HARVARD
MUSEUM OF COMPARATIVE ZOOLOGY

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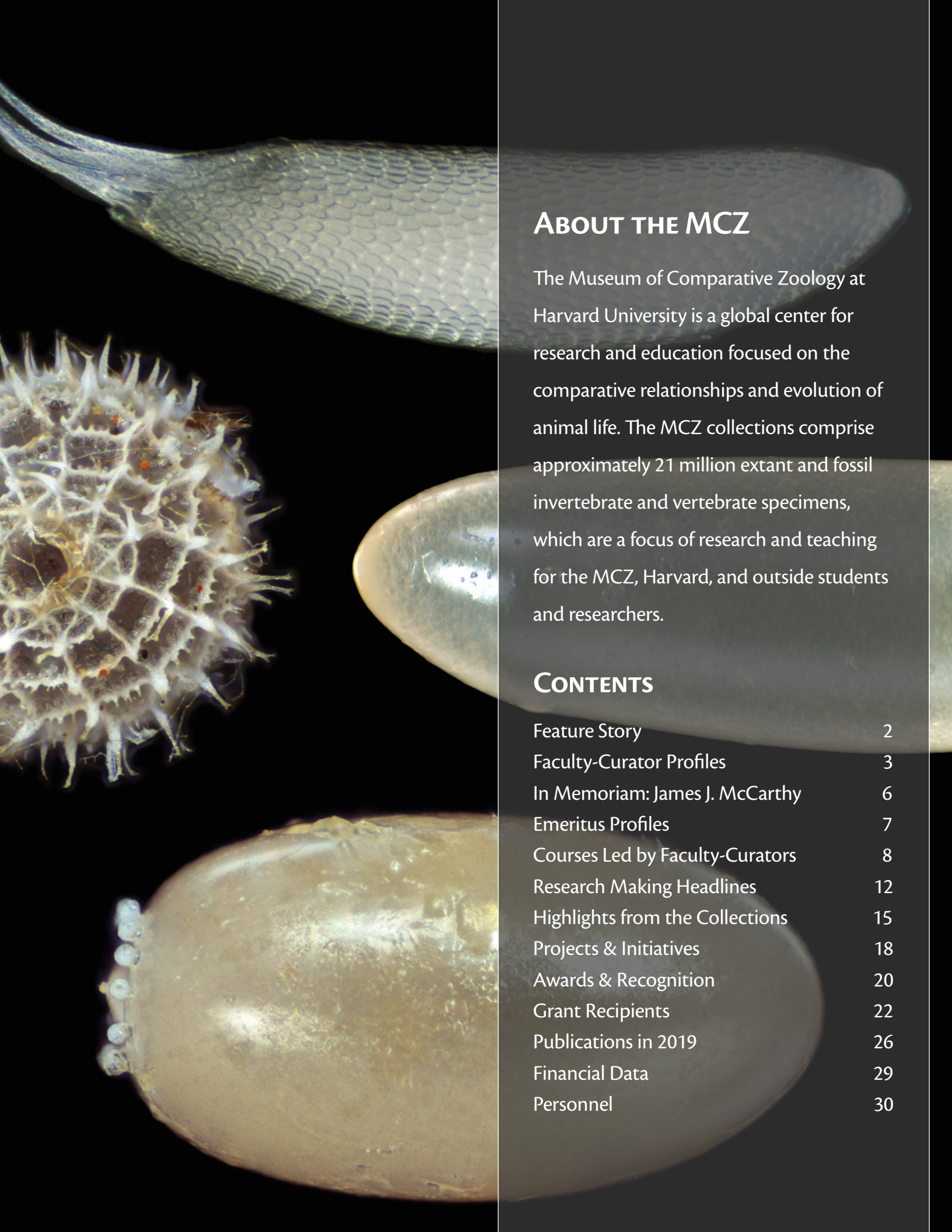
Museum of Comparative Zoology

Harvard University

Annual Report

2019 • 2020



About the MCZ

The Museum of Comparative Zoology at Harvard University is a global center for research and education focused on the comparative relationships and evolution of animal life. The MCZ collections comprise approximately 21 million extant and fossil invertebrate and vertebrate specimens, which are a focus of research and teaching for the MCZ, Harvard, and outside students and researchers.

Contents

Director's Message

Put on your mask, wash your hands, stay six feet apart, and what on Earth is Zoom?

As spring semester began last January, none of us had any idea of how dramatically—and, for some, tragically—our world was about to change. Just two months later, as we were administering midterm exams, finalizing plans for spring break course field trips, awarding summer travel grants, and dozens of us were planning field and conference trips, Harvard responded to the COVID-19 pandemic by closing the Cambridge campus and cancelling all domestic and international travel. With only a few days to prepare, curatorial staff were instructed to work from home and all courses—lectures, labs and final exams—were moved online. I am intensely proud of the many ways the MCZ community responded to these challenges—developing innovative software to adapt to online teaching, transitioning undergraduate summer projects to remote research opportunities, and seizing the opportunity to complete collection management tasks compatible with home offices. Whether it was embarking on that cross-country bike ride they'd always dreamed of, developing skills as a birder and nature photographer, or creating learning opportunities for students living thousands of miles from campus, MCZ's faculty-curators found ways to fill the void left when research field trips weren't possible. The Harvard Museums of Science & Culture also successfully migrated its public programs online and, in so doing, expanded its global reach and "visitations" well beyond what it had experienced previously.

Responding to the pandemic has been MCZ's preoccupation for most of 2020, and while we have been able to manage it successfully, our success has come at great cost. Yet, we had already experienced sadness and loss last fall following the passing of two key members of the MCZ community, Prof. James J. McCarthy and Mr. Robert G. Goelet. Jim McCarthy was an internationally recognized biological oceanographer and the MCZ's eighth director but, as described elsewhere in this report, he was perhaps best known for his accomplishments in the area of public policy and for bringing the world's attention to the drastic consequences of climate change. Bobby Goelet was a longtime member of the Museum's governing board, the MCZ Faculty. To say that Bobby led a very full life doesn't come close to capturing all that he did and experienced. After graduating from Harvard in 1945 with an AB in history, Bobby successfully managed his family's investment firm. At the same time, he was a passionate believer in the value of natural history collections and collections-based research, and in that capacity he held many distinguished appointments, including Chair of the Board of Trustees of the American Museum of Natural History. At MCZ, Bobby contributed a series of gifts that enriched our programs, from faculty-curator salaries to the purchase of specimen cabinets to grants for student projects.

More so than in any of my previous 19 years as director, MCZ's accomplishments over the past year are the result of the tremendous energy, commitment, hard work and resilience of our dedicated students, staff and faculty-curators. To them I say, thanks for a job well done. I hope you enjoy reading about them on the following pages.

Jennifer Berglund

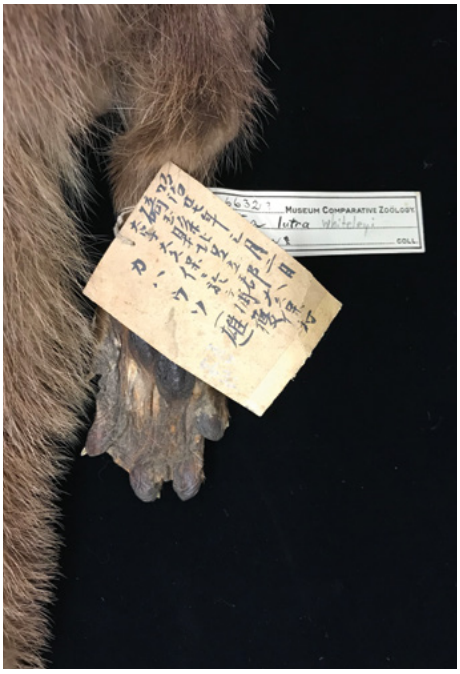
James Hanken
Director

About the cover: Osprey, *Pandion haliaetus*, landing in nest in Cape Cod. Photo by Gonzalo Giribet.

Opposite page: Insect eggs come in all shapes, sizes and ornamentation. Clockwise from top: Hawaiian fly, *Drosophila mimica*; two-spotted cricket, *Gryllus bimaculatus*; milkweed bug, *Oncopeltus fasciatus*; and imperial hairstreak butterfly, *Jalmenus evagoras*. Images by Samuel Church and Seth Donoughe.

Significant Progress and Unexpected Benefits

During early 2020, the world faced a pandemic that was rapidly evolving. When the decision was made to close Harvard's campus in mid-March, the MCZ had only a week's notice before the shutdown.



Mark Omura

Thanks to focused database efforts and a Japanese visiting researcher's translation assistance, this record for *Lutra lutra whiteleyi* in MCZbase is enriched with valuable information.

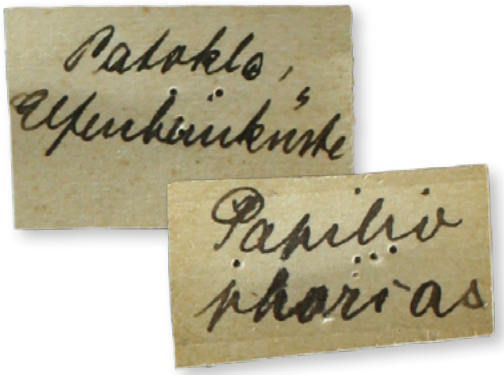
According to **Linda Ford**, director of collection operations, "The mood was urgent due to the seriousness of the situation, and all staff dedicated their limited time on campus to getting what they needed so they could effectively transition to working from home."

Many curatorial associates quickly gathered files and scanned materials that would be useful for remote projects for their staff. The way forward was clear: focus on ongoing data entry and cleanup efforts for MCZbase, the museum-wide collections database containing more than 2.2 million records for over 21 million specimens in 9 research collections. These records include species information, images, geographical data and 3D models.

Data enhancement and standardization have been tasks for collections staff for many years, but the shutdown provided the unexpected benefit of time to concentrate on the effort. "Typically, curatorial staff only spend a portion of their days attending to the database," says **James Hanken**, director of the MCZ, "but because of the campus closure, they have been able to dedicate an unprecedented amount of time to it."

