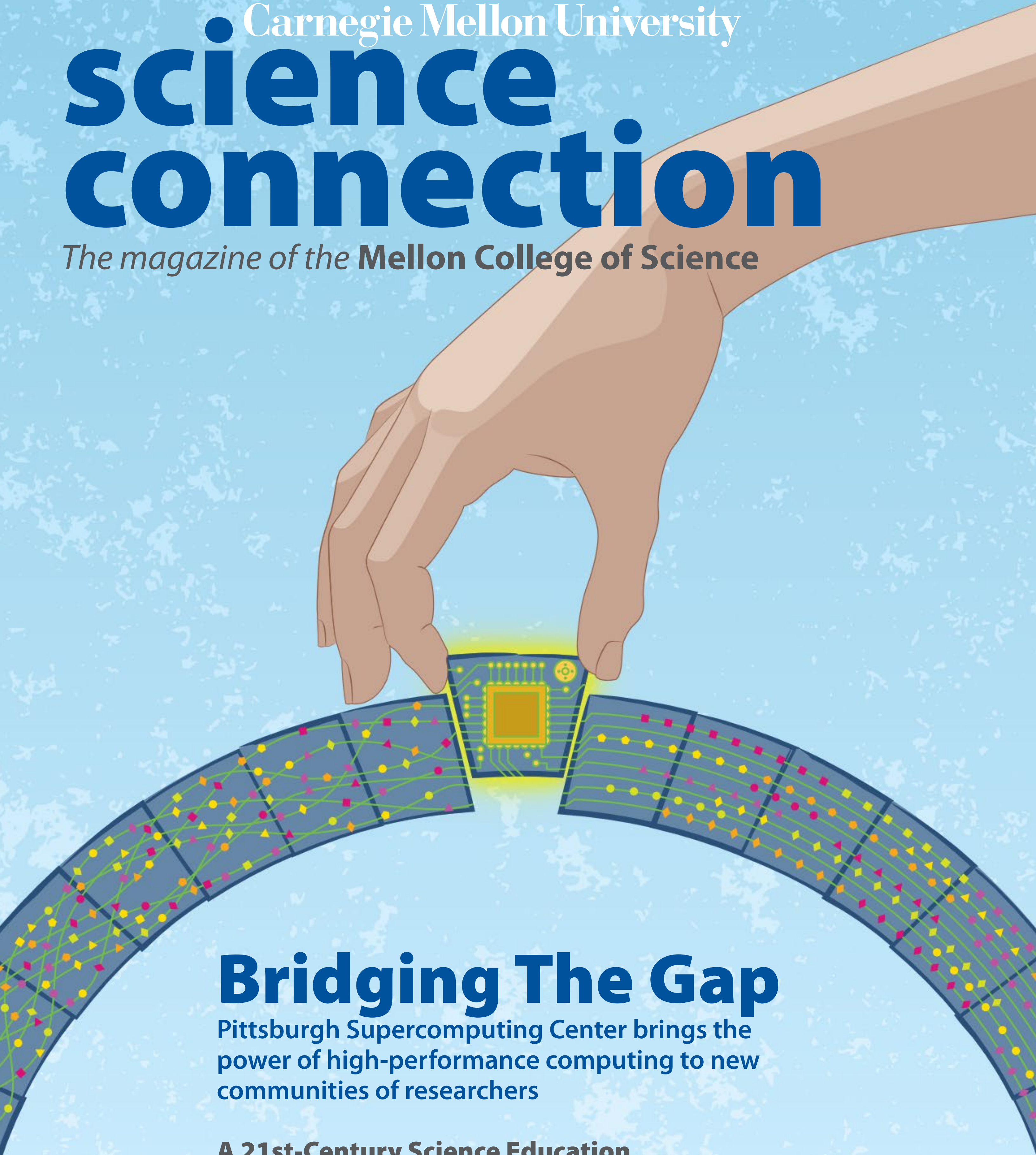
Carnegie Mellon University

science connection

The magazine of the **Mellon College of Science**



Bridging The Gap

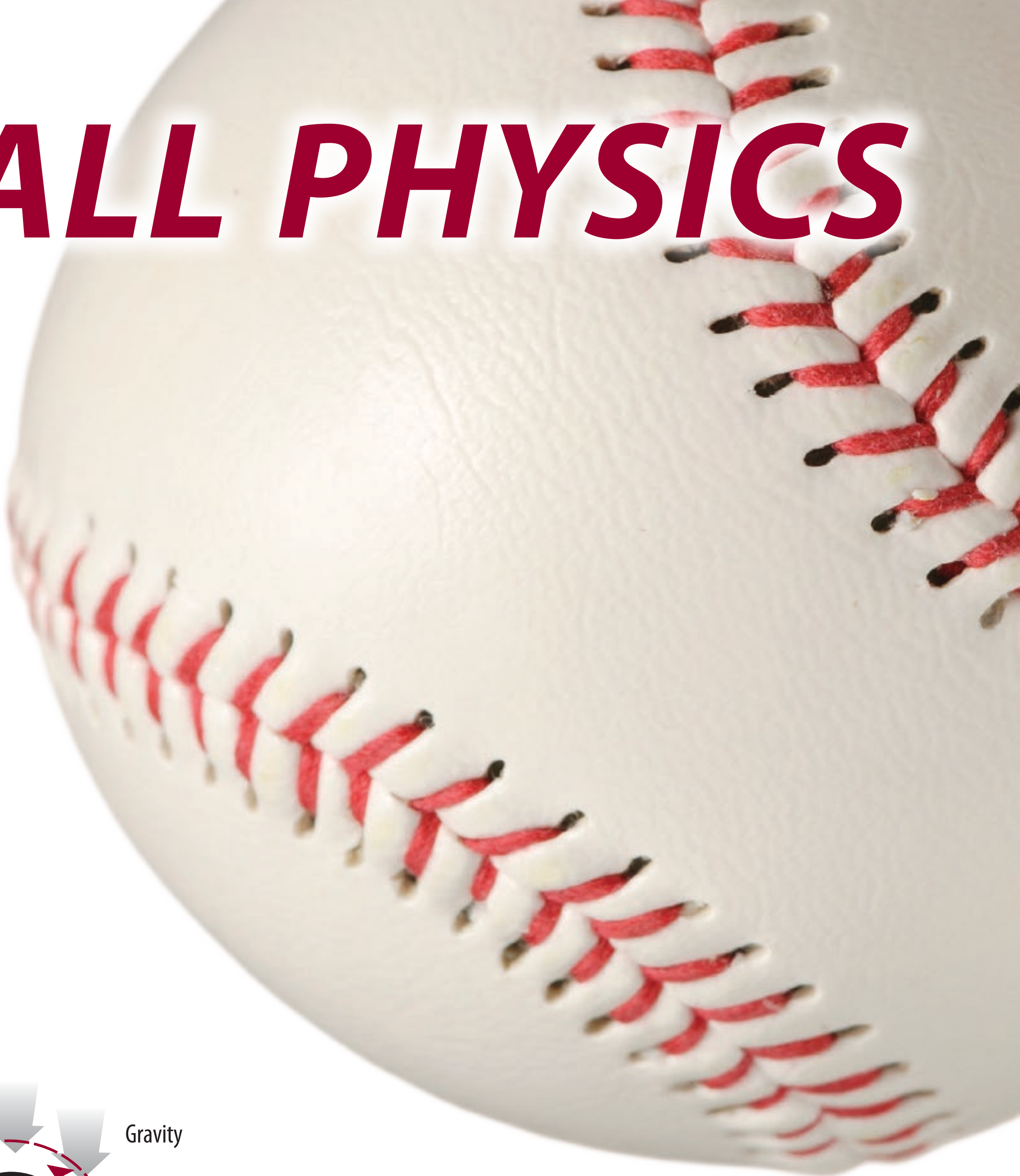
Pittsburgh Supercomputing Center brings the power of high-performance computing to new communities of researchers

A 21st-Century Science Education

MCS launches its new Core Education

December 2015, volume 8 number 1

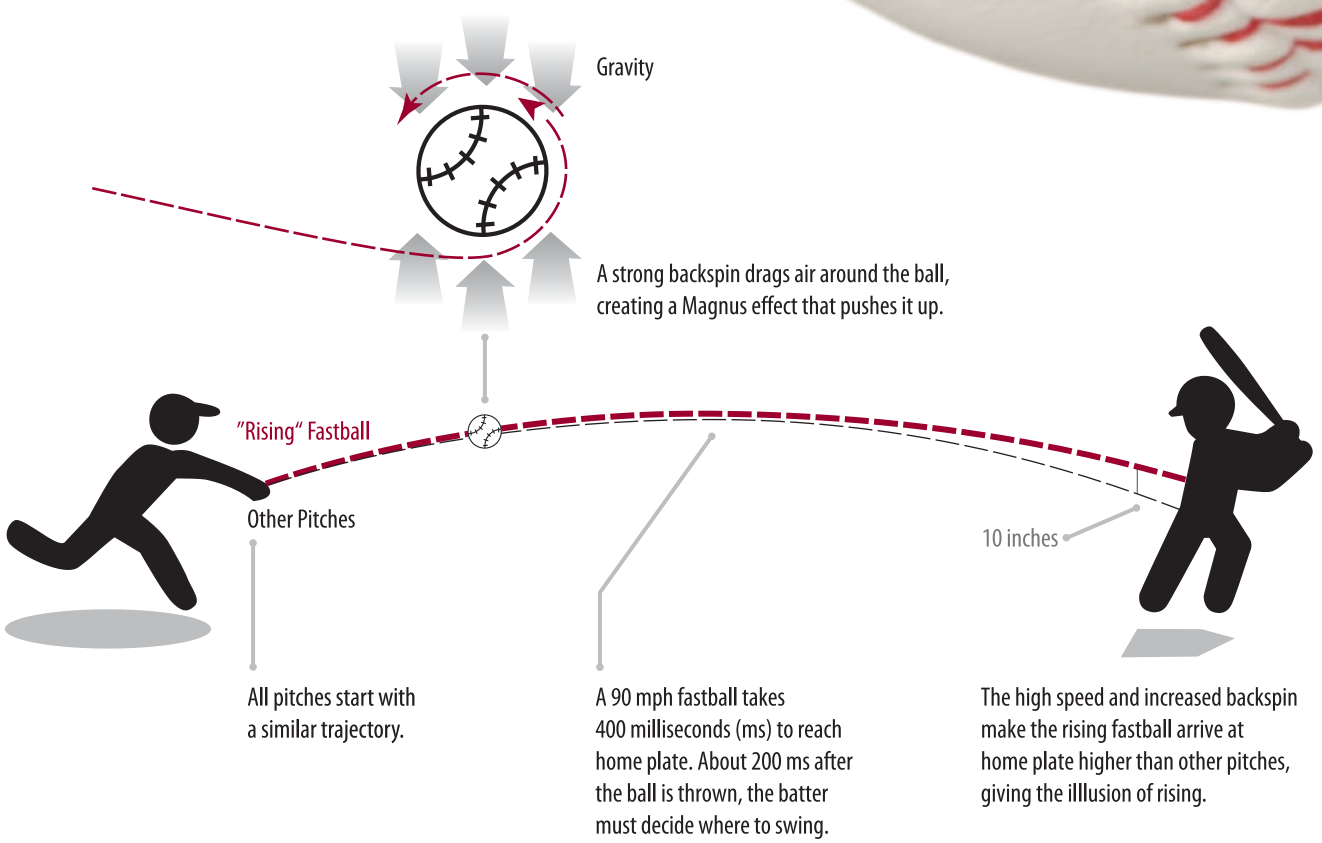
FASTBALL PHYSICS



Legend has it that the fastest pitchers in baseball can defy physics and make a pitch rise as it crosses the plate. This spring, Physics Professor Gregg Franklin and other CMU faculty took to the big screen to describe the science behind this legend and answer other questions about baseball's most revered and feared pitch. Fastball, a documentary produced by Carnegie Mellon Trustee Thomas Tull and directed by Emmy winner Jonathan Hock, premiered at the Tribeca Film Festival in April 2015.

It turns out that a rising fastball doesn't actually rise. It just doesn't fall as fast as other pitches.

Here's how Franklin explains the phenomenon of the rising fastball. "It's the difference between where [the batter's] brain is telling him the ball is going to be and where it actually is when it crosses home plate."



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Departments

During the more than eight years that I've been at the helm of the Mellon College of Science, we've built upon the College's foundation of conducting pioneering research and educating leaders in science and technology. We have taken advantage of Carnegie Mellon's multidisciplinary character and great strengths to move in new research directions where we can develop world-class programs. We've secured major gifts to support new centers, graduate fellowships, and chairs. This past year, several projects have come to fruition and new projects have started, such as seed-funding of very promising new research directions involving MCS and CIT faculty. Some of the completed initiatives are highlighted in this issue of Science Connection.

A project that may well have the greatest lasting impact is the new MCS Core Education, which was introduced this fall after many years of intensive development (page 11). We've added innovative elements to our educational program, already known for integrating excellent classroom instruction with authentic research experiences and outstanding advising, to better prepare MCS graduates to face and shape the 21st-century world.

Several years ago we drew up plans to revitalize the Mellon Institute, the iconic building that is home to the Departments of Biological Sciences and Chemistry, in order to make its interior match the quality of the science being done within its walls. We've started by transforming the entrances on the third floor and creating spaces for informal interaction and collaboration (back inside cover); the second phase of renovations will take place in 2016.

