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Marrow Cells and Metastases Bridge Between Sciences

Virtual Battlefields

Got Zinc?

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The Future of Manufacturing

PENNSTATE 1855

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Research that has real-world impact

As a land-grant institution, Penn State always has strived to pursue research with real-world impact. With fundamental science as a foundation, translating innovative ideas and technologies into effective practices that accelerate economic development and improve quality of life is a top priority. As evidence of our commitment, our research expenditures supported by industry and private partners have exceeded $100 million in each of the last six years. Over the same period, our Office of Technology Management filed 341 patent applications while issuing 101 patent licensing agreements—many to new start-up companies aiming to commercialize Penn State ideas.

Public universities are expected more than ever to be prime drivers of economic prosperity within their regions. We see opportunity in this challenge. Just last year Penn State radically altered the landscape for our industrial partners by allowing them free access to any patentable technology resulting from the research they support. And we are currently in the early phases of building programs that will even more rapidly move Penn State ideas through proof of concept, proof of relevance and into commercialization.

We are optimistic about the future. Penn State stands at the leading edge of a new boom in innovative manufacturing that will create jobs and new technologies, and sustain economic growth in Pennsylvania and beyond. Shale gas and reduced domestic energy costs are attracting industry back to our shores; a skilled workforce and advanced technologies can keep them here. You will find a prime example of Penn State's value in "Manufacturing the Future," starting on page 24. The remaining pages abound with other ways Penn State research clearly aims to improve lives. Enjoy the read.

Neil A. Sharkey
Interim Vice President for Research

ON THE COVER: Detail of a laser-based direct deposition system, one of several direct digital manufacturing systems housed in Penn State's Center for Innovative Metal Processing by Direct Digital Deposition (CIMP-3D). The Center was recently named the manufacturing demonstration facility for additive manufacturing by the U.S. Department of Defense. See story on page 24. Photo by Patrick Mansell

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» Beetles Use Bugs

SOME SYMBIOTIC BACTERIA LIVING INSIDE COLORADO POTATO BEETLES CAN TRICK PLANTS INTO REACTING TO A MICROBIAL ATTACK RATHER THAN THAT OF A CHEWING HERBIVORE, SAY PENN STATE RESEARCHERS. THE BEETLES WITH BACTERIA ARE HEALTHIER AND GROW BETTER, TOO.

"For the last couple of decades, my lab has focused on induced defenses in plants," says Gary Felton, professor and head of entomology. "We had some clues that oral secretions of beetles suppressed defenses, but no one had followed up on that research."

Seung Ho Chung, graduate student in entomology working with Felton, decided to investigate how plants identified chewers and how herbivores subverted plant defenses.

According to Felton, the beetles do not have salivary glands and so they regurgitate oral secretions onto the leaves to begin digestion. These secretions contain gut bacteria.

Plant defenses against chewing insects follow a chemical pathway that suppresses digestion and growth. Plant defenses against pathogens follow a different pathway. When the antimicrobial response turns on, it interferes with the response to chewing, allowing the beetles to develop more normally.

Chung and Felton used tomato plants to identify exactly what was turning off the response to chewing. They allowed beetle larva to feast on antibiotic-treated leaves and natural leaves and found that on the antibiotic-treated leaves, the beetles suffered from the plant's anti-herbivore defense, but on the natural leaves the larva gained more weight and thrived.

Subsequent investigations of the expression of genes in the anti-herbivore pathway and the production of enzymes showed that the presence of bacteria decreases the anti-herbivore response.

The researchers found 22 different types of bacteria in the beetle gut, but only three types suppressed the anti-herbivore response. They are now looking to see if these bacteria are present in Colorado potato beetles all over the U.S. and in Europe. —A'NDREA ELYSE MESSER

Facebook and Self-Esteem

How social media users create and monitor their online personas may hint at their feelings of self-esteem and self-determination, an international team reports.

"The types of actions users take and the kinds of information they are adding to their Facebook walls and profiles are a reflection of their identities," says **S. Shyam Sundar,** Distinguished Professor of Communications and co-director of the Media Effects Research Laboratory at Penn State. "You are your Facebook, basically, and despite all its socialness, Facebook is a deeply personal medium."

People with lower self-esteem tend to be much more concerned with what others post about them on Facebook, while users with higher self-esteem spend more effort on adding information to their personal profiles on the social network, says Sundar.

The researchers say that people with both high and low self-esteem spend time crafting their online personas on Facebook, but choose different paths in that construction. Individuals with higher self-esteem have a greater sense of agency and spend more time adding information about their family, education and work experience to their profiles, according to the researchers. Users who have lower self-esteem continuously monitor their wall and delete unwanted posts from other users.

The findings may lead to alternative ways to make money for online social networks. Because Facebook users see the social network as an extension of their self-identity, they may be willing to pay for features on social networks, says Sundar. —MATT SWAYNE

DEMENTIA, DELIRIUM AND DECLINING HEALTH «

MORE THAN HALF OF ALL PATIENTS with pre-existing dementia will experience delirium while hospitalized. Failing to detect and treat their delirium early leads to a faster decline of both their physical and mental health, health researchers say.

"Delirium is often overlooked and minimized in the hospital setting, especially in persons with dementia," cautions **Donna M. Fick,** Distinguished Professor of Nursing at Penn State. "But delirium is deadly, costly and impacts patient functioning."

The researchers followed 139 hospitalized adults, ages 65 and older, with dementia and found that patients who developed delirium had a 25 percent chance of dying within 30 days.

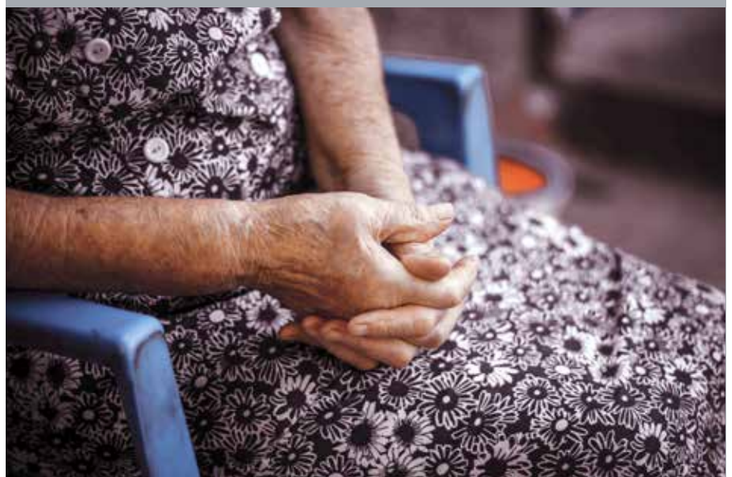
Dementia is an irreversible, progressive condition that affects cognitive and physical function. Symptoms usually occur over months to years and can include memory loss, inability to solve simple problems, difficulties with language and thinking, and personality and behavior changes.

Delirium, on the other hand, is a reversible cognitive condition that comes on quickly and if caught and treated early can be resolved. Many of the symptoms of delirium may appear similar to dementia, but signs such as marked inattention and sleepiness or hyperactivity can help differentiate between the two.

For their study, Fick and colleagues focused on the combination of disorders, known as delirium superimposed on dementia, or DSD. They found a 32 percent incidence of new delirium in the hospitalized patients with dementia. These patients stayed in the hospital about four days longer than patients without delirium, and had a reduced level of physical and mental ability when they left the hospital. They were more likely to have died a month after their hospital stay.

Previous studies have found the cost of delirious episodes rivals those for diabetes and heart disease. Decreasing the length of stay by just one day would save more than $20 million in health care costs per year.

Common causes of delirium are infections, dehydration and medication changes. A third of the patients in this study arrived at the hospital dehydrated. —VICTORIA M. INDIVERO



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Turkey Season

A change in the length of wild turkey hunting seasons in several wildlife management units may enhance management of the species going forward, says a Penn State wildlife scientist, working in conjunction with the Pennsylvania Game Commission.

Duane Diefenbach, adjunct associate professor of wildlife ecology and leader of the Pennsylvania Cooperative Fish and Wildlife Research Unit, says the current wild turkey study, which is a collaborative project conducted by Penn State, the Game Commission, the U.S. Geological Survey and the National Wild Turkey Federation, indicates that switching the length of the hunting season in eight wildlife management units for the next two years may lead to better flock management.

"Fall season lengths are the primary means of wild turkey population management by wildlife management unit," he says. "Season lengths are set to meet a conservative level of harvest because—when combined with natural annual population fluctuations—small changes in hen harvests can adversely affect population growth."

The results of previous research suggest that harvests exceeding 10 percent of the population will lead to declines, notes Mary Jo Casalena, biologist with the game commission and Diefenbach's co-investigator. The purpose of this study is to determine the actual levels of fall hen harvest and survival, and to determine whether an increased season length will result in harvest levels that lead to a decline in the turkey population.

By switching season lengths between study areas, researchers can attempt to answer the question of whether the harvest gained by adding an extra week to a two-week season exceeds a sustainable level of harvest.
—JEFF MULHOLLEM

CORAL SURVIVORS

Although they may look similar, coral species are incredibly diverse, and that diversity may help them withstand harsh environments brought on by climate change, says a team of researchers led by **Iliana Baums,** associate professor of biology at Penn State.

