WHERE DISCOVERY AND INNOVATION MEET

SPRING 2013
VOLUME 1, NUMBER 2

insights

THE RESEARCH CHRONICLE OF THE **COLLEGE OF SCIENCE AND MATHEMATICS**

Tropical Forests

The Last Refuge for Threatened Species and Natural Ecosystem Processes

While tropical forests contribute significantly to global ecological health, ecology researchers still know amazingly little about what causes the disappearance of a population or an entire species.

MONTCLAIR STATE UNIVERSITY

Experiential Learning: The Foundation of Research and Education

Just after Dr. Margaret Simpson introduced herself as our instructor for the elective course Invertebrate Zoology, she announced that no one, absolutely no one, gets a grade of A in her class unless they teach her something she could not learn on her own. This ambitious sophomore knew he could indeed teach her something and set out on a semester long journey to get that A. When the semester ended and I had to face that final grade of B+ it was the start of my career as an Invertebrate Zoologist. Dr. Simpson, realized how hard I worked trying to discover something new, something she could not find in a book or journal (no internet in those dark days of the 1970s) or learn from a colleague, something that would lock in that grade of A. When this fine and insightful college professor recognized that I was "turned on" by the excitement that could come with discovery, she invited me to pursue research in her laboratory! And so began my personal journey in the biological sciences. And it began not just with the quest to discover, but with appropriate readings, in this case the works of Charles Darwin. Other than his classic tomes on evolution, Darwin was renowned for his work on barnacles. So with new insight of Darwin's infatuation with these strange crustaceans, I set out on a path to discover the role of the fronto-lateral horn glands uniquely found along the sides of the head of barnacle larvae. Back then if you asked me why, what possible value could this research have, I'd have come up empty. It was just the utter joy of knowing I might discover something no one else knew! That was enough.
In those helter-skelter days of the early seventies, a time when science was thought to either have all the answers or instead was believed to be evil incarnate having created weapons of mass destruction, Agent Orange, and seemingly having no solutions to the ongoing build-up of environmental toxins, a debate started about the role of research among higher education educators. Did an educator who "did science" offer more to the students than an educator who maintained current knowledge solely through the literature? Was this a true debate or a red herring, a schism that impacted higher education that needed immediate resolution or a debate that would drag on without end?

Flash forward to today and ask a random handful of college science or math educators how they were routed into their careers and you're likely to hear about someone who was exposed to some opportunity as a student to pursue research. You'll likely find someone who asks questions, someone who pursues answers to those questions, and someone who hopes to bring the excitement of discovery to their students. And yet decades later we still ask, is a faculty scholar, a faculty member who pursues a research agenda better equipped to educate? How often do we hear the mantra that "research informs teaching and teaching informs research"? So often that, without thinking it rolls off the tongue? Or does it emerge only after serious deliberation? And is this a uniquely American issue? Gabrielle Baldwin from the Centre for the Study of Higher education at the University of Melbourne notes that of the "Nine Principles Guiding Teaching and Learning" at the University of Melbourne, the second principle is that an extensive research culture should permeate "all teaching and learning activities". So convinced are the faculty of this fine Australian institution that the concept is firmly embedded in who they are. On the other hand Pascarella and Tereenzini (2005) found an inverse relationship between research productivity and quality of teaching. While the latter authors suggest that this reflects more of a student perception than reality, it does add tinder to the fire. In this edition of Insights you'll find articles that suggest discovery, defined as research in the truest sense, yields scientists and teachers who are what Boyer would have called "teacher-scholars". Our Science Honors Innovation Program (SHIP) students are challenged to pursue their own research agenda with a mandate that they have an article in review at a peer review journal before they graduate (note: peer reviewed articles are the demonstrable unit of currency in research). SHIP graduates are now in medical schools, graduate schools, industry and one, who was a middle school English teacher, has now moved into STEM education. Our students in the EdD program in Mathematics Education pursue research that helps us better understand the learning process creating, in large part, educators who are more deeply attuned to the way we learn and with a deeper appreciation for the deeper essence of mathematics. And the Insights article on Dr. Jackie Willis demonstrates a transition from a totally focused mammalian biologist who, over the past several decades retained her large mammal research program while in parallel becoming a national leader in K-12 science education. In all cases the process of pursuing research is, by its very nature, producing inquiry and we know that inquiry (in the Socratic sense) is the basis of education.

Relatively recent buzz words in education include "experiential learning"...this is the old adage "teach a man (sic) to fish". While these proverbs are found across culture and time, the theoretical basis can be found in the early work of Dewey (1933) and later in Kolb (1984) who defines a holistic pattern of learning that includes a blending of experience, perception, cognition and behavior. This is how we learn, this is how we do science, this is what our SHIP students pursue, this is what our EdD students pursue, this is what guided a mammalogist into STEM education, and a naïve undergraduate determined to discover into a career in the sciences. In all, experientialism is the foundation of research and education. The first principle from the University of Melbourne meant to guide teaching and learning is to create an "atmosphere of intellectual excitement". The Teaching - Research Nexus, or better, the Learning - Research Nexus is a natural that extends back in time to some of the early, true experimental scientists (think Francis Bacon, Antoine Lavoisier, Louis Pasteur) and is the driver for today's innovation, discovery and "intellectual excitement". Experiential opportunities for students can create the passion and the joy of discovery with an end point being someone who wants to keep discovering through life; that is, a scientist. Margaret Simpson knew this.