The past eight years have been exciting both for the College and for me. Reflecting on all that has been accomplished, but also on the new CMU Strategic Plan for the decade ahead, I have decided it is time to pass the leadership on to a new dean who can lead into the 2020s. I plan to refocus my time and effort on research and education in my roles as Buhl Professor of Theoretical Physics and Director of the McWilliams Center for Cosmology, and through my involvement in construction of the Large Synoptic Survey Telescope. I'm proud to have been a part of what MCS has accomplished, and I look forward to being a part of the next chapter.

Fred Gilman

Fred Gilman
Dean, Mellon College of Science
Buhl Professor of Theoretical Physics

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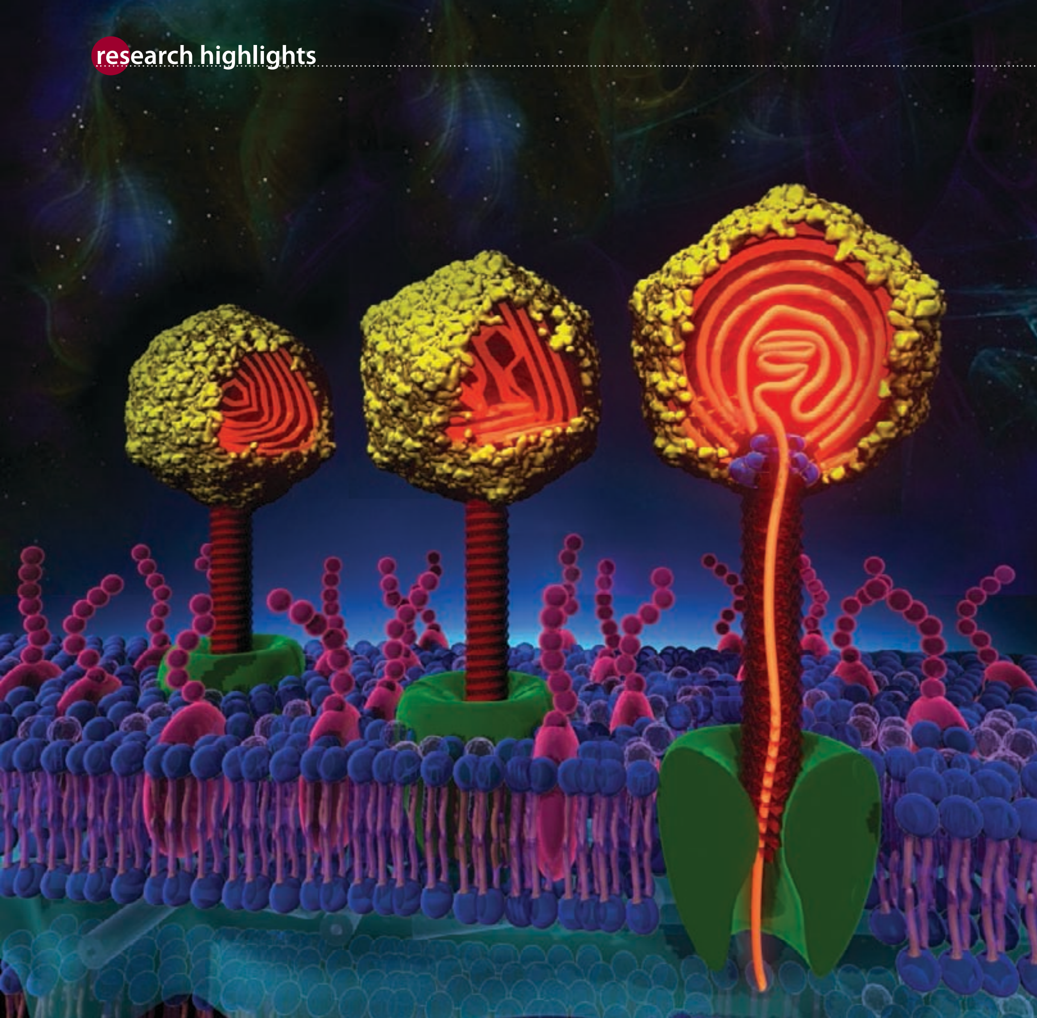


Researchers Identify Virus's Achilles' Heel

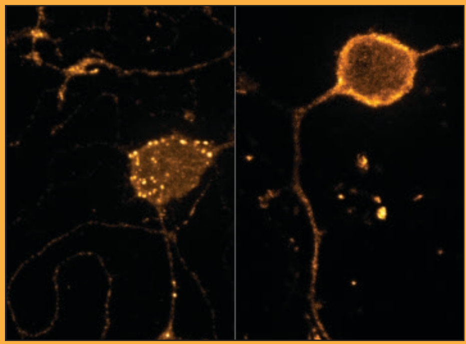
All viruses have industrial-strength shells that surround and protect the genetic material within, enabling the viral particles to remain stable and infectious. Biophysicist Alex Evilevitch and colleagues have identified that tough shell's Achilles' heel, which could provide a target for interfering with virus stability. The outer shell, called a capsid, encases a virus's genetic material. In some viruses, DNA is packaged so tightly that it exerts a tremendous amount of pressure on the interior capsid wall. This pressure is what propels DNA out of a small portal in the virus's capsid and into a host cell. Evilevitch and physics graduate student David Bauer have discovered that the portal is the capsid's weakest structural part. Using a novel differential scanning microcalorimetry assay they developed, the researchers looked at portal complex stability in three different viruses that contain double-stranded DNA. The results show that the mechanical force of the genome pushing against the virus's portal destabilizes it and makes it prone to breaking open. The results suggest that the portal complex has evolved to withstand the outward force of the packaged genome while maintaining the ability to efficiently release DNA during infection. Further understanding of this balance between internal pressure and portal stability offers new insights into ways to interfere with viral replication, as well as designing viral vectors for gene therapy.

Artist's rendering of a virus ejecting its DNA into a host cell.

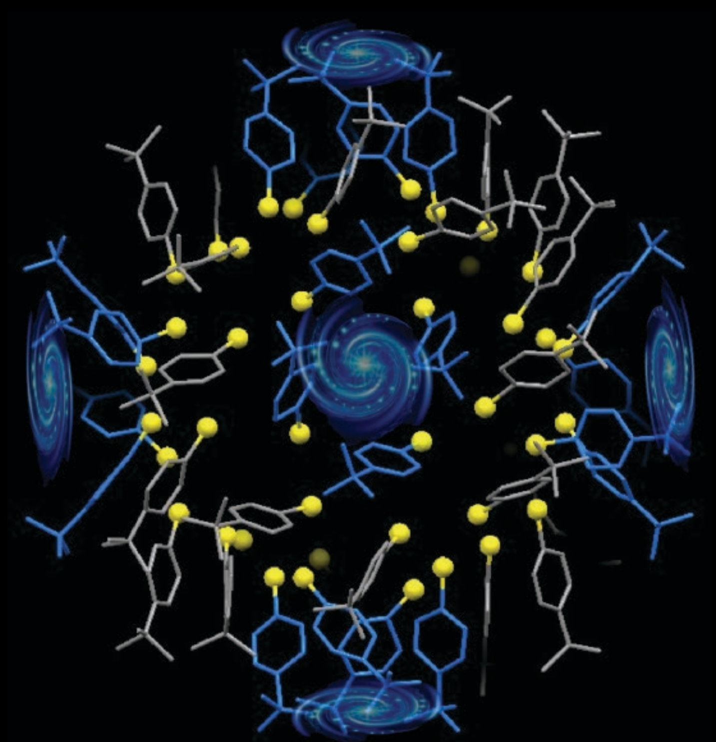
TOP: TING LIU AND ALEX EVILEVITCH; PUTHENVEEDU LAB

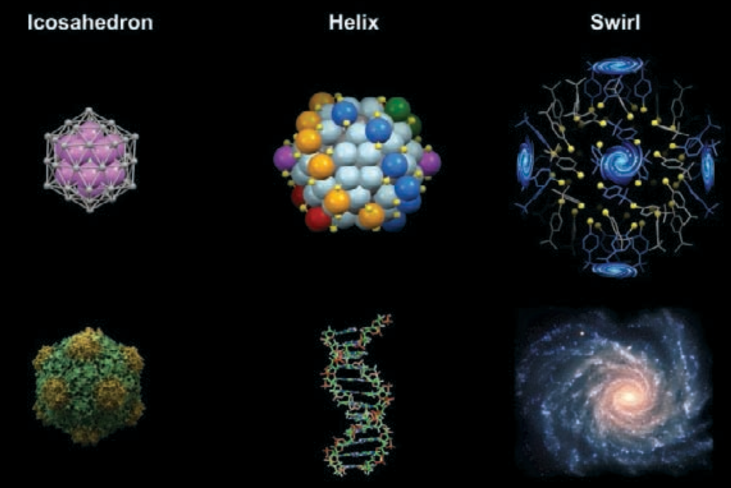
Pain Fine-Tunes Pain Relief

At the cellular level, pain and pain relief are caused by two different signaling pathways. But the two pathways are linked, according to Manojkumar Puthenveedu, assistant professor of biological sciences. That link could provide a target for fighting addiction. When a person experiences pain, a peptide called substance P activates the neurokinin 1 receptor on a neuron's surface. When a person takes an opioid like morphine to relieve pain, the drug activates a different receptor called the mu-opioid receptor. Puthenveedu and his colleagues wondered if perhaps crosstalk between these pain- and analgesia-signaling pathways might hold clues to why some pain management drugs are prone to creating tolerance or addiction. To find out, Puthenveedu visualized mu-opioid receptors in live cells and in real time. When activated by an opioid, only some of the mu-opioid receptors returned to the cell surface. This mechanism, in part, explains why patients quickly build tolerance to opioids—if the receptors aren't at the cell surface, the drugs can't bind to them and enter the cell. But when the researchers used substance P to activate the pain-causing neurokinin 1 receptor, the mu-opioid receptors recycled back to the cell's surface more quickly.



After treatment with DAMGO, an opioid that binds to the mu-opioid receptor, the receptor is internalized in endosomes (left). After DAMGO washout, the receptor is recycled back to the cell surface (right).



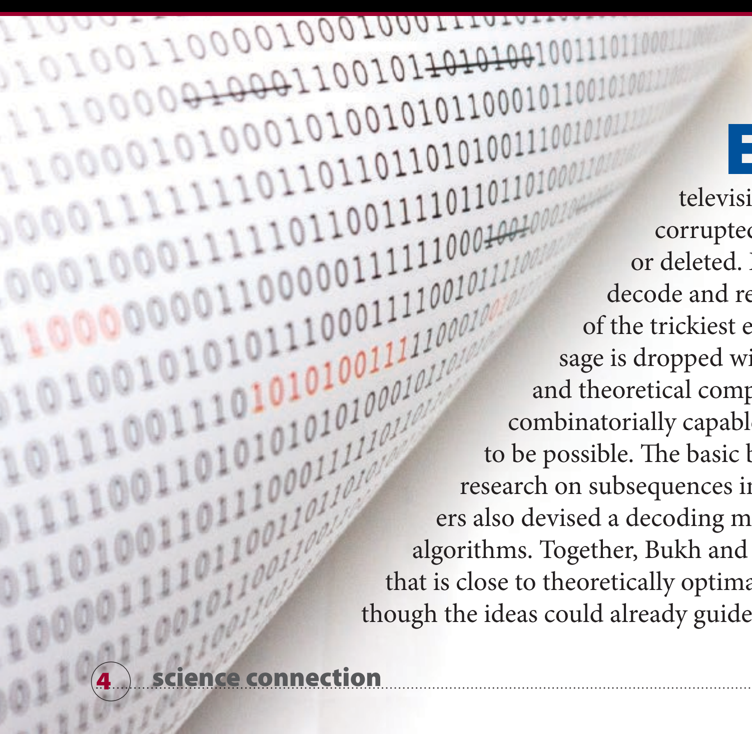


Structure patterns at all scales.

Tiny Gold Nanoparticles Reflect Nature's Patterns

Our world is full of patterns, from the twist of a DNA molecule to the spiral of the Milky Way. New research from Chemistry Professor Rongchao Jin has revealed that tiny synthetic gold nanoparticles, known as Au_{133}, exhibit some of these same patterns. Jin and graduate student Chenjie Zeng used X-ray crystallography to solve the structure of Au_{133}, which is made up of 133 gold atoms and 52 surface-protecting molecules. It is the biggest nanoparticle structure ever resolved with X-ray crystallography.

Au_{133} particles consist of three layers: a gold core, the surface molecules that protect it and the interface between the two. In the crystal structure, Zeng discovered that the gold core is in the shape of an icosahedron. At the interface between the core and the surface-protecting molecules is a layer of sulfur atoms that bind with the gold atoms. The sulfur-gold-sulfur combinations stack into ladder-like helical structures similar to a DNA double helix. Finally, attached to the sulfur molecules is an outer layer of surface-protecting molecules whose carbon tails self-assemble into fourfold swirls reminiscent of the way the Milky Way galaxy is arranged. Knowing the surface structure is key to using the nanoparticles for applications, such as catalysis, and for uncovering fundamental science, such as the basis of the particle's stability. In this case, these particular patterns are responsible for the high stability of Au_{133} compared to other sizes of gold nanoparticles.

