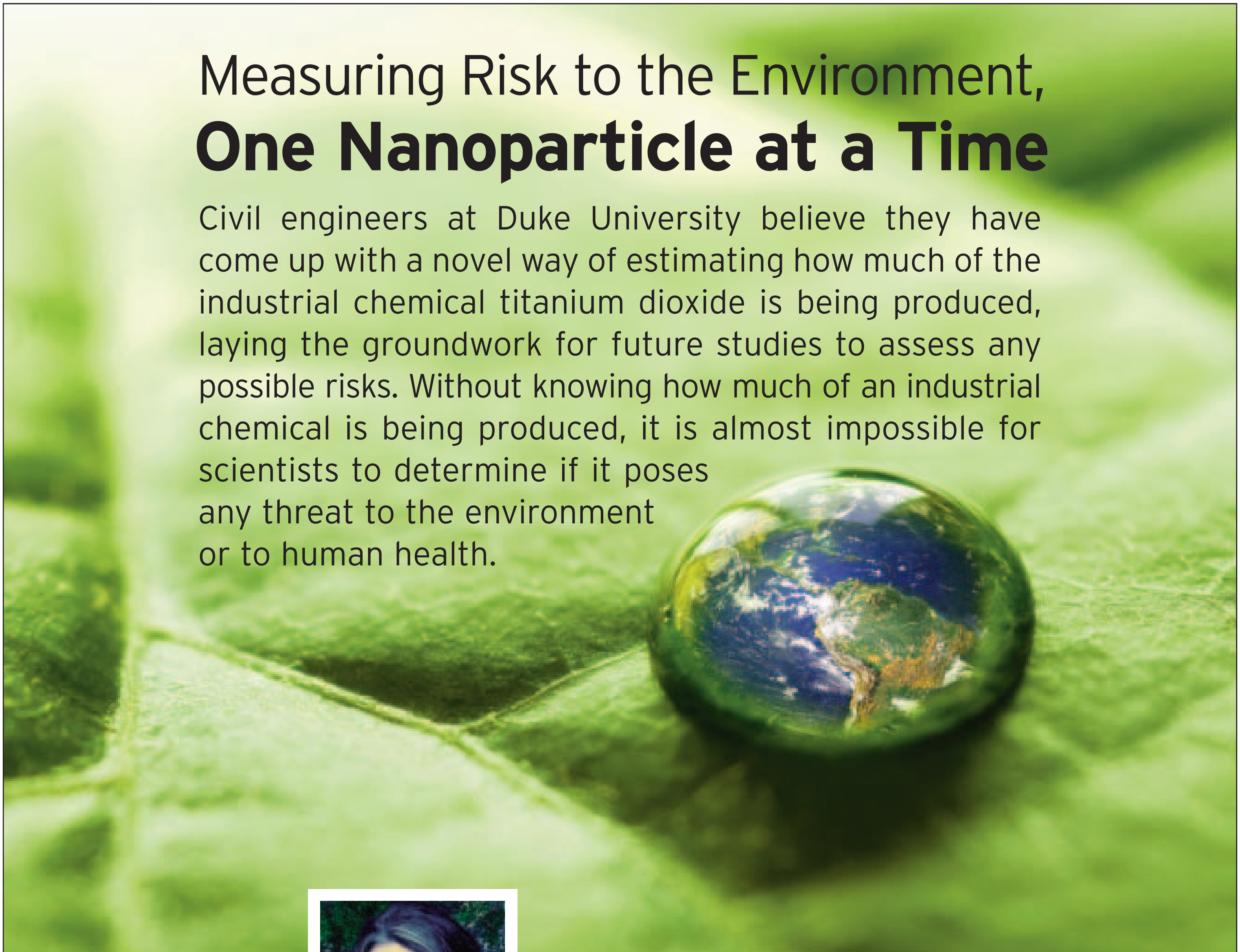
DUKE CIVIL+ENVIRONMENTAL ENGINEERING UPDATE

PRATT SCHOOL OF ENGINEERING AY 2009



Measuring Risk to the Environment, **One Nanoparticle at a Time**

Civil engineers at Duke University believe they have come up with a novel way of estimating how much of the industrial chemical titanium dioxide is being produced, laying the groundwork for future studies to assess any possible risks. Without knowing how much of an industrial chemical is being produced, it is almost impossible for scientists to determine if it poses any threat to the environment or to human health.

Christine Robichaud

This information is especially valuable if the chemicals are in the form of nanoparticles, which possess unique properties because of their miniscule size. Nanoparticles are attractive for a wide range of products, little is known about their consequences in the environment. One of the most widely used is the nanoparticle form of titanium dioxide, which can be found in such diverse products as sunscreens and toothpaste to paints and papers. It is also used in water treatment.

"The biggest problem we face in trying to determine any risks of titanium dioxide nanoparticles is that no one really knows how much of it there is," said Christine Robichaud, graduate student in civil and environmental engineering at Duke's Pratt School of Engineering. The results of her analysis were published online in the *Journal of Environmental Science and Technology*.

Robichaud found it especially difficult to collect this data since the companies that process titanium dioxide were not willing to reveal information they deemed proprietary. Undeterred by this gap in the data, she used a novel approach developed by collaborators Lynne Zucker and Michael Darby at the University of California, Los Angeles, to estimate the rate of innovation in the biotechnology industry.

continued on page 3

These are exciting and dynamic times

for Duke's CEE department. Our education, research, and service activities are increasingly at the fore of the University's priorities and directly aligned with the greatest needs of the country at large.

The signature of Duke's university-wide strategy is "Knowledge in the Service of Society". This is also the essential core of what civil and environmental engineers do everyday. It is quite clear that we in CEE have a central role to play in the assent of Duke as a major international hub for advancing the state of society. And the needs are great at this time. Not since the efforts to pull the country from the depths of the great depression has there been such a clear and sustained call for leadership by the profession of civil and environmental engineers. We are being looked to for progress on green technologies, meeting the challenge of climate change, re-imagining our transportation system, modernizing and securing our infrastructure, meeting the food, water, and hygiene needs of the developing world, and developing sustainable energy sources – just to name a few.

I am excited to say that we have an extraordinarily talented team in CEE and some clear advantages over our competitors as we race to lead the research into developing new technological solutions and to train a talented and creative cadre of new engineers to tackle these problems.

The department's leadership stature is evidenced in its contribution to both identifying the problems and developing the solutions. Earlier this year our school hosted the Summit on the National Academy of Engineering Grand Challenges, where leading scholars and practitioners were brought to Durham to articulate and focus attention on the greatest challenges faced by society today and the most promising approaches toward meeting them. Prominent among the challenges discussed are: Energy and the Environment; Access to Clean Water; and Restoring and Improving Urban Infrastructure. The department is wasting no time in its race toward solutions. For example, during this past year a team led by CEE Professor Mark Wiesner won a $14 million grant from the NSF and EPA to create at Duke the Center for the Environmental Implications of NanoTechnology (CEINT), which is dedicated to elucidating the relationship between a vast array of nanomaterials and their potential environmental exposure, biological effects, and ecological consequences.

Knowledge in the Service of Society.

Members of the CEE team continue to win awards and attract broad attention. For example, Assistant Professor Claudia Gunsch has won the NSF CAREER award; Professor Miguel Medina has been elected President of the American Institute of Hydrology; Professor of the Practice Joseph Nadeau won the 2009 James M. Robbins Excellence in Teaching Award from the national Chi Epsilon Society; Professor Henry Petroski has been elected to the Distinguished Member level of the American Society of Civil Engineers; and, Professor Roni Avissar has just been appointed Dean of the Rosenstiel School of Marine and Atmospheric Science at the University of Miami. We are sad to see Roni leave Duke, but we also recognize that as our team's accomplishments become increasingly important and visible so too will other schools be increasingly drawing their future leaders from our team.

This summer we welcome Associate Professor Lee Ferguson to the CEE faculty. Lee expands the reach of our Environmental Engineering efforts, with his outstanding program of teaching and research centered on the fate and effects of contaminants in environmental systems. We are also strengthening our ties to the Nicholas School of the Environment with this appointment, as Lee's position is jointly housed between CEE and the Nicholas School.

The department continues to expand its support for our students' service to society as well. As you will read later on, many of our CEE undergraduates are working to improve the lives of people living in developing countries. Our students are also honing their skills in design competitions focused on real world problems. These experiential education opportunities are a true hallmark of our approach to training tomorrow's engineering leaders.