The researchers sampled the lobe coral *Porites lobata* in the Eastern Pacific Ocean off the West Coast of Central America and analyzed the genetic samples to reveal differences among various sample locations. When the scientists analyzed their data they found an unexpected pattern: two separate lineages of coral looked deceivingly similar and sometimes live together in the same location.

While the researchers believed that all of the samples were *Porites lobata,* they found some that belonged to the species *P. evermanni,* which typically are found near Hawaii. *P. evermanni* is less susceptible than *P. lobata* to bleaching, which happens as a result of a reaction with algae and increased water temperature.

"If water temperatures continue to rise, and they surely will, coral species that succumb to bleaching more easily will die," Baums says. "So we're going to see a shift in the relative abundance of these two species."

However, the good news is that the corals seem to be survivors, Baums says.

"It's a rough place for coral to live but they are still hanging around," Baum says. "So if we can figure out how to slow down climate change and keep identifying some hardy corals, we can do something about preserving coral reefs."

There are two possible explanations for the difference in bleaching. The algae that are living there may be different and able to stand hotter water temperatures, or the corals themselves may be different.

Coral reefs protect shorelines from battering hurricanes and generate millions of dollars in recreation revenue each year. They also provide habitat for an abundance of seafood and serve as a discovery ground for new drugs and medicines. —BARBARA KENNEDY

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Courtesy Kiya Riverman

Penn State graduate student Kiya Riverman detonates explosives at a remote site near the calving front of Pine Island Glacier, an extension of the Antarctic ice sheet.

Polar Pebbles Get Good Vibes

Instead of carrying bulky seismometers through the vast fields of the Arctic and Antarctic, research teams may be able to use a smaller, portable device to measure the thickness of ice, thanks to a Penn State researcher.

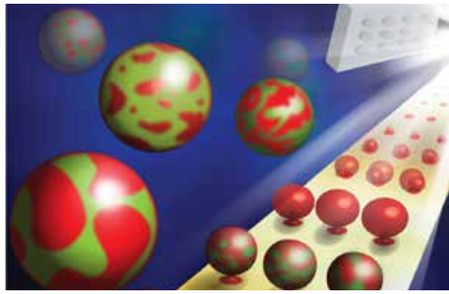
Sridhar Anandakrishnan, a geoscience professor who has traveled to Antarctica and Greenland to study what the ice sheets can reveal about climate change, is working on a prototype for a new seismometer that is wireless.

The ice sheets are incredibly large, stretching for miles in every direction. When the research group steps off the plane, they stand on ice two miles thick, comprised of thousands of built-up layers. But without seismometers, it would be impossible to see those layers.

The devices, called geoPebbles, are hexagon-shaped, about nine inches high and the diameter of a large dinner plate. A rectangular battery fills most of the interior, with sensors fitting on either side. A circuit-board fits on top, followed by the lid. Anandakrishnan described them as laptops without screens; they're equipped with WiFi and don't have to be plugged in. They even charge wirelessly.

"I had the vision for geoPebbles several years ago, but the technology wasn't quite there yet," he explains. "It's only recently that it has caught up to what we wanted to accomplish. There's a huge opportunity in the field of geosciences for IT specialists to come in and help us develop these new technologies."

Once the prototype is finalized, the team will ship the geoPebbles to the research site and place more than 100 on the ice. The devices will record behavior from seismic waves moving through the ice sheet created by buried explosives and sledgehammer blows. —KATIE JACOBS



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Microprinting Artificial Cells

Low-cost artificial cells manufactured using microprinting may one day serve as drug and gene delivery devices and in other important applications, say Penn State biomedical engineers. The artificial cells also will allow researchers to explore actions that take place at the cell membrane.

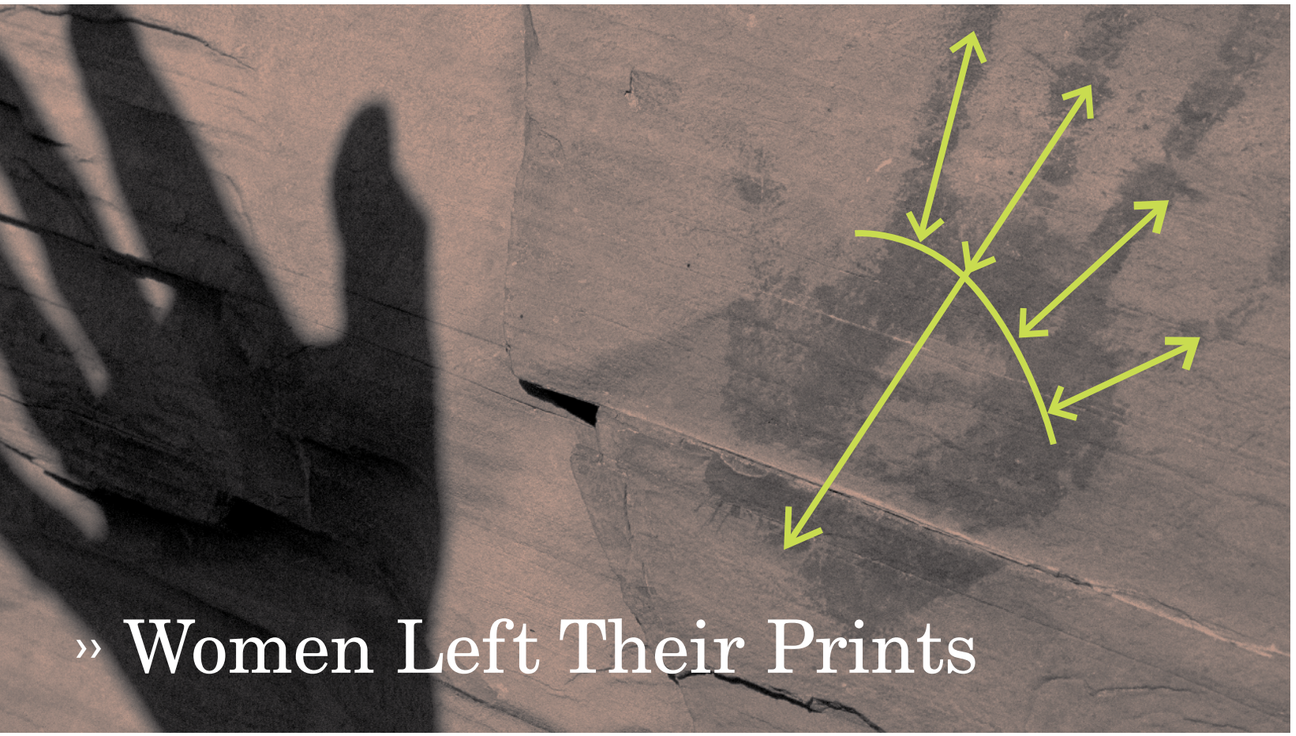
"In a natural cell, so much is going on inside that it is extremely complex," explains **Sheereen Majd,** assistant professor of biomedical engineering. "With these artificial cells—liposomes—we have just the shell, which gives us the ability to dissect the events that happen at the membrane."

Understanding how drugs and pathogens cross the cell membrane barrier is essential in preventing disease and delivering drugs, and researchers have created artificial cells for some time. However, Majd's team is creating large arrays of artificial cells, made of lipids and proteins, of uniform size that can either remain attached to the substrate on which they grow, or become separated and used as freely moving vessels.

"The trend in the pharmaceutical industry is that they like to do high throughput screenings," says Majd. "They could use a large number of these artificial cells all of the same size with the same conditions in an array and monitor many cells at once."

The researchers' cells are also different because they contain lipids with protein components the way cell membranes exist in nature. The various proteins allow certain materials to enter and leave the cell.

"These giant proteoliposomes closely mimic cellular membranes," says Majd. "So they are excellent model systems for studying processes that happen at the surface of cells such as the molecular events that occur when pathogens and drugs enter cells."
—A'NDREA ELYSE MESSER



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» Women Left Their Prints

PLASTER HANDPRINTS FROM KINDERGARTEN, HANDPRINT TURKEYS, HANDPRINTS OUTSIDE GRAUMAN'S CHINESE THEATRE IN HOLLYWOOD—ARE ALL PART OF MODERN LIFE, BUT ANCIENT PEOPLE ALSO LEFT THEIR HANDPRINTS ON ROCKS AND CAVE WALLS. NOW, A PENN STATE ANTHROPOLOGIST CAN DETERMINE THE SEX OF SOME OF THE PEOPLE WHO LEFT THEIR PRINTS, AND THE MAJORITY OF THEM ARE WOMEN.

Dean Snow, emeritus professor of anthropology, came across the work of John Manning, a British biologist who a decade ago tried to use the relationships of various hand measurements to determine not only sex, but such things as sexual preference or susceptibility to heart disease. Snow wondered if he could apply this method to the handprints left in cave sites in France and Spain.

"Manning probably went way beyond what the data could infer, but the basic observation that men and women have differing finger ratios was interesting," says Snow.

Unfortunately, most cave art photographs lack size indication, making it difficult to determine relative size. Snow visited a number of caves and the few existing images with size indications. He also collected hand images from people with European and Mediterranean ancestry.

