In complying with the letter and spirit of applicable laws and pursuing its own goals of diversity, the University of Maine shall not discriminate on the grounds of race, color, religion, sex, sexual orientation, including transgender status or gender expression, national origin, citizenship status, age, disability, or veteran's status in employment, education, and all other areas of the University of Maine. The University provides reasonable accommodations to qualified individuals with disabilities upon request. Questions and complaints about discrimination in any area of the University should be directed to the Director of Equal Opportunity, The University of Maine, 5754 North Stevens Hall, Room 101, Orono, ME 04469-5754, telephone (207) 581-1226, TTY (207) 581-9484.

Cover images courtesy of University Relations.

A member of the University of Maine System
From the Director

Greetings!

I am pleased to present the Office of Research and Sponsored Programs’ (ORSP’s) Annual Research Highlights 2009.

*Highlights 2009* contains narratives that are representative of the visionary research being conducted across the University and funded with extramural dollars. It also includes statistical data such as the dollar values of extramural awards and submissions, and a breakdown of extramural dollars awarded by funding source, more of which may be found in the *ORSP Annual Report of Extramural Activity* issued at the close of each fiscal year and made available online at: http://orspdocs.umesp.maine.edu.*

*Highlights 2009* introduces readers to *Elysia chlorotica*, a marine creature with the remarkable ability to perform life-sustaining photosynthesis, and *Geobacter*, an “iron-eating” microorganism with ties to arsenic contamination in groundwater. Readers will learn how ice cores containing tens of thousands of years of the earth’s climate history are informing scientists about more recent and abrupt climate changes, and what plant seeds, crop pests, infectious diseases, and computer worms all have in common.

Also within these pages are stories that reflect the University’s strong commitment to moving research beyond the walls of the laboratory and into the field through service to the citizens of Maine, whether that be supplying potato growers with current information about potential disease outbreaks, developing a dynamic ecosystem model for lobster fisheries management, or equipping children of deployed military personnel with tools to cope with their parent’s long absences from home.

I hope readers of *Highlights 2009* find it informative. Those wishing to read more about University research can do so by exploring the *Research* and *UMaine Today* links on the University website located at: http://www.umaine.edu.

Michael M. Hastings
September 30, 2009

* Note that small differences in data reported in *Highlights* and the *Annual Report* are attributable to changes in start and stop dates on project funding.
Looking for a Better View

Phytoplankton, the microscopic single-celled drifters of the sea, form the base of the food web in the ocean and play a vital role in the health of all global ecosystems. Fueled by the sun, these tiny plants collectively convert carbon dioxide (CO₂) and nutrients into plant matter, and in the process, release oxygen. Through this “simple” activity, phytoplankton supply about half of the oxygen present in Earth’s atmosphere, and take up large amounts of greenhouse gas in the form of CO₂, helping to mitigate the effects of global warming and making them major movers and shakers in the global carbon cycle.

Researchers use estimates of marine primary productivity (the rate at which plant biomass [in units of carbon] is produced by the growth of phytoplankton in an area per day) as a means of assessing phytoplankton abundance and distribution and, thus, carbon flux in the ocean. When compared to other measurements, such as temperature and nutrient availability, these assessments provide a picture of how phytoplankton and the marine ecosystem as a whole may be contributing to, and be affected by, climate and environmental change.

Data used to estimate primary productivity can be collected via several different measurement platforms: ship-based, space-based, and in-water, though each has limitations. No one platform alone can answer researchers’ questions regarding changes in primary productivity patterns or the factors that drive them.

To understand why, imagine a tall glass filled with seawater with the bottom 80% covered by duct tape. What is happening on the surface layer is easy to see, while the

continued on page 8
What do plant seeds, crop pests, infectious diseases, and computer worms have in common? Amazingly, quite a bit when it comes to how each disperses across its respective landscape, the focus of research for Associate Professor of Mathematics David Hiebeler.

