Absolute Value
From the chalkboard to the boardroom, mathematicians are in demand

Cellular Closeup
Imaging technologies to study living cells in real time

A Chemist’s Journey
Catalina Achim makes her way from Communist Romania to Carnegie Mellon

Navigating Your Genes to Health
Alumnus Dietrich Stephan makes it personal
Moving toward nano data storage

In the data storage industry, bigger isn’t better. To improve the process of creating bit-patterned media—a nanoscale way of storing data in increasingly tiny spaces—MCS physicists are leveraging their expertise in nanoparticle development.

GOAL: Transfer nanoparticle pattern to magnetic storage material

MCS physicists have developed a rigid, regular nanoscale pattern that has a density greater than 3 terabits per square inch, nearly four times the density of conventional data storage.

CHALLENGE: Keep pattern in place during etching process

Before etching the pattern into the silicon wafer, the surfactant coating the nanoparticles must first be removed because it blocks the substrate from being etched. But without surfactant, there is nothing to prevent the nanoparticles from clumping together.

SUCCESS: Created new pattern transfer and etching techniques to faithfully transfer pattern

Before removing the surfactant, an additional layer of SiO₂ was added to the surface of the nanoparticle array to stabilize it. The SiO₂ layer conformed to the nanoparticles and, through a series of steps, ended up being the substrate onto which the pattern became etched.

FUTURE PLANS: The next step is to use the etched SiO₂ layer to transfer the pattern to a magnetic material that is capable of data storage.

This research was carried out by physics graduate student and McWilliams Fellow Chip Hogg with advisors Sara Majetich, professor of physics, and Jim Bain, professor of electrical and computer engineering, and supported by the National Science Foundation and the Carnegie Mellon Data Storage Systems Center.
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Phage Hunters
First-year students use sophisticated research tools to unearth a virus’s secrets

Navigating Your Genes to Health
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Chemistry Student Mixes It Up
Paul Jasinto immerses himself in college life

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Letter from the Dean
Research Highlights
Inside MCS
Over the past year, much of the world has felt the impact of the economic downturn. While the class of 2009 faced one of worst job markets in years, MCS students have continued landing jobs despite the economy. Of note are a recent crop of young math alumni, featured in our cover story, who have taken the problem-solving mindset they developed as undergraduates and channeled it into successful careers at Microsoft, Lockheed Martin, Bank of America, and JPMorgan.

At MCS, we give our students a strong quantitative background that enables them to tackle problems far afield, making them very marketable to the top companies and the best graduate schools in the country. As soon as students arrive on campus, they begin learning how to think critically about open-ended scientific problems.

In the new Phage Genomics class, first year students from across MCS are truly engaged in the scientific process as they isolate, characterize and sequence the genomes of bacteriophages. In this course and many others, we teach our students how to come at scientific problems from fresh angles using innovative interdisciplinary approaches, which is a hallmark of an MCS education.

In this issue of Science Connection, you can read about these and many more examples—from advancing imaging technologies to working to make the promise of personalized medicine a reality—of how MCS students, faculty and alumni are thinking outside of the box to create innovations that truly make a difference.

With best wishes for the coming year,

Fred Gilman
Dean, Mellon College of Science
Buhl Professor of Theoretical Physics
Biological Sciences Professor Aaron Mitchell has identified a novel regulatory gene network that plays an important role in the spread of common, and sometimes deadly, yeast infections caused by *Candida albicans*. Mitchell and colleagues found that the zinc-responsive regulatory protein Zap1 prevents the production of soluble β-1,3 glucan, a sugar that is a major component of biofilm matrix. The biofilm matrix provides an environment in which yeast cells can thrive, promoting infection and drug resistance. Mitchell also identified other genes whose expression is controlled by Zap1 that encode for two types of enzymes, glucoamylases and alcohol dehydrogenases, which both govern the production and maturation of matrix components.

Understanding the mechanisms by which biofilms develop and grow will allow the researchers to develop therapeutic small molecules that will block biofilm formation and diagnostic tools that can detect biofilms before infections spread.

ZAPping Infection

In the nanoworld, size really does matter. For some applications, the smaller the nanoparticle, the better. Chemist Rongchao Jin has developed gold nanoparticles that are a mere 1 nanometer in size. The tiny nanoparticles are comprised of only 25 gold atoms, but they are imbued with unique electronic and magnetic properties. Even though they are made of gold atoms, and a nugget of gold isn’t magnetic nor does it have a discrete electronic structure, the nanoparticles’ infinitesimally small size yields new properties.

During synthesis of the ultra-small clusters of gold atoms, Jin and coworkers used elegant chemical methods to precisely control the number of atoms in each nanoparticle, something that nanochemists have dreamed of doing. Wielding this level of control is necessary for producing nanoparticles of uniform size and shape so that their distinct properties can be investigated. Jin’s well-defined nanoparticles are comprised of 25 gold atoms and 18 thiolate protecting ligands, which are necessary to cushion the nanoparticles and prevent them from clumping together in solution. He characterized the particles using mass spectrometry, verified their composition using thermogravimetric analysis and determined their structure by X-ray diffraction.

With the gold nanoparticles’ structure in hand, Jin continued his investigation into the particles’ properties. He and his colleagues discovered that the gold nanoparticles have unique electronic and magnetic properties that Jin plans to take advantage of. He’s laying the groundwork to collaborate with engineers in Carnegie Mellon’s Data Storage Systems Center to explore the utility of using the gold nanoparticles to fabricate high-density magnetic data storage devices. Jin is also taking advantage of the nanoparticles’ unique electronic properties by exploring their use as part of a nanoarray chemical sensor and as highly selective catalysts for industrially important oxidation and hydrogenation processes. In the meantime, Jin and his coworkers still spend plenty of time in the chemistry lab, synthesizing new batches of gold nanoparticles with 20, 38 and 144 gold atoms. Stay tuned for what novel properties these newest nanoparticles might possess.

Gold Nanoclusters — One Nanometer, New Properties

(A) Crystal structure of 25 gold atom nanoparticles protected by 18 phenylethylthiolate ligands (Au25 core diameter: 1 nm), (B) and (C) show the anatomy of the structure.
Neuroscientist Alison Barth has identified a new anticonvulsant compound that has the potential to stop the development of epilepsy. The research discovery builds on her previous work identifying a potassium channel known as the BK channel whose increased activity is associated with seizure disorders. Using an experimental model for epilepsy, Barth blocked the BK channel using the drug paxilline. After a first seizure, paxilline was effective at completely blocking subsequent seizures. Understanding how BK channels work in seizure disorders and being able to target them with a simple treatment represents a significant advance in the ability to understand and treat epilepsy.

Physicists Tom Ferguson and Helmut Vogel spent the summer at the CERN Laboratory near Geneva, Switzerland, conducting tests to be sure that the Compact Muon Solenoid (CMS) particle detector was operating smoothly in preparation for the Large Hadron Collider (LHC) restart this fall. Instead of detecting proton-proton collisions, which the detector will do when the LHC is up and running, the CMS team — including a Physics postdoc and two graduate students — did a test run detecting cosmic rays, which rain down on the Earth every second. They took advantage of the ubiquitous cosmic rays to check the CMS detector’s readout and to conduct a precision alignment of the detector. While the CMS team was on-site at CERN, MCS physicists Jim Russ and Manfred Paulini, along with three postdocs and a graduate student, monitored the quality of the CERN data from the CMS “mirror site” at Fermilab near Chicago.