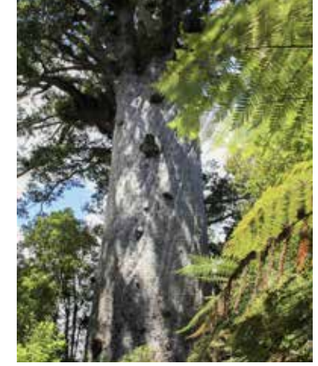
He found he needed a two-step process for the modern hands to successfully differentiate men from women. Measuring the overall size of the hand separated the adult male hands from the rest. Comparing the ratios of the index finger to the ring finger and the index finger to the pinky distinguished between adolescent males and females.

There is a lot of overlap between males and females in modern populations, he explains. "But old hands all fall at or beyond the extremes of the modern populations. Sexual dimorphism was greater then than it is now."

When he applied his two-step process to handprints on cave walls in Spain and France, Snow concluded that 75 percent of the handprints were female.

"By just eyeballing, I'm more accurate with the modern hands than the formulas I developed," he says. "There are some variables there that I'm not aware of yet. The algorithms are pretty good, but they could be better."

—A'NDREA ELYSE MESSER



Australian Trees in South America

Today in Australia it's called Kauri, and in Asia, Dammar, but it doesn't exist in South America unless planted there. However, 52 million years ago the giant coniferous evergreen tree known as Agathis thrived in the Patagonian region of Argentina, according to **Peter Wilf,** professor of geosciences and a member of an international team of paleobotanists who have found numerous fossilized remains there.

"These spectacular fossils reveal that Agathis is old and had a huge range that no one knew about—from Australia to South America across Antarctica," Wilf says.

Agathis trees now grow thousands of miles from Argentina, ranging from Sumatra to New Zealand. They prefer mountain rain forests, where it is wet and warm year-round and are prized for their soft, workable wood. "There is a fossil record of Agathis in Australia and New Zealand, where it still lives," he says, but Agathis fossils have never been found anywhere else until now.

Wilf and his colleagues worked at two sites in Patagonia, where Agathis grew when South America was part of the supercontinent of Gondwana, comprised of South America, Antarctica and Australia. Much earlier, India, Madagascar, New Zealand and Africa separated and moved north, but around the time of these fossils, South America was just beginning to part from Antarctica, which was not ice covered at the time.

"Climate change in Antarctica—the cold and ice—killed them there, and a change to seasonal dryness in southern South America put an end to them in Patagonia," Wilf says. Fossilized pollen cones recovered by Wilf's team allowed direct comparison to trees growing today, indicating that the Argentinian fossil Agathis belongs to the same natural group as those living today in the tropical West Pacific.

"Agathis is a dramatic example of survival via huge range shifts, from the far south to the tropics, in response to climate change and land movement over millions of years," Wilf notes.

—A'NDREA ELYSE MESSER

THE LIGHT-SKIN MUTATION «

ALL INSTANCES OF A GENE mutation that contributes to light skin color in Europeans came from the same chromosome of one person who most likely lived at least 10,000 years ago, according to Penn State College of Medicine researchers.

While the genetics of skin color is largely unclear, past research by Distinguished Professor of Pathology **Keith Cheng** using zebrafish identified a key gene that contributes to lighter skin color in Europeans and differs from West Africans. Cheng reported that one amino acid difference in the gene SLC24A5 is a key contributor to the skin color difference between Europeans and West Africans.

Now **Victor Canfield,** assistant professor of pharmacology, together with Cheng, has studied DNA sequence differences across the globe, examining segments of genetic code that have a mutation and are located closely on the same chromosome and are often inherited together. This mutation, called A111T, is found in virtually everyone of European ancestry. It also is found in populations in the Middle East and Indian subcontinent, but not in high numbers in Africans. Researchers discovered that all individuals from the Middle East, North Africa, East Africa and South India who carry the A111T mutation share common traces of the ancestral genetic code in the corresponding chromosomal region—evidence that all existing instances of this mutation originate from the same person.

The pattern of proportions of people with this lighter skin color mutation indicates that it occurred somewhere between the Middle East and the Indian subcontinent. Thus Middle Easterners and South Asians, which includes most inhabitants of India, Pakistan and Bangladesh, share significant ancestry, according to the researchers. This mutated segment of DNA was itself created from a combination of two other mutated segments commonly found in Chinese, Japanese and Koreans.

The differences in skin color affect skin cancer rates. Europeans have 10 to 20 times more instances of melanoma than Africans. However, despite also having lighter skin, East Asians have the same melanoma rates as Africans. The reason for this difference can only be explained after the gene mutations for both groups are found. This understanding could lead to better treatments for melanoma.

—MATTHEW SOLOVEY

HOW FLOWERS EVOLVED ‹‹

Publication of the newly sequenced genome of the Amborella plant, pictured here, sheds light on a fundamental event in the history of life on Earth—the origin of all major food crops and all other flowering plants. The research addresses the question of why flowers suddenly proliferated on Earth millions of years ago, says **Claude dePamphilis,** professor of biology at Penn State, and the overall principal investigator for the Amborella Genome Sequencing Project.

Amborella, a small tree found only on the main island of New Caledonia in the South Pacific, is the sole survivor of an ancient evolutionary lineage that traces back to the last common ancestor of all flowering plants. As scientists decipher its genome, they are uncovering evidence of evolutionary processes that paved the way for the amazing diversity of the more than 300,000 flowering plant species on Earth today.

The sequenced Amborella genome, researchers say, is proof that the ancestor of all flowering plants, including Amborella, evolved following a "genome doubling event" that occurred about 200 million years ago. Some duplicated genes were lost over time but others took on new functions, including contributions to the development of floral organs.

"Genome doubling may offer an explanation for the apparently abrupt proliferation of new species of flowering plants in fossil records dating to the Cretaceous period," dePamphilis says. Generations of scientists have worked to solve this puzzle, known as Darwin's "abominable mystery."

Comparative analyses of the Amborella genome provide the first global insight into how flowering plants are genetically different from all other plants on Earth, and gives new clues about how seed plants are genetically different from non-seed plants. —BARBARA KENNEDY

Photo by: Joel McNeal

CO TOGETHER IME

›› BY MATT SWAYNE

Millennium Science Complex Bridges Life Sciences and Materials.

Patrick Mansell (2)

IF SUPERMAN WERE IN THE MARKET FOR OFFICE SPACE AT PENN STATE, THE SMART MONEY WOULD BE ON THE SUPERHERO SETTING UP SHOP AT THE **MILLENNIUM SCIENCE COMPLEX**, THE NEW STATE-OF-THE-ART RESEARCH BUILDING THAT SWEEPS OVER THE LUSH GARDEN AND CAREFULLY MAINTAINED GROUNDS BETWEEN BIGLER AND POLLOCK ROADS ON THE UNIVERSITY PARK CAMPUS.

Patrick Mansell (3)

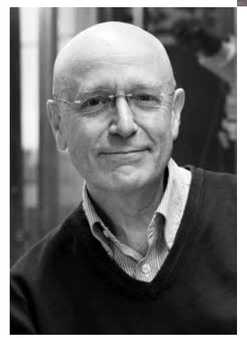
But the Man of Steel might be disappointed. The Millennium Science Complex is designed to bring people together, not keep them away.

In less than two years since it opened, the complex—which houses both the Materials Research Institute and the Huck Institutes of the Life Sciences—has established itself as a global resource for cutting-edge technology and expertise, and as a hub of science outreach. The facility hosts hundreds of high school students from across Pennsylvania who seek to immerse themselves in science and technology, allows business people from around the nation to tap into its world-leading expertise, and has become home to researchers across the University who are investigating everything from how the brain works to how to turn the body into a power generator.

"The Millennium Science Complex is a unique facility where, for the first time ever, we're bringing together researchers in the life sciences and materials sciences to address and solve the critically important issues of the day," says **Peter Hudson,** Willaman Professor of Biology and director of the Huck Institutes of the Life Sciences. "How we control infections, how we understand how the brain works, how we can start to find solutions for ailments such as diabetes—this can all be achieved through specialized interdisciplinary teams, and that's what we're doing here."

Steven Schiff, director of the Penn State Center for Neural Engineering, is just one of the 900 Penn State faculty and student researchers using the nearly 300,000-square-foot complex. Schiff's group is a prime example of how the Millennium Science Complex inspires the merger of life and materials sciences: he leads an international team of theoretical physicists, engineers, biological engineers, physicians and anthropologists who are establishing a network of collaborations to explore the human brain.

Schiff says that the complex has helped him assemble this team of number-crunchers and creative problem-solvers, theorists and empiricists, to address some of the biggest challenges in brain science, such as more effective treatments and possible cures for Lou Gehrig's disease (amyotrophic lateral sclerosis). Researchers at the center also are collaborating with scientists and physicians working on improving the diagnosis and treatment of malaria and neurosurgical diseases in East Africa.



Schiff

An academic smoothie

"The brain is a complex place and we require different types of expertise to try to understand it," Schiff says. As he leads a tour of his center's third-floor headquarters, he points out a long hall of offices full of researchers specializing in mathematics, physics, neuroscience and other disciplines that many people might not necessarily associate with brain science.

He uses a fruity comparison to explain this expert collaboration.

"Some might say that putting crates of fruits on the same shelf is a kind of collaboration, and others might say another type of collaboration might be making a fruit salad, but what we're reaching for is a blender," says Schiff. "We're trying to create a community."

