DISCOVERY.
INNOVATION.
IMPACT.

THE 2014 RESEARCH REPORT OF THE UNIVERSITY OF VERMONT

Above: View of the west side of the University of Vermont's proposed Science, Technology, Engineering, and Mathematics (STEM) Complex.
For more on the STEM Complex and its role in fostering research, see page 8.

On the front and back covers: A "wire image" of the starting point for all research and intellectual inquiry — the human brain.

We are very pleased to share with you the spirit of discovery, innovation and impact that drives the groundbreaking research taking place at the University of Vermont. UVM is a flagship research institution, and is proud to be one of the nation's public land-grant universities. For more than two centuries, the University of Vermont has engaged in research leading to scientific advances, technological innovation, economic development and enhanced quality of life.

The scope of research at the University of Vermont is broad and diverse, including the fields of human health, energy, food systems, neuroscience, complex systems, animal science, the environment and more. The depth and quality of our research is enhanced by the co-location of a highly ranked medical school and health center with our main campus. Our faculty, staff, and students are engaged — as a community of scholars — in research and discovery that will lead to solutions to the grand challenges we face as a people and a planet today, and must overcome to ensure a safe, sustainable and prosperous tomorrow.

The solutions to these grand challenges (water, food, energy, security, health and healthcare) are complex and are most often found at the intersections of multiple disciplines. The scale and ethos at UVM provide the ideal environment for the personal connections and scholarly collaborations that lead to innovative cross-disciplinary research — a hallmark of our enterprise and a key to our success.

Never has our role as a public research university been as important as it is today. We seek global solutions to grand challenges, but we also take seriously our role in creating jobs, helping build the state's knowledge economy and contributing to sustainable economic growth in Vermont and across the region. Equally important is our role in preparing graduates for success in a complex and ever-evolving world.

We are enormously proud of the research taking place at the University of Vermont. This report provides a sampling of the remarkable things happening on our campus. We invite you to learn more about our continuing journey of discovery, innovation and impact.

DAVID V. ROSOWSKY, PH.D.
PROVOST AND SENIOR VICE PRESIDENT

JOHN N. EVANS, PH.D.
INTERIM VICE PRESIDENT FOR RESEARCH

Left to right: Provost David Rosowsky, UVM President Tom Sullivan, and Interim Vice President for Research John N. Evans review plans for the University's proposed STEM Complex.

DISCOVER MORE

Explore the opportunities to engage our scientists, partner on innovations and support the research mission. Visit:

UVM.EDU/DISCOVERY

RESEARCH HIGHLIGHTS, FACTS & FIGURES

Public research universities have a fundamental responsibility to create knowledge and seek its application for the public good. At the University of Vermont, this tenet is central to our research enterprise. In service to the state, the nation, and the world, UVM discovery takes place in many settings: in laboratories and clinics, agricultural farmlands and research forests, in waterways across the state and in field studies across the globe. The result — innovations that have a significant and positive impact on our lives and the world around us.

With $35 Million in New Funding, UVM Center Aims to Improve Health through Cost-Effective Behavior Change

While policymakers seek to devise the perfect healthcare roadmap, a select few researchers are focusing on a specific intersection — where health, behavior and chronic disease meet — to determine how best to reduce disease risk and prevent premature death. That's the point at which University of Vermont Professor of Psychiatry and Psychology Stephen Higgins, Ph.D., and colleagues working in the Vermont Center on Behavior and Health (VCBH), hope to make a difference. The unprecedented $34.7 million in new grants Higgins received to fund this work in fall 2013 speaks volumes regarding the promise of his group's unique approach.

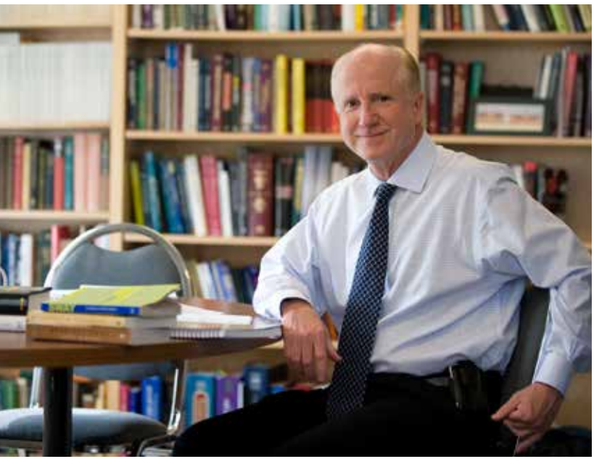
Vermont Center on Behavior & Health
The University of Vermont

Supported by a five-year, $11.5 million Institutional Development Award Center of Biomedical Research Excellence (COBRE) grant from the National Institutes of Health (NIH), the VCBH is one of only three centers in the nation addressing the important challenge of behavioral health from a behavioral economics perspective and the only center directing its considerable scientific and clinical resources towards reducing health disparities.

An internationally respected expert, Higgins is best known for his pioneering research and success in contingency management, a psychological strategy designed to change behavior using modest financial incentives, such as vouchers for groceries and exercise. Soon after the arrival of the COBRE funding, Higgins received a prestigious five-year, $19.5 million Tobacco Centers of Regulatory Science (TCORS) award from the U.S. Food and Drug Administration and the NIH, marking UVM's first P50 — or "specialized center" — grant. UVM is one of just 14 institutions nationwide selected to participate in this new, first-of-its-kind regulatory science tobacco program designed to generate research to inform the regulation of tobacco products — still the leading cause of preventable death and disease — to protect public health.

A third grant notification of a five-year, $3.7 million NIH grant for another smoking-related study closely followed the COBRE and TCORS grants, adding to the VCBH's growing list of projects.

"Unhealthy personal behaviors — substance abuse, physical inactivity, obesity — account for 40 percent of premature deaths in the U.S. annually and substantially increase healthcare costs and health disparities by being overrepresented among economically disadvantaged populations," says Higgins, whose goal is to better understand the causes and devise more effective prevention and treatment interventions for such unhealthy behaviors. ◗



Stephen Higgins, Ph.D., in his office at the Vermont Center on Behavior & Health.

With over 40 years of research data in the lab notebooks behind him, Kenneth Mann, Ph.D., is now leading breakthrough research on coagulation and trauma.

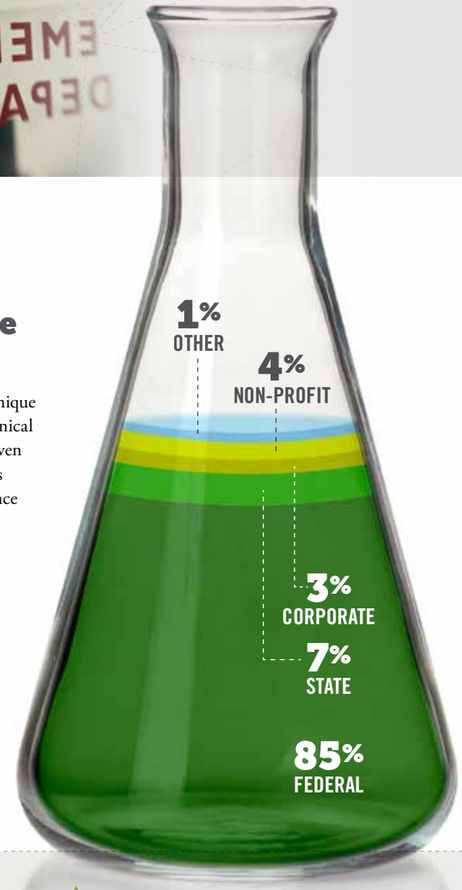
$24 Million Grant Funds Study of Trauma-Induced Bleeding Syndrome

With more than four decades of expertise in the field of blood coagulation, Kenneth Mann, Ph.D., professor emeritus of biochemistry, is perfectly matched to his role as lead investigator of a five-year, $23.8 million multi-center, multidisciplinary National Institutes of Health study focused on a deadly bleeding syndrome — called coagulopathy — that occurs without warning in some trauma patients. Called TACTIC (Trans-Agency Consortium for Trauma-Induced Coagulopathy), the project is a cooperative effort funded by the National Heart, Lung and Blood Institute that establishes a unique collaboration between the NIH and the Department of Defense. Faculty representing five departments at UVM are leading projects for the grant.

When a person sustains a traumatic injury, whether on the battlefield or in a car accident, he/she typically suffers serious physical damage, explains Mann, who adds that often doctors treat the injuries and, if all goes well, the patient gradually heals. However, some patients, regardless of proper treatment, can suddenly suffer from uncontrolled bleeding and die. It is believed that the shock from the trauma induces a "storm" of coagulation and inflammatory problems that prevent their blood from clotting.

"There are no analytical tools that allow emergency department staff to conclude that coagulopathy is occurring in trauma victims; the physicians and staff are left without resources to guide an effective therapeutic approach," Mann says. The TACTIC group, he adds, is "starting from 'ground zero.'"

This trans-agency endeavor links the NHLBI-supported TACTIC program with Department of Defense (DoD) clinical trauma research centers in a unique initiative that integrates laboratory, clinical and early translational, hypothesis-driven research by leading investigators across the country and enables the basic science investigative units to explore clinical specimens obtained from the DoD centers. Mann and the project's leaders believe strongly that their multidisciplinary approach to the problem of coagulopathy — addressing it from the perspectives of the best experts in the fields of clinical science, basic biology, laboratory science and animal research — will help identify a solution to treating this deadly consequence of severe trauma. ◗



Sources of Grants and Contracts

(AVERAGE FY11–FY13)

	AMOUNT	PERCENTAGE
Federal	$103,899,264	85%
State	$8,159,396	7%
Corporate	$3,669,756	3%
Non-Profit Organizations	$4,499,838	4%
Other	$1,305,640	1%

Grants & Contracts (AVERAGE FY11–FY13)

Annual Grants & Contracts	$121,533,894
Number of Proposals (applications)	1,156
Number of Awards (successful applications)	692
People Supported by Awards	1,550

A Partnership Focused on Building a Smarter Grid

Much of the U.S. power grid, though it may seem high-tech, actually represents decades-old technology and design. The IGERT program seeks to create a smarter, more reliable grid for the nation.

The IGERT program — for Integrative Graduate Education and Training — is the National Science Foundation's flagship interdisciplinary training program for preparing U.S. Ph.D. scientists and engineers to address complex, real-world problems. And that means that "smart grid" experts like UVM's Paul Hines, Ph.D., and his colleagues are working across traditional disciplines. The University of Vermont Smart Grid IGERT program — a $3 million, five-year partnership between UVM, Sandia National Laboratories, and several Vermont utilities and industrial corporations — has "a particular focus on the interactions of energy systems with human and group behavior and with public policy," explains engineering professor Jeff Marshall, Ph.D., who directs the UVM IGERT — which is why his team draws researchers from engineering, computer science, public policy, psychology, mathematics, community development, economics, natural resources, and neuroscience.

In the broadest view, the "smart grid" is a new approach to making electrical power systems work better. Using information technologies — ranging from data-collecting meters at the household to sophisticated computer models of how power flows from city to city — a smart grid seeks three goals for electricity: to be cleaner, cheaper, and more reliable. This is a challenge. "If we do have a smarter grid, it's also a more complex system. So there are a lot more options about what to do," says Josh Bongard, Ph.D., a computer scientist and one of fifteen UVM faculty members that are involved in the Smart Grid IGERT. A key part of the smart grid is designed to allow greater use of renewable power, such as solar and wind. Historically, these sources have been a headache in power grids because they're unpredictable and variable. Who knows when the wind will blow? But the smart grid embraces this reality, drawing on more nimble delivery designs that invite participation from power consumers. ◗

COLLEGES & SCHOOLS OF UVM

College of Agriculture and Life Sciences
1 Dean Thomas C. Vogelmann, Ph.D.

College of Arts and Sciences
2 Dean Antonio Cepeda-Benito, Ph.D.

School of Business Administration
3 Dean Sanjay Sharma, M.B.A, Ph.D.

College of Education and Social Services
4 Dean Fayneese S. Miller, Ph.D.

College of Engineering and Mathematical Sciences
5 Dean Luis Garcia, Ph.D.

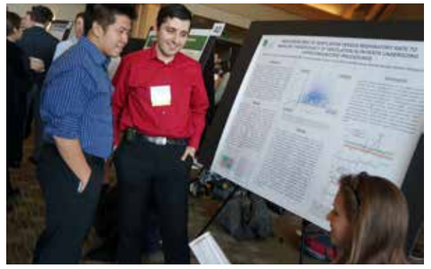
College of Medicine
6 Dean Frederick C. Morin, M.D.

Rubenstein School of Environment and Natural Resources
7 Interim Dean Jon D. Erickson, Ph.D.

College of Nursing and Health Sciences
8 Dean Patricia A. Prelock, Ph.D.

Honors College
9 Dean Abu Rizvi, Ph.D.

Graduate College
10 Interim Dean Cynthia Forehand, Ph.D.



UVM medical students were among the 336 graduate and undergraduate presenters at the 2014 Student Research Conference.

The Next Generation of Researchers Present at UVM's Student Research Day

The 2014 Annual Student Research Conference featured three-hundred and thirty-six students — 198 undergraduates and 138 graduate students — showing posters and making oral presentations at the conference. Seventy-one academic programs were represented from all 10 of UVM's colleges and schools. Student projects ran the gamut from a study on the impact of chronic pain on cognitive functioning to research on bacterial blooms and fatty acids transfer in the Lake Champlain food web to an order book analysis of NASDAQ market data. ◗

Bringing Science to the Farm

The UVM Dairy Center of Excellence (DCE) at the Miller Research Complex is focused on creating research partnerships between UVM scientists and local private farms, with the goal of increasing the economic viability of Vermont agriculture. Since he launched this novel concept in 2010, College of Agriculture and Life Sciences Dean Thomas Vogelmann, Ph.D., has grown the DCE to 19 Vermont farm partnerships and leveraged more than $1 million devoted to the DCE's research priorities.

Now DCE scientists pursue on-farm studies on animal nutrition and health maintenance, disease prevention and treatment, animal welfare, calf and heifer rearing, forage research, new dairy product development, environmental sustainability and evaluation and implementation of innovative technologies.

DCE Director André-Denis Wright, Ph.D., professor and chair of animal science, published over a dozen papers in the last year from his work on developing strategies to increase the efficiency of nutrient utilization in livestock, and to reduce their enteric methane emissions. His research has made significant contributions in the area of molecular microbiology, adding to our understanding of the microbial populations involved in biomethanation and leading to engineering microbiological improvements that benefit energy yields and economic return for dairy farmers. ◗

André-Denis Wright, Ph.D., in his lab at the UVM Dairy Center of Excellence.

Food Systems Hackathon Harvests New Ideas

Just the idea of a "hackathon" suggests a certain kind of energy — creativity and crazy skill mixed with the thrill of a challenge. That maker mentality came together at this winter's conference of Vermont's Northeast Organic Food Association (NOFA-VT), a large gathering of stakeholders from farmers to policy makers, researchers and consumers. In combination with the conference, UVM co-sponsored a food systems hackathon, inviting Code for BTV, a brigade of Code for America, which recruits civic-minded technology experts to problem-solve in their own communities. The groups, combining their areas of expertise, brainstormed about problems that just might be answered by an app built to help a farmer collect data from the field or a retailer seeking a source for golden beets.

Participants first prioritized ideas based on overall importance to Vermont's food system. Teams were then tasked with picking an idea and developing the concept, including features and benefits, timeline and potential liabilities. ◗

Can an app help that? Participants in the Food Systems Hackathon at UVM brainstormed ways to aid farmers.

"THE MHISSION SYSTEM EFFECTIVELY LINKS POPULATIONS TO A WIDE ARRAY OF SERVICES … PROVIDING THE CONNECTION WITH HEALTH CARE AND HUMAN SERVICE DELIVERY IS REALLY THE ESSENCE OF WHAT IT DOES."

—Thomas Simpatico, M.D., Professor of Psychiatry

Professor of Psychiatry Dr. Thomas Simpatico, above left, with Chittenden County State's Attorney T.J. Donovan, at the Costello Courthouse building in Burlington.

On a MHISSION: A Public Health Approach to Justice

Individuals suffering from substance abuse and mental health challenges often end up in the criminal justice system without ever having accessed the treatment that might have prevented their entry in the first place. The State of Vermont, through the office of Chittenden County State's Attorney T.J. Donovan, administers a Rapid Intervention Community Court (RICC) program. Hailed by Vermont Governor Peter Shumlin as "a model for a more effective and humane approach to drug-related crime," the program is designed as a pre-charge system through which offenders are quickly assessed using evidence based screening tools and offered diversion to community programming, services, and community-based accountability programs. In order to provide its ground-breaking service, the RICC Program relies on the use of a novel web-based information system, called MHISSION (pronounced "Mission") that Professor of Psychiatry Thomas Simpatico, M.D., a former Metro Chicago Bureau Chief for the Illinois State Mental Health Authority, brought to UVM and Vermont in 2004. "The MHISSION System," says Simpatico, "is a web-based application that provides unique cross-organizational workflows with embedded decision support mediated by an advanced computing system."

MHISSION has been financed though a variety a of funding streams that include private capital as well as grants from the Veteran's Administration, and the U.S. Health and Human Services' Substance Abuse and Mental Service Administration. These have allowed Dr. Simpatico and his team to adapt the MHISSION System to serve the veteran population, focusing particularly on veteran jail diversion, in addition to other criminal justice-related populations.

"The MHISSION system effectively links populations to a wide array of services," Simpatico says. "That can apply to the homeless population, persons with mental illness and/or substance abuse, veterans, etc. Providing a connection with health care and human service delivery is really the essence of what it does."

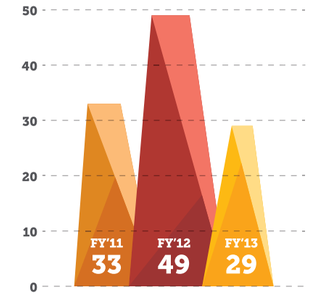
Hailed by Vermont Governor Peter Shumlin as "a model for a more effective and humane approach to drug-related crime," Simpatico's most active current project is a pilot program with Chittenden County's Rapid Intervention Community Court. Developed in partnership with Chittenden County State's Attorney T.J. Donovan, RICC's original aim was to reduce recidivism; with MHISSION's support, offenders with untreated addiction or mental illness get help, eliminating the need for incarceration.

According to Donovan, the time is ripe for criminal justice system reform, and a web-based technological tool like MHISSION is just the ticket to facilitate that change. "We have traditionally looked to address substance abuse and mental illness issues through the lens of public safety with a focus on punishment," he says. "In the partnership I have developed with Dr. Simpatico, we believe we can enhance our public safety by addressing these issues through the lens of public health. What we've done is create an alternative system of justice that is community-based, using public health strategies to enhance our public safety."

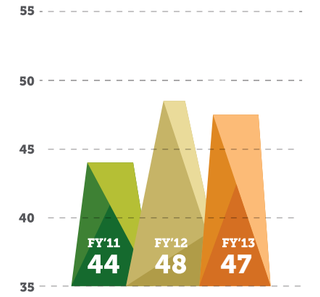
Sometimes, says Corine Farewell, director of UVM's Office of Technology Commercialization (OTC), "The technology is so new that licensing to a startup company is the most desirable way to bring the invention to the market." Such was the case with MHISSION. With the OTC's support, Simpatico established MHISSION Translational Systems in 2012. "Having a spinoff allows us to be more agile in responding to the needs of a growing array of clients," he says.

