



# Marine Biological Laboratory



THE UNIVERSITY OF  
**CHICAGO**

2017-2018 ANNUAL REPORT

## Contents

- 2 Highlights
- 6 Financials
- 9 Gifts
- 21 Leadership
- 22 Advisory Bodies
- 23 MBL Scientists

The MBL Annual Report is published by the Marine Biological Laboratory. Although the greatest possible care has been taken in the preparation of this record, the MBL recognizes the possibility of inaccuracies. If any are noted, please accept our apology and advise us of any corrections to be made.

Office of Communications  
Marine Biological Laboratory  
7 MBL Street  
Woods Hole, MA 02543  
[comm@mbl.edu](mailto:comm@mbl.edu)  
[www.mbl.edu](http://www.mbl.edu)



## OVER 100 YEARS OF SCIENTIFIC DISCOVERY

Since its founding in 1888, the MBL has drawn the world's greatest minds in science to Cape Cod to carry out some of their most creative and far-reaching work. Fifty-eight scientists affiliated with the MBL have been recognized with Nobel Prizes.

The laboratory, affiliated with the University of Chicago, is dedicated to scientific discovery—exploring fundamental biology, understanding biodiversity and the environment, and informing the human condition through research and education.

# Highlights

Highlights

Financials

Gifts

Leadership

Advisory Bodies

MBL Scientists



## University of Chicago Launches Undergraduate Courses at MBL

The University of Chicago introduced intensive, undergraduate September Courses on the MBL's Woods Hole campus in 2017. Thirty-five students participated in the pilot courses, which ran for three weeks before UChicago's fall quarter began. Taught by faculty from both the University and MBL, the courses took advantage of the MBL's world-class educational facilities and complemented areas of MBL scientific excellence, including microbiome studies, marine biodiversity and genomics, neuroscience, and building customized scientific instruments. Combining lectures with labs, fieldwork, and opportunities for student research projects, the MBL September Courses are open to all majors at UChicago and count toward an undergraduate biology requirement. After the success of the pilot, the courses were offered again in 2018.



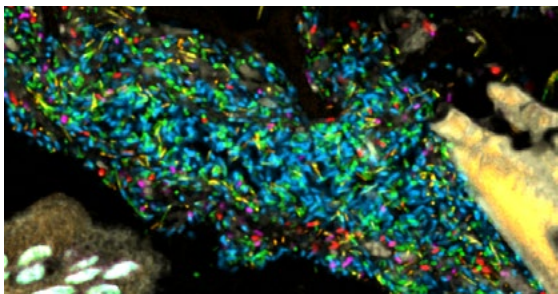
## Team Discovers a Significant Role for Nitrate in the Arctic Landscape

Very low levels of nitrate, an essential plant nutrient, are found in arctic tundra soil, so scientists had assumed that plants in this biome do not use nitrate. But a study co-authored by four MBL Ecosystems Center scientists challenged that notion. The team found that plants in northern Alaska's tussock tundra take up nitrate at comparable rates to vegetation in nitrate-rich ecosystems. The findings are important in the context of climate change, which is expected to increase nitrogen—and potentially nitrate — levels in tundra soil. As the climate warms, the microbial processes that generate nitrate could speed up. Woody shrub species, such as birch and willow, could become more dominant and shade out other arctic plants. The team's discovery is important to factor into future projections of arctic tundra species composition. Proc. Natl. Acad. Sci. DOI: 10.1073/pnas.1715382115



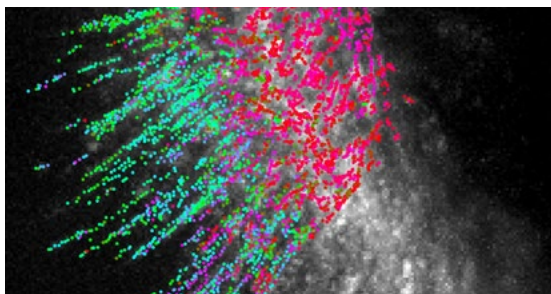
## Nipam Patel Named Director of the Marine Biological Laboratory