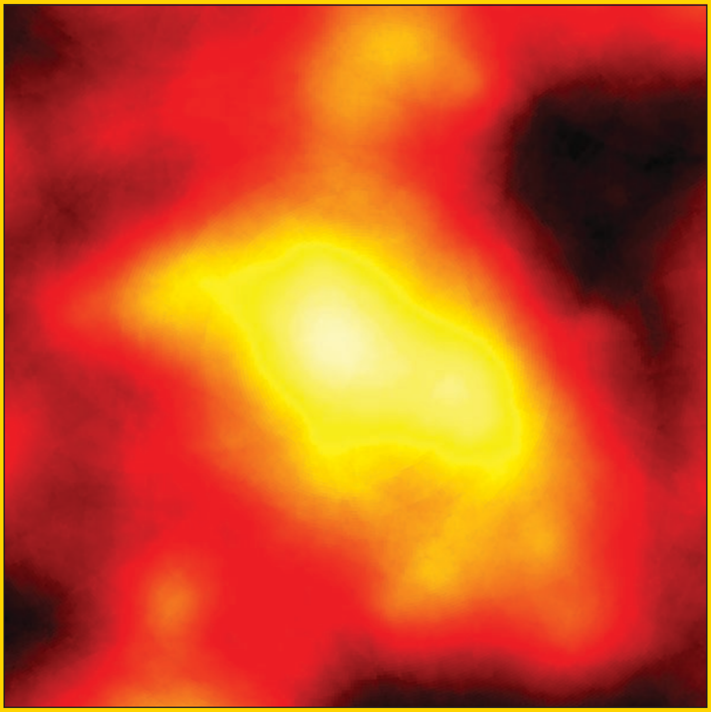


Error-Correcting Codes

Error-correcting codes are saviors of the digital age. They safeguard the transmission of digital information in our computer hard drives, digital televisions, cell phones and satellite communications. Any given message can be corrupted randomly or maliciously during transmission—bits are erased, flipped or deleted. Error-correcting codes are built into messages to enable the receiver to decode and recover the original message from its distorted, error-riddled form. Some of the trickiest errors to code against are worst-case deletions in which part of the message is dropped without any trace that it ever existed. Pure mathematician Boris Bukh and theoretical computer scientist Venkatesan Guruswami have constructed codes that are combinatorially capable of correcting a larger fraction of deletions than was previously known to be possible. The basic building blocks for the error-correcting codes are based on Bukh's earlier research on subsequences in words. And because codes need to be decoded efficiently, the researchers also devised a decoding method based on Guruswami's previous research on error-correction algorithms. Together, Bukh and Guruswami have constructed a way to code against worst-case deletions that is close to theoretically optimal. The researchers note the method is not yet practical in its current form, though the ideas could already guide better heuristic constructions.

RONGCHAO JIN; NICOLE READING

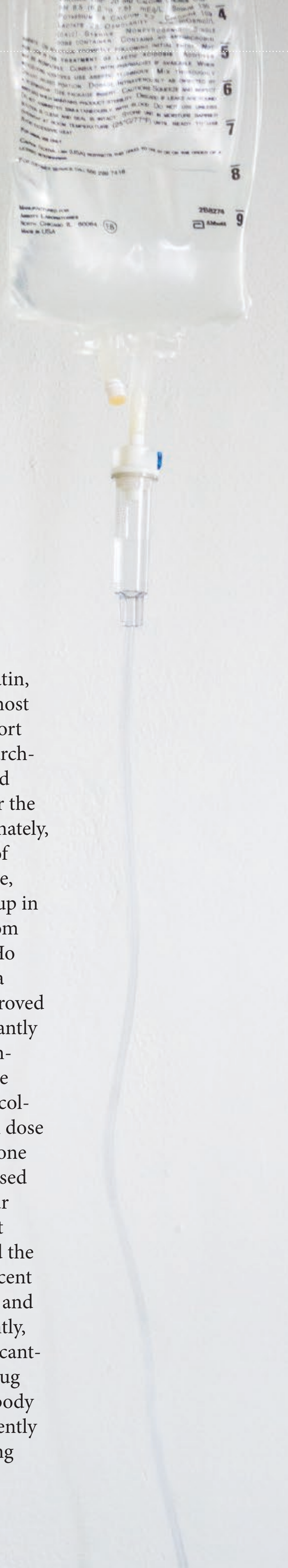
Unexpected Gamma-Ray Emission From Dwarf Galaxy May Point to New Understanding of Dark Matter



The above image represents a region of the sky surrounding the newly discovered dwarf galaxy Reticulum 2. The brightness in the center indicates a possible gamma-ray signal coming from the direction of Reticulum 2. The image was generated using the authors' search algorithm applied to Fermi gamma-ray data.

NASA/DOE/FERMI-LAT COLLABORATION/GERINGER-SAMETH & WALKER/CARNEGIE MELLON UNIVERSITY/KOUSHIAPPAS/BROWN UNIVERSITY; NICOLE READING

A newly discovered dwarf galaxy orbiting the Milky Way has offered up a surprise—it appears to be radiating gamma rays, according to an analysis by physicists at Carnegie Mellon, Brown and Cambridge universities. The exact source of the gamma rays is uncertain at this point, but it might be a signal of dark matter. No one knows exactly what dark matter is, but a leading theory suggests that dark matter particles are WIMPs, or Weakly Interacting Massive Particles. When pairs of WIMPs meet, they annihilate one another, giving off high-energy gamma rays. Because dwarf galaxies are thought to lack other gamma-ray-producing sources like black holes and pulsars, a gamma ray flux from a dwarf galaxy would make a very strong case for dark matter. Using data from NASA's Fermi Gamma-ray Space Telescope and an analysis technique they developed, Assistant Physics Professor Matthew Walker and postdoc Alex Geringer-Sameth found gamma rays coming from the direction of the newly discovered galaxy in excess of what would be expected from normal background. There doesn't appear to be a conventional reason that this galaxy should be giving off gamma rays. Further study of this galaxy's attributes could reveal hidden sources that may be emitting gamma rays, so the researchers caution that while these preliminary results are exciting, there's more work to be done to confirm a dark matter origin.



IV Nutrition Source Could Improve Effectiveness, Reduce Side Effects of Chemotherapy Nanodrugs

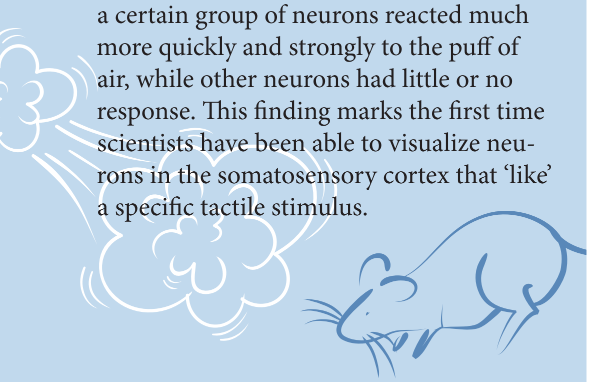
Platinum-based drugs, including cisplatin, carboplatin and oxaliplatin, are among the most prescribed and most potent chemotherapy drugs. In an effort to reduce the drugs' side effects, researchers are creating nanotechnology-based chemotherapeutics that aim to deliver the drugs specifically to tumors. Unfortunately, tests show that only a small fraction of the drugs accumulate at the tumor site, with the majority of the dose ending up in the liver and spleen. New research from Biological Sciences Professor Chien Ho may change that. He discovered that a single dose of Intralipid, an FDA-approved intravenous nutrition source, significantly reduces the accumulation of platinum-based chemotherapy nanodrugs in the liver, spleen and kidneys. Ho and his colleagues administered a single, clinical dose of Intralipid to a rat model followed, one hour later, by a dose of a platinum-based chemotherapy nanodrug. Twenty-four hours later, the researchers found that pre-treatment with Intralipid reduced the accumulation of the drug by 20.4 percent in the liver, 42.5 percent in the spleen and 31.2 percent in the kidney. Consequently, the toxic side effects decreased significantly in these organs, and more of the drug remained available and active in the body for longer periods of time. Ho is currently investigating the possibility of bringing this research to a clinical trial.

Going With The Flow

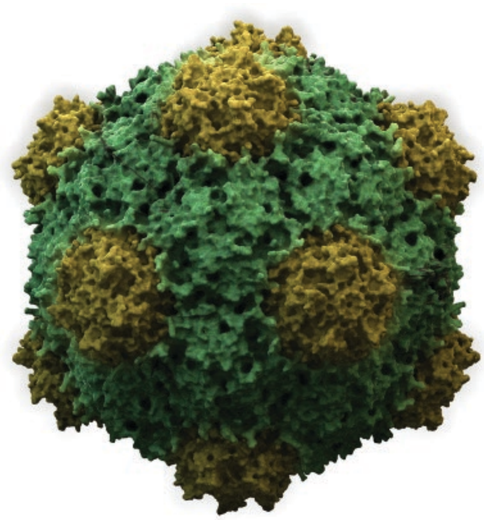
An inhaled aerosol medication could effectively treat pockets of bacteria-infested mucus that clog the lungs of people with cystic fibrosis—if it could only get there. Aerosolized drugs tend to deposit and release their contents in portions of the lung where airflow is good. As a result, airways blocked by mucus, which are areas that often need the drug the most, might not ever receive any medication. A team of researchers from the Mellon College of Science and the College of Engineering are developing ways to get inhaled drugs to spread throughout the airways after they land—even over top of clumps of mucus. Their secret weapon is surfactant, a class of molecules, including soaps and lipids, that move to the surface of a liquid and change the liquid's surface properties. The researchers found that adding surfactants to a drug formulation enables the aerosolized droplets to easily spread along a surface—much like a drop of dish soap spreads across a sink full of water. Chemical Engineering graduate student Ramankur Sharma and Physics graduate student Amy Stetten are testing different surfactants to observe how they spread on surfaces that mimic the watery lining of the lung. Their most successful candidates are a synthetic surfactant called fluorosurfactant, and a naturally-occurring surfactant, the lipid DMPC. In lab experiments, Sharma and Stetten added their surfactants to a drug mimic, nebulized the formulation into a fine spray, and deposited it on the model surface. In both cases, the surfactant-laden droplets spread much more than surfactant-free droplets. The researchers, led by CMU professors Steven Garoff, Todd Przybycien and Bob Tilton, are working with the University of Pittsburgh's Tim Corcoran and Doug Reed to test their surfactants in a mouse model. The findings could lead to aerosolized medications that, instead of staying where they land, will spread over blockages and deliver drugs throughout the airways.

Neuroscientists Have a Better Feeling About Sense of Touch

Our sense of touch is critical—it allows us to feel texture, temperature, pressure, pain or vibration. Although scientists know a good deal about the molecular receptors that mediate the different types of somatosensation, they know little about how touch is represented in the brain. Biological Sciences Professor Alison Barth and her colleagues have, for the first time, linked a group of neurons in the brain to a specific type of somatosensation—a puff of air directed at a mouse's whiskers. Using the fos-GFP mouse, a transgenic mouse model Barth created to study activity in live neurons, the researchers found that a certain group of neurons reacted much more quickly and strongly to the puff of air, while other neurons had little or no response. This finding marks the first time scientists have been able to visualize neurons in the somatosensory cortex that 'like' a specific tactile stimulus.