Hiebeler uses computational and mathematical models to better understand the population dynamics of living systems. Now, with a five-year, $400,000, National Science Foundation CAREER Award, Hiebeler is investigating the importance of spatial structure to the spread of infectious diseases and, in particular, how heterogeneity or variability in the population affects the transmission of and recovery from these diseases.

Hiebeler began his explorations in ecological and epidemiological mathematics modeling the spread of plants in forested landscapes. Using a “lattice” pattern resembling a checkerboard but with many more squares, seeds could be spread in one of two ways - “near-dispersal” or “far-dispersal.” Near-dispersed seeds could be dropped only on land immediately adjacent to the parent plant while far-dispersed seeds were cast to the wind to settle where they would. What Hiebeler wanted to know is how successful each of these two methods was under varying conditions such as the availability of “good” landing sites as determined by such factors as soil quality, rainfall and sunlight; and “bad” landing sites such as a space already occupied.

Hiebeler found that the likelihood of propagation by either mode is dependent upon the quantity and arrangement of habitat. For instance, when 70% of habitat is destroyed and what good landing sites remain are randomly situated, far-dispersed seeds thrive because of their mobility, while near-dispersed seeds are driven to extinction because of overcrowding. If, instead, habitat is situated in clusters, meaning there are sufficient good landing sites immediately adjacent to the parent plants for seeds to “take,” near-dispersed seeds hold their own.

Now imagine that instead of seeds being dispersed to good and bad landing sites across a landscape, public health officials are distributing vaccinations to halt the spread of an infectious disease. Is the most effective strategy to broadly distribute the vaccination or target “clusters” of the population, or a combination of both and in what ratio?

With the involvement of undergraduate, graduate and high school students in the UMaine Spatial Population Ecological and Epidemiological Dynamics (SPEED) Lab, Hiebeler has begun to find answers to these questions. His model divides the population into communities called “households,” which may represent dorms within a school, schools or neighborhoods within a city, cities within a region, etc. Interactions within and between infected and uninfected households are varied, as are intrinsic household recovery rates as influenced by factors such as environmental conditions, behavioral differences, and ethnic or genetic backgrounds.

Preliminary results suggest that, as with the seeds, spreading the vaccine as evenly as possible across households is most effective at halting the spread of disease. “Clustering” vaccinations within certain households leads to local “hot spots” where infection breaks out and spreads more quickly. If households have different intrinsic recovery rates, the disease will reach higher sustained levels than it would if all households had identical recovery rates, which is what most epidemiological models assume.

Hiebeler is applying his models to other real world problems including crop pests such as maggot flies in commercial blueberry fields in Maine with pesticides being applied in various patterns, and to studying the spread of malicious software such as computer worms in networks that often use biologically-inspired dispersal strategies.

- Wendy Eckert
“I’m not such an ugly slug-ling!”

Along the east coast of the United States, in primarily brackish saltwater marshes, live small marine creatures with an amazing ability to capture and exploit the photosynthetic properties of their algal food source.

*Elysia chlorotica*, a species of sea slug, feeds on the alga *Vaucheria litorea*, slicing or puncturing the alga’s cells. The sea slug filters the contents and discards all but the chloroplasts, which it engulfs and absorbs into the cells of its expansive digestive system.

Dispersed and lying just one cell layer beneath the sea slug’s epidermis, these “stolen” chloroplasts, or *kleptoplasts*, transform *E. chlorotica*, ugly duckling-like, from a reddish-brown hatchling to an emerald green, solar-powered “walking leaf”; perfectly camouflaged from predators and equipped to sustain itself photoautotrophically in times of food scarcity.

Uncovering the mechanisms by which *E. chlorotica* is able to perform these feats is the focus of study for University of Maine Biochemistry Professor Mary Rumpho-Kennedy. With a $495,000 grant from the National Science Foundation (NSF), Rumpho-Kennedy is delving further into the sea slug’s chloroplastic uptake and retention process in order to determine the minimum levels required to actuate photosynthesis, and to discover why the algal chloroplasts are assimilated rather than rejected by the host cells.