Significant progress has been made during the extended period of remote work. Staff across the various collections undertook numerous projects to improve data quality, with a special emphasis on georeferencing, which assigns GPS coordinates to locality information described in words in the database, information especially critical for research that seeks to analyze species distribution over time and space.

While much of this work has been voluminous but routine, some collections efforts required more creative solutions. The majority of specimen data in the Entomology collection, for example, is recorded on slips of paper pinned beneath the insects. These tiny bits of information—many more than a century old, handwritten in myriad languages—often provide the only data for an insect specimen. During remote work, Entomology staff transcribed thousands of photographed specimen labels for Lepidoptera (butterflies and moths). But when labels had challenging handwriting,



were written in non-Latin alphabets or had translations of long-outdated names, curatorial staff enlisted the help of the global Twitter community, posting the labels for interpretation by entomologists and transcription enthusiasts, often with success.

"On one hand, remote work has been difficult because we can't physically access the specimens we use for research and teaching," Hanken says. "On the other hand, because so many of our past activities have emphasized digital data and digital representations of these specimens, we've been able to successfully make this transition."

At right, challenging labels for *Papilio phorcas*, above, were deciphered via an appeal on Twitter.

Faculty-Curator Profiles

Andrew A. Biewener

Charles P. Lyman Professor of Biology
Director, Concord Field Station

Prof. Biewener studies the biomechanics and neuromuscular control of animal movement on land and in the air. His goal is to understand general principles that govern the biomechanical and physiological design of vertebrate animals related to movement in natural environments, work with engineers to develop bio-inspired robotic designs and develop improved neuromuscular models for treating human movement disorders.

Scott V. Edwards

Professor of Organismic and Evolutionary Biology
Alexander Agassiz Professor of Zoology
Curator of Ornithology

Prof. Edwards' research focuses on the evolutionary biology of birds and related species, combining field, museum and genomics approaches to understand the basis of avian diversity, evolution and behavior.

Current projects use genomics technologies to study the evolution of flightlessness and other traits in birds; phylogeography and speciation in Neotropical and Australasian birds; and the genomics of host–parasite coevolution between house finches and a recently acquired bacterial pathogen, *Mycoplasma*.

Kris Snibbe/Harvard University

Stephanie Mitchell

Brian D. Farrell

Monique & Philip Lehner Professor for the Study of Latin America
Professor of Organismic & Evolutionary Biology
Curator of Entomology
Director, David Rockefeller Center for Latin American Studies
Faculty Dean, Leverett House

Prof. Farrell's research is broadly concerned with the evolution of ecological interactions between host plants and animals and their parasites, such as insects and other tiny consumers.

His current projects include applying next-generation sequencing to speciation and phylogenetic studies of associated species, documenting biodiversity in the Dominican Republic, and repatriating digital information from scientific specimens of insects and fossils in museums to their countries of origin.

FACULTY-CURATOR PROFILES

© Casey Dunn

Gonzalo Giribet

Alexander Agassiz Professor of Zoology
Professor of Organismic & Evolutionary Biology
Curator of Invertebrate Zoology
Harvard College Professor

Prof. Giribet's primary research focuses on the evolution, systematics and biogeography of invertebrate animals, including the use of morphology and next-generation sequencing techniques.

Current projects in the Giribet lab include a comprehensive study of the harvestmen of New Zealand, their systematics and biogeography; mollusk phylogenomic projects; and exploring techniques to use degraded DNA from old museum specimens in phylogenomics and population genomics. The lab also works on other projects on systematics and biogeography of arthropods and onychophorans, among other groups.

Kris Snibbe/Harvard University

Hopi E. Hoekstra

Professor of Organismic & Evolutionary Biology
Professor of Molecular & Cellular Biology
Alexander Agassiz Professor of Zoology
Curator of Mammalogy
Howard Hughes Medical Institute Investigator

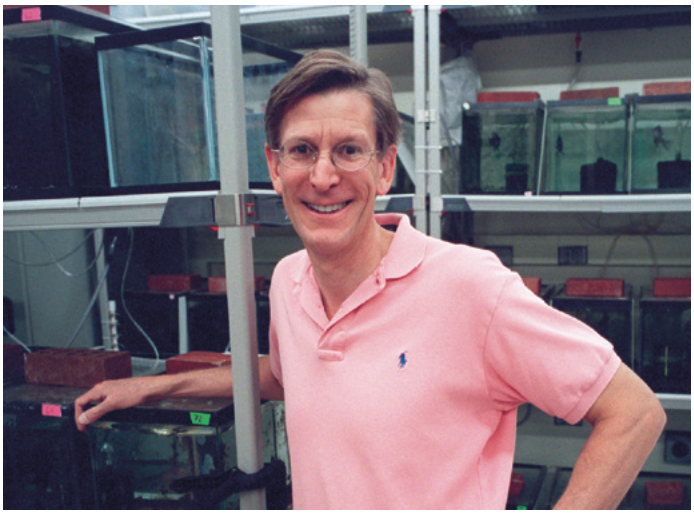
Prof. Hoekstra combines field and laboratory work to understand the evolution of mammalian diversity. Her research focuses on the genetic basis of morphological and behavioral variation, primarily in rodents, identifying both the evolutionary processes and the molecular mechanisms responsible for traits that help organisms survive and reproduce in the wild. Research in the Hoekstra lab integrates ecological, behavioral, genetic, developmental and neurobiological approaches.

Catherine Weisel

James Hanken

Professor of Biology
Alexander Agassiz Professor of Zoology
Curator of Herpetology
Acting Curator of Malacology
MCZ Director

Prof. Hanken utilizes laboratory-based analyses and field surveys to examine morphological evolution, developmental biology and systematics. Current areas of research include the evolution of craniofacial patterning, the developmental basis of morphological novelty and life-history evolution, biodiversity informatics, and systematics and evolution of neotropical frogs and salamanders.



Stephanie Mitchell

George V. Lauder

Henry Bryant Bigelow Professor of Ichthyology
Curator of Ichthyology
Harvard College Professor

Prof. Lauder's research focuses on the biomechanics of fishes and the development of robotic models for studying aquatic locomotion.

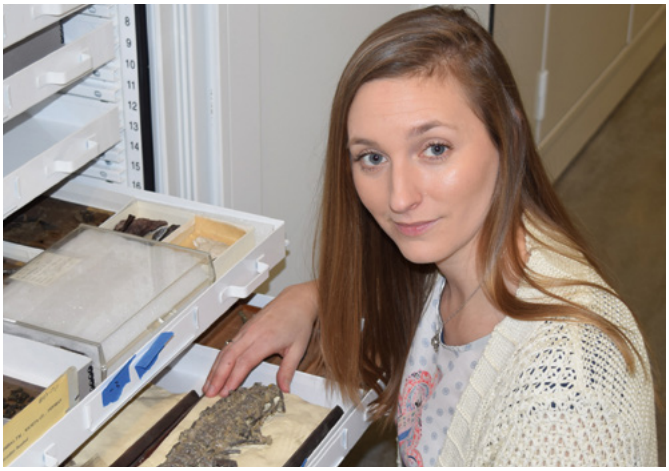
His current studies focus on the structure and function of shark skin and other fish surface structures and research with various robotic fish models, including a tuna robot. Additional broad interests include biological fluid mechanics and theoretical approaches to the analysis of form and function in organisms.

Javier Ortega-Hernández

Assistant Professor of Organismic & Evolutionary Biology

Curator of Invertebrate Paleontology

Prof. Ortega-Hernández's research focuses on the evolution of metazoans that first appeared and rapidly diversified during the Paleozoic Era (ca. 541 to 251 million years ago). His group specializes in the study of exceptionally preserved Cambrian and Ordovician fossil biotas around the world, with a strong interest in the morphology, phylogeny and development of panarthropods and their relatives. The lab combines traditional paleontology with cutting-edge techniques to investigate exceptional fossils, test macroevolutionary hypotheses through deep time, and better understand the origin of the major animal groups that have shaped the biosphere for more than 500 million years.



Paul Whatmough

Stephanie E. Pierce

Thomas D. Cabot Associate Professor of Organismic & Evolutionary Biology

Curator of Vertebrate Paleontology

Prof. Pierce's research is focused on major morphological and ecological transitions in vertebrate evolution through an examination of the fossil record. Her work tends toward 3D modeling and experimentation of the musculoskeletal system, with particular attention to the link between form and function. Current projects focus on two key events in the fossil record, the fish-to-tetrapod and "reptile"-to-mammal transitions.

Isabella Kirkland

Naomi E. Pierce

Sidney A. & John H. Hessel Professor of Biology

Curator of Lepidoptera

Prof. Pierce's research focuses on the behavioral ecology of species interactions, particularly the coevolution between plants, pathogens and herbivores, and symbioses between ants and other organisms.

Her laboratory integrates approaches from phylogenetics, ecology, behavior, genomics and comparative methods to investigate patterns of reciprocal adaptation and diversification exhibited by organisms that live in close association with each other.

Mansi Srivastava

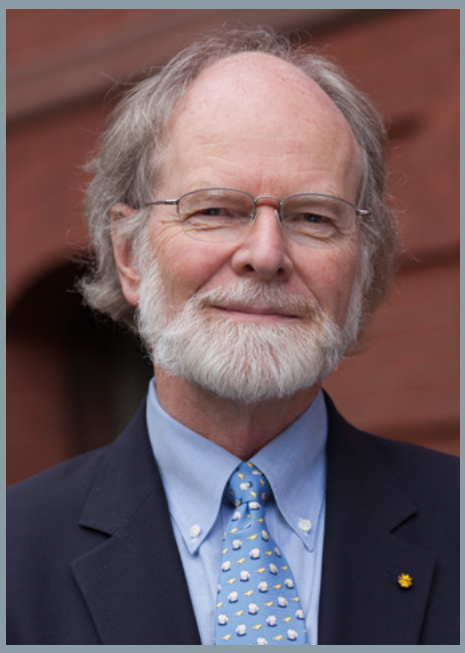
John L. Loeb Associate Professor of the Natural Sciences

Curator of Invertebrate Zoology

Tim Bradbury

Prof. Srivastava's research focuses on understanding the evolution of animal development and regeneration. Her group utilizes the three-banded panther worm, *Hofstenia miamia*, which she has developed as a new acoel model system. Acoels represent the sister-group to all animals with bilateral symmetry, which allows the study of genetic mechanisms that span 550 million years of animal evolution. Current projects in the lab range from identifying gene regulatory networks for regeneration to determining the embryonic origins of pluripotent stem cells to understanding the origins of bilaterian nervous systems.