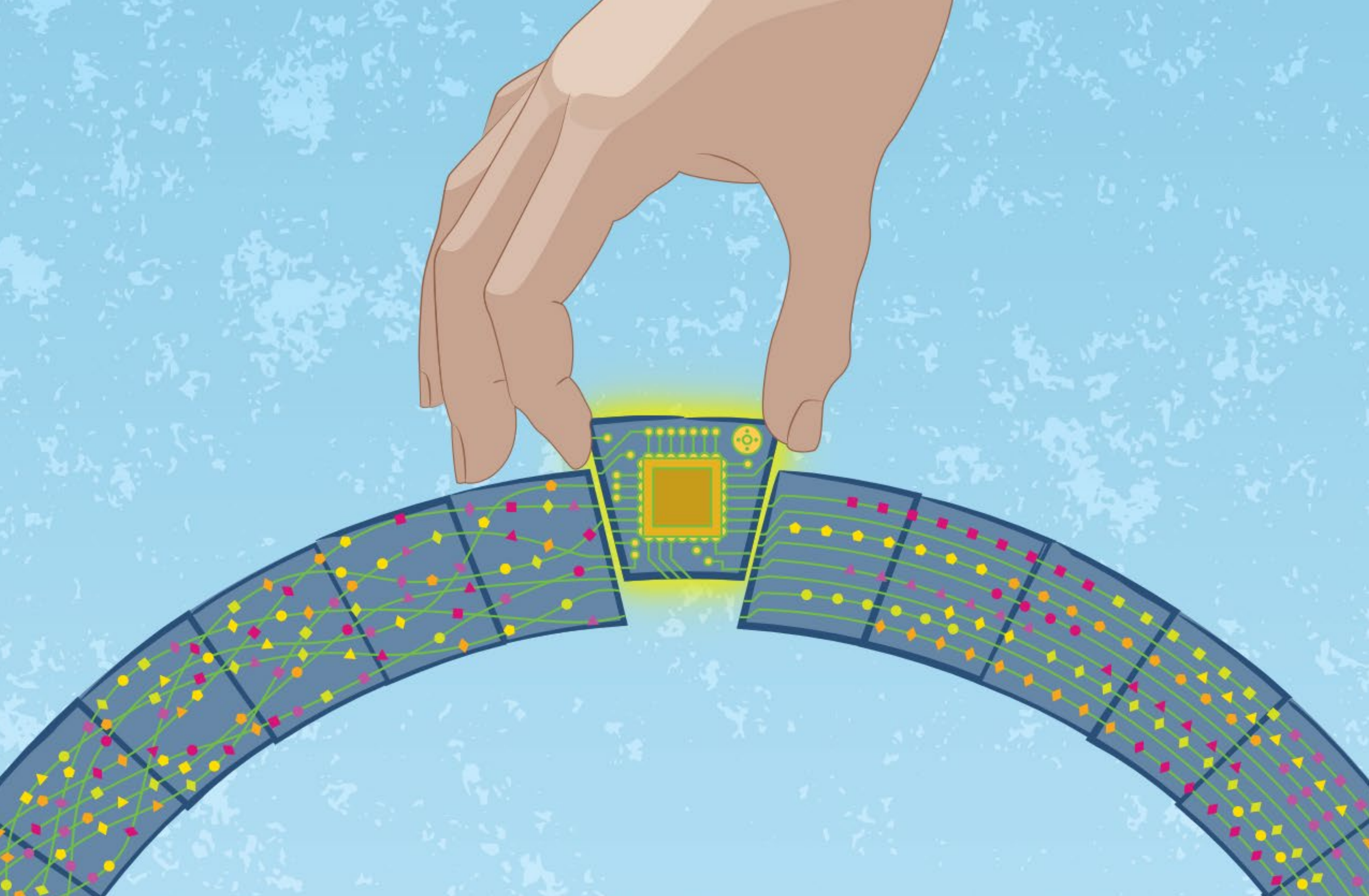


Chemists Weigh Intact Virus Mixture With Mass Spectrometer



Chemists in Carnegie Mellon's Center for Molecular Analysis have entered a new frontier in mass spectrometry (MS) research. Led by Research Professor of Chemistry Mark Bier, the team has for the first time successfully used matrix-assisted laser desorption ionization MS to analyze a mixture of intact virus particles. Because of their size, which can be more than a million times larger than a water molecule, viruses have not been widely studied using MS. Most instruments are unable to efficiently detect such large molecules at low charge states or must resort to creating high charge states that require high-resolution mass analysis. But Bier's group used a cryodetector-based matrix-assisted laser desorption/ionization time of flight mass spectrometer, called a Macromizer, that can analyze low charge heavy ions with a significantly higher signal than mass spectrometers with standard ionizing detectors. Using the Macromizer, the researchers weighed and separated a mixture of two variants of cowpea mosaic virus—one weighed 5.65 megadaltons and the other weighed 4.84 megadaltons. These weights were close to the theoretical weights proposed for the virus particles. Bier hopes that the technique can be used to analyze and study other viruses, and will be helpful in understanding the robustness of viral structure, the mechanics behind viral infection and provide new ways of virus detection and treatment.

CLOCKWISE FROM TOP: WIKIMEDIA; MARK BIER; COLLEEN WILSON AND SHIMARU, FROM THE NOUN PROJECT



Bridging The Gap

Pittsburgh Supercomputing Center brings the power of high-performance computing to new communities of researchers

by Kenneth Chiacchia

When Tiziana Di Matteo successfully ran her MassiveBlack computer model of the early Universe, her work was only half done. She needed to analyze the raw numbers that resulted from that simulation, and to create visualizations that made the results understandable.

"Our simulation studies large volumes of the Universe, but we also want to do it at very high resolution," said Di Matteo, professor of physics at Carnegie Mellon. To understand the properties of large astronomical structures and make predictions for upcoming telescope observations, she added, the simulation had to model matter at very different scales.

The initial simulation ran on a massively parallel traditional supercomputer. But the second step required a very different type of high-performance computing (HPC) resource: one that emphasized large memory and the ability to handle the massive amount of data generated by the initial model—three terabytes needed to be held at once in the computer's memory.

NICOLE READING

To carry out this second step, Di Matteo chose the data-intensive computational systems at the Pittsburgh Supercomputing Center (PSC), a joint CMU/University of Pittsburgh research center formally contained within MCS.

It's About the Data

High-performance, data-intensive computing (HPDIC) addresses research problems that are limited by data movement and analysis as much as by computational performance.

"HPC expertise is now required in fields that never before employed supercomputers," says Pitt Professor of Physics Ralph Roskies, Scientific Director and co-founder of PSC. "Researchers without a computational background find themselves navigating HPC resources that aren't known for ease of use."

PSC has become a leading force in HPDIC and in serving the new communities of researchers who require it, adds Carnegie Mellon Professor of Physics Michael Levine, PSC Scientific Director and co-founder.

"Since 2008, we have increasingly been designing our resources to address an expanding need for storage, handling and analysis of data at ever-increasing scales," Levine says. "The next step in this evolution is our upcoming system, Bridges, which will provide a more variable and flexible computing environment than has been available with traditional HPC resources."

Late last year, PSC received an award from the National Science Foundation (NSF) to create the $9.65-million Bridges system, which represents a pivot toward inherently user-friendly systems, as well as toward data handling and analytics for which traditional HPC resources often aren't well suited. PSC began building Bridges in October, and it will be completed in 2016.

Reaching New Research Communities

Curtis Marean, a professor at the Institute of Human Origins, School of Human Evolution & Social Change, Arizona State University at Tempe, epitomizes the "new community" of HPC users. A paleoanthropologist, he leads an international collaboration exploring sites of human habitation in the Cape Floral Region of South Africa 150,000 to 50,000 years ago.

Marean's group has focused on the factors by which Homo sapiens, which nearly went extinct at a glacial maximum 150,000 years ago, somehow turned the game around, expanding beyond Africa and replacing earlier hominids, such as the Neanderthals, beginning about 50,000 years ago. The researchers built "agent-based" models of human behavior on desktop computers to try to understand how the near-extinction event changed us, leading to more complex social organization, advanced planning in tool manufacturing and the first artistic representations.

"Humans cooperate with non-kin at spectacular levels of complexity," Marean says. "So what we want to know is what are the contexts of evolution for those special features of humans? When did they arise, and why did they arise?"

To understand this transition, the researchers needed to up-scale their agent-based model and unify it with climate and vegetation simulations. The group has used PSC's now-retired Blacklight system to model climate, vegetation and human behavior separately; Bridges will be an important tool for combining the models.

"I cannot stress enough how important the support has been from PSC," Marean says. "They have provided us with the machines and the people; the machines of course being the high performance computing, but the people are what make the use of the machines possible."

Designed for Disruptive Flexibility

Bridges will continue the trend toward large random access memory (RAM) pioneered by PSC's earlier systems, such as the recently retired Blacklight. The new system will feature a total of 283 terabytes of RAM and more than 27,000 cores. But Bridges was also designed from the ground up for novel flexibility to meet user needs.

"Historically, HPC systems have been designed to achieve maximum hardware performance at the current level of technology," says Nick Nystrom, PSC director of strategic applications and principal investigator for the Bridges project. "Researchers would then have to figure out how best to use the machine. By comparison, while we have designed Bridges to achieve maximum performance, we have also engineered the system from the outset to meet user needs in unprecedented ways."

Bridges will allow for some interactive access, much as users have on their personal computers, instead of waiting in a queue for time on the machine. This is a disruptive change

Propelling the Science

PSC's data-intensive and specialized HPC systems have provided crucial computational support to fields that include those that traditionally have used HPC and those that have not. In addition to researchers in traditional HPC fields such as Physics Professor Tiziana Di Matteo with her cosmology project, these systems have helped researchers make significant advances in a number of fields.

- In collaboration with D.E. Shaw Research, PSC hosts a specialized Anton supercomputer that can perform molecular dynamics simulations of biomolecular systems in the microsecond to millisecond range, far longer than typically possible on general-purpose computing systems. More than 200 biomedical scientists across the United States have used this unique resource to conduct biomolecular simulations of unprecedented length.

- Carnegie Mellon Associate Professor of Chemistry Maria Kurnikova used the Anton supercomputer at PSC to model the molecular dynamics of the diphtheria toxin, shedding light on how that protein inserts itself into a target cell's membrane.

- The Galaxy project at Penn State uses PSC computation, storage and networking systems to supply the genomics community with whole-genome and transcriptome sequencing tools. PSC's resources have allowed Galaxy to automatically shift users with the largest data and memory needs to PSC's data-intensive supercomputers.

- Carnegie Mellon Professor of Computer Science Tuomas Sandholm, whose group manages the national UNOS organ-sharing organization's automated recipient/live donor matching system, used PSC's Blacklight supercomputer to discover means for increasing the number of difficult-to-match patients receiving transplants without decreasing the total number of transplants.

PSC's contributions extend beyond providing hardware and support. PSC researchers in its Public Health Applications and Biomedical Applications groups collaborate with researchers elsewhere on a number of projects. The HERMES simulation tool, for example, models vaccine and other medical supply chains. Other collaborations model biological systems at the cellular and subcellular levels, including several projects reconstructing neural architectures in zebrafish, mouse and human brains from electron microscopy images of tissue slices. PSC staff also continue to advance HPC technology, especially in the file systems, storage, networking and programming environments.

from traditional supercomputing practice that could prove an important new direction in HPC. Users will also be able to access Bridges' high-performance computing and data resources by easily launching jobs, orchestrating complex workflows and managing data from their web browsers without becoming skilled HPC programmers.

Virtualization will provide secure environments for emerging software and support reproducibility for data analytics and computational science, as well as greater portability and interoperability with cloud services. Bridges will also support databases for data analytics and management. This is important for researchers whose work requires investigation of extremely large databases such as The Cancer Genome Atlas funded by the National Institutes of Health (NIH).

Finally, Bridges will run common software tools used by researchers such as the Hadoop and Spark ecosystems, Python, R, MATLAB® and Java. This is another way in which researchers will be able to bring previously successful methods to Bridges with minimal re-tooling and maximal reproducibility.

Together, Nystrom adds, these innovations will enable researchers to use the system at their own levels of computing expertise. "Bridges users will likely range from those who wish to maintain a desktop- or even mobile-like experience in the HPC environment, to HPC experts wanting to tailor specific applications to their needs," he says.

Allocation of PSC Services

Funding, primarily from the NSF and the NIH, enables PSC to provide allocations of supercomputing time at no charge to applicants conducting non-proprietary research. Most users acquire PSC allocations through the NSF's national Extreme Science and Engineering Discovery Environment (XSEDE) program, of which PSC is a leading member.

In addition to providing time on its supercomputers and access to its software, PSC also offers intensive user support, largely through XSEDE.

"PSC staff with particular scientific and computational expertise play very active roles in consulting with users," says Roskies, who is a co-PI in XSEDE and co-directs its Extended Collaborative Support Service (ECSS). "In some cases, PSC staff involvement in projects has extended to collaborating on grant proposals."

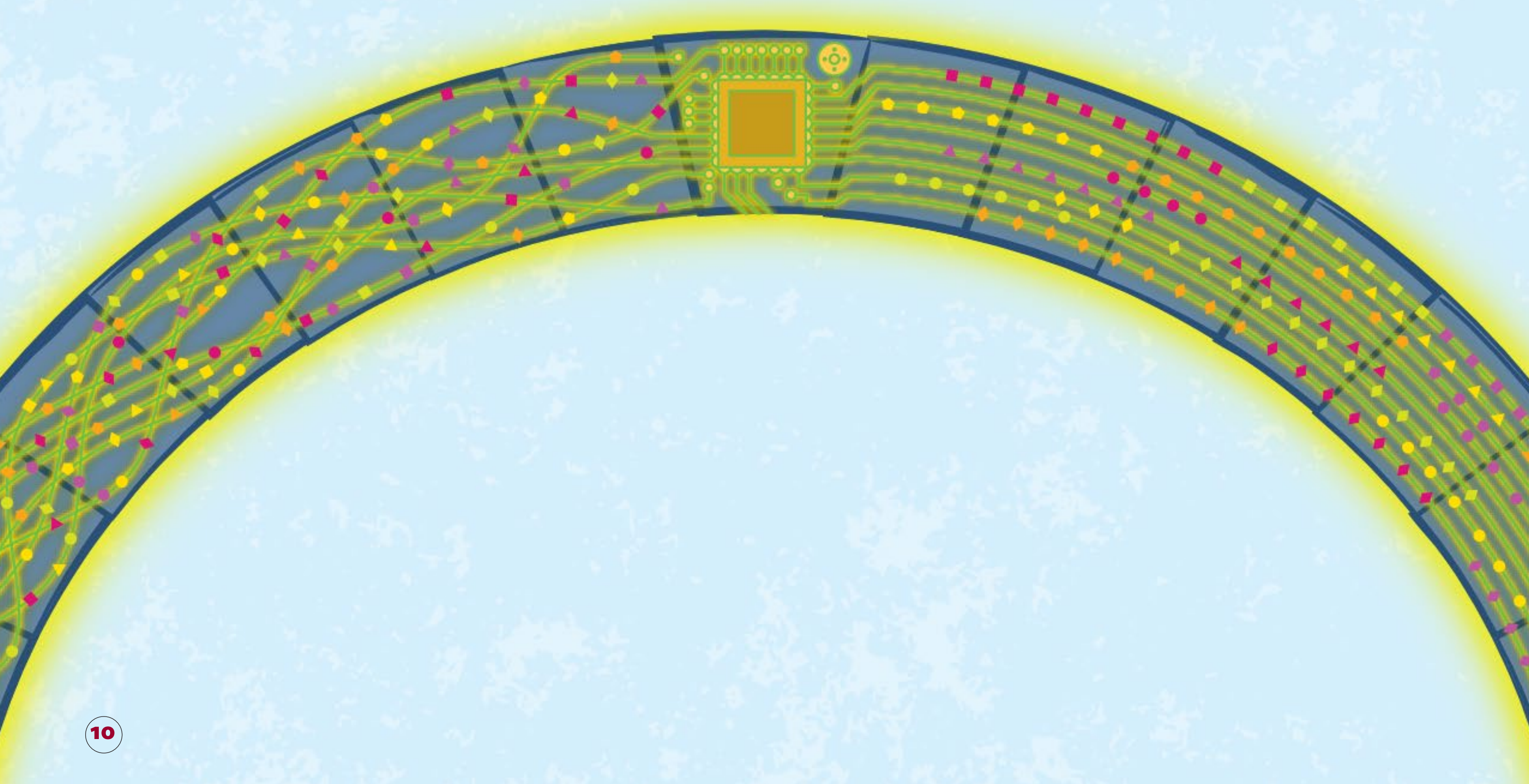
"The idea is that users can get the precise level of support they need," says Sergiu Sanielevici, PSC director of scientific applications and user support and manager of the Novel and Innovative Projects program in ECSS, which focuses on assisting users from communities that are new to advanced computing. "That can range from simple instruction, such as how to log into the system, to expert computational collaboration."