Rumpho-Kennedy is also testing the hypothesis that algal genes are transferred and integrated, along with chloroplasts, into the sea slugs’ nuclear or mitochondrial genome by a process known as Horizontal Gene Transfer (HGT). And whereas occurrences of Vertical Gene Transfer of DNA from one to another generation of organisms are common, and HGT between closely-related eukaryotes (multi-cell organisms with nuclei containing their DNA) and HGT between two unrelated eukaryotes, such as the sea slug and alga, has not.

From discovering novel anti-cancer compounds synthesized by the symbiotic organism to explaining the absence of an immune-rejection response in the sea slug, the implications of Rumpho-Kennedy’s research are far reaching in their potential to benefit human health, including serving as a model for immuno-therapy and drug delivery systems. In addition, successfully demonstrating HGT is akin to witnessing evolution in action.

The public can get a glimpse into Rumpho-Kennedy’s research by accessing the multimedia educational materials available on an interactive website located at: http://www.sbe.umaine.edu/symbio/index.html.

-Wendy Eckert

Integrated multi-trophic aquaculture raises several commercial species in one location, an innovative strategy that can increase sustainability and profitability for marine farmers. Dr. Susan Brawley and graduate student Nic Blouin are developing methods for growing native Maine seaweeds in concert with salmon farms. The method involves “seeding” nets with seaweed before deployment around Cooke Aquaculture’s salmon facilities in Cobscook Bay. In 2008-2009, through molecular investigations of the life history of *Porphyra* (supported by an $83,129 grant from NOAA), Brawley and Blouin improved culture technology and reduced generation times for the macroalgae, and deposited their results in two public culture collections in Maine and Texas for use by other scientists.
Cutting to the Core

Ice cores are proving to be the key researchers need to unlock the Earth’s natural climate history, assess human impact on climate, and more accurately predict our world’s climate future. With greenhouse gases on the rise and the potential for abrupt climate change looming on the horizon, answers cannot come quickly enough.

For the last several decades, Paul Mayewski, Director of the University of Maine’s Climate Change Institute (CCI), has travelled the globe in a race against the clock to retrieve these “frozen time capsules” before they are destroyed by global warming. Now, armed with $1.6M in funding from the W.M. Keck Foundation, Mayewski is poised to revolutionize ice core-based climate reconstruction.

Mayewski’s office is the ice caps, ice sheets and glaciers of the world’s most remote regions. Using a hollow drill to bore deep into the frozen landscapes, he and fellow researchers extract long cylinders of ice that hold hundreds to many thousands of years worth of historical data about the planet’s temperature, precipitation, atmospheric and oceanic circulation, sea ice extent, biological and terrestrial productivity, and climate controls such as greenhouse gases, volcanic activity, aerosols, and solar variability. Then, in much the same way as a forester can look at rings on a tree or a geologist look at sedimentary layers in the earth, Mayewski and his team analyze the accumulated layers of compacted snow and ice and their inclusions (such as ash, dust, and atmospheric gas) to reconstruct climate histories where instrumental climate records are sparse.

Mayewski’s initial focus on the project is to advance ice core research by implementing cutting edge innovations in the processing and analysis of ice cores. Current ice core sampling techniques do not provide the resolution needed to analyze cores from regions with very low snow.

Saving Spuds

The wet, cool conditions ever present in Maine this summer create an ideal environment for the spread of late blight, a virulent fungal disease responsible for the Irish potato famine 160 years ago. While not directly harmful to humans, this disease can be devastating to potato and tomato crops. Its millions of spores are easily carried by the wind for long distances, up to several miles, allowing the disease to wreak havoc with ease.

Jim Dill, a UMaine Extension professor and pest management specialist warns, “If left untreated, late blight can take down a field in 3-5 days.” This is a scary prospect for Maine farmers. With a total economic value of more than $500M, potatoes are the top agricultural commodity in the State. Since 1977, UMaine Cooperative Extension’s Potato Integrated Pest Management (IPM) Program has worked closely with growers and processors to maximize the value of the crop and protect the industry’s 60,000 acres of potatoes from damage due to disease and predation from insects and other pests.