I invite you to learn much more about our activities by exploring our website: **www.cee.duke.edu**

Sincerely,

John Albertson
W. H. Gardner, Jr., Department Chair

cee

Faculty Tribute

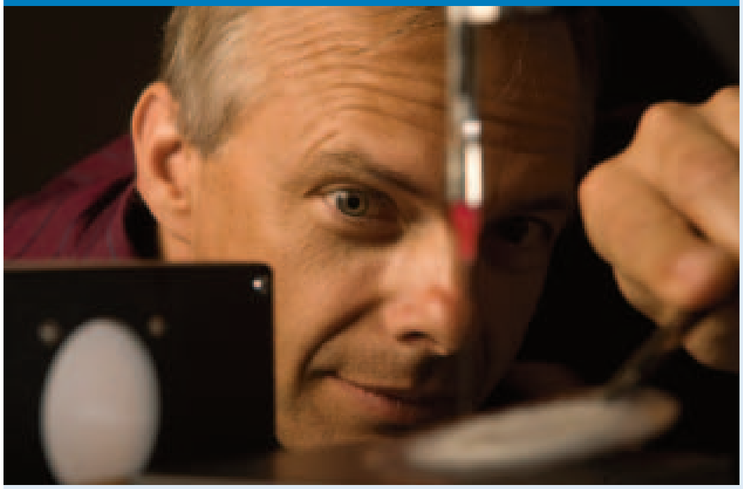
Tribute to Lawrie Virgin

Professor Lawrie Virgin is returning to the faculty of the Department of Mechanical Engineering and Materials Science after leading the CEE department as chair for three years.

His term of leadership was characterized by a continued strengthening of the department's undergraduate and graduate programs, and strong growth in sponsored research. Most notably, under Lawrie's chairmanship, a departmental team led by Mark Wiesner won the $14.4 million NSF/EPA funded Center for the Environmental Implications of NanoTechnology to explore the potential ecological hazards of nanoparticles. Accompanying the winning of this center was important faculty growth in the area of environmental engineering, including the hiring of professor Marc Deshusses, a leader in the field of bioremediation, and associate professor Lee Ferguson, a specialist in environmental toxicology and chemistry applications of high-performance mass spectrometry. The undergraduate program in CEE, always a strength of the department, continued to evolve with a remaking of the water resources and environmental engineering curriculum; Lawrie's administrative leadership was critical in guiding the program through ABET review of its programs in AY 08-09.

Lawrence Virgin

Other hallmarks of Lawrie's leadership are to be found throughout the department. For example, Lawrie launched an annual newsletter publication to raise the visibility of Duke CEE with colleagues and alumni, and a new department website to improve recruitment. In addition to the aforementioned revamp of the environmental engineering curriculum, Lawrie led the establishment of new fluids and structural mechanics laboratories for undergraduate classes. He also emphasized graduate student recognition and strongly supported the Senol Utku Annual Award for best pre-Ph.D. peer-reviewed journal papers. The department is grateful for his service.



“We combined science and engineering knowledge with business and economic modeling to come up with what we think is the maximum amount of titanium dioxide nanoparticles out there,” Robichaud said. “By taking the amount of bulk titanium dioxide produced, which is better understood, and applying the rates of new technologies to convert it to the nanoparticle form found in journal articles and patent applications, we estimated the maximum ceiling amount.”

titanium dioxide powder

Based on her calculations, Robichaud found that the production of titanium dioxide nanoparticles was negligible in 2002 and rose to about 2.5 percent of the total amount of titanium dioxide produced today. By 2015, nanoparticle production is estimated to be about 10 percent of the total, as more companies switch to newer technology. Under the most aggressive scenario, practically all of titanium dioxide in the U.S., about 2.5 million metric tons, would be in nanoparticle form by 2025, Robichaud concluded.

“Knowing the amount of this material is important because the more of it we make, the more likely it is to enter the environment and come into contact with humans with unknown consequences,” said Mark Wiesner, professor of civil and environmental engineering and senior member of the research team. He also directs the federally funded Center for the Environmental Implications of NanoTechnology (CEINT), which is based at Duke.

“We do not have a good handle on how much is out there, and even less about what that might mean,” he continued. “Finding an upper limit on the potential for exposure is the critical first step in assessing risk. Even if these nanoparticles are toxic, a low exposure to them may limit the risk. We just don’t know yet. I like to use the example of sharks. Everyone knows they’re dangerous, but not if you spend your entire life in Nebraska.”

Now that the researchers have a better idea how much of this nanomaterial could be produced in the coming years, they plan to focus on specific types of products.

“We want to get a better idea of where in the process these nanoparticles might be released into the air, water or soil,” Robichaud said. “It could be during mining, during the production of the nanoparticles, production of the specific product using the nanoparticles, the use of the product, or its ultimate disposal.”

The research was funded by National Science Foundation and CEINT. Other members of the team, from Duke, are Ali Emre Uyar, Michael Darby and Lynne Zucker.

Duke Leading New NSF, EPA Funded Center

to Study the Environmental Implications of NanoTechnology

The National Science Foundation (NSF) and the Environmental Protection Agency (EPA) have awarded $14.4 million to create the Center for Environmental Implications of NanoTechnology (CEINT) to explore the potential ecological hazards of nanoparticles.

Nanoparticles are as much as a million times smaller than the head of a pin and have unusual properties compared with larger objects made from the same material. These unusual properties make nanomaterials attractive for use in everything from computer harddrives to sunscreens, cosmetics and medical technologies. However, the environmental implications of these materials are virtually unknown.

The CEINT research team plans to define the relationship between a vast array of nanomaterials — from natural to manmade to incidental, byproduct nanoparticles — and their potential environmental exposure, biological effects, and ecological consequences. Nanomaterials that are already in commercial use as well as several present in nature will be among the first materials studied.

CEINT’s core research team brings together internationally recognized leaders in environmental toxicology and ecosystem biology; nanomaterial transport, transformation, and fate in the environment; biogeochemistry of nanomaterials and incidental airborne particulates; nanomaterial chemistry and fabrication; and environmental risk assessment, modeling, and decision sciences. CEINT is led by director Mark Wiesner, James L. Meriam Professor of Civil and Environmental Engineering at Duke’s Pratt School of Engineering. Wiesner specializes in nanoparticle movement and transformation in the environment.

> “The mesocosm facility will be a highly instrumented shared facility that will engage researchers from around the world.”
>
> - WIESNER

CEINT deputy director Gregory V. Lowry from Carnegie Mellon University and co-principal investigator Kimberly Jones from Howard University each specialize in nanoparticle movement and transformations in the environment. Mike Hochella, a nanogeochemist from Virginia Tech, and Rich Di Giulio, an ecotoxicologist from Duke, are also co-principal investigators. Rounding out the team are CEINT collaborators Gordon Brown, a geochemist from Stanford University, and Paul Bertsch, a soil scientist from the University of Kentucky.

One activity for the research team over the coming year is to develop 32 tightly controlled and highly instrumented ecosystems in the Duke Forest in Durham, N.C. Known as mesocosms, these living laboratories provide areas where researchers can add nanoparticles and then study the resulting interactions and effects on plants, fish, bacteria, and other elements.

CEINT

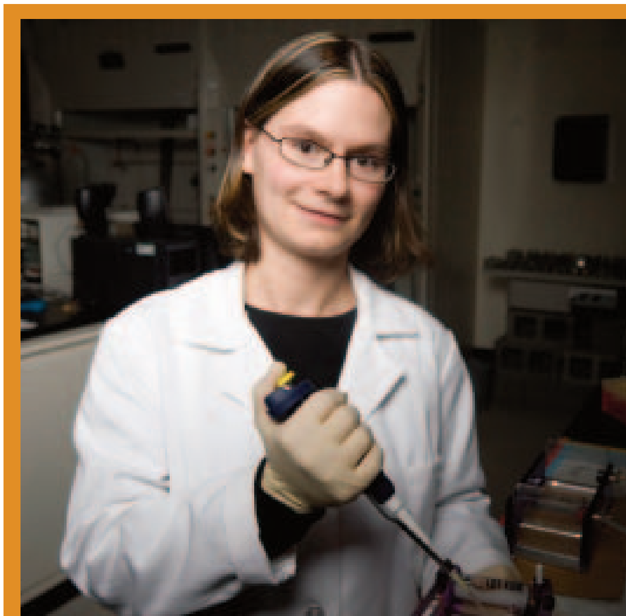
Center for the Environmental Implications of NanoTechnology

http://ceint.duke.edu

ENVIRONMENTAL PROCESS ENGINEERING

Marc A. Deshusses, professor, specializes in innovative methods of removing pollutants or noxious odors from the air using biological systems. His work is at the forefront of creating systems in which colonies of voracious microbes cleanse the air of pollutants. These systems can take different forms. One is a biofilter, where polluted air is humidified and passed through a packed bed of compost, wood chips or activated carbon that are coated with microorganisms. As the air passes through the material, the pollutant vapors are degraded. Another approach is known as a biotrickling filter, which is a biological scrubber where simultaneous absorption and biodegradation of polluted air takes place. Polluted air is mixed with a scrubbing solution, such as water, in a column packed with random plastic material, lava rock, open-pore foam or other inorganic support material. Like the biofilter, the materials are coated with a microorganism biofilm, which aerobically degrades the absorbed pollutants. Deshusses believes that these, and other biological systems, have great potential for the biotransformation of a wide range of substances, including numerous man-made pollutants. The potential for these novel and environmentally friendly bioprocesses for pollution control has yet to be fully exploited.

Mark Wiesner, James L. Meriam professor, specializes in environmental nanotechnology and membrane science applied to environmental engineering. He is the director of the Center for the Environmental Implications of NanoTechnology.



