MBL

# Catalyst

Biological Discovery in Woods Hole

*Founded in 1888 as the Marine Biological Laboratory*

Spring 2008
Volume 3, Number 1

IN THIS ISSUE



## The Joys of MBL Education

**From spindles in the sand to discoveries in the lab**

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## From the Director


MBL Catalyst

Spring 2008 Volume 3, Number 1

*MBL Catalyst* is published twice yearly by the 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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About the cover: Participants in the Physiology course (and some of their children) take a break from the laboratory to mix science and fun on a beach in Woods Hole. In the foreground is a sand sculpture they created of the mitotic spindle, the kinetic structure that separates chromosomes during cell division. Photo courtesy of Ron Vale.

Online extras: For full image descriptions, supplemental materials, and other information related to this issue, visit:
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*Dear Friends,*

*When I first came to the MBL as a graduate student in 1965, I couldn't have imagined how immensely productive and rewarding that summer would be. I came here to take a course, but I also had a specific research goal in mind: I wanted to learn how to isolate a certain structure from cells, the mitotic spindle. When I got to Woods Hole, I found out that Lenny Rebhun and Bob Kane, both experts in spindle isolation, were at the MBL, so I camped out on their doorsteps and asked them to teach me. They were very generous with their time, and I learned everything I could from them. As it turned out, that wonderful summer at the MBL was pivotal to the discovery of tubulin, the structural subunit of microtubules, which my colleagues and I purified at the University of Chicago later that year.*

*My first MBL experience was one of discovery, and, as you'll see from the stories in this issue of* MBL Catalyst, *that is what is so special about education at the MBL. It is a place where students experience discovery, often for the first time, and it's hard to overstate how powerful, even imprinting, that experience can be. Not only do students at the MBL learn a tremendous amount about the practice of science, they also experience it in an emotional way. They see the fun and joy in science, and they become inspired investigators of the living world.*

*As a student at the MBL, I was overwhelmed in the best sense of the word. There were many more interesting lectures than I had time to attend. The beauty of Woods Hole also made a deep impression. At night, after leaving the lab, we often went swimming in places where we could see the phosphorescent marine organisms rolling off our arms. The idea that you could do some experiments and then walk to the beach, play chess, and interact with the best minds in science – it made for unforgettable experiences.*

*My thanks to John Dowling, of Harvard University, who serves as guest science editor for this issue of* MBL Catalyst. *A vision researcher who founded three MBL courses over the past four decades, John is one of many scientists from around the world who have built the MBL's reputation for excellence in education. I'd also like to acknowledge Lenny Dawidowicz, the MBL's Director of Education, and his staff, who expertly guide and support many of our courses.*

*In closing, the MBL is the only place I know of where the intensity of scientific discovery, the beauty of the environment, the informality of personal interactions, and the capacity to both work and play are so well combined. It's a special mix, and it's why people fall in love with doing science at the MBL.*

Gary Borisy

*Director and Chief Executive Officer*
*Marine Biological Laboratory*

# Catalyst

## In this Issue

MBL

# Learning to Transform

## The MBL gives young scientists the experience of a lifetime

"We see the sparkle in the students' eyes. These people go home hooked on neurobiology research. Some, as has happened many times, will come back to the MBL as visiting researchers or course faculty to mold the next generation."

—PAUL DE WEER, M.D., Ph.D., University of Pennsylvania; lecturer, MBL Neurobiology course

"This course transforms students and faculty alike in an amazingly positive way; it's fantastic."

—KAREN A. MESCE, Ph.D., University of Minnesota; faculty, MBL Neural Systems & Behavior course

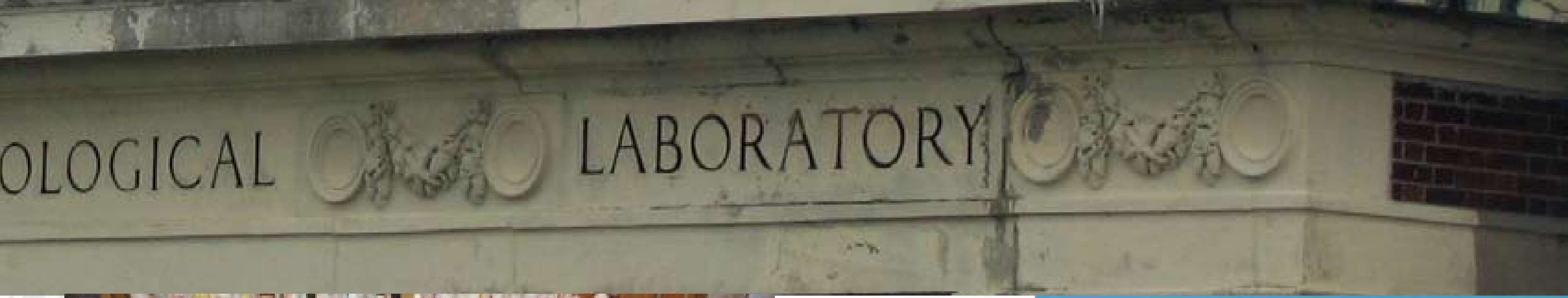
Everyone knows how life-changing some experiences can be. One falls in love, or gives birth to a child, and the world is never the same again.

Such a transformation might not be expected from taking a course. And yet, at the Marine Biological Laboratory in Woods Hole, this happens.

The MBL's summer courses in the biological sciences train hundreds of the world's top graduate students and postdoctoral fellows every year. And for many, the experience leaves them profoundly changed.

*"This course, in short, completely changed my life. It was the most scientifically thrilling environment I've been a part of, with students and mentors excited to learn, to take risks, and collaborate on research. Indeed, it set a high bar for the atmosphere I aspire towards in my own research group."*

— MARGARET GARDEL, Ph.D., University of Chicago; alumna, MBL Physiology course (2004)




*"My experience at the MBL was truly transformative. I found myself literally thrilled each day by the new concepts I learned. Of all the educational experiences I have had, those six weeks at the MBL changed my way of thinking the most."*

— OPHIR KLEIN, M.D., Ph.D., University of California, San Francisco; alumnus, MBL Embryology course (2004)

*"These courses literally changed my life. I became part of a big family and tradition that people often refer to as 'the MBL experience.' It is truly a scientific awakening, in which the curiosity of others is contagious, and it catapults scientific careers."*

— ULISES RICOY, Ph.D., Oregon Health and Sciences University; alumnus, MBL SPINES course (2005) and Neurobiology course (2006)

How does MBL education effect such positive change in scientists – and in science? In this issue of *MBL Catalyst*, we explore the unique MBL model of *training for discovery.*

"What makes the MBL Embryology course so attractive to me (and keeps me coming back each year) is the opportunity to teach students who really care; students who are willing to take time out from their own personal research programs to develop a broader perspective."