With a $285,984 award from the U.S. Department of Agriculture, Dill and his team coordinate a statewide network of electronic weather stations, and survey 100 potato fields on a weekly basis for weeds, insects and diseases so they can track potential pest outbreaks and provide growers with current information on specific and timely treatments in order to minimize pesticide applications and maximize potato yield. Last year, Maine potato farmers saved an estimated $17M of their crop from potential threats such as late blight as a direct result of the Potato IPM program.

Late blight has made an early arrival to the area this year thanks to the recent sale of infected seedlings by “big-box” retailers throughout New England and the Mid-Atlantic states. IPM specialists have warned growers (commercial and home alike) to be on the lookout for the disease and warn their neighbors if late blight is found as “this is a community disease and it takes the community working together to manage this disease effectively.”

- UMaine Today Staff Writer
The University of Maine: A Leader in Research

In FY2008, the University of Maine’s research expenditures totaled $95.04M, placing it again among the top 100 public research data. The University’s high standing is a result of its commitment to improving the State of Maine’s economy through collaboration...

In FY2009 University of Maine researchers submitted a total of 677 requests for extramural funding, an increase of 9.4% from FY2008 and 57.4% from FY1999. The dollar value of these requests totaled $272.6M, up from $217.3M and $109.8M in FY2008 and FY1999, respectively.

The University of Maine received $57.3M in extramural awards, up from $47.9M in FY2008 and $30.1M in FY1999, which represents an increase in the number of awards received of 6% over FY2008, and 37% over FY1999 levels.

The most recent data available (2007) reflect a success rate of 33.8% for number of submissions to number of awards.  

1Allowing for lag time between proposal submission and award receipt.

Of the total extramural dollars awarded to the University of Maine in FY2009, the largest contributions were $37.4M or 65.4% from Federal sources and $16.5M or 28.9% from the State. Of note is an increase in FY2009 over FY2008 of $12.2M or 27.1% in State contributions in the form of Maine Technology Asset Funds bond money, of which the University was awarded $13.1M of the $24.8 million available. The balance of contributions is attributable to Industry, Foundations and Other sources that combined for 5.7% of total FY2009 extramural dollars awarded.

2Federal and State awards such as those to the Maine Agricultural and Forestry Experiment Station are not included in these data.

3UMaine’s Department of Industrial Cooperation is responsible for processing the majority of Industrial contracts. The industry activity reported herein represents a minority of those processed by ORSP.

Of the total FY2009 extramural awards, 73.6% or $42.1M were for projects designated as Research; 1.8% or $1M as Instructional; and 24.6% or $14.1M as Other projects.

These numbers represent a 22.4% increase, 57.4% decrease and 27.4% increase, respectively, as compared to FY2008.

4The "Other" category includes awards such as those for drug and alcohol abuse programs, safe campus and green campus projects.
Research in higher education in the United States, according to the National Science Foundation (NSF) which collects this research and expenditure data, is driven by collaboration with industry and from significant infrastructure investments made by the Maine Legislature and Maine voters.

Figure IV: Dollar Value and Percent of FY2009 Extramural Funding Awards by Sector

The FY2009 dollar value of extramural awards received was greatest in the Education ($9.5M), Environmental ($8.7M), and Advanced Materials ($7.1M) sectors, and lowest in the IT/Computer ($1.3M) and Precision Manufacturing ($683,268) sectors.

*ORSP’s breakdown of funding by sector is independent of that reported for the Maine Economic Improvement Fund (MEIF).

Figure V(a): FY 2008 & 2009 Number of Awards by Sector

Figure V(b): FY2008 & 2009 Dollar Value of Awards by Sector

Colored bars correspond to sectors pictured in Figure IV for FY2009. Grey bars reflect values for FY2008.