By Dr. Robert S. Prezant
Dean, College of Science and Mathematics

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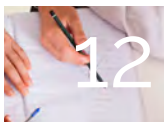
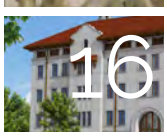
insights

The Research Chronicle of the College of Science and Mathematics

insights is collaboratively produced by the College of Science and Mathematics research faculty and members of the Dean's staff in an effort to broaden awareness and understanding of the scope and relevance of the college's research initiatives as well as the critical role research plays in preparing the next generation of scientists.

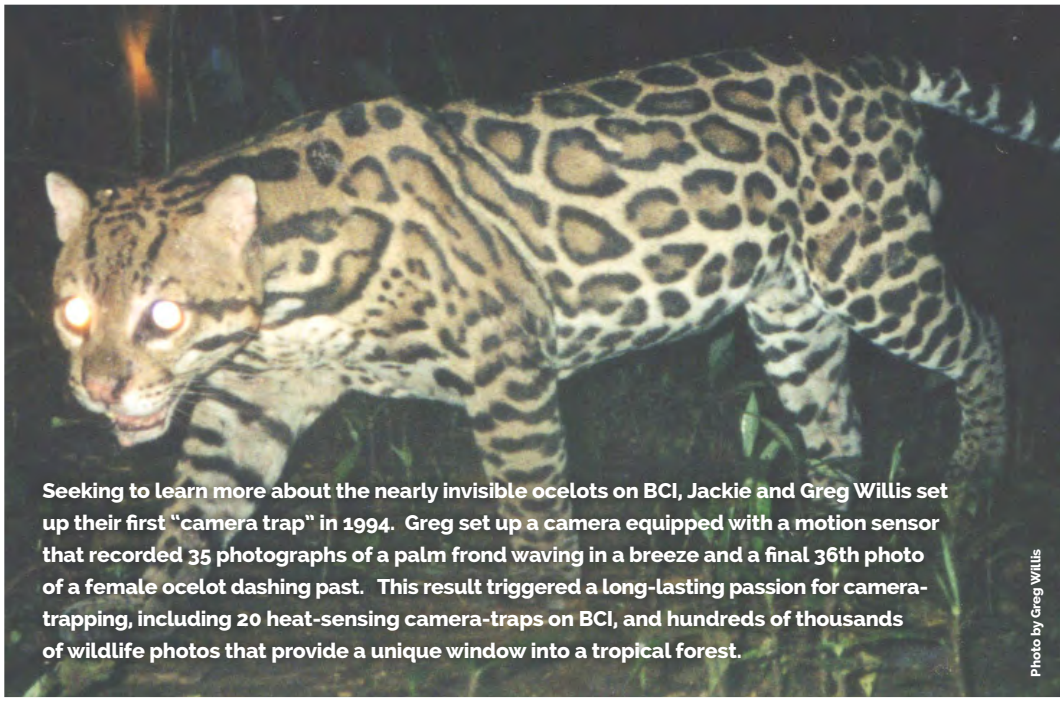




What began in 1923 as small field station on Barro Colorado Island (BCI) in the Panama Canal Zone has developed into one of the leading research institutions of the world. The Smithsonian Tropical Research Institute's facilities provide a unique opportunity for long-term ecological studies in the tropics, and are used extensively by some 900 visiting scientists from academic and research institutions in the United States and around the world every year. The work of resident scientists has created a better understanding of tropical habitats and has trained hundreds of tropical biologists.

The Howler monkey is known for its loud, guttural howls that can be heard up to three miles away.

Photo by Greg Willis



Seeking to learn more about the nearly invisible ocelots on BCI, Jackie and Greg Willis set up their first "camera trap" in 1994. Greg set up a camera equipped with a motion sensor that recorded 35 photographs of a palm frond waving in a breeze and a final 36th photo of a female ocelot dashing past. This result triggered a long-lasting passion for camera-trapping, including 20 heat-sensing camera-traps on BCI, and hundreds of thousands of wildlife photos that provide a unique window into a tropical forest.

Photo by Greg Willis

The rich diversity of 32 species of frogs and toads on BCI includes the Cane toad which has a ravenous appetite, lays thousands of eggs at a time, and is toxic to predators.

Research by Jackie and Greg Willis found that among BCI's red-tailed squirrels (*Sciurus granatensis*), females may live as long as 10 years and are the dominant gender.

Photo by Katrina Macht

Tropical Forests

The Last Refuge for Threatened Species and Natural Ecosystem Processes

By Dr. Jackie Willis

In the 1980s and 1990s, while more than 60 species of frogs in Central America passed quietly into the oblivion of extinction, Dr. Jackie Willis, of the College of Science and Mathematics' (CSAM) Professional Resources in Sciences & Mathematics program (PRISM), and her wildlife photographer husband, Greg, worried about what these changes meant for the future of tropical mammals and the forests in which they live. Any time an entire species disappears, there will be a ripple effect in the remainder of the ecosystem. While tropical forests contribute significantly to the global ecological health, ecology researchers still know amazingly little about what causes the disappearance of a population or an entire species.