Silicon’s Liquid-Liquid Phase Transition

It’s a curious situation, at least scientifically—ice floating on water, solid silicon floating on liquid silicon. In most materials, their solid states are denser than their liquid states, which causes the solids to sink. The unusual volume expansion of frozen water and silicon that causes them to float is probably connected to the existence of a liquid-liquid phase transition, where at a certain temperature two different states of liquid exist, each with their own characteristics. Although computer simulations initially predicted the existence of two liquid silicon phases, further simulations and experiments failed to produce the necessary evidence to prove their presence, until now. Using rigorous first-principles calculations based on quantum mechanics, Physics Professor Michael Widom and former graduate student Panchapakesan Ganesh (S’07) have, for the first time, proved the existence of this liquid-liquid transition in silicon. First-principle calculations start with established laws of physics, and make no assumptions or approximations, leaving little room for question. Such calculations provide the most accurate predictions for the structural properties at high pressures and temperature, since conducting actual experiments in these conditions is near impossible. The computations revealed that a liquid-to-liquid phase shift, evidenced by the presence of a van der Waals loop, occurred when silicon was supercooled to 1200 degrees Kelvin; silicon normally freezes at 1700 degrees Kelvin. A van der Waals loop occurs when pressure grows as volume increases, marking a thermodynamically unstable situation. The unstable condition is resolved by transforming into two coexisting states of differing densities—in this case two distinct forms of liquid silicon, each having its own unique and dissimilar properties. One was high density and highly coordinated with metallic properties, much like normal liquid silicon, and the other was low density, low-coordinated and semimetallic, with a structure closer to that of solid silicon.


Healing Broken Bones

Broken bones usually heal on their own. But there are many cases when patients’ fractures fail to heal. MCS scientists, including Newell Washburn, Krzysztof Matyjaszewski and Jeffrey Hollinger, have developed hyaluronic hydrogels that may help the healing process. The hyaluronic hydrogels are synthetic alternatives to demineralized bone matrix, which physicians currently use to encourage damaged bone tissue to heal. Demineralized bone matrix, a biological material obtained from cadavers, is rich in growth factor proteins that signal bone cells to multiply and form complex bone tissue, while other proteins in the matrix regulate the activity of the growth factors. Demineralized bone matrix is in limited supply, however, and because it comes from a human donor, there is a risk of transmitting viruses to the recipient.

Members of the Washburn lab, including Sidi Bencherif (S’09), a graduate student in the Washburn and Matyjaszewski groups, have been developing hydrogels as alternatives to demineralized bone matrix. Hydrogels, which are considered to be the state-of-the-art in tissue design, are made from polymers that swell in water to form a gel-like material. They interact with growth factors much like demineralized bone matrix does, providing scaffolding for bone cells to proliferate and form new tissue. The researchers have created a flexible hydrogel using biologically active and degradable hyaluronic acid, an important component of cartilage and skin. They found that, in vitro, the hydrogels promoted cell proliferation, differentiation and mineralization of pre-osteoblast cells, cells that aid the growth and development of bone.

RDCs Reveal Natural Products Structure

The plant wasn’t giving up its secrets. The *Jaborosa parviflora* plant contains natural compounds known as withanolides that have a variety of medicinal properties, but researchers studying the plant couldn’t determine the molecules’ 3D chemical structures using conventional NMR techniques. They turned to chemist Roberto Gil who has been developing an NMR methodology to measure a relatively new NMR parameter known as Residual Dipolar Couplings (RDCs) in small organic molecules. Using RDCs, Gil was able to unambiguously determine the structure of the small molecule jaborosalactol 24, a withanolide found in the *Jaborosa parviflora* plant. Now, with the structure in hand, the researchers are investigating the small molecule’s function. They’ve already discovered that it slows the growth of breast cancer cells and therefore may have potential as an anti-cancer agent.

- Pittsburgh Supercomputing Center scientist Marcella Madrid, chemist Maria Kurnikova and colleagues conducted a series of large-scale computer simulations of HIV-1 reverse transcriptase (RT), the multi-functional protein that replicates HIV’s genetic material and plays a critical role in HIV’s ability to replicate and infect new cells. The scientists simulated RT with and without DNA, simulations that involved 123,000 atoms. Notably, they extended the simulation for 40 nanoseconds of biological time, much longer than any previous similar work. The simulation revealed that the DNA “twists and slides,” which may facilitate its positioning at RT’s active site. Interfering with this motion could disrupt RT’s function, thus preventing HIV from replicating.
- With the help of several TeraGrid computational resources, including the supercomputer Big Ben at the Pittsburgh Supercomputing Center, physicist Colin Morningstar and his colleagues in the Hadron Spectrum Collaboration team used a sophisticated, computationally demanding approach called lattice QCD to calculate — for the first time — an excited-state spectrum of hadrons. Lattice QCD is essential as a means to reconcile theory with experimental observations and extract insights into the physics of hadrons, particles made from quarks and held together by the strong force. These findings will help to guide large-scale accelerator experiments, especially at the Thomas Jefferson National Accelerator Facility in Virginia.
For years the groans of math students have echoed off academic walls far and wide: ‘When am I EVER going to use this stuff??’ But a ranking of the 200 best and worst jobs in the country reveals that using that stuff may be just what the doctor, or teacher, orders for a successful career. It turns out that mathematicians—those theorem-proving denizens of the derivative—have the best job in the country.

From CNBC and NPR to the Wall Street Journal, everyone has been talking about what makes mathematicians stand out above other occupations. And it’s not just the pleasant, autonomous, low stress work environment. Mathematicians earn excellent salaries and the job outlook is very promising—they’re in demand in industries ranging from software giants and global marketing firms to banks and government entities like the Food and Drug Administration.

That high demand is good news for Carnegie Mellon’s math majors. While recent graduates are facing one of the toughest job markets in memory, MCS math grads are easily finding jobs, some of them with starting salaries topping most anything seen in the recent past.

“Industry recruiters are looking for people with good quantitative skills, and mathematicians are hard-wired to be problem-solvers,” said Renée Starek, assistant director of Carnegie Mellon’s Career Center. “Our math majors have what these companies are looking for. They can pursue any career that they want.”

So what makes a mathematician so versatile? Zalenda Cyrille, who graduated from Carnegie Mellon in 2001 with a degree in math, says it’s the “analytical, problem-solving mind” that a math major develops from his or her education.

And there are problems aplenty in both industry and academia that can benefit from a mathematician’s acumen. Take Cyrille, for example. As an undergraduate she interned at the National Security Agency, where she learned the basics of cryptography and worked on real-world national security problems. Now, she’s
an associate engineering manager at Lockheed Martin, where she directs teams of engineers that work on special projects for the defense contractor.

Cyrille’s career is a far cry from the stuffy academic image most people have of mathematicians—an outdated stereotype dating back to days of pocket protectors and horn-rimmed glasses. These days you can find math “nerds” leading teams of engineers, like Cyrille does, or helping Las Vegas’s top casinos decide how to invest their money. “The most common question I get from students is, ‘What can I do with a math degree?’ ” Starek said. “My answer: ‘Anything!’ ”

After her internship with the National Security Agency, Cyrille had recruiters from companies like Lockheed Martin and Raytheon pounding on her door. She went with the offer from Lockheed Martin, which, she says, gave her a blank slate to plan her future. “It was basically, ‘What do you want to do?’ ” she said.

Lockheed gave Cyrille the opportunity to join a rotational program that allowed her to try out different jobs, which she did before working her way up to a management position. They also helped her earn her master’s degree in systems engineering from Virginia Tech.

It’s a Mathematical World

“At our core is the desire to know numbers, to dig down to the essence of a problem to find out what makes it tick,” said John Mackey, associate department head for Mathematical Sciences. “Is there a discipline out there that doesn’t need someone to analyze at such a deep level?”

In the aerospace industry, mathematicians model airflow over airplane bodies and develop tools for inventory control for airplane parts in the factory. In the biological sciences, mathematicians use differential equations to determine how cells move and to create models that describe the dynamics of the immune system, human immunodeficiency virus (HIV), and various drug combinations. For mathematicians, in a world that is becoming more quantitative and more mathematical, the possibilities are endless.