Figure VI: University of Maine Designated Research Space FY2003, FY2005, FY2007

As mandated by Congress (42 U.S.C. 1886), the National Science Foundation and National Institutes of Health jointly conduct a biennial survey of scientific research and engineering facilities at research-performing colleges and universities and non-profit biomedical research centers and hospitals in the U.S. for the purpose of gauging the adequacy and state of those facilities.

For this survey the University of Maine collects and records annually data on designated research space, which has increased from 451,366 ft.$^2$ to 662,286 ft.$^2$, or 46.7%, between FY2003 and FY2007. Data for FY2008 and FY2009 were unavailable at time of printing.

For children of deployed military personnel in Maine, UMaine Cooperative Extension has four words: You are not alone.

Cooperative Extension coordinates the Maine chapter of Operation Military Kids, part of the 4-H/Army Youth Development Project funded by the Department of Defense. The program provides community-based support through programming and services to children of military guard and reserve parents.

4-H Extension Educator Karen Gagne says military kids may experience separation anxiety and fear for their parents’ welfare, which can manifest in a range of ways including anger, acting out, depression and physical ailments. By recognizing what these children are going through, Operation Military Kids helps meet their needs. It keeps children engaged and connected with their deployed parents by providing tools to help the children cope. Volunteers help families learn how to share their lives through digital photographs, videos and audio files; and they distribute Hero Packs containing stationary, books, disposable cameras, resource materials and a handwritten note of thanks to the families for their strengths and sacrifices. For teens, wilderness survival camps at Bryant Pond emphasize team building, leadership development and service learning; activities that help these kids gain new skills, find their strengths and build resiliency.

Supported by a network of their peers, these teens often mentor younger military children and become involved in Speak Out for Military Kids, an outreach initiative in which teens share their experiences in their schools and communities.

- UMaine Today Staff Writer

activity in the bottom layers is obscured. Researchers face this same difficulty when trying to see into ocean layers. Ship-based measurements provide researchers with detailed information about relatively small areas of space and time, but are unable to give them an accurate “big picture” of global productivity. In contrast, satellites allow rapid global coverage and provide a good “big picture,” but since they see only the top several meters of the water column, cannot portray what’s going on at depth. Nor are they capable of seeing through the clouds, a considerable limitation in regions with persistent cloud cover.

University of Maine Professor of Marine Sciences and Oceanography Mary Jane Perry and her colleagues, Professors Andrew Thomas and Neal Pettigrew, are hoping to peel away the tape obscuring their view of the ocean depths and measure what’s going on below the surface and the clouds by adding new technology to the mix: robotic underwater gliders capable of profiling through the water column for up to a month at a time.

Perry has received $803,753 in funding from the National Aeronautics and Space Administration (NASA) to couple space-based measurements with this new in-water technology to achieve progress in quantifying marine productivity and improve carbon cycle and ecosystem modeling.

Her team’s toolbox has three elements: satellite data, autonomous glider observations, and chemical analysis of water samples. Satellite and gliders are both fitted with optical sensors that, very simply put, measure light in the visible wavelengths. Because particles respond to light differently, often with characteristic optical signatures, measurements from these sensors serve as proxies for biogeochemical variables in the ocean (such as dissolved organic materials, phytoplankton, and suspended sediments). The plan is to compare the two complementary remote sensing systems and analyze water samples to validate the relationship between optical proxies for carbon cycle components and their chemical counterparts.

Perry is confident that adding this new dimension will improve understanding of the carbon cycle and significantly improve the ability to use satellite data to view the global carbon cycle and its time and space variability. In other words, hopefully these three platforms together will provide researchers with a high resolution “big picture” of global productivity and the story behind, or in this case, beneath it.

- Amanda Ashe
The earth’s stock of renewable natural resources is in decline. The global community, as well as individual nations, is grappling with how best to manage those resources so as to meet present needs while ensuring sufficient resources remain for future generations.