Because there are no sharp changes in temperature in the tropics, researchers did not imagine that weather affected mammals seriously. The belief was that the tropics are extremely stable places to live and that life is fairly easy for mammals. Now, because of the research conducted by the Willis', among others, we know this is not so. Jackie and Greg started a project in 1983 to collect long-term data on the numbers of individuals of different species of mammals on the 100-year-old Smithsonian Tropical Research Institute on Barro Colorado Island (BCI), Panama.

Their data have already contributed to a global database of work on tropical forest ecology, published in 2012 in the prestigious scientific journal, *Nature*. Research, including the Willis', shows that more than half the tropical ecological preserves around the world are in danger of declining biodiversity unless something is done to set up buffer zones around them. Major threats include encroaching farmland, invasive species, hunting by humans, changing climate and low genetic diversity. The research group, under the leadership of William Laurance, stated that "The rapid disruption of tropical forests probably imperils global biodiversity more than any other contemporary phenomenon." To underscore the urgency of need and the volatility of animal numbers, Jackie and Greg documented that a 2010 fruit crop failure on BCI was associated with an excess of mammal carcasses in the forest and an estimated death of 30 - 70 percent of some species that are dependent on fruits. They have found that the end of the rainy season and the early dry season (November - January) are difficult times for mammals every year because fruits tend to be scarce.

They are now trying to discover why conditions change in the forest on BCI by, for example, measuring the fruit production of certain tree species that are important mammal food sources at critical times of the year. Fruit production (and therefore food supply), varies widely from year to year and by tree species. Correlations between rainfall and sunshine, both important for trees to produce fruit, are anticipated, but do not always serve as predictors of famine. The El Niño weather pattern sometimes correlates with fruiting patterns but does not explain all data on mammal population fluctuations.

Jackie and Greg Willis take their annual 62-mile walk through Barro Colorado Island to count the island's mammal populations. For 28 years, the Willis' have made this trek, observing dozens of mammals, including pumas, ocelots, and margays.

In another aspect of their research, the Willis' have trapped and marked squirrels with tiny ear tags and necklaces with colored beads to get a mark-resighting estimate of the size of the squirrel population in one 10-hectare area. This data on individual squirrels revealed territorial behavior of females and the remarkable new

Photo by Greg Willis

An ocelet eats an iguana.

knowledge that tropical squirrels may live to be 10 years old, discoveries biologists didn't even suspect before this work. They are now using surveillance cameras to document life history data for an important predator species, ocelots, and finding that the so-called "solitary" carnivore has an active social life and provides excellent care for its young.

The data on mammal numbers being measured by Jackie and Greg Willis on Barro Colorado Island in Panama is demonstrating that long-term studies in the world's tropical forests are important. The ramifications of their work are profound for our understanding of the web of life, including the earth's human population.

The Rainforest Connection LIVE!

Jackie and Greg Willis were early pioneers in the use of live, interactive videoconferencing technology to broadcast directly into science classrooms.

Launched in 2003, The Rainforest Connection Live was developed by Jackie and Greg and is sponsored by PRISM, The Bristol-Myers Squibb Center for Science Teaching and Learning, the College of Science and Mathematics at Montclair State University and The Smithsonian Tropical Research Institute, Panama.

"We give students a singularly unique learning experience by enabling them to interact with 'real world' science research, including showing how researchers study habitats and animals, and explaining basic ecological principles and animal ecology."

Dr. Jackie Willis

The award-winning interactive science education program reaches more than 100 classrooms each year in 9 states, and 4 countries, and originates from rainforests in Panama, Belize, Thailand and Australia.

A Fine Romance

How zebrafish research may lead to novel reproductive technologies

By Dr. Carlos Molina

Get the ambiance right, the temperature and lighting just so and romance happens! Zebrafish are breeding almost every day in the Science Hall lab of Professor Carlos A. Molina, in the Department of Biology and Molecular Biology.

Dr. Molina and his students are studying how ovulation is regulated in zebrafish with an aim toward development of an ovarian-specific transgenic zebrafish to provide new insights into the molecular mechanisms of ovulation—research that may lead to the development of novel reproductive technologies, helping many human couples struggling with infertility.

His laboratory previously developed a transgenic mouse model with an interesting ovarian phenotype, namely, mature transgenic mice displaying a significantly enhanced ovulation rate compared to the wild type mice. This work was funded by two grants from the Eunice Kennedy Shriver National Institute of Child Health and Human Development of the National Institutes of Health and is the basis of a patent application.

Currently, his scholarship program has focused on understanding the causes of these altered ovarian functions. To that end, Molina and his students are engineering ovarian-specific transgenic fish. The transgenic fish will express genes whose expression are to be restricted to the ovaries. The resulting progenies are being characterized and analyzed for the expression specifically in the ovaries, and for the ability to ovulate in the transgenic female fish.

The research group is also conducting morphological studies of the ovaries. This animal model will be used to continue the characterization of the role of specific genes with ovarian function as a suitable substitute to the previously developed mouse model. The zebrafish animal model is playing a key role in today's biomedical, environmental and toxicological research.

The goal for his future research is to generate other potential transgenic animal models. To that end, Molina has established two important international collaborative efforts with Drs. Nicholas S. Foulkes and Wei Ge. Dr. Foulkes is an internationally recognized expert in transgenesis techniques in fish. He is a professor at the Institute of Toxicology and Genetics, at the Forschungszentrum Karlsruhe/KIT, in Karlsruhe, Germany. Dr. Ge is the director of the Cell and Molecular Biology Programme at The Chinese University of Hong Kong, an international expert in ovulation techniques in fish.