Mark Fields, a 2008 Carnegie Mellon math grad, took the problem-solving skills he developed from his undergraduate education and turned them into a full-time position at Microsoft. Fields, who considered applying to graduate schools before beginning his job search, says that the training he acquired as an undergraduate prepared him for his career in ways that might not have been obvious at first.

“The process of debugging a program is not too different from the process of going through and checking to see if you wrote a proof properly,” Fields said. “You can have a bug in a proof just like you can have a bug in a program.”

A fair number of recent Carnegie Mellon math grads are also applying their skills where you might least expect them these days—the moneyed halls of high finance. While it seems like the opposite should be true, jobs in finance are still there, waiting for trained mathematicians to fill them.
Eileen Tucker, a 2009 Carnegie Mellon grad with degrees in mathematical sciences and statistics, works for JPMorgan, but she didn't have the smoothest ride getting there. After her sophomore year, Tucker completed a 10-week internship with Bear Stearns that culminated in an internship offer for the summer after her junior year (2008). When the company collapsed and was sold to JPMorgan, JPMorgan not only honored the original internship offer but also offered Tucker a full-time job in its Financial Analytics of Structured Transactions (FAST) division.

As an intern, Tucker worked with the FAST group, which does all of the analytics for the company's fixed income products. Now that she's an analyst for the group, Tucker develops different models at various default and interest rates, follows them over different yields, and relays the model's predictions to traders who use the information to make decisions. A good portion of Tucker's fellow interns were business majors, but Tucker's background in math and statistics set her apart.

"It was particularly advantageous to have a less conventional background doing an internship in finance," said Tucker. "The math degree just seems to be very versatile. You can apply math to pretty much anything; it's more a way of thought than necessarily a trade skill."

Tamara Friedlander is another math graduate who turned her degree into a job in finance. After graduating in 2007 with degrees in mathematical sciences and statistics, she landed a job with Bank of America's Quantitative Management Associate Program (QMAP), which prepares individuals with exceptional quantitative and interpersonal skills for careers as quantitative management professionals. Her current job is to develop reporting and analytics that deal with overdrafts for corporate and commercial clients. Given the current economic situation, there has been an increased focus on all areas of risk, including overdrafts, explains Friedlander.

"Allowing a client to overdraft is in essence extending unsecured credit, so it is important to understand this behavior in terms of what drives the overdrafts, how quickly clients pay us back, if systemic overdrafts are reflective of something else, etc.," she said.

Friedlander is part of a group that is answering these types of questions through data analytics and by developing meaningful reporting and metrics to better understand and manage this risk.

She says the problems she analyzes at Bank of America require the same core skills she learned at school. And despite the trouble in the financial industry, those talents remain in high demand at Bank of America.

"I've noticed at the bank that they really do value this skill set," said Friedlander, whose program hasn't reduced its targets in terms of recruiting.

It's not just the banks that are on the lookout for math students. Starek, who provides career and professional development advising to students in the college's math department, says she doesn't foresee a waning demand for our students.

"In the past three years, despite the economy, there has been no difference in the rate of math students accepting employment offers or going on to graduate school, which indicates that the jobs are still there and that our students are in high demand," Starek said.

In a world that's becoming more mathematical, where a math education can springboard its students into more fields than even their own models could predict, the answer for teachers confronted with the "What will I ever do with this stuff?" question is simple. Whatever you want.
Cellular Closeup

Imaging Technologies to Study Living Cells in Real Time

Trying to find one cell out of trillions in the human body or one tiny protein among the thousands inside a single cell is much like trying to pick out one star in a night sky full of billions. While astronomers build larger and larger telescopes to look deeper into space to distinguish that one celestial body of interest, scientists at the Mellon College of Science are developing smaller and smaller molecular technologies to peer more closely into living things, visualizing biological processes with greater precision and clarity than ever before.

Above: Fluorescence confocal microscope image of the actin cytoskeleton in a living HeLa cell visualized with intracellularly expressed Fluorogen Activating Protein and fluorogenic dye Malachite Green-Ester.
Finding a protein needle in a cellular haystack

As scientists decode the human genome, they are gaining a better understanding of the structure of individual proteins that control the health of cells and the normal behavior of cell division. What scientists don’t know in detail is how all of the proteins interact with each other in real time in the 3D space of the cell. Uncovering these interactions could reveal how normal cells function and how things go awry in diseases like cancer and Alzheimer’s. Scientists at the Molecular Biosensor and Imaging Center (MBIC) are creating tools to do just that.

“We’re developing a powerful toolbox of intracellular fluorescent probes that will enable us to find out when a protein is being made, when it is being degraded and when it is interacting with another target protein in living cells, getting us closer to fully understanding cell networks and how they function in health and disease,” explains Alan Waggoner, professor of biological sciences and director of MBIC, a National Institutes of Health Technology Center for Networks and Pathways.

The MBIC team has created fluorogen activating proteins (FAPs), probes that emit fluorescent light only when bound to a fluorogen, an otherwise non-fluorescent dye added to the cell by scientists. This is a step away from traditional fluorescent proteins, like green fluorescent protein (GFP), that are always aglow once expressed in cells. With the novel FAPs and associated fluorogens, the MBIC team can control when the protein lights up, a feature that is key to overcoming the difficulties inherent in pinpointing multiple, closely associated proteins inside living cells.

“Molecules that are close together in a living cell can’t be discriminated,” explains Marcel Bruchez, associate research professor of chemistry and program manager of MBIC’s Technology Center for Networks and Pathways. “That’s just the physics of the diffraction of light.”

Imagine trying to spot five proteins that are located in the same area of the cell. If each protein were labeled with GFP, the fluorescent signals from each protein would blend together, so that all you would see through the microscope is a giant green blur. If you labeled each protein with a differently colored fluorescent probe, you would improve your ability to resolve these molecules, but there aren’t enough colors available to distinctly label all of the different proteins in a cell. However, if you labeled each of the five proteins with a FAP, you could “turn on” the fluorescence of the proteins one at a time—avoiding fluorescent interference from nearby proteins—to see exactly where in the cell each protein is located. This is possible because the two components—FAP and fluorogen—must combine to give off a signal.
Fluorescent confocal microscope images of a living NIH 3T3 cell tagged internally with GFP (left panels) and externally with a protease biosensor developed by Peter Berget (right panels). At the start of the experiment (0 minutes), the cell is bathed in the fluorogenic dye malachite green. The dye does not emit a fluorescent signal until the protease is present (14 minutes).

“This is a very powerful method because it generates single molecule information that you can use to build a picture of the structure of the biological process or object at which you’re looking,” said Bruchez. “This new approach has the potential to do multi-color super-resolution imaging with a substantially reduced experimental complexity.”

The new FAP technology has already provided a substantial improvement in resolution, according to Bruchez. Using the FAPs, the MBIC researchers have been able to image proteins with a 1–2 nanometer accuracy. With GFP, the accuracy is approximately 20 nanometers. The beauty of MBIC’s new technology comes down to some elegant organic chemistry and molecular biology. They have created FAPs that have the properties of organic dyes, like high brightness and photostability, but that also can be genetically expressed in a cell along with a protein of interest, giving FAPs a clear advantage over current fluorescent technologies, which offer either high brightness or genetic control, but not both.

MBIC scientists are exploiting the unique properties of the FAPs to help cell biologists tackle research questions that cannot be answered using current technologies. Raymond Frizzell, professor and chair of the Department of Cell Biology and Physiology at the University of Pittsburgh, has been studying the anion channel CFTR, which spans the membrane of cells found in tissues that produce mucus. A mutation in the gene causes cystic fibrosis. Frizzell wants to know how the miscreant CFTR protein migrates to the cell surface in diseased cells compared to the normal protein in healthy cells, something that’s not possible to monitor with current technologies. The new FAP technology is already making headway in resolving this problem.