James J. McCarthy



C. Cambon

A mid-winter's day grew even colder on December 11, 2019, when Prof. James J. McCarthy died following a years-long battle with pulmonary fibrosis. So ended a remarkable career of scholarship and service to the Museum of Comparative Zoology, where Jim had been the Alexander Agassiz Professor of Biological Oceanography since 1980 and the Museum's director from 1982 to 2002. Yet, his professional accomplishments had profound impacts well beyond MCZ, Harvard and even the United States.

Among many distinctions, Jim led a working group of the third Intergovernmental Panel on Climate Change, whose report identified the global scale of climate impacts already evident in ecological systems, as well as the vulnerability of people in both developed and developing countries who are without sufficient adaptive measures to deal with the impacts of impending extreme events and sea level rise linked to climate change. As a result of this report and related efforts, the IPCC shared the 2007 Nobel Peace Prize with Al Gore.

Jim was a master at working behind the scenes to effect substantive change in the status quo. Indeed, he may be the one person over the last 40 years most responsible for the current configuration of environmental biology at Harvard, in all its many manifestations. He was, for example, the main driving force, together with a small number of faculty colleagues, responsible for the founding of the Harvard Museum of Natural History in the late 1990s. Today, the HMNH manages the public programs of the MCZ, the Harvard University Herbaria, the Botanical Museum, and the Mineralogical and Geological Museum.

As MCZ director, Jim championed MCZ's public outreach, including educational programs for Boston and Cambridge schoolchildren, evening science lectures, and the overhaul of many of MCZ's outdated exhibit galleries. These efforts reflected his ardent belief that scientists have an obligation to share their discoveries with the public—both young and old—and that museums, in particular, should play a dominant role in public education. He was particularly fond of MCZ's natural history travel program, which literally was the first of its kind in North America and possibly the world. Beginning with a single whale-watching trip to the Gulf of California in 1975, the program grew under Jim's encouragement. By 1990 the program was sponsoring trips to Central and South America, the Galapagos, Africa, Antarctica, New Zealand, French Polynesia, Bali and the North Sea. Many of the trips were led by Jim and his wife Sue.

Peter Wiebe

To many of us in the MCZ, however, what we will remember most about Jim McCarthy was his humanity, kindness and basic decency. He always sought to bring out the best in others, be they friends, relatives, students or colleagues, and could always be counted on for sage advice and thoughtful words of encouragement. We will miss him. Our planet will miss him.

—James Hanken

Emeritus Profiles

Justin Ide

A. W. "Fuzz" Crompton

Fisher Professor of Natural History, Emeritus

Prof. Crompton, former curator of Mammalogy, was the director of the MCZ from 1970 to 1982, having served as director of both the Peabody Museum of Natural History at Yale University and the South African Museum in Cape Town.

His primary research interests include the origin and evolution of mammals, functional anatomy, and neural control and evolution of feeding in recent and fossil vertebrates. Prof. Crompton received two Guggenheim fellowships for his research on vertebrate paleontology and functional morphology, and in 2011 received the Romer-Simpson Medal from the Society of Vertebrate Paleontology.

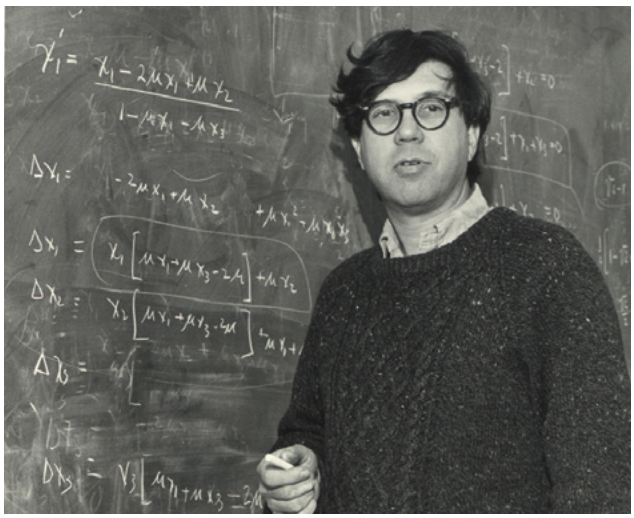
Edward O. Wilson

Honorary Curator in Entomology

Pellegrino University Professor, Emeritus

Beth Maynor Finch

Prof. Wilson is considered the founder of sociobiology and has developed the basis of modern biodiversity conservation. He has received many of the world's leading prizes in recognition of his research, creative literature and environmental activism and holds 40 honorary doctoral degrees from universities and colleges in America and Europe. Prof. Wilson was awarded two Pulitzer Prizes for his books *The Ants* (1990, with Bert Hölldobler) and *On Human Nature* (1978). He received the TED Prize in 2007, where he articulated the concept of the Encyclopedia of Life, and the Hubbard Medal in 2013, the rarely given highest award of the National Geographic Society.



Richard C. Lewontin

Professor of Biology, Emeritus

Alexander Agassiz Professor of Zoology, Emeritus

An evolutionary geneticist, Prof. Lewontin pioneered the field of molecular population genetics by merging molecular biology and evolutionary theory, as well as the philosophical and social implications of genetics and evolutionary theory.

Among his many books are *The Genetic Basis of Evolutionary Change*; *Biology as Ideology: The Doctrine of DNA*; *Human Diversity*; and *The Triple Helix: Gene, Organism and Environment*.

Robert M. Woollacott

Professor of Biology, Emeritus

Prof. Woollacott joined the faculty in 1972 and retired in 2018. His teaching and research focus is on the reproduction of marine invertebrates, especially larval biology, as well as human impacts on life in the sea.

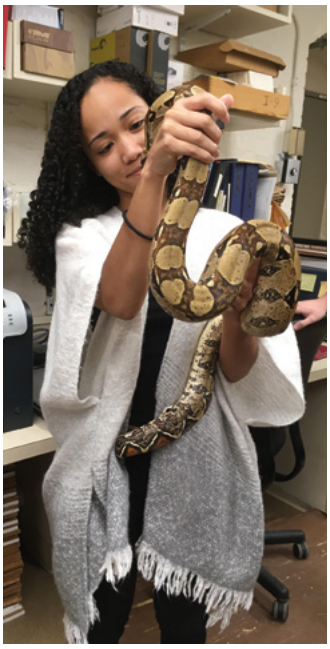
Courses Led by Faculty-Curators

Academic Year 2019–2020

Naomi Pierce

OEB 155R: Biology of Insects

OEB 167: Herpetology



Inbar Maayan

Organismic and Evolutionary Biology

OEB 10: Foundations of Biological Diversity
Brian D. Farrell (and Elena Kramer, Peter Girguis)
An integrated approach to the diversity of life, emphasizing how chemical, physical, genetic, ecological and geologic processes contribute to the origin and maintenance of biological diversity.

OEB 11: Introduction to Tropical Biology
Gonzalo Giribet (and David Haig)
Introduction to concepts of tropical biology and tropical biodiversity with a focus on the ecology, physiology and diversity of rainforest and tropical coral reef ecosystems.

OEB 51: Biology and Evolution of Invertebrate Animals
Gonzalo Giribet (and Cassandra Extavour)
Introduction to invertebrate diversity, covering the development, adult anatomy, biology and evolutionary relationships of the main animal phyla including sponges, mollusks, annelids and arthropods, among others.

OEB 57: Animal Behavior
Naomi E. Pierce (and Bence P. Olveczky)
A review of the behavior of animals under natural conditions, with emphasis on both mechanistic and evolutionary approaches.

OEB 126: Vertebrate Evolution
Stephanie E. Pierce
A comprehensive survey of the origin and evolution of vertebrates through an examination of the fossil record. The primary focus is on major events in Earth's evolutionary history, with an emphasis on anatomical and physiological transformations in fish, amphibians, reptiles, birds and mammals.

OEB 150: Exceptional Paleobiological Insights into Animal Evolution
Javier Ortega-Hernández
Explores the importance of soft-tissue preservation in the rock record through an overview of major exceptional fossiliferous sites around the world and throughout the Precambrian to Mid-Phanerozoic, with particular emphasis on the evolutionary history of invertebrate animals.

OEB 155R: Biology of Insects
Naomi E. Pierce
An introduction to the major groups of insects. The life history, morphology, physiology and ecology of the main taxa are examined. Topics include the phylogeny of terrestrial arthropods, an analysis of abiotic and biotic factors regulating populations, and the use of insects in biological control.

OEB 167: Herpetology
James Hanken
An introduction to the biology of amphibians and reptiles. Lectures and laboratories examine the morphology, systematics, natural history, behavior, ecology, evolutionary relationships and biogeography of all major taxa.

OEB 173: Comparative Biomechanics
Andrew A. Biewener
An exploration of how animals and plants contend with their physical environment, considering their biomaterial properties, structural form and mechanical interaction with the environment.

OEB 190: Biology and Diversity of Birds
Scott V. Edwards
An introduction to the biology of birds. Covers the fossil record and theories for avian origins, physiology and anatomy, systematics, speciation processes, behavior, vocalizations, demography and conservation.

OEB 213: Evolutionary Convergence, Mass Extinctions and the Shape of Life
Javier Ortega-Hernández
An examination of how processes acting through deep time affect fundamental biodiversity patterns, including topics such as the origin of animals, the rapid diversification of major clades and the impact of extinction.