A member of the minnow family, zebrafish is an important vertebrate model organism in scientific research.

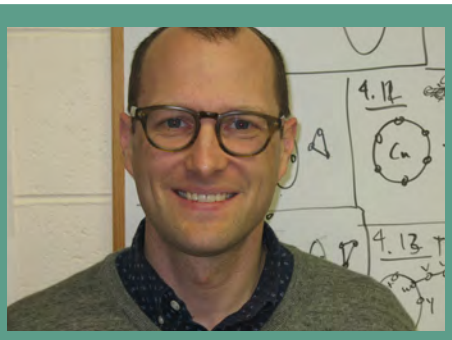
The Color of MATH

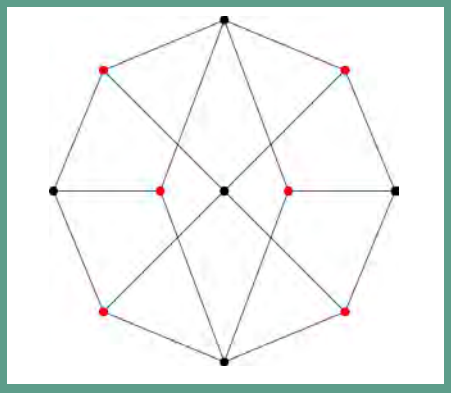
By Dr. Jonathan Cutler

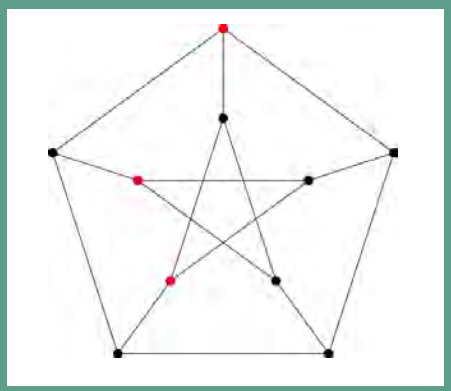
A number of real-world problems can be solved using mathematics that, at first glance, may seem highly abstract. Consider, for example, the challenges faced by a university that would like to schedule classes so that students can take required courses in their majors without conflicts, or creating models that, for example, describe interactions between gases with certain restrictions on which particles can exist near each other.

It turns out that these problems are related to the famous Four-Color Problem in mathematics. This problem in fundamental mathematics asks if it is possible to color any map with four colors so that regions sharing a boundary receive different colors. More general versions of these problems are related to H-colorings of graphs for various "color" graphs H.

Dr. Jonathan Cutler in the Department of Mathematical Sciences, whose mathematics research is in the area of graph theory and combinatorics, has been working on many problems related to counting the number of H-colorings of graphs. One example of this involves counting the number of independent sets in a graph, a problem with applications to scheduling problems.







Pentagons provide important information to mathematicians who are studying the characteristics of particular kinds of graphs. In the examples above, known as the Herschel graph (top), and the Petersen graph (bottom), interesting characteristics are depicted. For example, the red vertices form an independent set since there are no edges present between any pair of red vertices.

For this and other examples, including the Widom-Rowlinson model of statistical physics, results describe the graphs on which there are the most states of these models. Much of this work is done in collaboration with Dr. Jamie Radcliffe at the University of Nebraska-Lincoln.

Students at Montclair State are deeply involved in Cutler's research program. James Alexander and Tim Mink, graduate students at Montclair State, were able to partially solve a conjecture of Galvin by giving an upper bound on the number of independent sets in a certain class of bipartite graphs, work that was published in the *Electronic Journal of Combinatorics*. Alexander is now pursuing a doctorate at the University of Delaware, while Mink is working as a course coordinator in the new Red Hawk Mathematics Learning Center.

Nicholas Kass, a former undergraduate student now in the doctoral program at the University of Nebraska-Lincoln, gave an upper bound for the number of H-colorings with a previously unstudied color graph, presenting this work in the undergraduate poster session at the Joint Mathematical Meetings, the largest mathematics conference in the U.S. Perhaps one day their work will lead to practical results like better class scheduling for students.

SHIP

STUDENTS SET SAIL

Toward their future as the next generation of scientists and professionals

By Dr. Philip Yecko

When IT major Marvin Lapeine was recently preparing for his second telephone interview with Google, College of Science and Mathematics (CSAM) staff members posed several practice questions to him. Asked what he considered to be his single greatest accomplishment during his academic career, Lapeine replied, "Being accepted into the SHIP program."

SHIP is the College of Science and Mathematics' Science Honors Innovation Program, which was launched in the fall of 2010 with its first cohort of 12 undergraduates and is now in its third year of operation. Lapeine's entry into SHIP opened the door for him to work side by side with Computer Science Professor Katherine Herbert in the creation of a tool for mobile devices that gives users the ability to analyze protein-ligand relationships in the phologenentic or evolutionary context. It was Lapeine's key role in this novel work that caught the eye of Google.

This research-intensive program for undergraduates majoring in one of the CSAM disciplines provides a wealth of opportunities for students to conduct research and to become deeply involved in the research community, both locally and globally. SHIP supports each student's research with an award of up to $5500 for research expenses, plus a summer stipend of $3000 and up to $2000 additional funding for travel to conferences and workshops.