In April, 2018, Nipam Patel, a leading scholar in modern evolutionary and developmental biology, was named MBL Director and a faculty member at the University of Chicago. Patel came to the MBL from the University of California, Berkeley, where he was professor and co-chair of the Department of Molecular and Cell Biology and professor in the Department of Integrative Biology. Patel has taught in the MBL Embryology course since 2001 and co-directed the course from 2007 to 2011. His scientific expertise encompasses the development of novel, genetic model organisms for biological study, and the application of advanced imaging technologies to probe the fundamental dynamics of living systems. Prior to his appointment at UC Berkeley in 2003, Patel was on the faculty at the University of Chicago, a Howard Hughes Medical Institute Investigator, and a staff associate at the Carnegie Institution.



### Mixed Organization of Gut Bacteria is Revealed by MBL Imaging Technology

Disruptions in the human gut microbiome are correlated with several diseases, including obesity and cancer. Yet little was known about the spatial organization of the nearly 1,000 bacterial species in the human gut, information that can reveal how the species interact with each another and with their host. A collaborative team including MBL Associate Scientist Jessica Mark Welch established a simplified, model human gut microbiome in germ-free mice and revealed its structure through microbiome imaging technologies developed at the MBL. They discovered a highly mixed community of bacterial species in the gut, unlike in the human mouth, where prior studies revealed distinctly organized assemblages of bacterial types. The mixing of microbiota inside the gut may create an evolutionarily stable community. *Proc. Natl. Acad. Sci.*: DOI: 10.1073/pnas.1711596114



### Internal Forces Directing Cell Migration are Revealed by Live-Cell Microscopy

How do cells move in a certain direction in the body—go to a wound site and repair it, for example, or hunt down infectious bacteria and kill it? Two MBL studies showed how cells respond to internal forces when they orient, gain traction, and migrate in a specific direction. Led by Whitman Center Scientists Clare Waterman and Timothy Springer, the studies focused on the activation of integrins, proteins that allow cells to attach to their external environment and respond to signaling. The teams discovered that when integrins unfurl from the cell surface and bind extracellularly, they simultaneously align in the same direction as a force inside the cell (actin retrograde flow). The research, which began as a project in the MBL Physiology course, was achieved with an imaging system developed by MBL scientists Tomomi Tani and Shalin Mehta. DOIs: 10.1073/pnas.1701136114 and 10.1038/s41467-017-01848-y



### Inspired by Octopus Skin, Engineers Develop a 3D Camouflaging Material

In a classic example of bioinspired engineering, MBL Senior Scientist Roger Hanlon collaborated with engineers at Cornell University to develop a synthetic “camouflaging skin” modeled on the real thing in octopus and cuttlefish. These cephalopods can instantaneously change their skin color and pattern for camouflage; they can also morph the skin into a textured, 3D surface, giving them a ragged outline that mimics seaweed or other objects. The team’s stretchable, pneumatically activated material takes a cue from the 3D bumps (papillae) that cephalopods can express on the skin in one-fifth of a second for camouflage, then quickly retract to speed away. Potential applications include a morphing material that regulates temperature by absorbing light in its 3D bumps and reflecting light in its 2D spaces. DOI: 10.1126/science.aan5627



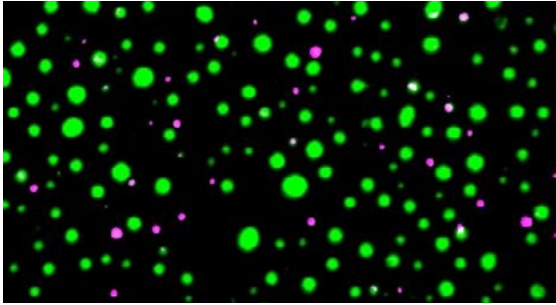
### Genes that Aid Spinal Cord Healing in Lamprey Also Present in Humans, MBL Team Finds