The tour leads to the laboratory, an open section where the members of the center blend together. Schiff's own resume is a blend of titles that is a bit of an academic smoothie: Brush Chair Professor of Engineering, professor of neurosurgery and professor of engineering science and mechanics. He also has a courtesy appointment as a professor of physics.

The center maintains links with Penn State Milton S. Hershey Medical Center, says Schiff, who continues to perform surgery there. "You'll find doctors who come here to work with engineering students, and engineering students may travel to Hershey to work with the doctors there."

The Millennium Science Complex provides Schiff's and many other teams of researchers with some of the most advanced technology available.

For example, a longstanding research initiative explores the world at the nanoscale level. The complex features two new electron microscopes that offer scientists and engineers a chance to view objects on a subatomic scale with high resolution. The Materials Characterization Lab's Titan and the Huck Microscopy and Cytometry Facility's Spirit BioTwin microscopes are among the most powerful of their kind in the world. Only a handful are currently operating in the United States.

Researchers also can use next-generation cell sorting machines that separate and analyze cells, including human cells.

In the Penn State Nanofabrication Laboratory, also located within the complex, scientists are using more than 70 characterization tools, along with other devices, to investigate graphene and other materials that may one day be used in everything from insect-sized robots to wearable phones and electronics.

Evolving new approaches

But the complex features more than fancy hardware. It brings its intellectual firepower to bear on issues that stretch far beyond the "hard" sciences. **Rachel Smith,** associate professor of Communication Arts and Sciences, collaborates with researchers here to explore social stigmas related to health and disease: how they developed in the past and how they are operating in the world today. In a forthcoming paper, she and David Hughes, assistant professor of entomology and biology, examine evolutionary aspects of stigmas.

"While I've had exposure to evolutionary psychology, my training did not prepare me to consider evolutionary claims or their influence on infectious disease dynamics carefully," Smith says. "For communication scientists, recent or modern often refers to events in the past three years. For many of my colleagues in the Center for Infectious Disease Dynamics, modern refers to the

Smith

Michelle Bixby (2)

Detail of a glass vase from Carlo Pantano's collection. A world-recognized expert on the science of glass, Pantano also enjoys glassblowing as a hobby.

CARLO PANTANO, DISTINGUISHED PROFESSOR OF MATERIALS SCIENCE AND ENGINEERING, HAS SERVED AS DIRECTOR OF PENN STATE'S MATERIALS RESEARCH INSTITUTE SINCE 1998. IN MAY, PANTANO WILL STEP DOWN AS DIRECTOR TO RETURN FULL-TIME TO RESEARCH AND TEACHING.

past 3,000 years. In addition, colleagues like David challenge me to consider patterns observed in other species, such as bees or lobsters."

Smith and Hughes discuss stigmas as a group-selection strategy for early humans. At one time in humanity's past, by isolating people with infectious diseases, stigmas may have minimized the spread of disease and allowed the group to stay strong. The researchers also describe how human patterns have changed in modern society, and how those changes created different, maladaptive consequences of infectious disease stigmas. They argue that stigmas do not increase the ability of modern societies to survive infectious diseases, but in fact may be important drivers of problematic disease dynamics and act as catalysts for failures in protecting public health.

Their findings are important to Smith's goal of learning how to craft health messages to promote positive prevention and treatment for HIV/AIDS and other global health concerns.

Learning together

Even though the Millennium Science Complex might appear to be dedicated exclusively to research, its faculty occupants take an open and immersive approach to teaching, according to **Carlo Pantano,** Distinguished Professor of Materials Science and Engineering and director of the Materials Research Institute.

"Here, students are immersed in a professionally staffed and equipped facility that focuses on interdisciplinary, multi-investigator research," Pantano says. "The experience for students is unique—vertical integration of ideas, designs and prototypes—and translation into engineering solutions, industrial manufacturing and commercial products. It adds another dimension to their education and prepares them to be leaders."

Throughout the building, students are engaged in projects. In one conference room, graduate students from a range of disciplines are acting as early reviewers of a fellow student's research paper, making sure there are no statistical or logical holes that could derail its acceptance. Participants in another group are helping each other practice defense of their doctoral dissertations.

It all goes to foster the spirit of the place. "We're here to find out how we can solve problems together that no one can solve on their own," says Schiff.

***Peter Hudson** is Willaman Professor of Biology and director of the Huck Institutes of the Life Sciences, pjh18@psu.edu. **Steven Schiff** is Brush Chair Professor of Engineering, professor of neurosurgery, professor of engineering science and mechanics, and director of the Penn State Center for Neural Engineering, sjs49@psu.edu. **Rachel Smith** is associate professor in Communication Arts and Sciences, ras57@psu.edu. **Carlo Pantano** is Distinguished Professor of Materials Science and Engineering and director of the Materials Research Institute, cgp1@psu.edu.*

Q: How did you become interested in engineering and what made you want to be a materials scientist?

A: I first became interested in engineering as a teenager. Working on cars was one of my hobbies and I was also lucky enough to land summer jobs in the industry. Those early jobs didn't just give me experience, they also taught me a lot about problem solving. I would see places where there were problems and I would think "That's something I could solve." I really enjoyed that challenge. In retrospect, I now know that an engineering education teaches one how to approach and solve problems, in general, whether you're an engineer or not.

Q: What role are materials scientists playing in creating next-generation technology and treatments?

A: Materials scientists are developing new materials and altering current materials to reduce the weight or volume of an object, without sacrificing properties or performance. The new A1 alloy that is used on new Ford pickup trucks saves about 700 pounds! Materials research is leading to an increase in the operating temperature of turbines to improve performance and efficiency in both aircraft and in land-based power generation facilities. The single crystal turbine blade that is used in high performance jet engines, for example.

The list of potential innovations is staggering. Materials enable lower cost electronics, new drug delivery methods, organ repair and reconstruction, medical diagnostics, higher speed electronics, safety and longevity of vehicles and structures, and longer-lasting batteries.

Q: Are there any areas of research that you think we should watch in the future?

A: New energy storage materials and methods. Also, watch how 3D printing will change engineering structures and devices. Of course, electronics—whether flexible, unbreakable, powered by the body, wireless, optical—will continue to depend on materials and devices. And smart materials, which respond to their environment, continue to show promise for use in automobiles, homes and the human body.

Q: What are some examples of cross-college collaborations going on at the Millennium Science Complex?

A: Our researchers are constantly collaborating and creating. We're creating functional materials for electronics and coatings that are one atomic layer thick. We're also exploring the use of nanomaterials for encapsulation and delivery of new drugs. To meet global energy needs, researchers are investigating flexible and printed electronics that can be used in products like displays and solar cells, as well as thin flexible glass for energy storage. Researchers are also creating the next generation of personal body sensors to improve health.

Besides the raw discoveries that our researchers are making, we're actually taking these discoveries and finding places for them in the marketplace through faculty start-up companies.

Q: What makes the MSC an interesting place to conduct research—and to teach and learn?

A: We have a community of faculty with broad expertise; collaborative research, teaching and advising. The building features state-of-the-art core facilities with a support staff. And then the students—they come alive outside the classroom and always want to describe or talk about their research. MRI itself provides an opportunity for researchers to vertically integrate our ideas and accomplishments. For example, I'm interested in the unique characteristics and properties of glasses. I work with glasses of all kinds—glass substrates for electronics or energy storage, glass fibers for reinforcement, optical fiberglass for communications, glasses for nuclear waste disposal, coated glasses for architecture, bioglasses and more, including my hobby of glassblowing.

At the MSC, I can walk down the hall to ask a colleague whose expertise is thin film electronics about the kind of electronic materials and processes they use for displays, and how the display glasses I am working with might interact with their materials and processes. Or they can come to me about the kind of glass that can meet their needs for a biological substrate or new optical device. The most exciting thing is using our individual expertise to discover new devices or structures—or products, or understanding—by working together with a common vision. —MS

GUARDING THE ETHER

CYBERSECURITY SCIENCE AIMS TO DISARM DIGITAL THREATS. | BY A'NDREA ELYSE MESSER

SOMEDAY, A MILITARY COMMANDER will look over a battlefield map to check the position of troops, tanks, artillery emplacements and the enemy, considering every contingency in the complex mission. Then the commander will glance at a monitor that shows the status of the electronic environment—communications frequencies, computer program security, hacker attacks and the responses to those attacks—and determine which digital threats require human intervention.

Commanders cannot do this yet, but the ability may not be too far in the future. A collaboration between the Army Research Laboratory and Penn State researchers is striving to develop a science to detect and model cyberattacks and the risks and motivations behind them. The goal is to create a response that can counter the attack and neutralize the attacker in real time.

While the U.S. military knows what to do to protect the physical battlefield, protecting the electronic battlefield is a new problem.

"Today's digital domain is more than just communications," says **Patrick McDaniel,** professor of computer science and engineering and principal investigator on the cybersecurity cooperative agreement. "The new military relies on sensors for vibration and heat, cameras for visual detection, antennas, a wide variety of digital devices that all run on software. The software and advanced electronics make the military much more effective—and much more vulnerable."

Opposing forces that are not in a position to go toe to toe with the U.S. military on the ground can still attack the digital domain. And as the electronics become more complicated, the attackers are getting smarter and smarter.

Developing a science of cybersecurity will not only benefit the military, but users of advanced electronics and software in all walks of life. Cyberattacks on department store credit cards, banking systems and even university grading systems are increasingly frequent, and the need for systems that can identify these attacks and respond rapidly is correspondingly urgent.