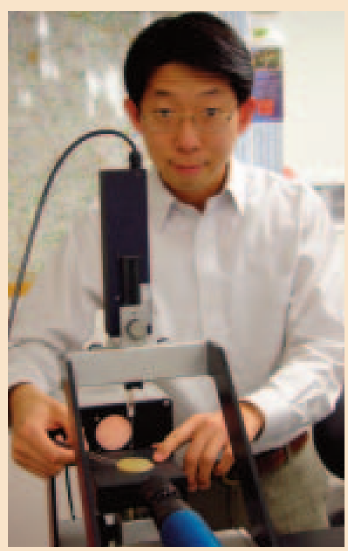
Claudia Gunsch, assistant professor,specializes in environmental molecular biotechnology, and particularly cell and molecular studies of bacteria and fungi, microbial biodegradation of emerging contaminants as well as the application of molecular biological methods to environmental engineering systems. Gunsch was awarded a five-year NSF CAREER award for a project titled "Genetic Adaptation Resulting from Exposure to Anthropogenic Contaminants." She aims to study how microorganisms adapt in water treatment systems.

Buckyballs Could Keep **Water Systems** Flowing

Microscopic particles of carbon known as buckyballs may be able to keep the nation's water pipes clear in the same way clot-busting drugs prevent arteries from clogging up.

Claudia Gunsch, assistant professor, led the team of engineers who found that buckyballs hinder the ability of bacteria and other microorganisms to accumulate on the membranes used to filter water in treatment plants. This attribute leads the researchers to believe that coating pipes and membranes with these nanoparticles may prove to be an effective strategy for addressing one of the major problems and costs of treating water.

"Just as plaque can build up inside arteries and reduce the flow of blood, bacteria and other microorganisms can over time attach and accumulate on water treatment membranes and along water pipes," said So-Ryong Chae, postdoctoral fellow in Duke's environmental and civil engineering department. The results of his experiments were published March 5, 2009 in the *Journal of Membrane Sciences*.



So-Ryong Chae

"As the bacteria build up on these surfaces, they attract other organic matter, creating a biofilm that slowly builds up over time," Chae continued, "The results of our experiments in the laboratory indicate that buckyballs may be able to prevent this clogging, known as biofouling. The only other options to address biofouling are digging up the pipes and replacing the membranes, which can be expensive and inconvenient."

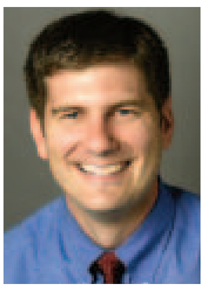
A buckyball, or C60, is one shape within the family of tiny carbon shapes known as fullerenes. They are named after Richard Buckminster Fuller, the inventor of the geodesic dome, since their shape resembles his famous structure.

"Biofouling is viewed as one of the biggest costs associated with membrane-based water treatment systems," said Gunsch. "These membranes have very small pores, so they can get stopped up quickly. If we could increase the time between membrane replacements by 50 percent, for example, that would be a huge cost savings."

The research was supported by the Office of Naval Research, the National Science Foundation and the Korea Research Foundation. Other Duke members of the team were Shuyi Wang, Zachary Hendren and Mark R. Wiesner. Professor Yoshimasa Watanabe, Hokkaido University, Japan, was also part of the team.

Heileen Hsu-Kim, assistant professor, specializes in environmental engineering, environmental chemistry, and nanogeoscience. A major focus of her work is the study of naturally occurring nanoparticles in earth systems and the biogeochemical transformation of mercury in the environment. She recently published "Precipitation and Growth of Zinc Sulfide Nanoparticles in the Presence of Thiol-containing Natural Organic Ligands" in the journal *Environmental Science & Technology* 42, 7236-7241 (2008). Hsu-Kim also serves as the co-adviser to FEMMES, an outreach program that encourages young women to pursue careers in science, math and engineering.

David Schaad, associate professor of the practice and associate chair, specializes in water and wastewater treatment design; disaster planning and recovery; wetland restoration; and energy sustainability. Schaad was recently named a Diplomate of the American Academy of Water Resources Engineers. He continues to develop unique educational opportunities for Duke students and organized student teams that traveled to Honduras, Peru, New Orleans, and Uganda in 2008. He is the faculty adviser for Duke's Engineers Without Borders chapter, and a cornerstone of the university's DukeEngage program, designed to provide service-learning opportunities for undergraduates. Schaad is a professional engineer in 21 states, and conducted more than 400 hours of engineering consulting work during 2008.

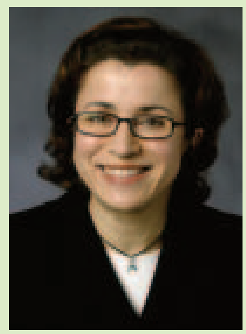


Andrey Khlystov, assistant professor, specializes in air quality research. His work encompasses the study of air quality in near-roadway communities; spatial variability assessment for improved exposure estimates; aerosol thermodynamics in relation to air quality forecasting and climate change predictions; and the development of microchip-based aerosol sensors. He was awarded a 1.5-year $159,752 grant from NSF for a project to develop the initial phase of a microfluidic impactor. In other work for the Environmental Protection Agency, Khlystov is exploring the dynamics of inorganic and organic aerosol nitrogen in the atmosphere. He recently published "Determination of Saturation Pressure and Enthalpy of Vaporization of Semi-volatile Aerosols: the Integrated Volume Method," in the *Journal of Aerosol Science*, 39, 876-887 (2008).

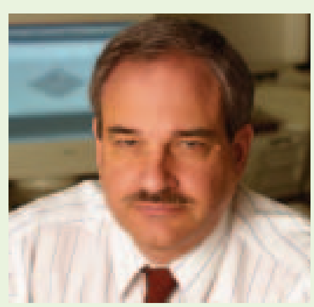
Jeff Peirce, associate professor, specializes in environmental engineering. His work encompasses collaborative large-scale engineering analysis networks for environmental research (CLEANER); applying engineering optimization theories and practices to emerging problems; and laboratory studies of microbial processes responsible for transformation of gases in contaminated soil and transport of gases to the lower troposphere. In 2008, Peirce presented a review of the CLEANER-WATers Science Plan at the National Science Foundation's CLEANER-WATers Network Community Workshop held in Arlington, VA. Peirce also serves as a lecturer in Duke's Fundamentals of Engineering series, designed to prepare students for the professional engineer exam.

HYDROLOGY & FLUID DYNAMICS

John Albertson, professor and chair, specializes in surface hydrology, the effects of climate on semiarid landscapes and water resources, hydroclimatic controls on infectious disease dynamics, and large eddy simulation of turbulence and turbulent transport in the lower atmosphere. In the past year, Albertson was awarded more than $1 million in research funding from NASA to predict the implications of semiarid land cover change on ecosystems' goods and services, and to identify controls and predictability of extreme drought persistence from remote sensing data. He was also awarded $397,000 from the National Science Foundation for a three-year study to extend our predictive capability of climate impacts on water resources in semiarid areas. Albertson recently published "Analysis of coherent structures within the atmospheric boundary layer," in the journal *Boundary-Layer Meteorology*, 131(2): 147-171, 2009.



Ana P. Barros, professor, specializes in environmental physics, hydrometeorology, remote sensing, natural hazards, climate change, and engineering infrastructure. In the past year, she was awarded a two-year $231,835 from NOAA for a project titled "Mapping the Terrestrial Tracks of Hurricanes and Tropical Cyclones Towards Elucidating Water Resource and Ecosystem Impacts and Recovery." Barros continues to lead the very popular first-year undergraduate course series Focus: Engineering the Planet. She also taught a course in principles of environmental modeling, offered for the first time. The course is designed to introduce students to finite-difference and finite-element methods as well as adjoint and Kalman filter models for data assimilation. She is a fellow of the American Meteorological Society.



Miguel Medina, professor, specializes in hydrologic and water quality modeling. His research encompasses contaminant transport within and across the surface and subsurface environments, including surface/subsurface interactions and mixing zones; wetland hydrology and water quality; and the development of a high-resolution acoustic velocity sensor. He recently published "The effect of Surface/Ground Water Interactions on Wetland Sites with Different Characteristics," in the journal *Desalination*, 226, 298-305, 2008. Medina is currently the president of the American Institute of Hydrology. As Director of Undergraduate studies, Medina led the department's recent ABET accreditation review.

Microbe Diet
Key To Carbon Dioxide Release

As microbes in the soil break down fallen plant matter, a diet "balanced" in nutrients appears to help control soil fertility and the normal release of the greenhouse gas carbon dioxide into the atmosphere.

When plants drop their leaves, stems, and twigs, this organic matter slowly becomes part of the soil as a result of decomposition, which is facilitated by bacteria and other microbes. This process adds soilplant nutrients to the soil and releases carbon dioxide into the atmosphere.

Amicare Porporato led a team of scientists who found that the proportion of nitrogen to carbon in this organic matter determines how much nitrogen becomes available to plants in the soil and how much carbon dioxide is released into the atmosphere. Their study also yielded a universal mathematical formula that can predict the decomposition process anywhere in the world. The results of the Duke analysis were published Aug. 1, 2008 in the journal *Science*.