"The primary focus of the program, which is funded by Merck and Roche, is the generation of innovative research that yields a written thesis and offers the students insight into the process of innovation," says SHIP director, Dr. Philip Yecko. "This research is guided by a faculty mentor, with additional guidance by professional colleagues from surrounding STEM industries."

For students like Lapeine, the SHIP program is an unparalleled opportunity for undergraduates to receive the preparation needed to become a full-fledged member of the next generation of scientists and professionals.

Turn the page to learn what some of the original 2010 SHIP students are doing today, along with a glance at some of the current SHIP students.

Since Merck and Roche began funding support for the program in 2010, 36 students have entered SHIP. Here is a glance at what some of the original 2010-12 SHIP students are doing today, as well as a few of the 2011-13 and 2012-14 participants.

DANIEL TRAUM '12 is in medical school at Kansas City University of Medicine and Bioscience. He was a double major in molecular biology and business administration with a concentration in marketing and a minor in chemistry. His undergraduate research studied virus inhibition with the use of natural substances. Traum also has worked in Emergency Services for a number of municipalities.
Mentor: Dr. Sandra Adams.

NADINE OREJOLA '12 is in graduate school at Plymouth State University in New Hampshire in the Master of Science program in environmental science and policy. She earned a bachelor's degree in geoscience with a concentration in environmental science. Her undergraduate research was on ice sheet dynamics from sediment core samples. Her professional aspirations include intensive work in the sciences and efforts to advance contemporary science.
Mentor: Dr. Sandra Passchier.

BINTA JALLOH '12 is enrolled in the Cleveland Clinic pre-med program with a fellowship. She majored in biology at Montclair State. Jalloh started doing research in her sophomore year in high school and while an undergraduate, conducted research at UMDNJ in the Graduate School of Biomedical Sciences. Additionally, she was accepted into Montclair State's MARC U-STAR program as well as the SHIP program. She plans to earn MD and PhD degrees and to pursue a career in clinical research as well as treating and caring for patients.
Mentor: Dr. Quinn Vega.

MARVIN LAPEINE '12 is an information technology major. He is currently involved in the LSAMP program as a scholar. His undergraduate research is in the bioinformatics field, working with database technology to explore various chemical compounds. His aspiration is to work as a software engineer and his SHIP research work has recently been published: *Marvin Lapeine, Katherine G. Herbert, Emily Hill, Nina Goodey, "Mobile Interaction and Query Optimization in a Protein-Ligand Data Analysis System," 2013 ACM SIGMOD/PODS, New York, New York, June 22-27.*
Mentors: Dr. Katherine Herbert and Dr. Emily Hill.

AMNA ADAM '14 is a Sudanese-American student majoring in biochemistry. She plans to pursue a master's degree in medicinal chemistry and either a PhD in neuroscience or an MD in neurosurgery. Currently, she works in Dr. David Rotella's Medicinal Chemistry Laboratory under the supervision of Dr. Sreedhar Tummalapalli. The project she works on is the Optimization of Protein Kinase Inhibitors for Tropical Disease. The work so far has produced compounds with good activity against the kinase and improved activity in a cell culture against adult and microfilarial worms.
Mentor: Dr. David Rotella.

KENNETH ANDREW SVOLTO '12 is currently studying at Carnegie Mellon University Graduate School, where he was awarded a fellowship from the Civil Engineering Department. He studied geoscience and art at Montclair State. Svolto has a military intelligence background with investigative experience in Southwest Asia and Afghanistan. Prior to joining the Army, he earned an Associate of Arts degree in history from Daytona State College. In addition, in conjunction with his military training, he earned an Associate of Applied Science degree from Cochise Community College in Intelligence Operations. Currently, Svolto is interested in understanding the fundamentals of the geosciences and exploring their applications for building a more sustainable future.
Mentor: Dr. Michael Kruge.

ARIEL CASNER '12 finished her SHIP research in fall 2012. She is now applying to medical schools, with UMDNJ her first choice. She was a molecular biology major at Montclair State. A member of the Honors Program, Casner also served as the vice president of the Honors Student Organization. She plans to study reconstructive surgery, specializing in pediatric craniofacial reconstruction.
Mentor: Dr. Scott Kight.

LINDSEY MIRRER '14 is pursuing a double major in aquatic and coastal science and a concentration in environment science/geoscience environmental science. She plans to earn a master's degree in environmental engineering to focus on environmental control processes, groundwater and soil pollution control, and inland and coastal environmental hydrodynamics. She is investigating how different types of land uses (urban, agricultural and forested) have affected the nutrient loads in streams in northern New Jersey.
Mentor: Dr. Meiyin Wu.

WAYNE ERNST '13 is majoring in physics with a minor in mathematics. He intends to go to graduate school to pursue research or teach at the university level. His undergraduate research has been in the field of fluid dynamics in Montclair's Complex Fluids Laboratory and he is interested in the field of thermodynamics.
Mentor: Dr. Ashuwin Vaidya.