Many of the genes involved in naturally regenerating a severely injured spinal cord in the lamprey are also active in repairing the peripheral nervous system in mammals, reported a team co-led by Jennifer Morgan, director of the MBL's Eugene Bell Center for Regenerative Biology and Tissue Engineering. This discovery is consistent with the possibility that in the long term, the same or similar genes may be harnessed to improve spinal cord injury treatment in humans. Lampreys are jawless, eel-like fish that shared a common ancestor with humans about 550 million years ago. After spinal cord injury, they progress from paralysis to full swimming behaviors within 10 to 12 weeks. Morgan collaborated with several MBL Whitman Center investigators on the study. DOI: 10.1038/s41598-017-18757-1



### Carbon Feedback from Forest Soils will Accelerate Global Warming, Study Projects

The surprising results of a 26-year experiment to discover how warming temperatures affect forest soil were reported by Jerry Melillo, Distinguished Scientist at the MBL. Soil warming stimulates periods of abundant carbon release from soil to atmosphere, alternating with spans of no detectable loss in soil carbon stores, the study found. This appears due to cycles in the capacity of soil microbes to degrade organic matter and release carbon. Overall, the results indicate that in a warming world, a self-reinforcing and perhaps uncontrollable carbon feedback will occur between forest soils and the climate system, accelerating global warming caused by burning fossil fuels. DOI:10.1126/science.aan2874



### **You're In or You're Out! Team Reveals How Cells Can Compose Liquid Droplets**

In 2008, MBL Physiology course participants proposed that simple phase separations – like oil separating from water – may be one important way to create order among the millions of molecules inside a cell. This landmark observation, reported in Science in 2009, has since been validated in numerous other studies. However, how molecules selectively enter one liquid droplet inside a cell, and not another, had not been explained. In a study that Science Magazine named one of the 2018 Breakthroughs of the Year, Amy Gladfelter and colleagues showed that RNA molecules assume specific 3D shapes, which helps them recognize one another and condense into the same liquid droplet. Gladfelter is a Whitman Center scientist from University of North Carolina, Chapel Hill. Science, DOI: 10.1126/science.aar7432



### **MBL Launches Cephalopod Program**

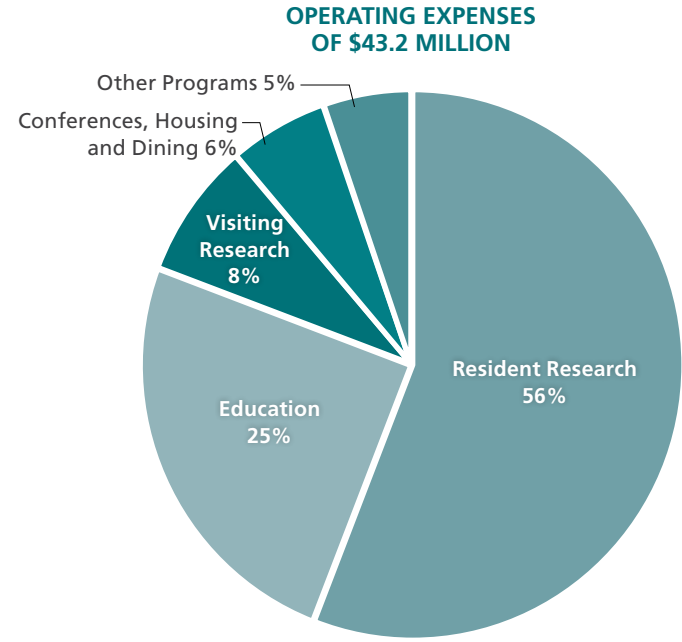
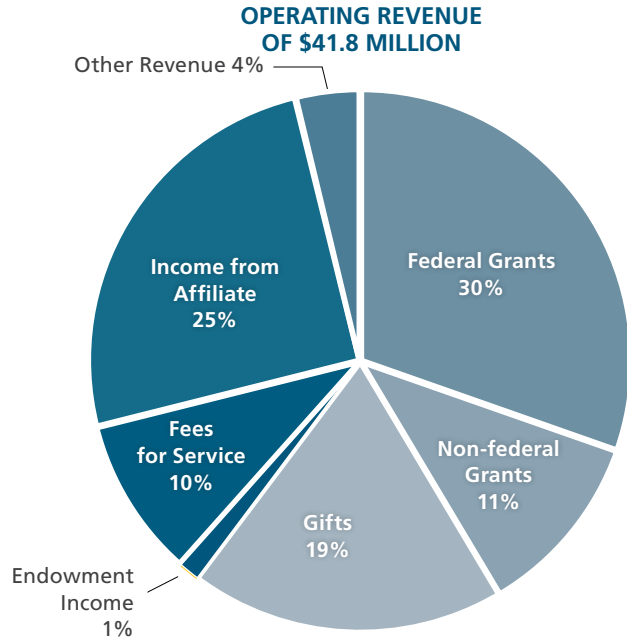
Building on the MBL's long history of basic research into cephalopod biology leading to significant discoveries in neuroscience, behavioral science, and other fields, the MBL launched the Cephalopod Program within the Eugene Bell Center for Regenerative Biology and Tissue Engineering. This program is pioneering new systems to culture cephalopods over multiple generations so they can be supplied to researchers at any time of year. It is also actively developing the first cephalopod research organisms that are fully genetically tractable, enabling scientists to study gene function relative to the species' anatomy and physiology, behavior, and evolution. With their extreme traits and features, including the most advanced behavioral repertoire among the invertebrates, cephalopods open unique avenues for scientific investigation and application in fields ranging from neuroscience and physiology to materials science, robotics, and artificial intelligence.