> "One of the key findings of this study is that microbes can adapt and do fairly well in a nutrient-poor environment."
> **- Porporato**

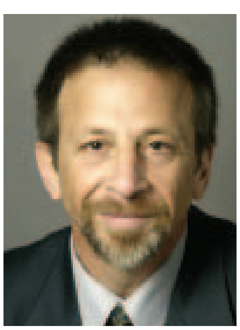
"For the first time, we have been able to demonstrate that the pattern of carbon dioxide release into the atmosphere through decomposition is governed by the same properties everywhere, from the Arctic Circle to tropical rain forests," said first author **Stefano Manzoni**, a Ph.D. candidate in civil and environmental engineering who works in the laboratory of professor Amilcare Porporato. "This provides a mathematical way of describing a critical natural process."

Stefano Manzoni

"One of the key findings of this study is that microbes can adapt and do fairly well in a nutrient-poor environment," Porporato said. "When their diet is lacking in nitrogen, microbes tend to react by releasing more carbon dioxide into the air and taking in less mineral nitrogen from the soil. So plants can get the much-needed mineralized nitrogen earlier in the decomposition process from the fallen organic matter."

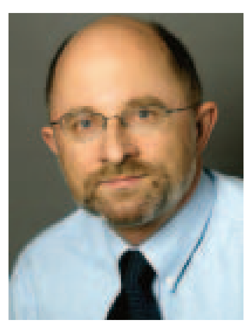
The research was funded by the U.S. Department of Energy and the National Science Foundation. John Trofymow of the Canadian Forest Service was also a member of the team. Much of the data used in the current analysis came from the Long-Term Intersite Decomposition Experiment (LIDET), a partnership of the U.S. Forest Service, Oregon State University and the U.S. Department of Forest Science, as well as the Canadian Intersite Decomposition Experiment (CIDET).

Amilcare Porporato, professor, specializes in ecohydrology, statistical and physical hydrology, soil biogeochemistry, sustainability, and water resources management. He published an article in the August 2008 journal Science titled "The global stoichiometry of the litter nitrogen mineralization." He is currently on sabbatical.

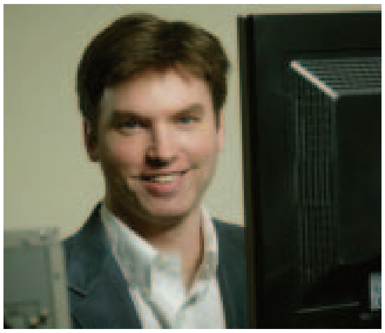


Avissar Named Dean

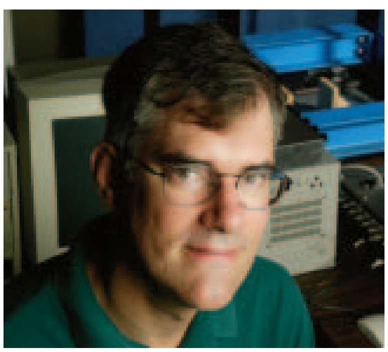
Roni Avissar, professor and former chair of civil and environmental engineering, has been named dean of the University of Miami's Rosenstiel School of Marine and Atmospheric Science. Avissar, a climatologist who has studied the way Amazon deforestation affects precipitation patterns around the world, joined Duke's Pratt School of Engineering in 2001, and served as the W.H. Gardner Jr. Professor and Chair of the Department of Civil and Environmental Engineering for five years. As Chair, he increased research expenditures from less than $1 million to $4.2 million, led a strategic planning process, increased the number of female faculty members, and revamped the doctoral program. Also a skilled helicopter pilot, Avissar was one of the first researchers to employ a specially equipped helicopter to collect environmental data, and has worked closely with NASA and NOAA to advance the field of atmospheric science.



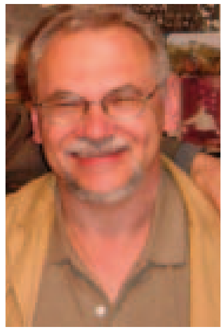
Zbigniew Kabala, associate professor, specializes in stochastic and deterministic theory of fluid flow and contaminant transport in saturated and unsaturated heterogeneous porous media; the theory of related measurements; field and laboratory studies in subsurface hydrogeology; stochastic fields and processes; and numerical and analytical methods and sensitivity analysis. His current research focuses on developing new measurement techniques for characterization of porous media, recovering contaminant release histories from current plume observations, and stochastic modeling of water and solute transport in saturated and unsaturated heterogeneous formations (including cracking soils).



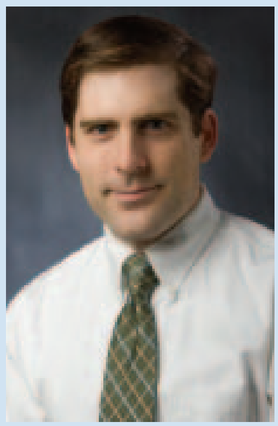
John Dolbow, was named the Mary Milus Yoh and Harold L. Yoh associate professor. His research focuses on the development of numerical methods for problems where evolving interfaces play a crucial role. Recent projects encompass the study of the role defects play in materials systems, and fluid-structure interaction. Dolbow was awarded more than $500,000 in research funding from the NSF and the AFOSR on projects that address membrane nanodomains and microstructured materials. Dolbow will now lead the department's graduate student recruitment as the Director of Graduate Studies.



Henri P. Gavin, associate professor, was certified as a professional engineer in North Carolina in 2008. His research focuses on structural dynamics and earthquake engineering with an emphasis on seismic hazard analysis and parametric or semiactive control systems. He is particularly interested in the protection of equipment and other building contents from earthquake hazards. Gavin is involved in the development and modeling of devices with controllable damping, the development and calibration of detailed models describing seismic hazards, and the use of such models in assessing the level of mitigation provided by equipment isolation systems.



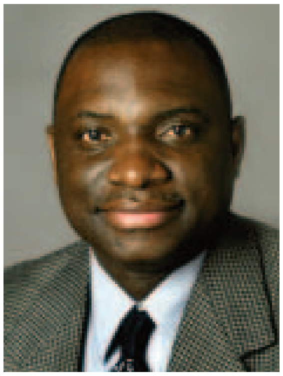
Tomasz Hueckel, professor, specializes in the mechanics of materials and geomechanics. He won the 2008 John Booker Medal of the International Association for Computer Methods and Advances in Geomechanics. This medal, awarded every four years, is the Association's top medal for specific accomplishments. His citation was for pioneering work in the area of environmental geomechanics, in particular for his seminal papers on thermoplasticity of geomaterials and on chemo-mechanical coupling. He was also awarded a Distinguished Visiting Professorship (three months) at the University of Montpellier II in France, and appointed to a three-person Commission of Evaluation of the research of all French laboratories involved in activities related to geomechanics of nuclear waste disposal. He was selected by ANDRA, the French National Agency for Management of Radioactive Waste. His current research is on chemo-mechanics of intergranular mineral contact (NSF grant) and on fundamental phenomena in monitoring principles of deep see subsidence (a grant from Eni-Italy).



Jeff Scruggs, assistant professor, specializes in structural dynamics and mechanics, with a focus on nonlinear systems and energy harvesting. Recent research has focused on optimization theory for energy harvesters such as ocean wave energy harvesting systems and controlling stochastically excited nonlinear vibrations systems when actuators have limited or no access to external energy. Scruggs coauthored an invited article in the "Perspectives" section of the February 27, 2009, issue of *Science* on the current state of the art in utility-scale ocean wave energy harvesting systems. He was also an invited participant in the National Academy of Engineers Frontiers in Engineering Forum in September, 2008.

Joseph Nadeau, associate professor of the practice, specializes in modeling the microstructural properties of composite materials. His work enables the custom design of such materials for wide-ranging applications. Nadeau was awarded the 2009 James M. Robbins Excellence in Teaching Award from national Chi Epsilon, the civil engineering honor society. He will lead the department undergraduate education program as the new Director of Undergraduate Studies. He is also the adviser for Duke's chapter of the American Society of Civil Engineers, and will host the 2010 Carolina's Conference competition in Durham. Nadeau is also certified in North Carolina as a professional engineer.

Henry Petroski, Aleksandar S. Vesic professor, specializes in the study of failure, design, and the history of engineering. In 2009, Petroski was awarded the prestigious Norm Augustine Award for Outstanding Achievement in Engineering Communications from the American Association of Engineering Societies. The award was given to Petroski for "communicating the excitement and wonder of engineering to a broad and diverse cross-section of the public through national and international media appearances, and for widespread readership of his many books, securing his place as the poet laureate of technology." He was also named a Distinguished Member of the American Society of Civil Engineers, and Forensic Engineer of the Year 2008 by the ASCE Technical Council on Forensic Engineering.



Fred Boadu, associate professor, specializes in environmental and exploration geophysics. His research efforts focus on the development of models and laboratory procedures to characterize the geological and engineering stability of unconsolidated geo-materials. Boadu was awarded a three-year $194,00 NASA project in the past year titled "Ground Truthing of Electromagnetic Signals from Earthquakes." One aspect of his research encompasses the role of fractures in nitrate contamination of groundwater in farming communities in rural Ghana. Boadu is also pursuing multidisciplinary research efforts with Fan Yuan in biomedical engineering to characterize tissues using impedance spectroscopy. The goal of the work is to use fractal concepts and artificial neural network models to interpret the measured data and thus enhance our understanding of the process.

