

The image is a composite of two microscopic views of biological structures. The left side features a dark blue background with a textured, wavy pattern. The right side shows a more detailed view of similar structures, characterized by vibrant, iridescent colors ranging from deep blue and purple to bright yellow and green, creating a shimmering, layered appearance.

Marine Biological Laboratory



THE UNIVERSITY OF
CHICAGO

2018-2019 ANNUAL REPORT

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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.

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From the Director



The MBL has had a remarkable influence on my career. The summer of 2019 was my eighteenth year in Woods Hole, and it has become a place that I cherish. As I transition from a seasonal faculty member and begin my tenure as Director, I am excited to build upon the MBL's extraordinary history and elevate it to even greater prominence.

Informed by strategic planning launched by prior leadership, the MBL is embarking on a path to achieve sustained success and new growth and expansion over the next five years. The strategic plan focuses on four key programming and organizational objectives including expanding the resident and the visiting scientist research programs, creating new educational offerings, including opportunities for undergraduates and high school students, and increasing the use of our conference facilities. While each initiative on its own will benefit the MBL, the full potential will only be realized if all of them are adequately aligned and resourced properly through philanthropy and grant support.

To achieve our goals in these key areas we must continue to make advancements in two major strategic research areas—imaging and new research organisms. We've made great progress on both of these fronts thanks to funders like the Chan Zuckerberg Initiative and their support of our Imaging Initiative, the Promega Corporation and their commitment to education, and the Millicent and Eugene Bell Foundation, who, with the Massachusetts Cultural Council, is enabling a broader array of public programming at the MBL through the renovation of the Lillie Auditorium.

I am tremendously grateful to all of our funders and to our faculty, staff, and trustees for their contributions and support. It's an exciting and promising time for the MBL and I look forward leading the laboratory as we begin a new chapter of biological discovery.

Sincerely,

A handwritten signature in black ink, appearing to read "Nipam H. Patel".

Nipam H. Patel
Director, Marine Biological Laboratory

Highlights

Director's Message

Highlights

Financials

Gifts

Leadership

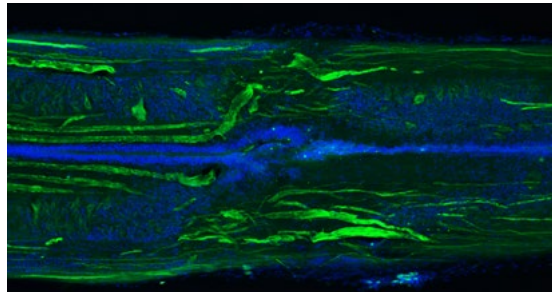
Advisory Bodies

MBL Scientists



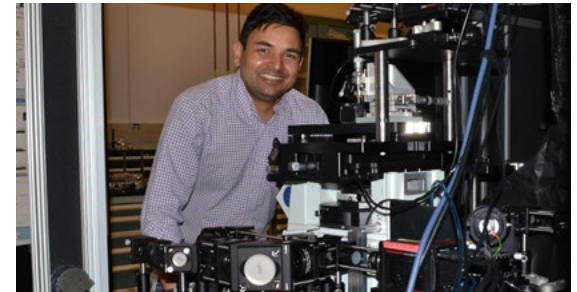
Pygmy Zebra Octopus is Bred through Multiple Generations for First Time

Marking a world first, the MBL Cephalopod Program succeeded in culturing the pygmy zebra octopus (*Octopus chierchiae*) through multiple generations in the Marine Resources Center. Breeding selected species of octopus, squid, and cuttlefish is a challenging yet essential part of the Cephalopod Program's mission to develop genetically tractable laboratory research organisms from this class of marine invertebrates. Cephalopods, which have been studied at the MBL for more than a century, provide fundamental insights in broad areas of research including neuroscience, evolutionary and developmental biology, sensory biology, and RNA editing, with potential applications in medicine, materials science, robotics and bio-inspired design.