McDaniel and his team are initially collecting information to solve the digital domain problem. They are trying to understand the missions, whether they are defensive—protecting a road or watching a village—or task oriented, such as collecting and distributing intelligence. They are also looking at offensive missions including jamming radio frequencies or otherwise blocking communications and penetrating enemy computers and networks.

Once that data is collected the team will create scenarios with mission specifics laid out. McDaniel provides an example:

> A soldier in the field sees someone who looks suspicious or in some way problematic. The soldier takes a photo and attempts to send it to headquarters for analysis. However, enemy operatives in the field know that intelligence is transmitted frequently in this manner so they try to block the radio frequency or disrupt the signal. The enemy's cyber objective is to stop, alter or slow down the transfer of the image and the resultant return of information to the soldier.

Patrick Mansell

Patrick McDaniel

A MEASURED RESPONSE

Building on the existing science of computing and networks, the researchers will first determine the exact nature of the threat. Is someone monitoring our radio frequencies? Is someone trying to log on to our computers? Was a passkey stolen? Determining exactly what needs to be detected is important, but what is done with that information is critical.

Not all attempts to log on to a system or monitor communications are important. Understanding the risk involved in a given attack determines the necessary counter steps. Corrupted software in essential systems can be a problem, while a massively redundant system with one component affected may not be as important.

Once an attack begins, what is the best way to respond? If someone is interfering with radio frequencies, should that communication channel be shut down, or simply switched to another frequency?

"It would be great if we had one unified equation to always determine how to do the best thing," says McDaniel. "Unfortunately, we can't know all the impacts and all the outcomes."

He likens the problem to that in medicine. "We have a set of circumstances with an underlying theory. We have the history and so we make an informed decision. That decision is not always correct, but with more information, difficult decisions become easier."

Sometimes, the solution will be obvious: A server observing unusual network traffic from an unknown entity determines it is under attack and filters that traffic. At other times, the solution will be less clear and a set of rules or algorithms are necessary to evaluate the attack and stop it. Sometimes a human operator will need to step in, evaluate the situation and make choices, but those will be well-informed decisions. Still, there may not be a perfect answer.

"We want to provide the military with advisory science of what are possible problems and provide enforceable and reasoned solutions within ranges that they can select from," says McDaniel. "We want to be able to make decisions to drive attackers to a state of ineffectiveness. If a network or computer is under attack, we want to be able to assess the situation, make decisions and alter the environment to prevent the attack from being successful."

__Patrick McDaniel__ is professor of computer science and engineering and principal investigator on the Collaborative Research Alliance "Models for Enabling Continuous Reconfigurability of Secure Missions," pdm12@psu.edu. Core funding for the alliance between the Army Research Laboratory and Penn State is five years with an optional five-year extension. A potential $48.2 million over the 10-year collaboration is possible. Working at Penn State with McDaniel are Thomas La Porta, Distinguished Professor of Computer Science and Engineering, and Trent Jaeger, professor of computer science and engineering. Also participating in the cooperative agreement are Carnegie Mellon University, Indiana University, University of California Davis, University of California Riverside and the Army Research Laboratory.

IN MOTHER'S MILK

BY SARA LAJEUNESSE

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Patrick Mansell

A KEY FACTOR IN NEONATAL ZINC DEFICIENCY MAY IMPACT LACTATION, INVOLUTION, AND BREAST CANCER.

It started when her son was just two months old with a diaper rash that would not go away. The blisters eventually spread across his body, including his face. He soon began to suffer from chronic ear infections, unusual for an exclusively breastfed infant who was not in day care. By the time he was six months old, his mother noticed that he was not as active as other babies his age, and he was also failing to gain weight.

"The pediatrician told me that my son was allergic to my breast milk and that I should wean him onto infant formula," she says. "I refused to stop breastfeeding, because I knew 'breast is best.' Instead, I eliminated all possible allergens from my diet. Only organic foods crossed my lips. Out went cow's milk, all things soy, eggs, gluten, and the dreaded peanut, but nothing helped."

That's when the woman contacted **Shannon Kelleher,** associate professor of nutritional sciences.

"This mother had read about our work on breast milk composition, and she asked us if we could figure out what was wrong with her milk," says Kelleher. "It turned out her milk contained only 25 percent of the zinc that it should and as a result the baby was severely zinc deficient. He was quickly put on zinc supplementation and within a week, his symptoms began to improve dramatically."

Kelleher has made a career of studying zinc's role in breast development, lactation, and involution—the process whereby the majority of breast epithelial cells rapidly undergo programmed cell death once an infant is weaned. She also investigates the consequences when these processes go awry, as they can in breast cancer and obesity.

Graduate student Steve Hennigar peers at a female mouse. Through their research, Hennigar and his advisor, nutritional scientist Shannon Kelleher, have advanced understanding of zinc's role in breast development, lactation, and involution.

GOT ZINC?

According to Kelleher, zinc is one of the most important micronutrients in breast milk: Infants need large quantities of it during the first months of their lives to support growth, immune function, and cognitive development. Yet despite zinc's importance, pediatricians aren't trained to detect the symptoms of its deficiency.

Now Kelleher and her colleagues may have found a way to recognize women who are at risk of having low milk zinc levels. The team has identified a mutation in a particular zinc transporter—called ZnT2—that causes defects in the milk-secreting mammary epithelial cells.

This mutation causes women to have severe zinc deficiencies in their breast milk—about a 75-percent reduction. "The woman who came to me with her zinc-deficient son actually had this mutation," she says.

To investigate ZnT2, Kelleher and her colleagues use mouse and human mammary epithelial cells, various mouse models, and clinical populations of breastfeeding women.

"Some 60 to 80 percent of women across the world are thought to be marginally zinc deficient just because of their diets," Kelleher says. "One of our important findings is that in mice, it takes only a slight zinc deficiency to have profound consequences on mammary gland development, the ability to lactate, and the effectiveness of involution. Now we're trying to understand why that is."

According to Kelleher, the amount of zinc in your diet does not affect the amount of zinc that makes its way into breast milk. "There is no evidence that milk zinc concentration can be affected by your diet, so taking zinc supplements won't help," she says. "Our research suggests that milk zinc levels may have more to do with whether or not you have genetic variation in ZnT2, or factors that affect the ability of ZnT2 to function properly."

A CANCER LINK

The same zinc transporter that influences milk zinc levels may influence a woman's predisposition to breast cancer.

"A higher breast density predisposes a woman to breast cancer," explains Kelleher. "Our zinc-deficient mice and our mice without ZnT2 all have dense breasts. They actually lay down collagen, fibrotic tissue in their mammary glands."

Kelleher and her colleagues are investigating whether women who are zinc deficient, particularly girls who are zinc deficient during puberty and into young adulthood, are also laying down more collagen in their breasts. The researchers want to find out if low zinc intake is associated with an inflammatory response in girls' breasts that results in the creation of fibrotic tissue, an increase in breast density, and thus an elevated risk of developing breast cancer. They also want to know if the genetics of ZnT2 or other zinc transporters increase a person's risk for breast density and cancer.

In addition to heightening the risk of breast cancer by contributing to dense breasts, ZnT2 may also do so by decreasing the length of time a woman is able to breastfeed.

"Scientists have long known that women who breastfeed have a lower risk of developing breast cancer than women who do not breastfeed," Kelleher says. "There seems to be something protective about breastfeeding, and this protection becomes greater the longer a woman breastfeeds."

Her team is investigating how ZnT2 influences involution following weaning. They have found that ZnT2 is critical for this process.

"About 80 percent of the cells in your breast die within 72 hours of weaning an infant," Kelleher says. "It's the most dramatic example of programmed cell death in biology. It's totally orchestrated, it's tightly regulated, and one hypothesis is that it may clean out all of the pre-malignant cells. So the more you breastfeed and the more fully you activate involution, the more fully you may remove those premalignant cells and eliminate them from becoming malignant in the future.

"Our mice with defects in ZnT2 function have delayed involution," she continues. "So we suspect that women who have defects in ZnT2 might not involute well either, and this may increase their risk for breast cancer."

LACTATION AND OBESITY

Just how does ZnT2 affect involution? Kelleher's graduate student, **Steve Hennigar,** aims to find out.

Previously, work by Kelleher's team showed that during lactation, ZnT2 is normally found on small organelles in the cell called vesicles. ZnT2 imports zinc into these vesicles, and the vesicles in turn secrete zinc into milk. Hennigar has found that during the early phase of involution, a cytokine called TNF-alpha, a protein involved in inflammation, stimulates the redistribution of ZnT2 from vesicles to lysosomes, organelles that are involved in programmed cell death.

"We have found that when zinc begins to accumulate in lysosomes it causes the cell to die," says Hennigar. "This is the mechanism that initiates the normal process of mammary epithelial cell death and involution following lactation."

Yet according to Hennigar, the process can go haywire when a mother is overweight or obese.

"Two-thirds of women of reproductive age in the U.S. are overweight or obese," he says. "These women tend to have difficulties initiating and maintaining lactation. We are investigating the possibility that zinc and ZnT2 might have something to do with this."