Raising Awareness of Ghanaian Farmers

It's not often that a group of eight women college students visits rural farming areas of Ghana. The group worked to raise the awareness of a serious issue facing the villagers. Their goal was also to help provide solutions to the problem of nitrates in the fertilizers used by farmers. The chemicals are leaching through the soil and have seriously contaminated the groundwater. All the villages use groundwater for drinking and other domestic purposes.

The Duke group — sponsored by DukeEngage — spent almost two months in the Nsawam district, part of the Greater Accra Region, located roughly 17 miles north of the capital, Accra. The students went to more than 30 villages, talked with farmers about the use of fertilizers and groundwater contamination, visited hospitals to experience firsthand the health issues caused by water contamination, and went to schools to help educate young Ghanaians on protecting themselves and the environment.

"The World Health Organization has established an eight parts per million (ppm) safety limit for nitrates in water. Many of the water samples from the boreholes were tested and were at least **four times this limit**, with one as high as 45 ppm."

"The main income for inhabitants in the region is the growing of pineapples," said **Fred Boadu**, associate professor of civil and environmental engineering and organizer of the trip. Boadu, a native of Ghana, was assisted by his graduate student Frederick Owusu-Nimo.

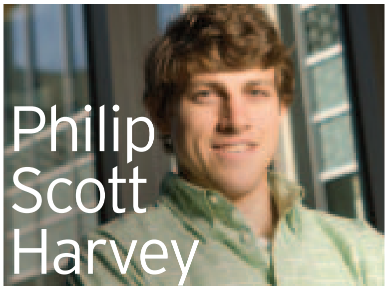
"Biologically, this is a good place to grow pineapples because the plants have short roots and the soil layer is thin," Boadu continued. "To enrich the soil for higher yield, farmers apply fertilizer. However, because the soil can only utilize so much, it often leaches down into the water table.

"The main problem is that most villagers use water from boreholes for their drinking and cooking needs," Boadu continued. "The World Health Organization has established an eight parts per million (ppm) safety limit for nitrates in water. Many of the water samples from the boreholes were tested and were at least four times this limit, with one as high as 45 ppm."

Visits to villages typically began with a meeting with the chief and elders. District and municipal officials sometimes accompanied the group as well as interpreters to provide much of the translation. Government agricultural officials on a few occasions also attended the meetings at the villages.

Undergraduate Student Focus

PRATT UNDERGRADUATE RESEARCH FELLOWS



Major: civil and environmental engineering
Adviser: Zbigniew Kabala, associate professor of CEE
Project title: Mixed-Type Boundary Value Problems For Aquifer Characterization

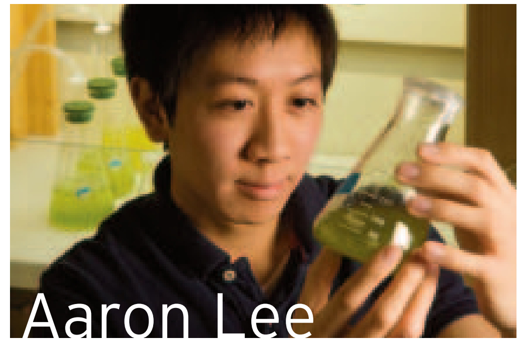
Abstract: Traditional well hydraulics invokes a simplifying assumption of uniform well-face flux, which allows analytic solutions. However, it is well known that for partially penetrating wells this assumption does not hold. By relaxing this assumption and considering zero flux along the unscreened portion of the well, a novel semianalytic model is found. First, the mixed-type boundary value problem for a flowing partially-penetrating well under constant head is investigated for an anisotropic, homogeneous, confined aquifer of finite thickness. The Laplace transform and finite Fourier cosine transform are used to solve the nondimensionalized initial boundary value problem. The well screen is discretized into a finite number of segments, each subjected to unknown well bore flux. Imposing the prescribed constant drawdown allows the determination of the well bore flux function through numerical simulation using Mathematica. Next, a partially penetrating well under constant pumping rate is investigated. After transforming the mixed-type boundary value problem to the Laplace domain, separation of variables is used to derive a general solution for the drawdown. Application of the Gram-Schmidt method yields an approximation for the coefficients in the general form of the depth-specific drawdown. This solution is used via superposition principle to construct a novel semianalytic solution for the dipole-flow test.

Future plans: Scott graduated with distinction in CEE in May 2009. He will attend graduate school at Duke in the CEE Program, working under Professor Henri Gavin. Scott received the James B. Duke Fellowship and a research assistantship.

Major: civil and environmental engineering
Adviser: Zbigniew Kabala, associate professor of CEE
Project title: Transient Pumping Schemes for Efficient Remediation of Contaminated Porous Media

Abstract: Currently, contaminated aquifers are cleaned using the pump-and-treat method in which water is extracted, cleaned, and then pumped back into the aquifer, in an endless cycle until contaminant levels are below regulatory standards. However, this method spans decades, due mostly to the slow process known as matrix diffusion. Matrix diffusion occurs when contaminants diffuse into dead-end pores, where they remain unaffected by external flow, and thus basically, become immobile. The process of removing these contaminants is then left to the very slow process of molecular diffusion, resulting in long durations of remediation. Mawer's hypothesis is that transient pumping rates, rather than steady rates, used in pump-and-treat remediation of aquifers should significantly increase the cleanup efficiency and lower the associated costs through significant shortening of required pumping times. Using FIDAP, a standard computational fluid dynamics software package, she numerically simulated flow through a channel with a single cavity. Mawer demonstrated, first, that steadystate flow through a channel and cavity barely penetrates the cavity and that large immobile zones form within the cavity, trapping contaminant. After testing various transient velocity functions, She found that in a step function flow-rate regime, in which the flow rate changed abruptly, a deep sweep of the cavity is produced. Such a deep sweep can significantly speed up the cleanup of the cavity, even if the contaminant is adsorbing to the walls.

Future plans: Chloe graduated with distinction in CEE in May 2009. She received the Eric Pas Award given for outstanding undergraduate independent study in CEE. She will be attending Stanford next year for a PhD in environmental engineering, with an emphasis in fluid mechanics and hydrology. She will be fully supported the first year.



Major: civil and environmental engineering
Adviser: Claudia Gunsch, assistant professor, CEE
Project title: Photoheterotrophic and Mixotrophic Growth Characterization of Microalgae for Biodiesel Production

Abstract: Currently, almost all biodiesel is produced from plant oils. However, recent attention has been given to algae as a source of biodiesel due to their widespread growth, higher growth rates, high lipid content and the ability to sequester carbon dioxide as part of photosynthesis. Furthermore, studies have shown that some algae species can also be used in wastewater treatment processes, suggesting that algae can be used in the dual function of wastewater treatment and biofuel source. One challenge of cultivating algae in wastewater is the presence of organic carbon sources, which creates the need of characterizing the growth and lipid content effects of the resulting photoheterotrophic or mixotrophic conditions. In this study, *Chlorella protothecoides*, *Chlorella vulgaris*, and *Scenedesmus quadricauda* were selected for further characterization due to their ability to treat wastewater and/or possession of high lipid content. Studies were performed in batch reactors under unsaturated light conditions. The data indicate that all species exhibited higher biomass concentration in the stationary phase with the addition of glucose in the media; however, the growth rates were not significantly different when the media was supplemented with glucose concentrations ranging from 0.5 to 5%. Both Chlorella species grew mixotrophically while Scenedesmus grew photoheterotrophically in the presence of glucose. Also, glucose concentration did not significantly affect the lipid content for any of the algal species.

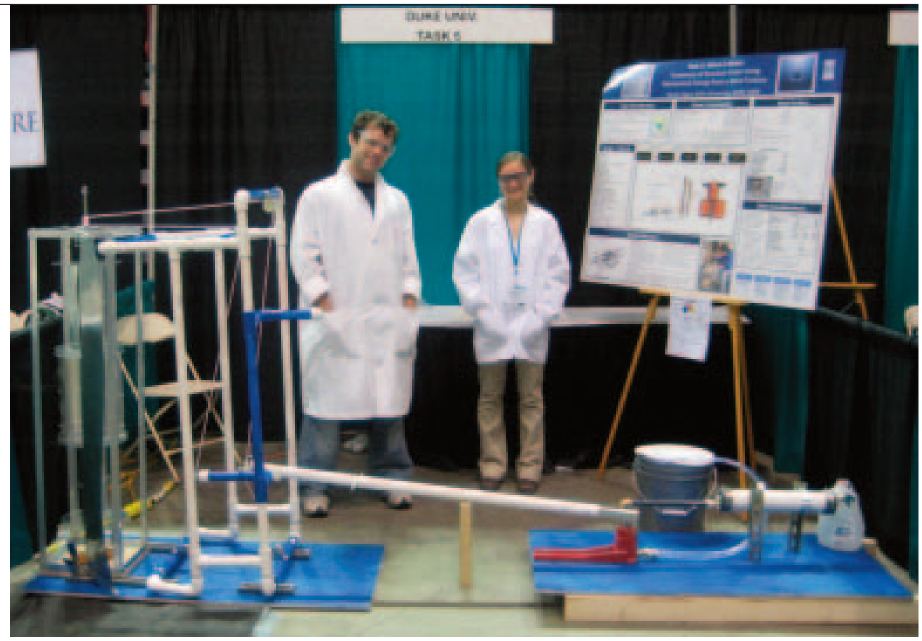
Future plans: Aaron graduated with distinction in CEE in May 2009. He received the Eric Pas Award given for outstanding undergraduate independent study in CEE and received an International Honors Program Certificate at graduation. In addition, Aaron received a Department of Defense SMART (Science, Mathematics & Research for Transformation) Fellowship. With this fellowship he will attend Stanford University for his masters in civil and environmental engineering.