Graduate Courses of Reading and Research

OEB 275R: Phylogenetics and Phylogeography in the Era of Genomics
Scott V. Edwards

OEB 306: Invertebrate Paleobiology and Evolution
Javier Ortega-Hernández

OEB 307: Biomechanics, Physiology and Musculoskeletal Biology
Andrew A. Biewener

OEB 310: Metazoan Systematics
Gonzalo Giribet

OEB 320: Biomechanics and Evolution of Vertebrates
George V. Lauder

OEB 321: Evolution of Regeneration and Development
Mansi Srivastava

OEB 323: Advanced Vertebrate Anatomy
Stephanie E. Pierce

OEB 334: Behavioral Ecology
Naomi E. Pierce

OEB 341: Coevolution
Brian D. Farrell

OEB 355: Evolutionary Developmental Biology
James Hanken

OEB 362: Research in Molecular Evolution
Scott V. Edwards

OEB 370: Mammalian Evolutionary Genetics
Hopi E. Hoekstra

OEB 399: Topics in Organismic and Evolutionary Biology
Scott V. Edwards


Javier Ortega-Hernández

OEB 150: Exceptional Paleobiological Insights into Animal Evolution

OEB 11: Introduction to Tropical Biology


Gonzalo Giribet

Gonzalo Giribet

OEB 11: Introduction to Tropical Biology

Freshman Seminar

FRSEMR 22T: Why We Animals Sing

Brian D. Farrell

Investigates the sounds and structures of different kinds of acoustic animals—including birds, mammals, frogs and insects—and the different kinds of habitats in which they produce their songs and calls.

FRSEMR 41U: Museums

Melissa Aja

FRSEMR 41U: Museums

James Hanken

Traces the history of museums from their beginnings centuries ago as personal collections maintained by private individuals to the modern institutions of today.

Life Sciences

LIFESCI 1B: An Integrated Introduction to the Life Sciences: Genetics, Genomics and Evolution

Hopi E. Hoekstra (and Andrew Berry, Pardis Sabeti)

An integrated approach showing how genetics and evolution are intimately related, together explaining the patterns of genetic variation we see in nature and how genomics can be used to analyze variation.

LIFESCI 2: Evolutionary Human Physiology and Anatomy

George V. Lauder (and Daniel E. Lieberman, Ian Wallace)

Explores human anatomy and physiology from an integrated framework, combining functional, comparative and evolutionary perspectives on how organisms work.

Embracing Remote Learning

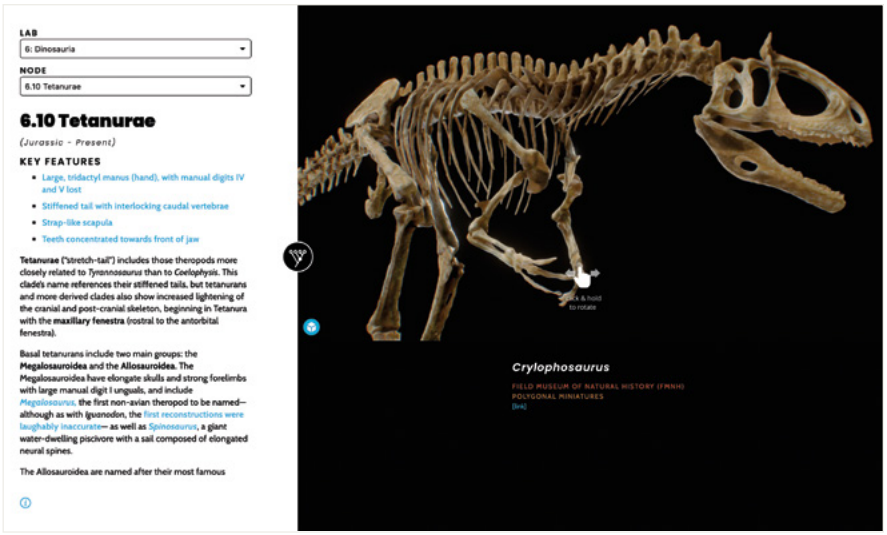
When it became clear that courses would be moving online for the remainder of Spring 2020, MCZ faculty-curators and their teaching fellows quickly transitioned their course content and the entire learning experience to the virtual space. In-person lab instruction, which relies heavily on fieldwork, scientific methods and interacting with physical specimens, required particularly creative solutions.

Pre-pandemic, **OEB 126: Vertebrate Evolution**, taught by **Stephanie E. Pierce**, included lab visits to the MCZ for students to view and interact with fossil specimens from the Vertebrate Paleontology collection, reinforcing information learned in lectures through hands-on observation of specimens and student presentations.

In an online environment, Prof. Pierce and her team had to ensure that students could observe hundreds of specimens remotely. **Phil Fahn-Lai**, the teaching fellow for the course, is an OEB graduate student and graduate fellow at Harvard's Derek Bok Center for Teaching & Learning. In collaboration with fellow Pierce lab members, Fahn-Lai spent his last days on campus using photogrammetry to scan and create 3D models of as many of the course's remaining fossil specimens as possible, and then used his web and graphic design skills to develop a tool to make them viewable.

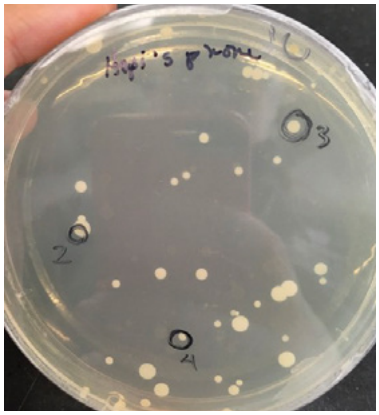
The result is Lab 3D, OEB 126's online platform for conducting labs. The website consists of three major components: a specimen viewer, where students interact with high-quality 3D models hosted on the Sketchfab website; a text pane that contains streamlined versions of lab handouts curated for the online environment and with links to relevant 3D models; and a phylogenetic tree pop-up that allows students to locate their specimens in an evolutionary context.

In the course taught by **Hopi E. Hoekstra**, **LIFESCI 1B: An Integrated Introduction to the Life Sciences: Genetics, Genomics and Evolution**, Prof. Hoekstra and colleagues recorded some elements of discussion and lecture for students scattered across the globe. They tried to keep the flow of the course similar to how it was before spring break, but without student access to labs, lab modules had to be modified.



Lab 3D, a website created by Phil Fahn-Lai for viewing 3D specimens and related materials in the lab of OEB 126: Vertebrate Evolution

One assignment required students to collect biological samples from their environments, extract the DNA and analyze the resulting data. For the online space, Prof. Hoekstra and her team collected samples from a variety of familiar objects, including a cell phone, the sole of a boot and a dog toy, and they recorded a teaching fellow modeling the DNA extraction process. These samples were sent to an external lab for sequencing and the resulting data were provided to students for analysis. Students then matched the DNA profiles of the samples to those in a database. Even though the students weren't able to do the sampling and extraction, they still participated in the scientific process, providing foundational knowledge and experience for future courses.



Hopi Hoekstra

Sample from Hopi Hoekstra's cell phone for remote labwork in LIFESCI 1B: An Integrated Introduction to the Life Sciences: Genetics, Genomics and Evolution

Creative solutions like these demonstrate instructional innovation and a dedication to educational excellence that will support high-quality learning experiences for students during exceptional times.

Research Making Headlines

Raúl Gómez

Becoming a Snake

The elongate and limbless body plan of snakes is one of the most extreme examples of the evolutionary versatility of vertebrates. It is also very old, beginning in the upper Middle Jurassic almost 170 million years ago, but few early fossils have been found that can shed light on the timing and physical changes that marked their divergence from ancient lizards.

Based on new fossils of the extinct legged snake *Najash* found in Patagonia, Argentina, including an exceptionally preserved 3D skull—the oldest articulated fossil snake skull in the world—**Tiago R. Simões** and colleagues clarify several long-standing problems on the origins of key features of the modern snake skull. Their analysis of a micro-computed tomography (microCT) scan of the skull revealed that it still had some primitive lizard-like features, like the jugal bone—which is analogous to the cheek bone—but that it also had characteristics of a modern snake skull. The lack of a jugal bone had been considered a key defining feature of all snakes, both ancient and living, an assumption disproved by the findings. Evolutionary analyses including *Najash* and other snake fossils demonstrated that early snakes retained robust rear limbs for at least the first 100 million years of their evolutionary history, signifying that this was a successful and stable, rather than a transitional, body plan before absence of limbs became predominant in snakes.

Garberoglio FF, Apesteguía S, Simões TR, Palci A, Gómez RO, Nydam RL, Larsson HCE, Lee MSY, Caldwell MW (2019) New skulls and skeletons of the Cretaceous legged snake *Najash*, and the evolution of the modern snake body plan. *Sci Adv* 5:eaax5833

Developing Flexibility

Mammals have specialized different regions of the spine such that each section takes on a variety of shapes and functions independent of the other spinal regions. This results in amazing functional diversity, such as the giraffe's elongated neck that allows it to nibble on treetops or the flexible back of the cheetah that allows it to run like the wind. But what prompted the early evolution of this complexity—the physical development of the regions or the need to adapt to new behaviors?

Rose Lincoln/Harvard University

Katrina Jones & Stephanie Pierce

Stephanie E. Pierce and **Katrina Jones** are investigating these questions to determine how and when—and why—changes occurred in the mammal spine. They have developed a tool to measure the relationship between form and function by evaluating the biomechanics of two modern species with very different spines—the tegu lizard and the domestic cat—that bracket the ancient transition to mammals.

They then applied this method to CT scans of synapsid fossils, the forerunners of mammals, finding that even though spinal regions evolved earlier, an evolutionary trigger was required in order to exploit this adaptation. For example, a burst in functional diversity was observed in advanced cynodonts, the closest synapsids to mammals, and was linked with the evolution of extreme spinal twisting. This twisting is used in living mammals while self-grooming fur, potentially indicating the evolution of an insulating pelage before the origin of mammals.

Jones KE, Gonzalez S, Angielczyk KD, Pierce SE (2020) Regionalization of the axial skeleton predates functional adaptation in the forerunners of mammals. *Nat Ecol Evol* 4:470-478

Wondrous Wings

Wings are useful for far more than flight. Wing patterns and colors help butterflies attract mates, warn off or hide from predators, or mimic other animals. In addition, recent research has discovered that butterfly wings have sophisticated physical adaptations to sense and control their temperature, triggering behaviors designed to cool or warm the wings as needed.