DAN FLORES '14 is majoring in molecular biology and minoring in chemistry. He is treasurer of the Biology Club and serves as a scholar with The National Science Foundation Louis Stokes Alliance for Minority Participation (LSAMP) program. He is interested in the field of immunology, virology and microbiology and is excited to have the opportunity to work with viruses and observe the effect that natural substances such as Curcumin have on them.
Mentor: Dr. Sandra Adams.

MICHAEL COHRS '12 earned a B.S. in physics from Montclair State with minors in chemistry and mathematics. He also holds a B.A. in Secondary Education from Canisius College in Buffalo, NY. Michael is currently teaching physics and chemistry at the Holmstead School in Ridgewood, NJ and plans to attend graduate school. He is interested in ecological studies with a focus on clean energy resources and environmental sustainability practices. As an undergraduate Michael did research in the field of fluid dynamics as well as working at a summer internship at the New Jersey Meadowlands Business Accelerator with an environmental sustainability consulting firm.
Mentor: Dr. Ashuwin Vaidya.

NANCI FIORAVANTI '13 is majoring in geography with a concentration in environmental studies. She plans a career in sustainability and environmental protection.
Mentors: Dr. Rolf Sternberg and Prof. Joseph Di Gianni.

PAMELA GUERRON '14 is a double major in mathematics education and physics with a concentration in astronomy. She is secretary of the Physics Club at Montclair State and a mentor in the LSAMP community. Her research examines fibers on the fluid tank at different velocities to find limits of oscillation and bending. She plans to pursue a master's degree in applied mathematics and a PhD in physics.
Mentor: Dr. Ashwin Vaidya.

HASSAN TAHIR '14 is majoring in molecular biology with a minor in chemistry. He is the vice president of the Biology Club, vice president of Global Medical Brigades and an affiliate of LSAMP. He hopes to earn an MD/PhD dual degree to connect both the medical and scientific aspects of healthcare which is crucially needed in translational medicine. He worked last summer as a molecular biology technician in a wet lab for Cancer Genetics Inc. His research involves finding the synergistic effects EGCg (a cathelin found within green tea) has on antibiotic resistant bacteria.
Mentor: Dr. Lee Lee.

Higher Math in Higher Ed

A look at the doctoral program in mathematics education

By Dr. Mika Munakata

Mathematics is a key factor to career success in the competitive work world in many areas including the social sciences, health sciences, physical sciences, engineering, business and medicine. Montclair State University's EdD program in mathematics education prepares students to work as mathematics educators in four- and two-year colleges, as mathematics curriculum developers, as leaders in school districts and educational agencies and as research-based teachers in the classrooms.

The students joining the EdD program arrive with a variety of life and professional experiences and interests related to mathematics education. All EdD students, both full- and part-time, engage in research projects grounded in practice with emphasis on affecting meaningful change in mathematics education. Working actively with doctoral faculty, doctoral students refine their research interests throughout their course of study. As many of our students are concurrently teaching at the secondary and collegiate levels, their research has the benefit of practical on-the-ground experience.

Jacky Dauplaise teaches full time at Wayne Hills High School but hopes to teach in higher education upon earning her doctorate. Her doctoral study is aimed at enhancing her education knowledge base and allowed her to join a community of educators. Dauplaise will soon begin her dissertation work, which she anticipates to be on the media's portrayal of teacher expectations. She is developing important expertise about the value of self-study by teachers.

"The EdD in Mathematics Education blends content, practice, and research from both the mathematics and educational perspectives," says program director Dr. Mika Munakata.

Having begun his doctoral studies in fall 2012, Jason McManus is interested in investigating the role of mathematics education at the undergraduate level, especially the extent to which mathematics serves as a "gatekeeper" and as a means to prepare students for careers. In his relatively short time in the program, he has worked on data collection for a professional development program with Newark Public Schools involving recording professional development sessions and checking alignment of modules with the new Common Core State Standards. He is also conducting clinical interviews with students taking courses at the Red Hawk Learning Center to assess their conceptual understanding. Last year, he worked on data analysis and preparation of manuscripts for the NSF-funded GK12 program. McManus is making important contributions to mathematics education research that may impact future generations of Montclair State undergraduates.

The EdD program continues the long and distinguished history of mathematics education at Montclair State. By blending content, practice and research from both the mathematics and education perspectives, graduates of the program are shaping the future in mathematics education in New Jersey and beyond.

Molecular Fingerprints

Distinguishing "legacy" versus newly contaminated sediments in New York/ New Jersey waterways

By Dr. Michael Kruge

As a result of decades of heavy industrial activity, major waterways in the New York/ New Jersey area bear a legacy of contaminated sediments. Although many industries in the region ceased operation years ago, contaminants that they discharged remain. In addition, urban runoff, atmospheric deposition of soot and sewage system overflows during storms provide ongoing sources of pollutants.

These pollutants constitute a cause for concern if, for example, people consume contaminated fish or shellfish caught in these waters. The chronically hazardous conditions distress local residents and impede economic development in the vicinity. Proposed remedial measures remain controversial, elusive and extraordinarily expensive.

Dr. Michael Kruge (pictured above) and a group a faculty and students have been studying two of the most severely impacted local waterways: the Gowanus Canal in Brooklyn, N.Y. and the lower Passaic River in northeastern New Jersey. The extremely high levels of pollution in the Gowanus Canal provoked the U. S. Environmental Protection Agency (EPA) to declare it a Superfund site in 2010, a designation reserved for the worst cases of pollution in the country. Similarly, a portion of the Passaic River near Newark's Ironbound district was also placed on the Superfund list.