Visualizing New Capabilities

If Marean is a good example of the new communities of HPC users, Di Matteo is undoubtedly of the "HPC expert" camp. Bridges' capabilities—most importantly its very large RAM—will enable her to analyze and visualize even more massive, detailed simulations.

Again, Bridges' novel flexibility may be its biggest virtue. Offering high-powered data analytics to old hands, its features will also help newcomers graduate to HPC with minimal re-training and maximal reproducibility.

More on PSC's successes as well as its HPC systems, independent research and allocation processes are at www.psc.edu.



A 21ST-CENTURY SCIENCE EDUCATION

by Amy Pavlak Laird

Articles in a recent issue of Nature examined what it will take to train the next generation of successful scientists. The conclusion? Definitely a deep knowledge of a discipline and mastery of the scientific method. "But there are other key requirements, such as the ability to think critically and solve problems creatively and collaboratively. Communication skills are a must, and mastery of modern technology helps."

In 2010, a committee of more than 20 Mellon College of Science faculty members came together to re-evaluate the MCS curriculum and they came to a similar conclusion: a multi-dimensional undergraduate experience is key to success as a 21st-century scientist. The committee reported its findings to MCS Dean Fred Gilman, who decided it was time to develop a new MCS core education. His charge was to establish measurable competencies and experiences every future MCS student should have upon graduation, and then to identify specific changes to existing courses or to create new courses needed to meet these outcomes. This past fall, after five years of intensive effort, MCS launched the result: an innovative approach to science education that fosters student growth in four dimensions—scholar, professional, citizen, and person.

"The new MCS Core Education re-envisions science education through a holistic view of the entire set of educational outcomes for an undergraduate science student, and then builds up a curriculum that prepares our graduates to thrive in the 21st-century scientific and social world they will face and shape," said Gilman.

Alumni Inspire the Heart of the Core

The MCS Core Education Committees looked especially to alumni for inspiration as they re-evaluated the curriculum. "When it came time to examine the core, we asked ourselves, 'What kind of experiences did our most successful alumni have at CMU? What qualities did they possess? Can we have a core education plan that aspires to help all of our students develop those qualities and experiences?'" explained Eric Grotzinger, MCS associate dean for undergraduate affairs and teaching professor of biological sciences.

It turns out that alumni, especially those who are successful professionally and personally, all had very similar experiences while they were MCS undergraduates.

"We learned that they were often scholars who immersed themselves in authentic research experiences. They took part in experiential learning and internships. They explored the arts and humanities. They used their science knowledge to improve society, to give back. They had a sense of balance in their lives," said Amy Burkert, vice provost for education and teaching professor of biological sciences.

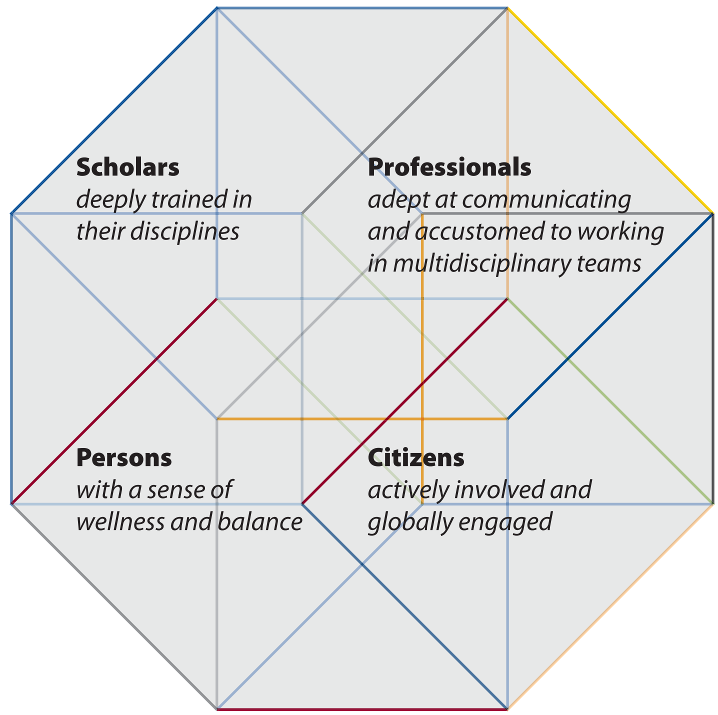
And it's not just anecdotal evidence from alumni that shows how important it is to be educated with this holistic mindset. Employers, graduate schools, medical schools and other professional programs want students with multi-dimensional qualities.

"Employers are looking for graduates who are really great technically but who are also prepared for the workplace of today and tomorrow," pointed out Maggie Braun, director of MCS core education.

Burkert adds that this isn't just what employers and graduate schools want. "There's also a lot of data and research that shows high-impact practices like undergraduate research or service learning trips actually help students learn, be motivated and help them refine how their future may unfold."

Preparing Students to be 21st-century Scientists

The new holistic, outcome-driven MCS Core Education fosters the growth of MCS students in four dimensions:



An ENGAGING Education

The hallmark of an MCS education—training students as scholars, involving them in research, having them go into depth in a major—isn't changing. The required courses in the majors remain largely the same, but the requirements for technical courses outside of the majors have expanded, and to satisfy them students can choose among a broadened list of courses in engineering, computational biology and statistics, among others.

"Hopefully now that students have more options and get to choose more of what interests them, they will be taking courses that they are excited about, taking them earlier on, and potentially spurring interest in the different areas of MCS," Braun noted.

The biggest change to the MCS core centers on the non-technical portion. There are several new courses that revolve around self-directed experiences that encourage students to broaden their knowledge of the arts, engage with their community and maintain a balanced life. The ENGAGE courses encourage students to take advantage of the rich environment that Carnegie Mellon and Pittsburgh offer. World-class drama productions, for example, are staged right in their backyard, but many students don't take the time to see one.

"It's not just about checking a box," Braun said, "It's helping them see that there's so much richness they are leaving on the table if they don't engage with the full college experience."

A New Vision for Science Education

The new MCS core education experience is unlike anything else out there. Benchmarking did not identify a similar program with such a comprehensive approach. The new Core Education is grounded in research through work with the university's Simon Initiative, which is leveraging learning science research to improve student outcomes. For example, MCS Core Education builds on the expertise of MCS faculty who have long been innovators in using technology-enhanced learning tools in the classroom and will systematically use assessment of educational

Features of the MCS Core Education

Junior Seminar: Prepares students for their impending transitions into professional life.

- Examine reciprocal relationships among science, technology, political forces, societal contexts and environmental issues
- Explore the interplay of science, innovation, public policy, entrepreneurship and business
- Interviewing, networking, resume writing

EUREKA! Discovery and Its Impact: Equips students with foundational knowledge, skills and perspectives that will support their development as emerging scientists.

- Observe important traits and characteristics of successful scientists and mathematicians
- Learn strategies for nurturing personal well being, academic success and ethical decision making
- Participate in effective and successful team projects, and develop oral and written communication skills

Global/Cultural Understanding Course: Expands students' global and cultural awareness.

- Take at least one course from a list of options to gain a better understanding of the diverse societies, economies and cultures in our interconnected world

ENGAGE in the Arts: Encourages students to broaden their knowledge of the arts and extend their global and cultural awareness.

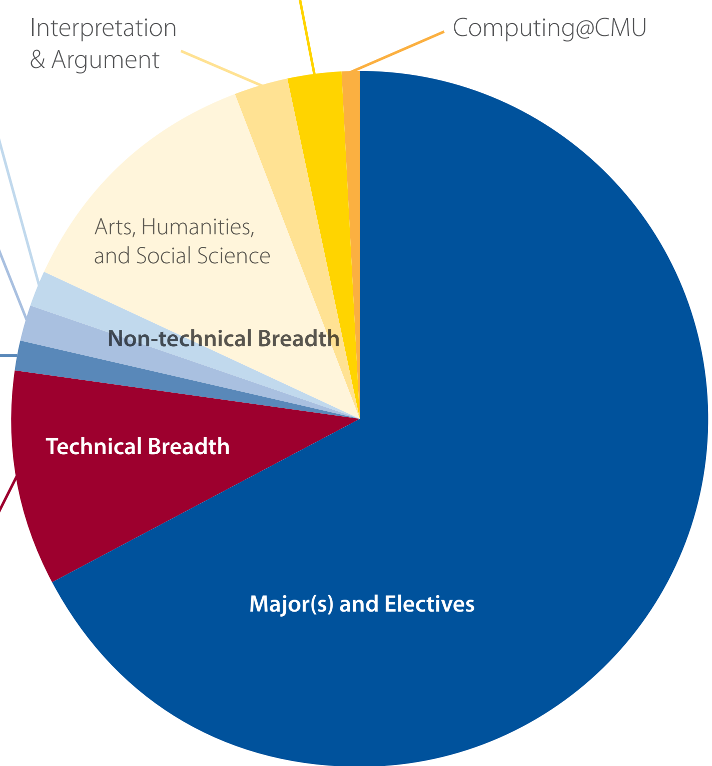
- Attend eight events such as exhibitions, concerts, theatrical performances and lectures with an arts focus
- At least two events should expose students to a culture different than their own

ENGAGE in Wellness: Encourages students to maintain a balanced life that promotes health and wellness in multiple areas.

- Assess their own wellness in areas including physical, social and financial
- Develop action plans for maintaining/improving personal wellness

ENGAGE in Service: Promotes MCS students' direct engagement with community development and service learning.

- Engage in a minimum of nine hours of work devoted to an organization of their choice



Technical Breadth: Broadly trains students in STEM fields to prepare them to work with others from a variety of technical backgrounds.

- Take one course outside of their primary major department from each of four categories: life sciences; physical sciences; mathematics, statistics, and computer science; STEM

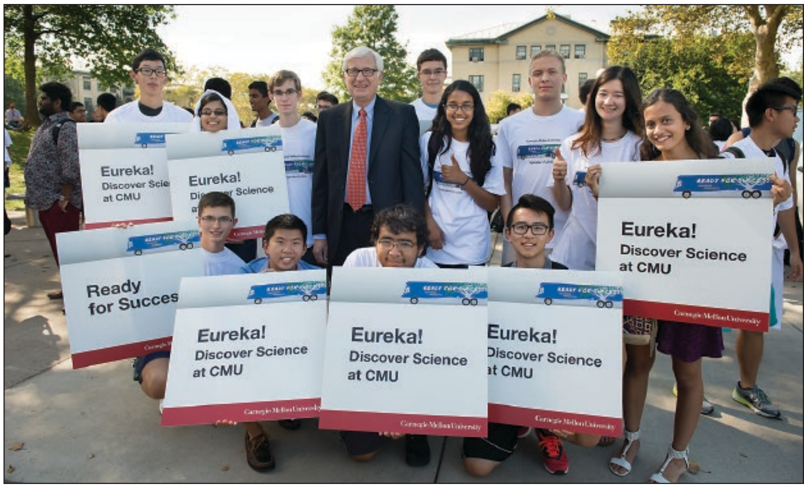
Requirements for Departmental Majors: Provides scientific depth within a chosen field, while allowing the freedom to use electives to focus on a particular field within the majors, pursue a secondary major or minor(s), or explore areas outside of MCS.

Data from the 2015–2016 Undergraduate Course Catalog: *coursecatalog.web.cmu.edu/melloncollegeofscience* outcomes for ongoing course development related to innovative approaches. One such innovation is the new first-year seminar, EUREKA! Discovery and Its Impact. The seminar was tailor-made for first-year students.

"MCS students come in excited about science. We're going to give them the tools to build on that enthusiasm and open their minds to new possibilities," Grotzinger said.

During the semester students hear from working scientists, including faculty and alumni, who delve into the details about what it's like to live the life of a scientist. They talk with students about their research, how they got to where they are, and the challenges and joys they experience every day on the job. Students also learn from experts about topics like transitioning to college life, how we learn, and work/life balance.

The lecture portion of EUREKA! brings together the entire entering class of MCS students, giving students with varied scientific interests the chance to get to know each other and to work together on team projects focused on an interdisciplinary science-related concept. In the recitation portion of the seminar, students work closely with upper-class mentors, a concept that evolved from a student-initiated mentorship program. In the program's earlier iteration, students signed up to be a mentor or a mentee, and they met weekly to discuss anything that was on their minds, from test-taking anxiety to whether or not to take a certain professor's class. Now, the mentorship aspect is woven into the first-year seminar.



Mellon College of Science Dean Fred Gilman with first-year students.

"The overarching goals of the class are to get students thinking about things that will be useful not only over the next four years but also life-long, and to get them excited about being here and being a part of MCS," said Braun, one of the seminar's creators.

"We hope, by the end of the seminar, that we've created a lot more transparency about our vision for the whole of the educational experience that students are going to receive within the college," said John Hannon, associate dean of student affairs and MCS director of integrative learning.