Butterfly wings contain a matrix of living tissue that is supplied by circulatory, neural and tracheal systems—indicating that they are dynamic, living structures—and these tissues require appropriate temperatures to function. To study the thermodynamic and thermoregulatory properties of the wings, **Naomi E. Pierce** and colleagues developed a novel noninvasive infrared hyperspectral imaging technique to map the temperature of the thin and delicate wing structures in various natural environmental conditions, finding that the living areas of the wing have a higher thermal emissivity, passively releasing heat to keep them much cooler than the non-living membranes in the rest of the wing, which are especially susceptible to overheating. Specialized scales on the surface of the wing have intricate nanostructures that function as black body absorbers to modulate temperatures of the tissues beneath them. Thus the wings as a whole act as sensitive temperature sensors, signaling to the butterfly to bask in the sun if the wings are too cool, orient as needed to catch the rays, and avoid overheating by flapping or closing their wings, turning around or moving away. They also discovered a novel "wing heart" that beats rhythmically to pump hemolymph (insect blood) directionally through the scent pad organs of male hairstreak butterflies. Together these results show that to fully appreciate the patterns produced on the wings of butterflies, it's important not only to focus on colors that are visible to us, but also to analyze wavelengths in the non-visible part of the spectrum, including the UV and near infrared.

Nanfang Yu

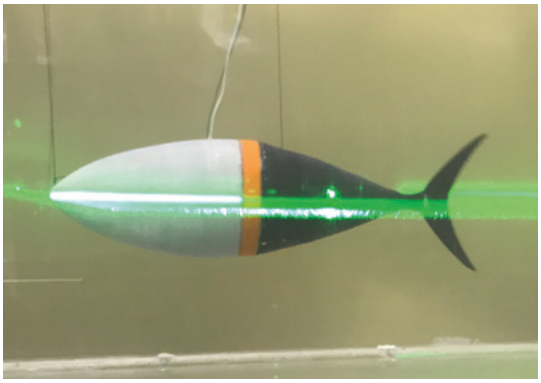
Tsai C-C, Childers RA, Nan Shi N, Ren C, Pelaez JN, Bernard GD, Pierce NE, Yu N (2020) Physical and behavioral adaptations to prevent overheating of the living wings of butterflies. *Nat Commun* 11:551

The Tortoise and the Hare

Bio-inspired robots use naturally occurring properties of organisms to improve performance, and in turn, can help researchers better understand those same organisms. This fortuitous feedback occurs in the experimental study of an underwater robot design based on the physical properties of tuna, remarkable endurance swimmers that are also capable of bursts of high speed when escaping from predators or feeding.

The majority of fish-like robots have operated at lower speeds, so the challenge was to create a robot with the capability of effectively propelling itself through the water at both lower and higher speeds. To develop the tunabot, a 10-inch-long robot based on a simplified body plan of the yellowfin tuna, *Thunnus albacares*, **George V. Lauder** and colleagues first identified major anatomical structures that affect propulsion and made a 3D model of the body. A motor in the robot's head connects to a drive shaft to power the tail, which is stabilized for fish-like lateral bending.

Then, Prof. Lauder, **Dylan Wainright** and **Valentina Di Santo**, working with collaborators at the University of Virginia, evaluated the tunabot's performance in a custom-built flow tank in the lab. Using new data from their research on live, free-swimming yellowfin tuna for comparison, they found that the tunabot has similar performance and power consumption, flapping its tail up to 15 times per second to reach higher speeds and, if fitted with a 10-Wh battery pack, could swim as far as 5.5 miles. Ultimately, the tunabot could help shed light on how open-ocean fish swim and inform the design of high-performance bio-inspired underwater vehicles.



George Lauder

Zhu J, White C, Wainwright DK, Di Santo V, Lauder GV, Bart-Smith H (2019) Tuna robotics: A high-frequency experimental platform exploring the performance space of swimming fishes. *Sci Robot* 4:eaax4615

Head Games

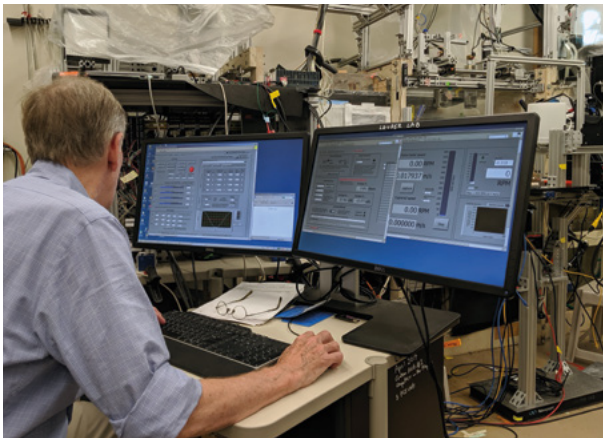
Yu Liu

The Chengjiang site in China's Yunnan Province is a richly fossiliferous deposit from the early Cambrian, dating to around 518 million years ago. The animals preserved in Chengjiang lived during the so-called Cambrian Explosion, and include several extinct arthropod groups that have an unfamiliar morphology, are extremely rare, or are incompletely preserved. These combined biases hinder our understanding of the early evolutionary history of this major phylum of invertebrates, whose modern members include insects, arachnids and crustaceans. Cambrian arthropods are particularly important as they play a key role in understanding the origin of the arthropod head, whose complex evolution has been scrutinized through anatomical, developmental and paleontological means.

Javier Ortega-Hernández and Yu Liu of Yunnan University have been collaborating on the study of Chengjiang arthropods using microCT to create virtual 3D models of the iron-rich fossils. This imaging method reveals features that are concealed within the rock, yielding high-quality morphological data along with information on the subject's affinities, ecology and evolutionary significance. Their recent paper in *Current Biology* focuses on the head of the species *Leanchoilia illecebrosa*, a member of Megacheira, an extinct group characterized by a pair of large raptorial limbs known as "great appendages." By studying small *Leanchoilia* juveniles, they found the presence of a reduced labrum—a flap-like structure overlaying the mouth in most living arthropods—a valuable anatomical feature suggesting that megacheirians are related to modern chelicerates like horseshoe crabs, scorpions and spiders. The use of microCT to study Chengjiang fossils holds great potential to revolutionize our understanding of these important organisms during a critical time in the history of life.

Liu Y, Ortega-Hernández J, Zhai D, Hou X (2020) A reduced labrum in a Cambrian great-appendage euarthropod. *Curr Biol* 30:3057-3061.e2

Taking the Plunge



Stephanie Pierce (2)

George Lauder

For decades, paleontologists have thought that dinosaurs lived on land or flew in the air but did not live in the water like some ancient reptiles. *Spinosaurus*, a large-bodied theropod like tyrannosaurs, was thought to have fed on fish by wading along the water's edge. Intriguingly, *Spinosaurus* had other adaptations like reduced hindlimbs, wide feet and a center of gravity more suited to water than land—but without a known method of propulsion, it was unclear whether it was fully aquatic or not.

In 2018 extensive remains of *Spinosaurus aegyptiacus*, the largest known spinosaurid, were excavated from Morocco's Cretaceous KemKem beds, including a young *Spinosaurus* thought to be the most complete dinosaur from the African continent. The fossils—found alongside evidence of a freshwater ecosystem dominated by ancient fish—reveal a flexible tail, more than 16 feet long with 3-foot vertical spines that form a vertically extended, fin-like structure unlike that of any other dinosaur. To evaluate if the tail could be used for propulsion in the water, **Stephanie E. Pierce** collaborated with **George V. Lauder** to model the tail—along with tails of two land-based dinosaurs, a modern crocodile, and a newt—to compare swimming efficiency. They created small two-dimensional plastic tails, attached them to a robot arm and measured the amount of thrust produced in water. They found the *Spinosaurus* model produced eight times the thrust of the land-based dinosaur tails, comparable to that of today's crocodiles, pointing to *Spinosaurus* having been an active and highly specialized large aquatic predator that hunted its prey in the water column.

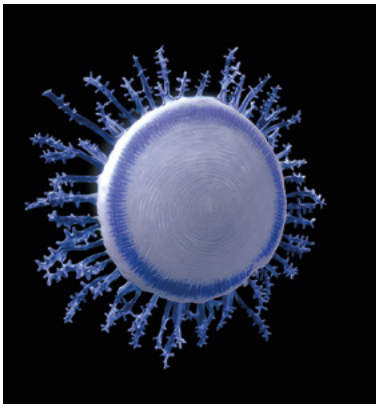
Ibrahim N, Maganuco S, Dal Sasso C, Fabbri M, 13 more including Lauder GV, Pierce SE (2020) Tail-propelled aquatic locomotion in a therapod dinosaur. *Nature* 581:67-70

Highlights from the Collections

Documenting Delicate Sea Creatures

The MCZ's spectacular 19th-century collection of glass teaching models by Leopold and Ralph Blaschka, the second largest in the world, has undergone significant transformations in the last two decades, including a major, multiyear restoration project. More recently, a similarly substantial effort has been undertaken to render the delicate glass sculptures of sea creatures in 3D to make them available to researchers and the public around the world.

Traditional 3D photography, called photogrammetry, involves taking multiple images of the subject from various angles and stitching them together. While this method is effective for some models, the reflective and transparent surfaces of other models make them less suitable, so new techniques were needed.



A paper by **James Hanken**, lead author Peter Fried and colleagues details how traditional photogrammetry, combined with a mesh generated through X-ray computed tomography (CT) scanning, can render glossy, translucent and intricate objects in 3D while preserving the delicate colors of the models. Fried has utilized this method to render more than a dozen of the Blaschka models of marine invertebrates in 3D and make them viewable on the website **Sketchfab**. "This procedure has the potential to render other reflective and translucent—and delicate—museum objects for archival purposes and make them widely available," says Prof. Hanken.

3D rendering of the Blaschka model of a greater argonaut, *Argonauta argo*. View on Sketchfab at skfb.ly/6G7M9.

At left: 3D rendering of the Blaschka model of the blue button jellyfish, *Porpita porpita*. View on Sketchfab at skfb.ly/6Nrx7.