The dilemma is not new. In 1968, Garrett Hardin, a renowned human ecologist, suggested that the system of ownership of a resource determines how well it is managed. Private ownership begets responsible management while common ownership begets what Hardin termed, “the tragedy of the commons.” In the first system, private property owners recognize their responsibility to care well for their property or experience directly the negative consequences of mismanagement through the property’s loss in utility. In the second system, not all who avail themselves of the common property place equal value on protecting it and may exploit it for their own benefit, to the detriment of all others. Hardin writes, “In a crowded world of less than perfect human beings, mutual ruin is inevitable if there are no controls . . .” Such is the classic collective action dilemma.

James Acheson, Associate Professor of Anthropology, studies the management of the “commons” and an award of $210,000 from the National Science Foundation is supporting his current research into the evolution of controls that govern two of Maine’s most important commons, its groundfish and lobster fisheries.

There is a stark contrast in the health of these two commons. Whereas lobster stocks and catches are at record highs, and a strong conservation ethic exists (i.e., a strong sense of stewardship, positive attitudes towards rules to enhance stocks, and political support for effective fisheries conservation legislation), the groundfishing industry has a history of weak ethics and equally ineffective controls and is experiencing record low stocks and catches.

Why the difference? Acheson attributes it to the differential development of norms and rules, and the institutions that govern the two fisheries. The fact that the groundfishing industry is just now embracing conservation ethics presents an ideal opportunity to observe the process. By connecting theory with practice, Acheson hopes that what he learns from his investigation will inform decisions regarding the management of other common pool resources such as forests, grassland, lakes and oceans.

Drawing on a rich body of research on collective action dilemmas, Acheson cites four theories that are fundamental to his task: Precondition, Mechanisms and Adaptive Behavior Theories, and Game Theory. Precondition Theory states that many factors work in tandem to set the evolutionary wheels in motion, factors including trust, homogeneity, group size, political entrepreneurship, social capital, and community. Mechanisms Theory focuses on the social interactions that give rise to norms and rules (those implicit or explicit cues for behavior based on the beliefs, attitudes and values of a group), and to the institutional structures that formalize both. Adaptive Behavior Theory describes the trial-and-error process individuals undertake in learning interactive strategies that result in the greatest benefits to themselves. Finally, Game Theory provides an effective framework within which to study this dynamic process. It simulates how rational individuals make choices based upon their preferences, their expectations of how others will act, and the frequency of their interactions with others.

The consensus among researchers is that people are most likely to develop rules for themselves if the groups are small and homogenous, if the group is stable enough that the members know a good deal about each other’s past performances, if the game is played repeatedly, and if the rules can be enforced. Acheson attributes the stark contrast in the health of the lobster and groundfishing industries to this axiom.

- Wendy Eckert

“In a crowded world of less than perfect human beings, mutual ruin is inevitable if there are no controls . . .”

What's in Your Water?

Those who are familiar with the movie, *Arsenic and Old Lace*, know that danger can lurk behind the most innocent of facades. And so it is with groundwater. From Bangladesh to Argentina, China to Hungary to the backyards of Maine, arsenic taints private water supplies across the world.

Arsenic exposure to humans can occur through media other than water (e.g., air), yet scientists have found groundwater to be the primary conduit. Where arsenic concentrations in drinking water are high (i.e., greater than 10 micrograms per liter by U.S. Environmental Protection Agency standards), so are infant mortality, premature births, stillbirths and miscarriages. Arsenic also is linked to a myriad of other serious health conditions including diseases of the vascular system, and skin, lung and bladder cancers.

continued on page 12

Cutting to the Core  

accretion, or that can “push interpretations down to storm event scale sampling.” Further, the sampling techniques are time intensive and susceptible to contamination because the ice core must be sub-sampled and, depending on the technique, melted prior to analysis.