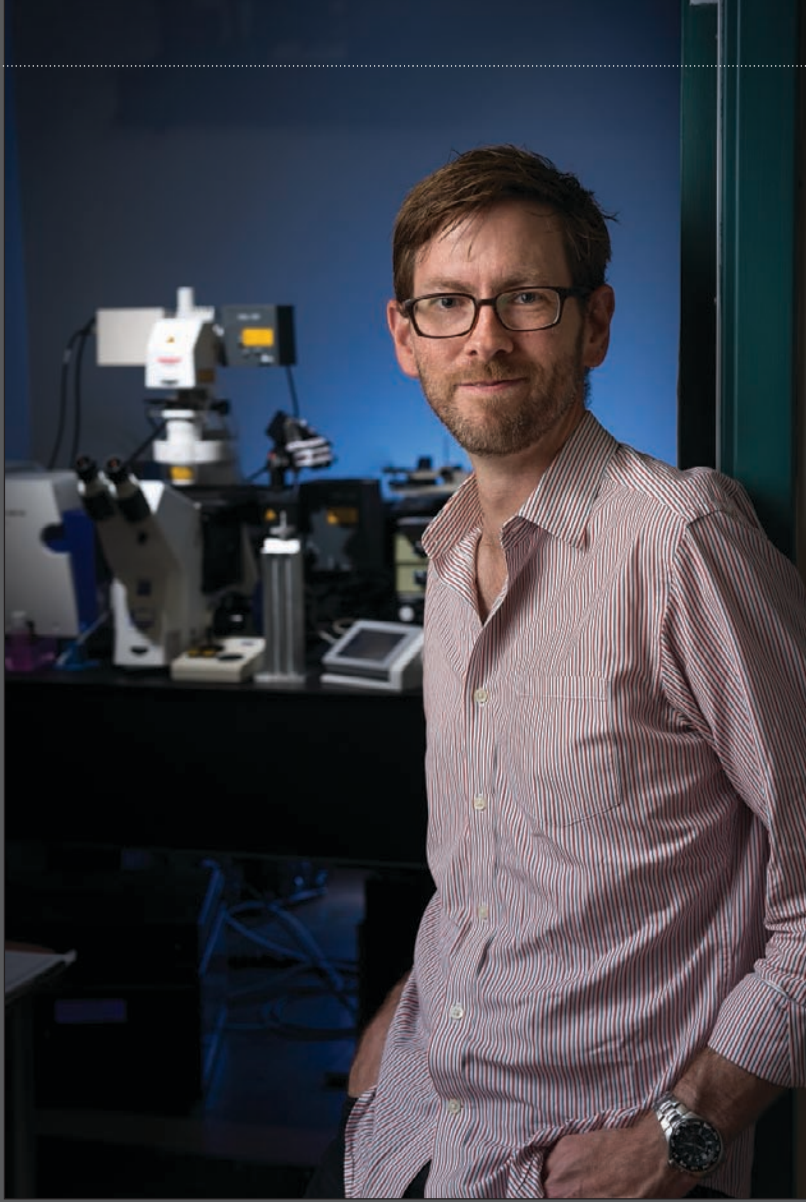
"The new MCS Core Education re-envisions science education through a holistic view of the entire set of educational outcomes for an undergraduate science student, and then builds up a curriculum that prepares our graduates to thrive in the 21st-century scientific and social world they will face and shape."

— Fred Gilman, Dean of the Mellon College of Science and Buhl Professor of Theoretical Physics

Stephanie Vereb, a senior biological sciences major, sees the value in what the core program will bring to an MCS education. As a TA for the EUREKA! seminar, she and her fellow TAs already have plenty of advice for first-year students, especially when it comes to the new core education program.

"We've been trying to stress to the first-years how lucky there are. They have no idea," Vereb said. "I'm happy with my time here, and everything worked out for a reason. But the reality is that this [core program] would have been super cool to do."

KEN ANDREYO



TIM KAULEN

Bright Ideas

Marcel Bruchez creates imaging tools to peer inside living cells

by Linda Schmitmeyer

When Marcel Bruchez talks about chemistry, his face alights with youthful enthusiasm. It doesn't matter if he's talking about the chemistry kit he received in third grade that helped him "blow things up" or his first American Chemical Society abstract. If he's talking about chemistry, he's excited.

"The great power of chemistry is that you're not constrained by what is available," says Bruchez, an associate professor of biological sciences and chemistry in the Mellon College of Science. "You can identify interesting biological problems and then design precisely the molecular details you need to interrogate, measure, and manipulate them."

He's been doing just that since his grad school days. As a Ph.D. student at the University of California, Berkeley, Bruchez modified nano-sized particles—called quantum dots—so they could be used to tag proteins and label cells, a technology that Science magazine named one of its Top Ten Scientific Innovations in 2003. Within months of that discovery, he co-founded Quantum Dot Corporation to market the new imaging tool to biologists and drug developers who sought a more detailed picture of molecular events.

"There is so much value to creating something that other people can use," says Bruchez, who learned that lesson from his father, a furniture salesman who eventually started his own company. "My dad recognized an opportunity for low-cost ergonomic seating in manufacturing lines rather than just in offices. My parents saw an opportunity and built a company around it."

That same entrepreneurial spirit burns bright within Bruchez.

Though Invitrogen purchased Quantum Dot Corporation a decade ago, Bruchez continues to solve biological problems with chemistry at his new company, Sharp Edge Labs, which he founded in 2011 with CMU professor and former Molecular Biosensor and Imaging Center (MBIC) director Alan Waggoner.

Named for the Pittsburgh beer emporium where the idea for the company was hatched, Sharp Edge Labs has developed a suite of imaging and detection tools that allow scientists to monitor the activities and locations of individual proteins found in living cells in real-time. Using these tools, Sharp Edge Labs can distinguish proteins less than 10 nanometers apart—a very sharp edge indeed.

"By carefully designing dyes and labeling protocols, we can quickly interrogate these properties in living cells," says Bruchez. "This allows us to test biological processes very quickly, at a throughput required for drug discovery."

Understanding these processes can directly impact our understanding of and treatment for disease, says Bruchez. To give just one example, MBIC researchers and their collaborators are using the tools to identify proteins inside cells that may control the function of drugs for cystic fibrosis, while at Sharp Edge, they are working to develop drugs that will make the disease more manageable.

Bruchez wears two hats as chief scientific officer at Sharp Edge and director of MBIC—a privilege he chalks up to the CMU culture.

"It's a place that recognizes the value of entrepreneurial experience and offers people with that experience the opportunity to contribute to academia," he says.

But he still thinks basic scientific research is a lot of fun. "I really like that gleam-in-the-eye, early-idea stage of 'How am I going to change the world next?'"

Getting Hands-On With Science

DNAZone, an MCS outreach program, brings lab experiments into Pittsburgh schools through its Classroom Kit Lending Library

by Hannah Diorio-Toth

When Pittsburgh Science and Technology Academy teacher Craig Kozminski introduced his 9th grade class to the topic of acids and bases, he used a kit from DNAZone's Classroom Kit Lending Library to augment his lesson. Taking out several clear vials of liquid from a large bin and setting them on his lab table, he started with one question: "What would cause these solutions to change color?"

Catalina Achim shows teachers how to use red cabbage to make a pH indicator at a DNAZone teacher workshop in August.

DNAZone, an educational outreach program organized by Carnegie Mellon University's Center for Nucleic Acids Science and Technology (CNAST), lends kits like "What is the pH? Chemistry of Acids and Bases" and "Kitchen Chemistry: Edible Emulsions" to local science teachers in an effort to bring life to the scientific concepts that students are learning in the classroom.

Kozminski's students divided up into groups of two or three and turned to the small boxes of materials in front of them for an answer. Inside each box they found the same items that Kozminski had asked them about: vinegar, lemon juice, and milk of magnesia. They also found several small plastic cups in which they were asked to individually pour their various liquids.

"The students were given no background information about pH besides whatever prior knowledge they were bringing to the table. Instead, we put things in the hands of the students first and then asked them to make discoveries," explains Kozminski.

After adding a homemade pH indicator made from boiled red cabbage to their samples, the students discovered that their original liquids had changed into a rainbow of vibrant colors. They then matched these colors to a pH scale, which revealed whether their liquids were acidic, basic, or neutral.

This type of learning, called inquiry-based learning, is used in many Pittsburgh-area schools and in schools across the country. The hands-on activities in DNAZone's lending library are designed to support this inquiry-based learning by challenging students to answer fundamental scientific questions or solve real-world problems.

"Our goal is to make learning science fun and engaging. We are inspired and informed by the research that we do and we want to pass that excitement to the students," says Professor of Chemistry and DNAZone Outreach Coordinator Catalina Achim.

The classroom kits, created by CNAST faculty members and students, are available to local middle school and high school teachers at no cost. They come with suggested lesson plans and activities that help students develop questions, make observations, and analyze their results. Students learn by doing—much like they would in professional scientific research.

"The lending library shows teachers that they don't have to create everything, but instead can leverage the resources around them," explains Pittsburgh Public School Science Coordinator Rhonda Graham.

One of those resources is the undergraduate and graduate students in CNAST. Several student volunteers develop new classroom kits throughout the year with the support and guidance of DNAZone and with resources like CMU's Leonard Gelfand Center for Service Learning and Outreach. They also take the

ALL PHOTOS BY TIM KAULEN

kits on the road to local schools and other local community and educational centers.

"The younger the mentor is, the greater the connectivity," says Professor of Biology and CNAST Co-Director John Woolford. "I think the fact that we have undergraduate students and graduate students working on outreach together with faculty is really fantastic, because the CNAST students are relatable and very clearly show what it looks like to be excited about science."

Chemistry graduate students Taylor Canady and Genoa Warner recently created a kit that explains the basic rules of DNA property and function using a unique ribbon model and used it with students at several outreach events this year.

"Given some time, the students are asking questions like, 'Does DNA bind to itself on the same strand?' or 'How do these buttons (which represent the nucleobases), make life happen?'" explains Canady. "I find these unguided bursts of inquisition truly exciting to see firsthand."

Sparking scientific questions like these has fueled DNAZone since its creation in 2008. The program was founded on the goal of giving children, who may not have access to the proper resources, the opportunity to learn the experimental aspects of the sciences.

"We all felt that an outreach program to educate the public was inherently valuable, especially at a time when science literacy rates seem to fall daily," says Professor of Chemistry and CNAST Co-Director Bruce Armitage. "Getting young people excited about science and making them life-long appreciators, if not practitioners, of science has always been really important to us."

The program reached about 300 students in 2014 through demonstrations and outreach events alone, but the DNAZone team decided to ramp up development of its lending library in an effort to increase their impact in the Pittsburgh area. Achim is confident that the classroom-kit model will allow for an even larger educational footprint.

"We thought about how we could give the lessons that we created a life of their own," explains Achim, "We found that we could empower teachers by directly providing them with the materials from our activities. By doing this, we could reach more people."

Just as Achim hoped, the lessons take on a life of their own each time a kit is borrowed by a teacher. As the kits leave Mellon Institute and are welcomed into a new classroom, they become a platform for teachers and students to create and innovate. The kits are simply a catalyst for one of CNAST's favorite reactions—learning.

Above: Items from DNAZone's "Chemistry of Color: Pigments in Art" classroom kit. The kit, which is available to Pittsburgh-area teachers, is fully stocked with materials for both teacher demonstrations and student experiments.

Hedging His Bets

Jeff Greco maximizes his math degrees

by Amy Pavlak Laird

Jeff Greco

Jeff Greco (S'93) dreads being asked that run-of-the-mill dinner party question: What do you do for a living? For Greco, it's not a straightforward answer. He's worked at banks, hedge funds, a university, brokerage firms and even ran his own business. Now he works at a top actuarial consulting firm. But he's not an actuary. And although his day-to-day duties involve quantitative analysis of market volatility for the life insurance and retirement savings industries, he's not just a typical "quant." When he started his first job in the finance industry, Greco didn't know what a bond was, or an option, or even what interest rates were.

"I didn't just not know it well," Greco said, "I didn't know it period." But he learned on the job and on his own time—from books, articles, first-hand experience and others in the field.

Now a portfolio manager with Milliman Financial Risk Management LLC, the leading provider of hedging services to the retirement savings industry, Greco attributes much of his success to his time at Carnegie Mellon.

"I have to say that, just generally, a lot of the things that worked out well for me are quite honestly due to my experience at Carnegie Mellon."

Greco arrived at Carnegie Mellon as an engineering major, but he instantly knew that engineering wasn't for him when he realized that he wasn't required to take many math classes beyond the first semester. He quickly turned things around—he joined the Mellon College of Science and the Department of Mathematical Sciences.

"I ended up in the math studies program, which was a godsend," Greco said. "I had never really experienced math in a rigorous way, and my professors—Bill Hrusa, Vic Mizel, Luc Tartar—really trained me how to think critically and rigorously. I don't know whether my experience at Carnegie Mellon was typical or uncommon, but I can definitely say that I learned how to think."

Greco thrived as a math major, excelling in the classroom and carrying out an undergraduate research project, which is becoming more common today but was rare at the time. Greco's research, the basis of his master's thesis, was on the motions of a simple class of thermoviscoelastic nonconductors.

After graduating with his bachelor's and master's degrees, Greco pursued a Ph.D. in applied math at the University of Chicago with the goal of entering academia to teach and conduct research. After a few years he had a change of heart and left the program.

"It just didn't feel like I was studying the things that were derived from the physical problems in the real world that I had been interested in. I thought, 'Well, maybe there's a better way to do that,'" Greco said.