Exceptional Eggs & Notable Nests

The Ornithology department has undertaken the task of imaging and transcribing data from specimen cards (egg cards) associated with the MCZ's collection of around 40,000 bird eggs and nests. In their final days on campus last spring, curatorial associate **Jeremiah Trimble** and curatorial assistants **Katherine Eldridge** and **John Mewherter** diligently scanned about 800 egg cards associated with 500 specimens. Working remotely, they then were able to translate, transcribe, vet and digitize the data contained on the cards.

"Traditionally, egg cards contain a vast wealth of information related to the specimens, including habitat, incubation time, nest location, behavior, plant species associated with the nest, and other important data," says Trimble. Egg cards in the Ornithology collection date from the 1850s, and they provide a snapshot of the birds' environments as well as insight into their breeding seasons and nesting ranges. The new information will provide significant supplemental data to enhance existing records for these specimens in MCZbase.

Jeremiah Trimble

Digging Into the Data

MCZ has been awarded three National Science Foundation grants to enhance and mobilize specimen records, which will benefit both science and society.

Jennifer Berglund

Breda Zimkus

Cryo-preservation of Type Specimens

The three-year grant *Collections in Support of Biological Research: Preserving the Genomes of the Type Specimens in the Museum of Comparative Zoology* will preserve the genetic identity of a large number of animal species represented in the MCZ collections, while also serving as a backup for the tissue of these specimens. The PI for the grant is **Gonzalo Giribet**, with co-PIs **Scott Edwards** and **Breda Zimkus**, assistant director of collections operations. "The main objective is to subsample and cryo-preserve tissues of nearly 17,000 primary types hosted at the MCZ, excluding insects," says Prof. Giribet. "It will benefit from the recently created Cryogenic collection at the MCZ, where the subsampled tissues will be housed and made available to other researchers." This initiative could then act as a trigger for similar initiatives at other museums and further global goals across disciplines that rely on genetic resources, including zoology, genomics and conservation biology.

Documenting Marine Biodiversity

Melissa Aja

About 75% of the 250,000 described species of marine organisms are invertebrates. The four-year grant *Documenting Marine Biodiversity through Digitization of Invertebrate Collections* will facilitate digitization of approximately 31,564 lots and 4,631 primary type specimens of MCZ's recent marine invertebrates, including cnidarians, echinoderms, crustaceans, brachiopods, polychaete worms and bryozoans. **James Hanken** is PI for the MCZ component. **Adam J. Baldinger**, curatorial associate, Invertebrate Zoology and Malacology, is co-PI.

"The MCZ collections of marine invertebrates are worldwide in scope, many resulting from expeditions in the 19th and early 20th centuries," says Baldinger. Digitization efforts will consist of entering specimen metadata into the database, georeferencing localities, imaging specimens, and capturing data for specimens that are attached to or growing on each other, like a barnacle on a mussel.

Mobilizing Mollusks

Jennifer W. Trimble

The MCZ Malacology collection includes 82,775 lots from the Eastern Seaboard that equal 710,600 non-fossil specimens of biologically and economically important species, including oysters, clams, mussels, scallops, whelks and squids. The four-year grant *Mobilizing Millions of Marine Mollusks of the Eastern Seaboard* will database 7,500 uncataloged lots from the Eastern Seaboard in the MCZ collection, clean the georeferences of 16,000 unique localities in MCZbase for specimens from this area, and prepare high-quality digital images of nearly 14,000 primary types for MCZbase. PI **Gonzalo Giribet** is joined by **Adam J. Baldinger** and curatorial assistants **Alana Rivera** and **Murat Recevik**.

Vanessa Knutson

"MCZ is part of a collaborative consortium that will collectively mobilize 53,000 fully georeferenced records representing 4.2 million specimens from the shore to the edge of the Exclusive Economic Zone, from the Canadian border to the Texas coast of the Gulf of Mexico, around 3,800 miles of coastline," says Baldinger. Specimen data will eventually be accessible through portals like InvertEbase and MolluscaBase and various aggregators such as WoRMS, iDigBio and GBIF.

Staff Highlight

Catherine Weisel

Adam J. Baldinger

In 1997, **Adam Baldinger** became the curatorial associate in Malacology and, in 2008, he began to manage the Invertebrate Zoology collection as well. Both collections are extensive in number and diverse in scope—the Malacology collection has an estimated 10 million shells—with some groups within Invertebrate Zoology, such as spiders, being among the most important in the world.

Many specimens date to MCZ expeditions and other collections activities in the late 19th century. "It's intriguing to see a specimen collected in 1849 and reflect on the people that have touched it before me," says Baldinger. "Hopefully, 150 years from now, my efforts will mean that others can continue to work with these specimens and collections."

Adam works closely with **Gonzalo Giribet** and **Mansi Srivastava**, curators of Invertebrate Zoology, and **James Hanken**, acting curator of Malacology. Along with five staff members, they are managing four significant grants to further digitize the collections and cryo-preserve tissue samples. "After working with Adam for two decades, I could not have wished for a more thoughtful, reliable and efficient colleague," says Prof. Giribet.

In his spare time, Baldinger's research interests are on amphipods, a group of ecologically important shrimp-like crustaceans on which he published his first paper as an undergraduate and which he continues to study. Several years ago, a park ranger in Death Valley National Park contacted him about a subterranean freshwater amphipod and sent samples. It turned out to be a new species, *Hyalella sandra*, which he described and named after his wife. A group of researchers also named a species of a small marine mollusk from Martinique *Teinostoma baldingeri* in recognition of his vital contribution to their work.

MCZ History

Many people associated with the Museum of Comparative Zoology have achieved great fame and notoriety since its founding in 1859. Yet, other individuals who made highly significant contributions to the Museum, and comparative zoology more generally, have for a variety of reasons been denied due recognition of their talents and accomplishments. Perhaps foremost among the latter is Robert A. Gilbert, who as an African American was denied opportunities for education, training and professional advancement that many of his contemporaries took for granted.

Mass Audubon Collection, Museum of American Bird Art

Robert Gilbert (far right) during a field excursion near Bethel, Maine

Born in South Carolina in 1869, Gilbert didn't begin working for the MCZ until 1919. His association with zoology, however, had begun in the mid-1890s when, at the age of 27, Gilbert was hired by Cambridge-based ornithologist William Brewster to assist with Brewster's studies of the birds of New England, and especially Massachusetts. This included the then-novel idea of bringing along a camera and glass-plate negatives in order to photograph birds and other animals and plants in their natural habitats.

Brewster was long credited as principal photographer, with little more than passing mention of Gilbert's contribution. That all changed in 2005, when biographer John Hanson Mitchell provided compelling evidence that most if not all of the remarkable images were actually created by Gilbert. Today, Gilbert is recognized as one of the earliest natural history photographers in North America, if not the world.

Projects & Initiatives

Samuel Church and Seth Donoughe (2)

The Importance of Primary Sources

The Ernst Mayr Library holds a wealth of biological resources and makes them available to researchers at Harvard and around the world. Much like the MCZ's specimens, the EML's diverse primary literature sources can be used to disprove old hypotheses or develop new ones. When the team of Samuel H. Church, Seth Donoughe and **Bruno A.S. de Medeiros**—led by OEB professor Cassandra G. Extavour—needed help with references to create a historical dataset on insect eggs, they turned to the EML.

To build this massive data set, the team compiled more than 3,000 references from the past 250 years, finding many online or on the shelves of the EML. However, still missing 350 tough-to-find sources, they approached **Mary Sears**, EML's head of public services, for support. "It was like detective work," says Sears, "because the citations were in relatively obscure journals and in several different languages. Ultimately I was able to contribute 265 books and journal articles to the project, published by museums, universities and scholarly societies from around the world."

Creating custom software to search the digital texts for egg morphological data, the researchers narrowed the results to 1,756 publications. The software analyzed images and extracted text, resulting in about 10,000 egg measurements for more than 6,700 insect species. Using the completed and verified dataset, the researchers disproved some popular hypotheses about egg size, finding instead that ecological considerations seem to be more important in determining egg morphology, pointing the way for future research and highlighting the importance of primary historical sources.

Church SH, Donoughe S, de Medeiros BAS, Extavour CG (2019) A dataset of egg size and shape from more than 6,700 insect species. *Sci Data* 6:104

Church SH, Donoughe S, de Medeiros BAS, Extavour CG (2019) Insect egg size and shape evolve with ecology but not developmental rate. *Nature* 571:58-62

Ernst Mayr Library

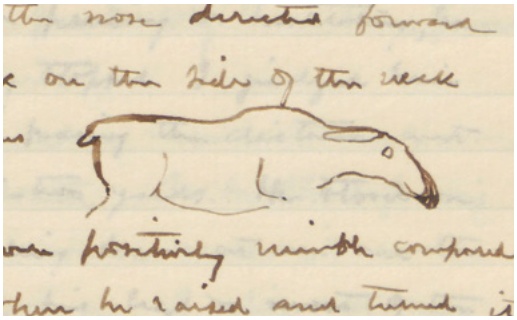
After campus closed in March, staff worked remotely to support MCZ research and teaching, making extensive use of digital repositories like the Biodiversity Heritage Library to provide materials to faculty, graduate students and curatorial staff. The EML website, library guides, blogs and other social media connected the MCZ and larger natural history community with library resources.

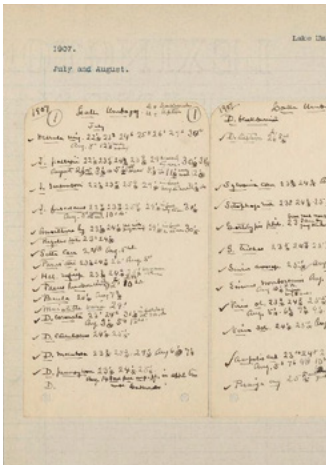
Biodiversity Heritage Library

EML staff, working with partner institutions, have enriched BHL content while focusing on unique MCZ collections, adding more than 200 books (34,955 pages) in the last year. On average, EML content in BHL is viewed by 9,513 users each month, a total of 29,108 views per month.

William Brewster Collections Digitized

Using the Atlas of Living Australia's DigiVol platform, volunteers and staff transcribed 2,647 pages of William Brewster's journals and diaries this year. Only 6% of the Brewster material housed in the archives remains to be digitized, and 20% of it has been transcribed and validated, including 15 journals (2,416 pages).