The Lamprey Regenerates its Spinal Cord Not Just Once — but Twice

Spontaneous recovery from spinal cord injury is almost unheard of in humans and other mammals, but many vertebrates fare better. The eel-like lamprey, for instance, can fully regenerate its spinal cord after it's been severed and resume swimming and other functions within 12 weeks. In a new study, MBL scientist Jennifer Morgan and colleagues discovered that lampreys can regenerate just as impressively after a second complete spinal cord injury at the same location. The study opens up a new path for identifying pro-regenerative molecules and potential therapeutic targets for human spinal cord injury. Morgan is director of the MBL's Eugene Bell Center for Regenerative Biology and Tissue Engineering. PLOS ONE, DOI: 10.1371/journal.pone.0104193



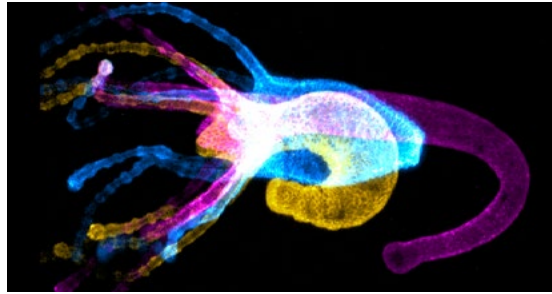
MBL Receives Chan Zuckerberg Award to Fund Imaging Scientist

Microscopy innovator Abhishek Kumar received an award from the Chan Zuckerberg Initiative to join the MBL's scientific staff as a key collaborator in the MBL Imaging Initiative, an emerging, interdisciplinary center dedicated to research, discovery, and training in biological imaging and analysis. Hundreds of scientists, students, and industry experts convene at the MBL each year for research at the interface of biology, microscopy instrument development, and computational image analysis. The Imaging Initiative supports and synergizes this community toward several goals: developing new microscopes to address a diversity of biological problems; improving image analysis speed and capabilities; and providing user-friendly imaging technologies and solutions so a wide range of students and scientists can adopt them for their research.



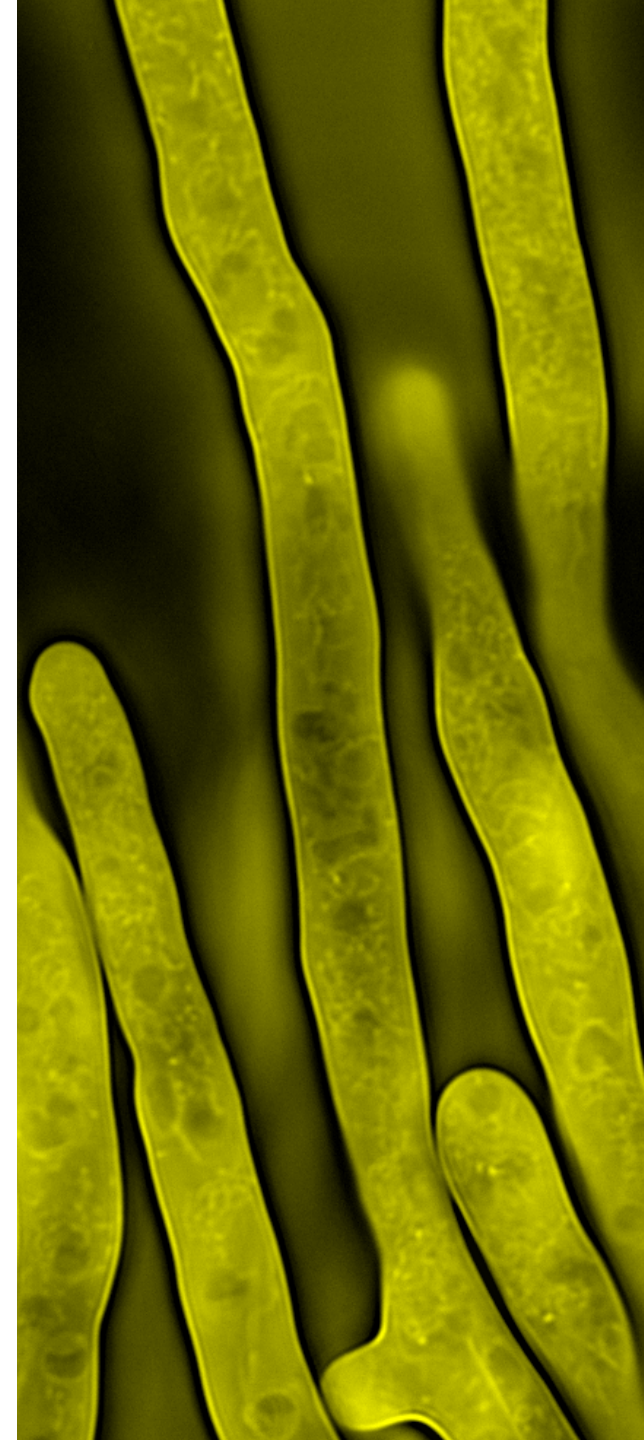
Scientists Identify Gene Partnerships that Promote Spinal Cord Regeneration