# Financials

## Fiscal Year

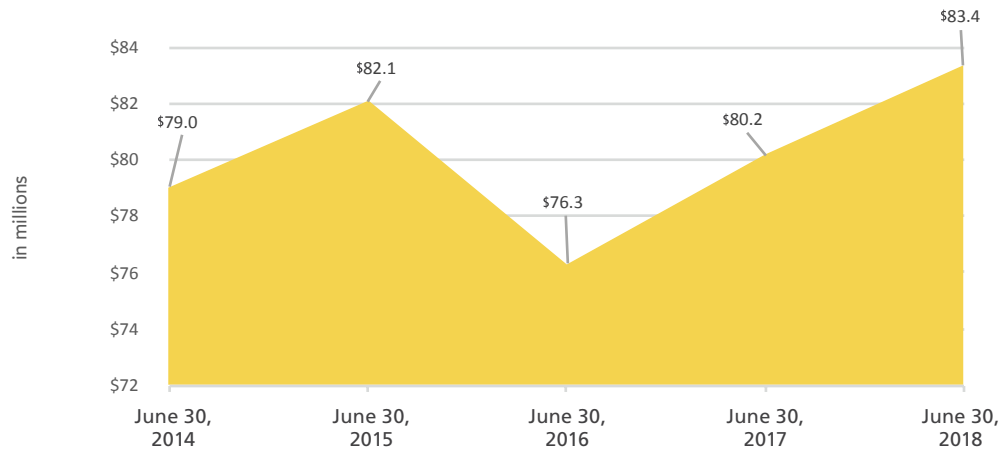
### June 30, 2018



The financial statements of the Marine Biological Laboratory for the fiscal year ending June 30, 2018 were audited by KPMG. Complete financial statements are available upon request from:

Financial Services  
 Marine Biological Laboratory  
 7 MBL Street  
 Woods Hole, MA 02543

### ENDOWMENT VALUE







# Report of the Development Committee

[Highlights](#)[Financials](#)[Gifts](#)[Leadership](#)[Advisory Bodies](#)[MBL Scientists](#)

I am pleased to report on the Marine Biological Laboratory's development progress for the 2018 Fiscal Year: July 1, 2017 through June 30, 2018.