In an experiment, Hennigar and Kelleher fed mice either a high-fat or low-fat diet. They found that about 75 percent of the obese mice were unable to maintain their litters past lactation day five, suggesting a lactation defect. Those obese mice that were able to lactate had increased levels of the TNF-alpha in their mammary glands, increased ZnT2 and zinc in their lysosomes, and increased markers of lysosome-mediated cell death. As a result, these mice underwent premature involution.

Patrick Mansell

Hennigar, left, and Kelleher, right, study changes in lactation-related cellular processes in mice fed on high-fat and low-fat diets.

Obesity is generally associated with increased inflammatory cytokines, Hennigar notes.

"Fat cells release cytokines, which attract immune cells, which then secrete more cytokines," he says. "It's a vicious cycle of inflammation that never gets resolved. We are currently trying to figure out how TNF-alpha redistributes ZnT2 to lysosomes. If we can figure that out, we can start looking at ways to prevent premature involution in overweight and obese women, perhaps by introducing dietary interventions aimed at reducing inflammation in the first place."

One of Kelleher's major motivations for conducting this work is her desire to help increase the number of breastfeeding women in the United States.

"The World Health Organization and American Academy of Pediatrics recommend exclusive breastfeeding through six months of age, but only about 14 percent of women meet this goal," she says. "There is some evidence that breastfeeding improves immune function and cognitive development in babies, and also reduces their risk of diabetes, obesity, and cardiovascular disease when they become adults."

"If we can better understand genetic and dietary factors that affect the ability of the mammary gland to work then we can design some interventions to increase the number of breastfeeding women in the United States and, by doing so, improve both infant and maternal health."

***Shannon Kelleher** is associate professor of nutritional sciences, slk39@psu.edu. **Steve Hennigar,** srh273@psu.edu, is a graduate student in Kelleher's lab.*

Bad to the **BONE**

Grad researcher investigates role of specialized marrow cells in metastases.

BY MELISSA BEATTIE-MOSS

When breast cancer spreads, the disease typically invades the long bones of the body, such as the femur and tibia. Inside these long bones, giant marrow cells known as megakaryocytes (or MKs) go into overdrive, and may contribute to destructive bone loss and embolisms.

In a healthy person, says Penn State graduate student **Walter Jackson,** MKs are responsible for producing the platelets needed for normal blood clotting, but in the course of certain diseases, including metastatic cancer, their number increases three- to five-fold.

"The breast cancer survival rate is about 90 percent when it's detected early but drops considerably lower once the cancer has spread to the bones," says Jackson. There hasn't been enough research on how these specialized bone marrow cells affect the spread of cancer cells, in spite of the fact that many cancer patients die of thromboembolism, or blood clots, he notes. "It's important that we learn more about bone metastasis and how to slow it down."

Under the guidance of Professor of Microbiology and Cell Biology **Andrea Mastro,** Jackson is working to tackle this problem head on. His thesis research project, "The Role of Megakaryocytes in Breast Cancer Metastasis to Bone," has resulted in a published paper (co-authored with Mastro and colleagues) and in his selection as winner of the 2013 Robert T. Simpson Graduate Award for Innovative Research award from the Department of Biochemistry and Molecular Biology.

A native of Shreveport, Louisiana, Jackson graduated as his high school's (Huntington High) valedictorian in 2003 before continuing on as a biology major—and football player—at Alcorn State University in Mississippi. Alcorn State is the oldest public historically black land-grant institution in the United States and is also the alma mater of Jackson's parents.

After receiving his bachelor's degree in biochemistry in 2007, Jackson entered the Alcorn State: Penn State University Bridges to the Doctorate Program, a National Institutes of Health-funded collaboration between the two institutions, with additional funds provided by Penn State's Huck Institutes of the Life Sciences.

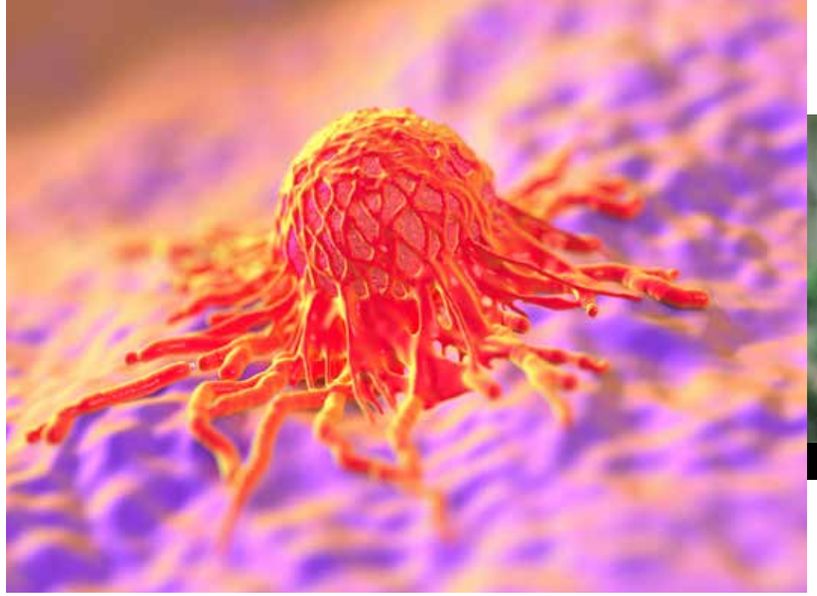
The program, designed to foster underrepresented students' matriculation directly into Penn State doctoral programs after completion of their master's degree in biological sciences from Alcorn State, was initially funded in 2006 for three years and was renewed for an additional five years.

Pamela Hankey, professor of immunology and coordinator of the Bridges program at Penn State, thinks Jackson exemplifies what the initiative can achieve. "This program is one of only fourteen Bridges to the Doctorate programs in the country and due to the hard work and dedication of students like Walter, it has been extremely successful," she says.

"I feel blessed to be a part of it," Jackson says. "I was one of the first ones in the program, so I figured I couldn't quit or fail, because I didn't want anyone else behind me to get discouraged and quit." He adds with a laugh, "I also had to prove that jocks can actually think!"

NEW CLUES TO CANCER'S SPREAD

In fact, Jackson—the youngest of a large, close-knit family—has been thinking about science for a long time. "I can recall being five or six years old and telling my mom and my aunts that I wanted to cure people." The end goal of his research contributing to improved care for real patients is never far from his mind. "My aunt recently died of cancer," he shares. "I haven't taken the MCAT [Medical College Admission Test] yet but it's still a possibility."



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Cancer cell

Patrick Mansell

WALTER JACKSON III

His research on megakaryocytes was inspired by observations made in Mastro's lab. While examining sections of femurs of mice with metastatic cancer, he and his colleagues noticed that megakaryocytes seemed significantly increased in number in the marrow of those mice with cancer compared with non-tumor-bearing mice.

Mastro, lead investigator on the study, explains that prior to these observations, there had been many "indirect connections" hinting that MKs might play a role in metastatic breast cancer, but no solid reports.

While their subsequent research hasn't yet cracked the entire mystery, Mastro and Jackson's results confirmed a marked increase of MK cells in the femurs of mice with breast cancer when compared to an uninoculated control group, suggesting a direct role in the spread of cancer to bone.

It is commonly accepted that cancer cells have ways of creating a micro-environment within the body that sets the stage for malignant colonization. The bone micro-environment is a complex one, explains Jackson, and includes an array of cytokines—small signaling molecules—and growth factors. Jackson and Mastro hypothesized that megakaryocytes contribute to growth of breast cancer cells in the bone either by preparing a niche for the cancer to grow and/or by responding to cytokines in the marrow.

Jackson notes that the interplay between cancer cells and host cells is a vicious cycle that leads to metastatic bone destruction and tumor growth. Rather than being overwhelmed by the disease's complexity, he says he's inspired to continue doing research. "There are many types of cells in the bone micro-environment," he explains, "including the resident cells such as osteoblasts, osteoclasts, stromal cells, and hematopoietic stem cells. This project made me eager to look at some of these other types of cells. In particular, I want to do human clinical research down the line."

In Mastro's view, Jackson is poised for continued success. In his recommendation letter for the Simpson Award, she wrote of her protégé, "Walter is dedicated and committed. He has taken charge of the project."

As a college football player, Jackson's position was offensive tackle. "I'm thinking now about blocking cells, not linebackers," he grins. "I want to learn more about how to block these MKs and slow the spread of metastases."

"The end goal," he says simply, "is to save lives."

***Walter Jackson III** is a Ph.D. candidate in immunology and infectious diseases, wzj103@psu.edu. His advisor, **Andrea Mastro,** is professor of microbiology and cell biology, a36@psu.edu.*

For more information about the ASU-PSU Bridges to the Doctorate Program, contact **Pamela Hankey,** professor of immunology, phc7@psu.edu.

MANUFACTURING THE FUTURE

BY DAVID PACCHIOLI

RICH MARTUKANITZ HOLDS TWO PROTOTYPES, ONE IN EACH HAND. BOTH ARE MODELS FOR THE SAME JET ENGINE BRACKET. THE HOLES WHERE THE BRACKETS WOULD ATTACH TO THE ENGINE LINE UP EXACTLY, AND THE OVERALL DIMENSIONS OF THE PARTS ARE ROUGHLY EQUAL, BUT THAT'S WHERE THE SIMILARITIES END.