Montclair State University students, along with faculty and staff members, have been conducting chemical analyses of sediments collected in both waterways, characterizing the principal organic pollutants in the sediments on the molecular level. These include petroleum, polycyclic aromatic hydrocarbons (PAHs) and compounds indicative of sewage input.

This environmental forensic approach is, in effect, molecular "fingerprinting" of the mixtures of contaminants found at various sites in the waterways. This permits distinguishing between the "legacy" contaminants emplaced decades ago and chemically-distinctive continuing inputs such as sewage discharges. Kruge's team has concluded that even if all presently contaminated sediments were removed by dredging, recontamination would continue to plague these waterways.

Top: the lower Passaic River in northeastern New Jersey and, bottom, the Gowanus Canal in Brooklyn, N.Y. In March 2010, the EPA added the Gowanus Canal to the Superfund National Priorities List, and a portion of the Passaic River near Newark's Ironbound District was also placed on the Superfund list.

PARTICIPANTS

- Prof. Michael Kruge, Earth and Environmental Studies.
- Kevin Olsen, Chemistry and Biochemistry and PhD Program in Environmental Management.
- Nicole Bujalski-Goicochea, MS Geoscience (2011). Present employer: U.S. Department of Defense.
- Eric Stern, Battelle Memorial Institute and CSAM research associate professor.

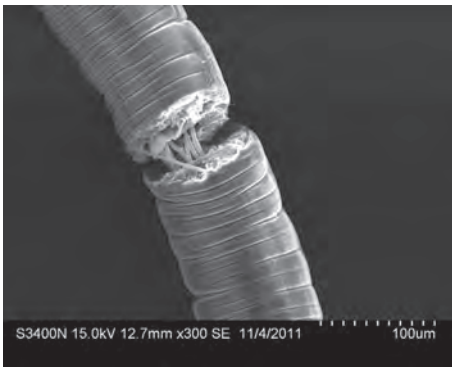
It's a Small World After All

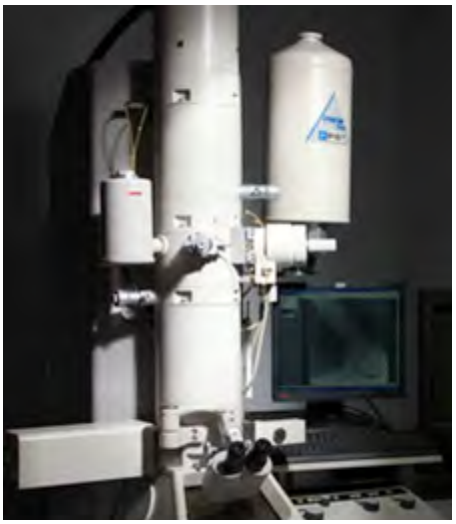
Microscopic analysis reveals the small world of material research

By Dr. Laying Wu

In the world of science, the answers to many critical questions reside in the smallest parts. Montclair State University's Microscopy and Microanalysis Research Laboratory (MMRL) houses electron microscopes which allow scientists to probe the shape, composition and structure of very small objects, from a single sand grain down to a single atom.

Earth and Environmental Studies professors Stefanie Brachfeld, Matthew Gorring, and Sandra Passchier and their students Audrey Burns, David Cuomo, Melissa Hansen, Daniel Hauptvogel, Carl Natter, Nadine Orejola, Natalie Romanoff, Brendan Reilly, Deepa Shah and Eric Sonnenwald use scanning electron microscopy (SEM) imaging and X-ray microanalysis to study processes deep within the earth, at the seafloor and beneath ice sheets. Electron microscopy examination of one-billion-year-old minerals in the New Jersey Highlands has enabled reconstruction of temperature and pressure conditions during ancient mountain building events. The surface textures and composition of individual sand grains from sediment collected from the seafloor surrounding Antarctica helps us reconstruct past environments, past ice sheet extent and the response of the Antarctic Ice Sheet to ancient warm periods, which in turn helps us to understand how the ice sheet might respond to the modern warming trend.





Professors John Siekierka and Shifeng Hou from the Department of Chemistry and Biochemistry and students Lessy Pereda, Akruti Patel and Agnieszka Chojnowki use scanning and transmission electron microscopy to characterize parasitic nematode body structure after treatment with drugs designed to disrupt collagen synthesis, and to characterize the structure of graphene and graphene-based sensors.

Biology and Molecular Biology professors Sandra Adams and Quinn Vega and students in the BIOL 112 Howard Hughes Medical Institute Science Education Alliance Phage Hunters Program use transmission electron microscopy to study *Mycobacterium* bacteriophage. Dr. Robert Prezant, MMRL director Dr. Laying Wu, and doctoral candidate Rebecca Shell are examining shell microstructure in species of lantern shells (bivalve mollusc) from Thailand. These studies help in understanding the environmental influence on the development of calcium carbonate structures often composing skeletons in marine organisms.

MMRL has also hosted visitors from NJIT, Bloomfield College, the University of Massachusetts-Boston, and SUNY Downstate Medical Center, fostering collaborative and interdisciplinary research among area and regional researchers and students.