The Patent Pathway: Ideas Born at the University of Vermont Become Real Products & Companies

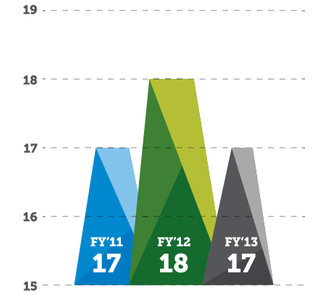
They begin as ideas in the minds of UVM researchers. After rigorous experimentation and testing, ideas that hold promise as patentable intellectual property and products are guided along the road to official recognition and protection by the Office of Technology Commercialization (OTC) to become viable contributors to our economy. (To learn more about the OTC, see page 45.)



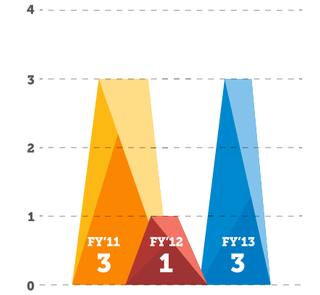
NO. OF INVENTION DISCLOSURES



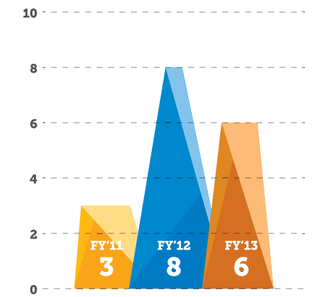
NO. OF LICENSES IN FORCE



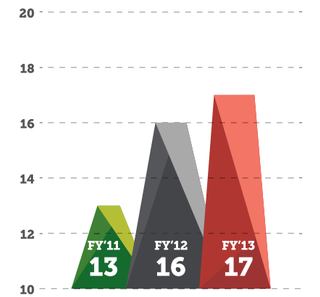
NO. OF NEW PATENT FILINGS



NO. OF STARTUP COMPANIES FORMED



NO. OF LICENSES



NO. OF TOTAL STARTUPS

ECONOMIC IMPACT

$438,725,000
UVM direct annual spending in Vt.

$1,009,000,000
direct & indirect impact on the Vermont economy

$390,725,000
in compensation & benefits to over 3900 faculty & staff

$450,000,000
invested in 82 major capital construction projects since 2002

$13,825,000
per year in visitor-related expenditures in Vt. economy

$1,600,000,000
in annual earnings of 31,400 alums living in Vt. (approx.)

$161,600,000
in state and local taxes paid by UVM alums living in-state

$617,000,000
total annual operating budget at UVM, a 15-to-1 return on state investment of $40.7M per year

DISCOVER MORE

Explore the opportunities to engage our scientists, partner on innovations and support the research mission. Visit:

UVM.EDU/DISCOVERY

RESEARCH FACILITIES

The University is its people, first and foremost. But those talented faculty, dedicated staff, and inquisitive students need superior facilities to realize their full potential. This is particularly true in the area of research and instruction in the sciences, where technology, equipment, and methods rapidly — and continuously — evolve. Research facilities at the University of Vermont serve a wide range of fields, from advanced computing, bioengineering, and clinical trials, to animal science and maple sugaring productivity. Now, the University is poised to enhance its inventory of research space with the construction and renovation of several critical facilities.

New STEM Complex Takes Shape

Science, Technology, Engineering, and Mathematics (STEM) is the collection of academic disciplines that has been associated with the most promising economic development opportunities — areas from which will come solutions to the greatest challenges we face as a nation, a planet, and a people (water, food, energy, security, health and healthcare). STEM disciplines also promise to be key to providing the most new jobs. In Vermont, Governor Peter Shumlin has called for significant growth in the number of STEM graduates to fill jobs in the state, to help attract new companies to Vermont with the promise of talented and well-educated university graduates, and to create new technologies and companies that will create new jobs in the state — in manufacturing, in wind energy, in smart grid technologies, in solar power, in aerospace systems, in biotechnology, in e-commerce, in health-care informatics, and in advanced computing.

The University of Vermont has identified a Science, Technology, Engineering, and Mathematics Initiative as a high priority, and in spring 2013 the UVM Board of Trustees granted preliminary approval for construction of a STEM Complex, a modern laboratory facility strategically crafted as a combination of new construction and renovation. Taken together, the STEM Compex will comprise a selectively renovated Votey Hall, a new laboratory building, and a new building for classrooms, team-based learning spaces, and offices, totaling more than 266,000 square feet. The STEM Complex will serve as a figurative spine for the Central Campus, bridging the magnificent buildings of University Row to the west, with the health sciences complex to the east, and the Davis Student Center and the residential life areas to the south. ◗

An architect's rendering of the entranceway of the east side of the proposed new UVM STEM Complex.

"CONSTRUCTION OF INNOVATIVE STEM TEACHING AND RESEARCH SPACES IS ESSENTIAL TO THE CREATION OF NEW CURRICULA AND NEW PROGRAMS THAT WILL INSPIRE AND ENGAGE STUDENTS IN ALL COLLEGES. SCIENTIFIC LITERACY, TECHNICAL COMPETENCY, AND AN UNDERSTANDING OF THE ROLE SCIENCE AND TECHNOLOGY PLAY IN SHAPING OUR SOCIETY MUST BE CONSIDERED CORE COMPETENCIES FOR A UVM GRADUATE."

— Provost David Rosowsky

DISCOVER MORE: Learn how you can support the STEM Complex project at: **UVM.EDU/DISCOVERY**

CAMPUS HIGHLIGHTS

The work of discovery goes on at UVM in many settings: laboratories and clinics, waterways, farmlands and forests, on campus, throughout the state and across the region.

MRI Center for Biomedical Imaging

This research-only facility was established in 2006, and in 2009 was selected by Philips for the first installation in North America of the Acheiva 3.0T TX magnet. Utilized for both basic science and clinical research projects, the Center specializes in functional and static brain imaging, with a full complement of imaging for all anatomic regions of the body.

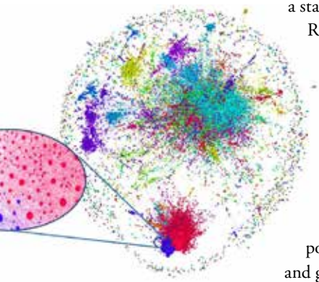
Melosira Research Vessel

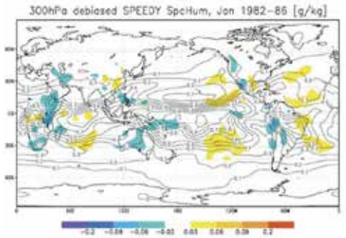
UVM's waterbound laboratory, the 45-foot-long Melosira, supports a wide variety of research activities, educational trips and public outreach related to Lake Champlain. The Melosira is staffed with a full-time Captain and Deckhand experienced in all aspects of limnological, geological, and fisheries sampling, with features including electronic charting, water quality measurement equipment, bottom samplers, scientific survey support, and more.

"Big Data" and the Vermont Advanced Computing Core

Supporting innovative computational research and education at the University of Vermont, the Vermont Advanced Computing Core (VACC) provides a valuable supercomputing resource and accessibility to the UVM research enterprise, attracting world-class faculty and strategic partnerships to both UVM and Vermont. Required for the wealth of emerging "big data" studies, the VACC supports diverse, multidisciplinary, and high-impact work in social media, global climate and weather prediction, health informatics, evolutionary robotics, contagion, renewable energy, and materials science, to name just a few.

UVM faculty and collaborators routinely run programs on the VACC that, taken in total each year, would need the equivalent of over 600 years — or eight human lifespans — on a standard computer. Recent UVM discoveries using the VACC include measurements of global happiness, new understanding of catastrophic power failures and grid resilience, models for U.S. hurricane prediction, studies of brain imaging and addiction, and new (quantum) knowledge of condensed matter physics.





Above and below left, data visualizations from UVM faculty and student work at the VACC. At right, a detail of the "Bluemoon Cluster" supercomputer.

Affectionately known by its many users as the "Bluemoon Cluster," the UVM VACC supercomputer was developed with IBM systems architecture in 2004. Since then, the facility has received three major upgrades with next-generation, IBM high performance computing (HPC) hardware in order to optimize performance and data storage while maximizing data security and energy efficiency for an increasing number of users.

VACC Director Melody Burkins, Ph.D., works closely with computing professionals from UVM Enterprise Technology Services (ETS) to invest in "green," energy-efficient hardware upgrades and use protocols that mirror those of international supercomputing centers, ensuring UVM faculty can easily collaborate with colleagues around the world.

The VACC currently supports over 240 active users across 35 disciplines and has been cited as a critical resource in faculty requests for over $160 million in competitive research funds since 2005. In addition to supporting innovative faculty, the VACC is a cornerstone of university-industry collaborations to advance state, regional, and national projects in energy, healthcare, and the environment. With the growth of "big data" research opportunities increasing almost daily, the VACC has become a unique and invaluable facility, positioning the University of Vermont well for highest-impact discovery and innovation in our digital age. ◗

The Vermont State Health Laboratory is seen in the rendering above, and during actual construction in April 2014, below.

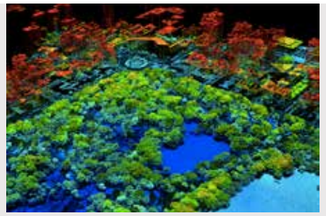
Vermont State Health Laboratory and UVM Research Facility Create 'State Scientific Campus' in Colchester

After more than a decade of discussion and planning, a groundbreaking ceremony was held in April 2013 for a new Vermont State Health Laboratory co-located with the University of Vermont Colchester Research Facility. Expected to be completed in fall 2014, the 47,844-square-foot building will be physically connected to the Colchester Research Facility.

Vermont Commissioner of Health Harry Chen, M.D., and UVM President Tom Sullivan were aligned in the vision to create a state scientific campus in Colchester, recognizing the benefits of partnering on specialized medical research, the potential for increasing research funding and enhanced recruitment, and cost economies resulting from sharing facilities.

The new building was designed collaboratively by the health department and UVM to facilitate collaboration between University researchers and public health scientists and maximize the advantages of having the two buildings in close proximity. A number of UVM scientists in biochemistry, medicine, pathology, and pediatrics are conducting work in the basic sciences and population science in laboratories in Colchester. Sharing specialized space with health department scientists increases opportunities for cooperative projects that bridge the distance from the research bench to the community to health policy. ◗

CAMPUS HIGHLIGHTS



Spatial Analysis Lab (SAL)

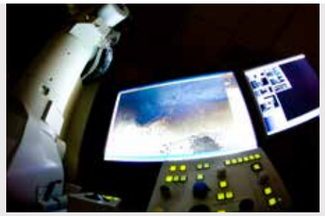
This lab is focused on the application of appropriate geospatial technologies to challenges in natural resources planning and ecology. With expertise in turning big geospatial datasets into high-value information for analysis, planning and management, the SAL specializes in land-cover mapping, development of databases and new applications for natural resource management, and biodiversity analysis.

Clinical Simulation Laboratory

A collaboration of the UVM Colleges of Medicine and Nursing & Health Sciences, and Fletcher Allen Health Care, the Sim Lab is actively involved in research to optimize the use of simulation in clinical training and to link educational activities to improvements in patient outcome. Investigators evaluate the impact of clinical innovations and facilitate the development of best practices and new technologies in health care.

Proctor Maple Research Center

This research center comprises 200 acres of wooded and open land, including an actively managed sugarbush for maple syrup production and research. In the laboratories, researchers explore efficient sap collection technologies (such as the improved tree tap seen above) and evaporation systems, weather variables affecting sap yield, sap biochemistry and microbiology, syrup chemistry, and basic research on the physiology and health of sugar maple trees.



The Microscopy Imaging Center (MIC)

This Core Facility is a multi-user resource for sample preparation and collection and analysis of images for biological and materials applications, as well as providing microscopy-based services, training, and consultation across UVM and Vermont. The MIC consists of multiple microscopy-based imaging systems, computers and software for image analysis, and is also a CAP-certified laboratory performing electron microscopic clinical diagnosis.

Paul Miller Research Complex

The Miller Complex functions as a teaching and working farm and an on-farm research facility with an emphasis on dairy research, equine sciences, mammary biology, milk quality, biosecurity and safety. The Complex plays a key role in the development and promotion of agriculture in the region, and is home to the UVM wetlands project which is researching ways to use wetlands and natural filters to reduce farm run-off pollution.

Laboratory for Clinical Biochemistry Research

This Laboratory is focused on understanding molecular risk factors for the development and progression of cardiovascular disease, diabetes, and other chronic diseases of aging. The lab has a role in hundreds of projects and multicenter cohort studies around the world, including the National Heart, Lung and Blood Institute's Cardiovascular Health Study, an ongoing study of risk factors for the development of cardiovascular heart disease.

CAMPUS HIGHLIGHTS

BIOMEDICAL SCIENCES

The largest and most expansive research focus at UVM is in the biomedical sciences, which accounts for well over two-thirds of the external funding that comes to the University. Ranging from the study of cancer at the molecular level, to bioengineering new lungs, to saving patients in their critical first hours after a stroke, physicians and biomedical scientists at UVM are engaged in creating new knowledge about disease and wellness at every level. Transformative milestones of discovery at UVM happen in the basic, clinical and behavioral sciences, and faculty are proving adept at successfully navigating an increasingly competitive landscape while continuing to serve in national leadership roles and mentoring the next generation of physicians and scientists.

Vaccine Testing Center Plays National Role in Global Research Effort

BETH KIRKPATRICK, M.D., PROFESSOR OF MEDICINE AND DIRECTOR OF THE VACCINE TESTING CENTER

The University of Vermont's Vaccine Testing Center (VTC) plays a key role in the fight against infectious diseases that impact much of the world's population. Founded in 2002 by Beth Kirkpatrick, M.D., the VTC runs a fully functioning unit for performing domestic Phase I, II and III vaccine trials and enteric challenge models; international field trials in infectious disease; and exploratory work in human immunology. The VTC has made significant contributions to the development and testing of many vaccines against infectious diseases of global importance, including typhoid fever, dengue fever, Campylobacteriosis, and infections with West Nile virus, cholera, rotavirus and polio.

The last five years have been very productive at the VTC. Multiple early-stage clinical trials conducted since 2009 in conjunction with the National Institutes of Health (NIH) and Johns Hopkins University show promising results for a vaccine against dengue fever, a disease reported to infect 50 to 100 million individuals annually. Results from this series of trials were published in March 2013 in the *Journal of Infectious Diseases,* and showed that the investigational vaccines are safe and stimulate strong immune responses in most vaccine recipients.

In July 2013, the VTC and two other US sites launched a Phase III placebo-controlled clinical trial for a single-dose oral cholera vaccine, sponsored by PaxVax, a company dedicated to the development of socially responsible vaccines. "UVM is one of only a few U.S. sites with experience doing this type of vaccine-challenge study," says Kirkpatrick, "which is why we were approached to participate." Over the next year, the VTC will continue work with PaxVax in a new trial to evaluate the same oral cholera vaccine in an older population of volunteers. Cholera causes an estimated three to five million cases and a reported 100,000 to 120,000 deaths annually, according to the World Health Organization, and the need for a single-dose oral vaccine is critical to addressing its disease burden.

Most recently, the VTC launched recruitment efforts for a year-long Phase I trial of a live-attenuated West Nile virus vaccine, developed by the NIH. This vaccine has been studied in healthy adults ages 18–50 and has been found to be safe, well-tolerated and immunogenic. Again in collaboration with Johns Hopkins and the NIH, the VTC will evaluate the West Nile virus vaccine's safety and immunogenicity in an older population aged 45–60.

Professor of Medicine Beth Kirkpatrick, M.D., directs the Vaccine Testing Center at UVM, where preventive agents for some of the world's most devastating infectious diseases have been tested during their development.

In addition to U.S.-based clinical trials, Kirkpatrick and colleagues from the University of Virginia received a Bill and Melinda Gates Foundation grant in 2011 supporting work to understand the spectrum of biologic and immunologic reasons for failure of oral polio and rotavirus vaccines in infants in Bangladesh and India. This four-year study enrolled over 1,000 infants in the urban slums of Dhaka and Kolkata, where oral vaccines underperform in the context of high levels of malnutrition and poverty. The study aims to find answers to better protect children in the developing world from death and disability due to vaccine-preventable diseases.

Customized Treatment for the Most Common Heart Rhythm Disorder

PETER SPECTOR, M.D., PROFESSOR OF MEDICINE

As a cardiologist, Peter Spector, M.D., has seen his share of patients suffering from the nation's most common heart rhythm disorder, atrial fibrillation (AF). AF is characterized by extremely irregular and fluctuating heartbeat and is responsible for up to a 24 percent increase in a patient's risk of stroke, and as much as a two-fold increase in the risk of death. But Spector has often felt powerless to help patients with advanced cases of AF.

The current treatments — medication and catheter ablation — are inadequate. In fact, most AF patients are not candidates for ablation, which uses targeted application of heat to change how electricity flows through the heart. Of the AF patients who are candidates for ablation, only about 75% see a cure. In the most advanced cases the success rates for ablation can be less than 50%.

In patients with simple abnormal heart rhythms, ablation has a high success rate because doctors can more easily record the heart's electrical activity and understand where to place catheters for the most effective outcome. In AF patients, however, the heart's rapid and disorganized electrical activity makes it difficult for doctors to interpret electrical recordings, draw conclusions, and understand how best to guide the procedure.

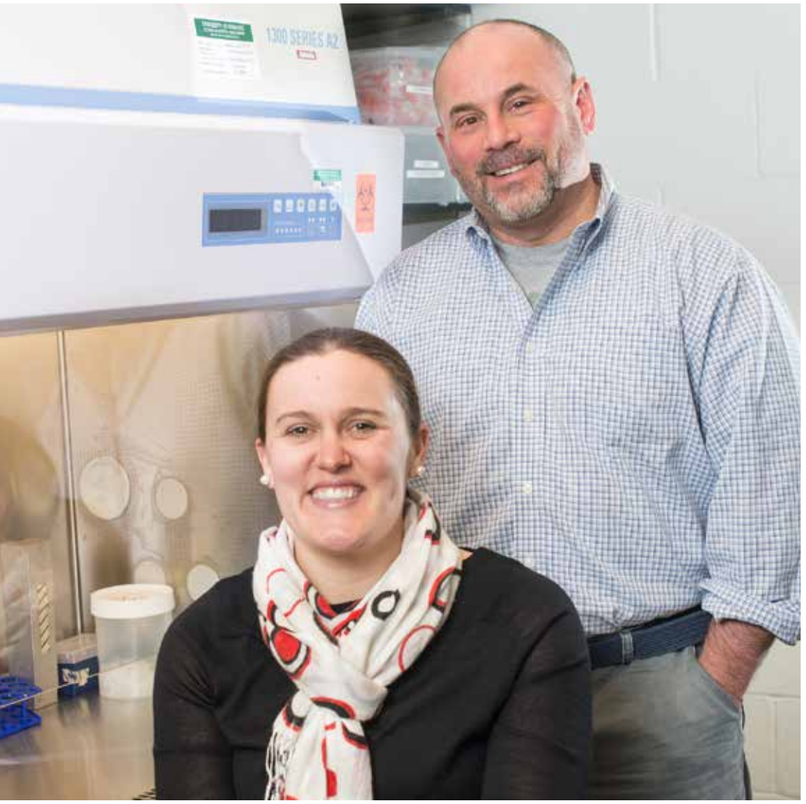
As a researcher, Spector aims to improve on the one-size-fits-all approach toward ablation. He is developing better mapping of the electrical activity and structure of an AF patient's heart via electrical recordings and CT scans. Through this improved mapping, doctors can more effectively target the sites in the heart that need to be addressed and deliver patient-specific treatment.