—ERIC WIESCHAUS, Ph.D., Princeton University; 1995 Nobel Prize laureate; faculty, MBL Embryology and Physiology courses and alumnus, Embryology course (1969)

# It Starts at the Top

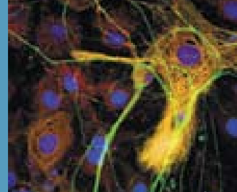
"Other things being equal, the investigator is always the best instructor," wrote C.O. Whitman, the MBL's first director, and this vision has shaped education at the MBL for over a century. The directors of MBL summer courses are exceptional research scientists who are dedicated to training the next leaders in their field. Every five years, the MBL selects new course directors from among the world's top scientists and offers them "freedom to set the syllabus for their course and how it will be taught," says Lenny Dawidowicz, the MBL's Director of Education. It's no secret that a roll call of MBL course directors, and the faculty they recruit, is a "who's who" of world leaders in biology and biomedicine.

*"It is exposure to these 'gods' that is really the unique aspect of this MBL course. The chance for students to meet with them, hear how they think, and carry out investigations with them, day by day, is irreplaceable. The impact is such that the course itself becomes the birthplace for the next leaders in the field."*

— ARTHUR HORWICH, M.D., Howard Hughes Medical Institute (HHMI)/Yale School of Medicine; lecturer, Physiology course

The students in the MBL courses are also extraordinary: smart, motivated, and from a variety of scientific backgrounds and nationalities. Often the course faculty outnumbers the students, leading to a wonderful dynamic of shared growth.

**Students often leave the MBL with new mentors and collaborators, or even a job offer, and a close group of friends who will always connect over their shared experience in Woods Hole.**



## Intensity of the Best Kind

Many of the students who come to the MBL are in transition — between academic laboratories, for example, or between disciplines of science — and they seek intensive, hands-on exposure to a new field of study. This is what the MBL courses provide.

*"I learned more in six weeks at the MBL than I did in four years of graduate school. The reason is simple: the course offered me, at crucial formative years, complete immersion in the laboratory techniques and in the knowledge of the complex and diverse topic that is developmental biology."*

— ALEJANDRO SÁNCHEZ ALVARADO, Ph.D., HHMI/University of Utah School of Medicine; alumnus, Embryology course (1995)

*"This MBL course is my favorite teaching venue, bar none. To me, it constitutes the very best elements of being a scientist, in establishing an atmosphere in which everybody, students and instructors, join together in asking questions about the world and sharing ideas about how to approach those questions. It is science at its very best, and somehow it brings out the best in everybody participating in it."*

— BRUCE P. BEAN, Ph.D., Harvard Medical School; lecturer, Neurobiology course

## Beyond Technique

The MBL courses are known to instill a "can do" confidence in students that carries forward into their careers. Students and faculty delight in the cutting-edge scientific equipment in the MBL courses, and a "Just try it!" atmosphere leads to innovative thought and experimentation. In the MBL courses, students discover the joy of practicing science, at the highest levels of creativity and achievement.

*"The course not only teaches an impressive variety of techniques, it ultimately impacts breadth of thinking, boldness of experimental design, and true collaborative spirit."*

— KRISTINA MICHEVA, Ph.D., Stanford University School of Medicine; faculty and alumna (1996), Neurobiology course

## The Woods Hole Factor

*"There is a special magic that occurs each summer when an MBL course gets together, institutional restraints melt, past academic achievement is forgotten, only desire and skill matter. It's a time out from ascending career ladders, a time to stop and think what a career is really about."*

— TOM REESE, M.D., National Institutes of Health; faculty, Neurobiology course

There is a certain something about the MBL that scientists recognize as unique and amazing, but is hard to describe. Part of it is the beauty of Woods Hole, "which manages to be both a charming seaside village and an intellectually thrilling place where Nobel Prizes are won," says Dennis Bray, Ph.D., of University of Cambridge. Despite the intensity of the MBL courses, a relaxed, casual atmosphere prevails, and students find faculty more accessible to share ideas with, and to laugh and have fun with, than is ever possible during

the academic year. Part of it is the vivid sense that history is made at the MBL, and has been for over a century. Some people call that special MBL factor "magic," others don't give it a name. They just know that they leave the MBL forever changed — and they can't wait to come back.

*"Now, as a supervisor of students, I can at least partially pass on to the next generation the expertise, enthusiasm, and joy of doing science that was transferred to me during that special summer at the MBL in Woods Hole."*

— ANNAKAISA HAAPASALO, Ph.D., University of Kuopio, Finland; alumna, Neurobiology course (1999)

## Science Training for All

In essential ways, the MBL Education Program keeps the same spirit alive today that it had in 1888, when the first course was launched (Invertebrate Zoology, which is still offered in contemporary form as Neural Systems & Behavior). The MBL has always embraced a democratic range of students, from high-school biology teachers to postdoctoral scientists and university faculty. And a close intertwining of study and hands-on research — learning science by doing — permeates every MBL course and program.

One of the most significant recent events at the MBL was the creation, in 2003, of the **Brown-MBL Graduate Program in Biological and Environmental Sciences**. Students take a progressive, interdisciplinary approach to advanced research in this Ph.D. program, which is offered jointly by Brown University and the MBL.

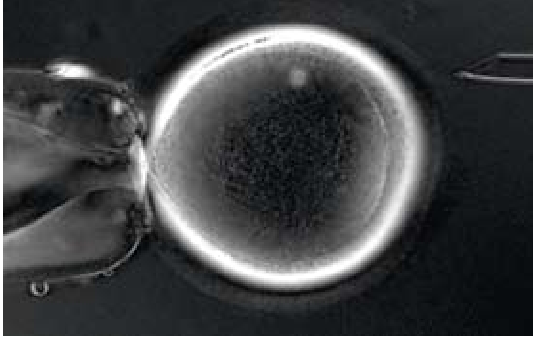
The MBL **summer courses** for graduate and postdoctoral students have an illustrious history. Lasting six to nine weeks, these intensive courses give students the "big picture" of a discipline through lectures, laboratory training, and individual research opportunities. Some of the courses, such as Embryology, have been taught for more than a century, and their alumni are the leading scientists in the history of their fields. The Physiology course, initiated in 1899 by renowned biologist Jacques Loeb, was the first course of its kind and it catalyzed the development of the subject at universities worldwide.

The "younger" summer courses founded in the 1970s — Neurobiology, Microbial Diversity, and Biology of Parasitism — have each, like the MBL's oldest courses, produced a spectacular cadre of disciplinary leaders. Frontiers in Reproduction, originally founded as a short course in 1998, trains scientists and clinicians in reproductive biology (long a focus of MBL research), and explores leading-edge techniques in infertility and reproductive medicine.

Shorter than the summer courses, the MBL **special topics courses** offer intensive training in particular techniques, approaches, or model organisms. Several address neuroscience or microscopy; the others delve into a range of fields, from bioinformatics, to molecular evolution, to history of biology.