In FY18 we raised \$12,279,819 in new private support for MBL's research and educational programs from over 900 individuals, foundations, and companies. This impressive figure is a testament to the MBL's history of scientific excellence, our powerful impact on biological research, and the vision of an equally impactful and sustainable future.

Funds raised in FY18 include \$812,963 in Annual Giving — unrestricted funds that are immediately available to meet operational needs. Much of MBL's Annual Giving program is made up of smaller gifts from the entire MBL community, gifts of \$50, \$20, and even \$10, that can add up to a large sum.

Several major gifts were also made in support of MBL programs and initiatives, including: an anonymous bequest of \$4.6 million in support of MBL research and education, a \$1.25 million grant from the Alfred P. Sloan Foundation supporting the *Deep Carbon Observatory Project*, a \$993,229 grant from the Simons Foundation for Bay Paul Center Distinguished Senior Scientist Mitchell Sogin's *Life Sciences-Simons Collaboration on Computational Biogeochemical Modeling of Marine Ecosystems*, \$565,571 from the Foundation for Agricultural Integrity for Ecosystem Center Associate Scientist Jianwu (Jim) Tang *Carbon Flux Project*, and \$500,000 from the Pannell Family Charitable Fund for the *Director's Discretionary Fund*.

The MBL development office continued to expand its outreach program of lectures, information sessions, and other events held in Woods Hole, Cape Cod, Nantucket, and Martha's Vineyard. I encourage all to show their support for MBL research and education. Every gift, whether it's \$20 or \$20,000, makes an impact! I'm grateful to Board members, MBL Council, Society members, scientists, alumni, faculty, friends, and to every one of our extraordinary donors.

On behalf of the Development Committee, the Board of Trustees, and the staff of the MBL – thank you all for your generosity!

A handwritten signature in black ink, appearing to read 'JP', written in a cursive style.

Gratefully,  
Jeffrey Pierce, Chair

*The Marine Biological Laboratory gratefully acknowledges the generous contributions and pledges of the individuals, foundations, and companies who supported our programs and operations.*

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*We gratefully acknowledge donors to the following funds that enable the Marine Biological Laboratory to stay competitive by attracting and supporting top researchers and students.*

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 Gay Holstein, Icahn School of Medicine at Mount Sinai  
 Michael Hoppa, Dartmouth College  
 David Horn  
 Corinne Houart, King's College London  
 Jonathon Howard, Yale University  
 Ronald Hoy, Cornell University

Kerwyn Huang, Stanford University  
 Julie Huber, Woods Hole Oceanographic Institution  
 Albert Hudspeth, Rockefeller University  
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 Karla Kaun, Brown University  
 Raymond Keller, University of Virginia  
 Darcy Kelley, Columbia University  
 Matthew Kelley, National Institutes of Health  
 Margaret Kenna, Boston Children's Hospital  
 Louie Kerr, Marine Biological Laboratory  
 Peter Kima, University of Florida  
 Sarah Kimmins, McGill University  
 Katie Kindt, National Institutes of Health  
 Jean King, University of Massachusetts Medical School  
 Nicole King, University of California, Berkeley; Howard Hughes Medical Institute  
 Peter Kner, University of Georgia  
 Rob Knight, University of California, San Diego  
 L. Lacey Knowles, University of Michigan  
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 Kenneth Korach, National Institute of Environmental Health Sciences  
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 Rosamund Langston, University of Dundee  
 Frederick Lanni, Carnegie Mellon University  
 Amanda Lauer, Johns Hopkins University  
 Luke Lavis, Howard Hughes Medical Institute - Janelia Research Campus  
 Gabriel Lazaro-Munoz, Baylor College of Medicine  
 Jared Leadbetter, California Institute of Technology  
 Heun Lee, California Institute of Technology  
 Ruth Lehmann, New York University School of Medicine; Howard Hughes Medical Institute  
 Mate Lengyel, University of Cambridge  
 Maria Leptin, European Molecular Biology Organization  
 Mark Lessard, Yale University  
 Paul Lewis, University of Connecticut  
 Jeff Lichtman, Harvard University  
 Emily Liman, University of Southern California  
 Xiaorong Lin, Texas A&M University  
 Jennifer Lippincott-Schwartz, Howard Hughes Medical Institute - Janelia Research Institute  
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 Margaret Livingstone, Harvard Medical School  
 Mary Logan, Oregon Health and Science University  
 Png Loke, New York University School of Medicine  
 Alejandro Lomniczi, Oregon National Primate Research Center  
 William Longabaugh  
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 Chris Lowe, Stanford University

Ellen Lumpkin, Columbia University  
Lawrence Lustig, Columbia University Medical Center  
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Howard Hughes Medical Institute  
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Paul Maddox, University of North Carolina, Chapel Hill  
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Mary Margot Maleckar, Allen Institute for Cell Science  
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Veronica Martinez-Acosta, University of the Incarnate Word  
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James McNally  
Emily Jane McTavish  
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Bartlett Mel, University of Southern California

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Suzanne Moenter, University of Michigan  
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Dianne Newman, California Institute of Technology  
Brian Norris, California State University, San Marcos  
Alison North, The Rockefeller University  
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Mihai Pop  
Kenneth Poss, Duke University Medical Center  
Olivier Pourquie, Brigham and Women's Hospital  
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Magdalena Preciado Lopez, National Heart Lung, and Blood Institute  
Chrysanthe Preza, The University of Memphis  
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JoAnne Richards  
Guy Richardson, University of Sussex  
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Ingmar Riedel-Kruse, Stanford University

Paolo Rinaudo  
Amariliz Rivera  
Mark Roberson, Cornell University  
Jacquelyn Roberts, Federation of American Societies for Experimental Biology  
Matthew Rogers, London School of Hygiene and Tropical Medicine  
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Charles Shuster, New Mexico State University  
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### Photos

Cover: Aerial view of Woods Hole and MBL campus (Matt Barton)

Inside front cover: Eel Pond and MBL (Emily Zollo)

P2: L to R: University of Chicago undergraduates collecting samples at Wood Neck Beach (Megan Costello); *Polygonum bistorta* (Allen Chartier); Nipam Patel

P3: L to R: Bacteria in a model human gut microbiome (Jessica Mark Welch); Color-coded actin filament orientation overlaid on the intensity image (Shalin Mehta); Giant Australian cuttlefish, *Sepia apama* (Roger Hanlon)

P4: L to R: Great Sippewissett Marsh (Megan Costello); Ona Bloom, left, and Jennifer Morgan with juvenile sea lamprey (Amanda R. Martinez); Soil warming study at Harvard Forest (Audrey Barker-Plotkin)

P5: Distinct protein droplets form with different RNA (E.M. Langdon et al, *Science* 2018); Flamboyant cuttlefish, *Metasepia pfefferi* (Tom Kleindinst); Great Sippewissett Marsh (Megan Costello)

P7: University of Chicago students sampling at Wood Neck Beach (Megan Costello)

P8: Jeffrey Pierce (Dan Cutrona)

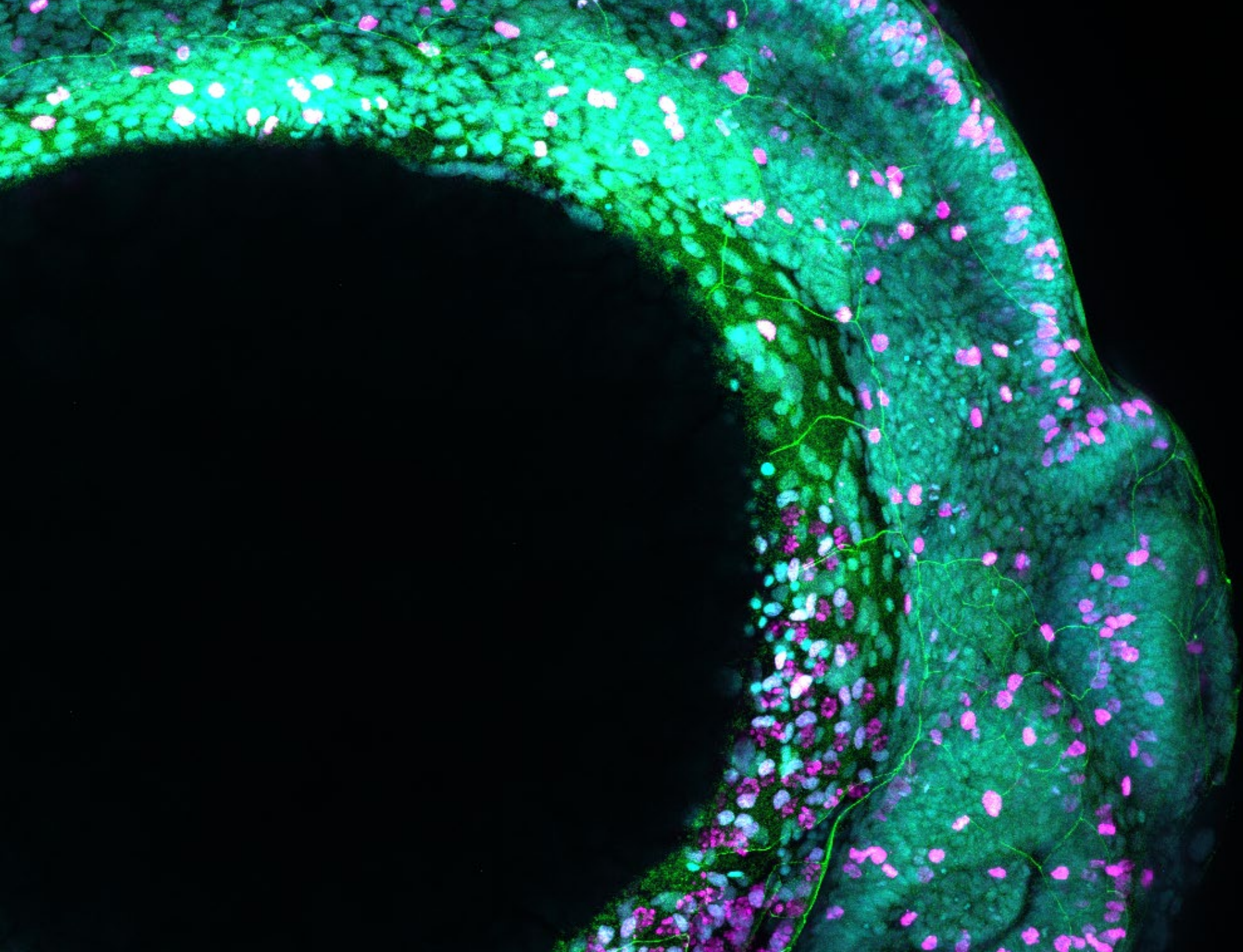
P19: Drawings of marine organisms and notes on their anatomy by UChicago student Jennifer Teng (Megan Costello)

P20: Eel Pond and MBL (Megan Costello)

P29: Aerial view of Woods Hole and MBL campus (Matt Barton)

Inside back cover: Whole crustacean (*Artemia*) larvae (Arnon Jurberg)





MARINE BIOLOGICAL  
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7 MBL Street  
Woods Hole, MA 02543  
[www.mbl.edu](http://www.mbl.edu)

1888

The image is a monochromatic blue-toned graphic. At the center is a circular seal. Inside the seal is a shield-shaped emblem. The top of the shield features a stylized evergreen tree. Below the tree is a dark rectangular box containing the year '1888' in white, bold, sans-serif font. The shield is flanked by two figures, possibly representing scientists or workers, whose forms are partially obscured by the shield's edges. The background of the seal is filled with intricate, detailed illustrations of various marine organisms, including shells, coral, and other sea creatures, arranged in a circular pattern around the central shield.