MBIC is also teaming with Diane Lidke, assistant professor in the Department of Pathology, University of New Mexico School of Medicine, to study aspects of immunity and inflammation. Consider an allergic reaction or an asthma attack. The activation of the inflammatory response happens very fast, and scientists want to know precisely how immune cells mount a defense so quickly in response to signals from their environment. Specifically, Lidke and the MBIC team are investigating Fc-epsilon receptors, which are found on certain types of white blood cells that play a major role in controlling allergic responses and promoting inflammation. They are looking at the receptor and its very early partners at the cell surface. FAPs could reveal these early events in the signaling cascade, providing new therapeutic targets that could prevent the onset of an asthma attack.

The nature of the FAPs also makes them ideal for use as biosensors, which are tools that can “sense” when a certain cellular activity, such as protein degradation, is taking place. Peter Berget, associate professor of biological sciences and a member of MBIC, has designed a FAP biosensor that responds to proteases, enzymes that cut apart proteins. Cells contain hundreds of different proteases that play important roles in everything from cancer cell metastasis to wound healing. Berget has developed a way to molecularly engineer FAPs so that they only become fluorescent when they are “cut” by a specific protease, giving off light only when the target protease is present.
Tracking cell therapies using MRI

Just as cell biologists strive to track protein interactions inside cells, scientists are also attempting to track the travels of individual cells among the 100 trillion cells in the human body. While spotting one individual cell might seem impossible, doing so could advance diagnostic tools and cell-based therapies, including stem cell therapies and cancer vaccines.

“We now have the ability to visualize non-invasively and with sensitivity individual cells and their movement to targeted sites,” said Chien Ho, professor of biological sciences and director of the Pittsburgh NMR Center for Biomedical Research, which has been funded continuously by the National Institutes of Health since 1988. “Our new approach offers almost unlimited potential for tracking cellular and developmental processes and for monitoring cell therapies.”

According to Eric Ahrens, associate professor of biological sciences and a member of the NMR Center, many cell therapy-based clinical trials are on hold until researchers adopt a method for evaluating where the therapeutic cells go once they are administered to a patient. A new MRI technology conceived of and developed by Ahrens surmounts this obstacle by allowing researchers to safely and easily monitor the migration of such cells using MRI. Ahrens and colleagues from the University of Pittsburgh Cancer Institute are working toward using his MRI technology to monitor the migration of a cellular immunotherapy in patients with colorectal cancer. The therapy, called a dendritic cell vaccine, involves a scientist taking cells from the patient’s own body, modifying the cells to produce a tumor antigen that fights cancer cells, and reinjecting them into the patient. Ideally, the cells migrate to the lymph nodes, activating an immune response. Until now, there has been no way to know if the vaccine had reached its target unless the patient began to show improvement. Ahrens’s technique provides visual evidence that the cells have gotten to where they need to be, a requirement for FDA approval of such technologies.

Ahrens’s method involves labeling dendritic cells with a colloidal suspension of tiny fluorocarbon droplets called a perfluoropolyether (PFPE) nanoemulsion. Then, when the labeled dendritic cells are administered to the patient, they can be tracked using 19F MRI. Unlike conventional MRI, which detects the nuclear magnetic resonance signal from protons contained in the mobile water in tissue, 19F MRI detects the signal from the nucleus of the fluorine atom. Fluorine is not normally present in the body at sufficient concentrations to detect, so the PFPE-labeled cells stand out in an MRI image, making it easy to see where the vaccine has traveled.

“Dendritic cells are also being investigated for treating other types of cancers like melanoma and prostate cancer,” said Ahrens. “We’re hopeful that we can use our technology for other types of cancers in the future.”

Imaging immune responses

Dendritic cells aren’t the only immune cells NMR Center scientists are tracking by MRI. Ho and his colleagues are using MRI to track macrophages as they infiltrate a transplanted heart in the early stages of organ rejection. The real-time tracking method can pinpoint exactly when and where rejection is taking place, and it’s all done non-invasively.

Physicians typically monitor patients for organ rejection following a heart transplant by performing frequent heart biopsies, invasive procedures that involve snipping out several tiny pieces of heart tissue to look for signs of rejection. But these procedures are problematic because they only sample small areas, possibly missing the first signs of rejection. Using MRI, Ho can scan the entire heart for the presence of macrophages, immune cells that recognize the transplanted heart as foreign and set in motion an immune response that could lead to graft loss and patient death.
“Successful translation of this work to the clinic ultimately will reduce the number of biopsy procedures and should greatly improve the quality of life for cardiac transplant patients,” said Ho. “Perhaps most importantly, this advance will allow doctors to tailor the dose of immunosuppressant drugs, providing highly personalized care.”

Ho’s method involves tagging macrophages with micrometer (MPIO)-sized paramagnetic iron oxide particles, which are very sensitive to the magnetic fields used during MRI. Because a macrophage’s job is to engulf foreign materials inside the body, such as bacteria, they will also engulf MPIO particles, rendering the macrophages magnetic. After injecting MPIO particles into rats that had received heart transplants three days earlier, the researchers used MRI to track macrophages that incorporated the particles. They spotted them in transplanted hearts. The locations of the tagged macrophages are highly defined on the MRI scan, indicating that the new tracking method is very good at pinpointing where rejection is taking place.

Recently, Ho and his colleagues have applied the same technique to cases of traumatic brain injury. The inflammatory process that occurs after a traumatic brain injury can be both helpful and hurtful, repairing injured tissue but releasing neurotoxic substances that cause additional brain damage. Using their method for tagging macrophages, the scientists tracked the cells as they infiltrated the brain after injury. Because macrophages may play a pivotal role at the interface between early detrimental and delayed beneficial effects of inflammation, understanding macrophages’ role in the inflammation process could be essential to developing effective therapies for the treatment of traumatic brain injury, according to Ho.

MCS scientists continue to push the boundaries of microscopy and MRI technology, developing state of the art imaging technologies to elucidate mechanisms underlying disease processes and to track—in real time—cellular behavior in health and disease.

These advances have the potential to unlock the mysteries of the human body, much as astronomers created bigger and better telescopes to unlock the secrets of the night sky.
When parents send their children off to college, they probably don’t expect them to be playing in the dirt during the first week of classes. But that’s just what students in the Phage Genomics Research course did as they hunted for bacteriophages, viruses that infect bacteria. Bacteriophages—or phages, for short—can be found naturally anywhere bacteria live, including water and soil, so the students collected soil samples from across campus and brought them back to the lab to isolate the phages contained in the soil. The next step was to mix the suspected phage with its bacterial host *Mycobacterium smegmatis*, a common non-pathogenic soil organism, and wait for signs of infection. Once each student identified an infected bacterium and isolated the phage from within, they spent the next several months characterizing the phage’s structure by electron microscopy, cloning and sequencing its DNA, and using computational methods to analyze its genome. Most importantly, the students experienced the process of doing real science.

“The whole point of the course is for them to learn how science works, how the process of investigation works,” said Javier Lopez, associate professor of biological sciences, who taught the course with Associate Professor Jonathan Jarvik and lecturer Kathryn Sheldon.

This is exactly what the Howard Hughes Medical Institute’s Science Education Alliance had in mind when it developed The Phage Genomics Research Initiative. Carnegie Mellon was one of twelve schools chosen to participate in the program during its inaugural year. Turi Alcoser, who chose to attend Carnegie Mellon because of the Phage Genomics Research course, wasn’t disappointed.

“As opposed to other colleges where I would only be taking intro courses, here I got to do real research,” he said. “I feel like I’m really learning in this class. I’m using my head and putting it all together.”
Take a closer look
at the students’ experimental and bioinformatic analyses of their phage.

Since the course centers around a real research problem that has no established answer—a far cry from cookbook-style experiments where the answers are already known—students were required to use their heads every day.

“We would ask our professors questions, and they wouldn’t know the answers. So we would do an experiment to figure it out,” said Cohen. (See above for the questions they asked and the experiments they conducted to find out the answers.)