Over several years, Spector has developed a method of analyzing electrograms to determine the density of rotors, or rapidly firing reentrant circuits, in the heart tissue of AF patients. The insight he has gained has allowed him to better understand why medications in AF patients stop working; why ablation is effective in early AF but not in more advanced AF; why medications sometimes work after an unsuccessful ablation but not before; why AF is common shortly after a successful ablation; and why AF is common after cardiac surgery.

Peter Spector, M.D., seen here in the Fletcher Allen Health Care cardiac ablation lab, works to develop ways to deliver better treatment to patients with the heart rhythm disorder atrial fibrillation.

Spector's research could result in significant increases in the rate of cure in AF patients. With AF creating an enormous burden on patients and the health care system, improving treatment would not only save lives but also would hold down costs. The significance of his research caught the attention of philanthropist and one-time heart patient Tom Evslin, who, with his wife, Mary, donated $1 million to support the scientific and clinical aspects of Spector's project. This work has now led to development of a new catheter and mapping approach to identify which areas in the heart should be targeted during an ablation for patient-specific ablation therapy.

In addition to establishing one of the leading electrophysiology programs in the nation, Spector has created a spinoff company, Visible Electrophysiology, LLC. With UVM bioengineer Jason Bates, Ph.D., Spector co-developed software that models the electrical behavior of the human heart, making it an effective tool for medical education and research applications. In their recent publication in the journal *Circulation: Arrhythmia and Electrophysiology,* Spector and Bates report the improvements they have made in training for electrophysiology. An editorial in a major electrophysiology journal has highlighted the article as recommended reading for cardiologists and researchers.



Daniel Weiss, M.D., Ph.D., standing, and Darcy Wagner, Ph.D., work to develop replacement lung tissue for patients with COPD and other illnesses.

Setting a New Bar in Lung Regeneration Research

DANIEL WEISS, M.D., PH.D., PROFESSOR OF MEDICINE

In end-stage lung disease, transplantation is sometimes the only viable therapeutic option, but organ availability is limited and rejection presents an additional challenge. Innovative research efforts in the field of tissue regeneration, including pioneering discoveries by Daniel Weiss, M.D., Ph.D., and colleagues hold promise for this population, which includes an estimated 12.7 million people with chronic obstructive pulmonary disorder (COPD), the third leading cause of death in the U.S.

Lung tissue bioengineering, which involves the use of a scaffold — or framework — of lungs from human cadavers to engineer new lungs for patients with end-stage disease, is the current focus of Weiss and his team's work. In the past two years, he and colleagues have published a number of articles on the topic of stem cell-related lung regeneration, including six articles in *Biomaterials,* the leading bioengineering journal.

These studies have examined multiple perspectives on the process of stripping the cellular material from these lungs – called decellularizing — and replacing it with stem cells (recellularization), in an effort to grow new, healthy lungs for transplantation.

Working in animal and human models, Weiss and colleagues have addressed numerous challenges faced during the lung tissue bioengineering process, such as the storage and sterilization of decellularized cadaveric scaffolds and the impact of the age and disease state of donor lungs on these processes. In one of their most recent *Biomaterials* studies, the researchers reported on novel techniques that increase the ability to perform high-throughput studies of human lungs which allow researchers an opportunity to closely examine cell types, growth factors, and environmental influences like mechanical stretch — normal breathing motions — that affect successful lung recellularization.

Darcy Wagner, Ph.D., a postdoctoral fellow in Weiss' lab, developed a technique to dissect out and recellularize multiple, small segments in a biological/physiological manner that would take into consideration the appropriate three-dimensional interaction of blood vessels with the lung's airways and air sacs. Working with UVM biomaterials engineer Rachel Oldinski, Ph.D., the researchers further developed a new method using a nontoxic, natural polymer derived from seaweed to use as a coating for each lung segment prior to recellularization. This process allowed the team to selectively inject new stem cells into the small decellularized lung segments while preserving vascular and airway channels. Use of this technique, which resulted in a higher retention of human stem cells in both animal and human scaffolds, allows the small lung segments to be ventilated for use in the study of stretch effects on stem cell differentiation.

Through another novel technique — thermography or thermal imaging — Weiss and colleagues developed a non-invasive and non-destructive means for monitoring the lung scaffolds' integrity and physiologic attributes in real-time during the decellularization process. The method could be used as a first step in evaluating whether the lungs and eventual scaffolds are suitable for recellularization and transplantation.

This study and Weiss' related publications over the past year and a half showcase the positive impact of the $4.26 million National Institutes of Health Director's Opportunity for Research grant he received in October 2010. In addition to these scientific accomplishments, Weiss has forged strong industry ties, and has several patents pending.

Working to Fine-Tune the Immune System

EYAL AMIEL, PH.D., ASSISTANT PROFESSOR OF MEDICAL LABORATORY AND RADIATION SCIENCES

Microbiologist Eyal Amiel, Ph.D., didn't think he wanted to study immunology, let alone make a career of it. But as co-author of a paper recently published in the journal *Nature Immunology,* Amiel is at the forefront of research that could eventually lead to changes in vaccine design, along with new approaches to treating immune-related diseases.

Amiel's research focuses on dendritic cells, which are critical to the immune system; their function is to process antibody-generating materials, or antigens, and present them to T cells, which then shape the immune response. His study considers the cellular upregulation of glucose, which maintains a cell's energy but also creates fatty acids that are secreted by the cell as part of its immune activity. Together with his colleagues, Amiel determined that the early consumption of glucose is vital to the activation of cells, in terms of the production and secretion of proteins that are essential to the cells' immune function. Amiel is already bringing these findings from mouse to human, having spearheaded a memorandum of understanding with the Champlain Valley Physicians' Hospital in Plattsburgh, N.Y., which will provide his lab with human blood cell filters, a waste product. The lab will reverse flush the white blood cells out and fill them with cultures, allowing them to make new observations about the innate immune response in humans.

Amiel's graduate work at Dartmouth, where he earned a doctorate in microbiology and immunology, focused on the two categories of receptors and the relationship between them — signaling cells, essentially the "on" switch to the cell's immune protection program, and recognition molecules that facilitate the engulfment of bacteria — and how they cooperate to bring bacteria to the surface. He found that if you take away some of the interactions between the two, you can push that fine balance of the immune system into problem areas like sepsis.

At New York's Saranac Lake-based Trudeau Institute, Amiel undertook a postdoctoral project, in which he studied the metabolic regulation of dendritic cell activity. When dendritic cells are activated, they undergo fundamental changes in their use of nutrients, increasing dependence on sugar consumption. Specifically, he wanted to gain an understanding of why cells change their metabolism when they're activated, whether that is necessary for their activation and what happens if it is modulated. By understanding the metabolic switch in both directions, Amiel hypothesizes we could increase immune activity where we might want to — in vaccines, for instance — or we could dampen it where that would be advantageous, as in autoimmune disease or hyper-inflammatory conditions.

In February 2014, Amiel received a patent for a method of producing activated antigen presenting cells and potential methods of using them in anti-cancer vaccines. He's looked at the application of dendritic cells on a melanoma model in mice, and his lab is beginning research into glutamine, which shares many properties with glucose, but may be more important in governing what cells do. One finding Amiel's lab has made is that the activation of dendritic cells means a shortening of their lifespan, which they've determined is metabolically linked. By manipulating key metabolic pathways, Amiel says, they can toy with their activation and cell survival, something that could result in dendritic cells that have both longer lives and bigger immune responses than their normal counterparts, and would therefore be beneficial in mounting an immune response to a tumor.

"The immune system is constantly riding that fine line between how much protection we can have without too much collateral damage," Amiel says, noting that the system is based on being toxic to the non-self. "It's really that fine line that makes immunology so interesting."

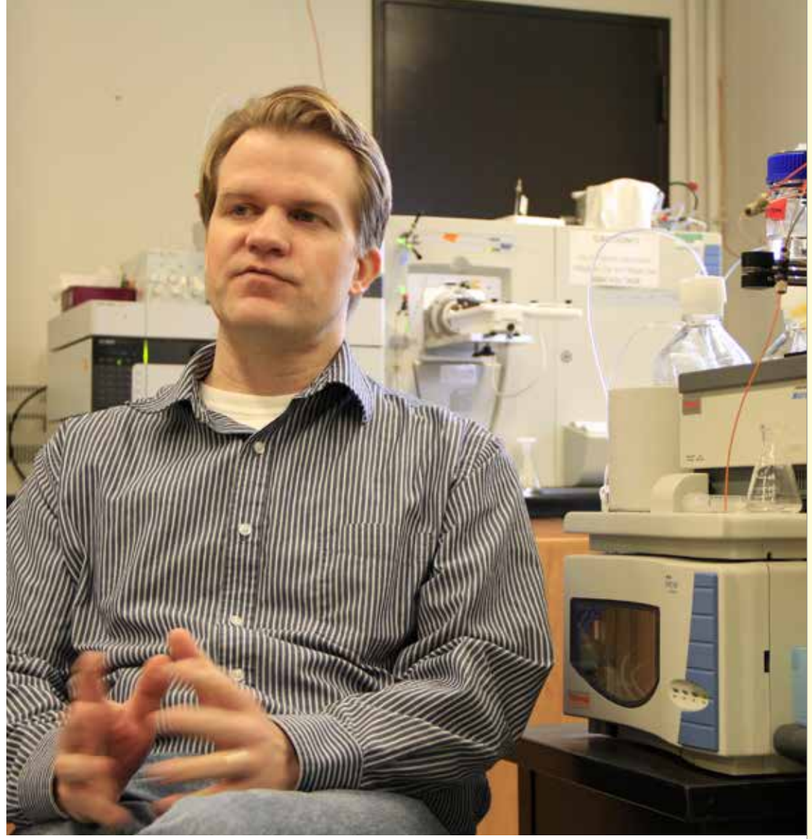
Eyal Amiel, Ph.D., studies the function of the immune system's critical dendritic cells.

"THE IMMUNE SYSTEM IS CONSTANTLY RIDING THAT FINE LINE BETWEEN HOW MUCH PROTECTION WE CAN HAVE WITHOUT TOO MUCH COLLATERAL DAMAGE … IT'S REALLY THAT FINE LINE THAT MAKES IMMUNOLOGY SO INTERESTING."

— Eyal Amiel, Ph.D.

Solving a Blood-Type Mystery

BRYAN BALLIF, PH.D., ASSOCIATE PROFESSOR OF BIOLOGY



Associate Professor of Biology Brian Ballif, Ph.D., led an international team of scientists who discovered the crucial molecule that controls an extremely rare blood type in humans.

In the early 1950's, a 66-year-old woman, sick with colon cancer, received a blood transfusion. Then, unexpectedly, she suffered a severe rejection of the transfused blood. Reporting on her case, the French medical journal *Revue D'Hématologie* identified her as, simply, "Patient Vel." After a previous transfusion, it turns out, Mrs. Vel had developed a potent antibody against some unknown molecule found on the red blood cells of most people in the world — but not found on her own red blood cells.

But what was this molecule? Nobody could find it. A blood mystery began, and, from her case, a new blood type, "Vel-negative," was described in 1952. Though rare, it is estimated now that more than 200,000 people in Europe and a similar number in North America are Vel-negative, about 1 in 2,500. For these people, successive blood transfusions could easily turn to kidney failure and death. So, for sixty years, doctors and researchers have hunted — unsuccessfully — for the underlying cause of this blood type.

Now a team of scientists including UVM biologist Brian Ballif, Ph.D., has found the missing molecule — a tiny protein called SMIM1 — and the mystery is solved. Reporting in the journal *EMBO Molecular Medicine,* Ballif, Lionel Arnaud of the French National Institute of Blood Transfusion, and their colleagues explain how they uncovered the biochemical and genetic basis of Vel-negative blood. Previously, Ballif and Arnaud identified the proteins responsible for two other rare blood types, Junior and Langeris, moving the global count of understood blood types or systems from 30 to 32. With Vel, the number rises to 33.

Before this new research, the only way to determine if someone was Vel-negative or positive was with tests using antibodies made by the few people previously identified as Vel-negative following their rejection of transfused blood. Not surprisingly, these antibodies are vanishingly rare and, therefore, many hospitals and blood banks don't have the capacity to test for this blood type. Ballif notes that Vel-negative blood is one of the most difficult blood types to supply in many countries, partly due to the rarity of the Vel-negative blood type, but also to the lack of systematic screening for the Vel-negative type in blood donors.

In response, the UVM and Paris researchers developed two fast DNA-based tests for identifying Vel-negative blood and people. These tests can be easily integrated into existing blood testing procedures — and can be completed in a few hours or less. "It's usually a crisis when you need a transfusion," says Ballif. "For those rare Vel-negative individuals in need of a blood transfusion, this is a potentially life-saving timeframe."

To make their discovery, the team in Paris used some of the rare Vel-negative antibody to biochemically purify the mystery protein from the surface of human red blood cells. Then they shipped them to Ballif in Vermont. The little protein didn't reveal its identity easily, and Ballif had to sort through thousands of proteins. After several experiments failed to find the culprit because of its unusual biochemistry and pipsqueak size, success came with the use of a high-resolution mass spectrometer funded by the Vermont Genetics Network.

Today, personalized medicine — where doctors treat us based on our unique biological makeup — is on the rise. "The science of blood transfusion has been attempting personalized medicine since its inception," Ballif notes, "given that its goal is to personalize a transfusion by making the best match possible between donor and recipient. Identifying and making available rare blood types such as Vel-negative blood brings us closer to a goal of personalized medicine."

With this new discovery, even that rare one person out of 2,500 that is Vel-negative has a way to receive a rapid blood-typing should they need a transfusion.

Vermont Cancer Center Researchers Target Epigenetic Mechanisms to Advance Cancer Detection and Treatment

Researchers at the Vermont Cancer Center (VCC) at the University of Vermont and Fletcher Allen Health Care are transforming the understanding of cancer biology and treatment of cancer. Investigations focus on molecular mechanisms of tumor/cell malignancy, host factors and tumor growth, cancer control and population health science, as well as transdisciplinary team approaches to cancer research. A common thread of inquiry and discovery is epigenetics in cancer — looking at heritable, but reversible, changes in gene function that do not involve changes in DNA sequence, in order to better understand how cancer develops and how this process can be modified to achieve better treatment outcomes.

VCC Co-Directors Gary Stein, Ph.D., and Claire Verschraegen, M.D., gathered scientists, physician-investigators, and students from across the University and around the country to share knowledge and develop ideas around the topic of epigenetics in cancer at the annual VCC Clinical and Translational Research Symposium. The fundamental understanding of the role genes play in cancer is evolving, and VCC researchers are leading the way in an international initiative to uncover key epigenetic mechanisms involved in development of cancer, yielding new insight about how cancers develop, and novel approaches to cancer treatment and control.

Hematologist-oncologist Marie Wood, M.D., is leading ground-breaking epigenetic research focused on early detection of breast and prostate cancer. Wood's most recent publication, looking at noncoding RNAs, is featured on the May 2014 cover of the *Journal of Cellular Biochemistry.* Partnering with VCC colleagues Stein, Jane Lian, Ph.D., Janet Stein, Ph.D., Nicholas Farina, Ph.D., Chris Francklyn, Ph.D., Scott Perrapato, D.O., Mark Plante, M.D., and Steven Ades, M.D., she is evaluating noncoding RNAs as biomarkers for risk assessment and early detection of cancer as well as risk for recurrence of cancer. This work represents the next generation of early screening capabilities, paving the way for a simple blood test that may reveal early biomarkers for cancer risk.

The work of cancer cell biologist Kaleem Zaidi, Ph.D., focuses on understanding epigenetic mechanisms that are compromised in human leukemia. He is principal investigator for a National Cancer Institute-funded grant to study the role of microRNAs in human leukemia. Partnering with collaborators at the Albany College of Pharmacy and Health Sciences, including Karen Glass, Ph.D., UVM adjunct assistant professor of biochemistry, Zaidi's current research has far-reaching implications for devising safe and targeted therapeutic strategies for treating human leukemia.

A major initiative in the Stein Lab — supported by a $2.1 million Pfizer Pharmaceuticals grant — is focusing on establishing epigenetic signatures for risk assessment of drug-related induction of cancer and tumor progression. Led by Lian, Janet Stein, and Gary Stein, the research is harnessing state-of-the-art analysis at the VCC Advanced Genome Technologies Core to investigate cancer treatment-related alterations in epigenetic control. Using these highly sensitive analyses, the Stein Lab aims to develop epigenetic signatures that will help evaluate the specificity and activity for the next generation of treatments for tumors that do not respond well to conventional approaches.

This body of epigenetic research is leading to new collaborations, clinical trials and key information critical to advancing new therapeutics, public health approaches to cancer prevention, and enhancing quality of life after cancer — all contributing to the VCC's mission of advancing cancer prevention, detection, treatment and survivorship in Vermont and beyond.

GARY STEIN, PH.D.
PROFESSOR AND CHAIR OF BIOCHEMISTRY AND CO-DIRECTOR OF THE VERMONT CANCER CENTER

CLAIRE VERSCHRAEGEN, M.D.
IRWIN H. KRAKOFF, M.D. GREEN & GOLD PROFESSOR OF MEDICINE AND CO-DIRECTOR OF THE VERMONT CANCER CENTER

MARIE WOOD, M.D.
PROFESSOR OF MEDICINE AND DIRECTOR OF THE VCC FAMILIAL CANCER PROGRAM

KALEEM ZAIDI, PH.D.
ASSISTANT PROFESSOR OF BIOCHEMISTRY

COMPLEX SYSTEMS

The analysis of "Big Data" is an emerging strength at the University of Vermont, and a field in which the institution has already begun to blaze new pathways. Complex systems research draws upon sophisticated mathematical modeling techniques to analyze real-world challenges, from developing next-generation information technology for a national smart grid to mapping the global influence of social media. UVM has an outstanding cadre of nationally- and internationally-recognized faculty who have published successfully in their disciplines and have attracted significant funding and partnerships to the University. The Vermont Complex Systems Center, one of the transdisciplinary research initiatives at UVM, facilitates collaboration and innovation across disciplines by engaging faculty in many areas, including the environment, health, materials science, the arts, psychology, biosciences, and multi-scale modeling. UVM is distinguishing itself as a place where scholars take an intellectually rigorous approach to systems thinking in tackling a variety of scientific and real-world problems across the natural, physical, and social domains.

For Robust Robots, Let Them Be Babies First

JOSHUA BONGARD, PH.D., ASSOCIATE PROFESSOR OF COMPUTER SCIENCE

Want to build a really tough robot? Forget about Terminator. Instead, watch a tadpole turn into a frog. Or at least that's not too far off from what University of Vermont roboticist Josh Bongard, Ph.D., has discovered, as he reports in the *Proceedings of the National Academy of Sciences.*

In a first-of-its-kind experiment, Bongard created both simulated and actual robots that, like tadpoles becoming frogs, change their body forms while learning how to walk. And, over generations, his simulated robots also evolved, spending less time in "infant" tadpole-like forms and more time in "adult" four-legged forms. These evolving populations of robots were able to learn to walk more rapidly than ones with fixed body forms. And, in their final form, the changing robots had developed a more robust gait — better able to deal with, say, being knocked with a stick — than the ones that had learned to walk using upright legs from the beginning. "This paper shows that body change, morphological change, actually helps us design better robots," Bongard says. "That's never been attempted before."

