medicine, his graduate students also began to influence his areas of research.

“Andreas Vitalis totally changed my life,” Pappu says of the 2009 doctoral alumnus now at the University of Zurich. “At that point, I had yet to meet a person who I’d say in an unqualified manner is a genius, and he is a genius. He came up with a clever way of capturing the effects of solvent without explicitly modeling them. That totally changed the ballgame for us.”

Pappu also credits Scott Crick, PhD, Allen Chen, PhD, and Albert Mao, PhD, — all lab alumni — for their contributions to his research, as well as the postdoctoral researchers and students currently in his lab, including Rahul Das, PhD; Tyler Harmon; Alex Holehouse; Ammon Posey, PhD; and Kiersten Ruff.

“Some days I’m the teacher, some days they’re the teachers and some days we solve problems together,” Pappu says.

But he doesn’t always talk science with those in his lab — Pappu is an avid cricket fan. He’s been known to have Google chats in the wee hours of the morning with colleagues who are also fans of the English bat-and-ball game.

There are two other people who have influence on Pappu’s life, and they are his wife, Natasha, and daughter, Minerva, 15.

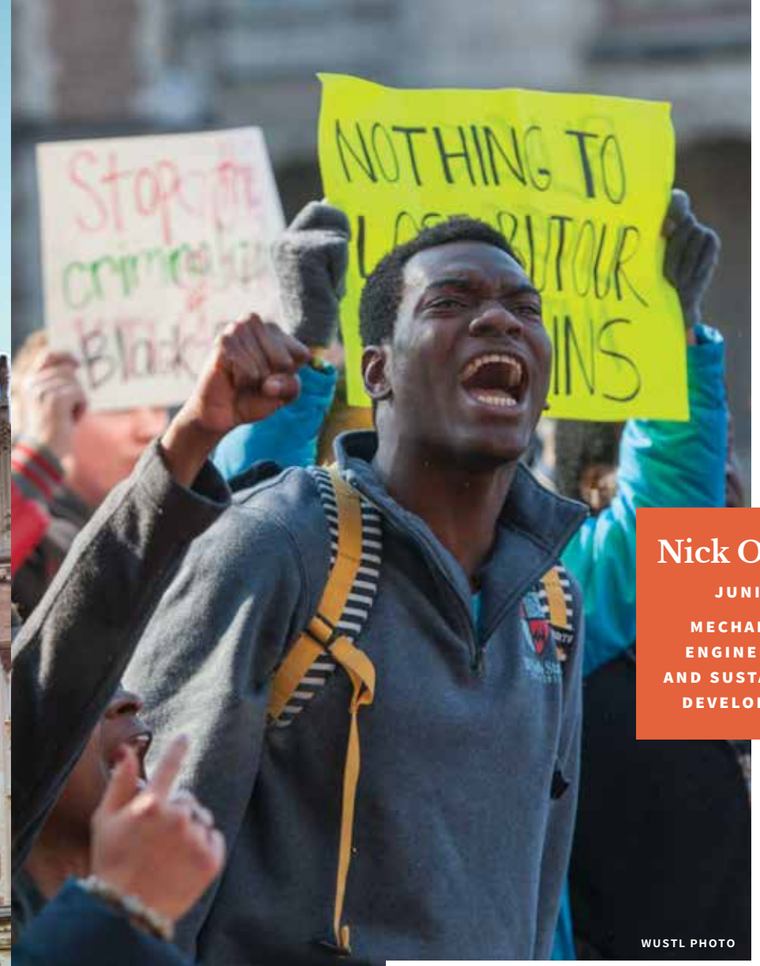
“My wife is my hero number one and my daughter is my hero number two. They keep me on the straight and narrow and remind me of what’s important, but so do the people I work with. These are phenomenal people.”

A **DAY** IN THE **LIFE**

School of Engineering & Applied Science undergraduate students are driven to improve society while they explore personal development. Our students learn, grow and lead inside and outside the classroom through rigorous studies, research and design projects with faculty, international trips, community engagement, student organizations and sports teams, entrepreneurial activities and more. What follows is a look at a day in the lives of eight very different Engineering undergraduate students who make our school unique and special.

See what it's like to be an Engineering student for the day: youtube.com/WUSTLEngineering

WUSTL PHOTO



WUSTL PHOTO

Nick walks though the Danforth Campus with other students as part of the #blacklivesmatter movement.

Nick Okafor

JUNIOR

MECHANICAL ENGINEERING AND SUSTAINABLE DEVELOPMENT

Any given weekday reflects my studies, where I could be in any combination of my mechanical design, public health, architecture or Portuguese classes. Despite being a primary engineering major, I've been able to take classes in three out of the four schools WashU offers (I hope to take a course on social entrepreneurship before I graduate).

Past my classes, WashU keeps me busy, to say the least. With administrative support, I've been able to launch my own student group, TESLA, which initiates after-school clubs at local middle schools to boost minority and female interest in STEM. I also try my best to stay civically engaged (I'm a 2016 Civic Scholar), so I join my friends in Students in Solidarity in various protests and displays to fight for the #blacklivesmatter movement and other causes supporting marginalized populations. By the end of the day, I'm tired, but I'm lucky to be able to return to Ruby 1, where I'm a Residential Advisor for the best floor on the South 40.