According to Tuajuanda Jordan, director of HHMI’s Science Education Alliance, students in the Phage Genomics class “will truly be contributing to the scientific knowledge about this phage, more and more questions will arise in their minds, and hopefully it will capture their scientific curiosity enough that they will want to pursue research as soon as they leave this class.”

This was certainly the case for Carnegie Mellon’s phage hunters. They were clamoring to come to the lab outside of class hours to check out their bacterial plates, to see how their experiment was coming along, and to anxiously look for results. And their appetite for research didn’t stop when the Phage Genomics course ended. Many of the students have conducted summer research and joined faculty labs this fall.

“I feel much more confident because of this class,” said Alcoser, whose newfound confidence and skill in the lab came in handy this summer as he conducted research at the Summer Research Institute at Carnegie Mellon.

And because there is still much to learn about their phage, some of the students are continuing as TAs for the Phage Genomics course. And Lopez will be at the lab bench with them.

“I love the course for the same reasons that the students love it—you’re actually doing real research, finding new things and experiencing the thrill of discovery.”

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**Process Flow:**

- **Island-3** is 99% identical to the Brujita phage.
- Brujita and Island-3's predicted integration site did not have a matching site in *M. smegmatis* genome.
- Island-3 is actually lysogenize *M. smegmatis*.
- Can Island-3 actually lysogenize *M. smegmatis*?
- Yes! All three lysogenize and confer immunity to superinfection.
- Out of time! Semester is over, but a few students will continue the investigation as TAs to mentor the new class of phage hunters.
- Conducted PCR experiments to look for phage DNA inside bacterial host.
- Found circular DNA inside the bacteria.
- Found Che9c integrates as predicted but no evidence of integration by Island-3.
- As expected, Che9c had matching integration site in the bacterial genome.
- Building upon preliminary results from the Joint Genomics Institute, finished sequencing Island-3’s genome.
- Entered Island-3’s sequence into Genbank* to compare it to all other phage genomes.
- Conducted a comparative analysis of the genomes of the three phages in the Group I Mycobacteriophage family—Island-3, Brujita and Che9c.
- Searched bacterial host *Mycobacterium smegmatis* genome for corresponding integration site using the data in GenBank.
- Conducted comparative analysis of the genomes of the three phages in the Group I Mycobacteriophage family—Island-3, Brujita and Che9c.
- Conducted PCR experiments to look for phage DNA inside bacterial host.
- Found circular DNA inside the bacteria.
- Found Che9c integrates as predicted but no evidence of integration by Island-3.
- As expected, Che9c had matching integration site in the bacterial genome.
- Tested lysogenization of *M. smegmatis* by Island-3, Brujita and Che9c.
Navigating Your Genes to Health

Alumnus Dietrich Stephan makes it personal

by Jennifer Bails

Dietrich Stephan (S’91) is not afraid to dream big—although realizing his grandest vision is going to mean searching for answers at the smallest imaginable level.

The human geneticist and biotech entrepreneur has spent the last 15 years at the forefront of the genomics revolution, working to unravel the root causes of common illnesses such as cancer and Alzheimer’s disease to develop better diagnostics and therapies.

His scientific journey began as a young child growing up in Pittsburgh, when he lost his mother to breast cancer in her early thirties.

“The physician saw a lump and told her to come back the next year, but by that time, the cancer had metastasized throughout her body,” Stephan recalls. “Her death seemed like such a waste, and it put me on this track of trying to figure out how to diagnose diseases early so you can treat them more effectively.”

After completing his undergraduate degree in the Department of Biological Sciences at Carnegie Mellon, Stephan earned his Ph.D. in human molecular genetics at the University of Pittsburgh and then held faculty appointments at Johns Hopkins University and the National Human Genome Research Institute.

He credits his studies at Carnegie Mellon with giving him a strong foundation in the biological sciences, complemented with rigorous, multidisciplinary studies in computer science, mathematics and physics. “At the time I didn’t see the applied benefits of everything I was learning,” he says. “But it definitely gave me the nuts and bolts to get into the career I’m in now.”

In 2002, Stephan helped launch the Translational Genomics Research Institute—known as TGen—in Phoenix with the goal of translating advances in molecular biology into smarter, better medical care. The nonprofit research center seeks to bridge the gap between genomic discoveries made at the lab bench and the clinical applications of those findings that can take years to reach the patient bedside.
“I went out into the desert to start this big genome institute that would shorten that time window,” Stephan says. “It’s a mission that really resonated with me because of my family history.”

During a sabbatical from TGGen, Stephan set his sights on Silicon Valley, where he co-founded Navigenics Inc., which provides personal genetic testing services directly to consumers. The company analyzes DNA extracted from saliva for risk markers that may predispose to dozens of health conditions such as breast and colon cancer, obesity and type 2 diabetes—and then advises patients on how to take steps toward prevention.

“We are really making use of the information from the Human Genome Project to improve health,” says Stephan, Navigenics’s chief science officer. “It was also immensely valuable for me as an academic scientist to learn how things work on the commercial side of the fence.”

At TGGen, Stephan learned how to move genomic-based disease research into the clinic as rapidly as possible. At Navigenics, he helped develop the tools needed to do individual genetic testing and deliver the results in a private and secure way.

Now Stephan hopes to combine this experience in his most visionary project yet—and make the promise of personalized medicine a reality.

This fall he aims to break ground on a $250 million research institute outside Washington, D.C. focused on how to tailor medical care to an individual’s DNA. Nearly 500 scientists at the Ignite Institute for Individualized Health will probe the molecular underpinnings of disease, in the process discovering new drugs, devices and diagnostic tests that can be customized for a patient’s unique genetic profile.

By screening for genetic predisposition to disease and managing that risk earlier in life, he believes it will be possible to keep people healthy longer, thereby achieving cost savings that could in turn be used to insure more people. In other words, using genomic tools for the prevention and early detection of disease in individuals could drive efficiency into the nation’s entire health-care system, according to Stephan, who anticipates the nonprofit center will be fully operational within five years.

“The whole goal here is to make a really big impact on chronic disease on a population-wide level and bring about healthcare reform by changing the medical paradigm from reactive and generalized to proactive and personalized,” he says.

It’s an ambitious dream, but Stephan feels he owes it to the memory of his mother—and to the millions of other families suffering from preventable losses—to make it come true.

“The whole goal here is to make a really big impact on chronic disease on a population-wide level and bring about healthcare reform by changing the medical paradigm from reactive and generalized to proactive and personalized.”

Dietrich Stephan

alumni briefs

- Kristine Ferrone (S’04) was selected as a crew member for the Flashline Mars Arctic Research Station (FMARS) 2009 mission in July. The FMARS is a habitation module in the Arctic run by the Mars Society, a non-profit organization promoting human exploration of Mars. Ferrone conducted an experiment to test the effectiveness of a new laser therapy for treatment of stress injuries, sore muscles, and bruises in the isolated space environment.

- Paul A. Medwick (S’88) and two of his PPG colleagues were awarded a Carnegie Science Award in May 2008 in the Advanced Manufacturing category for development of Solarban® 70XL glass — the first-ever “triple-silver” solar-control/low-emissivity coated glass. Medwick is a Senior Research Associate at PPG Industries’ Glass Business and Innovation Center in Pittsburgh.

- Jeffrey Pyun (S’02) received a 2009 Sloan Research Fellowship Award. The two-year, $50,000 fellowship will allow Pyun, an assistant professor of chemistry at the University of Arizona, to expand his research on the preparation of magnetic nanocomposite materials and the mesoscale assembly of nanoparticles into hierarchically ordered structures.

- Stefanie Sydlik (S ’07) was named to the 2009 U.S. National Rowing Team and represented the United States at the 2009 World Rowing Championships in Poznan, Poland. Sydlik won a bronze medal as a member of the Lightweight Women’s Quadruple Sculls crew.
Chemistry Student Mixes It Up

In September, Bill Gates presented the keynote address at dedication ceremonies for Carnegie Mellon’s Gates Center for Computer Science and the Hillman Center for Future-Generation Technologies. As a Gates Millennium Scholar, Paul Jasinto had the chance to meet the man who helped make his education possible—and his dreams come true.