Bongard's research, supported by the National Science Foundation, is part of a wider venture called evolutionary robotics. "We have an engineering goal," he says "to produce robots as quickly and consistently as possible." In this experimental case: upright four-legged robots that can move themselves to a light source without falling over. "But we don't know how to program robots very well," Bongard says, "because robots are complex systems. In some ways, they are too much like people for people to easily understand them."

Which is why Bongard and other robotics experts have turned to computer programs to design robots and develop their behaviors — rather than trying to program the robots' behavior directly. Using a sophisticated computer simulation, Bongard unleashed a series of synthetic beasts that move about in a 3-dimensional space. Each creature — or, rather, generations of the creatures — then run a software routine, called a genetic algorithm, that experiments with various motions until it develops a slither, shuffle, or walking gait, based on its body plan, that can get it to the light source without tipping over. Some of the creatures begin flat to the ground, like tadpoles or, perhaps, snakes with legs; others have splayed legs, a bit like a lizard; and others ran the full set of simulations with upright legs, like mammals.

"WE HAVE AN ENGINEERING GOAL — TO PRODUCE ROBOTS AS QUICKLY AND CONSISTENTLY AS POSSIBLE. BUT WE DON'T KNOW HOW TO PROGRAM ROBOTS VERY WELL, BECAUSE ROBOTS ARE COMPLEX SYSTEMS. IN SOME WAYS, THEY ARE TOO MUCH LIKE PEOPLE FOR PEOPLE TO EASILY UNDERSTAND THEM."

—Joshua Bongard, Ph.D.

And why do the generations of robots that progress from slithering to wide legs and, finally, to upright legs, ultimately perform better, getting to the desired behavior faster? "The snake and reptilian robots are, in essence, training wheels," says Bongard, "they allow evolution to find motion patterns quicker, because those kinds of robots can't fall over." After solving the challenge of movement as one discrete problem, the robots can then tackle balance as a separate issue.

After running 5,000 simulations, each taking 30 hours on the parallel processors in UVM's Vermont Advanced Computing Core, Bongard took the task into the real world, building a relatively simple robot out of Lego Mindstorm kits. The physical robot is four-legged, like in the simulation, but the Lego creature wears a brace on its front and back legs, which tilts it as the controller searches for successful movement patterns.

"While the brace is bending the legs, the controller is causing the robot to move around, so it's able to move its legs, and bend its spine," he says, "it's squirming around like a reptile flat on the ground and then it gradually stands up until, at the end of this movement pattern, it's walking like a coyote. It's a very simple prototype, but it works; it's a proof of concept."

Associate Professor of Computer Science Joshua Bongard, Ph.D., has created robots that can actually change their body forms while learning how to walk. His research in "evolutionary robotics" is funded by the National Science Foundation.

From Bacteria to Biofuels: Understanding Cellular Survival

MARY DUNLOP, PH.D., ASSISTANT PROFESSOR OF COMPUTER SCIENCE

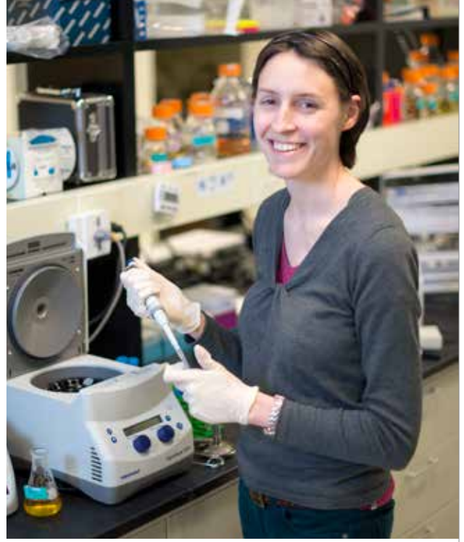
Mary Dunlop, Ph.D., is looking into how organisms respond to changing environments, and in doing so, she's crossing disciplines, using synthetic and systems biology to research natural and manufactured cellular processes. Dunlop, assistant professor in the School of Engineering and associate faculty member in the Vermont Complex Systems Center, was the recipient of the National Science Foundation's CAREER Award, the Outstanding Junior Faculty Award from UVM's College of Engineering and Mathematical Sciences, and the U.S. Department of Energy's Early Career Award. She's interested in studying how microscopic organisms — bacteria — handle macroscopic phenomena — antibiotic resistance and biofuel production.

"My lab takes two different perspectives," says Dunlop. "One is trying to understand natural examples of how cells can deal with changing environments. The other is exactly the opposite direction, where we try to build completely novel feedback systems that don't exist in nature."

That work begins with the basic knowledge that bacteria, though single-celled, have a complexity and a level of individuality that renders them useful models of more intricate biological systems. Through studying E. coli, Dunlop and her team of five graduate students and one undergraduate have found that even cells that are genetically identical can take on different phenotypes, or characteristics, allowing them to "hedge against uncertainties in the future." That may translate to a microbe's ability to evade antibiotics, for example, by turning on an efflux pump that will force the drugs away or at the very least make the organism more tolerant of them; another reaction might be a change in its cell membrane composition. Regardless of the response, if it were shared by an entire colony that could be costly — especially if there's little likelihood of an antibiotic encounter. Instead, such a task is generally relegated to a smaller subset of the population, which, says Dunlop, serves as an insurance policy. That way, if something were to happen to the responsive subgroup, the surviving cells would still be able to regenerate. Although she and her colleagues focus on E. coli, the mechanisms are common to a variety of different microbes, Dunlop says, including pathogens.

Their research is focused on why the changes happen, but Dunlop says it's not impossible that one outcome down the road would be a finding that when cells diversify their responses, they trade off which cells in a given population are antibiotic resistant and for how long. That may be important from a clinical perspective because knowing how long that transient resistance lasts may affect length of treatment. For the most part, however, they remain focused on costs and benefits of the different cellular approaches to survival — that bet hedging within the cells: some might survive while others do not, but even so they have collectively diversified their responses. Dunlop uses time-lapse microscopy — basic time-lapse photography under a microscope — with fluorescent colors to assess changes and establish quantitative histories of the cells over time.

On a somewhat larger scale, Dunlop's lab is researching the creation of transportation biofuels from cellulosic — plant-matter — sources. While most biofuel is currently made from corn and sugar cane, Dunlop is looking at the end process of converting recycled material — debris from forests, grass clippings, and the like. Likening it to making beer, in which the level of alcohol is naturally self-limiting to avoid yeast die-off, Dunlop says cells that are converted to biofuels suffer from the same toxicity concerns.



Mary Dunlop, Ph.D., researches optimizing the environments for long-term cell survival, which has major implications for such fields as biofuel production.

"That's a real problem for making biofuel," says Dunlop. "You want to make a lot of fuel to be efficient and cost effective, but after a certain point, the cells start to die." In an effort to make microbes more robust, Dunlop is studying their tolerance mechanisms, using organisms that exist in harsh environments, such as areas around natural oil seepages in the ocean, or near oil rigs or spills. Such microbes, whose primary purpose is to eat hydrocarbons, have developed a tolerance to high quantities of biofuel-like compounds; Dunlop hopes to find which genes are responsible and eventually crossbreed them with E. coli to create a more durable cell.

"MY LAB TAKES TWO DIFFERENT PERSPECTIVES … ONE IS TRYING TO UNDERSTAND NATURAL EXAMPLES OF HOW CELLS CAN DEAL WITH CHANGING ENVIRONMENTS. THE OTHER IS EXACTLY THE OPPOSITE DIRECTION, WHERE WE TRY TO BUILD COMPLETELY NOVEL FEEDBACK SYSTEMS THAT DON'T EXIST IN NATURE."

—Mary Dunlop, Ph.D.

The Dow Jones of Happiness

PETER DODDS, PH.D., PROFESSOR OF MATHEMATICS & STATISTICS AND DIRECTOR OF THE COMPLEX SYSTEMS CENTER
CHRISTOPHER DANFORTH, PH.D., ASSOCIATE PROFESSOR OF MATHEMATICS & STATISTICS AND FLINT PROFESSOR OF MATHEMATICAL, NATURAL, AND TECHNICAL SCIENCES

Want to measure how financial markets are faring? Check Dow Jones or the S&P 500. Want to measure how happy the world was yesterday? Check… wait a minute. You can't measure global happiness, can you? Yes you can — we've built a tool to do the job, say Peter Dodds, Ph.D., and colleague Chris Danforth, Ph.D.

These UVM scientists, working with others from the MITRE Corporation, have been gaining international attention over the last few years for the creation of what they're calling a hedonometer. It's a happiness sensor — and it made the front page of the *Wall Street Journal*.

Visit hedonometer.org and you'll see a wavering graph that rises and falls like a ticker at the New York Stock Exchange. Except instead of averaging the value of thousands of companies, the hedonometer compiles and averages the emotional state of tens of millions of people.

"What it's doing right now is measuring Twitter, checking the happiness of tweets in English," says Danforth, who co-led the creation of the site with mathematician Dodds. But soon the hedonometer will be drawing in other data streams, like Google Trends, the *New York Times,* blogs, CNN transcripts, and text captured by the link-shortening service Bitly. And it will be data-mining in twelve languages.

The research team made headlines — including *Time* magazine and *The Atlantic* — when they reported on the happiest and saddest cities in America: Napa, Calif., at the top and Beaumont, Texas, at the bottom. In future versions of the hedonometer, the researchers plan to make this kind of geographically linked data available, allowing as-it-happens observation of how a happiness signal varies, say, between Seattle and San Diego.

"Reporters, policymakers, academics — anyone — can come to the site," says Danforth, "and see population-level responses to major events." Like the Boston Marathon bombings, the saddest day measured by the scientists in nearly five years of observations.

The hedonometer draws on what scientists call the "psychological valence" of about 10,000 words. Paid volunteers, using Amazon's Mechanical Turk service, rated these words for their "emotional temperature," says Dodds. The volunteers ranked words they perceived as the happiest near the top of a 1-9 scale; sad words near the bottom. Averaging the volunteers' responses, each word received a score: "happy" itself ranked 8.30, "hahaha" 7.94, "cherry" 7.04, and the more-neutral "pancake" 6.96. Truly neutral words, "and" and "the" scored 5.22 and 4.98. At the bottom, "crash" 2.60, the emoticon ":(" 2.36, "war" 1.80, and "jail" 1.76.

Using these scores, the team collects some 50 million tweets from around the world each day — "then we basically toss all the words into a huge bucket," says Dodds — and calculate the bucket's average happiness score. As the site develops, the scientists anticipate that it will be gathering billions of words and sentences daily. "Our method is only reasonable for large-scale texts, like what's available on the Web," Dodds says. "Any word or expression can be used in different ways. There's too much variability in individual expression" to use this approach to understand small groups or small samples. For example, "sick" may mean something radically different to a 14-year-old skateboarder than it does to his pediatrician. But that's the beauty of big data. Each word is like an atom in the air when you're trying to figure out the temperature. It's the aggregate effect that registers, and no individual tweet or word makes much difference.

Changing which words are used to assess the overall emotional picture, "is like changing the filter on a lens you're using," explains Dodds. "You can take out all the color, or you can turn up the contrast, but you can still see the picture."

Professor of Mathematics and Statistics Peter Dodds, Ph.D., at center, and his colleague, Associate Professor Chris Danforth, Ph.D., have developed a system for analyzing millions of bits of data to assess the "emotions" of the online world.

Leading the Charge for Smarter Electric Vehicle Management

PAUL HINES, PH.D., ASSISTANT PROFESSOR OF COMPUTER SCIENCE; **JEFF FROLIK, PH.D.,** ASSOCIATE PROFESSOR OF ENGINEERING

Growth in plug-in electric car sales is good news for the environment in terms of oil consumption and air pollution. But this growing fleet will put new strain on the nation's aging electrical distribution systems, like transformers and underground cables, especially at times of peak demand — say, six in the evening when people come home from work. How to manage all these cars seeking a socket at the same time — without crashing the grid or pushing rates through the roof — has some utilities wondering, if not downright worried. A team of UVM scientists co-led by Paul Hines, an expert on power systems, has created a novel solution, which they reported on in the March 2014 issue of *IEEE Transactions on Smart Grid,* a journal of the Institute of Electrical and Electronics Engineers.

"The key to our approach is to break up the request for power from each car into multiple small chunks — into packets," says Jeff Frolik, Ph.D., Hines' colleague in the College of Engineering and Mathematical Sciences and co-author on the new study.

By using the nation's growing network of "smart meters" — a new generation of household electric meters that communicate information back-and-forth between a house and the utility — the new approach would let a car charge for, say, five or ten minutes at a time. And then the car would get back into the line and make another request for power. If demand was low, it would continue charging, but if it was high, the car would have to wait.

"The vehicle doesn't care. And, most of the time, as long as people get charged by morning, they won't care either," says Hines. "By charging cars in this way, it's really easy to let everybody share the capacity that is available on the grid."

Taking a page out of how radio and internet communications are distributed, the team's strategy will allow electric utilities to spread out the demand from plug-in cars over the whole day and night. The information from the smart meter prevents the grid from being overloaded. "And the problem of peaks and valleys is becoming more pronounced as we get more intermittent power — wind and solar — in the system," says Hines. "There is a growing need to smooth out supply and demand."

At the same time, the UVM team's invention — patent pending — would protect a car owner's privacy. A charge management device could be located at the level of, for example, a neighborhood substation. It would assess local strain on the grid. If demand wasn't too high, it would randomly distribute "charge-packets" of power to those households that were putting in requests.

"Our solution is decentralized," says Pooya Rezaei, a doctoral student working with Hines and the lead author on the new paper. "The utility doesn't know who is charging."

Instead, the power would be distributed by a computer algorithm called an "automaton" that is the technical heart of the new approach. The automaton is driven by rising and falling probabilities, which means everyone would eventually get a turn — but the utility wouldn't know, or need to know, a person's driving patterns or what house was receiving power when.

Others have proposed elaborate online auction schemes to manage demand. "Some of the other systems are way too complicated," says Hines, who has extensive experience working with actual power companies. "In a big city, a utility doesn't want to be managing millions of tiny auctions. Ours is a much simpler system that gets the job done without overloading the grid and gets people what they want the vast majority of the time."

UVM scientists Pooya Rezaei, Paul Hines, Ph.D., and Jeff Frolik, Ph.D., think packets of power can revolutionize the way electric companies deal with the coming tide of plug-in cars.

4 Questions: The Lake Champlain Watershed

JUDITH VAN HOUTEN, PH.D., UNIVERSITY DISTINGUISHED PROFESSOR OF BIOLOGY AND DIRECTOR OF THE VERMONT GENETICS NETWORK

University Distinguished Professor of Biology Judith Van Houten, Ph.D., leads a $20 million effort funded by the National Science Foundation to help Vermont adjust to complex environmental change.

As Vermont's climate becomes warmer, wetter and more volatile, the need for research-based predictive tools to inform policy and land-use decisions in the state has never been greater. A $20 million grant from the National Science Foundation to Vermont EPSCoR is helping Vermont develop just this innovative decision-making capability, placing it at the forefront of states focused on creating informed public policy in a changing world. Awarded in 2011, the five-year grant centers on the Lake Champlain Basin. It brings together Vermont higher education institutions, state agencies, non-profit groups and the private sector through Vermont EPSCoR, the Experimental Program to Stimulate Competitive Research, based at the University of Vermont.

The research has both natural and social science components. Interdisciplinary teams of natural scientists are gathering data on the chemical, physical, geological and biological processes in the lake. Social scientists are conducting extensive surveys of lake users, landowners in the basin, and public officials to gather data on external factors impacting the lake and to understand how decisions affecting lake health are made. Eventually, all the data will be integrated in an overarching modeling platform where decision-making scenarios can be tested. Professor Judith Van Houten, Ph.D., is directing the research program.

Q: You're about halfway through the grant. How are things going?

A: Very well. We spent a lot of effort putting high-tech buoys in the lake to gather data and that's going well — we've gathered data for two summers and three winters. The National Science Foundation just gave us a new $6.7 million grant to put even more sensors in the lake and surrounding watershed.

Q: How about the social science side of things?

A: We've also made good progress there. In year one, we had a mediated modeling workshop with people from across the state attending. The purpose was to gather concerns and issues that we would then use for our scenario testing. In May, in a second statewide meeting, we're going to narrow down the 100 or so management interventions that came up earlier to six or seven key ones that will inform our scenario testing.

Q: What is the scenario testing feature?

A: The scenario-testing feature of the project is one of its most valuable features. If we want to know the impact of wider roads, zoning mandating smaller lawns, pesticide control or new targets for total nutrient loading in agriculture, those data can be fed into the model, and their outcome can be determined in advance of any action. That sort of advanced capability will not be available anywhere but in Vermont. It is very exportable, and NSF is very interested in that.

Q: You're using a complex systems approach for this research. Why?

A: The research is designed to take into account the many factors that affect the lake, such as the land use, streams and rivers of its watershed and the dynamics of the lake itself. Ultimately, these many factors contribute to algal bloom, changes in invasive species, and other changes in the lake. We want to bring a holistic view to the Lake Champlain Basin, the lake and its watersheds, and a complex systems approach — where we can model outcomes when many variables interact with one another — is tailor-made for that approach. To give you a sense of how sophisticated the platform is, we'll have a hydrologic model that looks at the watershed, a lake model, an agent-based model that looks at users and decision-makers, and a localized climate model — all of them integrated with one another.

ENVIRONMENTAL SCIENCE

One hundred-fifty years ago, Vermonter George Perkins Marsh was the first writer to propose that human beings were agents of change, that the world as we know it is the result of the confluence of both natural phenomena and human activity. Today, in the hall that bears his name and in collaborations across campus, UVM faculty are conducting research to help us understand, engage and protect the world we live in. Ranging from fundamental science related to the natural environment, landscapes, and watersheds to emerging areas of demand such as global change and the pressing need for effective science, policy, management and communication, research on the environment reaches across colleges, departments, and disciplines.

Listening to Lake Trout to Build a Sustainable Population

ELLEN MARSDEN, PH.D., PROFESSOR OF ENVIRONMENT & NATURAL RESOURCES AND DIRECTOR OF THE WILDLIFE AND FISHERIES BIOLOGY PROGRAM

Under the surface of Lake Champlain, dozens of lake trout are making weird noises. That's because transmitters, about the size of a AA battery, have been surgically implanted inside these fish. As they swim around, the transmitter sends out a high-pitched "ping." You — and the fish — can't hear it, but receivers on the bottom of the lake can. And this lets scientists track the movements of the fish, whether they're cavorting off the Burlington waterfront or brooding in Mallets Bay.

Professor of Environment and Natural Resources Ellen Marsden, Ph.D., created the Champlain Acoustic Telemetry Observation System to track the movement of lake trout.

Listening to lake trout is just one research project supported by this technology, the Champlain Acoustic Telemetry Observation System (CATOS), created by Professor Ellen Marsden, Ph.D., and colleague Jason Stockwell, Ph.D., at UVM's Rubenstein Ecosystem Science Laboratory. CATOS, which is modeled after a similar system in the Great Lakes (GLATOS), began with 12 acoustic receivers deployed throughout the lake. Another 14 will be added in 2014, with plans to continue expanding coverage.

Why do we care about the movement of lake trout? "All of the lake trout you see out in Lake Champlain right now are stocked fish," says Marsden. Lake trout, which disappeared from Lake Champlain around 1900, have been stocked by the state since 1972. "The goal is to restore a self-sustaining population," Marsden says, since lake trout play an important ecological role as a top predator. "Why pay for something that could be naturally produced?"