Undergraduates in the accredited **Semester in Environmental Sciences** learn how to conduct ecological research by doing it. In addition to classes, the students pursue laboratory and field investigations with faculty mentors from the MBL Ecosystems Center.

The MBL offers **training workshops for high-school science teachers**, while journalists learn the ropes of hands-on research in the MBL's **Science Journalism Program**. For a complete list of courses, descriptions, and contact information, please visit: www.mbl.edu/education. •



## Microscope System Based on MBL Technology Illuminates Stem Cell Research

A noninvasive, polarized light microscope invented at the MBL played a crucial role in a recent breakthrough in embryonic stem-cell research aimed at developing medical therapies. In a paper published in *Nature*, a team led by Shoukhrat Mitalipov (Oregon Health & Science University) reported the successful derivation of stem cells from cloned monkey embryos. While embryonic stem cells have been made from cloned embryos in a mouse, this is the first time they have been produced in a primate. Mitalipov's stem-cell derivation succeeded, he says, largely due to the Oosight™ system developed by Cambridge Research & Instrumentation Inc. (CRi), using technology invented at the MBL by senior scientist Rudolf Oldenbourg, research associate Guang Mei, and associate research scientist Michael Shribak. Former MBL research scientists David Keefe and Lin Liu, both faculty in the MBL's Frontiers in Reproduction course, worked with Oldenbourg to adapt the technology for somatic cell nuclear transfer and embryology. The Oosight™ system is based on the LC-PolScope™, a polarized light microscope invented at the MBL that that allows one to visualize molecular order directly in living cells with unprecedented sensitivity, resolution, and speed. The LC-PolScope™ technology is being adapted for different applications by CRi and is sold under trademarks such as Oosight™ and Abrio™. (*Nature* 450: 497-502, 2007) •

## Nitrogen Pollution Overwhelms Filtering Capability of Streams

**Increasing nitrogen runoff from urban and agricultural land-use is interfering with our streams' and rivers' natural processes for removing this pollutant before it endangers downstream ecosystems, reports a nationwide team of 31 ecologists, including MBL senior scientist Bruce Peterson and research assistant Suzanne Thomas. The results, published in *Nature*, are based on a major study of 72 streams in 8 regions across the U.S. and Puerto Rico. "Our findings demonstrate that streams containing excess nitrogen are less able to provide the natural nitrogen removal service known as denitrification," says Peterson. In denitrification, bacteria help convert nitrate in the water to nitrogen gases that then escape to the atmosphere. "This means humans can easily overload stream and river networks to the point that nitrate removal is not sufficient to prevent eutrophication downstream, the scenario where algae grow out of the control and oxygen may fall to unhealthy levels." The ecologists say these and other findings underscore the importance of controlling human-generated nitrogen runoff, and provide critical information to land-use managers contemplating large-scale land conversions for projects including corn farming for biofuels production. (*Nature* 452: 202-205, 2008) •**


## MBL Creates Portal for Online "Macroscope" to Explore Life's Mysteries

The first 30,000 pages of the online Encyclopedia of Life (EOL) <www.eol.org> went live recently to the acclaim of scientists and educators worldwide. Launched in 2007, the EOL is a monumental, unprecedented effort to create a Web page for all 1.8 million named species of animals, plants, and other forms of life on Earth. The MBL is playing a major role in developing the EOL. The EOL Biodiversity Informatics Group, based at the MBL, developed the software infrastructure and Web portal for the EOL, with each species page created from an aggregation of text, images, video, scientific data, and other information drawn from many sources, and all vetted by scientific experts. The MBLWHOI Library is also an important player through its leadership role in the Biodiversity Heritage Library consortium, which has scanned more than 2.5 million pages of fully searchable, natural history literature for the EOL. In essence, EOL will be a microscope in reverse, or "macroscope," helping users to discern large-scale patterns across species. Scientists say the EOL could, for example, help map vectors of human disease, reveal mysteries behind longevity, suggest substitute plant pollinators for places where honeybees no longer provide that service, and foster strategies to slow the spread of invasive species. "The EOL provides an extraordinary window onto the living world, one that will greatly accelerate and expand the potential for biological and biomedical discovery," says Gary Borisy, MBL director and CEO and a member of the EOL Steering Committee and Distinguished Advisory Board. The EOL is the effort of a consortium that includes the MBL, Harvard University, the Smithsonian Institution, the Field Museum of Chicago, the Biodiversity Heritage Library, and Missouri Botanical Garden. •

## The Evolutionary Secrets of Desert Cells

It turns out the desert isn't nearly as devoid of life as it looks. In an article published in *BioScience*, MBL senior scientist Zoe Cardon provides an overview of the remarkable diversity of green algae living in desert crusts, where they and numerous other microbes help prevent wind and water erosion, control water runoff, keep the soil fertile, and sequester and process nitrogen. This "green algal underground," say Cardon and her colleagues, offers important insights into the survival secrets of green plants. And though they still resemble the green algae commonly found in ponds, desert green algae have been evolving over millions of years to survive the extreme pressures of desert life. "Green algae are very closely related to the larger green plants we are all used to seeing around us on land. Very few of those larger plants are able to survive being dried out in deserts, or even in

gardens when we forget to water, but these tiny, simple green algal cells can be dried out and wetted up and still survive. Learning about how they tolerate harsh desert conditions may provide clues to how and why more familiar larger green plants evolved to tolerate (or not tolerate) desiccation," says Cardon. The study of microbiotic desert crusts is of increasing importance to managers of western arid and semi-arid land who are working to preserve these hard-working-yet-fragile ecosystems. (*BioScience* 58: 114-122, 2008) •

## Sponge Offers Insights into the Basics of Immunity

Sponges are the simplest of all animals, lacking nerves, muscles, and organs. But as the oldest animals still in existence on Earth, they've obviously got what it takes to survive. One striking ability of sponges, reports a team led by MBL Whitman investigator Xavier Fernàndez-Busquets, is their tissues recognize "self" or "non-self" with a specificity that rivals the human immune system. The team uses grafting techniques to study tissue acceptance and rejection in the red beard sponge. Their research can illuminate not only the medical problem of tissue rejection in transplant patients, but the evolutionary origins of immunity. In a paper published in the *Journal of Immunology*, Fernàndez-Busquets and his colleagues found that a commonly used immunosuppressor in human transplantation, cyclosporin A, effectively blocks tissue rejection in marine sponges. "This indicates that the cellular mechanisms for regulating self- and non-self recognition in vertebrates might have appeared at the very start of metazoan evolution," says Fernàndez-Busquets, of the Institute for Bioengineering of Catalonia, Spain. "It is likely that recognition of self was a prerequisite for maintaining individual genomes separate, which in turn was a must for the evolution of multicellular animals." (*Journal of Immunology* 179: 5927-5935, 2007) •

# Science as a Calling

## Finding community, in many ways, in the Brown-MBL graduate program

*By Gillian Galford*

**Vital Statistics:**
**Gillian Galford**

HOMETOWN: Portland, Oregon

DEGREES: B.A; Earth & Planetary Sciences/ Environmental Studies, Washington University, St. Louis (2004); M.Sc., Geological Sciences, Brown-MBL Graduate Program in Biological and Environmental Sciences (2006)

AT PRESENT: Galford expects to complete her doctorate in the Brown-MBL program in 2009.