Funds from the Keck award will be used to purchase equipment and develop a sampling system that will allow an entire section of ice core to be analyzed at the length at which it was collected with minimal sample processing. The end result: continuous, contamination-free, high-resolution sampling of 40+ elements. Since the core is not melted prior to analysis, this method allows for preservation of the sample for future analysis, a significant benefit in a growing field where techniques are evolving and new measurement capabilities are added, but access to ice in some regions of the world is dwindling.

Mayewski’s team also intends to develop novel techniques for collecting climate data in the world’s most remote regions. For years scientists have been searching for the “holy grail” for ice core research: *in situ* sampling of ice core chemistry. Mayewski is teaming up with Bob Lad, Director of the UMaine Laboratory for Surface Science and Technology (LASST), to fabricate a prototype sensor system that utilizes a thin-film metal oxide sensor embedded in the tip or wall of an ice core drill to measure select gases as a function of drilling depth. LASST has demonstrated success with the sensor on a variety of gases, yet challenges remain. LASST and CCI will have to address issues such as how to incorporate the sensor(s) into the drill assembly, how to handle the system’s power and thermal management needs, and how to make the entire system robust enough to withstand harsh environments. Prevail in these trials, and their quest for the grail may be rewarded with an amazing advancement in ice core research and the opportunity to uncover climate mysteries available through no other techniques.

- Amanda Ashe
University of Maine Researchers Receive $13 Million in First Round of Maine Technology Asset Fund Awards

In 2007, the Maine State Legislature authorized and the voters of the State of Maine approved $50M in bond funds for research, development and commercialization projects that boost economic development and create jobs across the State.

**Advanced Nanocomposites for the Renewable Energy Industry**

Robert Lindyberg, Project Director, Asst. Director of Boat-building & Composites Projects

$5M awarded to expand the Advanced Engineered Wood Composites Center (AEWC) facilities. Additions include: a laboratory and office space to support processing of nanocomposites from lignocellulosic fibers, and a laboratory for pilot manufacturing and large-scale structural testing of advanced composite structures for the energy industry, the fastest growing market for composite products.

**Ultra-High Resolution Imaging Facility**

Sam Hess, Project Director, Assoc. Professor of Physics & Astronomy

$159K awarded for the construction of an ultra-high resolution microscope user-facility at the University of Maine. The imaging facility will be based on a new light microscopy technique (BP-FPALM: biplane fluorescence photoactivation localization microscopy) that provides 3-D imaging of living cells with previously unheard of resolution, allowing researchers to measure dynamics of single molecules in living cells.

**Building Capacity & Excellence in Maine’s Marine Aquaculture R&D Infrastructure**

Nick Brown, Project Director, Manager of Operations, Cooperative Center for Aquaculture Research (CCAR)

$2.6M awarded for the purchase and installation of hatchery-related equipment at CCAR. Investigators will assess the economic cost/benefit of an intensive (grow-out from egg to harvest) land-based approach to the aquaculture of the green sea urchin, *Strongylocentrotus droebachiensis*, an overfished species highly prized for its roe.

**Forest and Ag Bioproducts Research, Development and Commercialization Facility**

Hemant Pendse, Project Director, Managing Director, Forest Bioproducts Research Initiative (FBRI)

$4.8M awarded for the renovation of FBRI facilities to provide a suite of spaces devoted to research, development and commercialization of forest and agricultural bioproducts ranging from bench top to pilot plant scale processing. The facilities will be designed to develop and demonstrate emerging biomass conversion technologies at an industrially significant scale.

**Maine Nanofabrication R&D Infrastructure Enhancement**

Rosemary Smith, Project Director, Professor of Electrical & Computer Engineering

$480K awarded to purchase nanofabrication equipment, a Rapid Thermal Processor and a Reactive Ion Etch tool, necessary for the University of Maine Nanotechnology R&D Clean room to remain state of the art.
In the United States, the geologic materials of the aquifer are the primary source of arsenic, and scientists have linked types of bedrock to arsenic concentrations in groundwater. In a study of well water in New Hampshire they found a greater likelihood that arsenic would be present in groundwater than in surface water, and that groundwater in domestic bedrock wells was significantly more likely to contain higher arsenic concentrations than the groundwater of wells dug in other geologic materials. Closer to home, 94% of drinking water in Maine comes from groundwater wells and, of that number, 90% sit in bedrock. In the Northport area, arsenic concentrations as high as 75 to 1300 micrograms per liter have been reported.