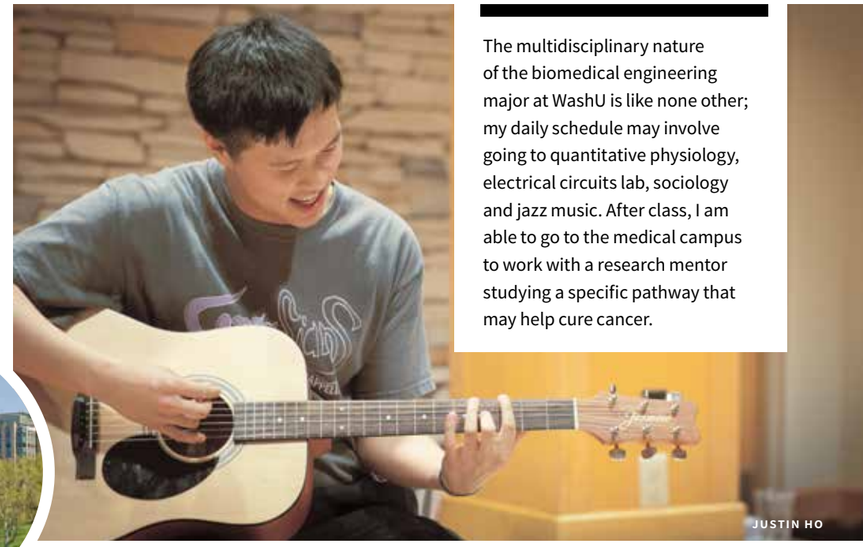
WashU students participated in protests on campus this fall in response to the events that took place in Ferguson, Mo., last summer.

Tony Wang

SENIOR

BIOMEDICAL ENGINEERING

School of Medicine



JUSTIN HO

The multidisciplinary nature of the biomedical engineering major at WashU is like none other; my daily schedule may involve going to quantitative physiology, electrical circuits lab, sociology and jazz music. After class, I am able to go to the medical campus to work with a research mentor studying a specific pathway that may help cure cancer.

Ananya Benegal

SOPHOMORE | BIOMEDICAL ENGINEERING

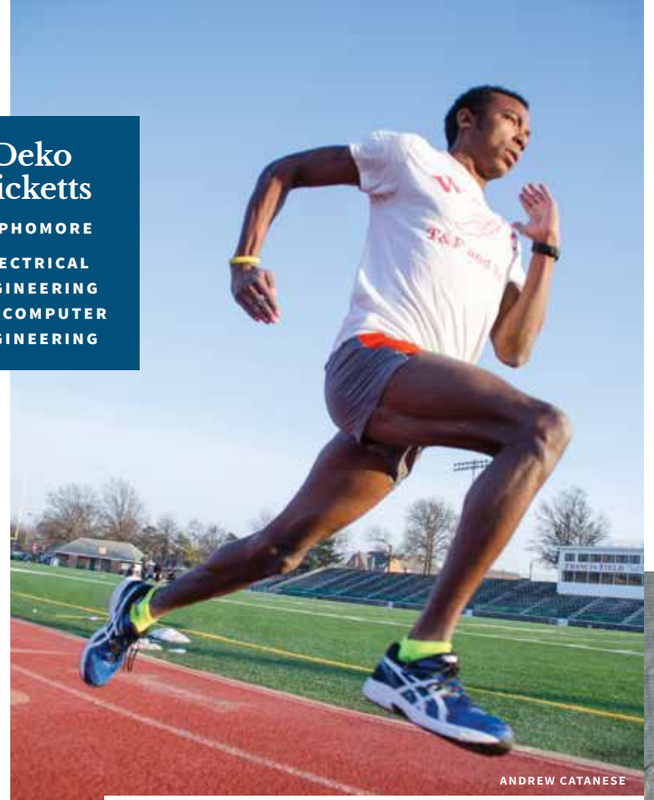
MINORS: ANTHROPOLOGY, GLOBAL HEALTH AND ENVIRONMENT

I do research in Professor Phil Bayly's lab in the Mechanical Engineering department, and today will be especially exciting because we have visitors! I am a Langsdorf Scholar and am in the James M. McKelvey Undergraduate Research Scholars Program, which provides programming and mentoring to undergraduate students who are participating in research. Today, the freshman McKelvey Scholars will be coming to tour Dr. Bayly's lab. I showed them a really cool demo involving strawberry Jell-O, sprinkles and a strobe light, then headed back upstairs to finish the mechanical tests I was running.

Deko Ricketts

SOPHOMORE

ELECTRICAL ENGINEERING AND COMPUTER ENGINEERING



ANDREW CATANESE

In mind, body and character, WashU has changed my life. Here, I am more than a student in pursuit of an electrical engineering degree. As an 800-(meter) runner, working with Coach (Jeff) Stiles has redefined my view of success, and I look to his definition in all walks of life. His culture carried me to All-American, but what it has done for me off the track is monumental in comparison.

The Associate Provost at WashU, Dr. (Dedric) Carter, challenged me to be innovative, entrepreneurial and collaborative during my time at WashU. Working with Professor (Parag) Banerjee last year, I tasted innovation, researching novel methods for third-generation solar cells. I took Dr. Carter's challenge head on this year, developing a small startup company with a few colleagues to design an interactive volumetric display that, if indeed possible, could blur the barrier between reality and the digital world. The WashU environment fundamentally fosters greatness at every level, in every person that walks across the Quad.

"WashU teaches us not to wait for it, but to ride toward it. The culture, the type of student that WashU creates, the professors' belief that we as students will change the world — the aura in these walls is intoxicating."

Taylor (right)

Taylor Blevin

SOPHOMORE

CHEMICAL ENGINEERING AND ECONOMICS

MINOR: ENERGY ENGINEERING

My involvement with student groups on campus has also allowed me to apply my skills to give back to the St. Louis community. I am currently a program leader for VERDE (Volunteers for Environmental Restoration, Development, and Education), a community service group affiliated with the Campus Y. I visit a local elementary school once a week with other volunteers to teach about environmental science and environmental issues.

Olin Library

Mindy Borovsky

SOPHOMORE | COMPUTER SCIENCE

MINOR: MATH

A typical day would start early with a 6:30 a.m. tennis practice followed by two morning classes, lunch with my Alpha Phi sisters, a stop in the library for some homework before my last class of the day, a quick dinner, a meeting for one of my activities, some additional time devoted to homework, and then catching up with friends. It is a juggling act, but I couldn't be happier!

