MBL 1888

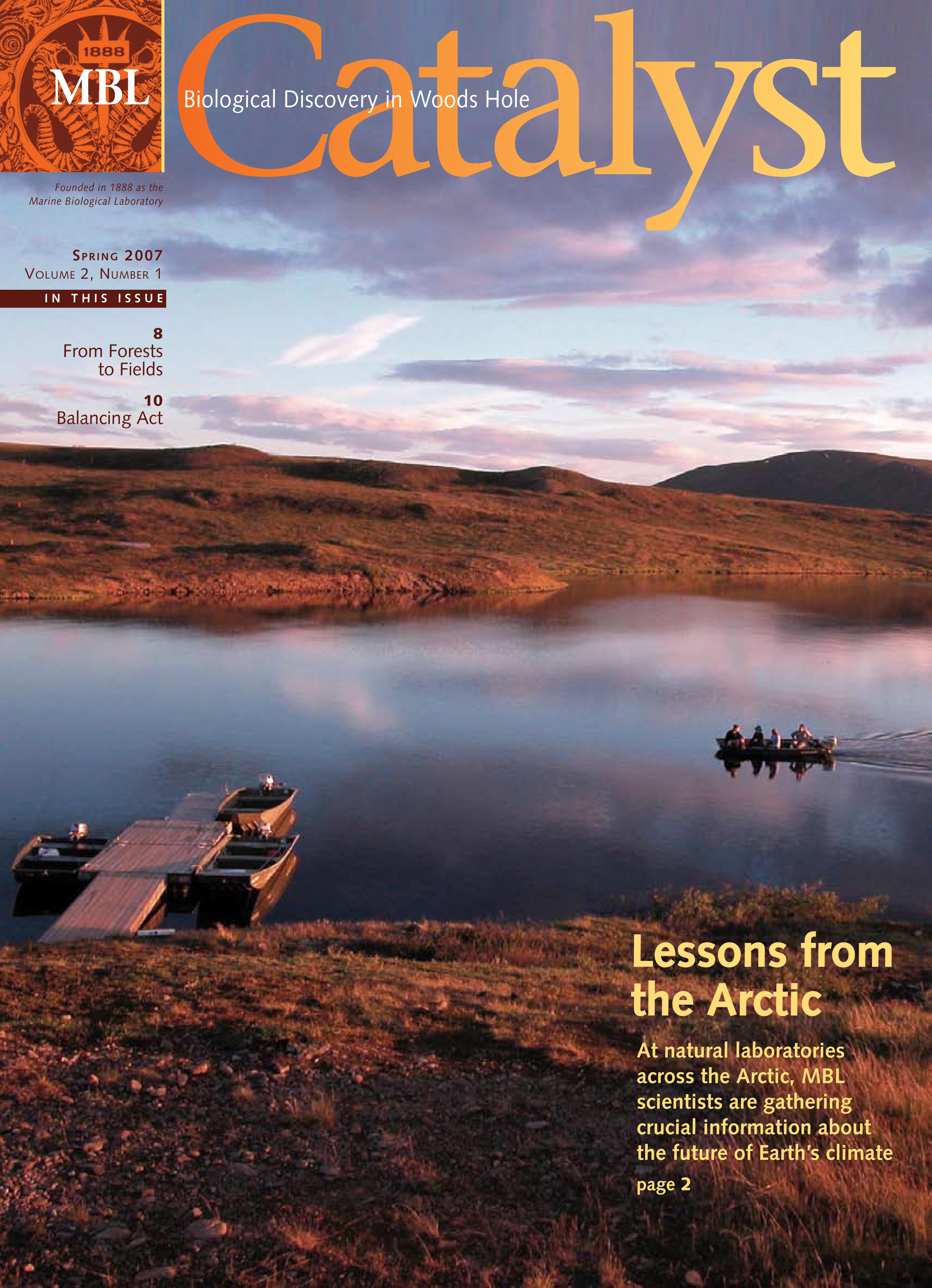
Catalyst

Biological Discovery in Woods Hole

Founded in 1888 as the Marine Biological Laboratory

Spring 2007
Volume 2, Number 1

IN THIS ISSUE



Lessons from the Arctic

At natural laboratories across the Arctic, MBL scientists are gathering crucial information about the future of Earth's climate

page 2

FROM THE EDITOR

Dear Friends,

Last August I had the good fortune to accompany a group of MBL Science Journalism Fellows to the Arctic, where we spent a week immersed in the environmental research being conducted at the remote Toolik Field Station in northern Alaska. The experience, the science, and the scenery were all remarkable in many, many ways.

In this issue of MBL Catalyst *you'll meet Toolik founder John Hobbie, an MBL Ecosystems Center scientist who has been conducting ground-breaking research in the Arctic for much of his distinguished career. I'm especially grateful to John for hosting our group and for patiently guiding us on our expeditions through the rough and tumble tundra.*

Our cover story, Lessons from the Arctic, *provides a glimpse of life at Toolik and conveys why it is such a special and important place for conducting climate change research. It also shows how, over three decades, the MBL's—and the nation's—Arctic research programs have grown and flourished there, paving the way for new PanArctic studies.*

Within these pages you'll also learn about the international reach of the MBL Ecosystems Center's research programs. The center's work in the area of global change is illustrated by our two feature stories, one written by center scientist Chris Neill describing his research in the buffer zones of Brazil's rivers and streams, and one profiling Chuck Hopkinson, who studies human impacts on vital estuaries at a National Science Foundation-funded Long Term Ecological Research site at Plum Island Sound, north of Boston.

We're also pleased to introduce you to Hugh Ducklow, the Ecosystems Center's incoming director. He'll tell you about his work at the MBL's newest research site—Palmer Station, Antarctica—and provide his perspective on why polar research is so critical to understanding Earth's climate. This article is especially timely as we begin celebrating the International Polar Year this spring.

Finally, you'll hear from Ecosystems Center co-director Jerry Melillo, who writes in his "Scientist's Eye View" commentary that the die is not cast in terms of climate change. There's still time, he says, to make choices today that will have a positive impact on the climate of tomorrow. Jerry was recently President of the Ecological Society of America and has served, throughout his career, on numerous international panels and committees addressing climate change. He is this issue's guest science editor, and I am most grateful for his guidance and keen editorial eye.

The response to the inaugural issue of MBL Catalyst *was overwhelmingly positive. I hope you'll enjoy this issue as well. Don't forget to visit* Catalyst *online for additional supplemental information <www.MBL.edu/catalyst>. As always, your comments are most welcome.*

Pam Hinkle

Pamela Clapp Hinkle

Editor-in-Chief
Director of Communications

MBL Catalyst

SPRING 2007 VOLUME 2, NUMBER 1

MBL Catalyst is published twice yearly by Office of Communications at the MBL in Woods Hole, Massachusetts. The MBL is an international, independent, nonprofit institution dedicated to discovery and to improving the human condition through creative research in the biological, biomedical, and environmental sciences. Founded in 1888 as the Marine Biological Laboratory, the MBL is the oldest private marine laboratory in the Western Hemisphere.

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Illustrations:
p. 4: A. Balser, Toolik Field Station; *p. 6:* P. Choi

About the cover:
A serene moment on Alaska's Toolik Lake, the site of numerous MBL Arctic research projects. Photo by Laura Broughton.

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Catalyst

In this Issue

MBL

Lessons from the Arctic

For three decades, MBL Arctic research programs have taught us how high-latitude ecosystems work. But there is still much to learn about how these rapidly changing environments will influence our climate.

In 1975, when newly hired Ecosystems Center scientist John Hobbie began searching for a location for a National Science Foundation (NSF) study of the Arctic, most of his research was based in Point Barrow, Alaska. But this barren spit of land that juts into the Arctic Ocean at the northernmost point of the U.S. was neither easily accessible nor inviting. So Hobbie and four others drove for six hours down the recently built gravel road alongside the oil pipeline, and found an ideal research site on the shores of a deep lake called Toolik (Inupiak for loon). Nestled in the northern foothills of Alaska's Brooks Range and a manageable drive along the road that runs from Fairbanks to Prudhoe Bay, the spot seemed perfect for the kind of aquatic research he and the NSF had in mind.

With seed money from the NSF and a lot of ingenuity, Hobbie began developing the Toolik Field Station, one tent and trailer at a time. "I'd hire a

cook and a camp manager every season and we added a new trailer about every two years," he says. "At first there were just eight of us working there."

Before long "the terrestrial ecologists started stopping by," Hobbie recalls. The site was ideal for their studies as well. Ecosystems Center investigators Gus Shaver, a terrestrial ecologist studying the effects of warming on tundra plants, and Bruce Peterson, a limnologist studying how changing levels of certain nutrients affect the health of Arctic rivers, soon began their own work at Toolik and the nearby Kuparuk River.

Thanks to the early efforts of John Hobbie and others at Toolik, this Arctic research camp now attracts ecological scientists from around the globe. "The Arctic is the proverbial canary in the coal mine of climate change," says Ecosystems Center co-director Jerry Melillo. "In this seemingly pristine part of the world, sea ice is melting at an alarming rate, polar bears are going hungry, and indigenous communities are being stressed."

A Leader in Arctic Research

The fact is the Arctic climate and environment are changing more rapidly than in other parts of the world. MBL scientists documenting these changes agree that they have dramatic consequences for regional plant and animal life, as well as the ability to alter essential global processes like the absorption of solar radiation, the production of greenhouse gases, and the cycling of freshwater.

The Toolik Field Station remains at the heart of this research. Now operated by the University of Alaska Fairbanks (UAF), it bustles with some 400 scientists from over 130 institutions, who regularly gather there to study the effects of climate change. Hobbie, now an MBL Distinguished scientist and the former Ecosystems Center co-director, is still active at the station, where he directs the NSF-funded Arctic Long Term Ecological Research (LTER) project.

Currently in its 20th year, the LTER project is an integral part of the Ecosystems Center's history—and its future. "The Toolik-based LTER helped establish the MBL as home to one of the world's premier Arctic research programs," says Melillo. At Toolik, Ecosystems Center scientists are documenting the effects of a 3.6° F temperature increase in northern Alaska over the past three decades and are using their data to predict ecological changes for larger regions over the next several centuries.

A New PanArctic Approach

The MBL's pioneering research at Toolik Lake was the foundation for several PanArctic studies that are examining how the Arctic ecosystem works as a whole—and how it influences Earth's climate.

Bruce Peterson's early work on the Kuparuk River, for example, grew into an Arctic large rivers study that is revealing much about the changing freshwater cycle. The research demonstrates that increasing runoff from Arctic rivers, along with increasing precipitation on the high-latitude oceans and the net melt of Arctic sea ice, are freshening the Arctic Ocean and subpolar seas. These mounting freshwater supplies are in turn freshening the North Atlantic Ocean and this excess freshwater may ultimately slow the ocean conveyor belt that affects the North Atlantic region's weather patterns.

The PanArctic approach is also central to an initiative the Ecosystems Center recently launched with UAF and a $3 million grant from NSF's International Polar Year. "Our goal is to study the major components of the Arctic system from four long-term observatories at strategic points representing the different changing environments and major ecosystems in the Arctic," says lead investigator Gus Shaver.

Shaver and his collaborators are measuring the carbon, water, and surface energy exchanges of the Arctic terrestrial landscape simultaneously to learn how changes in these key environmental regulators are altering the entire Arctic. "It's an opportunity to test whether fine-scale studies we've done at Toolik Lake can be useful in extrapolating to larger landscapes to resolve important questions about the Arctic as a source or a sink for carbon and its role in regulating global climate," Shaver says. The project is also creating a much-needed central database for information on all aspects of the Arctic ecosystem, including its terrestrial, atmospheric, and oceanic components.

Collaboration and Education

The new PanArctic study builds on the MBL's knack for creating successful scientific partnerships. Shaver and his colleagues have established a network of scientists based in key locations who are willing to be part of a coordinated effort. The network capitalizes on well-established research sites with existing data sets, including the Toolik Field Station in Alaska; the Northeast Science Station in Cherskii, Russia; the Zackenberg Research Station in northeast Greenland; and the Abisko Scientific Research Station in northern Sweden.

Like many MBL initiatives, the project features a significant educational component. The public will be able to track the research via the Toolik Field Station website <http://www.uaf.edu/toolik/>. Additionally, project scientists are designing an Arctic studies survey course for upper-level undergraduates and beginning graduate students through UAF, an effort that will help create a new generation of Arctic scientists.

Arctic Lessons, Global Lessons

Scientists and students who study the Arctic still have many lessons to learn. And though Arctic research has come a long way since John Hobbie first claimed Toolik Lake back in the seventies, the question on many scientists' minds is whether the Arctic of the future will be a drastically different ecosystem than what it is today. "It's a big question because as the ecosystems there change in response to climate, their role in regulating future climate also changes," says Shaver. "Answering it requires the development of coordinated science that is PanArctic in its coverage."

"Our research has taught us that Arctic systems don't just passively respond to climate change," notes Shaver. "In fact, the carbon, water, and energy balance of the Arctic landscape plays an important role in regulating the local, regional, and global climate. We need to view the PanArctic as a single, regional environmental system that interacts with the global environmental system." •

Ecosystems Science at the MBL

The Ecosystems Center was founded by the MBL in 1975 as a year-round research program, and is one of the premier research centers of its kind. Its mission is to investigate the structure and functioning of ecological systems and predict their response to changing environmental conditions, to apply the resulting knowledge to the preservation and management of natural resources, and to educate both future scientists and concerned citizens.

Headquarters: C.V. Starr Environmental Sciences Building, MBL campus

Research Focus

- Climate change
- Environmental shifts caused by globalization
- Human-induced changes affecting our coastal zones

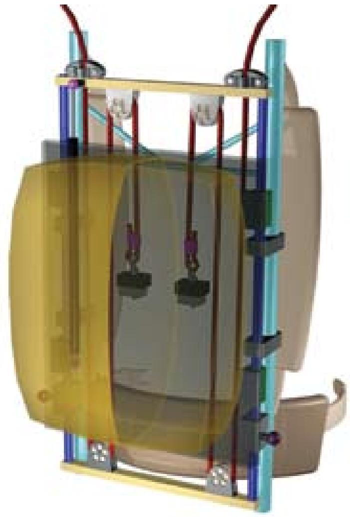
Field Sites: Massachusetts, Alaska, Greenland, Eurasia, Sweden, Brazil, and Antarctica

Hands-On Education

- Postdoctoral training
- Semester in Environmental Science (SES), emphasizing hands-on environmental research for undergraduates
- Undergraduate internships
- Brown-MBL Graduate Program in Biological and Environmental Sciences
- Science Journalism Program, providing hands-on training in ecological research to professional journalists
- Schoolyard LTERs, promoting the involvement of students, teachers, and local residents in our research in Barrow, Alaska, and on the Massachusetts North Shore

Funding

Fully funded by grants and contributions. The newly established John E. Hobbie Scientific Research Endowment is a discretionary fund that supports the exploration of emerging areas of ecology, fills gaps in support of existing research programs, and furthers John's vision of collaboration and excellence in ecosystems science. Contributions in support of this fund and other Ecosystems Center projects are welcome.



New Backpack Lightens the Load

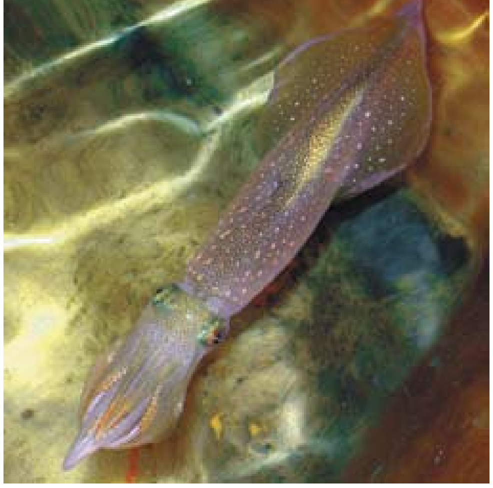
An MBL Whitman Investigator has invented an ergonomic backpack that could reduce the risk of orthopedic and muscular injuries to children, emergency workers, and others who use backpacks to carry loads. Lawrence Rome, a professor of biology at the University of Pennsylvania, and colleagues recently described the design of and the mechanics behind the invention in the journal *Nature*. With traditional backpacks, the load is typically attached tightly to the body; the mass of the backpack must undergo the same vertical displacement as the hip, which moves up and down during walking. Having the load suspended with bungee cords, Rome's ergonomic backpack allows the load to stay at a nearly constant height from the ground while the wearer walks or runs. This reduces the vertical displacement of the load and the resulting dynamic forces exerted on the wearer's shoulders and joints by a remarkable 82 to 86 percent. The reduction in dynamic force is easily felt, says Rome, and has practical consequences. "An immediate application would be to use it in backpacks carried by schoolchildren, a well-known cause of musculoskeletal injury and a recognized international public health problem." Rome has formed a company called Lightning Packs, LLC to further develop and commercialize the backpack. (*Nature* 444: 1023-1024, 2006) •

Sea Urchin Genome Uncovers Remarkable Connection to Humans

Scientists recently announced the decoding and analysis of the genome of the California purple sea urchin. Results of the project, published in *Science*, as well as in a special issue of *Developmental Biology*, show a remarkable genetic connection between the spiny creatures and humans. Researchers found that urchins have the most sophisticated innate immune system of any animal studied to date, that they carry genes associated with human diseases such as muscular dystrophy and Huntington's, and that they have genes associated with taste, smell, hearing, and balance. The sea urchin has been an important model at the MBL for many years, particularly in the study of developmental biology. In fact, a number of scientists with MBL ties were part of the sequencing effort, including project leaders Eric Davidson and Andrew Cameron of the California Institute of Technology, who are both MBL Corporation members; Brown University biology professor and MBL senior scientist Gary Wessel; Boston College biology professor, David Burgess, an MBL corporation member and chair of the MBL Education Committee; Embryology course faculty Charles Ettensohn of Carnegie Mellon University and David McClay of Duke University; 1994 Physiology course alumnus and NASA Ames Genome Research Facility Director Viktor Stolc; and MBL 2005 summer research fellow Robert Morris of Wheaton College. (*Science* 314: 941-952, 2006; *Developmental Biology*: 300, 2006) •

There's No Scent Like Home

Tiny larval fish living among Australia's Great Barrier Reef spend the early weeks of their lives swept up in ocean currents that can disperse them far from their birthplaces. Given such a life history, one might assume that these fish would be genetically homogeneous within their dispersal area. Yet diversity is found to be surprisingly high and individual reefs contain different fish populations. For such rich biodiversity to have evolved, some form of population isolation is required. Research published this year in the *Proceedings of the National Academy of Sciences* by MBL scientists Gabriele Gerlach and Jelle Atema and their colleagues showed that many fish species can discriminate odors in ocean currents and that some species can use home reef scent to return to the reefs where they were born. The homing behavior could support population isolation and slow genetic divergence, thus possibly favoring the ultimate formation of new species. "This research shows that the spatial distribution of these aquatic organisms is far from being random despite long larval dispersal stages of several weeks," says Gerlach. "Apparently, these larvae use sensory mechanisms to orientate and find their way to appropriate habitats or express successful homing behavior to their natal spawning sites. This might play a major role in processes of population separation and, eventually, of speciation." The research could also have important management implications not only for the Great Barrier Reef, but marine environments in general. (*PNAS* 104: 858-863, 2007) •



"ZIP Code" Hitches Cargo to Motors for Transport in Neurons

In a paper published in the *Proceedings of the National Academy of Sciences*, MBL Whitman Investigator Elaine Bearer and her colleagues identified a peptide that attaches cargo to anterograde motors for transport in nerve cells. In long axons, anterograde motors carry cargo from the cell body towards the synapse. By selectively hitching cargo to anterograde motors, this peptide acts like a "ZIP Code," specifying the address of the synapse for cargo delivery. The peptide comes from amyloid precursor protein, or APP, a major component of the senile plaques in brains of Alzheimer's disease patients. This is the first report of a direct functional role of APP in transport, although evidence has been accumulating that defective transport may play a role in Alzheimer's disease. At the MBL, Bearer, a professor at Brown University Medical School, studies molecular transport of herpes simplex virus (HSV), using the squid giant axon as a research model. In this study, which was funded in part by Dart Neurosciences LLP through a Dart Neuroscience Scholars Program award to Bearer, the researchers replaced HSV with plastic beads of the same size, coated them with synthetic peptides, and injected them into the squid giant axon. Using video microscopy to monitor movement, she and her team found that beads coated with one short peptide from APP, which they called APP-C, were transported quickly down the squid axon towards the synapse. According to Bearer, human APP-C is nearly identical to APP-C in squid, worms, and fruit flies, making it likely that this peptide plays a universal role in cargo trafficking inside neurons and other cells. The results support the idea that APP is also involved in HSV transport in neurons and raise the possibility that APP could play a wider role in the recruitment of the transport machinery for anterograde shipments in general. (*PNAS* 103: 16532-16537, 2006) •

Squid Skin Reveals Hidden Messages

In the animal world, squid are masters of disguise. Pigmented skin cells enable squid to camouflage themselves—almost instantaneously—from predators. Squid also produce polarized skin patterns by regulating the iridescence of their skin, possibly creating a "hidden communication channel" visible only to animals that are sensitive to polarized light. Research published online in *Biology Letters* by MBL research associate Lydia Mäthger and senior scientist Roger Hanlon presented evidence that the polarized aspect of the skin of the squid, *Loligo pealeii,* is maintained after passing through the pigment cells responsible for camouflage. While the notion that a few animals produce polarization signals and use them in communication is not new, Mäthger and Hanlon's findings present the first anatomical evidence for a "hidden communication channel" that can remain masked by typical camouflage patterns. Their results suggest that it might be possible for squid to send polarized signals to one another that are invisible to fish or mammalian predators, most of which do not have polarization vision. These messages could contain information regarding the whereabouts of other squid, for example, or the presence of a predator. Investigation of this masked polarization signaling system in squid and other cephalopods in natural environments could provide insight into animal camouflage mechanisms and may uncover similar examples in other species. (*Biology Letters* 2: 494-496, 2006) •

From Forests to Fields

by Christopher Neill

On Tanguro Ranch, studies that evaluate the consequences of large-scale soybean agriculture in the Amazon could help reduce farming's effects on rivers.

After "mad cow" disease broke out in the United Kingdom and three other European countries late in 2000, the European Union responded by banning the feeding of animal-based protein rations to livestock. The resulting shortage of animal protein ricocheted around the global commodity markets and increased the demand for feeds made from soybeans—whose nutritional properties and amino acid content make them the best plant-derived high-protein feed for animals. Half a world away, at the agricultural frontier along the southern edge of Brazil's Amazon Basin, large soybean farms are quickly emerging to meet that demand. Fifty percent of Europe's soy imports now come from Brazil. The country's soy exports to China have also grown dramatically, from less than 1 million tons in 1999 to more than 7 million tons in 2005. The MBL's Chris Neill is working in Brazil to better understand the impacts of large-scale soybean farming on the environment and to design more ecologically sound approaches to growing soybeans.

Driving ten hours north and west from the city of Goiânia, into the heart of the Amazon soybean region in the state of Mato Grosso, it is clear that Brazil's emergence as a major player in the global soybean markets has ecological consequences. Here on the ground, at the boundary—or ecotone—between the open, scrub-like "cerrado" and the evergreen tropical forest to the north, the landscape is being totally transformed. From our truck we see large fields stretching to the horizon, worked by huge machines designed solely to plant, harvest, and transport soybeans. While some of this land had been cleared years ago for pasture, many soybean fields are now being created by clearing native cerrado, and increasingly, native tropical forest.

I have been traveling with my colleague, Alex Krusche, from the University of São Paulo (USP), to Tanguro Ranch, a sizeable farm in the headwaters of the Xingu River, a large tributary that joins the Amazon River from the south. Alex and I are meeting with Vania Neu, a USP graduate student who is helping install water level loggers, wells, and other instruments to examine exactly how the expansion of soybeans influences the amount and quality of water that makes its way out of small watersheds and into the vast Amazon drainage network.

This work, funded by grants from the National Science Foundation to the MBL's Ecosystems Center and Brazil's State of São Paulo Research Foundation to USP, brings together a team that also includes Helmut Elsenbeer, a hydrologist from Germany's University of Potsdam, and biogeochemist Eric Davidson and ecologist Daniel Nepstad of the Woods Hole Research Center. The owners of Tanguro Ranch, the agricultural consortium Grupo Maggi, are Brazil's largest soybean buyers and exporters, which means our research could have far-reaching implications for the management of millions of acres of land in the Amazon.

My colleagues and I are in Brazil to answer two very basic questions. First, how will transforming land from forest to agriculture change the amount of water that runs off of land and the pathways, or "flowpaths," by which the water reaches streams? Second, how do these flowpaths determine the amount and concentrations of dissolved and particulate materials that reach the Tanguro River and the Darro River, which feed the Xingu and ultimately the Amazon River?

Tanguro Ranch is the perfect place to address questions like these because we can study and compare, in one manageable location, the Amazon's three most important land uses: entire watersheds that still have native forest, watersheds that have been completely converted to pasture, and watersheds that have been completely converted to soybeans.

Tanguro's size, nearly 200,000 acres, means that these experiments will be large enough to capture some of the complex ways water runs off from different portions of watersheds, like broad, flat uplands and areas with steeper slopes near streams.

One aspect of watershed function we are most interested in is understanding how near-stream areas called riparian zones help buffer the chemistry of streamwater from changes that take place elsewhere in the watershed. These areas fill with water during wet periods and are biologically rich and hydrologically important. Ranchers in the Amazon often clear riparian zones along small streams so cattle can walk directly into streams to drink, a practice that affects the quality of stream water.

Over the next two years, we will study riparian zone function in six watersheds: two each in forest, soybean fields, and pastures. We will measure total stream discharge to learn how much water reaches the stream via runoff over the soil surface, through shallow flowpaths in soils, or by way of deep flowpaths through the regional groundwater. We will also measure these pathways and analyze water chemistry at two places in each watershed—one where distinct stream bank riparian zones are lacking and another where streams are bordered by much better developed low-lying and regularly inundated floodplains.

We expect to find that clear-cut areas will have greater total runoff and that more runoff will reach streams through shallow flow pathways. But we may also be in for some surprises. If most water is buffered through riparian zones, especially when streams reach a critical size, it may alleviate some of the effects of clearing within watersheds. And here is where this research is linked to a practical application. If riparian areas act as critical controls on water quality, the conservation of forest buffer zones around streams in soybean-growing regions could offer an important measure of protection for Amazon rivers. At Tanguro Ranch, this could translate into preserving the water quality and aquatic habitats in the Xingu and Kayapó indigenous reserves, which lie barely 62 miles (100 kilometers) downstream and together make up one of the largest areas of protected rainforest in the world.

The agroindustrial expansion of soybeans brings many threats to native Amazon ecosystems. But it may also bring opportunity. Some of this opportunity comes in the form of international pressure and preferences of consumers and importing countries—in places like Europe—which increasingly demand that trade in agricultural products not increase Amazon deforestation and that imported products be produced in an environmentally sustainable manner. Today, new soybean farms in the Amazon are required to leave 80 percent of their area as forest—a requirement that is rarely complied with.

Soybean farms that meet stricter environmental requirements may gain access to more lucrative and stable markets. So Tanguro Ranch has another important role to play here. Tanguro's owners, Grupo Maggi, have considerable leverage to demand compliance with environmental laws on Amazon soybean farms. Backed by solid research that demonstrates where and how the reserve lands might do the most environmental good—such as along streams—globalization could begin to play an important role in Amazon conservation.•

Christopher Neill is an associate scientist in the MBL's Ecosystems Center, who regularly conducts research on small Amazon streams in Brazil. He is currently at the University of São Paulo on a Fulbright Scholarship.

Balancing Act

How do you weigh protecting the life-sustaining resources Earth's ecosystems provide for free against the human actions that impact them? The MBL's Chuck Hopkinson is helping with the math.

Chuck Hopkinson isn't your average outdoorsman. Whenever this avid hiker, boater, skier, and swimmer is in nature, he takes in a lot more than just the scenery. What he sees is the literal value of what nature provides us for free: oxygen to breathe, water to drink, and natural resources to harvest.

In fact, Hopkinson, a senior scientist with the MBL's Ecosystems Center, has recently helped create a novel way to evaluate the natural resources too many of us take for granted. In a paper published last February in *BioScience*, he and several colleagues describe a balance-sheet approach known as "ecosystem services-based management," a promising new tool that links ecology and economics.

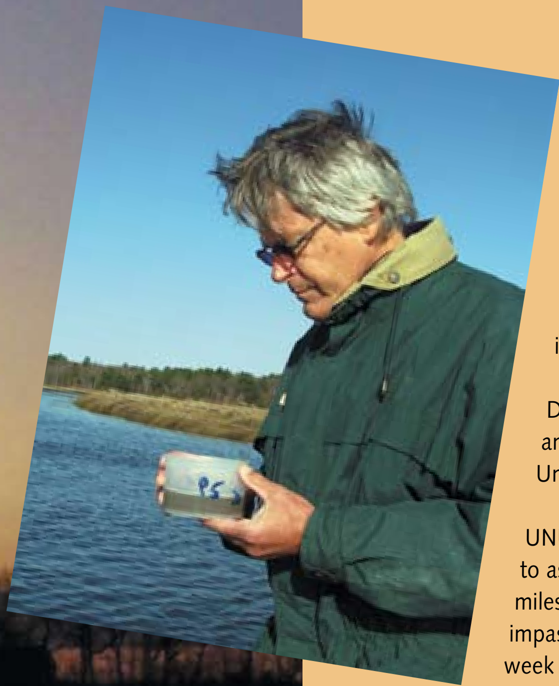
The new method assigns absolute values to the services that ecosystems provide to society and the human actions that degrade these services. "It's a way for natural resource managers to quantify the change in value of ecosystem services so they can base their actions on minimizing the value of service reductions," says Hopkinson.

One area that could benefit from this approach is Plum Island Sound in northeastern Massachusetts, where Hopkinson is the lead principal investigator on the Plum Island Ecosystem Long Term Ecological Research project.

Since the mid-1980s, MBL Ecosystems Center scientists and their collaborators have been documenting environmental changes in the Plum Island Sound estuary, which is heavily affected by rapid rates of development. The suburbanization is occurring in two watersheds that run through 26 towns and drain into the sound. Managers in these communities need to evaluate the impacts of their land and water use on an ecosystem that provides shelter from storms and supports migrating birds and a lucrative shellfishery.

Increasing use of the watersheds for the sale and export of water to towns outside the watershed, as well as for sewage and stormwater drainage, has changed the delivery of water, nutrients, and sediments to the coastal zone, reducing river flow and causing wetland loss. Town officials are now faced with difficult decisions about how to provide an adequate water supply while maintaining river flow, preserving open space, restoring migrating fish populations, and maintaining the coastal fishery.

Applying the ecosystem-services approach would enable resource managers to weigh the value of doing nothing (allowing growth to proceed without regulation) against replumbing sewer and stormwater systems that are impacting the watersheds. "With values placed on each of the primary ecosystem services—ranging from water supply and aesthetics to food production—town managers could score these two options, or others," says Hopkinson. "For some towns, beautiful vistas and a healthy clam crop would mean more than revenue from selling water. Other towns might choose differently, depending on how the various groups of people within the towns value different ecosystem services."



An expert on salt marsh ecology and coastal ecosystems who has studied natural systems for most of his career, Hopkinson believes the ecosystem-services method will help officials in charge of coastal resources like Plum Island Sound manage their natural capital more wisely. “We have begun discussing these new approaches with resource managers at local and state levels in Massachusetts,” he says. “Others have been doing this at the regional and national levels.”

The approach was recently embraced in New Jersey, where state administrators have contracted with the University of Vermont’s Gund Institute for Ecological Economics to provide an analysis of the capital value of New Jersey’s natural ecosystems. “Gund scientists will be able to give them the value of their natural forest lands, their Pine Barrens, their coastal wetlands,” Hopkinson says. “With this knowledge, New Jersey resource managers can begin to assess the long-term ‘condition’ of their ecosystems through change analysis and evaluate the costs of human activities that result in environmental degradation.”

Hopkinson hopes to eventually see ecosystem services-based management implemented on a broad scale, and is promoting the idea not only as a scientist, but also as an outdoorsman committed to preserving Earth’s resources for future generations. “If we want our children to be able to enjoy the outdoors as much as we do, we need to become better stewards of nature,” he says. “If we don’t develop better solutions to environmental challenges, such as managing nitrogen emissions and runoff from agriculture and urban systems, conserving water, and reducing greenhouse gas emissions, we’re likely to see dramatic changes and deterioration of natural systems. We need to work with nature rather than against it.” •

Vital Statistics: Chuck Hopkinson

RESEARCH FOCUS: Wetland and aquatic ecology in watersheds, estuaries and continental shelves; microbial ecology; carbon, nitrogen and phosphorous cycling; land-sea coupling; global ecology; and systems ecology, including modeling and integrated assessment

DEGREES: B.S. in biology, Ursinus College; M.S. and Ph.D. in marine science, Louisiana State University, Baton Rouge

UNUSUAL FIELD EXPERIENCE: Sailed to Antarctica to assess a research site only to turn back just miles before reaching his destination because of impassable ice. “It was a beautiful and exciting four-week trip to nowhere,” Hopkinson says.

OUTDOOR ACTIVITIES: “I’ve always been interested in outdoor activities like hiking, camping, canoeing, skiing, boating, and swimming,” says Hopkinson. “The more natural the systems, the more I’ve enjoyed the experience. At some point I became interested in knowing how natural systems worked and what could be done to protect them.”

Primer: Long Term Ecological Research

Evidence that Earth’s ecosystems are changing is mounting to say the least. One way to understand the effects of these changes is through extended scientific assessments known as Long Term Ecological Research (LTER) projects. With funding from the National Science Foundation, LTER scientists study model ecosystems over many years, then use math and computer modeling to predict how environmental changes will affect them—and similar ecosystems—in the future. Such research is crucial to the wise management of our planet for the benefit of future generations.

MBL Ecosystems Center scientists currently have leadership roles in LTER projects located in the Alaskan Arctic (Toolik Lake), at Plum Island Sound in Massachusetts, and at Harvard Forest, also in Massachusetts. With the arrival of new Ecosystems Center director Hugh Ducklow this May, the center will soon add an LTER in Antarctica to its project list.

• At our Arctic and Antarctic LTER sites, MBL scientists study the effects of warmer temperatures in the most sensitive ecosystems on Earth.

• At the Plum Island Sound LTER headquarters, they ponder the effects of land use change, climate change, and sea level rise on the productivity and sustainability of the coastal zone.

• And at Harvard Forest they investigate how forests will respond to climate change.

MBL Moment

...with

Hugh Ducklow

incoming director of the MBL Ecosystems Center

Hugh Ducklow is a marine ecologist who studies plankton dynamics and biogeochemistry and works regularly at Palmer Station in Antarctica. In May he will become the director of the MBL's Ecosystems Center. He is currently the Glucksman Professor of Marine Science at the Virginia Institute of Marine Science (VIMS) at the College of William and Mary. His research centers on the interactions between climate change and ecosystem function, especially on the Antarctic Peninsula, a region that is warming especially fast. Hugh has conducted research in the North Atlantic, central North Pacific, equatorial Pacific, Arabian Sea, Red Sea, Southern Ocean, Great Barrier Reef, Caribbean, Black Sea, Baltic Sea, Hudson River, and Chesapeake Bay.

Celebrating the International Polar Year

March 2007 marks the launch of the International Polar Year (IPY), a worldwide effort to advance our understanding of how Earth's remote polar regions impact global climate systems. The goal of the campaign is to bring about fundamental advances in many areas of science, and to inspire young men and women toward future careers in science and engineering. The MBL is committed to the study of both Arctic and Antarctic ecosystems, and is proud to participate in IPY.

When he becomes director of the Ecosystems Center in May, Hugh Ducklow will help oversee the MBL's involvement in IPY. We asked him why polar research and education are so important, what he hopes the International Polar Year will accomplish, and what he has learned from his own polar research.

MBL Why should we study polar regions that most people don't think much about on a regular basis?

HD One answer is, just because they're there. The polar regions are fascinating places. In many ways they're the last frontiers—still (relatively) unspoiled ecosystems we don't really know very much about. But polar regions have enormous significance for the habitability of our planet. They regulate the planetary climate and serve as reservoirs for biodiversity, particularly of large mammals and seabirds, but also of microbes, plants, invertebrates, and fish. These important ecosystem services are being diminished and threatened by climate change, pollution, and overexploitation. We need to understand how these remote and extreme ecosystems work and what we can do to save them before it's too late.

MBL What is the importance of the International Polar Year and how is the MBL participating?

HD The 2007-09 IPY <http://www.us-ipy.gov/> builds on the three previous IPYs (1883, 1933, 1957) to raise public awareness and gain a global-scale understanding of the functioning, significance, and future of Earth's polar regions. The MBL's Ecosystems Center is being funded by the National Science Foundation's (NSF) Office of Polar Programs <http://www.nsf.gov/dir/index.jsp?org=OPP> to conduct research in both the Arctic and the Antarctic. Ecosystems Center scientists Gus Shaver, John Hobbie, and Ed Rastetter will team up with colleagues at the University of Alaska and in Russia to set up climate/ecosystem observatories in Alaska and Siberia to work closely with projects in Sweden, Canada, and Greenland. Their long-term goal is to establish a continuing web of international sites, all taking the same measurements, for understanding the changing balance of energy, carbon, and water in the Arctic polar ecosystem. Ed Rastetter will also lead a mathematical modeling team whose goal is to predict future changes in such things as carbon storage in plants and soils around the entire Arctic.

When I arrive at the MBL, I'll bring along the Palmer, Antarctica Long Term Ecological Research (LTER) project <http://pal.lternet.edu/> that's been investigating the marine coastal and continental shelf ecosystem of the west Antarctic Peninsula since 1990. The Ecosystems Center is now home to three NSF-supported LTER projects. With my colleague Dr. Alison Murray, of Nevada's Desert Research Institute, I'll be starting a new IPY project in association with the Palmer LTER. Ocean ecosystems in both polar regions experience strong and rapid transitions from the prolonged darkness and sea ice cover of the polar winter to strongly illuminated open waters in the springtime. This change triggers phytoplankton blooms, re-supplying possibly starving microbial communities with fresh organic matter. Our new project, "IPY: Bacterioplankton genomic adaptations to Antarctic winter" seeks to understand how bacteria and Archaea (a group of microbes that superficially resemble bacteria but are genetically as distinct from them as human beings) cope with the dramatic environmental changes and extreme conditions of the Antarctic marine environment. Most of our previous work has taken place in the Austral spring and summer (October to March), but in our new project we'll go to Palmer Station in the winter (July-August). We envision additional collaboration with new colleagues at the MBL's Bay Paul Center in this work. We're very excited.

"[Antarctica] is changing at all levels, from melting glaciers and shrinking sea ice to changes in phytoplankton and zooplankton, to declining poplulations of ice-adapted Adèlie penguins, seals, and whales."

MBL Your research is based in Antarctica. What do you study there, how did you get interested in this work, and is it really as cold as it looks?

HD As principal investigator for Palmer LTER, I study rapid climate change in the Antarctic Peninsula and how the marine ecosystem (nearly all Antarctic ecosystems are marine) is responding to the warming. Our region is currently experiencing one of the most rapid rates of temperature increase on the planet, having warmed in winter by 6° C (10.8° F) since 1950. As a consequence, the ecosystem is changing at all levels, from melting glaciers and shrinking sea ice to changes in phytoplankton and zooplankton, to declining populations of ice-adapted Adèlie penguins, seals, and whales. My particular research is focused on biogeochemical processes of the carbon cycle, including bacterial decomposition of organic matter, particle sedimentation, and carbon dioxide absorption.

I became interested in Antarctica when I was invited to go along on an oceanographic cruise by a colleague in 1994. Seeing "The Ice" for this first time changed my career (and life). I've been going back ever since.

How cold does it get? Actually our part of Antarctica isn't all that cold. Even before it started to warm up, people at McMurdo and South Pole (the other U.S. bases) called the Peninsula the Antarctic Banana Belt. The year-round climate is like Washington, DC, or Falmouth, Massachusetts, during January. In January at Palmer Station, it's daylight all the time, and on calm sunny days temperatures can reach the low to mid 40s F. That's still rare though, and it's more common to be windy, overcast, and about 35° F—occasionally with rain, sleet, or drizzle. It really doesn't snow much either. In fact, I predict trees growing at Palmer in 50 years.

MBL As incoming director, what do you think are the Ecosystems Center's strengths and what do you hope to accomplish in your new role?

HD The center's main strength is its strong tradition of scientific excellence and intellectual excitement, exemplified and led by John Hobbie and Jerry Melillo. My main goal is to continue that tradition and build upon our strengths by maintaining the center's focus on ecosystems, the principal building blocks of the Earth system. •

Gifts & Grants

The **Alfred P. Sloan Foundation** awarded $1,210,000 for the continued support of the **International Census of Marine Microbes** project led by Mitchell Sogin, director of the MBL's Bay Paul Center.

The **National Science Foundation** awarded $820,001 for **"The Arctic LTER Project: Regional Variation I Ecosystem Processes and Landscape Linkages."** John Hobbie, distinguished scientist at the MBL, is the principal investigator.

The **Gruss Lipper Family Foundation** renewed funding in the amount of $460,450 for the **Gruss Lipper Research and Educational Fund for Israeli Scientists** over a period of three years.

NASA awarded $388,101 for a project titled **"From Early Biospheric Metabolisms to the Evolution of Complex Systems."** Mitchell Sogin is the principal investigator.

The **G. Unger Vetlesen Foundation** renewed its grant of $350,000 in support of the **Josephine Bay Paul Center for Comparative Molecular Biology and Evolution**; the program to develop **marine models for biomedical research** in the MRC; and to support **veterinary services** at the MBL. •

Accolades

- MBL Corporation member **Thomas D. Pollard**, chair and Sterling Professor of Molecular, Cellular and Developmental Biology at Yale University, and former MBL Physiology course faculty member **Joan Steitz**, Sterling Professor of Molecular Biophysics and Biochemistry and a Howard Hughes Medical Institute Investigator at Yale, received the 2006 Gairdner International Awards, which are among the most prestigious in science.

- MBL Corporation member and former Physiology course director **Joel Rosenbaum** (Yale University) received the American Society of Cell Biology's prestigious 2006 E.B. Wilson Medal, which recognizes "significant and far-reaching contributions to cell biology over a lifetime in science."

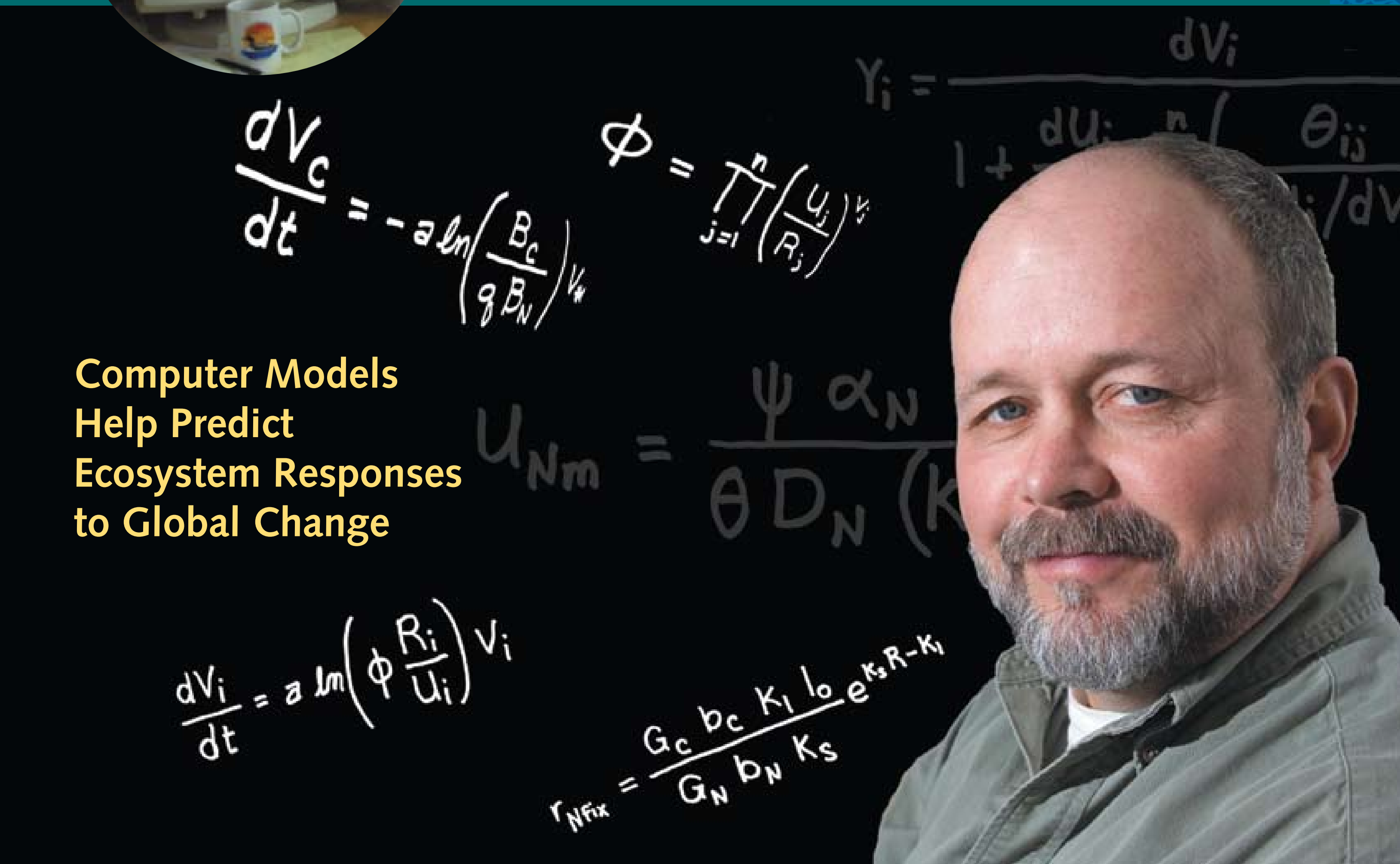
- Congratulations to MBL Corporation members/Whitman Investigators **Robert Goldman** (Northwestern University) and **Robert Palazzo** (Rensselaer Polytechnic Institute) who will serve, respectively, as 2007 President-Elect of the American Society for Cell Biology and the President-Elect of the Federation of American Societies for Experimental Biology.

- **Robin Marantz Henig** (Science Journalism Program alumna and member of the program's Advisory Committee) was awarded the National Association of Science Writers 2006 Science-In-Society Award for her book, *Pandora's Baby: How the First Test-Tube Babies Sparked the Reproductive Revolution* (Houghton Mifflin). The winners are chosen by their peers to receive the highest honor in science writing.

- MBL Corporation member and Embryology course alumnus (1951) **Joseph Gall** recently won a Lasker special achievement award. Gall was recognized by the Lasker Foundation for "a distinguished 57-year career—as a founder of modern cell biology and the field of chromosome structure and function; bold experimentalist; inventor of *in situ* hybridization; and early champion of women in science."

- The MBL congratulates **Roger D. Kornberg** of Stanford Medical School, who was awarded the 2006 Nobel Prize in Chemistry for "studies of the molecular basis of eukaryotic transcription." Kornberg was a faculty member in the 1982 MBL Physiology course. •

Environmental Crystal Ball



Computer Models Help Predict Ecosystem Responses to Global Change

Ed Rastetter stares at his computer screen in amazement. After months of work, his simulation model has just predicted that terrestrial ecosystems may be several times less effective at removing excess carbon dioxide from the atmosphere than previously expected. The results could help answer the many "what if" questions related to the effects of the greenhouse gas on future climate change.

Rastetter's model ties together thousands of hours of fieldwork and theory development from ecologists all over the world and is just one of many simulation models developed at the MBL's Ecosystems Center. Through the use of models, Rastetter and his colleagues analyze the complex interactions among ecosystem processes like the accumulation and cycling of carbon, nutrients, and water.

Models are at the heart of ecosystems science. A synthesis of many ideas from many sources, they are rarely based on a single experiment or even the work of a single team of researchers. Models not only integrate a lot of information, but also help give rise to new experiments. "There is a constant interplay between field and lab experiments and simulation models," explains Rastetter. "This linked activity helps us ask better science questions. We build models of how we think the world works, we test those models, and rework them. Then we test and rework them again. Eventually we end up with a model that will allow us to make useful predictions."

Models can also be used to "try out" alternative experiments on the computer, where they are cheap to run, and thereby avoid squandering thousands of dollars on ineffective field experiments. Once the best field approach is identified and implemented, the new experiments and measurements help advance the next iteration of modeling and the cycle starts again. "In the end, we know we understand a system when we are able to model it reliably," says Rastetter. •

Ed Rastetter is a senior scientist in the MBL's Ecosystems Center. He synthesizes field and laboratory data using simulation models to study how plants and microbes optimize their use of resources like carbon, nitrogen, light, and water, and how that optimization might influence the response of ecosystems to global change.

Scientist's Eye View

Climate Change: The Grand Challenge for All of Us in the 21st Century

Jerry Melillo is co-director of the MBL's Ecosystems Center and a professor of biology at Brown University. He oversees research on global change, management of coastal zone ecosystems, and globalization and transformation of the tropical landscape. Melillo specializes in understanding the impacts of human activities on the biogeochemistry of ecological systems, using a combination of field studies and simulation modeling. In 1996 and 1997, he served as the Associate Director for Environment in the U.S. President's Office of Science and Technology Policy. Melillo just completed terms as the President of the Ecological Society of America and of the Scientific Committee on Problems of the Environment (SCOPE), the environmental assessment body of the International Council for Science. In 2000, he was named an honorary professor in the Institute of Geophysical Sciences and Natural Resources Research, Chinese Academy of Sciences. Melillo is a recently elected member of the American Philosophical Society, the oldest scholarly society in the United States. He has published more than 200 peer-reviewed articles, two ecology textbooks, and three edited volumes on biogeochemistry.

by Jerry Melillo

The newest report from the Intergovernmental Panel on Climate Change confirms that fossil fuel burning and deforestation are driving climate change by releasing carbon dioxide and other greenhouse gases into the atmosphere. More warming and rising sea level are on the way. Projections are that by the end of the century, global temperature will rise by between 4.3 and 11.5° F (2.4 to 6.4° C) if carbon dioxide emissions continue to grow at a rapid rate. This temperature rise is likely to be associated with more extreme precipitation and faster water evaporation, leading to greater frequency of both very dry and very wet conditions. Also, sea level will continue to rise, perhaps by as much as 1 to 2 feet (26 to 59 centimeters)—or even more with rapid melting of the polar glaciers.

Changes in temperature, precipitation, and sea level will be disruptive to society in many ways. Throughout the world, climate change will reduce the capacity of ecosystems to deliver essential services such as the cleansing of air and water, the stabilization of landscapes against wind and water erosion, and the maintenance of environments for recreation. Many people's health will be adversely affected. Warmer temperatures will exacerbate air quality problems such as smog, and increase levels of airborne pollen and spores that aggravate respiratory disease, asthma, and allergic disorders. Climatologists have cautioned that continued climate change will increase the likelihood of large forest fires, extensive floods, and more intense hurricanes and associated storm surges.

The good news is, the die is not cast. We have a choice about how much climate change we, and future generations, will experience. The wise course of action is to be aggressive about keeping greenhouse gas emission rates as low as possible as we transition away from a fossil-fuel-driven economy. This must be done with care so our attempted solutions do not create new problems. As we expand biofuels programs such as making ethanol from corn, we must consider the environmental and socioeconomic consequences of our actions: increased production of nitrous oxide (a greenhouse gas 100 times more powerful than carbon dioxide) when we fertilize corn to increase crop yields; loss of biodiversity if we convert areas of natural vegetation to corn monocultures; higher food prices as farmers cater to energy demand rather than food production. Biofuels should be part of our plan to reduce greenhouse gas emissions, but holistic thinking about them is imperative if we want to avoid unintended consequences!

The holistic-thinking imperative also applies to how society copes with climate changes that are unavoidable. Many of these actions will be related to land-use changes such as re-establishing and maintaining flood plains and coastal wetlands that function to reduce the loss of life and property during extreme weather events. Blueprints for these actions should be based on a mix of social, economic, and environmental considerations.

Climate change is the grand challenge for all of us in the 21st century. We need to form partnerships among government leaders, the business community, and scientists and engineers to address this challenge. And we must find ways to create a dynamic economy while protecting and improving the environment. Scientists at the MBL's Ecosystems Center are working to make this vision a reality. •

Treasures from the MBL's Rare Books Room

Lord Mulgrave On Ice

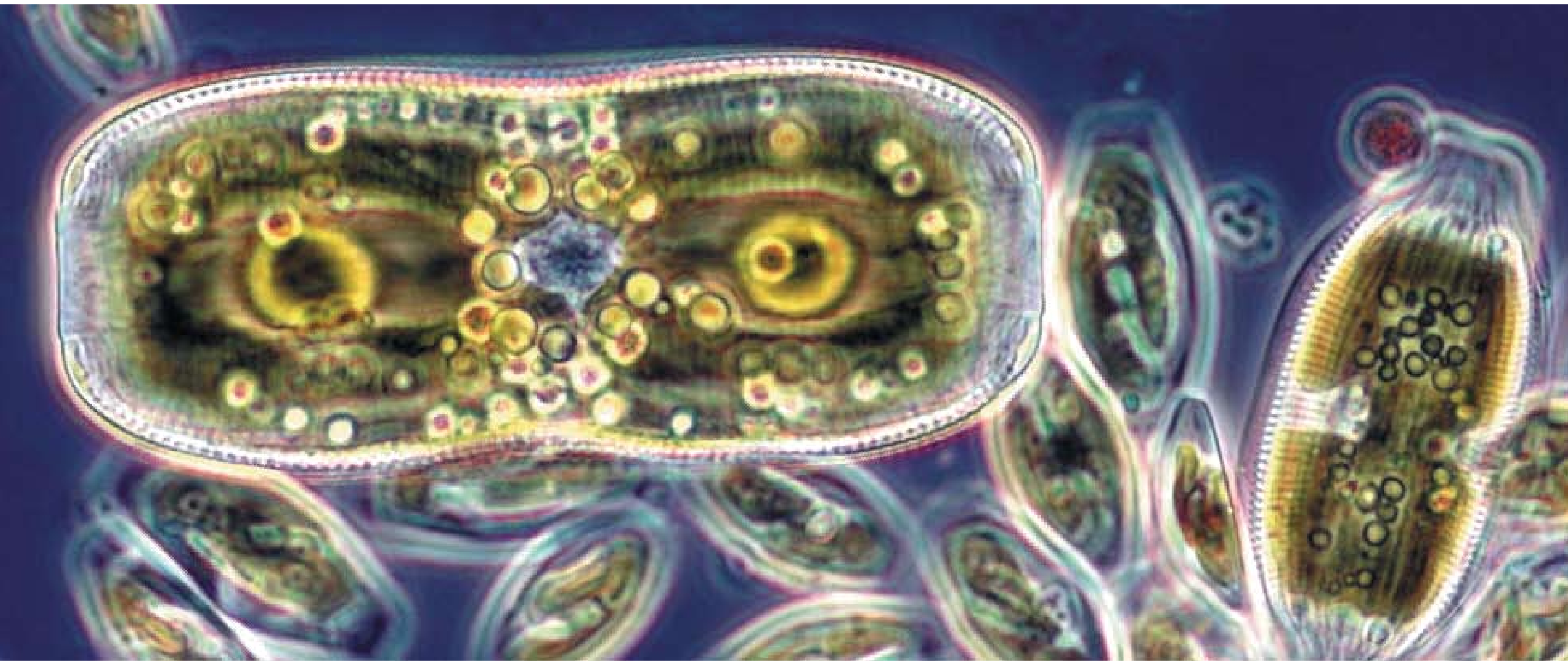
This subtle watercolor by British artist Robert Cleveley dramatizes the 1773 Arctic expedition of the HMS *Carcass* and the HMS *Racehorse*, the latter commanded by Captain C. John Phipps (the 2nd Lord Mulgrave). Phipps sailed from England, crossed the Norwegian Sea, and reached Spitsbergen, Norway, in a bid to find a northwest passage to India, which would help Britain exert imperialistic control over the country. Despite this political goal, scientific research did occur onboard, with Phipps making the earliest known record of a sounding of the Norwegian Sea, which at 686 fathoms brought up a bottom-sample of very fine, soft blue clay. Perennial ice in the East Arctic Ocean may have led Phipps to his decision to return home, convinced the passage to India would not be found. That ice is progressively shrinking and showed an abrupt decline of up to 50 percent between 2004-2005, according to S.V. Nghiem and other researchers at the California Institute of Technology.

From *Adventures by Sea from Art of Old Time*, by Basil Lubbock, published by The Studio Limited, London, 1925. This book is part of the MBLWHOI Library's Montgomery Collection of books on Arctic and Antarctic exploration.

In the Next *Catalyst*

Marine microbes like these pennate diatoms

are the engines of our biosphere and are critical to our survival. Other microbes, including certain viruses and bacteria, are potentially harmful to humans. Yet we have only begun to understand microbial biology, evolution, and diversity. Our next *MBL Catalyst* will explore exciting advances MBL scientists in the Josephine Bay Paul Center for Comparative Molecular Biology and Evolution are making in these research areas.



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