Lauren Wessel

Major: civil and environmental engineering
Adviser: Mark Wiesner, Professor of Civil and Environmental Engineering
Project title: Comparative toxicity of C60 aggregates towards mammalian cells: role of the tetrahydrofuran decomposition

Abstract: C60 fullerene is being manufactured on a largescale and is a promising material due to its unique physiochemical properties. However, previous studies have reported that colloidal aggregates of C60 (nC60) produce toxicity in fish and human cell cultures. The preparation method of the nC60 raises questions as to whether the observed effects stem from the fullerenes themselves or from the organic solvents introduced during the preparation of the fullerene suspensions. The goal of this study was to elucidate the mechanism by which tetrahydrofuran (THF) treatment to enhance the preparation of nC60 leads to cytotoxicity in a mouse macrophage cell line. Results demonstrate that THF/nC60, but not fullerol or aqueous nC60, generates cellular toxicity through a pathway that involves increased intracellular flux and mitochondrial perturbation in RAW 264.7 cells. Interestingly, the supernatants of the THF/nC60 suspension rather than the colloidal fullerene aggregates could mimic the cytotoxic effects. These supernatants were demonstrated to contain toxic THF degradation products, including butyrolactone and formic acid. Thus, the role of nC60 in the cellular responses is likely not due to the direct effect of the nC60 material surface on the cells but is related to the conversion of THF into a toxic byproduct during the preparation of the THF/nC60 suspension. These byproducts appear to be formed as a result of exposure to oxygen over time rather than through fullerene-catalytic reaction.

Future Plans: Lauren graduated with distinction in CEE in May 2009. She was part of the team that won the WERC Design Competition 2009 1st Place Award for PV Monitoring System Design, and the Oak Ridge Associated Universities Award for Environmental Engineering Realization 2009. Next year Lauren will work as an associate consultant at Bain & Company in New York City. She plans to pursue an MD/MBA program in two to three years.



Duke Wins at WERC Contest

After years of heading to New Mexico to compete in a prestigious design competition and coming home empty-handed, this spring Pratt finally has not one, but three prizes, with one team taking first place honors in their division.

One winning team designed an inexpensive and reliable wind-powered water treatment system for use in the developing world, while the other devised a system to monitor the efficiency of solar panels.

The competition, held annually for the past 18 years at New Mexico State University, drew student teams from across the country and Canada. The event is sponsored by WERC: A Consortium for Environmental Education and Technology Development (formerly known as the Waste-management, Education and Research Consortium).

Bryan Grant, Lauren Wessel, Adam Dixon and Nick Menchel - winner of the PV Monitoring System Task

"We've been getting closer each year," said **David Schaad**, CEE associate professor of the practice and faculty advisor for both teams. "Because this competition is often part of some of the competing schools' design courses, many of those teams work on their projects all year. Most of our students have less than a semester to complete their entries, from design to fabrication."

There are usually six tracks in the competition, each one posing a specific real-life challenge or problem to be solved. Each team gives poster and PowerPoint presentations and fabricates a scale version of their device. All were judged by a panel of scientists, academicians and industry representatives.

The first-place Duke team, led by **Adam Dixon**, BME senior, designed a monitoring system that takes into account such environment factors as wind, temperature and sunshine in determining if a particular solar unit is operating at peak efficiency. This team also won the Oak Ridge Associated Universities award for developing a prototype, which is closest to being patentable.

"We designed a system that monitors the output of a particular unit to see if it is performing up to its full potential," Dixon explained. "As more and more of these solar units are installed, the technical know-how is decreasing. Our system can gauge the effects of environmental variables and give you a percent of how much of the unit's output is being used and how much is being lost."

In addition to Adam, other team members included **Bryan Grant** (ECE), **Nick Menchel** (CEE), **Lindsay Rawot** (CEE), and **Lauren Wessel** (CEE), with additional help from **Parv Aggarwal** (ECE].

The second Duke team, which garnered "Most Innovative Design" in their division, tackled the task of designing a water treatment system powered purely by wind to supply the daily needs of a village of 100 without the use of electricity.

That team, led by **Alison Ernst**, MEMS senior, had 15 students with diverse majors, many in the Energy & Environment Certificate program. In addition to **Nick Millar** (CEE), who led the pump/power transmission subteam and **Pim Dangkulwanich** (Chemistry), who led the water treatment subteam, the other team members included: **Matt Ball** (CEE), **Sam Beardsley** (CEE), **Spike Brehm** (CEE), **J.P Dolphin** (Political Science), **Aaron Lee** (CEE), **Will Liew** (MEMS), **Trisha Lowe** (CEE), **Lyndsey Morgan** (CEE), **Peter Perez** (CEE), **Clement Ramos** (MEMP), **Natalia Rossiter-Thornton** (grad student-CEE), and **Deshira Wallace** (Environmental Science and Policy).

"We developed a wind-driven device made up of readily available and inexpensive materials. We determined that the device could filter up to 1,000 liters of water a day, more than enough to fulfill the daily needs of a 100-person village."

-ERNST

"We developed a wind-driven device made up of readily available and inexpensive materials," Ernst explained. "For example, the vertical turbine blades to drive the pump for the full-scale device could be made from empty oil drums. We determined that the device could filter up to 1,000 liters of water a day, more than enough to fulfill the daily needs of a 100-person village."

Ernst and her team hope that other groups that work with people in the developing world – such as Engineers Without Borders – can follow up by using their design in countries in desperate need of clean water.

"This is a great hands-on experience for our students, both inside and outside Pratt," Schaad said. "When you are able to connect a conceptual thought from your own mind and then to actually see it realized and functional – that's pretty phenomenal. It's not only a meaningful reinforcement of the learning process, but a gratifying personal experience."

Duke and the Lord Foundation provided the financial support for the teams attending the competition.

Members of the host consortium include the University of New Mexico, New Mexico Institute of Mining and Technology, Dine College, and the U.S. national laboratories at Sandia and Los Alamos.

SENIOR DESIGN HIGHLIGHTS

Danielle Ouellette, left, Dana Nicholson, right

Students in **CE192, Integrated Structural Design**, are viewing their team's design in the 3-D Duke Immersive Virtual Environment (DiVE). Student teams collaborated throughout the semester to design a structure for a 50,000 square foot multi-disciplinary research facility. All structural elements (columns, beams, slabs, foundation walls, and footings) were designed by the students to withstand design loads (dead, live, snow, wind, and earthquake) and serviceability (deflection) criteria.

(l-r: Thomas Burkland, Kevin Brightly, Devin McDaniel)

(l-r: Ersen Akici, Edmund Finley)

GRADUATE HIGHLIGHTS

Doctoral candidate **Frederick Owusu-Nimo** won the Mack Gipson award from the National Association of Black Geologists & Geophysicists. The award provides $1,500 to promising students in the geo-science profession. Frederick is a student of Associate Professor Fred Boadu.

Doctoral student **Rawad Saleh** won a student poster competition at the 27th Annual Conference of the American Association for Aerosol Research. Rawad's poster described a novel method to study gas/particle interactions of organic substances in ambient aerosol. Rawad, whose graduate adviser is Assistant Professor Andrey Khlystov, aims to improve our ability to predict the fate of such components in the atmosphere and their effects on global climate and human health.

Doctoral candidate **Amrika Deonarine** won the 2009 Environmental Chemistry Graduate Student Paper Award from the American Chemical Society. This is the highest award given to students by the ACS Division of Environmental Chemistry. Amrika earned this award for her paper titled "Precipitation of mercuric sulfide nanoparticles in NOM-containing water: Implications for the natural environment," co-authored with her research advisor Assistant Professor Helen Hsu-Kim. The article was published in Environmental Science & Technology and she received a $1000 award.

Doctoral student **Prabhakar Shrestha** won a 4th Place Student Presentation Award at the AMS 11th Conference on Atmospheric Chemistry held in Phoenix, AZ. His advisor, Ana Barros, notes this was the first conference where Prabhakar presented his doctoral work and that 'anyone who is anyone' (including Nobel Prize winners) in Atmospheric Chemistry attends this meeting, so the competition was intense.

Engineers Without Borders

Engineering Change Uganda

An overarching and more long-term goal was to help a local organization – **Rural Agency for Sustainable Development** (RASD) – become able to fund its own activities without outside help.

A group of 13 Duke students – nine from Pratt Engineering – headed to Uganda with three engineering-related goals – bring the Internet to the local community, improve the ability of local coffee growers to process their beans, and study the use of novel biomass materials to replace the use of charcoal. The trip, directed by associate professor of the practice, **David Schaad**, was supported by DukeEngage.