Alex Blustein

SOPHOMORE

SYSTEMS ENGINEERING & FINANCE

Through a new WashU program, the Israel Summer Business Academy, I was able to work and study abroad in Tel Aviv, where I was a student consultant for FieldIn, an agriculture technology startup that provides real-time farming solutions. It was a unique experience I will never forget. Last semester, I was fortunate enough to work as the campus ambassador for Anheuser-Busch InBev, where I helped promote the Global Management Trainee Program. I have been amazed at the wealth of professional opportunities so early on in my WashU career.

Olivia Sutton

SENIOR | BIOMEDICAL ENGINEERING

MINORS: ART, BIOMEDICAL PHYSICS

My first destination: the art school for a meeting with Professor Jamie Adams, a renowned painter and anatomist, and my independent study professor who is helping me learn medical illustration. He critiques my work for the week — detailed studies of the vertebrae — and assigns me to investigate the skull for next week's independent study project.

My friends and I meet at Seoul Taco, a St. Louis must, and a Korean-Mexican fusion restaurant on Delmar Loop, the eclectic, historic street that sits conveniently barely off campus! I'm vegetarian, so I go for the tofu burrito. My boyfriend picks the bulgogi (beef) bowl.

Ruth Carr Chandeysson

FROM UNWELCOME TO 'ONE OF THE BOYS'

Written by **BETH MILLER**

What would it be like to be the only person like you in a class of 600 people?

Ruth Carr Chandeysson knows. She was the only woman to graduate from Washington University in St. Louis, and in the state of Missouri, in 1957 with a bachelor's degree in engineering.

"When I started, I was really looked down upon," she recalls. "Everyone kept saying, 'She's not going to make it.' It turned out that I did."

Ruth vividly recalls one professor who particularly challenged her.

"He said, 'This degree is not going to help you change diapers, and it's not going to be able to make your husband happier,'" she says.

In the mid-1950s, women pursuing engineering degrees were perceived as unfeminine, violating social norms or simply seeking a husband. Ruth came into WashU as none of those things and with nearly more experience in some areas than her professors.

A native of University City, Ruth was the daughter of a land surveyor. From a very young age, she tagged along with her father and helped him with his jobs, learning the craft along the way. By age 12, she was running her own survey crew and working for her father. She excelled in her math and science classes at University City High School so much that her guidance counselor sought out what requirements Ruth would need to be admitted into WashU's engineering school.

Ruth as a child learning to survey with her father

"He also told me there was a bright boy out there who didn't have a place at the school because I got his spot. I told him that if that boy were that bright, he'd have beaten me out for the spot. He stopped challenging me after that."

1957

Ruth graduates from WashU and is the only woman from the state of Missouri to graduate with a bachelor's degree in Engineering.

Ruth Carr Chandeysson and her husband, Paul Chandeysson, MD

Ruth, who earned a degree in civil engineering, is a role model for women in engineering at Washington University. While she was not the first woman to earn a bachelor's degree in the school, she stayed the course for the full four years, when several women before her had dropped out.

JOHN BOAL

UNIVERSITY ARCHIVES

Ruth Carr (highlighted) as a member of the Engineering Council in 1957.

Ruth Carr was the 1957 Military Ball Queen, escorted by Cadet Colonels Hugh Crull and Ted Oberhellman.

One of those requirements was a metal working shop, which up to that point, was only for males. The guidance counselor had to petition the school board to allow Ruth to take the course.

Although some WashU students and faculty created an unwelcome atmosphere for her, Ruth didn't let it get her down.

"I always found it kind of a challenge," she said. "I thought if I'm better than most of them, they'll have to admit that I'm at least as good as they are."

It didn't take long for her classmates and professors to realize she could hold her own.

"I took surveying classes with the head of the department, and it was obvious that I knew enough about surveying that it didn't bother anybody in my class that I was bright enough to do it," she said. "After that, they all wanted to be with Ruthie."

Ruth was elected Engineering Ball Queen as a sophomore and Military Ball Queen as a senior. She was a member of the Engineering Council as well. But, as with today's students, she spent a lot of time studying — but not all of her time.

In her freshman English class, all but one of the other students ignored her. That student, Paul Chandeysson, was the only male student who would hold the door open for her after class. They began dating around Christmas time that year and have been married for 56 years. They now have three children and six grandchildren.

By the end of her education at WashU, Ruth had become "one of the boys," her professor wrote in an article that appeared in the Missouri Engineer newsletter. She graduated in the top 10 of her class.

Paul Chandeysson, MD, earned bachelor's degrees in mechanical and electrical engineering at WashU in 1958, a master's in nuclear engineering from Stanford University in 1962, and a medical degree from George Washington University in 1976. He is the medical officer for the U.S. Food & Drug Administration and oversees the division that regulates medical devices such as pacemakers, artificial hearts and heart valves.

While Paul finished his bachelor's degrees at WashU, Ruth worked in the stress analysis group at Emerson Electric on Little John missile system used by the U.S. Army in the 1950s and '60s. Her group designed and tested the jettisonable shoes on the bottom of the rocket.

A woman working as an engineer in the late 1950s was certainly rare, but Ruth's expertise carried her far.

> "It was pretty high-level aerospace engineering, and that requires a great deal of sophisticated engineering. She was up to that."

"She rocked 'em and socked 'em with what she could do," Paul says.

While she loved her work, she ran into some discrimination in the corporate world.

"My supervisors at Emerson asked me to sign my name R.E. Carr," she says. "A couple of times, people would call and ask for R.E. Carr, and when I got on the phone, they said they wanted to talk to R.E. Carr 'the man.' When I said I was R.E. Carr, they asked for a supervisor. My supervisor told them I did the work, so they would have to talk to me. Usually they decided I knew what I was talking about, so it worked out ok."