Steps in the process: Additive manufacturing from idea to finished product to quality control. (1) CAD model for a strut bracket for a formula style race car designed by Penn State students for the 2013 Formula SAE competition; **(CIMP-3D/Vincent Maranan);** (2) actual bracket produced from the design in the CIMP-3D **(CIMP-3D/Patrick Mansell);** (3) X-ray computed tomography image of the finished bracket. Color coding compares the actual scanned part with the ideal CAD model it was built from. **(CIMP-3D/Griffin Jones)**

NEW CENTER AIMS TO PUSH THE BOUNDARIES OF 3D PRINTING.

THE FIRST DESIGN, A THICK, HEAVY CHUNK, would make a good doorstop. The second is a hollowed out set of spider arms, like a splayed but sturdy rack of ribs.

The prototypes are the before and after of a open competition, sponsored by GE to redesign an actual engine bracket, making it 30 percent lighter while retaining its strength and mechanical properties. The difference illustrates some of the promise of additive manufacturing.

"You're reimagining components from the ground up," says Martukanitz, director of Penn State's Center for Innovative Materials Processing through Direct Digital Deposition, known as CIMP-3D. "You can manufacture components having features and characteristics that are near impossible to do with conventional processes. And you drastically cut manufacturing time, materials—and cost."

Additive manufacturing, sometimes known as 3D printing, is exactly what it sounds like. Working from a computer-generated 3D model, a "printer" puts down layer after layer of material, adding layers until the design is realized in a finished part.

Admittedly, there's a lot of hype attached to this new technology. But there's plenty of real-world promise, too. "It gives new freedom and flexibility to design engineers," Martukanitz says. "There's lots of excitement about this in the aerospace, medical, and oil and gas industries. Additive manufacturing is leading the resurgence of manufacturing in the U.S."

CIMP-3D, created in early 2012, aims to be a world-class resource for that resurgence. A University-wide collaboration, the Center draws faculty from the College of Engineering, the College of Earth and Mineral Sciences, the Materials Research Institute, and the Applied Research Laboratory. It has its roots in a quarter century of ARL expertise in laser-based deposition technologies—the core of the region's powder metal industry.

"We were doing this before additive manufacturing was in vogue," says Martukanitz, "so we have a leg up. When the field got hot, we were able to respond very quickly, because we had the infrastructure and the expertise already in place. CIMP-3D just brings everything together."

In early 2013, when President Obama announced the National Network for Manufacturing Innovation (NNMI), a network of advanced manufacturing hubs, the Center was designated as the metals node for the pilot National Additive Manufacturing Innovation Institute, now known as America Makes.

The 8,000-square-foot facility, located in Penn State's Innovation Park, is operated by ARL, with industrial partners Sciaky, Inc., an electron-beam welding manufacturer based in Chicago, and Battelle Memorial Institute of Columbus, Ohio. It includes a design lab outfitted with a polymer prototyping machine, and a manufacturing demonstration facility that houses, in addition to an array of laser-, electron beam-, and ink jet-based deposition systems, an x-ray computed tomography machine that scans the interiors of finished parts, detecting defects and allowing for reverse engineering.

Researchers focus on advancing the technology, which means everything from improving design and manufacturing processes to basic materials science. Modeling is a major emphasis, and covers not just design but the ability to predict material properties and performance.

"It's really virtual experimentation before we build a part," Martukanitz says. "We have to address concerns that these processes produce the characteristics required for critical applications.

"We're not making doorstops, or trophies," he adds. "We want to make critical components: components for electrical and mechanical systems, orthopedic implants, and jet engine parts." For now, the focus is mostly on metal components, which are produced in both near-net and net shape. The first need finish machining, Martukanitz explains, while the latter are ready to go right out of the printer. Already, though, Center researchers are looking at the possibilities for making parts from advanced materials, including ceramics and composites.

Gary Messing, codirector of the Center, is head of the department of Materials Science and Engineering and a ceramic scientist. "Additive manufacturing conditions can be radically different from those for conventional processes," he says. "There's a lot of materials science to be done to understand microstructures and properties. But I think ceramics have a role to play in this."

The Center was recently named the manufacturing demonstration facility for additive manufacturing by the Department of Defense. Among other things, that means industrial partners can try out processes on the Center's advanced systems, and also get expert advice. A recent change in the University's intellectual property policy whereby intellectual property that results from industry-sponsored research no longer is mandated to be owned by the University has helped attract interest in the facility from large corporations like Boeing, Northrup Grumman, Moog Corporation, Pratt & Whitney, and Siemens, as well as small start-ups and individual entrepreneurs. Martukanitz reports more than 800 visitors to the Center since its opening.

Last but not least, CIMP-3D boosts a robust education and training program for students and companies. Center co-director **Tim Simpson,** professor of mechanical and industrial engineering, leads this effort in partnership with Penn State Digital Fabrication Network, known as DIGI-Net, and the Learning Factory, where teams of engineering students partner with industry to help solve real-world engineering problems for their senior design projects.

"What distinguishes us from other facilities of this type is both our breadth and depth of technologies," says Martukanitz. "We can cover a wide range of enabling technologies relevant to additive manufacturing, such as design, analysis, materials, processing, characterization, and validation. We have faculty interests all over the board. We really are one-stop shopping. I don't think there's anyone else that can say that."

__Richard Martukanitz__ is head of the laser processing division in the Applied Research Laboratory and director of Penn State's Center for Innovative Materials Processing through Direct Digital Deposition, rxm44@psu.edu.

BOOKS

POSTAL PLOTS IN BRITISH FICTION, 1840-1898; Readdressing Correspondence in Victorian Culture

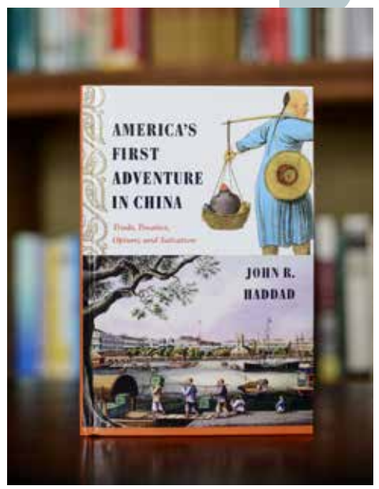
by Laura Rotunno, associate professor of English, Penn State Altoona

(PALGRAVE MACMILLAN)

Today, handwritten personal letters are widely regarded as old-fashioned. In the 19th century, however, letters were the sole form of communication between people across miles. But for the middle and lower classes, sending letters was prohibitively expensive. The British government changed that with a postal rate reduction.

That mid-1800s reduction had a profound cultural impact, Rotunno writes, stimulating an increasingly educated middle class. Newspapers became cheaper, putting more information into people's hands and encouraging letters to the editor.

Novelists feared the new wave of literacy would threaten their livelihoods. While they couldn't stop the tide of new writers, novelists could take advantage of the new popularity of letters by using them in books to move plots along or to clarify a character's thoughts. Rotunno focuses on four books that contain letters — Charles Dickens' *David Copperfield*, Wilkie Collins' *The Woman in White*, Anthony Trollope's *John Caldigate*, and Arthur Conan Doyle's *The Sign of Four*. Each of these works reflects the social changes taking place in Great Britain and the impact those changes had on the populace and on the writing profession itself.



AMERICA'S FIRST ADVENTURE IN CHINA: Trades, Treaties, Opium and Salvation

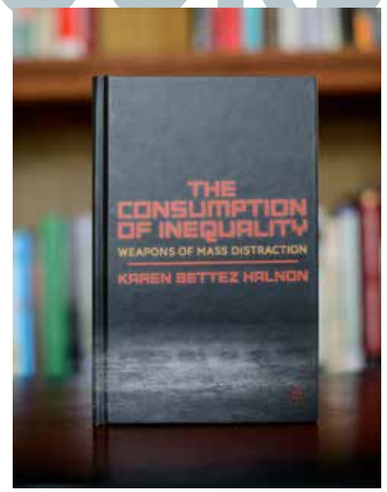
by John Haddad, associate professor of American studies and popular culture, Penn State Harrisburg

(TEMPLE UNIVERSITY PRESS)

In 1784, Americans made their first voyage to China, hoping to obtain wealth, convert the Chinese to Christianity, and even to command a Chinese army. Haddad's narrative history of how China and America first met focuses on the experiences of American traders, missionaries and adventurers as they traveled to a land whose inhabitants didn't know the United States even existed.

Haddad uses special collections, along with 19th-century travel and missionary accounts of people and events in southern China, to follow the activities of those pioneer American expatriates. He demonstrates how they brought traditional American pragmatism and entrepreneurship to bear in their dealings with the Chinese. The Americans' use of a combination of savvy business skills, religion and opium established for the U.S. a unique presence in China, ultimately creating the basis for a long, complicated, and fruitful series of trade and cultural interactions between the two countries that continues to this day.

The book is a culmination of the research Haddad conducted during his 2010-11 Fulbright grant experience in China and is his second book about the relationship between China and the United States.