Little is known about why the trout disappeared more than a century ago. For more than a dozen years, Marsden has been trying to find out what's preventing them from thriving today. To do this, she's employed other technologies, like underwater, remote-controlled video, to learn more about the fish's habits and habitat. The data collected suggest that all is well for the naturally spawned young lake trout up to about four weeks of age. The trout are spawning successfully, eggs deposited in November are hatching successfully in April, and plenty of fry are emerging out of the substrate. "Now, we're continuing to push that research forward to understand what happens to those fry as they progress through life," she says.

There are three factors that could be affecting the fish: disease, predation and starvation. "We're fairly confident there aren't any diseases we don't know about in the lake," Marsden says. So that leaves the other two to explore. With the addition of exotic species into the lake, predation could be a possibility. And while young fish are feeding successfully on the reef, there may be a food supply imbalance in deeper waters leading to starvation. "It's hard to find that smoking gun," Marsden says. "At about four weeks old, they leave the spawning reef, and they should be going off into deeper water. It gets very hard to follow them at that point."

CATOS will help researchers find new spawning sites, learn more about lake trout spawning behavior, and uncover the movements of the fish throughout the year — all putting Marsden closer to solving the mystery of what's happening to Champlain's lake trout.

Tracking the Greenland Ice Sheet's Big Melt

PAUL BIERMAN, PH.D., PROFESSOR OF GEOLOGY

Professor of Geology Paul Bierman, Ph.D., does fieldwork at the edge of the Greenland ice sheet.

If the whole Greenland ice sheet — which covers more than 80 percent of the country — were to melt, global sea level would rise twenty-three feet, drowning coastal cities on every continent. Warm spells are becoming increasingly common in Greenland; during the summer of 2012 the surface of the ice sheet melted over a far greater area than ever before observed. But the deeper details are devilishly important. Exactly how warming will affect ice in Greenland and West Antarctica remains one of the least understood variables in global climate models.

Professor Paul Bierman, Ph.D., and a team of international colleagues want to create a clearer picture of how quickly such a melt-off could happen. Backed by National Science Foundation funding, the scientists invest time in the field in Greenland and in the lab at their home institutions in search of answers.

To augur its future with greater precision, the scientists look to the past, collecting rocks and sand that, back in Bierman's lab at UVM, let them measure how extensive the Greenland ice was over the last ten thousand years as temperatures rose and fell. This relatively short record will, in turn, allow the team to interpret far-more-ancient sediment from the bottom of the ocean. Hidden in the ocean muck, the geologists think they'll be able to uncover the story of Greenland's ice stretching back millions of years.

The minerals that they collect travel back to Bierman's shop in Vermont, one of the few cosmogenic isotope laboratories in the world, where they are painstakingly dissolved to yield nearly pure quartz. From the quartz, Bierman and his graduate students extract the element beryllium and then ship it to Scotland, where colleague Dylan Rood, Ph.D., tests the beryllium in a specialized mass spectrometer, capable of detecting a single atom out of a million billion atoms.

Why would four geologists interested in understanding climate change want to collect bags of sand in order to count the atoms of beryllium in its quartz? Cosmic rays. This radiation, born at the beginning of the universe, rains down on the planet, penetrating the top few meters of the earth's surface. And where it does, ever so rarely, it smashes into oxygen within the quartz, knocking a chunk off. What remains from the busted oxygen is a special form of beryllium, the rare isotope 10Be. The longer the quartz is exposed to the sky, bombarded by cosmic rays, the more 10Be accumulates within its crystals. But buried under snow and ice — shielded by, say, the Greenland ice sheet — no 10Be accumulates in the quartz. So the amount of beryllium in a grain of sand can reveal how long it was exposed, versus how long it was buried under ice. Collect enough of these grains, from enough spots in Greenland, and the scientists could begin to sketch a picture of when and where ice rested there in the past and what that could mean for the future thousands of miles away.

In April of 2014, Bierman and his colleagues made a major discovery about Greenland that they reported in the journal *Science,* which was then reported in media around the world. Again using beryllium, the scientists tested samples from the bottom of the 10,019-foot GISP2 ice core extracted in 1993. They were greatly surprised to find tundra soil that has been frozen there for 2.7 million years — providing evidence that the center of the Greenland ice sheet has persisted much longer than previously known, enduring through many past periods of global warming. But temperatures are on a path to be "far warmer than the warmest interglacials in millions of years," said Bierman. "If we keep on our current trajectory, the ice sheet will not survive."

"IF WE KEEP ON OUR CURRENT TRAJECTORY, THE ICE SHEET WILL NOT SURVIVE."

— Paul Biermann, Ph.D.

Calculating the Benefits of Nature

TAYLOR RICKETTS, PH.D., GUND PROFESSOR OF ECOLOGICAL ECONOMICS AND DIRECTOR OF THE GUND INSTITUTE

When Professor Taylor Ricketts talks about making advancements in global conservation efforts, he isn't so much worried about fuzzy little creatures necessarily, unless they're native bees. Ricketts is interested in "ecosystem services" — the economic benefits nature provides — and in calculating their value in terms of finances, but also in their financial, cultural, and health-related value.

"There's a whole mess of things that native ecosystems and the species in them do that confer serious value to us," says Ricketts. "It's just that we're pretty bad at understanding and accounting for them and including them in our decision making."

Food is an obvious benefit, but Ricketts is most concerned with how wetlands purify water for drinking downstream, for example, and how they controlled floods — or didn't — during 2011's Tropical Storm Irene, how forests are able to capture carbon and slow climate change, and the importance of wild bees in crop pollination.

Seventy percent of the world's major commodities need to be pollinated in order to fully set fruit, and Ricketts is working to determine how much less a farmer would earn if this "free service" weren't available. He spent time on a coffee farm in Costa Rica and calculated the farm would produce about 20 percent less coffee, which translates to an annual loss of roughly $60,000 in income. He's currently investigating the same question on Vermont blueberry farms, and notes it's already clear that blueberry farmers need bees, and that many of those bee species are declining.

The decrease in the native bee population can be blamed on increased pesticide use, as well as the tilling of soil, which is where many of them nest. A standard response is to truck in boxes of honeybees and hope they'll do the work of the wild bees, but Ricketts says that's like owning one stock rather than an entire portfolio, and trusting that you'll still make money. Diversity — in nature, as in investing — is essential to stable returns. Although honeybees can help, they're often not specialized and efficient enough to fully replace native bees.

"It's heartening that farmers are thinking about other strategies," says Ricketts of the effort to make habitats welcoming to wild bees. He's currently taking part in a five-year USDA-funded study to conduct experiments on pollinator strips, which are growing in popularity worldwide. Large areas of wildflowers that flower all summer have been purposefully planted near crops where they serve as an enticing buffet for the bees, which will stay around to enjoy them even after the crops themselves have finished flowering.

Ricketts also co-founded the Natural Capital Project, a partnership among UVM, Stanford University, the University of Minnesota, the World Wildlife Fund, and the Nature Conservancy, that's working to quantify the role of nature in sustainable investment and policy decisions. He's working with Vermont's State Agency for Natural Resources to determine the flow of economic benefits of Vermont's conservation investments — parks, land trusts and the like. He notes the project wouldn't have been possible 10 years ago, because scientists have only recently gotten good at putting a dollar value on such things in a credible way.

Fitting in time to teach undergraduate and graduate courses in landscape ecology and ecosystems services, Ricketts is also working internationally to help governments and NGOs determine how changing natural conditions affect people's health. So he's looked at whether pollinator declines result in poorer diets and more nutritional disease in developing countries, and how conservation of watersheds around the world can reduce water-borne diseases like diarrhea in children. The message for health ministries is that investing in conservation efforts can be a cost-effective public health strategy for their own citizens.

"That's putting nature and our decisions to destroy it or keep it in really concrete health terms," says Ricketts. As with all of his projects, the overarching goal is to make conservation more central to decision making, for individuals and governments.

Professor of Environment and Natural Resources Taylor Ricketts, Ph.D., is an expert on the benefits of bees, and is part of a USDA-funded grant to study "pollinator strips."

"THERE'S A WHOLE MESS OF THINGS THAT NATIVE ECOSYSTEMS AND THE SPECIES IN THEM DO THAT CONFER SERIOUS VALUE TO US. IT'S JUST THAT WE'RE PRETTY BAD AT UNDERSTANDING AND ACCOUNTING FOR THEM AND INCLUDING THEM IN OUR DECISION MAKING."

— Taylor Ricketts, Ph.D.

Examining the Health Effects of Biodiesel Fuel

NAOMI FUKAGAWA, M.D., PH.D., PROFESSOR OF MEDICINE

Worldwide, air pollution claimed seven million lives in 2012, according to a report released in March 2014 by the World Health Organization. As America seeks to become less dependent on imported oil, the pressure has increased to use alternative fuels such as biodiesel. Over the past decade, annual production of fuel derived from vegetable oils or animal fats has spiked from 25 million to over 1.1 billion gallons. The biodiesel industry bills the fuel as renewable, biodegradable and nontoxic — safe for both humans and the environment — because, unlike the petroleum diesel used by most vehicles, it is essentially free of sulfur and aromatics.

For Dr. Naomi Fukagawa and many other scientists, however, the jury is still out on the health and environmental effects of biodiesel. They recognize that there is a significant correlation between air pollution and the development of disease, most recently reinforced by the World Health Organization's International Agency for Research on Cancer, which reports that outdoor air pollution is linked to cancer in humans. Yet scientists have little evidence about how particulate matter — and therefore how and which specific fuels — harm human health.

Over 25 years of research has linked petrodiesel fuel emissions to human diseases such as asthma, chronic bronchitis, chronic obstructive airway disease, cardiopulmonary diseases, and cancer. But what remains unclear is what mechanisms occur — at the cellular and molecular levels — when the human body is exposed to airborne particulate matter produced by such emissions. Similarly, researchers do not fully understand the biological effects of exhaust stemming from biodiesel or biodiesel blends, Fukagawa explains, even though combustion of pure biodiesel fuel is associated with lower emission of particulate matter.

In a recent study funded by a nearly $1 million National Institutes of Health (NIH) Challenge Grant and published online in the journal *Environmental Science & Technology,* Fukagawa and her colleagues shed more light on the impact of petrodiesel and biodiesel emissions on human health. Comparing tailpipe particle emissions measurements generated by a light-duty diesel engine using petrodiesel (B0) and a biodiesel blend (B20) composed of 20 percent soy biodiesel and 80 percent petrodiesel, the scientists examined the underlying biological mechanisms affected in human lung epithelial and white blood cell lines, as well as in a mouse model. To determine potential contributions to health outcomes, they conducted biological assays for inflammatory mediators and oxidative stress biomarkers.

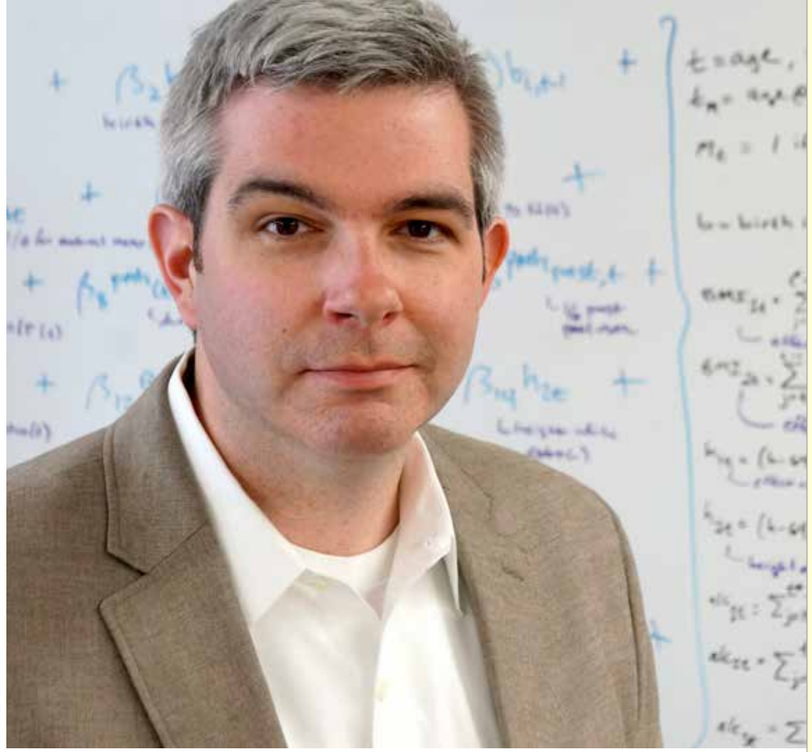
The results did not fully rule out health risks in the biodiesel blend, despite the fact that it produced less particle mass than the petrodiesel, the researchers noted. Instead, the study indicated that the B20 particles may contribute to greater biological effects per mass than B0, leading to potentially greater health risks. Fukagawa hopes the team's research lays the groundwork for future studies examining the relationship between airborne particles and lung and heart disease, helping reduce the adverse health consequences of air pollution.

As part of the NIH-funded work over the past several years, Fukagawa's team also has touched on the biological effects of emission particles — both petrodiesel and biodiesel — from a food systems perspective. With about 925 million people experiencing hunger worldwide, Fukagawa recognizes that biodiesel, which often is produced from corn and soybeans, can have a significant impact on food availability and pricing. With America moving toward alternative fuels such as biodiesel, she and other scientists want to know the full ramifications.

Professor of Medicine Naomi Fukagawa, M.D., Ph.D., works to fill in a crucial gap in scientific knowledge of how airborne particulate matter affects human health.

Synthetic Chemicals and Breast Cancer Risk

THOMAS AHERN, PH.D., M.P.H., ASSISTANT PROFESSOR OF SURGERY



Assistant Professor of Surgery Thomas Ahern, Ph.D., M.P.H., through his Komen Foundation-funded research, examines the risks of exposure to highly ubiquitous synthetic chemicals.

Vermont Cancer Center scientist Thomas Ahern, Ph.D., M.P.H., is interested in the potential roles of hormonal signaling, dietary patterns, and energy balance in cancer development, as well as interventions that help prevent cancer. He recently received a $450,000 Susan G. Komen Environmental Challenge Grant to study breast cancer associated with exposure to synthetic chemicals called phthalates.

Phthalates are used extensively in modern consumer products including toys, plastic goods, lotions, and medications. While nearly 85 percent of Americans have detectable levels of these compounds in their bodies, individuals who ingest phthalates through daily medications have dramatically higher exposure. Ahern, a molecular epidemiologist whose research interests concern the impact of prescription drug exposures and tumor molecular profiles on breast cancer outcomes, is launching a three-year study of phthalate exposure through medications and subsequent risk of breast cancer.

The chemicals are thought to disrupt hormonal signaling in the body, and may be involved in cancer development. Preliminary studies suggest a link between phthalates and breast cancer risk, but the Institute of Medicine has stressed the need for definitive evidence of this link. Ahern's project — an epidemiologic study in collaboration with Aarhus University in Denmark — will provide strong evidence for whether such a link exists.

"Should we find an association between phthalate exposure and breast cancer risk, our study would motivate a change in clinical practice so that women are treated with phthalate-free versions of the drugs they require," Ahern says. "It may also motivate a change in pharmaceutical manufacturing so that phthalates are replaced with safe alternatives."

These measures could substantially reduce the risk of breast cancer in a highly exposed population in just a few years' time. On the other hand, if the new evidence points to no link between phthalate exposure and breast cancer risk, women can be reassured that exposure to phthalates through prescription drug regimens does not promote breast cancer development.

"It's an important and very topical project, conducted here in Vermont," says Komen Vermont-New Hampshire Affiliate President Becky Burke. "It may have ramifications on breast cancer thinking and possible prevention the world over."

"SHOULD WE FIND AN ASSOCIATION BETWEEN PHTHALATE EXPOSURE AND BREAST CANCER RISK, OUR STUDY WOULD MOTIVATE A CHANGE IN CLINICAL PRACTICE SO THAT WOMEN ARE TREATED WITH PHTHALATE-FREE VERSIONS OF THE DRUGS THEY REQUIRE. IT MAY ALSO MOTIVATE A CHANGE IN PHARMACEUTICAL MANUFACTURING SO THAT PHTHALATES ARE REPLACED WITH SAFE ALTERNATIVES."

— Thomas Ahern, Ph.D., M.P.H.

3 Questions: Climate Change

ASIM ZIA, PH.D., ASSOCIATE PROFESSOR OF COMMUNITY DEVELOPMENT AND APPLIED ECONOMICS

International efforts to deal with climate change have been — many experts argue — a spectacular failure. United Nations treaties, including the 1997 Kyoto Protocol that the United States chose not to ratify, form a very leaky bucket for catching greenhouse gases. A new book, *Post-Kyoto Climate Governance* (Routledge), by Associate Professor Asim Zia, Ph.D., a fellow in the Gund Institute for Ecological Economics, ranges across several disciplines, looking for the causes of failure in international climate policy and searching for solutions. These may require dramatic new approaches, like global taxes, new forms of organized confrontation, and a willingness to reconsider reflexive attachments, he argues, like a belief in the benefits of free trade.

Q: Free trade is the quasi-religion of countries around the world. How does advocating for limits on free trade fit into real politics?

A: That's really the problem here. I call it, in my book, the politics of ideology. There's a free-market, free-trade ideology that is dominating the discourse in an institutional setting. Or take the carbon tax. In the EU, the carbon tax has been aligned with certain green parties or some left-wing parties, so there is a radicalization of the discourse. But if you look at it rationally, if you look at all the analysis, these coupled human/natural system computer simulation models will tell you that the carbon tax and trade tax have low transaction costs, and they would stimulate local markets. This approach could revitalize local communities that are losing their vitality to grow, for example, local organic food. And this kind of food production is an important piece in this picture for reducing methane emissions and reducing carbon emissions from agro-industrial systems. Then there are energy implications. Decentralized energy systems could be promoted, like solar and wind and community-based energy systems, through taxes and institutional reforms. But that is not being talked about. Whenever somebody mentions international carbon taxes someone else says, "Oh, that's not politically feasible." Well, why is that? It's not really feasible because those lobbies have been able to hijack the discourse.

Q: What is it going to take for governments to change and adopt new approaches to climate?

A: This is a democracy. So there are always checks and balances, and that is one of the challenges in climate change. Historically, policy changes are incremental unless you look at revolutions like the Stalinistic revolution or the Iranian revolution. And the climate change challenge is that we need fast change, radical change, within existing institutions. A carbon tax, an international trade tax: these are radical changes.

Q: What are your personal hopes and fears about climate change?

A: I, myself, come from a developing country. Pakistan is very vulnerable. Both Pakistan and India are very vulnerable to climate change — and they have done the least to cause it, but they would suffer the most in the first fifty years or so. I have been working there in setting up early warning systems, dealing with climate-refugee problems. The massive flooding in 2010 was part of the trend of more and more flooding during the monsoon season. If you look at the last sixty years of data, you can see that this is caused by climate change. So we are trying to understand the planning regime in Pakistan so that we don't have more development in those regions that would be affected by floods or droughts. That is very personal to me. I have been in the refugee camps. I have seen people who have been displaced for years. After the 2010 floods, twenty million people were displaced and two million are still displaced today, after three years. I was there two months ago and visited a couple of camps. It's very personal to me, because those are the people seeing climate change up front.

Asim Zia, Ph.D., associate professor of community development and applied economics, assesses the shortcomings of recent international climate change policy, and seeks new solutions.