An overarching and more long-term goal was to help a local organization — Rural Agency for Sustainable Development (RASD) — become able to fund its own activities without outside help. By the end of their time there, the group established an Internet café that was actually turning a profit for RASD, which will help them become self-sufficient and able to fund their own initiatives.

Last year the Duke group installed solar-powered computers. This year's mission, which was presented with more of a technological challenge, was to bring the Internet to an area where the closest connections were 30 bone-jarring miles away in Kampala. The team came up with a plan utilizing a technology that has become ubiquitous worldwide. They were able to access the Internet from a general packet radio service (GPRS) router that was getting the signal from a cell phone tower in town.

The café has another benefit – it will be much easier for RASD officials to prepare and submit grant proposals. The system was running fine when the team left in late August.

The group also went with the intent of demonstrating how coffee growers could shell harvested beans cheaply using a form-made sheller out of concrete. What they discovered was that the growers, since they were selling only the basic commodity, could gain value by cutting out middlemen, such as the shippers. Members of the group helped organize the growers so that they could more cheaply get their product to Kampala for sale and increase their profits.

With the community members, the team also started a project to explore possible alternatives to charcoal, which is a staple for cooking. They looked at such biomass materials as corn cobs, coffee shells or sawdust. While the use of coffee shells may have some potential, more work needs to done. The community members are continuing to study the problem, just as are the students back at Pratt.

The problem with coffee shells is that they densely pack, as compared to corncobs, which can be stacked. Because of this, it's hard for enough air to get inside to fuel a hot fire. The team plans to continue working on the problem in 2009.

As another way of helping the RASD become more self-sufficient, the group engineered and helped construct a large workshop and furnished it with such tools as a drill press, table saw, and welding equipment.

The community members started a vocational education class in early September, and the workshop gave them the tool and space needed to conduct the classes.

While at RASD, Duke students helped them build a workshop, buy the tools, hire a teacher and looked at the school's financials to make sure it was economically sustainable. By the end of September 2008, they had eight students.

Making corncob charcoal.

First users of the Internet café.

Engineering Change **Peru**

Even though it involved backbreaking work with axes and shovels on sun-baked Peruvian bedrock, Maggie Hoff would go back in a heartbeat. For the people.

For much of this past summer, Hoff and 11 other students —including eight from Duke engineering —dug ditches and laid pipe to deliver much-needed clean drinking water to the inhabitants of a squatter community on the hillsides overlooking the Moche Valley on Peru's northern coast. Called Cuidad de Dios, the community of 60 families was formed about a dozen years ago, when flooding from an El Nino forced people who had previously lived on the valley floor up into the highlands.

Although Ciudad de Dios is only about 30 minutes inland from the ocean, it is situated in the desert, receiving less than 2 millimeters of rain each year.

Students and villagers moving pipe; Hoff talking with a native of Cuidad de Dios.

> "Remembering the concepts of frictional losses in pipe flow from my Fluid Mechanics class never seemed so important as when I was trying to calculate whether or not 300 people could feasibly get water from a springbox 3 km away!" **- HOFF**

"Even though it was a tremendous amount of work, especially the physical labor, I would go back again," said Hoff, a civil and environmental engineering junior from Pecatonica, Illinois. "The memories of breaking through bedrock with a pickax are certainly still vivid in my mind, but they are also dominated by recollections of my wonderful, interesting and loving friends in Ciudad de Dios."

This year's visit to Cuidad de Dios was actually Hoff's second. Last year, during a two-week preliminary visit as part of the Engineers Without Borders program, Hoff and other students talked to the people and gathered information about their needs.

On her return from the first trip, Hoff, with the help of **David Schaad**, associate professor of the practice in civil and environmental engineering, and in cooperation with the UNC chapter of EWB, conceived of a plan to bring water three kilometers across the arid landscape to the people. Schaad, working in cooperation with Liliana Paredes and Joan Munne of the Spanish Language Program, developed the DukeEngage supported program - **Engineering Change in Peru**.

A key aspect of the program was not only to bring water to the people but to build relationships with the people and ensuring that they felt an ownership with the project.

"More than anything, we wanted to truly get to know the community and understand their way of life and their needs, because you can't truly help someone until you understand them," Hoff said.

While the water project was the largest part of the trip, the students also worked on community beautification, including trash collection, and the painting of a large mural, with the aid of local children, in the town's central plaza.

They also made adobe bricks and used them to construct signs, which were plastered and painted, to clearly mark an archeological site nearby. First excavated by Brian Billman, University of North Carolina-Chapel Hill, the site is a former home of the Moche, a pre-Incan society of Peru. In exchange for helping to protect the site from looters, Billman funds a development project of the community's choice each year. His organization— MOCHE (Mobilizing Opportunities through Community Heritage Empowerment)— has built a schoolhouse in the town and was a facilitator of the water project.

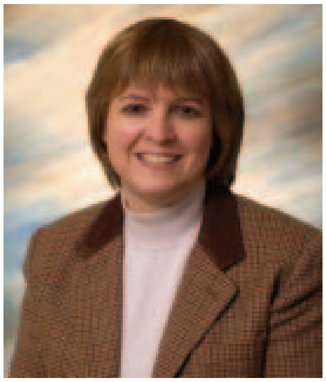
While the students made contributions that will greatly improve the quality of life for community of Cuidad de Dios, Hoff keeps returning to the impact the people made on her personally.

"On one particularly hot day, they were not expected to work, but we students were working anyway," she said. "Halfway through our laborious morning, we saw an enormous group of women and old men from the village, everyone who didn't have to be at other paid jobs, coming towards us with their makeshift shovels and picks in hand. Seeing all of them, walking towards us across the desert outside of their community, voluntarily contributing their time and hard work to a project that meant so much to both them and us, is an indelible image in my mind."

Hoff, who has been involved with Engineers Without Borders since her freshman year at Duke, feels that her experience in Peru will have an impact in deciding what she will ultimately do. The Peace Corps is a short-term option. The field work in Peru was also an opportunity to put to use some of lessons learned back in the classrooms of Duke.

"To see direct applications of the equations and theories I have learned energizes me for my academic work - it provides motivation for learning things that sometimes seem irrelevant," she said. "Remembering the concepts of frictional losses in pipe flow from my Fluid Mechanics class never seemed so important as when I was trying to calculate whether or not 300 people could feasibly get water from a springbox 3 km away!"

Combining Biology, Environmental Engineering



Kathy Banks has a tough time come college basketball season. She grew up in Kentucky, did her undergraduate work at the University of Florida and earned graduate degrees in environmental engineering from two schools separated by eight miles and different shades of blue – University of North Carolina (M.S.E.E.) and Duke (Ph.D. '89).

"It's always difficult to choose, so I usually root for whoever is the underdog. But I am pretty much guaranteed getting a team in the Sweet 16," she says with a laugh.

Now in the School of Civil Engineering at Purdue University, where she has served as Bowen Engineering Head for the past four years and Professor of Civil Engineering for the past 12 years, Banks said that during her graduate studies at Duke, faculty encouraged her to take classes outside of engineering, which permitted her to combine her passions for biology and environmental engineering.

During her time at Purdue and the prior eight years on the faculty of Kansas State University, Banks established an international reputation in the burgeoning field of biological remediation, harnessing the capabilities of plants and microbes as a tool for mediating pollution.

"The Duke faculty always encouraged my expanded interest in biology," she said. "I worked on applied research in the area of wastewater treatment at UNC, and when I came to Duke, I was able to study the fundamental principles of systems that I couldn't have done anywhere else. With all of the specialized labs across Duke's campus, I immersed myself in the basic sciences."

As her career has progressed, the balance between the applied and fundamental research has ebbed and flowed.

"After graduation, I moved away from a fundamental focus to more practical applications because of the availability of Superfund funding," she said. "Over the last 20 years, I've conducted quite a bit of field research, but for the past three or four years, the pendulum for me has swung back in the fundamental research direction. It's been fantastic! I felt in the last few years that I needed to focus on basic scientific questions, closer to what I worked on at Duke. It's been great fun."

Percolation, **ice caps** and supercomputers

Omar Ghattas thinks big. And that's not just because he's in Texas.

His specialty is modeling the dynamics of the earth—from the propagation of seismic waves through the crust, to the flow of heated rock deep in the mantle, to the dynamics of polar ice sheets. To carry out these mammoth tasks, he needs as much computational power as he can get, which is why he's in Austin, Texas, home of the world's largest academic supercomputer.

"My primary focus is on modeling large complex geophysical systems, so everything I do by necessity involves supercomputing," said Ghattas (B.S. '84, M.S. '86, Ph.D. '88), John A. and Katherine G. Jackson Chair in Computational Geosciences and Professor of Geological Sciences and Mechanical Engineering at the University of Texas at Austin.

"An earthquake is a good example of a complex system that would be hard to study without a model, and for that you need a supercomputer," he explained. "Another example is convection in the earth's mantle, where heated rock rises from the core to the crust and then cools and descends. These convection patterns are responsible for tectonic plate motion. Computer models can provide a better understanding of these dynamics as they can simulate what occurs over geological time scales and ultimately their influence on earthquakes and volcanoes."