THE CONSUMPTION OF INEQUALITY: Weapons of Mass Distraction

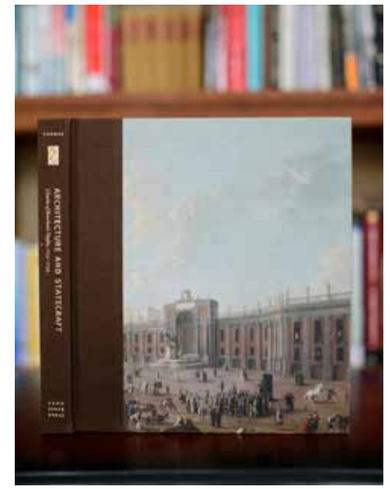
by Karen Halnon, associate professor of sociology, Penn State Abington

(PALGRAVE MACMILLAN)

Popular consumer culture frequently makes recreational and ideological fun of poverty and lower class living, Karen Halnon contends. In her book, she delineates how this phenomenon devalues the poor and such traditional minorities as gays and the physically or mentally handicapped by promoting materialism and individual desires over the collective good.

Halnon describes how the fashion industry, pop culture icons such as Honey Boo Boo, and so-called redneck comedy transform basic elements of life for the poor and disadvantaged sectors of society into fodder for consumption by the more privileged sectors. She immerses the reader in popular consumer culture ranging from "black ghetto cool" and poor white trailer park chic to faux dive bars and upscale bowling alleys. As she traces how segregation, stigmatization, and incarceration encourage and reinforce social stratification, Halnon offers a wealth of descriptive and statistical information about gender-specified classes and races in the United States.

The book draws on Halnon's extensive research on the ill effects of excessive consumerism, and her wide-ranging scholarly interests in such areas as capitalism and class, empire and imperialism, and liberation theology.



ARCHITECTURE AND STATECRAFT: Charles of Bourbon's Naples 1734-59

by Robin Thomas, associate professor of art history

(PENN STATE PRESS)

Many modern cities can be easily identified by the architecture of their public buildings. Mention New York, Paris or Sydney, and people envision the Empire State Building, the Opera Garnier or the Sydney Opera House. Robin Thomas takes his readers back in time to the origins of the modern city by examining the remaking of Naples, Italy, under King Charles Bourbon of Spain. He addresses the political, social, economic and cultural importance of the royal building program.

"The 18th century was a golden age of public building," Thomas writes. "Governments constructed theaters, museums, hospices, asylums and marketplaces to forge a new type of city, one that is recognizably modern. Yet the dawn of this urban development remains obscure."

In 1737, King Charles Bourbon of Spain embarked upon the most extensive architectural and urban program of the entire century. A comprehensive study of these Neapolitan buildings does not exist, and thus Thomas' book fills an important gap in the scholarship and connects Charles' urban improvements to his consolidation of the monarchy. By intertwining architecture and sovereignty, Thomas provides a framework for understanding how politics created the 18th-century capital.

DANGEROUSLY SLEEPY: Overworked Americans and the Cult of Manly Wakefulness

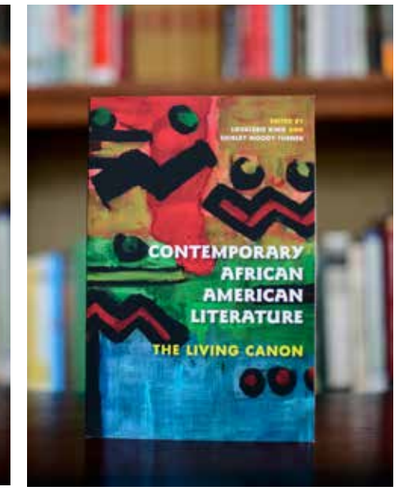
by Alan Derickson, professor of labor and employment relations and history

(UNIVERSITY OF PENNSYLVANIA PRESS)

From early American philosophers, such as Benjamin Franklin, to today's caffeine-fueled Internet entrepreneurs, Americans—especially men—have learned to equate sleeping with laziness, often at the expense of their health and safety, says Alan Derickson. Pairing masculinity with avoiding sleep became even more pronounced as the nation entered the industrial age. As industries became more capital intensive, equipment could not sit idle for extended periods. Paper, steel, railroads and many other large business enterprises required employees around the clock to maintain production.

Derickson shows that evidence of sleep-related health and safety problems in the workplace began to surface during the Industrial Revolution. By 1913, studies found a correlation between working long hours and the number of accidents, and began to link sleep deprivation with cardiovascular diseases, chronic fatigue and increased susceptibility to ill-health in general.

The attack on sleep continues today, Derickson argues. Entrepreneurs who have become Internet moguls, like Facebook's Mark Zuckerberg, are often praised for their marathon programming sessions. "The race for status and riches," Derickson maintains, "has continued to fascinate masses of spectators who have eagerly consumed televis·on programs, movies, books and Internet offerings featuring overworking, undersleeping entrepreneurs."



Michelle Bixby (6)

CONTEMPORARY AFRICAN AMERICAN LITERATURE: The Living Canon

Edited by Lovalerie King, director, African Research Center, and associate professor of African American Studies; and Shirley Moody-Turner, assistant professor of English

(INDIANA UNIVERSITY PRESS)

King and Moody-Turner bring together in a collection of essays top senior scholars, award-winning novelists, and some of the most promising young scholars working in African American literary studies to showcase the lively discussions taking place around contemporary African American literature. An underlying theme is the ongoing relevance of that body of literature to our collective understanding of American history, society and culture.

The essays document the vitality and dynamism of the African American literary tradition and aim to encourage new ways of reading and thinking about a range of works by contemporary writers, while expanding the canon of what typically constitutes African American literature. Contributors explore the work of Toni Morrison, Edward P. Jones, Trey Ellis, Paul Beatty, Mat Johnson, Kyle Baker, Danzy Senna, Nikki Turner and many others. In making their editorial selections, King and Moody-Turner make the case that diversity, innovation and canon expansion are essential to maintaining the vitality of African American literary studies.

PENN STATE LAUREATE KEN WOMACK

Patrick Mansell

Even by the standards of his usual busy life, the last eight months have been non-stop for Kenneth Womack. Selected by President Erickson and a review committee as Penn State's laureate for the 2013-14 academic year, Womack—associate dean for Academic Affairs and professor of English and integrative arts at Penn State Altoona—has spent two semesters traveling across the Commonwealth. In addition, he went home to his native Texas to speak to three alumni chapters there, as part of the University's "Research On The Road" initiative.

"My vision for my laureate year has been to share my passion for literary and musical appreciation, as well as the significance of pursuing lifelong learning opportunities," explains Womack. "Through my scholarship on the Beatles, for example, I challenge my audience to hear the familiar works of the group from new and more sophisticated perspectives. As a novelist, I am interested in bringing key moments in contemporary American history to life so as to provide readers with new lenses through which to consider our shared experiences. In both instances, my work is ultimately about seeing the familiar from different, possibly unexplored vantage points."

Melissa Beattie-Moss recently interviewed Womack at his Altoona office.

MM: *What do you think you'll remember most about your experience as Laureate?*

KW: I think the most rewarding aspect of the laureate year has been the opportunity to experience how important Penn State is to folks—not just in Pennsylvania, but also around the country. It has been genuinely moving to see how much people value our University and the power of education as a means for cultural exchange.

MM: *What was it like returning home to Texas to meet with our alumni chapters there?*

KW: It was wonderful! I learned that our alumni in general—and certainly the Penn Staters in Texas we met—are hungry for interaction and connection with their University. They were often overjoyed at being able to meet with a Penn State researcher and to engage in a learning experience. Both the Laureate program and "Research On The Road" seek to make this kind of interaction possible on a regular basis. We should be looking for more chances to create these kinds of opportunities for Penn Staters far and wide.

MM: *All of your novels deal with huge traumatic public events, such as Hurricane Katrina or the 9/11 terrorist attacks. Yet typically the main characters are marginal, invisible or even possibly imaginary. Why do you think you're drawn to create this type of character?*

KW: I am fascinated by people who live on the margins—as, indeed, most of us do. The Thoreauvian notion that the "mass of men lead lives of quiet desperation" is as real as ever, particularly in the Internet age. This is true about life in general, and always true about major public happenings, where untold thousands exist on the periphery as triumph and tragedy unfold. I am interested in trying to imagine what they would report—if only anyone ever thought to ask them.

MM: *What do you say to people who aren't aware of the field of cultural studies? How has your Beatles research been received by the audiences you've addressed?*

KW: It's been enthusiastically received, and of course that's very gratifying to me. I think the Beatles are a wonderful and intriguing case in point about the nature of mass culture. We have an insatiable hunger for consuming it, yet we rarely take the time to afford it with the appropriate level of interpretation and critical reflection. This kind of cultural study allows us to understand the subject at hand, as well as why it becomes so very important in our individual worlds—and what role it plays, often unexamined, within them.

MM: *Any advice for the incoming Laureate, Associate Professor of Theatre Susan Russell?*

KW: My best advice would be to create as many presentation opportunities as possible—to enjoy the moments when your "canned" talks don't necessarily come off as planned. I have found the impromptu, improvisational moments to be the most fascinating and rewarding—those instances where the magic happens between speaker and audience.

A graduate student in the School of Visual Arts hones traditional studio skills that allow expression of the creative impulse. Like other modes of discovery, art is a continual search for new insights and follows many paths, ultimately helping us respond intelligently and imaginatively to a world of continual change. Photo by M. Scott Johnson.

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Plumbing the Pole:

Sridhar Anandakrishnan is bringing wireless seismometers to Antarctica.

SEE STORY, PAGE 5

Courtesy Sridhar Anandakrishnan