FOOD SYSTEMS

Food systems play an important role locally, nationally and globally, by impacting soil and water quality, human health and nutrition, global economics, packaging and transportation interests, and overall food and energy security. The foundation of this nascent field of study is strongly represented in the existing and emerging strengths at UVM, building on our service as a land-grant university with a deep connection to Vermont's working landscape. As one of UVM's transdisciplinary research efforts, the Food Systems Initiative supports over 140 research projects that address local and regional food systems issues, with a focus on developing viable, regionally-based additions and alternatives to the global food system. These alternatives target a revitalization of regional agriculture while improving public nutrition, protecting the environment and advancing the local economy. This work dovetails with the rising public interest in sustainable, secure, and healthy food systems and the growing national recognition of UVM and Vermont as leaders in sustainable food systems practice.

Innovation in the Maple Sugaring Process

TIMOTHY PERKINS, PH.D., PROFESSOR OF PLANT BIOLOGY AND DIRECTOR OF THE PROCTOR MAPLE RESEARCH CENTER

Abby van den Berg, Ph.D., and Timothy Perkins, Ph.D., with one of their revolutionary maple saplings at UVM's Proctor Maple Research Center.

Four years ago, Professor Tim Perkins, Ph.D., and colleague Abby van den Berg, Ph.D., cut the top off a maple tree. As researchers at UVM's Proctor Maple Research Center, they wanted to learn more about sap flow. Instead, they discovered an entirely new way to make maple syrup. "It's revolutionary in some ways," says Perkins.

Their new technique uses tightly spaced plantations of chest-high sugar-maple saplings. These could be single stems with a portion — or all — of the crown removed. Or they could be multiple-stemmed maples, where one stem per tree can be cut each year. Either way, the cut stem is covered with a sealed plastic bag. Under the bag, the sap flows out of the stump under vacuum pressure and into a tube. Voilà, huge quantities of sap.

Typically, a traditional sugarbush produces about forty gallons of maple syrup per acre of forest by tapping, perhaps, eighty mature trees. With this new method, the UVM researchers estimate that producers could get more than four hundred gallons of syrup per acre drawing from about six thousand saplings. The new technique has the potential to enhance business for existing syrup producers, the researchers think, and defend Vermont's maple industry from threats that range from climate change to spiking land costs to Asian long-horned beetles.

"We didn't set out to develop this system," says van den Berg. "We were looking at ways to improve vacuum systems." But, during a spring thaw, the tapped tree, from which they had removed the crown, just kept yielding sap under vacuum pressure. And more sap and more sap.

"We got to the point where we should have exhausted any water that was in the tree, but the moisture didn't drop," says Perkins. "The only explanation was that we were pulling water out of the ground, right up through and out the stem." In other words, the cut tree works like a sugar-filled straw stuck in the ground. To get the maple sugar stored in the trunk, just apply suction.

While the cut plantation saplings will regrow branches and leaves from side shoots — and can be used year after year — "the top of the tree is really immaterial for sap flow under vacuum-induced flow," Perkins says.

The scientists stress that there is still much to be explored. To date, they've made several conference presentations to maple syrup producers about their research and applied for a patent.

Putting Vermont Farms to the Test

JOHN BARLOW, D.V.M., PH.D., ASSISTANT PROFESSOR OF ANIMAL SCIENCE

Assistant Professor of Animal Science John Barlow, D.V.M, Ph.D., researches milk quality issues to help on-farm cheesemakers improve the safety of their products.

Stacked 15 high, 1,500 culture plates line the bench of John Barlow's lab at UVM. This is the collection of just one day at one Vermont farmstead cheesemaker's farm. Barlow's large-scale, entire-farm sampling hopes to come up with some novel pathogen-detection technology that may be particularly useful to small-scale, on-farm cheesemakers. His research on various forms of *Staphylococcus* will fill in the gaps in food safety professionals' knowledge: which agents are beneficial in the culturing of cheese, and which may affect human health.

The UVM animal scientist's epidemiology research addresses on-farm practices and milk quality using molecular biology to identify pathogens that influence milk quality. Building on the research of UVM listeria expert Catherine Donnelly, Ph.D., on how the safety of raw-milk cheeses informs national policy, Barlow's work is year two of a three-year $300,000 transdisciplinary grant from the USDA National Institute of Food and Agriculture.

On each of up to five Vermont farms that make artisan cheeses, Barlow and his team take milk samples from the mammary glands of all the cows in the herd, swabs of 15 different skin sites from six of the cows, and 15 different environmental samples from walls and stanchions. "This results in running about 1,500 culture plates per farm," says Barlow of the project whose goal is to collect from five artisan cheese-producing farms. "From this we typically select about 300 *Staphylococcus* species bacterial isolates for identification and molecular typing."

Back in the Barlow lab, Robert Mugabi, a second-year doctoral student, examines these for potential virulence characteristics such as the ability to form biofilms and antibiotic resistance genes. "We are doing a comprehensive survey to look for sources of *Staphylococcus aureus* and *Staphylococcus* species," Barlow explains. "The former is a food safety pathogen of concern, but other species appear to be important for the cheesemaking process and may play a beneficial role as important normal bacterial flora on the cow skin." To further complicate matters, some *Staphylococci* carry antibiotic resistant genes that could affect human health, which may act as a reservoir for antibiotic-resistance on dairy farms.

While it is too early to make conclusions, by using molecular typing techniques Barlow and colleagues are making progress in understanding the source of the sporadic new infections in these herds, which generally have a low prevalence of udder infections caused by this pathogen.

"Molecular typing has revealed some novel strains," Mugabi says. "However, there is still a lot to discover that could be important in answering some critical questions in animal health, food safety and public health."

Barlow continues to collaborate with Donnelly, and UVM researchers in community development and applied economics, David Conner, Ph.D., and Sarah Heiss, Ph.D., are also making major contributions to the social science aspects of the project. "We are proud of the transdisciplinary approach to this project," says Barlow. He and Donnelly are particularly excited about the opportunity to collaborate with Conner and Heiss as they work to understand how the public views artisan cheese farms and raw milk, and how social networks may influence perceptions of food safety.

> "WE ARE HERE TO HELP ARTISAN CHEESE PRODUCERS IMPROVE ANIMAL HEALTH, MILK QUALITY AND FOOD SAFETY..."
>
> —John Barlow, D.V.M., Ph.D.

"In the big picture, we are here to help artisan cheese producers improve animal health, milk quality and food safety," Barlow says, "and also to help these producers understand how consumers perceive these attributes for Vermont farms and how this affects their perception of food safety risk and ultimately their purchasing decisions."

Vermont Wheat Makes a Comeback

HEATHER DARBY, PH.D., EXTENSION ASSOCIATE PROFESSOR

In the nineteenth century, Vermont farmers grew some 40,000 acres of wheat each year. But as the soils, railroads, and climate of the Midwest triumphed in the intense competition of grain commodity markets, Vermont wheat production steadily declined and all but disappeared. Wheat fields have begun to sprout once again in Vermont in the past decade, thanks in large part to the research and outreach of UVM Extension agronomist Heather Darby, Ph.D. Darby began studying the viability of growing wheat in Vermont in 2004, later taking that work into the field with Roger Rainville on his Borderview Farm in Alburgh, Vermont, where they began trials with organic spring and winter wheat varieties.

As the local food movement grows, particularly in Vermont, for many it has come to include the desire to have daily bread sourced close to home. Darby points to a rash of recent food safety problems in the global food system, climate change, worries about energy supplies, and skyrocketing commodities prices as part of the changing food landscape.

"People want some control of their food and they want to be connected," Darby says, "The localvore thing is moving beyond the gourmet foodie market — it's now about knowing where your food came from."

Vermont has the highest per capita spending on local foods of any state, according to USDA figures, and that desire to eat local has increasingly come to include bread. Until very recently, however, few bakers were willing to incorporate Vermont-grown wheat in their products, complaining of low quality and limited supply. This has driven Darby to look for varieties that not only will survive in Vermont but produce flour with the protein levels, gluten strength, and taste that bakers demand.

"When the farmers, bakers, millers, and Extension actually started listening to each other, things really took off," Darby says. To help, Darby opened a cereal grain quality laboratory in UVM's Jeffords Hall with funding from the USDA's National Institute for Food and Agriculture Organic Research and Education Initiative program. There, she and her team test wheat samples from farmers on a sophisticated machine that measures what millers and bakers call "falling number." If it rains just before harvest, or wheat contains too much moisture, it may start to sprout. This releases an enzyme that starts breaking down the starch and protein in the grain — which results in off-flavored flour and weak dough.

Randy George — one of the pioneers in baking bread from local wheat and the co-owner of Red Hen Bakery in Middlesex — started as a skeptic but credits Darby for what happened next. "There were a lot of good intentions, but we were bumbling around in the dark until she got the farmers and bakers together," he says, "and soon we saw dramatic improvements in quality." Local farm tours, a trip to Denmark, visits with millers and agronomists in Quebec, and other education spearheaded by Darby helped farmers to understand better the subtle issues that determine wheat quality, including harvest timing, drying techniques, and variety selection. The result: flours with higher falling numbers and better protein levels. Before too long, Red Hen was selling a hundred loaves a day of their purely Vermont-wheat Cyrus Pringle bread, named in honor of UVM's nineteenth-century botanist and wheat breeder.

"WHEN THE FARMERS, BAKERS, MILLERS, AND EXTENSION ACTUALLY STARTED LISTENING TO EACH OTHER, THINGS REALLY TOOK OFF."

—Heather Darby, Ph.D.

Heather Darby, Ph.D., founded a cereal grain quality laboratory at UVM to find the best wheat strains to grow in Vermont soil.

Into the Coffee Lands

V. ERNESTO MÉNDEZ, PH.D., ASSOCIATE PROFESSOR OF PLANT AND SOIL SCIENCE

Professor Ernesto Méndez, Ph.D., knows that being an agronomist alone isn't enough to understand and affect the complex issues of agricultural sustainability and farmer wellbeing. That's why he's devoted his research and teaching career to transdisciplinary and action approaches that integrate systemic thinking with on-the-ground impacts.

Méndez leads UVM's Agroecology and Rural Livelihoods Group, a "community of practice," in Méndez's words, where graduate students and researchers study ecological and socioeconomic sustainability in agricultural landscapes.

While many food systems researchers at UVM focus on pressing local and regional issues, Méndez brings a largely international perspective to his scholarship. Born in El Salvador, his academic pursuits brought him to the United States, where his international research interests focus on the interactions among agricultural, ecological and socioeconomic factors on smallholder coffee farms in Mexico and Central America, and keep him connected to his Mesoamerican roots.

As an inherently transdisciplinary field, agroecology allows Méndez to integrate research on conservation, sustainable coffee production and farmer livelihoods. Méndez also believes that research should support, and not simply reflect, the people and landscapes under study. For this reason, he employs a Participatory Action Research (PAR) methodology, which integrates community-based research with an orientation towards tangible improved outcomes. The PAR approach seeks to incorporate community members into a process of research, reflection and action, and explicitly recognizes the important role of non-researchers in this process.

Méndez's international focus, transdisciplinary lens and novel research techniques have resulted in enviable productivity: 14 papers he has contributed to, often as the lead author, have been published in peer-reviewed journals or have been accepted for publication in the last 18 months.

Méndez has particular interest in sustainable production, environmental conservation and livelihood strategies that smallholder coffee farmers in Central and South American and Africa can employ to address a diversity of challenges, ranging from fluctuating coffee prices to climate change. Members of the Agroecology and Rural Livelihoods Group, known as the ARLG, have ongoing research projects in El Salvador, Mexico and Nicaragua focused on annual periods of seasonal hunger experienced by many smallholder coffee farmers between May and September. These projects focus on contributing factors and strategies for ameliorating *los meses flacos* or "the thin months."

A recent longitudinal food security study (2007–2013) in coffee communities of Mexico, Guatemala and Nicaragua, conducted by the ARLG in collaboration with the International Center for Tropical Agriculture, yielded a key finding related to the thin months. "A strategy of income diversification in conjunction with continued investment in coffee production resulted in livelihood improvements for coffee farming families," Méndez says.

Méndez's work has been supported by Biodiversity International, the Interamerican Foundation and Oxfam America, among others. Since he came to UVM in 2006, his research has also been funded by Keurig Green Mountain (formerly Green Mountain Coffee Roasters), which has devoted significant resources over the past 15 years to helping coffee farmers develop strategies for surviving the thin months. The company has also funded two student fellowships and additional projects related to smallholder coffee research with the ARLG. Despite his many projects, Méndez continues to pursue new funding and collaborations. In March 2014, he was appointed to the advisory committee of the Collaborative Crop Program of the McKnight Foundation, a Minnesota-based family foundation.

Méndez devotes some of his research agenda to working in Vermont. He is currently a collaborating leader of the Vermont Agricultural Resilience in a Changing Climate initiative, which employs strategies ranging from on-farm trials to policy analysis to identify best practices for Vermont farmers.

Associate Professor of Plant and Soil Science Ernesto Méndez, Ph.D., has international research interests that seek to understand and improve the lives of smallholder coffee growers throughout Mexico and Central America.

3 Questions: Getting to the Roots of Childhood Obesity

RACHEL JOHNSON, PH.D., M.P.H., R.D., ROBERT L. BICKFORD, JR. PROFESSOR OF NUTRITION

Rachel Johnson, Ph.D., M.P.H., R.D., has made a career of researching the science behind childhood obesity — with 101 peer-reviewed papers in scientific journals, 12 book chapters, and funded grants and contracts totaling nearly $3.5 million. Thanks to her authoritative research credentials and knack for communicating clearly, Johnson has become a go-to national public health advocate for groups like the American Heart Association (AHA), whose nutrition committee she chairs. Most recently, she has worked with NBC News to develop the nutrition content for the network's new website, Parent Toolkit.

Rachel Johnson, Ph.D., M.P.H., R.D., is a worldwide expert on childhood obesity. Her work on the American Heart Association statement on sugar and cardiovascular disease drew more than 60 million hits on the AHA website.

Q: With new USDA guidelines requiring kids to take fruits and vegetables at school lunch, you've been working on innovative research to evaluate what's actually being consumed. Can you talk about that?

A: There are amazing interventions to get kids to eat more fruits and vegetables — farm-to-school programs, school gardens — so we're interested in accurately measuring what they're eating. My lab has developed state-of-the-art digital imaging so that we can go into cafeterias and measure what's on kids' trays when they leave the lunch line and again before they throw their food out. Our method is accurate within two grams, about the weight of one pea pod. We have about 20 undergraduates who we train to do the imaging and coding. There's been a lot of interest. When I look ahead I would love for our lab to become the go-to place in the country to help evaluate the efficacy of these interventions.

Q: You were first author on a major scientific statement for the AHA calling attention to the link between added sugars and cardiovascular disease. What has been the impact of that?

A: It's been huge. The AHA said that most of their scientific statements get about 28 million media hits and for this paper it was more than 60 million. It was instrumental in changing some of the guidelines that the AHA was using for the Heart-Check Food and Meal Certification Programs (on packaging and menus) because they didn't have an added sugars guideline before. Now there are limits on the amount of added sugars that can be in certain foods.

Q: You've played a significant role in identifying a major source of excess calories for kids. Where do you think the country's been and where is it going in terms of pediatric obesity?

A: Between 1940 and the 1990s the curve makes a big X with soft drink consumption going up and milk consumption going down. So I started looking at children's beverage consumption patterns and how that impacted their overall diet quality. We were one of the first to show that when kids don't have milk at lunch they don't come close to meeting their dietary needs — and the beverages displacing milk add empty calories. Now there's a bright light at the end of the tunnel on childhood obesity, we've seen some slight reductions in places that have been aggressive about making changes. It's a lot of policy changes — we've worked on education policy changes and physical activity standards. There are going to be new regulations in schools about limiting food marketing to kids, and about using food for fundraisers. I think we're going to see a new world in the next ten to fifteen years that's going to blow us away when we look back. At my kids' high school there were banks of vending machines with soft drinks and candy and snack foods, and all the bake sales. It was just crazy. It's going to seem like the days when people smoked in their offices when we look back. It's just not cool.

NEUROSCIENCE AND BEHAVIOR

Interdisciplinary neuroscience and behavioral research at UVM spans the spectrum from genes and molecules to complex behaviors, with an active translational path from bench to bedside to community and back again. The new Vermont Center on Behavior and Health, founded in 2013 with $35 million in federal grants, complements several strong programs already in place at the University, including the Neuroscience, Behavior and Health Transdisciplinary Research Initiative, the Neuroscience Center for Biomedical Research Excellence, and a robust research program in Neurological Sciences. These efforts underscore a focus on investigating relationships between personal behaviors and risk for chronic disease and premature death, with a specific emphasis on understanding mechanisms underpinning risk, and developing effective interventions and policies to promote healthy behavior.

Harnessing Technology for Treating Wait-Listed Opioid-Dependent Vermonters

STACEY SIGMON, PH.D., ASSOCIATE PROFESSOR OF PSYCHIATRY AND DIRECTOR OF THE CHITTENDEN CLINIC

With opioid dependence at epidemic levels and treatment waitlists at an all-time high, Stacey Sigmon, Ph.D., has taken a stand to ensure effective and timely treatment for patients — particularly those in rural states like Vermont. Sigmon's work in behavioral pharmacology and substance abuse treatment over the past two decades has led to a research program dedicated to developing creative and successful pharmacological treatments for rural opioid-dependent patients, a population she is intimately familiar with in her role as director of Vermont's first and largest methadone clinic. She is also director of the Behavioral Economics and Intervention Science Core of the Vermont Center on Behavior and Health.

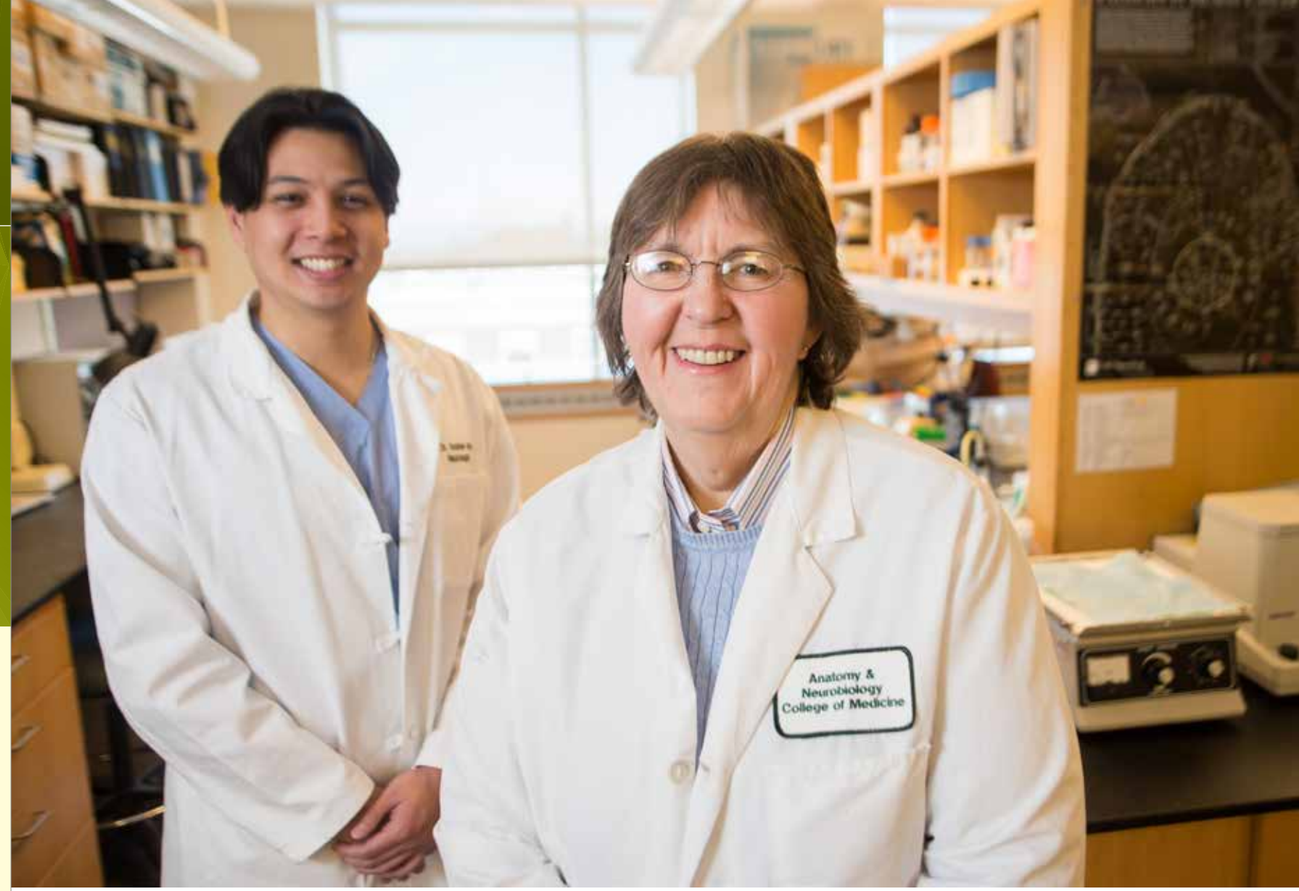
Associate Professor of Psychiatry Stacey Sigmon, Ph.D., has worked to develop successful pharmacological treatments for rural opioid-dependent patients.