MBL researchers are one step closer to solving the mystery of why humans create scar tissue after spinal cord injury, leading to lifelong damage, while some animals can fully regenerate the spinal cord and recover function. MBL scientist Karen Echeverri and colleagues identified gene “partners” in the axolotl salamander that, when activated, allow the neural tube and associated nerve fibers to functionally regenerate after severe spinal cord damage. Interestingly, these genes are also present in humans, although they are activated in a different manner. “It doesn’t appear so far that axolotls have regeneration-specific genes,” said Echeverri. “It’s all about how these genes partner with other genes directly after injury, and how that partnership drives the organism either toward regeneration or forming scar tissue.” *Nature CommBiology*, DOI: 10.1038/s42003-019-0335-4



Muscle Activity Map in Hydra Illuminates How Nervous System Creates Behavior

For the first time known, a team led by MBL Whitman Scientist Rafael Yuste mapped the full-body muscular activity of an animal while it was moving and behaving. The study, which built on the team’s prior success in mapping full-body neural activity in Hydra, pinpointed seven distinct patterns of muscle activity in Hydra and discovered that individual muscle cells can participate in multiple patterns with different kinetics. Their observations add to mounting evidence that the coordinated activity of many cells working together — in this case, across an entire organism — generates new functional and behavioral properties that are not present in single cells. It also brings the group closer to “breaking the neural code” and understanding the relationship between a stimulus and its neural response. Yuste, from Columbia University, has led the MBL Hydra Lab each summer since 2017. *Current Biology*, DOI: 10.1016/j.cub.2019.05.012





Leaving Microbes out of Climate Change Dialogue has Major Consequences

More than 30 microbiologists from nine countries published a warning to humanity that omitting microbes – the support system of the biosphere – from the climate change equation will have major negative consequences. Their Consensus Statement “looks to place microbes at the center of the world stage in terms of importance to climate change biology,” the scientists wrote. “We must learn not just how microbes impact climate change (e.g. production and consumption of greenhouse gases), but also how microbes will be impacted by climate change and other human activities.” The statement’s authors included MBL Director of Research David Mark Welch. MBL scientists are world leaders in microbial ecology, having co-directed the International Census of Marine Microbes, played instrumental roles in the NIH’s Human Microbiome Project, and currently co-direct the Census of Deep Life, which is exploring microbes beneath the ocean floor. *Nature Reviews Microbiol.*, DOI: 10.1038/s41579-019-0222-5



Linda Hyman Tapped to Lead MBL Education Division

Linda E. Hyman, associate provost at Boston University School of Medicine, was named the new Burroughs Wellcome Director of Education at the MBL. Hyman brings more than 25 years of experience to the position, which oversees direction of all the MBL’s academic programs, including the world-renown Advanced Research Training courses. She will lead the expansion of MBL offerings at all levels, from secondary students to undergraduates, graduates and post-graduates, capitalizing on the facilities and resources of the MBL and leveraging the MBL’s relationship with the University of Chicago. At Boston University Medical School, Hyman led the Division of Graduate Medical Sciences (GMS), which oversees all graduate students and postdoctoral trainees. An accomplished and active scientist with expertise in molecular genetics, Hyman was also a Professor of Microbiology at GMS.



Prince Albert II of Monaco Visits MBL

HSH Prince Albert II of Monaco spent a day visiting the MBL, where he demonstrated his strong commitment to marine science, exploration and protection. His Serene Highness sailed on the MBL's collection vessel, the Gemma; viewed marine species in the Marine Resources Center; attended a panel discussion on adapting to climate change; viewed original volumes from the MBLWHOI Library documenting the scientific discoveries of Prince Albert I, a pioneering oceanographer; and received a comprehensive overview of the MBL's marine and environmental research. He also announced a commitment from the Prince Albert II of Monaco Foundation to funding SeaBase at MBL, an open-access infrastructure for integrated data on marine organisms and their habitats for the purpose of understanding and protecting marine biodiversity and ecosystems.