UNUSUAL FIELD EXPERIENCE: In Tanzania, Galford conducted an independent study of elephant migration corridors that revealed a complex pattern of movement through national parks, conservation areas, protected forests and—at a critical crossroads—a private ranch. "Keeping the elephants from raiding farms for food saved many of their lives," she says.

As I stand in a sweeping field of soybean crop that, just a few years ago, was native savanna, I realize I am in exactly the place I want to be.

Here, in the Brazilian Amazon, I am pursuing science I am passionate about in a socially relevant context. As I explore how the conversion to agriculture — which is rapidly altering the Amazon — impacts the release of greenhouse gases from soil, I can connect with Brazilian residents and their concerns. Here, I can put into action a lesson I have learned over many years:

***What is best for the environment is also best for the local community.***

The path that led me to the Brown-MBL graduate program — and to this leafy soybean field — began long ago. As a child, I spent hours combing the Oregon coast for small rocks to add to my collection. (No one guessed that I would become a geologist.) During high school, I taught soil sciences to middle-school students in an outdoor education program. I explored the woods, tidal pools, and rivers with strong mentors, gaining a sense of place, a passion for learning about the natural world, and a strong environmental ethic.

As a teenager, I witnessed the human-development aspects of environmental sustainability when I served as a supervisor for Amigos de las Americas. We helped communities in the Dominican Republic and Paraguay take on self-identified issues, including public health concerns that had a strong connection to the local environment (such as latrine construction). A few years later, as an undergraduate at Washington University, I spent a semester studying wildlife management in the greater Serengeti ecosystem in Tanzania, Africa. There, too, I saw firsthand that the health of the environment and of societies are closely coupled. Efforts towards environmental preservation are only sustainable if they include the wellbeing of neighboring communities.

I pursued an academic breadth in college — from the ecology of the Serengeti, to the geology of Hawaiian volcanoes, to environmental problems in U.S. history, to energy issues. I also worked in a NASA-funded remote sensing lab. These experiences reinforced for me the strength of spatial analysis in the environmental sciences, such as remote sensing and Geographic Information Systems (GIS) technologies, particularly at the interface of policy and management.

Galford's research colleagues from the University of Sao Paulo set out to make gas flux measurements on a tilled soybean field during the dry season (Comodoro, state of Mato Grosso, Brazil).

When it came time to search for a graduate school, I sought out programs where I could pursue my interest in remote sensing applications to earth systems science. This led me to Jack Mustard, professor of Geological Sciences at Brown University. The opportunities at Brown, including the new Brown-MBL joint program, sounded perfect. I connected with Jerry Melillo, co-director of the MBL Ecosystems Center, as a potential mentor, and we decided to bridge Brown's expertise in remote sensing with the MBL's expertise in ecosystems modeling to address environmental sustainability.

Jerry's work in the Brazilian Amazon immediately drew me in. The landscape there is rapidly transforming as Brazil seeks to meet social and economic goals through agricultural development, such as converting savanna lands to soybean farms for cash-crop export. What are the environmental impacts of this large-scale conversion of forest and savanna to intensive, row-crop agriculture? For my doctoral research, I am estimating greenhouse-gas emissions from land-use and land-cover change in the region. Practices such as tillage, fertilization, and irrigation impact the greenhouse gases that are emitted from soil; this release of carbon and nitrogen means the soils are losing nutrients. Local farmers want to know how to conserve nutrients in their soils, which we can help them do as we find ways to manage agriculture to reduce greenhouse-gas emissions. On a larger scale, Brazil is interested in the carbon trading market, where reductions in carbon dioxide emissions are economically rewarded. Managing Brazil's agricultural resources as a carbon sink, rather than a carbon source, makes economic as well as environmental sense.

When I started out in the Brown-MBL program, I knew it would be an adventure. I was a part of the first class admitted, so some bumps in the road were expected, but I also looked forward to shaping my own highly unique graduate experience. The program gives me access to a diverse range of expertise, as well as the opportunity to travel and work with international collaborators and contribute to an interdisciplinary group to synthesize research findings in the Amazon. Beyond that, I've found a niche in which I can apply my passion for earth-systems science to a topic relevant to society. In short, I've found a calling. •

*"I knew it would be an adventure."*

## A Partnership Grows

Since its creation in 2003, the Brown-MBL Graduate Program in Biological and Environmental Sciences has grown steadily. Three students have been awarded degrees and 16 are now enrolled. Most impressively, the students — who choose an advisor from each institution — are working with faculty from a wide variety of Brown departments and MBL research centers.

"We are finding natural bridges between Brown and the MBL," says Mark Bertness, a Brown professor of biology and one of the architects of the joint program. "It's the way for the program to grow with strength."

Several students are taking advantage of synergies between the MBL Ecosystems Center, with its global network of field sites, and Brown's Environmental Change Initiative, which includes faculty from ten different departments. "In studying human impacts on the environment, Brown can contribute many perspectives," Bertness says, including expertise in sociology, political science, and population studies.

Brown and MBL also have reciprocal expertise in the general areas of molecular evolution and microbial diversity, says Mitchell Sogin, director of the MBL's Josephine Bay Paul Center. "Brown has strength in computation biology, and MBL has strength in genome sequencing," Sogin says. "We can offer students a powerful combination of disciplines by uniting Brown's expertise in remote sensing and modeling with the MBL's expertise in molecular microbial ecology," he adds.

Currently, other Brown-MBL students are drawing on the MBL's expertise in cellular imaging at the Architectural Dynamics in Living Cells program, and in nanoparticles at the Molecular Physiology Program. In addition to jointly mentoring students, Brown and MBL faculty are successfully finding new paths for collaborative research.

"There are no bounds to how far the Brown and MBL partnership can go, even beyond the graduate program," Bertness says. •

# Wired to Learn

*Up-to-the-minute course explores the neural basis of behavior*

"Anyone can learn how to do an experiment, but it's best to learn quickly!" says Ed Boyden.

Boyden, age 28, knows a thing or two about quick. He was a young electrical engineer when he took the MBL Neural Systems & Behavior (NS&B) course in 2000, an experience he says "changed my life." After his doctorate in neurosciences at Stanford, he landed a faculty position at MIT, where he now has a joint appointment in two departments.

Boyden loved the framework of NS&B, where every two weeks the students learn a new methodology for analyzing the nervous system of a different animal — the leech, the songbird, the fruit fly, the electric fish, for example — relative to some aspect of the animal's behavior.

"The fun part is you learn the methodology in a few days. Then you are supposed to do something cool with it, develop data, and discover something new," Boyden says. "And you do that four times over eight weeks, sometimes tackling a system you've never even heard of."

For Boyden, the "gentle pressure" of presenting new data at the end of each two-week cycle, and hearing what the other 19 students had done, was hugely rewarding. "You see which approaches were fruitful, which ones weren't," he says. "You discover how to think about (nervous) systems, how to look at their complexity and think about what is most important in each. In some ways, you are learning how to pick research problems. And each cycle is only two weeks. You can try something out. If it fails, you haven't lost six years of your Ph.D. program."

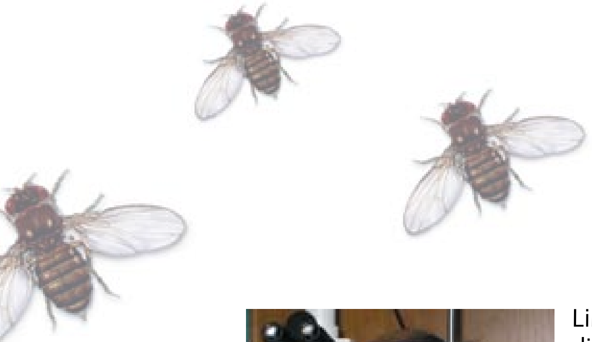
Boyden wants to start up a new course at MIT called "How To Think" that, he says, has roots in his NS&B experience. "I think NS&B allows you to do rapid prototyping of ideas," he says. "The course is perfectly framed to allow people to generate questions and to try and answer them."

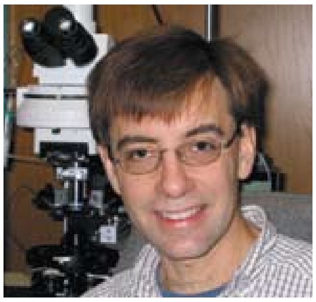
He isn't the first to praise the course's structure. When Janis Weeks of University of Oregon — who taught in NS&B for many years and co-directed it for five — wrote a funding proposal for the course a decade ago, it got a perfect score of 100 from evaluators at the National Institutes of Health. "The NIH asked us if they could use Janis's application as a model of how to structure this type of training grant," says Lenny Dawidowicz, MBL's Director of Education.

According to Weeks, a main component of the special NS&B mixture is the student diversity, which has been a hallmark since the course began in 1978, well ahead of the current trend in interdisciplinary education. "Some of our students have had neuroscience training, but we also get people from physics, engineering, psychology," she says. "The course brings them all along. The faculty is great at bringing out the best in all students."

"We will turn anyone into a fearless experimentalist," says Catherine Carr of University of Maryland, also a former director and faculty member in NS&B.

Also ahead-of-the-curve is the course's focus on how neurons and neural circuits produce behavior. As Boyden says, "NS&B is really about trying to tackle things at a level of description that is higher than a molecule. The point was to figure out how these computational elements generate behavior. That is a very powerful viewpoint that people are only starting to rediscover en masse in neuroscience right now."





*Michael Dickinson*

Like all of the MBL courses, NS&B is continually refreshed by the perspective of new directors. Most recently, co-directors Michael Dickinson of California Institute of Technology and Sarah Bottjer of University of Southern California emphasized the "integrative approach" of studying any animal system — from fruit fly to songbird — at multiple levels, from genes to cells to neural circuits to behavior. They also stressed mathematical and computational approaches to study design, which has been a growing trend in the course and in the field. "One of our mantras was, this is not just a techniques course!" says Dickinson. "We put as strong an emphasis on the intellectual skills as on the technical skills."

"We also increased the lab time and cut back on lecture hours, because the students get so into the lab work," Dickinson says. Farzan Nadim, a Rutgers professor who was a student in the course and then taught in it for many years, says NS&B "is all hands-on, and I cannot imagine a better guide to laboratory neuroscience…From that first day, when I stuck an electrode in a leech neuron and recorded action potentials, I was hooked. I knew that I would never be a pure mathematician and that this would change the path of my life."

Sailing through many sets of directors is the course's high social energy, close student-faculty interactions, and sense of play. Martha Peterson, the MBL's Education Lab Coordinator, recalls hearing Dickinson play the ukulele in the lab, sometimes dueting with Joel Levine, University of Toronto, on jazz recorder.

"In a course like this, the atmosphere could become really competitive," says Janis Weeks. "But the faculty are terrific; they make a real effort to make it fun, to put people at ease. It's still demanding, but there is a lot of crazy, fun stuff that goes on." •

*Janis Weeks*

## The Meeting of Minds

The MBL is a paradise for training in neuroscience. The trend began in 1951, when the first young Grass Fellows arrived for a summer of neuroscience research guided by faculty mentors. Since then, hundreds of postdoctoral fellows have found their legs as independent investigators in the Grass Lab at the MBL, which flourishes to this day through the support of the Grass Foundation. Collectively, the impact of these fellows on the growth of neuroscience worldwide has been extraordinary.

The next big event in MBL neuroscience training was the 1970 advent of the now-famous Neurobiology course, an intensive laboratory course focused on cellular and molecular approaches. Currently, eight neuroscience courses are offered at the MBL during the summer months, creating a stimulating intellectual confluence of the top neuroscientists in the field. Besides Neurobiology and NS&B, other courses address computational neuroscience; the neural development of the zebrafish; and training for underrepresented minority students (the Summer Program in Neuroscience, Ethics, and Survival, or SPINES). The MBL's reputation as "Neuroscience University," as one course alumnus calls it, is enhanced by the presence of more than 100 visiting investigators pushing the frontiers of the field.

In 2007, the MBL received the Distinguished Service Award from the Association of Neuroscience Departments and Programs (ANDP) for its long-standing contributions to neuroscience education. In presenting the award, ANDP President Alison K. Hall said the MBL's neuroscience courses "have transformed legions of students and faculty who have marveled at the labs in Loeb and Lillie, the access to such generous instructors, and the intimate and casual conversations about the functions of the brain that go long into the night and change forever how one thinks about neuroscience." •

MBL Moment

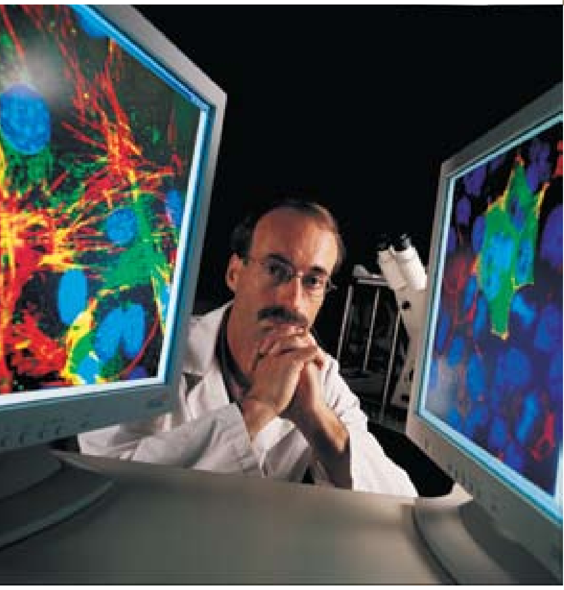
*...with*

**Ron Vale**

*Co-Director, MBL Physiology Course*

# The Joy of Discovery

## Ushering in the New Cell Biology



*Ron Vale first came to the MBL in 1983 as a graduate student, where he was exposed to the revolution in video-enhanced microscopy pioneered by Robert Allen and Shinya Inoué. Within three summers, Vale and his MBL collaborators Tom Reese, Bruce Schnapp, and Mike Sheetz had made the landmark discovery of kinesin, the first member of a motor protein superfamily that supports cell division and the transport of cell cargo. Presently, Vale is a Howard Hughes Medical Institute investigator and chairman of the department of cellular and molecular pharmacology at the University of California, San Francisco. Vale calls the MBL "a magical place where one encounters interesting people and exciting science can happen."*

*Recent evaluations of the MBL Physiology course lead to an inescapable conclusion: This course is red-hot, among students, faculty, and visiting scholars alike. Comments such as, "this is the very best course of its kind, bar none," "this is the future of cell biology," "it brings students and faculty to the very cutting edge of research" are the norm. When Ron Vale of the University of California, San Francisco, and Tim Mitchison of Harvard Medical School became the course's co-directors in 2004, they revamped it to anticipate the future of cell biology, and to prepare students to go out and meet it. In the first week, the students learn techniques in biochemistry, microscopy, and biological computation. They then participate in three research modules, each lasting two weeks, each led by a different faculty member and focused on quantitative approaches to important issues in cell biology. While not its purpose, the Physiology course has been generating exciting scientific ideas and research results, leading to 33 abstracts presented at American Society of Cell Biology meetings and 7 publications since 2004. Below, Ron Vale gives his insights on the course's unquestionable success.*

**MBL** **Do you agree that the Physiology course represents "a working model of the new cell biology," as one biophysicist describes it?**

**RV** I think a big goal of the Physiology course is to explore what "the new cell biology" means and perhaps in a small way to help shape it. We have had many great successes over the years in biology: the genome has been sequenced, much of the ultrastructure of the cell is known. But I think it's fair to say we still don't really understand how cells work, how cells make decisions, how they take in information from their environment and respond appropriately. There are still basic mysteries to be solved, such as how a single fertilized cell develops by its miraculous internal programs into a complete organism. Part of what we all have to come to grips with is developing new technologies and even new ways of thinking that will get at these mysteries. Our philosophy for the Physiology course is, first of all, that we need to train biologists who are much broader thinkers than they have been in the past. They will have to be much more expansive, much more familiar with many disciplines of science, and with ways to integrate information. So we bring traditional biologists into the course, but also people who think in terms of physics (statistical mechanics, soft condensed matter physics), computational biologists, and people who think deeply about imaging. We mix these ingredients together by bringing in the right people, both in the faculty and in the student body. That is the key.

**MBL** **Have you had difficulty attracting students to the course who aren't biologists?**

**RV** At the beginning, Tim and I wondered if we would get even close to filling half the class with physics and computational students, which was our goal. Would they apply? Because if that didn't happen, the whole spirit and initial intention of the course would have failed. But the number and quality of applications from students in these disciplines have been truly remarkable. We are getting the most outstanding students you can imagine. These people are likely to be the future leaders in the interface between these various fields.


**MBL** Rather than spending a lot of time on training exercises, the course plunges the students into several different research situations. Why?

**RV** Our view is, while we do want to teach the students techniques, we more want to teach them how to think about science and experiments. We want to show them the elements of science that you can't get in a textbook or a protocols book. How do you pick problems in science, and once you start working on a problem and start your experiments, how do you interpret results, how do you prioritize what to do the next day in order to maximize your chance of discovery? Those are the untold secrets of science. These are the kind of things that we hope to convey by having students work in this very intense environment at the MBL. In this intellectual beehive, students, faculty, and teaching assistants (TAs) are all thinking about how to make discoveries on an incredibly short time scale. We do a lot of the preparation for the course research in advance — making the reagents, preparing the cell lines — so the students can come in and have fun. We bring them up to the discovery phase of the research. That's not totally realistic, but it's fun for everyone — the faculty and TAs included.

**MBL** A big part of the excitement must be that the inquiry is open-ended.

**RV** Oh, I totally agree. We tell the students that these are not exercises — this is real research. Some of the experiments will succeed and others will fail. Some projects get started in one direction and then take a very different U-turn — which is often student-driven — and the detour can turn out to be more interesting than the original project. The students experience a spectrum of what goes on in real research, only on an amazingly compressed time scale. But you know why it is so good? I think students can smell genuine problems and real research. If you bring them exercises or things that are not that exciting, they will probably respond accordingly. We really try to bring them research questions that are at the leading edge of the new cell biology, if you will. And the students respond enormously well. They want to know the answer, they want to contribute, they want to participate in the joy of science. And they work so hard. It's incredible to watch the students when they arrive in a new research rotation. They may know nothing about the problem or the techniques involved, or even the field. But they are so sharp and so motivated, and they come up to speed in an incredibly short period of time. It's truly remarkable, sometimes even shocking, how far the students are able to take the research in 12 days.

**MBL** The Physiology faculty are among the best in the world in their fields. How do you convince them to come to Woods Hole and teach?

**RV** The faculty love coming back to the course. In some ways, they are like students again themselves. They have time here that is free from all their other commitments. They bring their research problem into the course, and a lot of the students are incredibly bright, even brighter than the faculty (!) and more knowledgeable in some areas. And so the faculty and the TAs are learning, too. And somehow, with everyone working as a team, the faculty often leave after two weeks with new results or new ways of thinking about their problem. For them, it's often the best investment of time that they can make. ●

**"I am sure that, once more, a cadre of future leaders in biology is in the making in the MBL Physiology course. Not just people who know how to run a gel, clone a gene, or adjust a microscope, but people who respect each other's approaches and know how to think straight, think deeply, and look for the tiny clues that lead to great, because quite unexpected, discoveries."**

*— Tim Hunt, Cancer Research UK; 2001 Nobel Prize laureate; former faculty, MBL Physiology and Embryology courses*

## Gifts & Grants

• The **National Science Foundation** awarded $1.32 million in support of the "Microbial Inventory Research Across Diverse Aquatic LTERs," a project that will assess microbial distribution at 13 marine and freshwater Long-Term Ecological Research sites. Linda Amaral Zettler, associate research scientist, is the principal investigator.

• The **MacArthur Foundation** awarded $1.1 million in support of the Biodiversity Heritage Library's massive effort to digitize and make freely available more than two million volumes of literature on the world's species. Catherine Norton, director of the MBLWHOI Library, one of the ten major libraries in the BHL consortium, is the principal investigator.

• The **National Institutes of Health** awarded $918,000 for a project titled "Mechanisms and Consequences of Deleterious Evolution in Bacteria." Associate scientist Jennifer Wernegreen is the principal investigator.

• The **Environmental Protection Agency** awarded $900,000 for a project "Nonlinear and Threshold Responses to Environmental Stresses Inland—River Networks at Regional to Continental Scales." Senior scientist Jerry Melillo is the principal investigator. •

## Accolades

• The **MBL** received the 2007 Distinguished Service Award from the Association for Neuroscience Departments and Programs, which represents 250 neuroscience programs in North America. The award, presented in November 2007 at the Society for Neuroscience Meeting, recognized the importance and significance of MBL's long-standing support of education and neuroscience education, in particular.

• MBL Embryology course alumnus **Mark Roth** (1980) was awarded a 2007 MacArthur Fellowship, known informally as a "genius grant." Roth is a cell biologist at Fred Hutchinson Cancer Research Center.

• MBL Whitman investigator **Lawrence Rome** (University of Pennsylvania) received a 2007 *Scientific American* "SciAm 50" award for his ergonomic backpack invention. The magazine annually publishes a list of outstanding people or teams for their achievements and leadership in shaping established and emerging technologies.

• MBL Distinguished Scientist **Shinya Inoué** published the book *The Collected Works of Shinya Inoué: Microscopes, Living Cells, Dynamic Molecules* (World Scientific Publishing). The book includes a DVD featuring Inoué's movies of active cells.

• **John Hobbie**, MBL distinguished scientist, was named the 2008 winner of the A.C. Redfield Lifetime Achievement Award of the American Society of Limnology & Oceanography (ASLO). The award recognizes Hobbie's contributions to microbial ecology and building institutions. The award will be presented in June 2008 at the ASLO summer meeting in Newfoundland.

• MBL senior research scientist **Paul Colinvaux** published a book on his 40 years of research in the Amazon: *Amazon Exhibitions: My Quest for the Ice-Age Equator* (Yale University Press).

• Congratulations to MBL Corporation member and former director **John Burris**, who will become president of the Burroughs Wellcome Fund effective July 1, 2008. Burris is currently president of Beloit College in Wisconsin.

• MBL Chief Financial Officer **Homer Lane** was appointed Vice President for Member Communications for The Association of Independent Research Institutes at their annual meeting in September 2007. •


Loaned Equipment Program

# No Request is Too Large or Too Small

The MBL course faculty send their "wish lists" for state-of-the-art scientific equipment to Martha Peterson, the MBL Education Lab Coordinator.

Need some chocolate? A confocal microscope? A Band-Aid? Duct tape? The person to see is Martha Peterson, who coodinates the "loaner program" of scientific instruments for the MBL courses. And in the equipment rooms in Loeb Laboratory, she keeps the other necessities of life.

The spectacular array of microscopes, cameras, electrophysiology rigs, and other instruments used in the MBL courses is thanks to the forward-thinking commercial vendors who lend it every summer.

"What they share with us is state-of-the-art," says Peterson. "Often we are the vendors' beta-testing site; they will bring an absolutely new piece of equipment and we shake it down here. That puts the courses on the cutting edge of instrumentation and experimentation."

The vendors benefit, too. "They realize, where else but the MBL can you get the best students and faculty in the world to work on your new equipment for a few weeks?" Peterson says. "They can survey the students and find out what they liked, what worked. And these students are all graduate or postdoctoral level, so many of them will have seed money to start up their own labs in a few years. It's great exposure for the vendors."

The loaned equipment program started in the 1970s with a handful of generous companies. It has since grown to an annual $22 million outpouring from 135 vendors, some of whom keep support personnel at the MBL all summer. Peterson collects "wish lists" for equipment from course faculty over the winter, and then places their requests with vendors, who do their best to oblige. "It all arrives in June," says Peterson. "The lobbies of Loeb are packed with boxes of high-end equipment. It takes a village to set it all up. It's great fun."

And should a more ordinary item be needed in a course, Peterson is happy to provide. "I don't want the faculty running around Loeb looking for a flashlight," she says. "I want them concentrating their expertise on the students and teaching them as much as they can in a short amount of time." •

# The Rewards of Teaching at the MBL

*By John Dowling*

John E. Dowling is the Gund Professor of Neurosciences at Harvard University, and a Trustee and immediate past President of the MBL Corporation. Dr. Dowling is the founding co-director of three MBL courses: Neurobiology, which he started with Michael Bennett in 1970; Fundamental Issues in Vision Research, co-founded with David Papermaster, then at University of Texas Health Science Center, in 1992; and Neural Development and Genetics of Zebrafish, co-founded with Nancy Hopkins of MIT in 1998. A distinguished vision researcher, Dowling has performed groundbreaking work on the functional organization of the retina, and is currently using zebrafish to study retinal development and genetic mutants specific to the visual system. He has been on the faculty of Harvard University since 1961, except for the period 1964-1971, when he was at Johns Hopkins University. Dowling is a member of the American Academy of Arts and Sciences, the National Academy of Sciences, and the American Philosophical Society. He is the author of four books and more than 250 publications. •

*Like many scientists, I first came to the MBL because I was invited to teach. I was an assistant professor at Johns Hopkins School of Medicine in the late 1960s when Francis "Spike" Carlson, chairman of Biophysics at Hopkins and then chairman of the MBL's Instruction Committee, invited me to Woods Hole to help establish a Neurobiology course. I met Mike Bennett of Albert Einstein School of Medicine my first summer at the MBL; we hit it off and began planning the course.*

*Neurobiology was still in its infancy at that time and there were few formal neurobiology courses taught. A training program in neurobiological techniques had been started at the MBL by Steve Kuffler and his Harvard colleagues in the late 1950s, but this program ended in 1966. Mike and I began the Neurobiology course in 1970. Joining us as faculty that first summer were Victor Whittaker of Cambridge University and Felix Strumwasser of California Institute of Technology. We were assigned limited space in the Whitman Laboratory, which meant we could only offer admission to eight students. The Grass Foundation generously provided start-up funds and equipment, but we had no money for scholarships. Nevertheless, all eight of the accepted students found support and came.*

*The focus of the new Neurobiology course was molecular and cellular neurobiology, which remains its focus today. We decided to teach the course in modules, with each of us overseeing a two-week session. For my module, students recorded electrical activity from the eye of the horseshoe crab. They first dissected and recorded from optic nerve fibers (much like Keffer Hartline did in the early 1930s at the MBL, which led to his 1967 Nobel Prize), and then they learned techniques for intracellular recording. Along the way, students were encouraged to try new experiments, with novel conditions, stimuli, or drugs. Lectures started the day, but the bulk of our time was spent in the laboratory, and we often finished at the Captain Kidd late in the evening. I was exhausted after the two weeks, but the students plunged right into the next module!*

*Besides the Neurobiology course, I have had the pleasure of being the co-founding director of two MBL special topics courses: Fundamental Issues in Vision Research; and Neural Development and Genetics of Zebrafish. Why does one start a new course at the MBL? Essentially, to introduce the best and the brightest young scientists from around the world to new and exciting research areas and challenges. In the Vision course, for example, we introduce young visual scientists to the major problems in the field, and how molecular biological and genetic approaches can potentially crack open some of the puzzles facing both the basic scientist and clinician. The Zebrafish course, on the other hand, provides practical instruction on what is possible to explore with this exciting new model system — from its earliest developmental stages to behavioral genetics and everything in between!*

*I have been involved in teaching and research at the MBL virtually every summer since 1970. The enthusiasm and eagerness of each new class is as inspiring and renewing as it was 38 years ago. Clearly, the Education Program at the MBL is more than alive and well, and it continues to be a gem in the MBL crown.* •

Treasures from the MBL's Archives

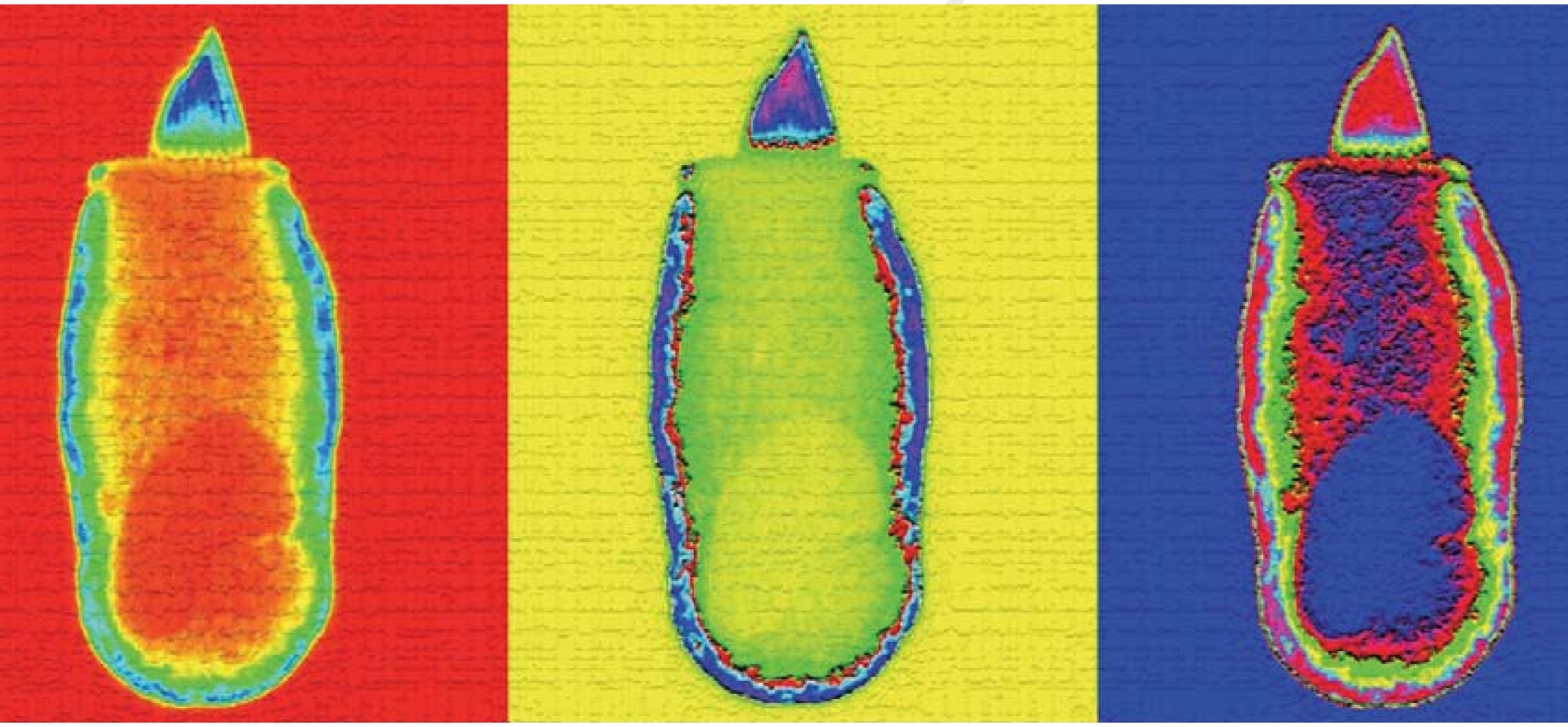
## On the Verge of Greatness

The 1979 MBL Embryology class, including course co-director Joan Ruderman of Harvard Medical School (standing, second from left); faculty member Tim Hunt of Cambridge University (seated, fourth from left); teaching assistant Eric Rosenthal of Harvard Medical School (sitting behind Hunt); and student Andrew Murray of Harvard University (back row, fourth from right). For more names, please go to www.mbl.edu/catalyst.

Although this may look like the cast from the musical "Hair," it is students and faculty in the 1979 MBL Embryology course, who might sense that a deep insight into how life works is developing in their midst. That summer, ideas began to align for the discovery of cyclins, key proteins that drive the cell-division cycle that creates, from a single fertilized egg cell, a fully developed organism. During course experiments, Joan Ruderman and Eric Rosenthal noticed that, after surf clam eggs were fertilized, striking changes occurred in the synthesis of unknown proteins in the eggs. Along with Tim Hunt, they began to study the proteins. But it wasn't until 1982 in the MBL Physiology course, when Hunt observed a distinct rise and fall in protein synthesis in fertilized sea urchin eggs, that he realized he must be looking at a fundamental regulator of cell division. Hunt was right, and he would share the Nobel Prize in 2001 for discovering the oscillation of cyclins. Ruderman, meanwhile, had cloned the cyclin genes and discovered how they work at the molecular level. Andrew Murray was in this stellar class of 1979, and he later wrote, "Like many important discoveries, cyclin reflected the intersection of fortune, a prepared mind, and the courage to build a hypothesis from one crucial observation." •

## In the Next *Catalyst*

**Seeing What No One Has Seen** You will find microscopes in virtually every MBL course and research group, alongside world-recognized leaders in microscopy and imaging. At the MBL, innovations in microscopy go hand-in-hand with deeper insight into the living world, from the dynamics of the cell to the structure of microbial communities. In the next *MBL Catalyst*, explore revolutionary advances in microscopy at the MBL, past and present, and the vistas they open to the scientist's eye.



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