Even as a small child, Paul Jasinto wanted to be a scientist. At times, he wavered between astronomer, archaeologist and physicist. But once he found chemistry, he was hooked. Now, thanks to the Gates Millennium Scholars Program, Jasinto can pursue that dream without worrying about how he’ll finance the education he so desperately wanted.

Funded by a grant from the Bill & Melinda Gates Foundation, the Gates Millennium Scholars Program awards scholarships to extraordinarily talented, low-income students of color. As a Gates Millennium Scholar, and with support from Carnegie Mellon, Jasinto will graduate from college debt-free.

“The Gates Millennium Scholars Program is the reason I am able to go to the school that I’ve wanted to go to for years. It’s the reason that I can focus on my studies and my extracurriculars instead of working,” said Jasinto, a sophomore chemistry major.

And focus he does. Jasinto began his first year at Carnegie Mellon eager to take advantage of every opportunity that came his way. He didn’t hesitate to jump right into the lab even before his feet hit campus, and he applied for and was accepted into the Phage Genomics research course (page 14), which gives first-year students the opportunity to conduct authentic research.

“I really love the fact that we did original research, which is not something I thought I would get my hands on as a freshman,” he said. “It’s a really excellent class. I learned lab skills, a sense of independence and a lot about conducting my own research.”

He put those newly acquired research skills to use during the summer in the bioorganic chemistry laboratory of Assistant Professor Subha Das.

“Paul has immersed himself fully in his Carnegie Mellon experience with an incredibly diverse portfolio of extracurricular experiences in addition to the demanding curriculum of a chemistry major,” said Karen Stump, teaching professor, director of Undergraduate Studies and Laboratories, and Jasinto’s advisor. “He is incredibly upbeat with a positive can-do attitude, and he loves Carnegie Mellon.”

student honors

• Brian Belardi (S’08) and Hanadie Yousef (S’08) both received a National Science Foundation Graduate Research Fellowship.
• Sharon Briggs (S’10) received an American Society of Microbiology (ASM) Undergraduate Research Fellowship, which enabled her to conduct research at Carnegie Mellon with Professor Aaron Mitchell to investigate how the drug Caspofungin induces a cell wall stress response in the yeast Saccharomyces cerevisiae.
• Michelle Stewart (S’10) and Justine Harkness (S’10) spent their summers in Budapest, Hungary and Melbourne, Australia, respectively, carrying out cutting edge undergraduate research with Howard Hughes Medical Institute International Research Scholars. The program, made possible through the Howard Hughes Medical Institute, aims to generate ways for students to research important topics and gain a perspective on how their work can affect people on a global level.
• Two MCS students have received the prestigious and nationally competitive Barry M. Goldwater Scholarship to support their
Any newly minted Ph.D.s have felt the terror. You are a new faculty member preparing to teach your first course. Where to begin? Perhaps with choosing readings or maybe designing assignments? Whether following a colleague’s materials or building a new course from scratch in your research area, it’s a daunting situation, to be sure. Corey Flynn, Ken Hovis, Jeanne Morin-Leisk and Melissa Witzberger set out to change that for Mellon College of Science students. The Biological Sciences graduate students started the Sciences Teaching Club, bringing together graduate students and postdocs from the sciences and engineering to hone their teaching skills and enrich their knowledge of pedagogy. They regularly hear firsthand from seasoned faculty members about their own teaching experiences and about the broad scope of opportunities available for teaching in the sciences at various types of institutions. Club members gather to discuss the art of teaching, pore over case studies and participate in microteaching workshops, during which they teach a small sample lesson and receive feedback from their peers and experts from Carnegie Mellon’s Eberly Center for Teaching Excellence.

For Hovis, participating in club activities and taking courses offered by the Eberly Center for Teaching Excellence were key to a successful turn as an adjunct faculty member at Robert Morris University. “There’s no way I would have been prepared if not for what I learned through the Eberly Center and the Sciences Teaching Club,” he said.

If you are a student interested in teaching in the sciences or an alumnus interested in sharing your experiences with current students, please contact Melissa Witzberger at mwitzber@andrew.cmu.edu or visit www.cmu.edu/bio/teaching-club.

In fact, he loves Carnegie Mellon so much that he literally became one of its biggest cheerleaders. Jasinto, a wrestler in high school, despaired when he learned that Carnegie Mellon didn’t have a wrestling team. His dorm’s Community Advisor suggested cheerleading as an alternative. Jasinto gave it a shot and ended up really liking it.

His school spirit and tremendous energy extend beyond the football field. Jasinto built booth and pushed buggy during Spring Carnival; is an RA at Hamerschlag; belongs to Sigma Alpha Epsilon; and mentors minority first-year students through COMPASS (Coaching Minority Progress and Academic Success in Science), a student-led program in MCS.

“I’m glad to be a part of student life. I love the entire experience,” he said.

Jasinto has been so touched by his experience as a Gates Millennium Scholar that he volunteers to speak to high school students about the program. A native of Florida, Jasinto takes time out of his visits home to travel to local high schools to encourage students to apply for the scholarship.

He can’t help but thank Bill and Melinda Gates for the opportunities that have come his way.

“Bill and Melinda Gates have made an investment in me. They’ve put faith in my potential. I’ve always been really driven, but this has motivated me even more.”

The Sciences Teaching Club

• Charlotte Jennings (S’09) received a National Institutes of Health (NIH) Pre-Doctoral Fellowship for research and training in the area of genetics/genomics, which she will use to enhance her evolutionary biology research at the University of California, Berkeley. • The Department of Defense has awarded Elaine Lee (S’10) a Science, Mathematics And Research for Transformation (SMART) Scholarship. The program supports undergraduate and graduate students pursuing degrees in science, technology, engineering and mathematics disciplines. • Greg Newby (S’09) is spending one year working on a research project with Andreas Plückthun at the University of Zurich as a Fulbright Scholar. He will begin his graduate training at the Massachusetts Institute of Technology next year.
A Chemist’s Journey
Catalina Achim makes her way from Communist Romania to Carnegie Mellon

By Jocelyn Duffy

What kept Catalina Achim (S’98) on the path to becoming a synthetic inorganic chemist at Carnegie Mellon was a mix of determination, hard work, focus and a positive, can-do attitude.

“Every big task or accomplishment is made up of a sequence of little tasks or accomplishments. We should dream big but shouldn’t judge ourselves only by the big accomplishments, but also by the succession of small ones,” said Achim. “This is how I proceed about my science and life in general.”

Achim was born in Macin, Romania, a very small town on the Danube River. She knew from an early age that she wanted to be a teacher like both of her parents. In high school, she fell in love with chemistry, and she set her sights on becoming a chemistry teacher. Achim had the good fortune to be exposed to research and realized that she loved doing it. Given the circumstances in Romania at that time, students could build a strong background in science, particularly in theory, but research opportunities were limited. Her friends discouraged her from pursuing research because, at the time, no one could get a Ph.D. in Romania. But she followed her heart and stuck with it.
When she graduated from the University of Bucharest in 1989, Romania was still under communist rule. Achim and her classmates were assigned jobs according to their GPA. Achim got a position at the Meteorological and Hydrological Institute, stationed at a post in the Carpathian Mountains, 200 miles outside of Bucharest.

"I went there and they said that they had nothing for chemists to work with. The only place they had sodium chloride was in the kitchen," said Achim.

It turns out that the position was a ruse, and her job was actually at one of the Institute’s air pollution labs in Bucharest. Since the city was considered “closed,” no one could officially be hired there. “Despite the fact that I was working in Bucharest, on the books I was not existing in Bucharest. I could not get a house or food rations there.”