Digitizing MCZ Collection Documents

EML has digitized the Paul Morris field notes, 470 cards for the Northcutt collection of microscope slides, two accession ledgers and 104 pages of the Catalogue of Fishes for the Boston Society of Natural History, and correspondence from the Herpetology and Malacology collections.

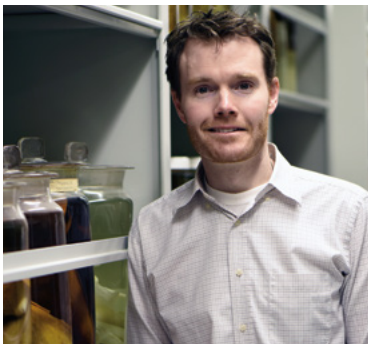
Harvard Museums of Science & Culture

While Harvard's public-facing museums have been active in the online space for years, the COVID-19 pandemic places new emphasis on virtual tours, talks and gallery displays. MCZ personnel regularly contribute to such outreach efforts, and they continue to do so via Harvard's web presence while campus is closed to visitors.

George Lauder

HMSC connects!

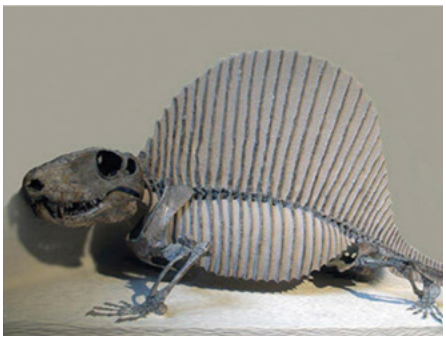
HMSC Connects!, a web initiative to expand online educational activities, launched in April. *HMSC Connects! Exhibit Spotlight* features *Sharks: Streamlined Swimmers*, which provides an orientation to shark physiology and highlights the Lauder lab's research into the effectiveness of shark locomotion. In a video, **George V. Lauder** uses a blue shark from the MCZ collection to explain how the external aspects of shark anatomy—the fins, tail and scales—help sharks move efficiently through the water. In a second video, lab member **Molly Gabler-Smith** explains how these scales, or denticles, improve shark hydrodynamics. In *HMSC Connects! Extraordinary Things*, the website shares the fossilized skeleton of *Dimetrodon milleri*, a mammal-like carnivore that lived before the emergence of dinosaurs almost 300 million years ago. It features **Stephanie E. Pierce** and explains how she uses digital scans of this fossil to create 3D models to understand how *Dimetrodon* may have moved.



Melissa Aja

Andrew Williston

The *HMSC Connects! Podcasts* take listeners behind the scenes of the museums, and in one episode, curatorial associate **Andrew Williston** talks about the MCZ Ichthyology collection and why collections are important for science and education as well as public viewing. Another podcast for Women's Suffrage Month goes into the contributions of women working in MCZ collections in the late 19th and early 20th centuries and Reed Gochberg's efforts to tell their stories in an exhibit at HMNH.



A Personal Quest with a Larger Purpose

This summer, Scott V. Edwards fulfilled his lifelong dream of cycling across the US, and, along the way, contributed to the quest for social justice. In early June he departed Massachusetts after dipping his wheels in the Atlantic Ocean. He reached Oregon and the Pacific Ocean in August, many days and adventures later.

He traveled unassisted, with 60 pounds of gear on a bike festooned with printed signs: #BlackLivesMatter, #BlackBirdersWeek and #ShutDownSTEM, a one-day work stoppage to highlight systemic racism in the scientific and academic communities. Prof. Edwards, MCZ faculty member and curator of Ornithology, experienced natural beauty, physical and logistical challenges, random acts of kindness and occasional racist comments, and copious birdsong.

"It's important for folks to see that African Americans do enjoy nature," he says. "It's important to showcase that we like camping and show it's not just the domain of others."

Ellie Steinberg

Scott Edwards

Awards & Recognition

Jennifer Berglund

Edward O. Wilson and James Hanken

Faculty-Curators

Andrew Biewener was elected a fellow of the American Association for the Advancement of Science.

Sarah Losso

Scott Edwards was elected to the American Philosophical Society and, along with a colleague, received the inaugural Inclusiveness, Diversity, Equity and Access (IDEA) Award from the American Society of Naturalists, the Society for the Study of Evolution and the Society of Systematic Biologists.

Two new species were named in honor of **Gonzalo Giribet**, *Panzosus giribeti*, an arachnid, and *Galathenemertes giribeti*, a ribbon worm.

Hopi E. Hoekstra received the 2019 C. Hart Merriam Award from the American Society of Mammalogists.

Javier Ortega-Hernández and Research Associate **Rudy Lerosey-Aubril** were jointly awarded a grant from Harvard's William F. Milton Fund. **Ortega-Hernández** received an award from the Harvard China Fund to support his work on South Chinese fossils.

Naomi E. Pierce was awarded the 2019 International Prize for Biology from the Japan Society for the Promotion of Science for her outstanding contribution to the advancement of research in fundamental biology.

Stephanie E. Pierce received the 2019 Fannie Cox Prize for Excellence in Science Teaching from Harvard's Faculty of Arts and Sciences.

A new genus of terrestrial lizard, *Wilsonosaura*, and a new bat species, *Miniopterus wilsoni*, were named in honor of **Edward O. Wilson**.

Postdoctoral Researchers

Andrew Gehrke received a Charles King Trust Postdoctoral Research Fellowship.

Aaron Hartmann received a Certificate of Excellence in Teaching from the Derek Bok Center.

Katrina Jones was awarded the Royal Society of London University Research Fellowship.

Nicholas Jourjine received a Ruth L. Kirschstein Postdoctoral Individual National Research Service Award and a Harvard Brain Initiative Young Scientist Travel Award.

Andreas Kautt received the Cameron Award from the American Society of Mammalogists and a postdoctoral fellowship from the German Research Foundation.

Kris Snibbe/Harvard University

Andrew Gehrke and Mansi Srivastava

Elizabeth Sibert was an International Ocean Discovery Program participant.

Tiago Simões received a postdoctoral fellowship from the Natural Sciences and Engineering Research Council of Canada.

Kelsey Tyssowski received a Life Sciences Research Foundation postdoctoral fellowship.

Graduate Students

Jennifer Austiff, **Nicole Bedford**, **Richard Childers**, **Blake Dickson**, **Nathaniel Edelman**, **Kadeem Gilbert**, **Alyssa Hernandez**, **Sang Il Kim**, **Vanessa Knutson**, **Sarah Losso**, **Olivia Meyerson**, **Zachary Morris**, **Shoyo Sato**, **Carl Schmitt**, **Zhengyang Wang** and **Brock Wooldridge** each received a Certificate of Distinction in Teaching from the Derek Bok Center.

Sloane Jackson

Inbar Maayan

Ryan Hulett received a Ruth L. Kirschstein National Research Service Award fellowship from the National Institutes of Health.

Sang Il Kim received a Graduate Student Research Enhancement Award from The Coleopterists Society.

Julian Kimura received a Qbio Student Fellowship supported by the National Science Foundation–Simons Center for the Mathematical & Statistical Analysis of Biology at Harvard University.

Inbar Maayan received a Society of Systematic Biologists Graduate Student Research Award.

Zachary Morris received a National Science Foundation Earth Sciences Postdoctoral Fellowship.

Pavitra Muralidhar received a National Science Foundation Postdoctoral Research Fellowship in Biology and was a finalist for the James F. Crow Early Career Researcher Award from the Genetics Society of America.

Kari Taylor-Burt received a Dean Shinagel Exceptional Teaching Assistant Award from Harvard Extension School.

Mark Wright was awarded a Robert A. Chapman Memorial Scholarship for Vertebrate Locomotion from the Harvard Faculty of Arts and Sciences.

Undergraduate Students

Dylan Ryals and **Allison Shu Ting Law** each received a Hoopes Prize for their thesis projects.

Adele Woodmansee received the Taliesin Prize for Distinction in the Art of Learning.

Staff

Christian Flynn, OEB administrative coordinator, and **Breda Zimkus**, assistant director, collections operations, each received a Dean's Distinction Award from the Faculty of Arts and Sciences.

Breda Zimkus received a Society for the Preservation of Natural History Collections Special Service Award, presented to the organizing committee for the SPNHC 2020 meeting.

Andrew Berry and Naomi Pierce

Naomi Pierce

Richard Childers

Special Commendation
Extraordinary Teaching in Extraordinary Times

This spring, undergraduates named instructors for special recognition, praising their flexibility and creativity in adapting to online teaching and their compassionate responses to the challenges faced by students during the pandemic.

The Harvard College special commendation was awarded to Scott Edwards and Teaching Fellow Gustavo Bravo (OEB 190); Teaching Fellow Philip Fahn-Lai (OEB 126); Teaching Fellow Dave Matthews (OEB 53); and James Hanken and Teaching Fellows Inbar Maayan and Jennifer Austiff (OEB 167).

Amy Li

Inbar Maayan

Naomi Pierce

Anne Kennedy-Yoon

John Schaefer

Grant Recipients

André L. Martins

Grants-in-Aid of Undergraduate Research

These grants support research by Harvard College undergraduates under faculty supervision. Priority is given to projects that utilize MCZ research collections, laboratories and facilities. Support for these grants comes from the MCZ's Myvanwy M. and George M. Dick Scholarship for Students.