While he models mantle flows in earth's deep interior, he also uses some of the same principles in modeling the flow of polar ices sheets and their critical role in affecting sea level rise or fall.

Much of Ghattas' time is spent directing the Center for Computational Geosciences in the Institute for Computational Engineering and Sciences. He also serves as the Co-Chief Applications Scientist for the 580 teraflops supercomputer at the Texas Advanced Supercomputing Center.

A one-year post-doc after graduate studies made his Duke stay nine years, a period he said jokingly should have earned him tenure as a student.

"During those nine years, I got to know many faculty members very well," Ghattas said. "Because at the time it was a relatively small program, we developed strong connections with faculty and fellow students. The computational mechanics program gave me a terrific background for my future work."

After leaving Duke, he took his first faculty position at Carnegie Mellon University, where he stayed for 16 years before coming to Texas in 2005.

Researching Disasters

Natural disasters are devastating events, especially in densely populated areas. What Hurricane Katrina did to the people of New Orleans has been well documented. **Laura J. Steinberg** (M.S. '89, Ph.D. '93) would know. She was on the faculty of Tulane University when the storm struck.

Maybe it's a coincidence that she is also one of the leaders of a new field within civil and environmental engineering known as Natech disaster research. Natech is the combination of nature and technological, and represents the study of natural disasters and their ability to devastate industrialized areas. Steinberg and fellow Natech researchers focus their efforts on the use of engineering to develop methods to reduce these impacts and clean up safely during and after the event.

"Cleaning up damaged industrial sites after natural disasters can be quite a challenge because there are usually so many other things going on."

"The area of Natech I work on is the vulnerability of industrial facilities to natural disasters like hurricanes or earthquakes," said Steinberg, Dean of the L.C. Smith College of Engineering and Computer Science and Professor of Civil and Environmental Engineering and Professor of Public Administration at Syracuse University.

"We also look at the environmental impacts of the release of toxic and hazardous materials, the difficulties in recapturing the contaminants, and mitigating their impacts," Steinberg continued. "Cleaning up damaged industrial sites after natural disasters can be quite a challenge because there are usually so many other things going on."

A year after Katrina, Tulane closed down its engineering department, so she joined the faculty of Southern Methodist University and one year later was named department chair in 2007. She became dean at Syracuse last year.

"It's the best job I've ever had," she said. "I work many hours a week interviewing faculty candidates, talking to our volunteer leadership and alums, going to evening functions, meeting with the faculty, and doing lots of travel. For example this June I'm going to Dubai to meet with a donor to discuss our construction internship for Syracuse civil engineers at his construction firm."

One thing Steinberg is particularly proud of is her new Dean's blog about engineering and engineering education (at lcs.syr.edu).

While she still has vivid memories of seeing cows off Old Erwin Road and the dusty photographs hanging on Hudson Hall's basement walls, she credits Duke's location for helping her succeed in life.

"I learned a great deal from my friends during graduate school, not just about engineering but about how to be a better person," she recalled. "I left the New York-New Jersey metropolitan area and came to a place filled mostly with southerners. They taught me gently and purposefully how to connect with people more easily. The rough edges I came down to Duke with became smoother. Without them, I would not have had the success I've enjoyed."

In Mother's Footsteps

Just like her mother, **Ilinca Stanciulescu** (Ph.D. '05) has always excelled at math and science, and also like her mother, she became a civil engineer. A native of Romania, Stanciulescu earned a B.S. and an M.A.Sc. in civil engineering from the Technical University of Civil Engineering in Bucharest, where her mother also taught.

When it came time to do her advanced studies, she came to the Pratt School of Engineering, where she earned a Ph.D. in civil engineering under the guidance of Tod Laursen, Chair and Professor of Mechanical Engineering and Materials Science and Professor of Civil and Environmental Engineering. She is now Assistant Professor of Structural Engineering at the University of Illinois at Urbana-Champagne.

"When you enter college, you go into a dedicated program. It is assumed from day one what educational path you will follow after high school. When we finish with our bachelor's degree, we have already taken more engineering classes than most graduate students here."

"The educational system in Romania is quite different than the system in the United States," Stanciulescu said. "When you enter college, you go into a dedicated program. It is assumed from day one what educational path you will follow after high school. When we finish with our bachelor's degree, we have already taken more engineering classes than most graduate students here."

"However, the Ph.D. programs are solely research, with no classes," she continued. "So by the times Romanians and Americans earn their Ph.D., they are pretty much equal in terms of education, though the route they took was different."

Stanciulescu's research interests are in computational mechanics (non-linear finite elements), constitutive modeling of materials, structural analysis, and non-linear dynamics.

"The applications of most of my research are in aerospace," Stanciulescu said. "I do a lot of collaborations with the Air Force. I spent two months last summer in the Air Force Research Lab in Dayton, Ohio. It was two months of just doing research, and I loved it. It reminded me of my time in graduate school at Duke when you could just think up problems and figure out how to solve them."

This fall, she will be moving to Houston, where she will become assistant professor of civil engineering at Rice University.

Recognizing Excellence

GRADUATE DEGREES: MAY 2009

Sara Joy Morey, M.S.
Adviser: Claudia Gunsch
Thesis: "Gene Silencing in *Pichia pastoris* and *Pseudomonas putida* for Water Purification"

Natalia Anna Maria Rossiter-Thornton, M.S.
Adviser: Claudia Gunsch

Jeffrey Curtin Bandy, Ph.D.
Adviser: Karl Linden
Dissertation: "Innovative Treatment Technologies for Reclaimed Water"

Anne C. Eischeid, Ph.D.
Adviser: Karl Linden
Dissertation: "Fundamental Mechanisms in the Extreme UV Resistance of Adenovirus"

Jean Kristen Guirguis, Ph.D.
Adviser: Roni Avissar
Dissertation: "Observations and Simulations of the Western United States' Hydroclimate"

Heidi Eichinger Holder, Ph.D.
Adviser: Roni Avissar
Dissertation: "A Helicopter Observation Platform for the Atmospheric Boundary Layer"

Shuyi Wang, Ph.D.
Adviser: Claudia Gunsch
Dissertation: "Microbial Impacts of Selected Pharmaceutically Active Compounds Found in Domestic Wastewater Treatment Plants"

DECEMBER 2008

Ernest Hotze, Ph.D.
Adviser: Mark Wiesner
Dissertation: "Fullerene C60: Implications and Applications of Reactive Oxygen Species Generation Under Irradiated and Non-irradiated Conditions"

Stefano Manzoni, Ph.D.
Adviser: Amilcare Porporato
Dissertation: "Stoichiometric and Hydro-climatic Controls on Soil and Litter Mineralization"

Changlong Wu, Ph.D.
Adviser: Karl Linden
Dissertation: "Phototransformation of Organophosphorous Pesticides: Approaches of UV, UV/H_2O_2 Advanced Oxidation and Sensitizing"

GRADUATE AWARDS

2009 Professor Senol Utku awards

The Professor Senol Utku Annual Award recognizes best pre-Ph.D. peer-reviewed journal papers of current doctoral students. The competition rewards the graduate student/faculty advisor team for intellectual excellence, creativity and highest quality work. The award promotes early writing of research articles among graduate students. 2009 winners are:

HIGHEST DISTINCTION

James Rigby and A. Porporato: "Spring Frost Risk in a Changing Climate," journal - *Geophysical Research Letters* (May 2, 2008)

HIGH DISTINCTION

Zachary Hendren J. Brant and M.Wiesner: "Surface Modification of Nanostructured Ceramic Membranes for Direct Contact Membrane Distillation", *Journal of Membrane Science* (November 2008) JMS-081126R1

Jessica Sanders J. Dolbow and T. Laursen: "On Methods for Stabilizing Constraints over Enriched Interfaces in Elasticity" *International Journal for Numerical Methods in Engineering* (2008) NME 2514

UNDERGRADUATE AWARDS

The Eric I. Pas Award – Aaron Lee from Brentwood, Tenn., Chloe Maria Mawer from Houston, TX, and Lindsay Ann Rawot from Bentleyville, OH (Presented to graduating civil engineering seniors judged by the faculty to have conducted the most outstanding independent study project.)

The Aubrey E. Palmer Award – Samantha Elise Beardsley from Columbia, S.C. (Presented to a civil engineering senior in recognition of outstanding academic achievement.)

The American Society of Civil Engineers Prize – Jessica Leigh Barlow, from Mountain Lakes, N.J., and Lauren Beth Lewis from Winston-Salem, N.C. (Awarded to outstanding seniors in civil engineering in recognition of exceptional impact on the student chapter.)

The William Brewster Snow Environmental Engineering Award – Samantha Elise Beardsley from Columbia, S.C. (Presented to a senior who has demonstrated academic excellence, interest and enthusiasm in the study of environmental engineering.)

GRADUATING WITH DISTINCTION:

Samantha Elise Beardsley
Alexander Thomas Brehm
Philip Scott Harvey, Jr.
Aaron Lee
Chloé Maria Mawer
Nicholas Michael Millar
Lindsay Ann Rawot
Jessica Ann Toy
Lauren Elisabeth Wessel

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