Achim made the best of the situation, and for six months worked in Bucharest, getting food from her parents. Then communism fell. Bucharest opened and the university started accepting doctoral students. In 1991, Achim accepted a position as a teaching assistant and began doing research again. Her son, Tudor, was born that same year.

“I started doing research at the university, but the infrastructure was very poor. That year, our budget for chemicals for the entire department was a few hundred dollars,” said Achim.

Her sister came to the United States to get her Ph.D. in 1992. At first Achim didn’t consider following her sister’s path because it would mean being separated from her son. However, insurmountable housing challenges already kept her from her son, and with research opportunities severely limited, Achim started considering what would be best in the long run for her family.

Her sister helped to convince her to apply to doctoral programs in the United States, because she knew Achim would thrive in the environment. Achim made the difficult decision to apply and was accepted to Carnegie Mellon in 1993. Her support network was critical to her decision. Her son Tudor remained in Romania, first with her husband and her parents and, a year later, with her parents when Achim’s husband joined her in the United States. Tudor followed two years later.

“Having a child increased tremendously my sense of responsibility. You can’t say something is too hard or not important. You have to make the best decision with the child in mind. I think that learning to make those tough decisions and having an increased sense of responsibility made me a better parent and a better teacher,” said Achim.

She arrived at Carnegie Mellon with the intention to study inorganic chemistry. She chose to focus on physical inorganic chemistry, the area she felt was the most challenging to her, enabling her to build a strong foundation. First, she worked with Eckard Münck, learning how to use spectroscopy to determine the properties of proteins that mediate charge transfer in biological systems. Then, building on what she studied at Carnegie Mellon, she went to Harvard for a postdoctoral position with Richard H. Holm, where she began synthesizing molecules for the study of charge transfer.

At Harvard, she learned how to synthesize peptides. It was a hard project that didn't lead to any publications, but the skill of synthesizing peptides transferred to making peptide nucleic acids (PNAs), the molecules that form a pillar of Achim’s current academic life.

“In the beginning of your career it’s hard to tell where your path will take you but it’s not hard to see the direction of the path. I took what I learned about electronic and magnetic properties of metal complexes from Eckard Münck and what I learned about making these complexes from Dick Holm and applied them in the context of nucleic acids to create my own new space in science.”

“Catalina Achim is a remarkable scientist, capable of generating many new ideas, technically proficient in executing experiments, and intellectually capable of taking on many different challenges in her area of chemistry. She ranks in the very top echelon of postdoctoral associates who have been in my laboratory in the last twenty years,” said Holm.

Achim returned to Carnegie Mellon as an assistant professor in 2001, where she could build on her expertise in inorganic chemistry and peptides. She joined Bruce Armitage and Danith Ly, who develop artificially synthesized PNAs, molecules that possess both DNA and protein-like properties. The group of scientists, who are at the forefront of PNA research, design PNAs with specific properties to serve a variety of needs. For example, Achim is using PNA to work toward the synthesis of small molecular-scale electronic devices.

So while Achim never could have predicted the places her career path would take her, she is happy as a mother, teacher and scientist.

“Until 1989, almost no Romanian had a passport. So by the time I finished college, I couldn’t have imagined that my career would take me to the United States. But I chose to do what I felt passionate about: chemistry, raising a child. I think that the feelings I had for what I was doing allowed me to achieve my goals easier and better.”

“We should dream big but shouldn’t judge ourselves only by the big accomplishments, but also by the succession of small ones.”

Catalina Achim
Krzysztof Matyjaszewski Receives 2009 Presidential Green Chemistry Challenge Award

By Jocelyn Duffy

Since its invention at Carnegie Mellon in 1995 by University Professor and J.C. Warner Professor of the Natural Sciences Krzysztof Matyjaszewski, atom transfer radical polymerization (ATRP) has become one of the most widely used methods for creating polymers with highly specific, tailored functionalities.

ATRP has been used to make polymers for coatings and adhesives, cosmetics, better pigment dispersants for inkjet printing and many other products. In an attempt to make the revolutionary process even better, Matyjaszewski has spent the last few years working to make it more environmentally friendly. For these efforts he received the 2009 Presidential Green Chemistry Challenge Award from the U.S. Environmental Protection Agency.

The Green Chemistry Challenge program promotes research and development of less-hazardous alternatives to existing technologies in an effort to reduce or eliminate waste, particularly hazardous waste, in industrial production.

“Approximately 400 billion pounds of synthetic polymers are produced each year. Often, hazardous chemicals are used to produce these important industrial products,” said Matyjaszewski. “We’ve been able to use environmentally friendly chemicals, such as vitamin C, to reduce the level of catalyst employed in ATRP by a factor of more than 1,000. This both enhances the scope of the procedure and reduces the environmental impact of polymer fabrication.”

Matyjaszewski and his research team accepted the award at an award ceremony held in Washington, D.C. on June 22, 2009. Matyjaszewski is the second chemist from MCS to win this award since its inception in 1996. Thomas Lord Professor of Chemistry Terry Collins received the award in 1999.

A Nobel Gift

By Jocelyn Duffy

Carnegie Mellon will become one of only a few universities in the United States to display a Nobel Prize Medal, thanks to a generous bequest by the late John A. Pople, former J.C. Warner Professor of the Natural Sciences. Pople, who conducted his groundbreaking research while at Carnegie Mellon from 1964 to 1993, won the 1998 Nobel Prize in Chemistry for his contributions to the field of quantum chemistry. At a time when people were just beginning to use computers to solve complex scientific problems, Pople developed computational methods that significantly advanced the theoretical study of molecules.

Two of Pople’s four children, Andrew and Hilary Pople, presented the medal to University President Jared L. Cohon at a ceremony held on October 5, 2009 in the Mellon Institute Auditorium.

“My father was a brilliant man in many ways. And one of the things that he was wise enough to know is that no scientist is an island. In order to achieve great results you need a good environment, outstanding students and colleagues, a supportive department and administrators, and the best technology,” said Pople’s son Andrew. “All this and more he found at Carnegie Mellon.”

The occasion was marked with the first in a biennial series of lectures honoring the late Nobel Laureate. Giving the inaugural John A. Pople Lectures in Theoretical and Computational Chemistry were Iowa State University’s Mark Gordon, one of Pople’s first students at Carnegie Mellon, and the University of California, Santa Barbara’s Walter Kohn, a former Carnegie Tech physics professor who shared the 1998 Nobel Prize with Pople. During the lectures, both speakers reminisced about Pople and spoke of their work.

The medal will be displayed in the Hunt Library beginning in the Spring of 2010.

faculty awards and honors

- Alison Barth received two awards from the Society of Neuroscience: the Research Award for Innovation in Neuroscience, which honors imaginative, innovative research, and the Career Development Award, which recognizes achievement and promise in neuroscience for early career professionals. - Robert Murphy was appointed to the National Advisory General Medical Sciences Council, which is composed of leaders in biological and medical sciences, education, health care and public affairs who perform the second level of peer review for research and research training grant applications assigned to the National Institute of General Medical Sciences, one of the National Institutes of Health. - Joel Stiles was appointed to the NIH’s National Advisory Research Resources Council, which provides laboratory scientists and clinical researchers with the tools...
New Faculty

Stefan Bernhard
Associate Professor, Chemistry
Specialty: Develops luminescent materials for solar energy conversion, including organic photovoltaics and catalysts for producing solar-generated hydrogen. Predicts and measures circularly polarized luminescence from specifically designed chiral metal complexes, intended for novel OLED display applications.
Education: Ph.D., Chemistry, University of Fribourg, Switzerland.

Maggie Braun
Assistant Department Head for Undergraduate Affairs, Biological Sciences
Specialty: Works with all Biological Sciences majors as the primary academic advisor, coordinates undergraduate research and mentors the BioSAC. Is a member of the Biological Sciences Department Undergraduate Curriculum Committee and the MCS Committee on Undergraduate Affairs.
Education: Ph.D., molecular, cellular and developmental biology, University of Pittsburgh.