After Paul graduated, the couple moved to El Paso, Texas, where he was in the Army for two years. Although she wasn't working, her team from Emerson often came to El Paso for product testing, and they would ask for her help with the testing.

From there the couple moved to California while Paul earned a master's degree, then on to

Waco, Texas, where Paul worked for Rocketdyne for 10 years. At age 36, he started medical school at George Washington University, while Ruth was home raising their three young children.

"Paul always said, 'You got the hardest job,'" she says.

Getting her education and working in the male-dominated engineering culture in the 1950s did create some soul searching, Ruth says.

"For a long time I had a feeling, 'Am I more of an engineer than I am a woman?'" she says. "But I decided I could be both. I really enjoyed being an engineer and a mother and a wife."

And that's the same advice she offers to female engineering students:

"Continue to be a woman," she says. "If you treat people right, they'll treat you right. It's much better to do the best job you can and be as good of an engineer as you can and still be a nice, friendly person."

2014

The encouragement and mentoring of young women in science and engineering is something Chandeysson believes in very strongly. Last October, she came to WashU to speak at a Women & Engineering Mentor Event that launched a new mentoring program for women engineering students and women in engineering careers.

Eight alumni honored at the 2015 Alumni Achievement Awards in April

Alumni Achievement Award

Suren Dutia is a passionate advocate for entrepreneurship. As an executive with extensive and successful multi-industry leadership experience, Dutia has made his mark in many areas, including Internet/e-commerce, document management software and medical instrumentation. After holding a number of leadership positions with Boston-based Dynatech Corp., in 1981 Dutia became president and CEO of Xscribe Corp., a publicly traded company in San Diego.

Marvin Gibbs, PhD, an engineer and entrepreneur, is the retired chairman and CEO for Red Lion Beef Corp., the parent company of Lion's Choice, a St. Louis-based restaurant. Before leading the local chain, Gibbs served in a variety of management positions with Monsanto, supporting sustainable agriculture practices and research.

Hanford Gross founded Gross Mechanical Contractors (GMC) in 1985 as a successor company to Gross Engineering Co. In 1991, as president of GMC, he made the decision to convert the project portfolio to one comprising power and process projects. In 2012, Gross retired from the company and is an adjunct instructor of mechanical engineering at WashU. He is a member of the WashU Construction Industry Advisory Council, the External Advisory Board for the UMSL/WUSTL Joint Engineering Program and of the Engineering Alumni Advisory Council.

Michael Holtz's SmartFlyer has established itself as a leader in the luxury travel industry and has quickly climbed from 45 agents in 2012 to 110 in 2015. Although SmartFlyer has annual revenue of $80 million, Holtz, as CEO, maintains a personal touch, developing a social media relationship with current and potential clients that allows SmartFlyer to respond rapidly to customer needs.

Michele Liebman held a variety of sales support positions before joining Edward Jones. She was named a limited partner in 1987 and a principal in 1994. For 15 years, Liebman's responsibilities included leadership roles within the information systems division. She led the effort to evaluate, select and implement the St. Louis headquarters' first office automation software, satellite vendor and integrated usability lab techniques.

Bruce Rittmann, PhD, is the director of the Swette Center for Environmental Biotechnology at the Biodesign Institute and a Regents' Professor in the School of Sustainable Engineering and Built Environment at Arizona State University. A member of the National Academy of Engineering, Rittmann is known for pioneering the development of the Membrane Biofilm Reactor, which uses naturally occurring microorganisms to remove contaminants from water.

Young Alumni Award

Harry Cheung has always found a combination of great ways to satisfy his competitive spirit and enthusiasm for computer software. Since making his mark at Google, Cheung has ventured into new territories as an angel investor for startups while serving as president of HNK Ventures. His dynamic portfolio of companies includes Media Spike, QWIKI, Badgeville and PrePay.

Dean's Award

Richard Mattione, PhD, has been recognized for his expertise with international investment markets constantly striving for excellence. Before retiring in 2013, Mattione was a partner at GMO LLC in Boston. At GMO, Mattione was responsible for the international equity investments in Japan, Hong Kong and Latin America. Prior to GMO, Mattione worked as an economist and market strategist at J.P. Morgan in Tokyo and New York.

Learn more about each awardee: youtube.com/WUSTLEngineering

Cheadle national champion at NCAA Indoor Track

BEAR SPORTS

Engineering senior Lucy Cheadle was named national champion in the women's 5,000-meter run at the 2015 NCAA Division III Indoor Track & Field meet March 14 in Winston-Salem, NC.

Cheadle also added All-America honors in the 3,000-meter race. Cheadle's two All-America finishes, along with a seventh-place showing for the distance medley relay March 13, led the WashU women to a 12th-place finish in the team standings with 15 points.

Anastasio joins College of Fellows of American Institute for Medical and Biological Engineering


MARK ANASTASIO

Mark Anastasio, PhD, has been elected to the American Institute for Medical and Biological Engineering's College of Fellows in recognition of his important contributions to biomedical engineering.

The College of Fellows is made up of the top 2 percent of accomplished medical and biological engineers responsible for medical discovery and innovation in academia, industry and government. There are more than 1,500 fellows in the College. Anastasio is professor of biomedical engineering and of electrical & systems engineering in the School of Engineering & Applied Science and of radiology and of radiation oncology in the School of Medicine. He is an internationally recognized expert on tomographic image reconstruction, imaging physics and the development of novel computed biomedical imaging systems. He has conducted pioneering research in the fields of photoacoustic computed tomography, diffraction tomography and X-ray phase-contrast imaging. He received a National Science Foundation CAREER award in 2006 for research related to image reconstruction topics.