Her latest project, funded by the National Institute on Drug Abuse, aims to develop a novel Interim Buprenorphine Treatment to help opioid-dependent Vermonters bridge challenging waitlist delays. She's proposed a treatment of five key components designed to maximize patient access to drug therapies for opioid dependence while minimizing current barriers to treatment success, including non-adherence, abuse and diversion of medication.

The first piece of Sigmon's five-pronged approach involves three months of maintenance therapy using the opioid agonist buprenorphine (Suboxone®), an FDA-approved treatment whose safety and efficacy Sigmon and her UVM colleagues have published on in journals such as *JAMA Psychiatry*.

The study's second approach relies on a state-of-the-art, computerized portable device (Med-O-Wheel) that dispenses each day's dose at a predetermined time, after which all medication is inaccessible. Clinical support — the third piece — will come from a mobile health platform that uses technology to deliver patient monitoring, education and support beyond the confines of the medical office. Sigmon's study will utilize a phone-based, Interactive Voice Response system to provide clinical support to patients by phone. The fourth feature involves an automated call-back procedure during which participants are contacted at randomly-determined intervals and directed to visit the clinic for a pill count and urinalysis. The fifth and final piece is the development and provision of an HIV and hepatitis educational intervention delivered on an iPad.

Sigmon hopes her newest study will provide an effective model for helping reduce drug-related risks and costs, and contribute to what she refers to as "a fundamental shift in how treatment of opioid dependence is conceptualized and delivered in the United States."



Diane Jaworski, Ph.D., right, and Andrew Tsen, M.D., are part of a UVM team discovering potential new brain cancer treatments.

A Food Additive's Potential Role in Brain Cancer Therapy

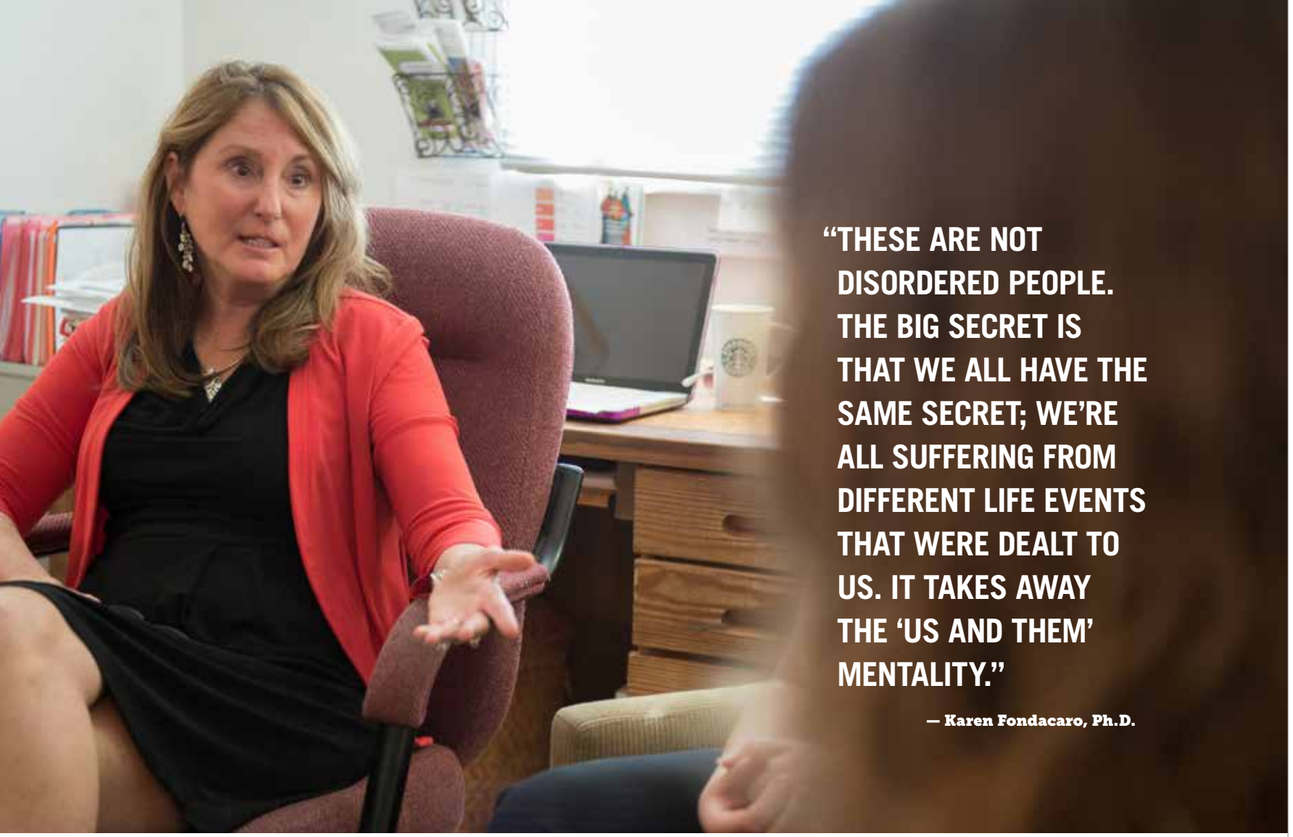
DIANE JAWORSKI, PH.D., PROFESSOR OF NEUROLOGICAL SCIENCES

A few studies have investigated acetate as a potential therapeutic agent, but none had examined its potential benefits in treating gliomas — brain tumors that originate in the glial cells of the brain — until Professor Diane Jaworski's research uncovered its impact. In searching for a novel therapy, she and her UVM colleagues discovered that the FDA-approved food additive glyceryl triacetate (GTA) shows promise as a treatment.

Jaworski first examined ASPA (aspartoacylase), an enzyme that breaks down a compound called N-acetyl-L-aspartate (NAA) into the amino acid aspartate and acetate. NAA is the brain's primary storage form of acetate, which plays a critical role in allowing genes to be turned on and off. In glioma, NAA levels and ASPA expression are decreased, reducing acetate bioavailability.

Aiming to reduce the tumor cells' uncontrolled growth, Jaworski and her team tested supplementation with NAA, but the results were surprising: NAA and another source of acetate in the brain, NAAG, increased the proliferation of glioma stem cells. Stumped by these findings, she was determined to find the missing link, and she did — in a Eureka Moment on her flight back from a cancer research conference: another acetate source, with the ability to cross the blood-brain barrier without ASPA, was the answer.

The solution turned out to be GTA, an agent that was found to decrease the growth of glioma stem cells in culture, as well as shrink brain tumors formed in mouse brains. The team first infected glioma stem cells with a virus to express luminescent enzymes. Then, tumor size and response to therapy was tracked over time utilizing highly sensitive imaging tools. The data revealed that GTA increased the effectiveness of chemotherapy treatment and increased survival. This research has been published recently in both the *Journal of Biological Chemistry* and the *International Journal of Cancer*. Because almost all types of cancer cells have reduced acetate, Jaworski believes that GTA will not only be effective on glioma cells, but potentially other cancers as well.



Clinical Professor of Psychology Karen Fondacaro, Ph.D., founded Connecting Cultures to provide mental health services to Vermont's growing population of refugees. A three-year federal grant funds her efforts to bring effective psychological services to torture survivors.

Serving Vermont's Growing Refugee Communities

KAREN FONDACARO, PH.D., CLINICAL PROFESSOR OF PSYCHOLOGY AND DIRECTOR OF THE UVM BEHAVIOR THERAPY AND PSYCHOTHERAPY CENTER

As Vermont's refugee population grows, the community has found a key resource at UVM's Dewey Hall. Six years ago, Karen Fondacaro, Ph.D., founded Connecting Cultures, a program providing mental health services to Vermont's refugee community. The clinic has since served more than 350 refugees from 29 different countries. Sixty-seven percent are torture survivors. Those numbers, and the real lives behind them, led Fondacaro to partner with groups both inside and outside of the University to expand the types of services offered to refugees (including legal, social and medical referrals), beginning in 2009 with the co-founding of New England Survivors of Torture and Trauma (NESTT).

With the three-year federal grant that funds NESTT recently renewed, Fondacaro has a mandate to provide psychological services to torture survivors, to empirically evaluate the effectiveness of treatment and to train other providers, which she does at both the national and local level, while also supervising graduate students.

The center's new treatment and research model is based on the "third wave" therapy known as ACT (Acceptance and Commitment Therapy). Fondacaro's work adapts ACT to match the cultural and linguistic barriers of working with refugee populations suffering from past torture and severe trauma. Fondacaro and her students are in the process of annualizing this intervention for other providers.

One key to the center's process is dispensing with labels that pathologize torture survivors. Fondacaro often shortens the abbreviation for what many of them suffer to PTS (post-traumatic stress). "These are not disordered people," she says. "The big secret is that we all have the same secret; we're all suffering from different life events that were dealt to us. It takes away the 'us and them' mentality."

A second, and critical, characteristic element is the center's novel integration of exposure therapy within an acceptance-based model. A radical difference is placing the timing and control of sharing a difficult story completely in the hands of the torture survivor-client. "The idea is that it's your story," Fondacaro says. "You were given a story that nobody would ever ask for, and you have the right to tell whomever you want or never tell anybody. Having control over the story is really freeing for people."

Within the groups (so far the center has run three with Bhutanese survivors and two with Somali-Bantu, with two more upcoming), everyone, even the initially reluctant, has voiced through an interpreter his or her story.

Part of the reason people open up, Fondacaro believes, is that the process is gradual. The clinicians begin by creating a sense of safety and trust through sitting, talking, singing, culture sharing. They teach mindfulness exercises and get to know their clients' values, often using pictures to represent the refugees' homeland, marriage and children.

When survivors do share their stories of unimaginable cruelty and violence, they are carefully monitored. Their stress levels do go up, but in the process they learn that they can tolerate the intense images, thoughts and emotions. Mindfulness techniques help them remain grounded in the safety of the present moment.

Fondacaro understands that telling and hearing the story facilitates habituation to the client's past trauma, one of the mechanisms of exposure therapy. But she believes another important dynamic is also at work — the impact of the community; therapy sessions almost always happen in a group setting. "There's a group of people saying, 'We're here to listen, we accept you, your story, and we can tolerate the intensity of feelings with you.'"

Ultimately, and this is the heart of ACT, the stories don't go away. Survivors don't get over them, and that isn't the point. "Being healthy isn't getting rid of the anxiety or sadness," Fondacaro says. "The aim is to be able to tolerate intense feelings and live a value-rich life."

Mapping the Teenage Brain

HUGH GARAVAN, PH.D., ASSOCIATE PROFESSOR OF PSYCHIATRY AND PSYCHOLOGY

Why do some teenagers start smoking or experimenting with drugs — while others don't? In the largest imaging study of the human brain ever conducted — involving 1,896 14-year-olds — scientists have discovered a number of previously unknown networks that go a long way toward an answer.

Professor Hugh Garavan, Ph.D., and former Postdoctoral Fellow Robert Whelan, Ph.D., along with a large group of international colleagues, report that differences in these networks provide strong evidence that some teenagers are at higher risk for drug and alcohol experimentation — simply because their brains work differently, making them more impulsive. Their findings were published in the journal *Nature Neuroscience* and further studies will be published in *Nature* in 2014.

This discovery helps answer a long-standing chicken-or-egg question about whether certain brain patterns come before drug use — or are caused by it. "The differences in these networks seem to precede drug use," says Garavan, who also served as the principal investigator of the Irish component of a large European research project, called IMAGEN, which gathered the data about the teens in the new study.

Associate Professor of Psychiatry and Psychology Hugh Garavan, Ph.D., conducted the largest-ever study of its kind on young people to help identify which people have a greater propensity for addiction.

"THE TAKE-HOME MESSAGE IS THAT IMPULSIVITY CAN BE DECOMPOSED, BROKEN DOWN INTO DIFFERENT BRAIN REGIONS … AND THE FUNCTIONING OF ONE REGION IS RELATED TO ADHD SYMPTOMS, WHILE THE FUNCTIONING OF OTHER REGIONS IS RELATED TO DRUG USE."

—Hugh Garavan, Ph.D.

In a key finding, diminished activity in a network involving the orbitofrontal cortex is associated with experimentation with alcohol, cigarettes and illegal drugs in early adolescence. "These networks are not working as well for some kids as for others," says Whelan, "making them more impulsive."

Faced with a choice about smoking or drinking, the 14-year-old with a less functional impulse-regulating network will be more likely to say, "Yeah, gimme, gimme, gimme!" says Garavan, "and this other kid is saying, 'no, I'm not going to do that.'"

Testing for lower function in this and other brain networks could, perhaps, be used by researchers someday as "a risk factor or biomarker for potential drug use," Garavan says.

The researchers were also able to show that other newly discovered networks are connected with the symptoms of attention-deficit hyperactivity disorder. These ADHD networks are distinct from those associated with early drug use.

In recent years, there has been controversy and extensive media attention about the possible connection between ADHD and drug abuse. Both ADHD and early drug use are associated with poor inhibitory control — they're problems that plague impulsive people.

But the new research shows that these seemingly related problems are regulated by different networks in the brain — even though both groups of teens can score poorly on tests of their "stop-signal reaction time," a standard measure of overall inhibitory control used in this study and other similar ones. This strengthens the idea that risk of ADHD is not necessarily a full-blown risk for drug use as some recent studies suggest.

"The take-home message is that impulsivity can be decomposed, broken down into different brain regions," says Garavan, "and the functioning of one region is related to ADHD symptoms, while the functioning of other regions is related to drug use."

That teenagers push against boundaries — and sometimes take risks — is as predictable as the sunrise. It happens in all cultures and even across all mammal species: adolescence is a time to test limits and develop independence.

But death among teenagers in the industrialized world is largely caused by preventable or self-inflicted accidents that are often launched by impulsive risky behaviors, often associated with alcohol and drug use. Additionally, "addiction in the western world is our number one health problem," says Garavan. "Think about alcohol, cigarettes or harder drugs and all the consequences that has in society for people's health." Understanding brain networks that put some teenagers at higher risk for starting to use them could have large implications for public health.

4 Questions: Research and Advocacy to Eliminate Stuttering

BARRY GUITAR, PH.D., PROFESSOR OF COMMUNICATION SCIENCES AND DISORDERS

Professor Barry Guitar is part researcher, part clinician and part evangelist for a form of speech therapy aimed at young children who stutter that he believes could be as effective as it is controversial in America and Europe. The therapy, developed in Australia in the 1990s, is called the Lidcombe method. Its key elements are two interventions that are anathema, Guitar says, to conventionally trained speech therapists in the West. In a daily 15-minute speech session, guided by weekly meetings with a clinician, parents praise their child for fluent talk. And, in an encouraging, upbeat tone, they periodically ask that stammered words be repeated.

Guitar is the only American academician doing research on the Lidcombe method. Three separate studies his research team have conducted over the last decade confirm its effectiveness.

With 25 years of funding from foundations and federal agencies like the National Institutes of Health, more than 100 published papers, and the fifth edition of his widely used college textbook, *Stuttering,* in the works, Guitar, who conquered a stutter himself, is one of the field's most respected clinicians and scholars.

Party because of his influence, the tide may be turning in his home country. The American Speech and Hearing Foundation recently asked Guitar to make a presentation at its annual meeting on how research has been used to develop the Lidcombe method and demonstrate its efficacy.

Q: You're utterly convinced of the efficacy of the Lidcombe method. Why?

A: Primarily because of the data that clinical researchers have gathered in more than 100 studies, including some bigger ones that are very rigorously controlled. They showed quite definitely that Lidcombe was better than competing therapies or taking a wait-and-see approach. Our own research has confirmed these findings.

Q: What is it about the therapy that, to this day, inspires the disdain of your academic colleagues in the U.S. and Europe, 20 years after it was developed?

A: I think it goes against the grain of what people naturally feel about kids who stutter — and the training of the last 50 years. They feel that if the child is struggling, and if they call attention to it or talk to the child about it, the child will become even more self-conscious. From my point of view, it's like your child falls and scrapes his knee up and starts crying and you think, I'm going to ignore this. The critics can't bear to think that merely praising fluent speech and asking a child to repeat stuttered words is going to work, and don't realize that — given the extensive counseling we do with parents — that's just a tiny piece of the program.

Q: Talk about the Lidcombe therapy session itself. It's fun for the child, right?

A: Yes. That's a *sine qua non.* In other words, don't do the therapy session if it's not fun for the kiddo. Stand on your head, or use candy, or other sorts of rewards, pick games the kid has fun with and give that child one-on-one attention, so that he or she has got time with a parent. It's a time the child enjoys.

Q: What would the possibilities be, do you think, if the Lidcombe method were widely adopted?

A: I think if people did Lidcombe and other similar therapies and were doing it carefully, and had training and were mentored, there's no reason that stuttering couldn't be wiped out. Obviously it depends on how well you can reach out. There are going be a lot of families who just couldn't afford therapy. But if you could reach out that way, and kept up the effort... then we could get stuttering down to a very tiny amount.

Professor of Communication Sciences and Disorders Barry Guitar, Ph.D., overcame a severe stutter in his youth. Today, with a quarter-century of federally financed research behind him, he advocates for the Lidcombe method of speech therapy.

ECONOMIC DEVELOPMENT & IMPACT

Research universities such as UVM are economic engines that provide the raw power of innovative discoveries that propel the renewal of existing fields of commerce, or open the way to entirely new commercial ventures that revolutionize the way we live and work. The University is a full-fledged member of the world around it, and it plays a vital role in the economy of its community in all the ways "community" can be defined: locally, regionally, nationally, and around the globe.

UVM Startup Can Power Trillions of Sensors in Everyday Objects

IoT might sound like the latest new texting acronym. What it actually stands for is more serious: a technology revolution waiting in the wings called the "Internet of Things."