Alex Evilevitch
Associate Professor, Physics
Specialty: Uses biophysical approaches to study the fundamental physical principles that control viral genome encapsidation and release as well as capsid stability. Creates tools to rationally design ways to interfere with encapsidation and to redesign viruses as drug-delivery agents.
Education: Ph.D., Physical Chemistry, Lund University, Sweden.

Manojkumar A. Puthenveedu
Assistant Professor, Biological Sciences
Specialty: Explores how membrane trafficking controls and coordinates the complex signaling pathways in the brain. Works with opioid receptors, which recognize addictive drugs such as morphine and heroin, to understand the role of membrane trafficking on drug addiction.
Education: Ph.D., Biological Sciences, Carnegie Mellon.

Michael Tarr
Co-director, Center for Neural Basis of Cognition; Professor of Psychology
Specialty: Explores how humans visually learn, process, and recognize objects using methods that include psychophysics, fMRI, and computational modeling.
Background: Ph.D., Brain and Cognitive Science, Massachusetts Institute of Technology; formerly the Co-Director of the Center for Vision Research, the Sidney A. and Dorothea Doctors Fox Professor of Ophthalmology and Visual Sciences, and Professor of Cognitive and Linguistic Sciences at Brown University.

In Memoriam: Edward Casassa
Professor Emeritus Edward F. Casassa died on June 19 at his home. He was 84. Casassa’s research publications on the statistical mechanics of polymer solutions are widely known as is his work on the concentration dependence of light scattering from dilute polymer solutions, the thermodynamics of multicomponent polyelectrolyte solutions and the basis for size exclusion chromatography. Casassa also served the polymer science research community for 27 years in various editorial capacities with the Journal of Polymer Science and its descendants. He came to work at the Mellon Institute of Industrial Research in 1956 and became a chemistry professor at Carnegie Tech in 1966.

Gregg Franklin Named Head of Physics Department
Gregg B. Franklin, professor of physics, began his duties as head of the Department of Physics on November 1. Franklin, who joined the Carnegie Mellon faculty in 1984, has been a leader among the medium-energy physics group and an innovator in teaching. He is a member of the multi-center G0 experiment that is attempting to determine what impact strange quarks and their antiparticle partners have on a proton’s electromagnetic properties. In the classroom, he was the first professor at Carnegie Mellon to use “clickers,” an interactive classroom response system that provides student feedback during a lecture.

Franklin served as MCS’s associate dean for Faculty and Graduate Affairs from 2002 through 2008.

and training they need to understand, detect, treat and prevent a wide range of diseases. • Nathan Urban received the Association for Chemoreception Sciences Young Investigator Award for Research in Olfaction, awarded annually to an outstanding junior scientist who is an emerging leader in the field of olfaction.
• Several MCS faculty members were elected fellows of national and international societies: Michael Widom and John Woolford, the American Association for the Advancement of Science; Paul Whitmore, the American and International Institutes of Conservation; Irene Fonseca and Robert Pego, the Society for Industrial and Applied Mathematics; and Ira Rothstein, the American Physical Society.

November 2009 vol. 2 no. 1
Leonard Kisslinger Recognized at Carnegie Mellon’s Celebration of Teaching

Leonard Kisslinger.

Every Tuesday afternoon, Physics Professor Leonard Kisslinger can be found in a Doherty Hall lab surrounded by dozens of middle school students conducting physics experiments. With help from Carnegie Mellon student mentors, the budding scientists are learning scientific methods and physics concepts as well as interpersonal skills and patience. Kisslinger, who has led the Carnegie Mellon Physics Concepts Outreach Program since 1998, was awarded Carnegie Mellon’s 2009 Gelfand Award in recognition of his dedication to getting inner-city children involved in science and scientific research. The program, which is funded by the Grable Foundation and supported by the Department of Physics, brings middle school students from Pittsburgh Public Schools to campus each week to learn science by doing fun, hands-on experiments under the guidance of student mentors and faculty. Much of the effort is centered on helping the students prepare a project to present at the Pennsylvania Junior Academy of Science competition. Dozens of students have competed in the local science fair and several have had success at the state level. Under Kisslinger’s leadership, the program has inspired countless students, both middle schoolers and their undergraduate mentors.

Established in 2009, The Gelfand Award is given annually to a member of the university community who has combined sustained, effective community service with academic coursework and a deliberate process of student reflection to enhance the learning experience and teach social responsibility to students while improving some aspect of life in the community.

Faculty, Students Named MCS Education and Research Award Winners

Julius Ashkin Teaching Award: Peter Berget

Profound dedication to teaching. Passion for scientific discovery. Exceptional mentoring skills. These are just some of the ways students and colleagues describe Peter Berget, this year’s recipient of the Julius Ashkin Award for Excellence in Teaching. Berget, associate professor of biological sciences, has been teaching and mentoring budding scientists for more than two decades, incorporating novel scientific material and new pedagogical methods into his courses. He was instrumental in developing the Summer Research Institute, and for several years he directed the Pennsylvania Governor’s School for the Sciences. His passion for science continues to inspire students every day.

Hugh D. Young Graduate Teaching Award: Benjamin Beppler

Benjamin Beppler can frequently be found amidst a swarm of students clamoring for his assistance. Beppler, a graduate student in the Department of Physics, has taught every semester he has been at Carnegie Mellon. He has mentored undergraduates, high school students and his fellow TAs. He also voluntarily staffed the Course Center every weeknight, starting the scheduled hours ahead of time, staying past closing time, and helping each of the students who crowded around him.

Dr. J. Paul Fugassi and Linda E. Monteverde Award: Heather Chalfin

Heather Chalfin (S’09) had many roles during her years at Carnegie Mellon. She was an educator, researcher, facilitator, team player and community servant. But above all else she was an excellent student, often being the top student in her classes and earning MCS College Research Honors. Chalfin, a biological sciences major with a minor in mathematical sciences, is this year’s recipient of the Dr. J. Paul Fugassi and Linda E. Monteverde Award, which recognizes a graduating female senior who exhibits the most outstanding academic achievement and professional promise.
In “Big Numbers in Small Spaces: Simulating Atoms, Molecules and Brownian Motion,” high school and undergraduate students are invited to consider how many molecules are in a single drop of water, or a single cell—then fly in and find out. Students have a ringside seat as atoms and molecules jostle and bump each other within the cozy environs of a human cell or a beaker on a lab bench. They watch red-blood cells passing through a vessel while discovering that each of these cells can hold about three-trillion water molecules.

“Big Numbers” is the newest instructional movie from Computational Modules in Science Teaching (CMIST), an educational outreach program of the National Resource for Biomedical Supercomputing (NRBSC) at the Pittsburgh Supercomputing Center (PSC). CMIST materials extrapolate from and bring life to classic textbook pictures and concepts, including osmosis and diffusion, which were featured in CMIST’s pilot module, “Molecular Transport in Cells.”

To view the movie, visit http://www.nrbsc.org/cmist

The CMIST production team is led by Joel Stiles, director of the NRBSC, associate professor in Biological Sciences and the Lane Center for Computational Biology, and includes simulation and visualization specialist Jacob Czech, e-learning specialist Jenda Domaracki, education outreach specialist Pallavi Ishwad and School of Music student composer Jason Mlynek.
Beijing Blues

When Physics Associate Professor Roy Briere started traveling to China to collaborate with scientists at the Institute of High Energy Physics in Beijing, little did he know that he’d end up on stage jamming with Beijing’s premier blues and jam band, the Woodie Alan Band. Members of the band invited Briere to join them during a gig for Daniel Pearl World Music Days. Briere, who’s been playing the harmonica for 30-odd years, didn’t know many of the songs, but he got some quick instruction: “They would tell me, ‘This is a fast shuffle in G.’ I’d just try to hang in there.” He must have hung in there pretty well—he played with the band for the entire second set.