Agarwal receives SAE International Medal of Honor


RAMESH AGARWAL

Ramesh Agarwal, PhD, the William Palm Professor of Engineering at Washington University in St. Louis, received the 2015 Society of Automotive Engineers (SAE) International Medal of Honor at the organization's World Congress April 21-23 in Detroit. The Medal of Honor, SAE's most prestigious award, recognizes an SAE International member for his or her unique and significant contributions to SAE International.

Agarwal, professor in the Department of Mechanical Engineering & Materials Science in the School of Engineering & Applied Science, has been on the Washington University Engineering faculty since 2001.

Alum Cox receives 2014 Air Force Cadet of the Year Award

Alexander Cox was named the 2014 Air Force Cadet of the Year at The Pentagon in Washington, D.C. He is the 15th recipient of the award.

2nd Lt. Cox earned a bachelor's degree in mechanical engineering, summa cum laude, and a master's in aerospace engineering from Washington University in 2014. He was a member of the AFROTC Detachment 207.

Pappu named Murty Professor of Engineering

Pappu (left) with Provost Holden Thorp

Rohit V. Pappu, PhD, has been named the Edwin H. Murty Professor of Engineering. He was installed March 2.

Pappu is professor of biomedical engineering and director of the Center for Biological Systems Engineering in the School of Engineering & Applied Science and a member of the Hope Center for Neurological Disorders and of the Division of Biology and Biomedical Sciences' Computational and Molecular Biophysics Program, both at the School of Medicine.

His research focuses on the form, functions and self-associations of intrinsically disordered proteins. He and his lab members have developed and used novel combinations of polymer physics theories, molecular simulations and biophysical experiments to provide definitive descriptors that relate information contained in these intrinsically disordered proteins sequences to their conformational characteristics and aggregation mechanisms.

WashU engineer wins annual St. Louis Award for his cancer-seeing glasses

In January, Samuel Achilefu, PhD, won the prestigious St. Louis Award for 2014 for his work in creating a technology using light to improve diagnosis and treatment of disease.

Achilefu heard from surgeons frustrated by the difficulty of removing every remnant of a patient's cancerous tumor. After dedicating five years to the project, he created cancer-visualizing glasses that were successfully used in surgeries for the first time last year. The technology could affect the outcomes of cancer patients across the world.

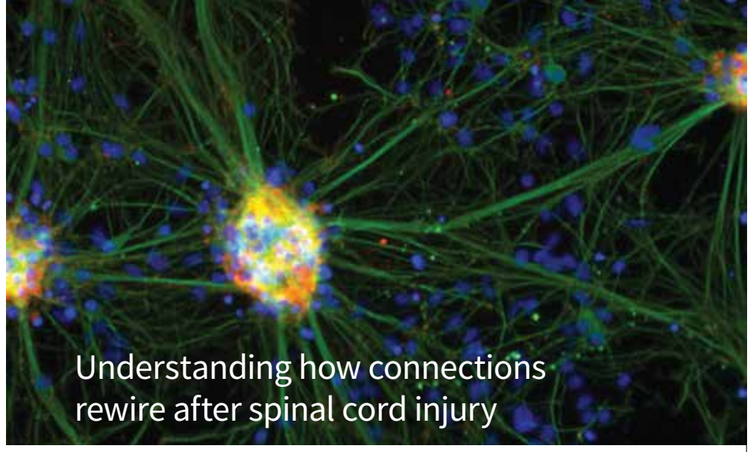
Giving back to the community is focus of Thurtene for two groups

At this year's Thurtene Carnival, members of two Greek organizations will be participating with a higher end goal in mind: to build a playground for students at an elementary school in north St. Louis, thanks in part to Engineering student Ellee Mullard.

Mullard, a senior majoring in mechanical engineering, is helping to lead the project, along with a committee, to raise at least $15,000 for a new playground at Farragut Elementary School in The Ville neighborhood. As a member of the Kappa Delta sorority, she helped to bring her sorority and the Beta Theta Pi fraternity into the project. Instead of spending thousands of dollars to build a façade for Thurtene Carnival, the members of Kappa Delta and Beta Theta Pi decided to do community outreach instead. Together, they are working to raise funds through a GoFundMe campaign and through grants and donations of supplies and materials.

Make a donation at: gofundme.com/farragutplayground

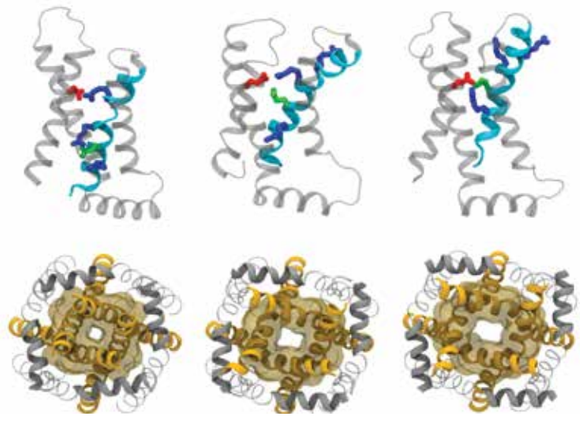
Farragut Elementary School playground



Understanding how connections rewire after spinal cord injury

Restoring function after spinal cord injury, which damages the connections that carry messages from the brain to the body and back, depends on forming new connections between the surviving nerve cells. While there are some delicate surgical techniques that reconnect the nerves, researchers are also looking at ways to restore the connections themselves at a cellular level.

With a five-year, nearly $1.7 million grant from the National Institutes of Health, Shelly Sakiyama-Elbert, PhD, professor of biomedical engineering and associate chair of the Department of Biomedical Engineering, is using novel methods to take a closer look at how these nerve cells grow and make new connections to reroute signals between the brain and the body that could restore function and movement in people with these debilitating injuries.