In New MBL Course, High-School Students Envision a Future in Science

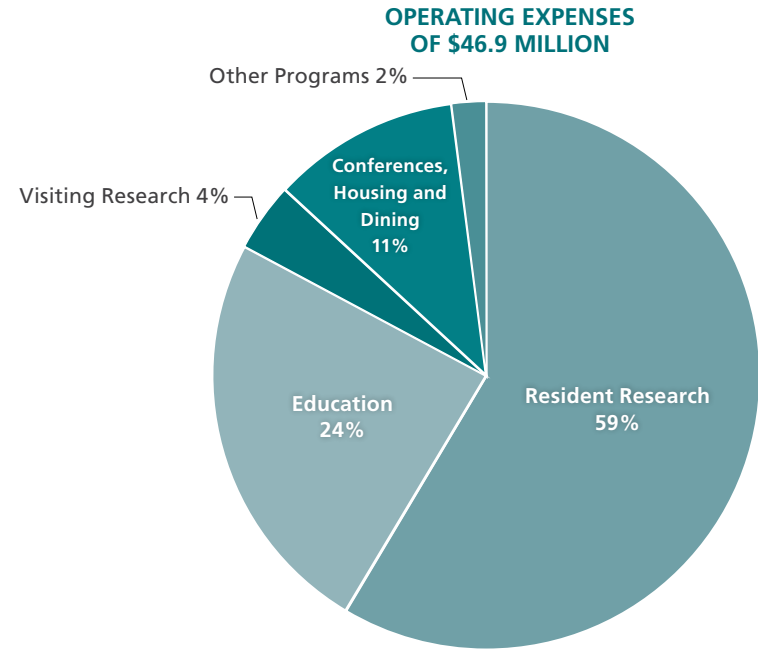
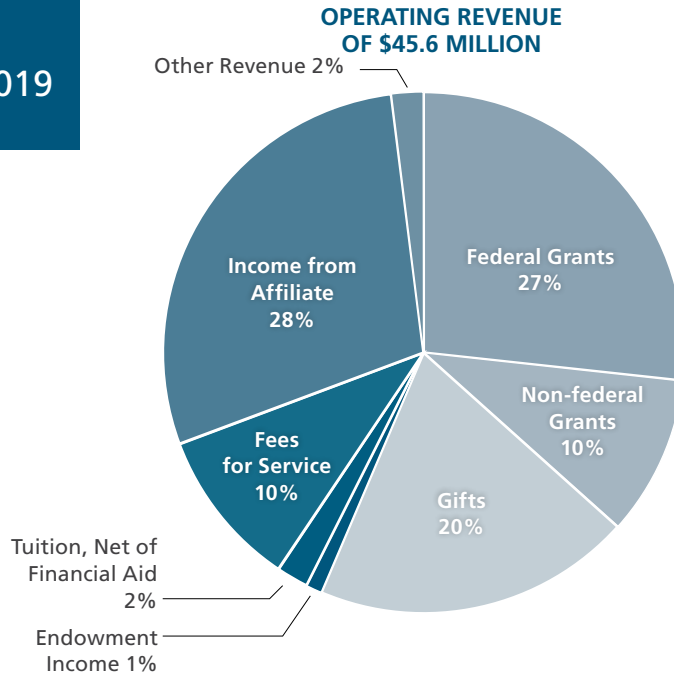
In partnership with the University of Chicago, the MBL launched the High-School Science Discovery Program, week-long courses that train students to undertake biological and ecological research using cutting-edge techniques usually reserved for college or graduate students. Developed in consultation with high-school teachers to meet curriculum requirements, the program introduces students to important trends and approaches in scientific research. The students collected marine specimens in Woods Hole and sequenced their genetic information; learned CRISPR-Cas9 gene editing techniques; imaged specimens on confocal microscopes and constructed 3D imaging datasets; and collected water samples from local salt marshes to evaluate their nitrogen levels. In addition to hands-on research training, the program is designed to give students, at a critical time in their decision-making, the opportunity to discover the many possible pathways to a career in science.