Finance turned out to be just what Greco was looking for. He took a job at Dean Witter where he got a crash course in the financial industry. He spent the mornings on the trading floor, observing and talking to traders, and the rest of the time in the research

ISTOCKPHOTO; COURTESY OF JEFF GRECO

department, collaborating with the research team to analyze and model new futures products and strategies.

He left Dean Witter to accept a senior research analyst position at Nation's Bank, which later merged with Bank of America. A few years later he became a senior quantitative strategist at Deutsche Bank.

"With each job I picked up a little bit more and a little bit more. As more of the picture filled in, I started to realize that I needed to learn very well the things that I didn't already know in order to really be a true quant in the finance industry."

To learn what he needed to know to take the next step in his career, Greco returned to his Carnegie Mellon roots. He picked up CMU math professor Steve Shreve's book, Stochastic Calculus for Finance.

"His book just laid out all of these obtuse and difficult topics in finance and made them very easy to understand. After you went through his book, you're like, 'I get it now.'"

Greco followed up his textbook learning by taking a two-day risk management course that Shreve offered in New York City.

"That was the missing piece. It got me on track for the rest of my career."

At Milliman, Greco works primarily with life insurers and fund managers, developing and improving risk-management techniques that help retirement investors and insurers mitigate market risk. While he carries out the research and quantitative analysis that's needed to run and maintain existing funds and evaluate their performance, a large part of his analysis involves building models that produce a near-term forecast of market volatility. Such models are the core component of the whole risk management process.

Although he didn't enter academia as he had once planned, Greco found himself back at the University of Chicago in 2002 as an invited lecturer for their financial mathematics master's degree program. He continues to teach the Fixed Income Derivatives course there as an adjunct professor.

So maybe there's no easy answer to the dreaded dinner party question. But it's clear that CMU—and MCS—are key characters in the story that follows.

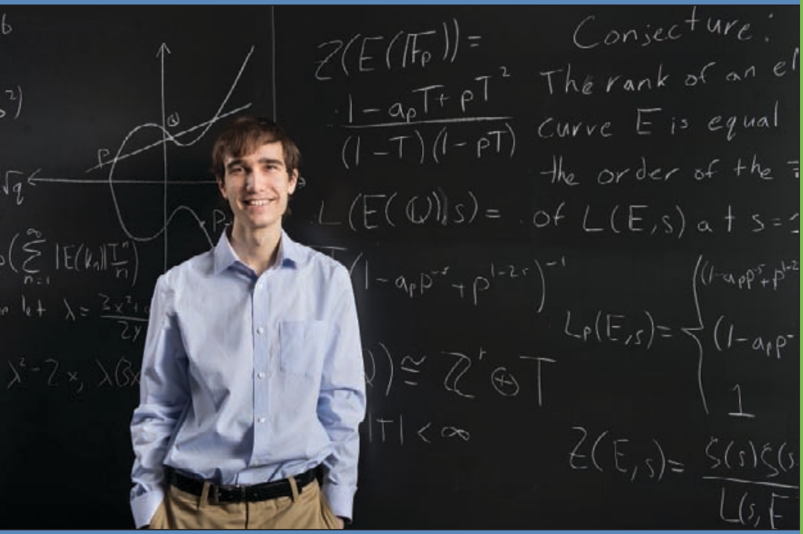
alumni briefs

- **Katie Cecil** (S'13) was awarded an NCAA Postgraduate Scholarship, which recognizes student-athletes who excel academically and athletically. As a member of CMU's women's tennis team, Cecil was a two-time All-American in singles and led the Tartans to two NCAA quarterfinals appearances.
- The National Science Foundation awarded Graduate Research Fellowships to **Stacey Chin** (S'13), a graduate student at Northwestern University, **Laura Filliger** (S'13) a graduate student at the University of Rhode Island, and **Shaina Mitchell** (S'14), a graduate student at the UNC-Chapel Hill Gillings School of Global Public Health.
- The New York Hall of Science named **Deren Guler** (S'09, A'12) its inaugural Design Fellow. Guler's company Teknikio makes do-it-yourself craft kits that teach students about circuitry, switches, and sensors. As a Fellow, she will further develop her designs through public workshops and feedback/prototyping with NY Hall of Science staff.
- The American Chemical Society's Division of Colloid and Surface Chemistry presented **Jill Millstone** (S'03) with the 2015 Unilever Award for Outstanding Young Investigator in Colloid and Surfactant Science. Millstone is an assistant professor in the Department of Chemistry at the University of Pittsburgh where she develops new tools for nanoparticle synthesis and provides insight into nanoscale reactions and particle properties.

Math Student Receives Gates Cambridge Scholarship

Tomer Reiter has plans to take the oldest and most famous mathematics examination in the world, and it's all thanks to the Gates Cambridge Scholarship program. Reiter (S'15), a recent mathematical sciences graduate, was selected as a 2015 recipient of the Gates Cambridge Scholarship to study at the University of Cambridge in the United Kingdom. He's currently enrolled there in a one-year course in mathematics that is referred to as Part III of the Mathematical Tripos, which culminates with an examination that will grant him a Master of Mathematics degree. He hopes to return to the United States and pursue his doctoral degree in mathematics and eventually become a professor.

"Math is beautiful," Reiter said. "One of the most satisfying things is when you have a strong intuition about why a statement should be true, and you finally find a proof. Carnegie Mellon has taught me how to tackle those difficult problems."



The Gates Cambridge Scholarship provides full support to students from outside the United Kingdom as they pursue a post-graduate degree at Cambridge University. There were 40 U.S. winners this year.

Ardon Shorr, Adona Iosif and Jesse Dunietz

Graduate Students Recognized for Science Communication Efforts

The field is dotted with students gesticulating at invisible things. Two students stand across from one another, circling their arms in synchrony. Another is hiding behind a tree, waiting to be coaxed out. This is improvisational theater training at its finest—but these aren't drama students. They're scientists. And they are out in the sunshine learning how to explain their work and why it matters.

"Communicating science is like throwing a ball—if you want someone to catch it, you have to pitch to where they are, not where you want them to be," said Ardon Schorr, a graduate student in Biological Sciences and co-founder of Public Communication for Researchers (PCR), a student-run group that hosts the improv training workshop and several other science communication training sessions throughout the year.

Shorr and PCR co-founders Jesse Dunietz and Adona Iosif, graduate students in the School of Computer Science, won CMU's 2015 Graduate Student Service Award for their efforts.

The three friends started PCR in 2012 to help graduate students learn about and practice ways to communicate science. Dunietz, Iosif and Shorr develop and host several workshops and seminars on topics like designing presentations and storytelling. They also give students opportunities to practice their new skills in a real-life environment, including interviews with a former 60-Minutes producer, performances with the Story Collider podcast, and a blog called Science Nonfiction. Their ultimate goal is to make science communication part of graduate education at the university level.

For more information and a list of PCR's workshops, please visit: ***www.cmu.edu/student-org/pcr***

KEN ANDREYO, TIM KAULEN

student honors

• The Carnegie Science Center presented chemistry graduate student **Danielle Chirdon** with the 2015 University/Post-Secondary Student Award for her research on materials for alternative energy sources, including organic solar cells, the photogeneration of hydrogen and rechargeable flow batteries. She also was recognized for her outreach work with K-12 students through Future Leaders in Science, an organization she founded. • Chemistry graduate student **Michael Polen** received an NSF Graduate Research Fellowship, which provides three years of support for the graduate education of individuals who have demonstrated their potential for significant achievements in science and engineering. • **Krista Freeman** was one of 55 U.S. graduate students selected to attend the 65th annual Lindau Nobel Laureate Meeting, during which Laureates and students exchange ideas, discuss projects and build international networks. Freeman, a physics graduate student, was also recently named chair-elect of the Forum on Graduate Student Affairs of the American Physical Society. • Biological Sciences graduate student **Anagha Kadam** won the Best Poster Award at the 20th Annual International Meeting on Microbial Genomics. She also won the Best Oral Presentation by a Student award at the 12th European

Chemistry Doctoral Students Win Chinese Government Awards for Outstanding Self-Financed Students Abroad

Award recipients who attended the ceremony in New York. Hongkun He is in the front row, first on the left, and Chenjie Zeng is in the front row, second from the right.

COURTESY HONGKUN HE, KEN ANDREYO

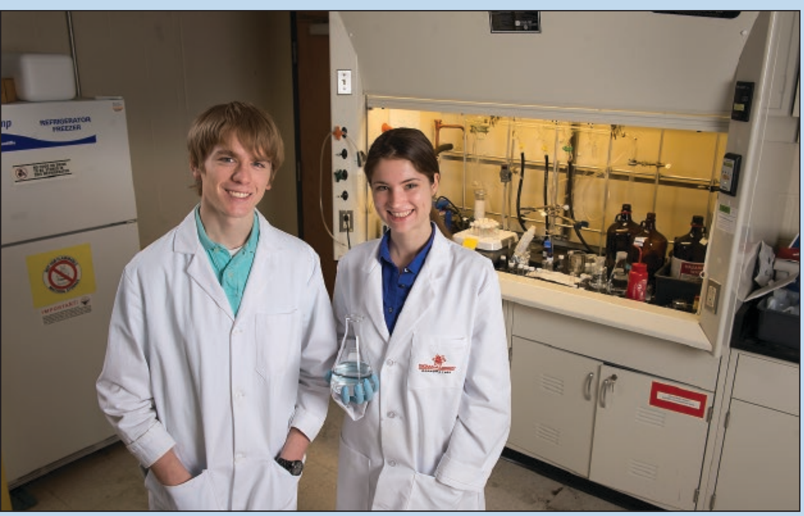
Two doctoral students studying in the Department of Chemistry received 2014 Chinese Government Awards for Outstanding Self-Financed Students Abroad. Given by the China Scholarship Council, the awards honor self-financed Chinese students studying overseas for their outstanding academic accomplishments. Hongkun He and Chenjie Zeng accepted their awards at a ceremony and reception held at the Chinese Consulate General in New York.

Hongkun He, who conducts research in the lab of Professor Krzysztof Matyjaszewski, has developed a new gel permeation chromatography technique for the characterization of polymerized ionic liquids and novel porous polymers for reversible carbon capture; both are considered to be breakthroughs in their respective fields. He also won the 2015 Graduate Student Award at the ACS Excellence in Graduate Polymer Research Symposium.

Chenjie Zeng works in the lab of Professor Rongchao Jin, establishing the structure of synthetic gold nanoclusters that contain tens to hundreds of gold atoms. The structure determines the properties of these tiny particles, making Zeng's work critical to developing gold nanoclusters for use in applications including catalysis, electronics, materials science and health care. This year, Zeng also received awards from the International Precious Metals Society and the Materials Research Society.

MCS Students Awarded Barry M. Goldwater Scholarships

Jillian Jaycox and Joshua Kubiak are Carnegie Mellon's newest Goldwater Scholars. They are among 260 college sophomores and juniors nationwide selected for the honor.



Joshua Kubiak and Jillian Jaycox

Jaycox, a biological sciences major, has plans to become a physician-scientist working within the field of immunology. She has conducted research with University of Pittsburgh Immunology Professor Sarah Gaffen (S'88), studying the immune response to bloodstream fungal infections, and with CMU Chemistry Associate Professor Subha R. Das, designing DNA nanoparticles made of backbone-branched DNAs. Jaycox is a member of the CMU cross-country and track teams and co-president of The Triple Helix, an undergraduate student journal focused on science, society and law.

As an undergraduate research assistant, Kubiak is working to improve methods of creating quantum dot backlights for more energy-efficient LCD screens for displays such as those on televisions or portable electronics. Kubiak, a materials science and engineering and chemistry double major, has conducted research with CIT's Michael Bockstaller, Robert Heard and Satbir Singh, plus MCS's Krzysztof Matyjaszewski. When not in the lab, Kubiak is a member of the CMU Racing team, Chem-E-Car and Engineers Without Borders.

Meeting on the Molecular Biology of the Pneumococcus. • The Carnegie Mellon team of mathematical sciences majors **Thomas Swayze** and **Samuel Zbarsky** and Science and Humanities Scholar **Linus Hamilton** placed fifth in the Mathematical Association of America's 75th William Lowell Putnam Competition, the premier mathematics contest for undergraduate students. Additionally, CMU had 55 students who scored among the top 507, the second most of any university. • Physics graduate student **Tabitha Voytek** won the outstanding collegiate member award from the Society of Women Engineers (SWE) "for being a role model for women in science and engineering and inspiring graduate student involvement in SWE through creative new initiatives." Voytek, who joined SWE as an undergraduate, is pursuing a Ph.D. with a focus on observational 21-cm cosmology. • The Schlumberger Foundation awarded Chemistry graduate student **Qing Ye** a prestigious Faculty for the Future Fellowship. As a fellow, Ye receives a grant of up to $50,000 per year to support her research into how atmospheric organic particulate matter derived from human activity can interact with organic particulate matter derived from natural emissions.

In Memoriam: Alumni Remembered for Pioneering Work in Chemistry, Mathematics

Stephanie Kwolek

Bachelor of Science, Chemistry, 1946

1923–2014

When Stephanie Kwolek arrived at the White House in 1996 to receive the National Medal of Technology, she was treated like a rock star by security guards and police officers. It should come as no surprise since Kwolek invented Kevlar®, the ultra-strong material found in bulletproof vests. In 1965, while working as a research chemist at the DuPont Company's Pioneering Research Laboratory, she discovered how to make aromatic polyamide molecules line up to form liquid crystalline polymer solutions of exceptional strength and stiffness. That discovery paved the way for Kwolek's invention of Kevlar®, a polymer that has hundreds of uses, including in fire-resistant fabrics, aircraft panels and boat hulls. Kwolek, who had an illustrious career at DuPont until her retirement in 1986, was inducted into the National Inventors Hall of Fame in 1994 and the Plastics Hall of Fame in 1997.