Heart's inner mechanisms to be studied with NIH grant

Jianmin Cui, PhD, has received a nearly $1.7 million grant from the National Institutes of Health to study the molecular bases for the function of potassium channels vital for the heart, brain, inner ear and other tissues.

The five-year grant from the National Institute of Neurological Disorders and Stroke will allow Cui, professor of biomedical engineering, to take a close look at some of the mutations in the potassium ion channels KCNQ1 and KCNE1 and their roles in cardiac disorders, including Long QT syndrome and cardiac arrhythmia.

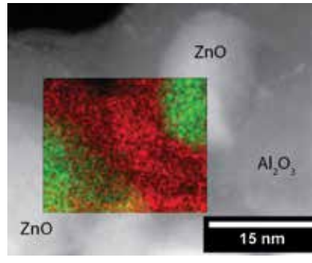
Peat fire emissions may shed light on climate change

RAJAN CHAKRABARTY

To study the climatic effects of carbon-containing aerosols emitted from peat fires, Rajan Chakrabarty, PhD, assistant professor of environmental engineering, has received a three-year, $530,000 grant from the National Aeronautics and Space Administration (NASA). Brent Williams, PhD, assistant professor of environmental engineering, is a co-investigator on the project, as is Wei Min Hao, PhD, an atmospheric chemist at the USDA Forest Service Fire Sciences Laboratory in Montana.

Burning of peatlands — an organic mixture of decayed and compacted leaves — creates the largest fires on earth. These high-moisture-containing fuels make up nearly three-fourths of earth's land mass and are believed to be the largest emitter of carbon from wildfires to the atmosphere. While plenty is known about the environmental effects of black carbon, the effects of peatfire smoke on human health and the climate are largely unstudied and an emerging field.

Nanotechnology changes behavior of materials, new research finds



One of the reasons solar cells are not used more widely is cost — the materials used to make them most efficient are expensive. Engineers are exploring ways to print solar cells from inks, but the devices don't work as well.

Elijah Thimsen, PhD, assistant professor of energy, environmental & chemical engineering, and a team of engineers at the University of Minnesota have developed a technique to increase the performance and electrical conductivity of thin films that make up these materials using nanotechnology. Their work was published in the Dec. 19, 2014, issue of *Nature Communications.*

Four faculty members win NSF CAREER Awards

24

Engineering faculty members have received the NSF CAREER Award

The NSF Early Faculty Career Development (CAREER) Program Award is one of the most prestigious recognitions an assistant faculty member can receive.

JOHN FORTNER

John D. Fortner, PhD, the I-CARES Career Development Assistant Professor of energy, environmental & chemical engineering, will study new composite materials for advanced water treatment with a prestigious Faculty Early Career Development Award (CAREER) from the National Science Foundation.

The five-year, $500,000 award is for his project titled "Development and Application of Crumpled Graphene Oxide-Based Nanocomposites as a Platform Material for Advanced Water Treatment."

Fortner plans to develop and engineer 3-D, nanoscale composites made of crumpled graphene oxide as multifunctional, platform materials for advanced water treatment technologies. To date, crumpled graphene oxide nanocomposites have not yet been evaluated for this purpose, despite having highly tailorable properties, including tunable chemistries and scalable production routes.

YASUTAKA FURUKAWA

Yasutaka Furukawa, PhD, assistant professor of computer science & engineering, has been awarded a prestigious five-year, $487,821 Faculty Early Career Development Award (CAREER) from the National Science Foundation to establish a computational framework for structured indoor 3-D modeling.

Furukawa combines 3-D computer vision of indoor scenes with the capabilities of Google Maps and Google Earth to create a unique, high-resolution, photorealistic mapping experience of indoor spaces. He plans to create indoor maps of buildings nationwide and intends to bring his technology to St. Louis to map Washington University's Danforth Campus.

AMIT PATHAK

The movement of cells, both alone and in groups, controls how our bodies function in health and diseases such as cancer. While this movement is a complex process, there are many questions about how this happens.

With an esteemed five-year, $500,000 Faculty Early Career Development Award (CAREER) from the National Science Foundation, Amit Pathak, PhD, assistant professor of mechanical engineering, plans to take a multidisciplinary approach to better understanding the cell migration process. By combining cell biology, computer simulation, micro-fabrication and biomaterials, Pathak expects to learn how mechanical properties of the body's tissues regulate how cells move, both individually and in groups, which will lead to new strategies to engineer the movement of cells. His project is titled "History-Dependent Cell Motility in Heterogeneous Microenvironments."

FUZHONG ZHANG

Engineers design metabolic pathways in cells to convert cheap raw materials into useful chemicals, biofuels and pharmaceuticals, but it's a delicate balance of systems for that to happen.

Fuzhong Zhang, PhD, assistant professor of energy, environmental & chemical engineering, will study these systems with a prestigious Faculty Early Career Development Award from the National Science Foundation. The five-year, $605,000 award is for his project titled "Synthetic Regulatory Systems for Dynamic Metabolic Pathways."

Zhang's research interests focus on applying synthetic biology, protein engineering, systems biology and metabolic engineering approaches to engineer biology. His goal is to create artificial biosystems that nature has not evolved and use them to turn microbial cells into microfactories for the efficient production of biofuels, drugs, materials and other value-added chemicals from sustainable resources.

Lu named Fullgraf Professor

Chenyang Lu, PhD, professor of computer science & engineering, has been named the Fullgraf Professor. He was installed March 16. He joined the faculty in 2002.

Lu's research interests include real-time systems, wireless sensor networks and cyber-physical systems, the Internet of Things and their applications in areas including health care, resilient civil infrastructure and smart homes. He also directs the Cyber-Physical Systems Laboratory.