For Jean MacRae, Associate Professor of Civil and Environmental Engineering, these numbers represent an ideal proving ground for her research. Armed with a $405,000 National Science Foundation CAREER Award, MacRae is investigating the biological factors that contribute to high concentrations of arsenic in groundwater, focusing specifically on what role microorganisms, present in affected areas, play in the process. The hypothesis? That through their respiratory activity, microbes catalyze the release of arsenic from a bound state with other elements, to an unbound state that leaves them free to disperse.

MacRae's preliminary results uphold her theory. She and her team of graduate students have been sampling bedrock wells in the Northport and Branch Lake areas and, through DNA analysis, have identified two types of microorganism, Geobacter and Sulfurospirillum NP4 (NP4), with strong correlations to arsenic concentrations in groundwater. Where greater numbers of Geobacter are present, greater too is the concentration of total arsenic (arsenate + arsenite). Similarly, as the number of NP4 increase, so too do levels of arsenite.

As nature would have it, microorganisms are unique in their ability to survive in both aerobic (oxygen-present) and anaerobic (oxygen-absent) environments. Under aerobic conditions, they take in and convert organic matter and oxygen to energy, expelling carbon dioxide and water as waste just as humans do during respiration. In oxygen-starved conditions like those present in subsurface soil and groundwater where Geobacter and NP4 thrive, anaerobes are able to substitute elements like iron (Fe) and manganese (Mn), abundant in the Earth’s crust, for oxygen. Byproducts in this case are these same elements, but altered (speciated), and exhibiting very different chemical and physical properties from when they were taken up in the process.

What is of particular interest to MacRae’s team is this link between arsenic mobility and iron speciation. As ferric hydroxide (Fe(III)), iron presents a surface on the bedrock to which arsenic “bonds” or “sticks” (adsorbs). Introduce Geobacter, which reduces ferric hydroxide to ferrous iron (Fe(II)), and this adsorptive property is diminished, effectively unsticking the arsenic from the surface. Similarly, NP4 reduces arsenate (As(V)) to arsenite (As(III)), unleashing a much more toxic form of the element that also exhibits less affinity for the bedrock surface and, therefore, more mobility and risk of contamination.

Geobacter and NP4 are two in what could turn out to be a long line up of suspects that MacRae identifies in this case. Meanwhile, the evidence the two have given up about their roles in the linked iron and arsenic cycles can inform decisions regarding engineered and natural systems including the placement of wells and septic leach fields (a source of organic matter), methods of purifying public water supplies or treating landfill waste, and how best to isolate contaminated sediment from lakes in Maine.

- Wendy Eckert
STAFF

PRE-AWARD SERVICES

Kathy Carson  
Grant & Contract Administrator II

Caryn Ines  
Grant & Contract Administrator

Andrew Ines  
Grant & Contract Administrator II

Charlene Kimball  
Grant & Contract Administrator III

POST-AWARD & FISCAL SERVICES

Wayne Astbury  
Grant Accountant

Debbie Carver  
Grant & Contract Administrator III

Jennifer Baker  
Financial Manager

Greg Kolvoord  
Grant Accountant I

Cindy Carusi  
Administrative Assistant II

Robert Lavigne  
Accountant

Arlene Russell  
Associate Director for Post-Award & Fiscal Services

TRAINING & COMMUNICATION SERVICES

Amanda Ashe  
Staff Associate

Wendy Eckert  
Sr. Officer for Research Administration & Strategic Analysis

INFORMATION TECHNOLOGY & REPORTING SERVICES

Robin Crocker  
Administrative Assistant II

Cliff Wilbur  
Information Systems Manager