John F. Nash

Bachelor of Science & Master of Science, Mathematical Sciences, 1948

1928–2015

John Nash is widely known for his influential work in game theory, for which he received the 1994 Nobel Prize in Economic Sciences. But many mathematicians consider his research on geometry and partial differential equations to be his most important and deepest work. Shortly before his death, Nash received one of the most prestigious honors in math, the Norwegian Academy of Science and Letters' 2015 Abel Prize "for striking and seminal contributions to the theory of nonlinear partial differential equations and its application to geometric analysis." Nash was a senior research mathematician at Princeton University, a position he held since 1995. Nash was a member of the National Academy of Sciences and a fellow of the American Mathematical Society. His life was dramatized in the 2001 film "A Beautiful Mind."

Left: Stephanie Kwolek receiving her honorary degree in 2001.
Right: John Nash at CMU when he received his honorary degree in 1999.

CARNEGIE MELLON UNIVERSITY

faculty awards and honors

- Chemistry Professor **Catalina Achim** has been selected to the 2015–16 ELATE (Executive Leadership in Academic Technology and Engineering) Class of Fellows at Drexel University, a one-year, part-time professional development program for women in the academic STEM fields.
- Assistant Professor of Mathematical Sciences **Boris Bukh** received a 2015 Sloan Research Fellowship, which stimulates fundamental research by early-career scientists and scholars of outstanding promise.
- The Simons Foundation selected Mathematical Sciences Professor **Alan Frieze** as one of its 2015 Simons Fellows in Mathematics. The fellowship enables research that can lead to increased creativity and productivity in research.
- Assistant Professor of Mathematical Sciences **Po-Shen Loh** and Assistant Professor of Chemistry **Kevin Noonan** received NSF CAREER Awards. The Faculty Early Career Development (CAREER) Program provides the National Science Foundation's most prestigious awards in support of junior faculty who exemplify the role of teacher-scholars.
- Assistant Professor of Mathematical Sciences **Po-Shen Loh** led the United States to victory at the 56th International Mathematical Olympiad, the world championship mathematics competition for high school students. Loh is the national coach of the six-person team, whose last first-place finish was in 1994.
- **Krzysztof Matyjaszewski**, the J.C. Warner University Professor of Natural Sciences, won the 2015 Dreyfus Prize in the Chemical Sciences for excellence in "Making Molecules and Materials." The international prize awarded by the Camille and Henry Dreyfus Foundation is given every two years to recognize accomplishments in different areas of chemistry.
- The American Society for Microbiology presented Biology Professor **Aaron Mitchell** with their 2015 Graduate Microbiology Teaching Award, which honors exemplary teaching and mentoring of students.

New Faculty

From left: Benjamin Hunt and Stefanie Sydlik

Benjamin Hunt

Assistant Professor, Physics

Specialty: Experimentally investigates the fundamental properties of condensed phases of matter. Exposes composite 2-D materials to very low temperatures and very high magnetic fields, and then studies electrons' quantum behavior under such extreme conditions.

Education: Ph.D., Physics, Cornell University; postdoctoral research, Massachusetts Institute of Technology.

Stefanie Sydlik

Assistant Professor, Chemistry

Specialty: Focuses on the synthesis of novel polymers and materials via the principles of rational design, with expertise in electronic, mechanical, and biological materials.

Education: Ph.D., Organic Chemistry, Massachusetts Institute of Technology; postdoctoral research, Massachusetts Institute of Technology.

In Memoriam: Lincoln Wolfenstein

Emeritus Physics Professor Lincoln Wolfenstein, an internationally acclaimed theoretical particle physicist, particularly in the area of weak interactions and elementary particles, died on March 27. He was 92. Wolfenstein is most well known for his contributions to the understanding of neutrinos, particularly his 1978 article "Neutrino Oscillations in Matter," which proposed that oscillations of neutrinos in matter would be different from oscillations in a vacuum. Two Russian scientists applied this theory to the problem of missing solar neutrinos; this became known as the Mikheyev-Smirnov-Wolfenstein effect in particle physics. Elected to the National Academy of Sciences in 1978, Wolfenstein was the recipient of the Bruno Pontecorvo Prize in 2005 and the American Physical Society's J.J. Sakurai Prize for Theoretical Particle Physics in 1992. He was a faculty member at CMU for 52 years.

TIM KAULEN, NICOLE READING, TIM KAULEN, TIM KAULEN

Faculty Chairs

Shirley Ho presents Eric Cooper and Naomi Siegel with a spectroscopic plate from the Sloan Digital Sky Survey. Each hole in the plate corresponds to an astronomical object, like a quasar, galaxy or star. During the survey, the plate was attached to the Sloan Foundation Telescope, and optical fibers were fed through each hole, allowing researchers to collect valuable spectroscopic data.

Shirley Ho Awarded Cooper-Siegel Professorship

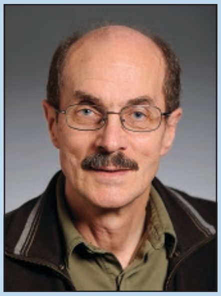
Astrophysicist Shirley Ho has been named the recipient of the Cooper-Siegel Professorship. Ho, an assistant professor of physics, is considered to be among the premier young researchers in astrophysics. She has devised methods for controlling systematic errors in data and analysis methodologies for large-scale astronomical surveys. She also conducts research aimed at understanding how dark energy accelerates the expansion of the universe. A member of CMU's McWilliams Center for Cosmology, Ho has received numerous honors, including the 2014 Macronix Prize, the Carnegie Science Award in the Emerging Female Scientist category, and the 2011 NASA Group Achievement Award. The professorship, established by CMU trustee Eric Cooper and his wife Naomi Weisberg Siegel, alternates between the Physics and Computer Science Departments at CMU and supports an early-career faculty member.

Neil M. Donahue Receives Thomas Lord Professorship in Chemistry

Neil Donahue

Neil Donahue, professor of chemistry, chemical engineering, and engineering and public policy and director of CMU's Steinbrenner Institute for Environmental Education and Research, has received the Thomas Lord Professorship in Chemistry. The professorship recognizes faculty whose work has a profound impact on the university, research and society. Donahue is an internationally recognized expert in atmospheric chemistry and air-quality engineering. His research focuses on the behavior of organic compounds in the atmosphere that adversely affect our health and impact our climate. He investigates a number of topics, including fundamental quantum chemistry and the way chemistry forms molecules that stick to particles in the air such as wood smoke and diesel emissions. He has published more than 150 peer-reviewed articles and is one of the most cited scientists in the field of geosciences.

Faculty, Students Named MCS Education and Research Award Winners

Susan Graul and Helmut Vogel

Julius Ashkin Teaching Award: Susan Graul

Recognizes unusual devotion and effectiveness in teaching undergraduate students

Nearly all chemistry majors pass through Associate Teaching Professor in Chemistry Susan Graul's back-to-back laboratory courses. By the end of those two semesters, students say that they really start to feel like chemists. Graul's students speak highly of her willingness to make herself available whenever they need help, and they rave about her clarity of communication and depth of knowledge. Graul's colleagues commend her for continually updating the course material to improve not only her courses but also her students' experiences in the courses.

Richard Moore Award: Helmut Vogel

Recognizes substantial and sustained contributions to the educational mission of MCS

Physics Professor Helmut Vogel is no stranger to teaching awards. Within his first six years at CMU, he won two—MCS's Julius Ashkin Award and the university's William H. and Frances S. Ryan Award for Meritorious Teaching—and his excellence in the classroom hasn't waned since. Throughout his 33-years with MCS, Vogel has taught nearly every semester and has made great efforts to establish new and better ways of teaching physics to majors and non-majors alike. He also has forged close bonds with his students, becoming more than a teacher—he is a mentor and a friend.

Hugh D. Young Graduate Teaching Award: Eric Wu

Recognizes effective teaching by graduate students

Eric Wu, a fourth-year Ph.D. candidate in the Department of Chemistry, is beyond his years when it comes to teaching, and his students have noticed. "I do not think I have ever seen so many students declare a TA to be 'perfect' or 'the best ever'," said Chemistry Teaching Professor Karen Stump. Wu's students say that he is awesome, fantastic, dedicated, knowledgeable, excellent, caring and has a superb ability to explain complex concepts.

David Menasche, Danielle Schlesinger and Eric Wu

Guy C. Berry Graduate Research Award: David Menasche

Recognizes excellence in research by MCS graduate students

Physics graduate student David Menasche focuses on mapping, at the microscopic level, how materials respond to stress. He uses near-field High Energy Diffraction Microscopy (HEDM) to map the internal structure of materials to pinpoint where failure and fracture begin. HEDM requires an X-ray source that is only available at Argonne National Laboratory's Advanced Photon Source. Menasche has become an expert at optimizing the X-ray beam optics, the detector and the data collection software.

Dr. J. Paul Fugassi and Linda E. Monteverde Award: Danielle Schlesinger

Presented to a graduating female senior with the greatest academic achievement and professional promise

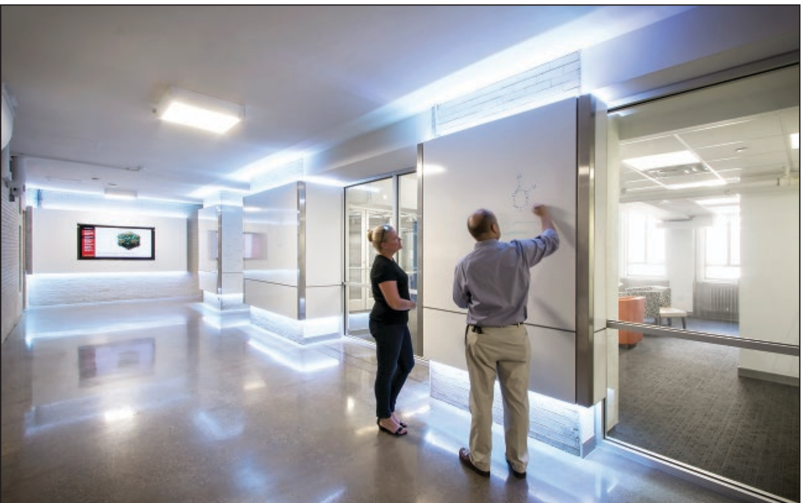
Danielle Schlesinger has distinguished herself as an interdisciplinary scholar, talented experimentalist and outstanding leader. The chemistry major carried out research in Biological Sciences Professor Jon Minden's lab that focused on visualizing proteome changes associated with the loss of the APC protein. She is the co-author of two publications related to her research. Schlesinger led the effort to build community within MCS by helping to start the MCS Mentor Program, create MCS Pride Day and revitalize the Dean's Student Advisory Council.

From left: Reinhard Schumacher, Tiziana Di Matteo, Colin Morningstar, Shelley Anna, Roy Briere and Michael Bockstaller

Physics Professors Named APS Fellows

Six Carnegie Mellon faculty members, including five affiliated with the Physics Department, have been elected fellows of the American Physical Society (APS). This represents the largest group of APS Fellows CMU has had in a single year. According to the APS, fellowship is a distinct honor signifying recognition by one's professional peers. The 2014 APS fellows from CMU are: Shelley L. Anna, professor of chemical engineering and mechanical engineering, and courtesy professor of physics; Michael R. Bockstaller, professor of materials science and engineering and courtesy professor of chemistry; and Physics Professors Roy Briere, Tiziana Di Matteo, Colin Morningstar, and Reinhard A. Schumacher.

NICOLE READING; COURTESY OF DEPARTMENT OF PHYSICS; NICOLE READING; TIM KAULEN



Renovations Revitalize Mellon Institute

Things are beginning to look different in the Mellon Institute. Visitors entering the building from the third floor entrances are now greeted by bright, open collaboration spaces—the result of the first phase of renovations to the 78-year-old building. The multi-phase revitalization project, led by Dean Fred Gilman, aims to transform the building into a facility that supports and reflects the exciting 21st-century science being done and taught in its labs and classrooms. Critical to this plan are comfortable, well-lit areas, like the lounge areas pictured here, where faculty and students from different labs and disciplines can meet to discuss new ideas. Dean Gilman and CMU's Campus Design & Facility Development department are currently working on plans for the second phase of the project, which will continue to enhance and improve collaborative spaces on the third floor and other areas of the building.

Top: A welcoming entrance greets visitors arriving from Bellefield Avenue.

Left, center: New spaces near the mail room facilitate informal interaction and collaborative work.

Left, bottom: A redesigned hallway brightens the loading dock entrance.

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Large Synoptic Survey Telescope First Stone Ceremony

This spring marked a major milestone for the Large Synoptic Survey Telescope (LSST), a telescope that will use a 3.1 billion-pixel camera to map the entire visible sky and create a new paradigm for ground-based astronomy. On April 14, dignitaries gathered at the project's site in Cerro Pachón, Chile for a First Stone Ceremony. Much like a groundbreaking, the ceremony is a Chilean tradition that marks the beginning of construction.

MCS Dean Fred Gilman (pictured above, center, with Steve Kahn, director of the LSST and Victor Krabbendam, LSST project manager) serves as both a member of the LSST Corporation's Executive Board and as chair of the Association of Universities for Research in Astronomy Council that is overseeing the LSST's construction. Carnegie Mellon is a member of the LSST Corporation, a consortium of universities, laboratories and research institutes. Faculty from the McWilliams Center for Cosmology have taken leadership roles in the project and are actively planning the science that will be done using LSST data.

Carnegie Mellon University