From left: Chenyang Lu, Lan Yang and Chancellor Mark Wrighton

Lu has made pioneering contributions to the field of wireless health by developing and piloting one of the world's first large-scale clinical monitoring systems that collects real-time vital signs from patients using wireless sensor networks. He also has contributions to wireless structural monitoring and control systems relating to the growing problem of deteriorating civil infrastructure in the U.S. and the world.

Yang named Skinner Professor

Lan Yang, PhD, has been named the Edward H. and Florence G. Skinner Professor in the Department of Electrical & Systems Engineering. She was installed March 16. Yang is professor in the Department of Electrical & Systems Engineering and heads the Laboratory of Micro/Nano Photonics Research Group.

Yang's research interests include fabrication, characterization and fundamental understanding of advanced nano/micro photonic devices with outstanding optical properties or novel features for unconventional control of light flow. Her group focuses on the silicon-chip-based, ultra-high-quality micro-resonators and their applications. She and her team have demonstrated the first on-chip micro-resonator-based particle sensors that can achieve not only detection but also size measurement of single nanoparticles one by one. Different materials also are used in her research to achieve advanced micro/nano photonic devices with desired properties, such as nonreciprocal light transmissions in a parity-time-symmetric optical resonator system, an all-optical analog of an electronic diode that allows current flow in one direction.

Wang develops world's fastest 2-D camera

Lihong Wang, PhD, the Gene K. Beare Professor of Biomedical Engineering, continues to make new discoveries in his groundbreaking technology that allows light deep inside living tissue during imaging and therapy.

Wang and his team developed the world's fastest receive-only 2-D camera, a device that can capture events up to 100 billion frames per second. Using the technique, called compressed ultrafast photography, Wang and his colleagues have made movies of the images they took with single laser shots of four physical phenomena: laser pulse reflection, refraction, faster-than light propagation of what is called non-information and photon racing in two media.

That's orders of magnitude faster than any current receive-only ultrafast imaging techniques, which are limited by on-chip storage and electronic readout speed to operations of about 10 million frames per second. The research appeared in *Nature.*

In other research, using a new high-speed, high-resolution imaging method, Wang and his team were able to see blood flow, blood oxygenation, oxygen metabolism and other functions inside a living mouse brain at faster rates than ever before. Using photoacoustic microscopy (PAM), Wang was able to take images of blood oxygenation 50 times faster than their previous results using fast-scanning PAM; 100 times faster than their acoustic-resolution system; and more than 500 times faster than phosphorescence-lifetime-based two-photon microscopy. The results were published March 30 in *Nature Methods.*

In addition, Wang and his team improved the focusing speed of time-reversed ultrasonically encoded (TRUE) optical focusing for applications in living tissue. The new TRUE technology is able to focus light inside a dynamic medium with a speckle correlation time as short as 5.6 milliseconds. The improved speed allowed Wang to achieve the first optical focusing of diffuse light inside a scattering medium containing living biological tissue. This research was published in *Nature Communications* online Jan. 5.

DEVON HILL

New master's degrees focus on biomedical engineering, data analytics

To continue to offer degrees that make School of Engineering & Applied Science graduates competitive in the workplace, the school is offering two new master's degrees and a new graduate certificate starting this year.

» Biomedical Engineering to add Master's of Engineering in Biomedical Engineering

» Electrical & Systems Engineering to add Master's in Engineering Data Analytics and Statistics

» Computer Science & Engineering to add graduate Certificate in Data Mining and Machine Learning

Elbow stiffness after injury focus of new research

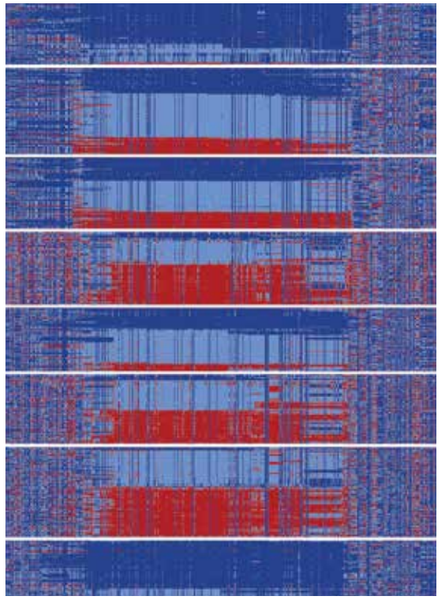
SPENCER LAKE

The elbow is one of the most anatomically and biomechanically complex joints in the body, with three separate bones meeting to provide motion to the forearm and hand. But injuries to any of these bones or to the ligaments or cartilage cause significant dysfunction, making everyday tasks painful and difficult.

Spencer Lake, PhD, assistant professor of mechanical engineering, has received a one-year, $19,919 grant from the American Shoulder and Elbow Surgeons to study the causes of stiffness and tightening, or contracture, of the joint after an injury to the elbow, called post-traumatic joint stiffness.

Despite its importance, the elbow is among the least studied joints in the body. Lake will team with Leesa Galatz, MD, professor of orthopedic surgery and chief of the Shoulder and Elbow Service at Washington University School of Medicine, to analyze the joint more closely with the ultimate goal of helping patients prevent post-traumatic joint stiffness after treatment for an elbow injury.

Big data allows computer engineers to find genetic clues in humans



Big data: It's a term we read and hear about often, but is hard to grasp. Computer scientists tackled some big data about an important protein and discovered its connection in human history as well as clues about its role in complex neurological diseases.

Through a novel method of analyzing these big data, Sharlee Climer, PhD, research assistant professor in computer science, and Weixiong Zhang, PhD, professor of computer science and of genetics at the School of Medicine, discovered a region encompassing the gephyrin gene on chromosome 14 that underwent rapid evolution after splitting in two completely opposite directions thousands of years ago. Those opposite directions, known as yin and yang, are still strongly evident across different populations of people around the world today.