Top photo: Electron microscope image of *Brugia malayi* parasite

Middle photo: MMRL Director Dr. Laying Wu

Bottom photo: an Hitachi H-7500 TEM equipped with a PGT X-ray detector and an AMT CCD camera is one the MMRL's transmission electron microscopes

The College of Science and Mathematics

WHERE DISCOVERY MEETS INNOVATION

Nestled along the southeastern ridge of the Watchung Mountains is New Jersey's second largest higher education institution, Montclair State University. With an unparalleled view of New York and New Jersey's ever-changing economic and societal landscape, Montclair State plays a uniquely important role in addressing the region's educational and workforce needs.

These changes are especially evident in Montclair State's College of Science and Mathematics (CSAM). Built on a legacy of excellence in science and mathematics teacher preparation, CSAM today plays a significant role in preparing the next generation of professionals and scientists.

"Over the last decade, our focus has been on advancing Montclair States's scientific research capacity to generate new discoveries, processes and technologies that will support the long-term growth of New Jersey's economy," said CSAM Dean Robert Prezant.

All measures of activity in CSAM have increased significantly over the last decade with a 44 percent rise in undergraduate enrollment, a 42 percent increase in graduate enrollment, and robust growth in research-active faculty who have, in turn, fueled a rapid expansion in research grant support from all major federal and state agencies.

The participation of New Jersey's business community has also grown remarkably in CSAM – from the establishment of an external Advisory Council comprised of senior executives from New Jersey's private and public sectors to numerous formal partnerships with some of the state's leading science-based companies. "These relationships significantly contribute to developing curriculum relevant to New Jersey's economic needs, supporting education and research opportunities for our students, and enabling discoveries and innovations that address critical economic and sustainability issues," said Prezant.

Two principal drivers guide Montclair State's science research. The first stems from the campus' proximity to a large segment of the nation's pharmaceutical, bio-pharma and health-related industries.

Montclair State University established the Margaret and Herman Sokol Institute for Pharmaceutical Life Sciences in 2007 to advance transdisciplinary research in medicinal chemistry, pharmacology, biochemistry, natural products chemistry, molecular biology, computational sciences, environmental toxicology and emerging technologies such as biomaterials and nanotechnology.

The second natural driver is due to CSAM's location in the nation's largest urban ecosystem which continues to face significant challenges in reversing a legacy of poor land-use decisions, compromised land and water quality, habitat degradation and loss, and non-sustainable use of natural resources.

Montclair State research scientists are currently engaged in a variety of initiatives that focus on environmental management, contaminant fate and transport, environmental modeling, remote sensing, hydrology, contaminant remediation, seismology, sustainability science, urban and coastal ecology, restoration ecology, biodiversity, watershed management, invasive species, fisheries ecology, climate studies, and epidemiological pharmaceutical global health issues.

"The work of our scientists in the life sciences and environmental management is not only aimed at discovering new knowledge and preparing well-educated professionals for New Jersey's workforce, but also on developing innovative solutions and technologies that hold both commercial potential and highly beneficial health and environmental outcomes," said Prezant.

CSAM AT A GLANCE:

- **Global research programs span six continents and 25 countries**
- **60% of all CSAM faculty have been recruited in past ten years and all from institutions known for research excellence**
- **200 faculty research publications every two years**
- **Strong Federal research support from NSF, NIH, DOE, DOI, NOAA, EPA, NASA, DOD, HUD, USDA**
- **75% increase in private/public sector partnerships and R&D collaborations in last five years**
- **44% increase in undergraduate and 42% increase in graduate students in last decade**
- **20 masters and doctoral programs - NJ's only PhD program in Environmental Management**
- **Leading source for health, life sciences and environmental fields**
- **Strong science and business leadership, transdisciplinary mindset and fast, flexible, creative entrepreneurial spirit**

Graduate student, Agnieszka Nawrocka Chojnowski, is part of a Sokol Institute/ Celgene research team developing selective inhibitors with the potential of becoming a drug to treat filariasis.

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Now is the time...

After more than a decade of growth and success in scientific research and student enrollment, the College of Science and Mathematics is looking to the future with a planned 100,000-square-foot, $55-million, state-of-the-art research center.

"The hard work of our faculty and staff has moved us to a point of more and enhanced research, significantly greater grant support and much higher enrollments," says College of Science and Mathematics Dean Robert Prezant. "But we're out of room. We want to continue to expand our research programs to extend the opportunities for the discovery phase of education that in turn supports our students and their future opportunities."

The proposed Center for Environmental and Life Sciences (CELS) will usher in the next generation of scientific research at Montclair State and is essential to attracting more students interested in careers in the sciences. "This Center is key to building upon our reputation as a growing research institution," Prezant says, "and will tangibly demonstrate our continued commitment to scientific excellence."

University administrators and researchers believe that having a state-of-the-art research facility such as the Center will help retain many of the New Jersey students who seek their science educations out of state. "Research brings science to life in a way that the mandatory laboratory courses cannot," says Dr. Johannes Schelvis, chair of the Department of Chemistry and Biochemistry. "Many top STEM students look for research opportunities before committing to a specific college or university. If we want to be in the race for these top students and want to keep top talent in New Jersey, it is essential to continue to enhance our research programs. The new CELS building will be a significant step forward in this effort."

To learn more about how you can invest in expanding New Jersey's research capacity, call Peggy Harris at 973-655-3440.