Financials

Fiscal Year

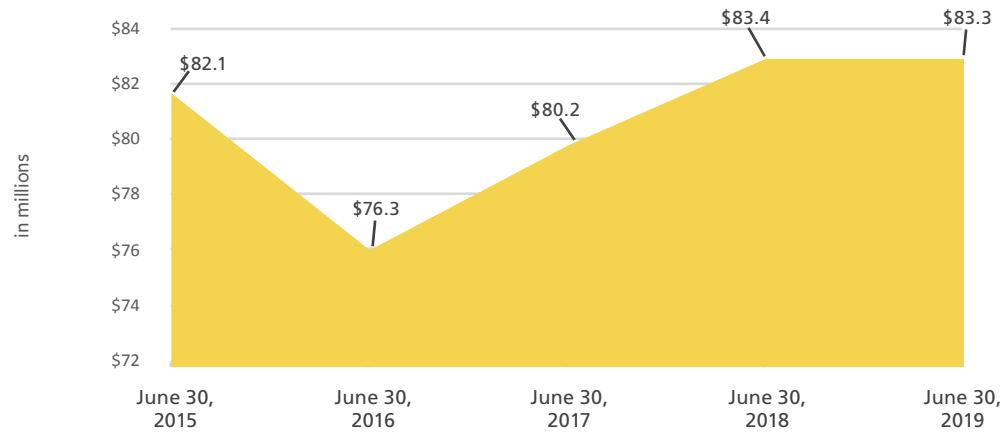
June 30, 2019



The financial statements of the Marine Biological Laboratory for the fiscal year ending June 30, 2019 were audited by KPMG. Complete financial statements are available upon request from:

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 rate = $0.1 \mu\text{m/s}$
 $(0.1 \mu\text{m})^2 / 5 \mu\text{s} = 2 \mu\text{m}^2/\text{s}$

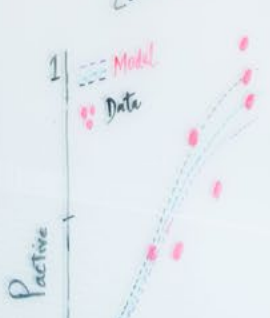
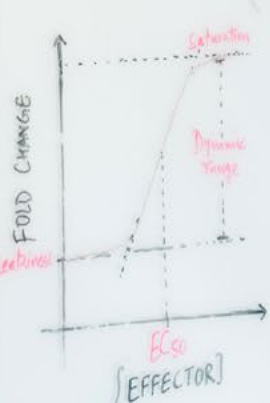
Buckling
 $+ E_{\text{rod}} - \mu g(L/x)$
 $2 \cdot l_p \cdot k_B T / L^2 \approx 0.5 \text{ N}$
 bundles
 10 filaments
 20 filaments
 30 filaments
 max = 2 μm

$E = h\nu$
 CLOSED ACTIVATED
 = 1 Protein
 How much laser power?

Hill-Wyman-Chance Model

$$P_{\text{active}} = e^{-E_a/kT} \left(1 + \frac{I}{K_a} \right)$$

$$P_{\text{active}} = \frac{e^{-E_a/kT} \left(1 + \frac{I}{K_a} \right)}{e^{-E_a/kT} \left(1 + \frac{I}{K_a} \right) + \left(1 + \frac{I}{K_c} \right)}$$
 Probability of protein being in Active state



Don't erase!!
 Helical gliding
 Cytoskeleton Motility is Most
 Lina
 Helical gliding diagrams
 motility models
 actin
 microtubule
 myosin
 Subpellicular MTs
 Inner Membrane Comp
 Plasma membrane
 Membrane Endocytosis
 rotational force F_{motor}



EQUAL EMPLOYMENT OPPORTUNITY

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Photos

Cover: Blue buckeye butterfly wing scales (Rachel Thayer)

Inside front cover: MBL campus from above (Matt Barton)

P1: Director Nipam Patel

P2: L to R: Adult pygmy zebra octopus (Taylor Sakmar); Regenerated Spinal Cord (Jennifer Morgan); Abhishek Kumar (Anthony Mautino)

P3: L to R: Axolotyl tanks (Dee Sullivan); Hydra (John Szymanski); Filamentous fungus *Ashbya gossypii* (Michael Shribak)

P4: L to R: Elevation in Great Sippewissett Marsh (Kelsey Chenoweth); Toolik Field Station; Burroughs Wellcome Director of Education Linda Hyman

P5: Prince Albert II of Monaco (*Falmouth Enterprise*); Students Rose Coviello, Clay Glovier, Yuka Masamura with MBL Senior Scientist Marko Horb (Dee Sullivan); Elevation in Great Sippewissett Marsh (Kelsey Chenoweth)