The results of their research, done with Alan Templeton, PhD, the Charles Rebstock professor emeritus in the Department of Biology in Arts & Sciences, appear in the March 27 issue of *Nature Communications*.

authenticity

In 1953, Ruth Carr entered Washington University as one of the few females in the School of Engineering & Applied Science. Having already overcome challenges in high school to take what was considered a course only for males, she stayed true to her desire to be an engineer. At WashU, she faced discrimination from faculty and fellow students despite her years of experience working with her father as a land surveyor. To prove herself worthy of a seat in male-dominated courses, she persevered through the insults and resistance, and the doubters soon learned she deserved her place. Through it all, she stayed positive and friendly — even helping other students with their homework — because it was important to her to be nice to everyone.

After earning a degree in civil engineering in 1957, Ruth went to work for a company in which men were the engineers and women were the administrative support. Not only were all of her coworkers and supervisors male, but her clients were, as well. Never doubting her abilities, Ruth persevered through the disrespect and continued doing highly sophisticated and technical work, eventually earning the respect of other engineers.

Due to the culture of 1950s middle America, from time to time, Ruth questioned whether she could be an engineer and a woman. But she stayed authentic to her desires to be both, as well as a wife and mother — a rare combination at that time. She had — and still has — the support of her husband, alumnus Paul Chandeysson, MD, as well as from her family, allowing her talents to shine.

Sixty years later, WashU and the School of Engineering & Applied Science place high value on the differences in individuals on campus. Our culture celebrates the backgrounds and perspectives that make each individual authentic and this university a supportive and inclusive environment.

The privilege of a lifetime is to become who you truly are.

— C.G. JUNG

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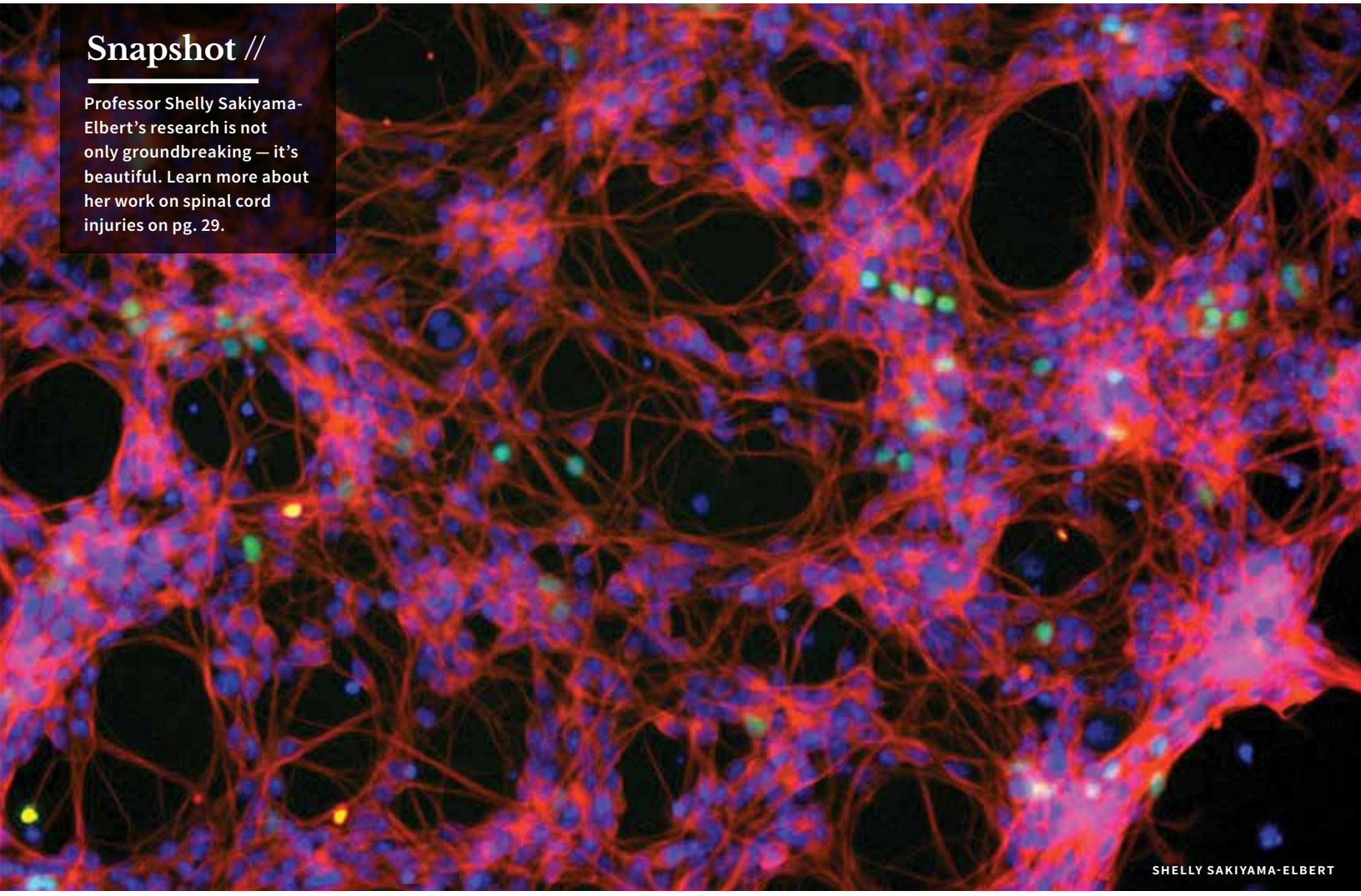

Snapshot //

Professor Shelly Sakiyama-Elbert's research is not only groundbreaking — it's beautiful. Learn more about her work on spinal cord injuries on pg. 29.

SHELLY SAKIYAMA-ELBERT

#wustlengineers: