MBL
Biological Discovery in Woods Hole

Catalyst

Founded in 1888 as the Marine Biological Laboratory

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IN THIS ISSUE

Powerful Partnerships

From Woods Hole to the World page 8

From the Director

MBL Catalyst

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MBL Catalyst is published twice yearly by the Office of Communications at the MBL in Woods Hole, Massachusetts. The MBL is a leading international, independent, nonprofit institution dedicated to discovery and to improving the human condition through creative research and education 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 Americas.

About the cover: Woods Hole Consortium directors Susan Avery (president and director, Woods Hole Oceanographic Institution), Gary Borisy (MBL director and CEO), and William Brown (president and CEO, Woods Hole Research Center). Photo by T. Kleindinst.

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Dear Friends,

Fifty years ago, twelve nations joined together as the first signers of the Antarctic Treaty, which set aside Antarctica as an international, demilitarized zone for scientific research and other peaceful pursuits. “Freedom of scientific investigation and cooperation shall continue,” the treaty declared, acknowledging the global partnerships “on the ice” that had already been forged. Today, this model for international scientific partnership is more relevant than ever, as the scale of the problems we face, both environmental and medical, demand that we leverage all resources toward their solution.

At the MBL, we recognize how fundamentally important our partners are, and in this issue of *MBL Catalyst* we are pleased to introduce some of them to you. We define partnership broadly. We have scientific partners all over the world who are essential to our research, such as in the International Census of Marine Microbes (p. 10). We have strong partners right here in the Woods Hole Consortium, which leverages the strengths of three local institutions to augment our range and scientific impact (p. 8). And we have extremely important partners in education, including Howard Hughes Medical Institute (see p. 2) and Brown University. On page 5, we proudly announce a significant expansion of the Brown-MBL relationship with the addition of more faculty and opportunities for collaborative research.

Our funders, both public and private, are not only investors in the MBL. They are truly partners in fulfilling our mission of leadership in the biological and environmental sciences and education. The largest funder of MBL programs is the federal government, particularly through the National Institutes of Health and the National Science Foundation. We also received more than $8 million in competitive grant funding in 2009 through the American Recovery and Reinvestment Act, which is spurring the economy through investments in basic research. The MBL also has vital, interactive partnerships with the state of Massachusetts, private foundations, and individuals. We greatly value not only the funding support, but the vision and expertise that our funding partners bring to us, and we share this with you in several articles in this issue.

Our sincere thanks to John E. Burris for serving as guest science editor for this issue of *MBL Catalyst*. Formerly the director and CEO of the MBL from 1992 to 2000, and now president of the Burroughs Wellcome Fund since 2008, John has seen the MBL from many perspectives and understands well our strengths and challenges. He has made many valuable contributions to the success of the MBL that we deeply appreciate.

This issue of *MBL Catalyst* is just the beginning of our spotlight on powerful partners. We have many more, such as our collaborators in the Encyclopedia of Life. Also crucial are our partners in the Long-Term Ecological Research (LTER) sites that MBL scientists direct in Antarctica, Arctic Alaska, and Massachusetts. The LTERs are an excellent example of the large-scale cooperation among scientists that is needed to illuminate the complexities of our rapidly changing environment. Perhaps MBL Ecosystems Center Director Hugh Ducklow, who directs the Palmer Station Antarctica LTER, has expressed best what the MBL hopes to promote. The Antarctic landscape is breathtaking, Hugh says, but the strong sense of shared purpose in the Antarctic scientific community is also what a visitor there will see, and never forget.

Gary Borisy

Gary Borisy
Director and Chief Executive Officer

In this Issue

Catalyst





Features

Departments

Building for the Future

HHMI invests in the unique character of scientific discovery at the MBL

It is sometimes good when your reputation precedes you.

This must be true in the case of Howard Hughes Medical Institute's decision to award $15 million to the MBL to renovate Loeb Laboratory, the much-loved but outdated research training building that brims each summer with students and faculty in the MBL courses.

The decision first gained traction at a meeting of HHMI's Medical Advisory Board, when the members were asked to dream a bit. If you had a significant sum to spend on advanced education in the biomedical sciences, what would be a valuable investment?

At the Loeb groundbreaking ceremony are (left to right): Susan Windham-Bannister (Massachussetts Life Sciences Center), Gary Borisy (MBL), Ed McCleskey (HHMI), and Tim Hurdelbrink (Shawmut Design & Construction).

> “The spirit of Loeb will be maintained.”
>
> — *Ed McCleskey, HHMI*

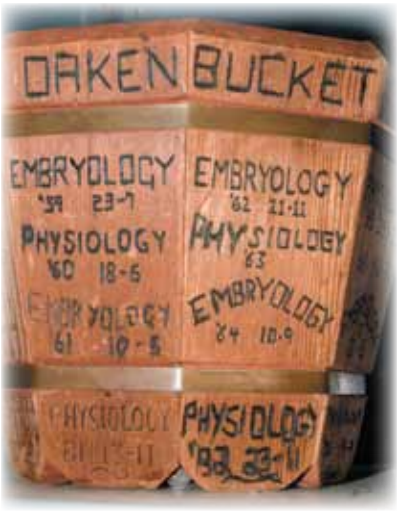
About a dozen ideas were floated, and an intensive review process then began. In the end, Thomas Cech, then president of HHMI and a Nobel laureate, approved two investments. One was $15 million to renovate Loeb Laboratory, provided the MBL raise the remaining $10 million needed for the complete project. Soon after, in fall 2008, the Massachusetts Life Sciences Center stepped forward and committed $10 million to launch the renovation, which will culminate with a celebratory ribbon-cutting this summer.

“What HHMI values about the MBL is this,” says HHMI Scientific Officer Ed McCleskey. “Obviously, the MBL courses are training the next generation of scientists. But *how* are they doing it? By exposing students to cutting-edge techniques with the absolute latest equipment, with hands-on, one-on-one instruction from the leading researchers in the field. That’s it. That’s the number one thing. The MBL is one of very few places that do this.”

Secondly, McCleskey says, “Cross-fertilization of scientific fields is huge, and very few places do it as fundamentally as the MBL. The reason for that is the MBL courses are more than just techniques; they are flagships for whole fields. Courses like Neurobiology, Embryology, Physiology, and Biology of Parasitism try to cover an entire subject. So if you are a physicist, say, and want to learn biology, the way to do that is at the MBL.”

McCleskey, who is a neuroscientist, remembers well the “old Loeb.” Before he joined HHMI in 2007, he was a senior scientist at Oregon Health & Science University’s Vollum Institute, and in 2004 he became co-director of the MBL Neurobiology course. During his four summers at the helm of Neurobiology (which he says was “a blast”), McCleskey spent many hours in the hallowed halls of Loeb Laboratory, which was built in 1970.

"The building didn't have modern facilities for vacuum, one of the most important things in a lab," McCleskey says. "There was no central dishwashing. And, oh boy, the salt water! It was pumped all over the building (for the marine animal tanks), and over 40 years a lot of leaks had developed. A big area of the Neurobiology lab couldn't be used because of leaks."



The Physiology and Embryology courses are archrivals on the baseball diamond, and they keep autographed balls from their annual match-ups in this bucket in Loeb. The tradition will carry forward in the "new Loeb."

"But the most important thing was not all the MBL courses could fit into Loeb," he continues. "The Biology of Parasitism course had to be held in an outpost in the Lillie building."

These problems will gratefully be resolved by the Loeb renovation, with much credit due to MBL Director of Facilities Richard Cutler and former Education Director Lenny Dawidowicz.

But despite its issues, "we all loved Loeb, we loved its idiosyncrasies," McCleskey says. "When you put together a lab in the old Loeb, it was like putting together a lab in a garage. It takes a special kind of scientist to pull that off. Very technically gifted people are drawn to it, and a real camaraderie develops as a result."

Indeed, when students arrive for an MBL course, they find a bare-bones room, smart faculty and, stacked in the hallway, boxes upon boxes of high-end microscopes, centrifuges, and other lab equipment worth about $22 million that is loaned to the MBL each summer by more than 135 companies. Soon, all hands are on deck to set up the lab in a rush of excitement.

"When students see the faculty get a complex lab up and running in what had been an empty room, that is truly inspiring, and they learn a ton from it,"

McCleskey says. "And that won't change in the new Loeb. The renovation is updating the infrastructure, and it will be a whole lot more convenient to work in there, but it doesn't make the place slick. The spirit of Loeb will be maintained."

The scientific ingenuity inspired by the MBL courses is important to HHMI not only from an educational perspective, but also in terms of its investment. "HHMI is a savvy investor, and likes to see its money leveraged," McCleskey says. "When someone donates money to the MBL for its courses, that money gets leveraged big time from two sources. One is all the companies that loan absolutely cutting-edge equipment to the courses. It's a wonderful synergy. And the second is the universities who continue to pay their faculty when they come to the MBL to teach a course. They are fine with this because the MBL is unique; it's not a competing university. We all think of the MBL as a national lab." • —DK

Reaching New Heights in Higher Education

A generous gift from Charles and Phyllis Rosenthal launches the Brown-MBL Partnership

(Left to right): Thomas Tisch, Brown University chancellor; Christopher Neill, Rosenthal Director of the Brown-MBL Partnership; Phyllis Rosenthal; Charles Rosenthal; Ruth Simmons, Brown University president; and Gary Borisy, MBL director and CEO at an event launching the new Brown-MBL Partnership.

How do you produce discoveries and future leaders in the life sciences? "By supporting the highest levels of teaching and research in biology, biomedicine, and environmental sciences," says Brown University President Ruth J. Simmons.

MBL Trustee and Brown Trustee Emeritus Charles Rosenthal and his wife, Phyllis, have done just that—by establishing an endowment of more than $2 million to support a dynamic new collaboration known as the Brown-MBL Partnership.

"Phyllis and I are proud to be able to contribute to the furthering of this world-class collaboration of scientific research, education, and discovery between two great institutions," says Charles Rosenthal.

The Brown-MBL Partnership is an outgrowth of the Brown-MBL Graduate Program in Biological and Environmental Sciences, founded in 2003, and will generate new joint research ventures, strengthen graduate education, and enrich academic offerings across both institutions. MBL Senior Scientist Christopher Neill has been named director of the Brown-MBL Partnership. The Rosenthal endowment directly supports this position.

"Establishing a partnership with Brown University was one of the most significant events in the MBL's history," says MBL Director and CEO Gary Borisy. "This increase in the strength and scope of our alliance is testament to our previous successes. We thank Charles and Phyllis for their investment in this exciting venture."

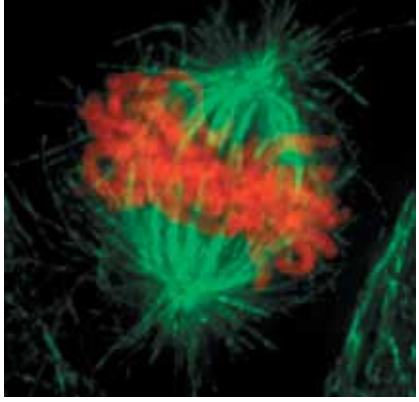
"I am delighted to expand our academic relationship with the MBL," says Simmons. "As a result of the generous endowment from the Rosenthal family, Brown students will gain regular access to a wider range of scientists in microbiology, biomedicine, and ecology, and Brown faculty will have more opportunities to collaborate with the MBL's scientists on groundbreaking research projects."

In addition to Neill, four MBL scientists will hold joint faculty appointments at Brown. They will teach advanced classes, advise graduate students, and spearhead joint research projects. Eighteen students are currently enrolled in the Brown-MBL Graduate Program in Biological and Environmental Science. Three Brown-MBL students completed their doctorates in late 2009.

The expanded partnership will focus on three scientific themes: ecosystems, environmental health, and microbiomes—populations of microbes that play key roles in the human body and the environment. While Brown and MBL researchers have collaborated since the inception of the joint graduate program, the new partnership will foster additional research collaborations and further introduce Brown graduate and undergraduate students to MBL scientists through enhanced course offerings and research opportunities in these targeted areas.

"Together, scientists at Brown and MBL have the vision, expertise, and analytical tools to bridge boundaries of disciplines and create a research and training environment in molecular biology, microbiology, and ecology that is unsurpassed in the world," says Neill. "In addition to fostering basic research, we aim to apply research to solving critical problems of human health and the environment."

An outreach initiative aimed at policy, translational research, and science-based decision-making will also help guide Brown-MBL research collaborations and academic offerings. •



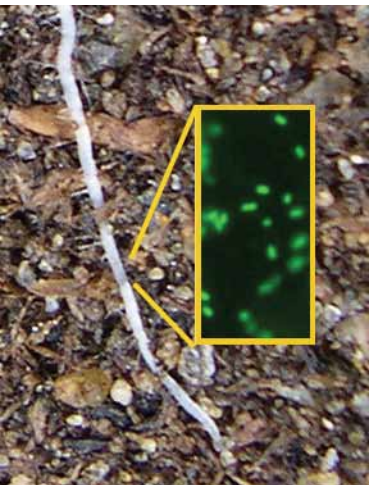
Kinetochore Consortium Discovers New Interactions in Cell Division

Cell division is a critical process in human development from the moment of conception on, and it is also at the heart of many diseases, including cancer. One crucial task of the dividing cell is to accurately separate the two identical strands of each chromosome (the chromatids) and send them into the two new daughter cells. Understanding the forces that drive chromatid segregation is the goal of the Kinetochore Consortium, an international group of researchers who collaborate each summer at the MBL. Recently, the group reported newly discovered interactions between sister kinetochores—the protein bundles at the contact point between the chromatids—and microtubules, the cellular "fibers" that attach to the kinetochores to pull the chromatids apart. To do this, the group developed a novel pipeline for preparing and photographing dividing human cells, as well as computational image analysis to quantify the interplay of sister kinetochores in three dimensions. "We believe we have developed new methods and gained insights that simply aren't available anywhere else. We couldn't have done this work anywhere except at the MBL," says Jason Swedlow, a professor at the University of Dundee in Scotland. In addition to Swedlow and members of his lab, the Kinetochore Consortium includes scientists from the laboratories of Gaudenz Danuser (Harvard Medical School), Patrick Meraldi (ETH Zurich, Switzerland), and Andrew McAinsh (Marie Curie Research Institute, England). (*J. Cell Biol.* 188: 665–679, 2010). •

MBL Scientists Partner with Fishermen, Industry to Launch Offshore Mussel Farms

Four experimental blue mussel farms were recently established in open waters off Massachusetts and Rhode Island as part of a pilot project aimed at laying the groundwork for a competitive fishery in the region. MBL researchers, local fishermen, and American Mussel Harvesters of North Kingston, R.I., which supplied the mussel seed, are collaborating on the project. "Historically, mussels are not a reliable fishery in Southern New England or most places," says project coordinator Scott Lindell, director of the MBL's Scientific Aquaculture Program. "They are typically wiped out by overfishing or starfish predation, and that is why there are few wild harvested mussel beds." The pilot study uses an innovative open-ocean system first tested by researchers at the University of New Hampshire. Anchored in 100 feet of water and suspended 30 feet below the surface, 500-foot buoyant longlines hold hundreds of biodegradable "socks" filled with mussel seed. There are several advantages to farming in offshore waters, according to Lindell. "The ocean currents supply ample food to promote fast-growing mussels," he says. The longline system also avoids predation by starfish and infestation by near-shore parasites. The hope is that the project will lead to a few dozen southern New England fishermen tending longlines, with each longline potentially producing 10,000 to 20,000 pounds of mussels per year. "Through this project, we're looking to promote sustainable aquaculture and help fishermen become sustainable stewards of the ocean," Lindell says. •

Glowing Biosensors Tell Scientists "Above Ground" About the Water Available to Plant Roots



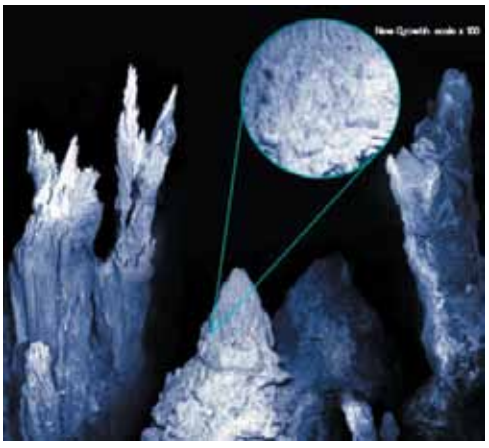
Ecosystems Center scientist Zoe Cardon and colleagues have developed novel biosensors that can report on the availability of water in the soil around plant roots at millimeter spatial scales. As reported in a recent issue of *Plant, Cell & Environment*, the biosensors produce green fluorescent protein (GFP) as a function of total water availability in a complex soil environment. "One reason we are developing these sensors is because all other water availability sensors used in soils, for example in agriculture or in pollution remediation, are the size of a pencil or larger," says Cardon. "But people are interested in *how* plant roots extract water from soils, or how the soil environment of microbes changes over time. These new biosensors are the only way to look at these millimeter scales at the water content in soils." Because the biosensors themselves are living, genetically engineered microbes, Cardon and colleagues subjected them to a battery of tests to make sure the amount of GFP they produced was due to soil dryness, and not to any other conditions. "This was a rigorous test of how the probes would work not only in controlled laboratory tests, but in natural, non-sterile soil," she says. (*Plant, Cell & Env.* 33: 199-210, 2010).•

Built-in Amps: Scientists Explore How Subtle Head Motions, Quiet Sounds are Reported to the Brain

When a sound is barely audible, sensitive inner-ear "hair cells"—which are neurons equipped with tiny, sensory hairs on their surface—pump up the sound by their very motion and mechanically amplify it. Richard Rabbitt of the University of Utah, a faculty member in the MBL's Biology of the Inner Ear course, reported last spring on the magnification powers of the hair cell's hairs. Recently, Rabbitt and MBL Senior Scientist Stephen Highstein reported that hair cells perform similarly in another context—in the vestibular system, which sends information about balance and spatial orientation to the brain. "We have 'accelerometers' in the head that report on the direction of gravity and the motion of the head to the brain," says Highstein. "We found that they respond with a greater magnitude than expected for very small motions of the head. This brought to mind a similar amplification of very small signals by the human cochlea, the auditory organ in the inner ear. In fact, the vestibular system and the cochlea have a sensory element in common: the hair cells." Rabbitt and Highstein found that, just as in the auditory system, the vestibular system's hair-cell response exhibits "compressional nonlinearity": The lower the strength of the stimulus, the more the hair cells "tune themselves up to amplify the stimulus, underlying the ability of the mammalian auditory system to detect a pin dropping and of the vestibular system to detect the slightest movement, such as the sway of a skyscraper in the wind," Highstein says. (*PNAS* 107: 3864-3869, 2010). •

Rare Microbes Can Wait Thousands of Years to Flourish, Scientists Report

Rare communities of microbes are able to wait out unfavorable environmental conditions—even over thousands of years—until conditions shift to spur their growth, report Mitchell Sogin, director of the MBL's Bay Paul Center, and colleagues. The team surveyed the microbes that live in the super-hot chimneys of The Lost City, a deep-sea hydrothermal vent field in the mid-Atlantic Ocean. Some of the Lost City vents were recently born, while others are tens of thousands of years old. Surprisingly, the team found "minority"



microbes that were hardly represented in some of the younger vents had grown to dominate their microbial communities in older vents. "The rare organisms were able to rapidly exploit the new niches as they arose because they had been previously selected for the same conditions in the past," the team reported. Sogin's laboratory carried out the DNA sequencing and informatics to identify what kinds (taxa) of microbes were present in the Lost City vent samples. "This study proves that these rare microbes that are closely related to the dominant taxa are not artifacts of DNA sequencing," Sogin says. "The organisms are real, they are capable of growing, and very subtle ecological shifts resulted in them becoming winning populations." (*PNAS* 107: 1612-1617, 2010). •

From **Woods Hole** *to* **tl**

The Woods Hole Consortium brings its research and policy expertise to the Co

Woods Hole Consortium directors (left to right): Bill Brown (Woods Hole Research Center), Susan Avery (Woods Hole Oceanographic Institution), Gary Borisy (MBL).

Woods Hole is a "brand" known around the world, and it signifies high-impact science in an intellectually stimulating and beautiful setting. This was not far from anyone's mind when the Woods Hole Consortium was founded last year.

"There is no place like Woods Hole, in terms of the scientific talent and synergies of its institutions in research and education. Our combination of institutions presents unique and powerful opportunities," says Gary Borisy, director and CEO of the MBL.

Borisy and the directors of Woods Hole Oceanographic Institution (WHOI) and Woods Hole Research Center (WHRC) realized that by forming the Consortium, they could leverage the expertise of the three institutions—and the reputation for excellence tied to the Woods Hole name—to tackle urgent and complex global problems, such as habitat destruction and climate change.

The Consortium had a chance to flex its muscles last December, when the directors and 18 scientists from the three institutions went to Copenhagen for the United Nations Climate Change Conference (COP 15).

"Copenhagen was a great opportunity to highlight the complementary strengths of the Consortium institutions," says Susan Avery, president and director of WHOI. The timing was right because the UN summit included, for the first time, an event focused on oceans and climate, at which Avery, Borisy, and WHOI scientist Scott Doney spoke. Linda Deegan of the MBL Ecosystems Center was also present.

"If you look at the language of the Kyoto Protocol and other climate treaties, what's missing is recognition of the critical role the ocean plays in Earth's climate system, and how climate warming is already having major impacts on the oceans and coastal zones," Borisy says. "That was one main reason the Consortium went to Copenhagen: To open up the dialogue on oceans and climate."

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penhagen climate summit

Borisy and Avery had the benefit of attending the Copenhagen summit under the auspices of WHRC, which has been deeply involved in the UN climate talks since they began in the late 1980s. "It was important for us to learn from WHRC's experience," Avery says.

And WHRC scored important policy victories at Copenhagen. For years, they have been working intensively to define an international mechanism to stop or slow the now-rampant burning, clearing, and degradation of the Earth's forests, especially in developing countries. Deforestation releases large amounts of carbon into the atmosphere that had been stored in the trees and soils. In the proposed mechanism, called REDD-plus, the industrialized nations would pay developing countries to preserve and restore their forests.

"A success of the Copenhagen Accord is that REDD-plus is mentioned several times (as an international strategy to mitigate climate change)," says Bill Brown, president and CEO of WHRC. While the Copenhagen Accord is not a legally binding document, he says, "it's a statement on behalf of the major powers that they can't really back away from."

Building on the success with REDD, the Woods Hole Consortium plans to combine its expertise on carbon sequestration in forests, soils, oceans, and coastal zones and bring it to the international climate policy dialogue. All of these ecosystems, when healthy and thriving, capture and store a large amount of CO_2 from the atmosphere. And all of them, when destabilized by climate warming and other threats such as pollution, are less able to sequester carbon.

"The Consortium members are looking at carbon in various ways, and we want to combine this into an integrated carbon information system, which would be a major effort but very useful for scientists as well as decision makers," Avery says. The collaborative groundwork is already laid, as scientists from both the MBL Ecosystems Center and WHRC have long studied terrestrial carbon capture and sequestration. WHOI scientists are experts on the oceans and carbon, particularly how climate warming is making the oceans more acidic, which makes it harder for some marine life to build their skeletons and shells and threatens human food supplies. The MBL also studies the ocean and carbon cycling, especially as mediated by microbes.

"I have heard people say, 'We have REDD, and now we need blue,' meaning oceans," says Brown. "Scientists from the three Consortium institutions also work in freshwater rivers, and at the edge of rivers where they go into the seas. There is still much to explore about carbon and water."

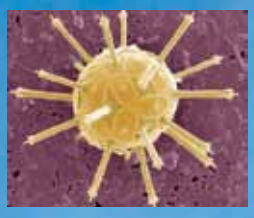
The Consortium is a collegial alliance, with the institutions remaining independent yet moving together in areas of mutual concern—of which there are many. Another current activity is its support of the OpenCape project, a plan to build a 350-mile fiber-optic telecommunications network serving Cape Cod and the Islands, with connections to Boston and Providence, R.I. In March, OpenCape received $32 million through the federal American Recovery and Reinvestment Act, which combined with $8 million in state and county funding will make the project a reality.

"This is absolutely critical to our work," Borisy says. "As research institutions, we move large amounts of data every day. Right now, we are limited by our pipeline. We are very excited about the potential OpenCape will bring."

"There are many opportunities to work together as a Consortium," Avery says, "in science and education, on infrastructure, as well as in arenas like the climate summits, where we can be the scientific voice for informed policy."

"The scale and urgency of the environmental and biomedical challenges our society faces demand that basic scientists step up the game, leverage our resources, and accelerate outcomes to make real headway," says Borisy. "That is the goal of the Woods Hole Consortium: to have an impact that is much greater than what any one institution can have on its own." • —DK

Strength in Numbers



How do you take a census of the smallest creatures in the sea?

Several ICoMM partners at a conference in India (left to right): ICoMM Scientific Advisory Council members Dorairajasingam Chandramohan and Kazuhiro Kogure, MBL scientist and ICoMM Program Manager Linda Amaral-Zettler, and Alfred P. Sloan Foundation Vice President Jesse Ausubel.

Now is the most exciting time, when "things start to unfold, and stories are being told."

This is how MBL scientist Linda Amaral-Zettler describes 2010, the "synthesis year" for a grand collaboration to describe the diversity of microorganisms living in all the world's oceans.

Although the International Census of Marine Microbes (ICoMM) is only six years old, it has amassed more than 25 million genetic sequences from microbes that swim in 1,200 sites around the Earth. It's a staggering amount of information on the microbial life in a diversity of niches—from polar bays to tropical seas; from estuaries to offshore; on corals, sponges, and whale carcasses; from surface waters to deep-sea smokers.

The rapid clip of the project has only been possible through the combined efforts of scientists from 22 countries—and a lucky break in the emergence of enabling technology.

"From the very beginning, when we were deciding how we could do a survey of marine microbes, it has been a community effort," says MBL Bay Paul Center Director Mitchell Sogin, who co-directs ICoMM with Jan de Leeuw of the Royal Netherlands Institute for Sea Research. Amaral-Zettler is the ICoMM program manager.

The oceans contain vast amounts of water and an astronomical number of microbes, the smallest and most abundant of the marine organisms. Obviously, a global census would take a whole lot of people leveraging a whole lot of time, knowledge, and research funding.

But Sogin and de Leeuw were not daunted. With funding through the Census of Marine Life, sponsored by the Alfred P. Sloan Foundation, they galvanized people to start the microbial survey without yet knowing how deep and wide they could cast the net. Early on, they made the crucial decision to collect not just genetic data on the microbes (which would separate them by type), but also contextual information on where they were found—latitude and longitude, ocean depth, water pH, salinity, and other conditions.

"Believe it or not, this is unique, this coupling of (genetic) diversity data and contextual data," says Amaral-Zettler. The big payoff is it lets the researchers ask ecological questions about microbial populations that otherwise could not be posed.

By 2006, the census had made a startling discovery, one that made headlines around the world. In one liter of seawater, Sogin and colleagues found more than 25,000 different kinds of bacteria—orders of magnitude more diversity than they had expected to find. They also discovered that while a few microbial types dominated, most of them were very low in abundance. Sogin called this new and unexplored realm of microbial life the "rare biosphere."

And soon after, the census really caught fire. Sogin heard about a powerful new type of DNA sequencer and quickly realized how he could analyze microbial diversity in many more samples, much faster. His new method, called "Pyro-Tagging," convinced the W. M. Keck Foundation to provide funds for the sequencer and to expand the census. An open call to scientists got an enthusiastic and high-quality response, and 40 new labs were chosen to send samples to the MBL for sequencing.

"What is truly incredible is that these samples came from a tremendous diversity of marine environments all over the globe," says Amaral-Zettler. "That was serendipitous. We were just lucky there was such global interest in the project."

"Sample collection is a very expensive game, mostly in terms of running ships," Sogin says, but the submitting labs paid for that, which relieved one financial hurdle for the census. Meanwhile, at the MBL, "we realized right away that we needed bioinformatics capabilities that didn't exist" to handle the data, Sogin says. So they designed VAMPS, a census-wide database that allows one to visualize microbial diversity in several graphical ways. They also built MICROBIS, a database that combines genetic data with information on the microbes' habitats.

Now they have a research gold mine, "an incredible database on the distribution of various marine microorganisms (bacteria, archaea, protists), through the participation of dozens of top-notch scientists around the world," says Jed Fuhrman, director of the Marine Biology and Biological Oceanography program at University of Southern California.

The next step is to mine it on a global scale, across the data from all 1,200 sites. This is a "major, major challenge," Sogin says, that demands they invent and improve upon tools for database retrieval. But there are tantalizing hints of stories that may emerge, based on regional findings that have already come from census partners.

How many kinds of microbes are in the ocean realms combined? An estimate of minimal diversity is forthcoming, Sogin says, and it will be big. Are there global patterns of microbial distribution based on geography or season? There may well be. Some of the most interesting questions revolve around whether microbes exhibit the "macro" ecological principles, such as succession, that have emerged for plants and animals over the past century. As Fuhrman says, will the census "inform us about truly universal patterns that illuminate unifying features of all life?"

"We think our analyses will tell us very interesting stories," Amaral-Zettler says. One thing the census has proven for sure: "There is a definite power in research coordination." • —DK

. . . with

Susan Windham-Bannister

President and CEO
Massachusetts Life Sciences Center

Susan Windham-Bannister, Ph.D., was appointed the first president and CEO of the Massachusetts Life Sciences Center in May 2008. Previously, she was managing vice president at Abt Bio-Pharma Solutions in Lexington, Mass. Windham-Bannister helped found the company and managed its consulting business, providing commercialization strategy services to firms in the life sciences sectors. She has 35 years of consulting experience in the life sciences industry. Windham-Bannister holds a B.A. from Wellesley College, a doctorate in health policy and management from the Heller School at Brandeis University, and she was a postdoctoral fellow at Harvard University's John F. Kennedy School. She has co-authored two books as well as several articles on competition in today's health care marketplace.

A Match Made in Massachusetts

The Massachusetts Life Sciences Center is an entity created by the Legislature to strengthen the state's global leadership in the life sciences. Through strategic investments totaling $1 billion over 10 years, the Center is deploying the state's Life Sciences Initiative, signed into law by Governor Deval Patrick in 2008. This initiative aims to cultivate the state's life sciences infrastructure, workforce, and translational research at critical phases of the development cycle, from basic science to the commercialization of medical therapies, products, and cures. As one of its first investments, in late 2008 the Center committed $10 million toward the renovation of the MBL's Loeb Laboratory.

MBL **Upon your appointment as president and CEO of the Center, you embarked on a "listening tour" around the state to meet with people in the life sciences industry, academia, government, disease advocacy groups, and in the investment community. What messages emerged?**

SWB The life sciences community understood that while the state's $1 billion Life Sciences Initiative is a great start, there was a real need for the Center to prioritize, to target our investments toward closing gaps and addressing major unmet needs. So our priorities are, first, to invest in our academic institutions and medical centers. Massachusetts is known for life sciences discovery and innovation, and these institutions play a critical role in that pipeline. Our second priority is supporting young companies because, especially in this economy, it's hard for them to get working capital. Third, we want to make sure the entire Commonwealth has the infrastructure it needs to drive discovery and development. Our investment in the renovation of Loeb Laboratory is one example of that. And our fourth priority is workforce development. One of the primary reasons companies choose to locate in or relocate to Massachusetts is our workforce. A final objective is to make sure there is a strong life sciences "ecosystem" in Massachusetts. We want to connect the dots, make sure the major players know each other and provide forums for their interaction, because that supports discovery, collaboration, and leveraging.

(From right, foreground): Massachusetts Governor Deval Patrick and Senate President Therese Murray view a presentation by MBL Senior Scientist Roger Hanlon of the Marine Resources Center. Behind them are, from right, MBL Director and CEO Gary Borisy, Susan Windham-Bannister, and former Representative Eric Turkington.

MBL **Cultivating the potential of regenerative medicine to alleviate suffering from disease and injury is written into the state's Life Sciences Initiative. Please describe the Center's investments in this field.**

SWB We recognize how important regenerative medicine is to the next wave of innovation in the life sciences in Massachusetts. So we have looked to see who is taking a leadership role, and we have invested there. One of our real interests in the MBL is the work you do related to this field. We have a wonderful cluster in regenerative medicine along the southern coast of the state. Along with the MBL, it includes researchers at the University of Massachusetts Dartmouth, some of whom spent last summer at the MBL as Eugene and Millicent Bell Fellows studying marine tissues as potential models for human tissue engineering. It also includes Organogenesis, a company to which we granted $7.4 million to build the world's first fully robotized tissue-manufacturing facility. We have also made significant investments in this field at the University of Massachusetts Medical School in Worcester, including $90 million for the construction of a new life sciences and advanced therapeutics research center and close to $9 million to create the Massachusetts Stem Cell Bank and the International Stem Cell Registry.

The 2009 Eugene and Millicent Bell Fellows, from left: Swati Mishra, Skander Limem, and Animesh Agrawal of University of Massachusetts Dartmouth.

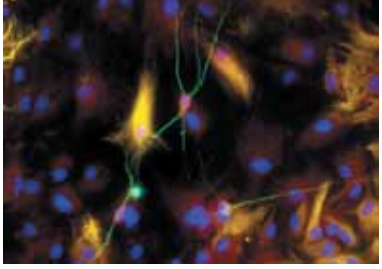
MBL **What cemented the Center's decision to commit $10 million to the renovation of Loeb Laboratory?**

SWB The investment was made to support the MBL's historical leadership in regenerative medicine and in all of its research, which are part of the state's leadership role in the life sciences. We also wanted to help the MBL leverage other opportunities. We are very proud that our $10 million grant enabled the MBL to move forward and receive a $15 million grant from Howard Hughes Medical Institute for the renovation. We also recognized how important the MBL is in training scientists, and that is a great leverage of our investment. It benefits the MBL directly, and it benefits scientists all around the world. The MBL was the perfect place for the Center to make one of our first investments.

MBL **Other than by continuing to fulfill our mission of excellence in research and education, how can the MBL help further the strategic goals of the Center?**

SWB A big part of our job is to put our scientists, institutions, and companies in touch with each other so they share their expertise, collaborate, and partner. (MBL Director and CEO) Gary Borisy has been incredibly generous in that regard. For example, he chaired a peer review panel that we convened to explore opportunities for our investment in the stem cell bank and registry at UMass Medical School, and his expertise brought huge credibility to the panel. Recently, we asked a global pharmaceutical company that is expanding its presence here how we could help them out, and the first thing they wanted to do was meet with Dr. Borisy, because they recognize that the MBL is a center for innovative work in the regenerative medical space. So we were happy to be able to make that introduction. I hope we can continue to call on the MBL to make its expertise available to the many Massachusetts institutes that would like to partner in some way. Second, we fully encourage all the great things the lab does to apply for research dollars from the National Institutes of Health. The MBL has been very successful in that regard, and we hope our investment will strengthen its ability to compete for those resources, which are an important source of money coming into the state. Third, the MBL is a great place to get young people interested in science. I am hoping that as time and resources allow, we find ways to give young people and high school students some exposure to the MBL. Finally, I would like to emphasize that the MBL has been wonderful about extending its partnership to us. We are so appreciative of the time, energy, and expertise that Dr. Borisy, the MBL staff, and many of the MBL scientists have extended. Our partnership with the MBL has been absolutely reciprocal. •

Gifts & Grants



The John D. and Catherine T. MacArthur Foundation awarded $3.8 million for "EOL Biodiversity Informatics." Nathan Wilson, director of Biodiversity Informatics for the Encyclopedia of Life, is the principal investigator.

The National Science Foundation awarded $2.8 million for "The Data Conservancy (A Digital Research and Curation Virtual Organization)." Senior Scientist David Patterson is the principal investigator.

The National Science Foundation awarded $1.1 million for "Validation and Development of Trypanosomal Inhibitors for Treatment of Sleeping Sickness." Adjunct Scientist Robert Campbell is the principal investigator.

The National Institutes of Health awarded $980,629 for "BioCurrents Research Center." Peter J.S. Smith is the principal investigator.

The G. Unger Vetlesen Foundation awarded $850,000 to support Marine Resources Center operations and Bay Paul Center faculty.

The Alfred P. Sloan Foundation awarded $486,812 to support the International Census of Marine Microbes Fund and the Center for Molecular Evolution. Bay Paul Center Director Mitchell Sogin is the principal investigator. •

Accolades

• MBL Senior Scientist and former Ecosystems Center Co-director **Jerry Melillo** has been named MBL Distinguished Scientist for his outstanding achievements and service to the scientific community. The honor is the highest recognition that the MBL can bestow on an individual. Melillo, a climate change expert who specializes in human impacts on terrestrial ecosystems, has conducted research at the MBL for more than three decades.

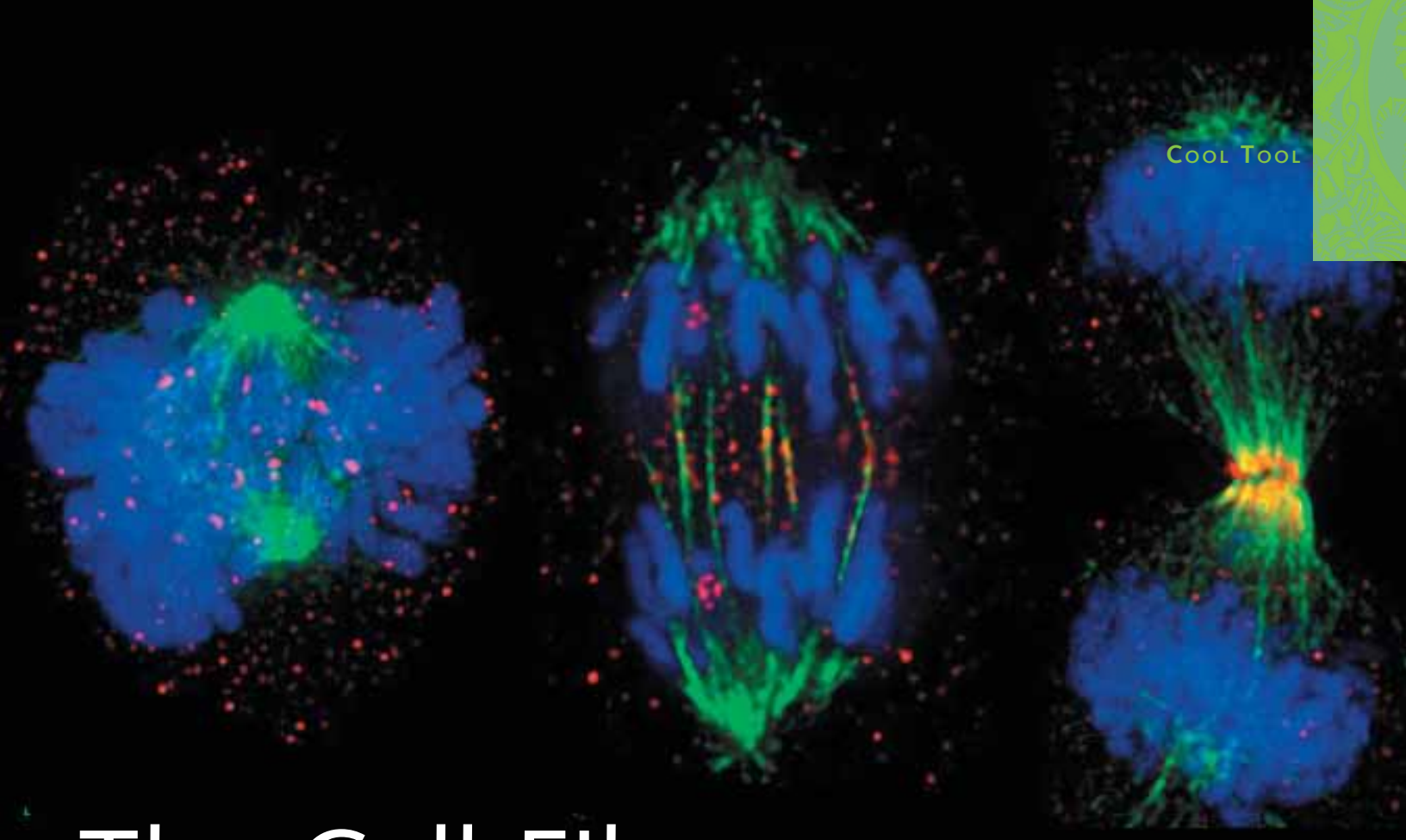
• Microbial Diversity course alumna **Molly Jahn** (University of Wisconsin) was named deputy under secretary of agriculture for science, education and economics at the U.S. Department of Agriculture.

• MBL Corporation member and trustee **John Dowling** (Harvard University) was awarded the Glenn A. Fry Medal in Physiological Optics at the Great Lakes Vision Research Conference in Columbus, Ohio.

• The Association for Library Collections and Technical Services has awarded the **Biodiversity Heritage Library** (BHL) a 2010 Outstanding Collaboration Citation. It will be presented in June during the American Library Association conference in Washington, D.C. MBLWHOI Library Director **Catherine Norton** is chairperson of the BHL, one of the founding components of the Encyclopedia of Life.

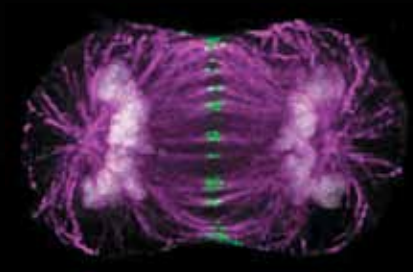
• **Thomas Schmidt** (Michigan State University) has been awarded the 2010 American Society for Microbiology (ASM) Graduate Microbiology Teaching Award in recognition of his dedication to students and for fostering an intellectually stimulating environment. Schmidt co-directed the MBL Microbial Diversity course from 2003 to 2008, during which he taught more than 100 graduate and postgraduate students. The award will be presented in May at the General Meeting of the ASM.

• Three 2009 Nobel laureates have MBL affiliations. **Jack Szostak** (Harvard Medical School/Massachusetts General Hospital), co-recipient of the Nobel Prize in Physiology or Medicine, was a 1982 Physiology course faculty member. **Thomas Steitz** (Yale University), 1981 Physiology course faculty member, and **Ada Yonath** (Weizmann Institute of Science), 1969 MBL independent investigator, were co-recipients of the Nobel Prize in Chemistry. •



The Cell Files

Not so long ago, scientists at great expense would work out the sequence for, say, a muscle protein in the frog, and the sequence would enjoy a small splash of notoriety upon publication in a scientific journal. After that, though, the data would fall into semi-obscurity, far from the fingertips of other researchers who may want to use it.



Those days are gone, however, thanks to the creation of public databases in the early 1980s where scientists can routinely deposit their DNA, RNA, and protein sequence data. Today, these giant repositories are indispensable in biomedical research, with powerful tools for searching, comparing, and extracting information.

The situation is not so evolved, though, for another highly valued resource: images and videos of cells. There are billions of cell images tucked in laboratory computers all over the world, many of them only viewable on the microscope system by which they were captured. Information on cells is critical to biomedical research: Cells are the building blocks of tissues, and abnormalities in their shape and motility signal many birth defects and diseases, including cancer.

Enter "The Cell: An Image Library," a burgeoning database being created by the American Society for Cell Biology and several partners, including the MBL. Scientists and even amateur microscopists are invited to deposit their cell images in this central repository, where they are vetted and annotated by biologists prior to inclusion. Eventually, the Image Library will illustrate abnormal cells and characterize the interactions of cells and drugs.

One huge service the library provides is the standardization of images gleaned from many sources. This is possible due to the Open Microscopy Environment, led by Jason Swedlow of University of Dundee, who co-directs the MBL's Analytical and Quantitative Light Microscopy course.

"You can go to the Image Library and obtain all the raw images from a particular experiment. So you can get the experiment's results— without its costs—even if you don't have that microscope yourself," says Holly Miller, director of the MBLWHOI Library Informatics Group.

John Hufnagle in Miller's group is developing the Web interface for the Image Library, which is launching at **http://cellimagelibrary.org**. Come take a look — and offer your best images! •

Hands-on Training: An Experiment that Works

John E. Burris is president of the Burroughs Wellcome Fund (BWF), an independent, private foundation dedicated to advancing the biomedical sciences through support of research, education, and related activities. BWF is an important funder of the MBL's education program. Prior to joining BWF in 2008, Burris was president of Beloit College from 2000 to 2008. He was director and CEO of the MBL from 1992 to 2000. Burris was also formerly executive director of the Commission on Life Sciences at the National Research Council/National Academies, and a faculty member at the Pennsylvania State University. He received an A.B. in biology from Harvard University and a Ph.D. in marine biology from Scripps Institution of Oceanography. He was formerly president of the American Institute of Biological Sciences and has served on numerous scientific boards internationally.

By John E. Burris

For at least the past thirty years, every report on science education has emphasized that the best way to learn science is to do science. In almost all scientific fields, that means designing and performing experiments and following the scientific method. In spite of this stream of reports, constant pleas from leading scientists, and declining test results, we still do too little experimental science at all educational levels. This shortcoming has been particularly highlighted at the K-12 grades, but it also holds true at the undergraduate and graduate levels.

This is where the MBL steps in and makes a difference, and why we at the Burroughs Wellcome Fund provide funding for MBL courses. The MBL is one of the few places today where demanding science experimentation is central to its courses. When intensive lab courses largely disappeared from the graduate curriculum some years ago, the argument was that they were expensive, time consuming, and unnecessary, as students would be adequately prepared during their first-year research rotation through different labs and through their individual research. At that time, many questioned the relevance of MBL courses. But most now recognize that MBL courses can be as critical to the education of students (and faculty) as they were when Gertrude Stein studied embryology at the MBL in the 1890s, or when Tim Hunt, Joan Ruderman, and their students discovered the protein cyclin during MBL course research in the early 1980s, a discovery for which Hunt was later awarded the Nobel Prize.

MBL courses introduce students to new topics and techniques, as well as to a cadre of fellow students and faculty with whom they tackle interesting research problems. Certainly, graduate students learn research techniques at their home institutions, but rarely are they introduced to so many techniques or have the chance to explore outside of their primary area of research. At the MBL, this happens all the time.

The MBL courses are in themselves experiments, adapting and changing after intensive evaluation. The long-standing policy to rotate MBL course directors every five years means new faculty, ideas, and approaches are constantly introduced, which keeps the courses on the cutting edge. These practices are far too rarely seen today in American education, where stories are legion of the same yellowed lecture notes (or PowerPoint slides) and the same cookbook labs used year after year. We attach far too little value to teaching at the undergraduate and graduate levels. More institutions should prize teaching as does the MBL, where it is a respected and revered activity.

If there is too little opportunity for hands-on science even at the graduate level, what does this mean for the rest of our educational system? In fact, we fail to engage our young people in science by not having them "do" science at multiple points during their education. In the short term, labs and experiments can be more costly as they involve equipment, supplies, and time. In the long term, though, teaching science only through lectures and readings will continue to be far more costly, as we turn off generations to being scientists or even to being scientifically literate. The MBL has shown us how to teach science properly at the most advanced levels. Now, it is up to all of us to follow its example. •

MBL investigators and students from Bryn Mawr College, the first college in the nation to offer women graduate education through the Ph.D. Pictured left to right in this 1896 photo are: Abigail C. Dimon, MBL Zoology investigator who later published research on regeneration with future Nobel laureate Thomas Hunt Morgan; Marie L. Minor, Zoology investigator; Grace T. Clarke, MBL Embryology course student; and Ida H. Ogilvie, Embryology course student and later founder of the Geology Department at Barnard College, Columbia University.

A Partnership With and For Women

Women were scarcely represented in science in the late 19th century, and one of the groups determined to change that was The Women's Education Association (WEA) of Boston. In 1876, the WEA funded the pioneering "women's laboratory" at MIT, which over seven years trained more than 500 women, many of them public-school teachers, in chemistry lab-bench techniques. Five years later, the WEA partnered with Alpheus Hyatt, director of the Boston Society of Natural History, to open a summer school in coastal Annisquam, Massachusetts, for instruction and research in biology. That school, where nearly half the students were women, was so successful that the WEA and the Society resolved to create a permanent marine laboratory. Thus the partners, with vigorous support from Boston colleges and universities, founded the MBL in 1888, with Hyatt as the lab's first president and the WEA donating funds as well as boats and equipment from the Annisquam school. Women were among the MBL's first trustees and comprised about half the enrollment in its first decade, including high-school teachers and, increasingly, candidates for higher degrees. The tradition of female leadership, as exemplified by Joan Ruderman, president of the MBL Corporation, continues today. •

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In the Next *MBL Catalyst*

Where Are They Now?

They are exploring the Earth, caring for cancer patients, continuing Nobel Prize-winning research, inspiring students of science. Some lead government agencies, others provide medical care in remote Third World regions. MBL alumni are all over the world, making good use of the ideas and know-how they acquired in Woods Hole. In the next issue of *MBL Catalyst*, we catch up with some of the movers and shakers among our extraordinary alumni.