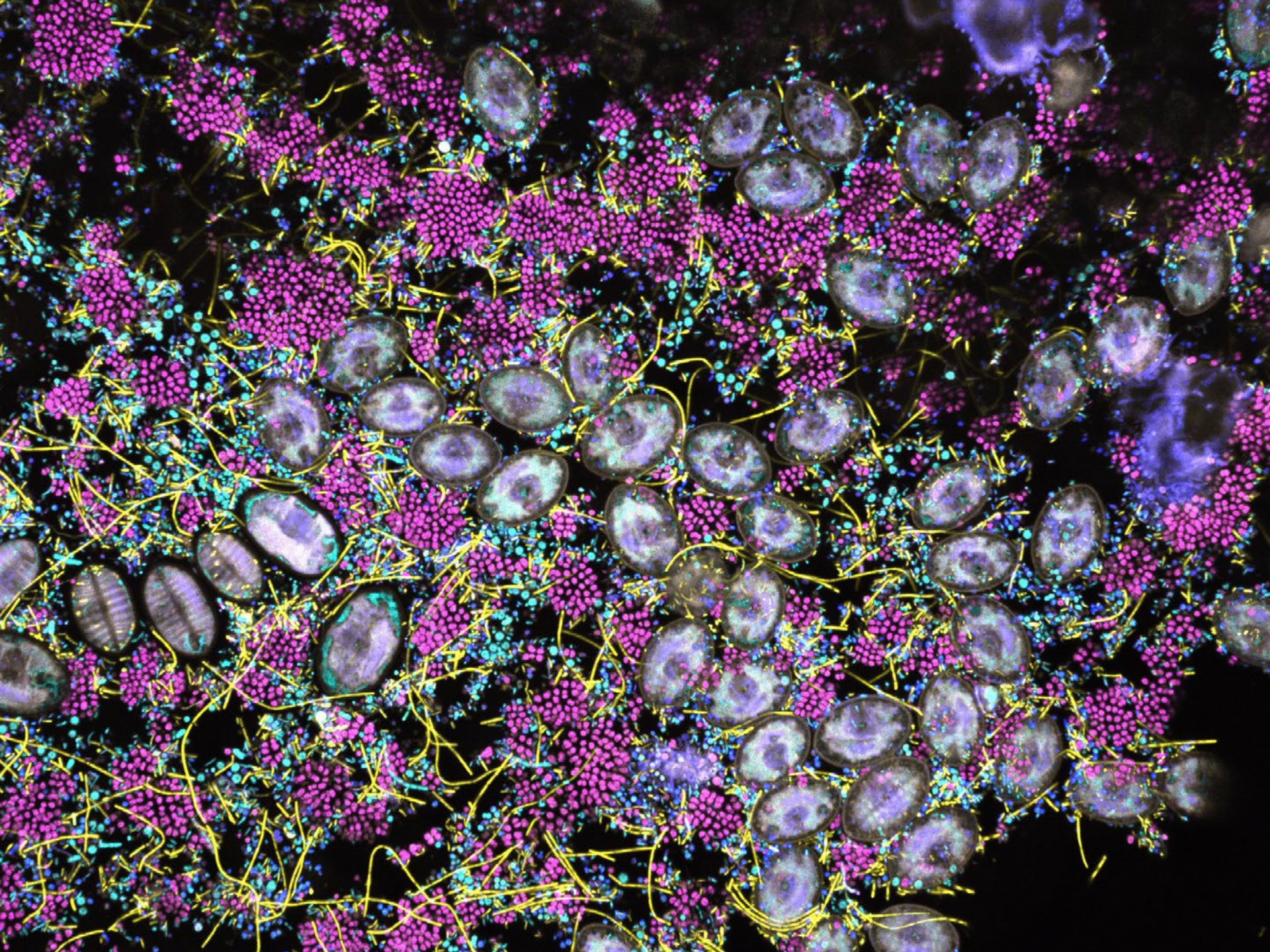
P7: Students from Glenbard East High School, Illinois and Hockaday School, Texas (Dee Sullivan)

P19: Physiology Course students in Lillie Auditorium (Megan Costello)

P20: Aerial view of Woods Hole and MBL campus (Matt Barton)

P27: Physiology Courses students (Megan Costello)

Inside back cover: Microbes on the surface of kelp (Jessica Mark Welch)



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1888

The image is a monochromatic blue-toned graphic. At the center is a shield-shaped emblem. Inside the shield, a stylized evergreen tree stands on a small base. Below the tree, the year '1888' is written in a bold, serif font. The shield is flanked by two figures, possibly representing scientists or workers, whose forms are partially obscured by the shield's edges. Surrounding the central shield is a large, circular border filled with intricate, detailed illustrations of various marine organisms, including shells, coral, and other sea creatures. The entire composition is set against a solid blue background.