In a few short years, trillions of wireless sensors — embedded in everything from buildings to vehicles to household appliances to the bloodstream, up from 10 billion shipped annually today — will convey data of every type, over the Internet, to interested parties of every kind.

Technology conceived at the University of Vermont could bring the sensor-driven IoT world closer to reality by helping overcome its Achilles' heel: how all those sensors will be powered, given the impracticality and expense of installing and changing batteries.

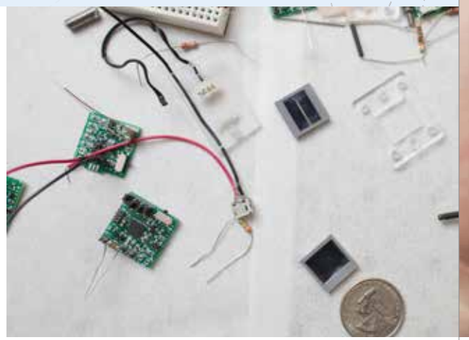
UVM alumnus Robert Andosca (M.S. in Materials Science/Electrical Engineering, Ph.D. in Materials Science/Physics) has made the idea of battery-powered sensors all but obsolete with a tiny vibration energy scavenging device, half the size of a sugar cube, that he developed with his Ph.D. advisor, UVM physics professor Junru Wu, Ph.D. The "MEMS" device — for micro-electromechanical systems — converts mechanical energy into electricity using a special "piezoelectric" material that generates a charge at the slightest jostle.

The company Andosca and Wu co-founded in 2007, MicroGen Systems, is on the verge of taking its first micro-power source products to market.

Kristofer Pister, chair of the Electrical Engineering Department at the University of California at Berkeley and a pioneer of wireless sensor networks, says MicroGen is poised at a potentially watershed moment.

"The market for wireless sensors is finally taking off, and their power requirements have dropped to the point where a good vibrational energy scavenger is plenty," Pister says. "And it looks like MicroGen has built a very good vibrational energy scavenger. It's an exciting time for the company."

Under the guidance of Wu, Andosca developed a novel theoretical model and optimum design parameters for the micro-scale harvester that allowed him to crank up its power to record levels.



Public recognition of the product's promise began in 2011, when Andosca powered a Texas Instruments wireless sensor with one of his prototype devices at a demo at the Sensors Expo in Chicago. *The MIT Technology Review* published a glowing review.

A year later, Andosca's Ph.D. dissertation — a distillation of his theoretical and experimental work on the energy harvester — was published in the journal *Sensors and Actuators* and became the seventh most downloaded paper of 2012 on the leading website *Science Direct*. And in 2013, the energy harvester won top honors at the MEMS Showcase at the MEMS Executive Congress in Napa, Calif.

> **"THE MARKET FOR WIRELESS SENSORS IS FINALLY TAKING OFF, AND THEIR POWER REQUIREMENTS HAVE DROPPED TO THE POINT WHERE A GOOD VIBRATIONAL ENERGY SCAVENGER IS PLENTY. … AND IT LOOKS LIKE MICROGEN HAS BUILT A VERY GOOD VIBRATIONAL ENERGY SCAVENGER. IT'S AN EXCITING TIME FOR THE COMPANY."**
>
> **—Kristofer Pister, Ph.D., University of California—Berkeley**

The success attracted funding. A Belgium-based holding company called Xtrion invested $3.9 million in the company. Nearly as important, it offered the capabilities of two majority-owned subsidiaries. The first, X-FAB, operates a series of state-of-the-art semiconductor-MEMS foundries in Europe, Malaysia and the U.S. MicroGen's products are now being manufactured at an X-FAB facility in Germany.

The second company, Melexis, produces integrated circuit sensor components for the automotive market.

UVM alumnus Robert Andosca, Ph.D., holds one of the "MEMS" devices developed from research done at UVM by Andosca and Professor of Physics Junru Wu, Ph.D. At left, a variety of small sensing devices under development at MicroGen Systems, the company formed by Andosca and Wu.

It has licensed MicroGen's technology to power its sensors in the tire-pressure monitoring systems mandated in passenger cars in the U.S. and the European Union.

Andosca has backstopped his R&D prowess with a business plan savvy enough to have won New York State's Creative Core Emerging Business Competition in 2012, earning MicroGen $200,000. The plan also helped MicroGen win three contracts from the New York Energy Research Development Authority totaling $3 million.

The plan calls for a strategically sequenced entry into the Internet of Things market, beginning with the industrial market in 2014, progressing to the tire-pressure monitoring systems market for high-use vehicles in 2016, moving to the passenger car market in the latter part of the decade and later targeting the wider IoT world.

Andosca has eager customers lined up in each of the first two phases — with the first X-FAB manufactured products coming to market in October 2014 — and anticipates annual sales of $100 million by 2019.

"MicroGen is at the right place at the right time at the tip of the IoT iceberg," he says. Not a bad place to be — for trillions of reasons. ◗

(MicroGen Systems is a UVM startup company that licenses patented intellectual property of the University of Vermont.)

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Erasing Boundaries for the Blind

From left: Michael Coleman, Ph.D., demonstrates the inTACT Eraser, designed for use by blind and visually impaired students, while his colleagues Michael Rosen, Ph.D., and UVM alumnus Joshua Coffee look on.

Michael Rosen has produced research related to people with disabilities for the past four decades, the last ten in the College of Engineering and Mathematical Sciences. It wasn't until he co-founded Engineering to Assist and Support You (E.A.S.Y), LLC with a colleague and a former student, however, that he felt like his research truly impacted lives.

"This company represents the first time that something I have been involved with as an academic engineer will end up in use by people who actually need it," says Rosen. "My research has resulted in refereed papers, conference presentations, and about eight patents, none of which led to things actually being in the hands of people with disabilities. It's a kind of closure towards the end of my career, but also represents a new beginning."

Since the launch of E.A.S.Y in 2012, Rosen, his colleague Michael Coleman, and CEMS alumnus Joshua Coffee ('11), have developed three highly innovative tactile graphics products that are expected to dramatically improve the way the blind and visually impaired (BVI) students, as well as professionals like engineers, mathematicians and artists, learn and communicate.

The inTACT Eraser fundamentally changes the way BVI students approach schoolwork by giving them the ability, for the very first time, to change, correct and update tactile graphics as they sketch. The handheld device allows users to flatten raised lines as they draw on the company's special inTACT Sketchpad, eliminating the tactile lines to the touch, similar to erasing pencil lines. The sketchpad, recently put into production by Progressive Plastics in Williamstown, Vt., allows users to make freehand tactile drawings by producing easy-to-feel raised lines with a stylus on a thin plastic drawing sheet.

"Without the eraser and sketchpad, raised-line drawing or calculating has been like working with crayons or a pen," says Coffee. "A sighted student would never do their math in pen in seventh grade, so the eraser should give BVI kids the confidence to work without the fear of making a mistake that can't be corrected."

Coffee is working with Pearson Education, a producer of K–12 educational content, to create interactive tactile graphical exercises and graphics similar to existing K–12 school text books for the sighted.

The inTACT Raised-line Printer will allow teachers and professionals to print tactile drawings from computer files and share them with others on the same plastic drawing sheets used in the sketchpad, which they can add to or modify using the eraser, making tactile drawing interactive for the first time. Another groundbreaking advance is a digitizing circuit board built into the base of the sketchpad, so drawings can be saved in standard digital graphics format and transferred to a PC.

The idea for E.A.S.Y grew out of a project in Senior Experience in Engineering Design (SEED) capstone course taught by Rosen, based on a conversation with a blind mathematician, who emphasized the need for new learning products for the blind. Rosen, Coleman and Coffee regularly attend the National Federation of the Blind (NFB) annual convention and state conventions to identify potential customers and problems that need solving.

Initial capital was secured from NFB, which led to UVM's Office of Technology Commercialization providing a low interest loan from the UVM Ventures Innovation Fund, and residency at the Vermont Center for Emerging Technologies. Other funding followed from the National Institutes of Health (NIH) in the form of a Phase-I small business grant with the potential for a much larger Phase-II grant.

"We often hear things like 'I could have been an architect' or 'where were you when I was in high school' and that's when we understand the significance of what we're trying to accomplish," says Coffee. ◗

"WE OFTEN HEAR THINGS LIKE 'I COULD HAVE BEEN AN ARCHITECT' OR 'WHERE WERE YOU WHEN I WAS IN HIGH SCHOOL' AND THAT'S WHEN WE UNDERSTAND THE SIGNIFICANCE OF WHAT WE'RE TRYING TO ACCOMPLISH."

—Joshua Coffee, CEMS Alumnus '11

The Office of Technology Commercialization: Bringing Innovations to the Marketplace

The growing support of the UVM Office of Technology Commercialization (OTC) for promising innovations is bringing more and more discoveries to the commercial marketplace. Some products have been the basis for startup companies, while others are licensed to existing companies. Increasingly, the further development of innovation occurs in the laboratory of the inventor in collaboration with the company to whom it has been licensed. "Our goal is to steward the technology through the necessary intellectual property channels to make the product or service available for the public good," explains Corine Farewell, D.V.M., M.B.A., Director of the OTC.

The OTC team consists of a blend of scientific, business, marketing, communications, and legal backgrounds tasked with keeping their fingers on the pulse of promising research at UVM. Their charge is to ensure that the technology transfer process begins as early as possible.

In FY 2013, the Office of Technology Commercialization received 29 invention disclosures. Those disclosures named over three dozen inventors from a variety of departments and units across the university. The disclosed inventions covered a broad range of scientific endeavors, encompassing both life sciences (diagnostics, therapeutics, research tools, and medical/surgical devices) and physical sciences (food systems, engineering, chemistry, and computer software).

In order to commercialize new technologies more effectively, universities often seek patent protection for their intellectual property. The University of Vermont filed 17 new patent applications while actively prosecuting 24 additional applications in the pipeline during FY13. The patent prosecution process is a multi-year commitment. The United States Patent and Trademark Office granted ten U.S. patents to the University of Vermont in FY 2013, evenly split with five each on life science or physical science subject matter. ◗

SPARK Program Helps Move Biomedical Research Concepts to Clinical Care

Markus Meyer, M.D., presents his inexpensive heart monitor design to the SPARK VT committee.

A new initiative from the Department of Medicine at the UVM College of Medicine is helping to bridge the divide between biomedical research and the market by bringing promising researchers together with business innovators and biotech leaders. Called SPARK VT, the goal of the program is to address the challenge of translating novel research from bench to bedside.

Based on a program developed at Stanford University, the department launched SPARK VT as a pilot in late 2012. Under the direction of Department of Medicine Chair Polly Parsons, M.D., the program's organizing committee — which included Professor of Medicine Mercedes Rincon, Ph.D.; department business manager Eric Gagnon, and Mark Allegretta, Ph.D., president and chief scientific officer of BioMosaics — put out a call to its faculty members and researchers for proposals aimed at translating novel ideas into therapies, diagnostics, or devices that could "advance rapidly into clinical care through commercialization or other pathways." This left a wide berth for any number of ideas — from therapeutic devices and medical applications available on smart phones to new chemical compounds or pharmaceuticals.

For the first SPARK VT round held in May of 2013, a panel of nine leaders from biotech, pharmaceutical, business, and legal fields heard presentations on five pre-selected proposals. The panel offered practical advice and challenged presenters to hone in on how their research was going to impact patients and improve care. Two projects — one presented by Markus Meyer, M.D., and the other by the team of Renee Stapleton, M.D., Ph.D., and Benjamin Suratt, M.D.— each received a $50,000 seed grant to help move their research from bench to bedside. Meyer is developing a fast and inexpensive way to test for heart function: A simple device to administer a small dose of nitrogen to a patient and time its flow through the body. Stapleton and Suratt are researching leptin — a protein hormone — as a therapy for Systematic Inflammatory Response Syndrome (SIRS). This syndrome includes sepsis and shock, and may result from trauma or infection.

One goal was for participants to apply for two National Institutes of Health grant opportunities that have seen an increase in funding at a time when many programs are being cut: the Small Business Innovation Research (SBIR) and the Small Business Technology Transfer (SBTT) grants. Both programs ask small businesses to collaborate with research institutions to help commercialize potential new technologies.

SPARK VT funding allowed both projects to move to the next phase of study. Meyer completed follow-up studies on the heart function monitor, and created a start-up company to support his venture. He also submitted an SBIR grant. Suratt and Stapleton have completed additional studies and submitted a patent application with help from UVM's Office of Technology Commercialization. They've also submitted several grant proposals, and are exploring possible industrial partners.

The Department of Medicine will hold a second round of SPARK VT presentations in June 2014, with the same invited panel of experts returning to learn about research from faculty members who submitted proposals. For this round, faculty from two additional departments were invited to submit proposals: Neurological Sciences and Obstetrics, Gynecology & Reproductive Sciences. ◗

3 Questions: Economic Impact of Globalization

STEPHANIE SEGUINO, PH.D., PROFESSOR OF ECONOMICS

Professor of Economics Stephanie Seguino, Ph.D.

Professor Stephanie Seguino is a macroeconomist studying the impact of globalization on income distribution and wellbeing. She's earned the ear of policymakers worldwide by showing that, while women — and ultimately children — bear the brunt, the entire economy suffers when some are marginalized. Seguino was a major contributor to a recently released report from the United Nations Development Programme (UNDP), Humanity Divided: Confronting Inequality in Developing Countries.

Q: Your research is directly influencing international policy at the United Nations, the World Bank, and the International Monetary Fund. What's that like and what shape is it taking?

A: There's nothing more gratifying than seeing that your work is useful to people, and I think it's really showing up in this Humanity Divided report. It's a major publication, so to get this debated on an international level — and be part of the conversation — is just extraordinary. I've been working for a long time to develop a framework for analyzing gender inequality. And I've been a strong critic of the World Bank and others who think if we provide equality of opportunity we shouldn't worry about equality of outcomes, that it's antithetical to capitalism to interfere. But a lot of the work I've done suggests that we do have to care about inequality of outcomes because that fuels inequality of opportunity. Just a simple example: if you are in a country in which men's wages are significantly higher than female wages, parents are going to differentially invest in their boys' education rather than girls', especially if their future social security is based on the earnings of their children, which is the case in many countries.

Q: You're starting new research that looks at the macroeconomic impact of racial inequality in the U.S.?

A: One of the things I want to do is to look at whether states that have the widest achievement gaps between black and white students grow more slowly than those states that do not. It's a way to argue that there are societal-wide effects of inequality. The research suggests that inequality is bad for the economy as a whole — it leads to more conflict, it leads to lower productivity growth in the future, it leads to more social spending on social services because people who are disadvantaged can't compete as well as others. We're starting with the U.S. because we have better data, but I think it will have broader implications once we establish the methodology. The issue of racial inequality is profoundly important for Europe.

Q: What's it going to take to eradicate global inequality?

A: Policies can help. Now more than ever we see a focus on inequality, and I think that we are at a political moment where it is feasible to adopt policies that we already know work.

The problem has been that the forces of globalization have really limited the role of government, and I think people believe that we have gone too far in that direction. It comes from anxiety — life has been economically insecure for the poor for a long time, but it's economically insecure now for the middle class and that's beginning to focus attention on this as a universal problem. It tells you a lot about sociological and psychological phenomena, that good ideas can lie around for a long time, but once they get a certain momentum you reach a tipping point in which the whole system will shift — and that's really more and more how I understand the world works. ◗

Clinical Trials: Research Translating to Improved Care

UVM/Fletcher Allen cardiologists prepare a transcatheter aortic valve replacement as part of a clinical trial.

Clinical trials are the testing of new treatments in humans after extensive laboratory research has been completed. Clinical trials find better ways to treat a specific disease and are a critical step in the development of new medications to treat diseases. Hundreds of externally-funded clinical trials of new medicines have been conducted at UVM and Fletcher Allen in the last decade, most targeting the nation's six most debilitating chronic diseases — asthma, cancer, diabetes, heart disease, mental illnesses and stroke.

In December 2013, "Research in Your Backyard," a special panel discussion, provided an overview of clinical trials in Vermont and their importance in offering both cutting-edge treatments to patients, as well as economic opportunities to our communities.

"The broad availability of clinical trials in Vermont ensures that promising novel treatments are locally available and that our community benefits from these emerging therapeutic opportunities," says Richard Galbraith, M.D., Ph.D., Director of the UVM Clinical Research Center. ◗

Using Technology to Engage Middle Schoolers

PENNY BISHOP, ED.D., PROFESSOR OF EDUCATION

Penny Bishop, Ed.D., leads the Tarrant Institute for Innovative Education at UVM.

When the Tarrant Institute for Innovative Education was launched in 2009 with a $5 million gift from the Rich E. and Deborah L. Tarrant Foundation, its 10-year mission was clear: Support technology integration in middle schools as a means of increasing student engagement and decreasing drop-out rates in Vermont. Today, five years into the ambitious initiative, the Tarrant Institute, an outreach, development and research arm of the College of Education and Social Services, is active in 10 middle schools around the state, has advisors working with the Burlington-Winooski Partnership for Change, a multi-district effort, and is being tracked by educators around the country eager to see if its approach to engaging a hard-to-motivate age group can be widely adopted.

The Tarrant Institute's grant, the largest in its history, was in a sense a bet the organization made on the scholarship of Penny Bishop, a professor of middle level education at UVM who became its director. Bishop has written extensively on using technology as an engagement strategy in the classroom and co-authored five books on effective middle grades practice.

"The institute's goal is to not only foster widespread use of technology in Vermont schools, but also to create a cadre of teachers who confidently employ it in service of what we know to be exemplary middle school teaching practices," she says. ◗

Career Skills Correlate with Volunteering

DAVID JONES, PH.D., ASSOCIATE PROFESSOR OF BUSINESS ADMINISTRATION

David Jones, Ph.D., studied volunteerism in depth at Keurig Green Mountain, Inc., formerly Green Mountain Coffee Roasters.

For almost a decade, David Jones has studied how company-supported volunteer programs increase employee loyalty, happiness and retention. Starting in 2006 with his study of a Green Mountain Coffee Roasters program to support and encourage its employees to volunteer and serve their communities, Jones began to note a pattern: Companies who invest in employee volunteerism can recoup those investments — and then some. Over time, he has completed more than 10 empirical studies, consulted with six companies — both local firms and large multinationals — seeking to set up volunteer programs, and seen his findings published in academic journals and scholarly book chapters. His studies about company volunteer programs, in turn, connect to his other research showing that many job seekers want to work for employers committed to sustainable business practices.

"I'm not setting out to try to show that these volunteer programs pay for themselves or that companies will always get a lot in return, but the results across several studies make a heck of a good story," Jones says. ◗

GENERAL
UVM FACTS

- **223** years since UVM was chartered in **1791** as the fifth college in New England
- **10** schools and colleges
- **109** bachelor's degree programs
- **9,970** undergraduate students
- **45** master's and **21** doctoral programs
- **1,357** graduate students
- **454** medical students
- **1,241** full-time and **303** part-time faculty
- **89%** of full-time faculty hold the highest degree in their discipline
- **35,614** degrees awarded since 2000
- **105,263** living alumni of the University

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Edward Neuert
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CONTRIBUTING WRITERS

Joshua Brown
Lee Ann Cox
Cheryl Dorschner
Sarah Keblin
Meredith Woodward King
Jennifer Nachbur
Erin Post
Jon Reidel
Amanda Waite
Sarah Zobel

CONTRIBUTING PHOTOGRAPHERS

Mike Bradley
Joshua Brown
Raj Chawla
Jeff Clarke
Andy Duback
Bob Handleman
Jamie Lent
Sally McCay
Mario Morgado
Alison Nihart
Erin Post

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