Recipient	Academic Dept./ Faculty Sponsor	Project Title	Amount
Kim Anyeji Boerrigter	OEB/Stephanie Pierce	These fins are made for walkin': A comparative musculoskeletal analysis of anglerfish pectoral fins	$4,000
Justin Duffy	OEB/Mansi Srivastava	Whole-body regeneration of *Nematostella vectensis*	$4,000
Kate Gonzalez	OEB/George Lauder	The effects of fish abundance on coral disease in Tela Bay, Honduras	$4,000
Jackson Kehoe	OEB/Javier Ortega-Hernández	Testing the evolution of body segmentation in trilobites	$4,000
Anne Kennedy-Yoon	OEB/Naomi Pierce	The effect of ant species on the morphology and fungal communities of their host, *V. drepanolobium*	$3,809
Keza Levine	OEB/Hopi Hoekstra	Deer mouse vocalization analysis	$4,000
Amy Li	OEB/Peter Girguis	Classifying marine benthos via hyperspectral imaging	$4,000
Chamberlain Mathis	OEB/James Hanken	Documentation and analysis of *Lepidobatrachus laevis* stomach development	$1,000
Logan Qualls	OEB/Javier Ortega-Hernández	Immediate family matters: Understanding interspecific differences in the genus *Isotelus*, and how members are related	$4,000
Maya Rayle	Harvard Medical School/Ali R. Zomorrodi	The eco-evolutionary dynamics of microbes	$4,000
Oliver Riskin-Kutz	OEB/Scott Edwards	Determining ecological influences on sea urchin grazing behavior in Northern California kelp forests	$1,000
Arianna Romero	OEB/Stephanie Pierce	Investigating locomotor adaptations in *Procynosuchus delaharpeae* (Synapsida, Cynodontia) with implications for ecological diversity in the mammalian stem	$4,000
Dylan Ryals	OEB/Brian Farrell	Transmission of honeybee parasites due to migratory beekeeping practice	$2,677
John Emory Sabatini	OEB/Hopi Hoekstra	Computational analysis of pup vocal recordings from four *Peromyscus* species	$4,000
John Schaefer	History of Science/ Janet Brown	Carnivorous plants: History, conservation and education	$4,000
Chidambaram Thillairajah	OEB/Scott Edwards	Convergence and coevolution between plumage coloration and light-sensitive visual pigments in antbirds (Aves, Thamnophilidae)	$4,000
Madeleine Waskom	OEB/Javier Ortega-Hernández	Modeling of Walcott-Rust thin sections	$4,000
		Total Awards	**$60,486**

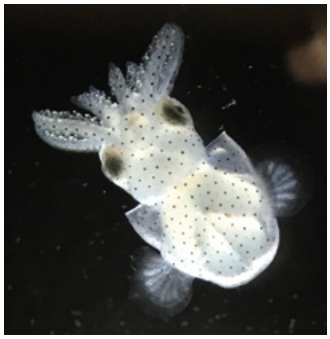
Putnam Expedition Grants

Putnam Expedition Grants are intended to support MCZ faculty-curators, postdoctoral fellows and graduate students in collecting specimens and data relating to the study of comparative zoology. Priority is given to projects that collect living specimens in regions where habitats are threatened or fossil specimens in regions most likely to hold important clues for unraveling evolutionary strategies. These grants are made possible by a gift from Mr. George Putnam Jr., AB 1949 and MBA 1951, and Mrs. Nancy Putnam.

Recipient	MCZ Department/ Faculty Sponsor	Project Title	Amount
Shahan Derkarabetian	Invertebrate Zoology/ Gonzalo Giribet	The unknown triaenonychid harvestmen of Australia. Expedition II: Queensland	$7,785
Gonzalo Giribet	Invertebrate Zoology	Following the leads of eDNA: In search of the Pyrenees' new species of Micrognathozoa	$4,700
Nicholas Herrmann	Herpetology/David Haig	Determinants of success in a novel environment: Testing how morphology and habitat use affect individual fitness in *Anolis* lizards	$11,200
Andreas F. Kautt	Mammalogy/Hopi Hoekstra	The genetic basis of predator aversion behavior in deer mice in the Channel Islands Archipelago, California	$6,997
Kelsey M. Tyssowski	Mammalogy/Hopi Hoekstra	Natural variation in morphology and behavior in arboreal and non-arboreal deer mice	$10,271
		Total Awards	**$40,953**

Gonzalo Giribet

Reinhardt Kristensen and Katrine Worsaae



Jennifer Austiff

Ken Miyata Grants

The Ken Miyata Fund in Herpetology and Ken Miyata Fund for Field Research support students who share Ken's interests as a naturalist, biogeographer and writer/photographer by defraying the costs of research by graduate students in herpetology. The funds were established by generous gifts from Barbara Wu, PhD 1981, and Eric Larson, AB 1977, and other close friends of Ken.

Recipient	MCZ Department/ Faculty Sponsor	Project Title	Amount
Inbar Maayan	Herpetology/David Haig	Island-wide variation and lineage diversification in Jamaican *Anolis* lizards	$12,110
		Total Awards	**$12,110**

Javawney Crooks

Inbar Maayan

Robert G. Goelet Research Awards

Goelet Awards support MCZ graduate student research projects. These grants are made possible through a gift from Mr. Robert G. Goelet.

Recipient	MCZ Department/ Faculty Sponsor	Project Title	Amount
Jennifer Austiff	Herpetology/James Hanken	Developmental mechanisms that underlie the evolution of the stomach of the frog, *Lepidobatrachus laevis*	$6,797
		Total Awards	**$6,797**

Yale Peabody Museum specimen by Jackson Kehoe

Shahan Derkarabetian

Matt Green

Alexander B. Orfinger

Pamela Yesenia Sánchez Vendizú

Pamela Yesenia Sánchez Vendizú

Ernst Mayr Travel Grants in Animal Systematics

Ernst Mayr Grants support travel for research in animal systematics and are open to the scientific community worldwide. The principal objective of these grants is to stimulate taxonomic work on neglected taxa and/or poorly described species. Ernst Mayr Grants typically facilitate visits to institutional collections, with preference given to research that uses MCZ's collections. These grants are made possible by a gift from professor and former MCZ Director Ernst Mayr.

Recipient	Institutional Affiliation	Project Title	Amount
Uttaran Bandyopadhyay	Zoological Survey of India	Identifying and resolving higher taxonomy of Indian Himalayan Phlogophorini (Lepidoptera: Noctuidae: Xyleninae) with special reference to the *Euplexia* genus group	$1,500
Russell D. C. Bicknell	University of New England, Armidale, Australia	Redescription of *Mesolimulus* based on exceptional fossils with three-dimensional preservation	$1,500
Damian Luis Castellini	Instituto de Investigaciones Marinas Y Costeras CONICET, Argentina	Systematics and taxonomic review of the flatfish *Paralichthys* genus in Southwestern Atlantic Ocean (Actinopterygii: Pleuronectiformes)	$1,500
Patrick J. Ciccotto	Warren Wilson College	Resolving the taxonomy of carps of the subfamily Labeoninae (Teleostei: Cyprinidae) of mainland Southeast Asia	$650
Brittany N. Damron	Universidade de São Paulo, Brazil	Taxonomic review and revision of the family Cosmetidae (Opiliones, Arachnida) in the MCZ collection	$1,500
Vinicius C. Espindola	Smithsonian National Museum of Natural History	A taxonomic review of the Western South Atlantic *Chimaera* (Chondrichthyes: Holocephali), with the description of a new species and three new records	$1,460
Edgar Gamero Mora	Universidade de São Paulo, Brazil	From species discovery to species description: The description of two new species of *Cassiopea* (Cnidaria: Scyphozoa)	$1,400
Olivia M. Gearner	Purdue University	Systematics and taxonomic revisions of the tok-tokkie beetles of Africa (Coleoptera: Tenebrionidae: Sepidiini)	$1,500
Lucas Roberto Pereira Gomes	Universidade Federal do Paraná, Brazil	Revision of Neotropical Anthomyiidae (Diptera) and phylogenetic analysis of the family	$1,500
Matthew W. Green	Clemson University	Inferring association and diagnosis of *Pycnopsyche* (Trichoptera: Limnephilidae) larvae and adults	$1,500
Zachary H. Griebenow	University of California, Davis	Resolving parallel taxonomy in the Leptanillinae (Hymenoptera: Formicidae), an enigmatic group of ants	$1,120
Karla Janet Humara Gil	Centro Universitario de la Costa, Universidad de Guadalajara, Mexico	Revision of *Ophioderma teres* complex (Echinodermata: Ophiuroidea) from the Eastern Pacific	$1,500
Ilgoo Kang	Louisiana State University	Important newly collected cardiochiline braconids housed in the Naturalis Biodiversity Center in Leiden (Hymenoptera: Braconidae)	$1,242
José Ricardo Assmann Lemes	Universidade Federal do Paraná, Brazil	Taxonomic revision and phylogenetic analysis of *Staphyus* Godman & Salvin, 1896, *Incisus* Grishin, 2019 and *Perus* Grishin, 2019 (Lepidoptera: Hesperiidae)	$1,500

Patrick J. Ciccotto

Recipient	Institutional Affiliation	Project Title	Amount
Abigail P. Martens	South Dakota State University	The Petr Starý Collection of Aphidiinae (Hymenoptera: Braconidae)	$1,500
André L. Martins	Universidade Federal do Paraná, Brazil	Taxonomic revision of *Dryinus* Latreille species (Hymenoptera, Dryinidae, Dryininae) from Neotropical region: With a new proposal of classification for species groups	$1,500
Bruno A. S. de Medeiros	Smithsonian Tropical Research Institute, Panama	New species of *Anchylorhynchus* Schoenherr, 1836 (Curculionidae: Derelomini)	$1,000
Jairo Andrés Moreno-González	Universidade de São Paulo, Brazil	Revision of the unidentified material of the enigmatic order Schizomida (Arachnida) housed in the MCZ	$1,500
Alexander B. Orfinger	University of Florida	Taxonomic revision of *Polycentropus* (Trichoptera: Polycentropodidae) from the Eastern Nearctic	$1,000
Lívia Pires do Prado	Universidade Federal do Pará and Museu Paraense Emílio Goeldi, Brazil	Taxonomic revision and phylogenetic relationships of the *Megalomyrmex* Forel, 1885 (Hymenoptera: Formicidae: Solenopsidini)	$1,000
Willians Lourenço Porto	Museo Argentino de Ciencias Naturales MACN-CONICET, Argentina	Revision of the Andean-Patagonian Triaenonychidae (Opiliones, Laniatores, Triaenonychidae)	$1,500
M. Guadalupe del Río	CONICET, División Entomología, Museo de La Plata, Argentina	Systematics on the weevil tribe Leptopiini (Insecta: Coleoptera: Curculionidae)	$1,500
Sebastian Salata	California Academy of Sciences	Taxonomic revision of *Pheidole* Westwood, 1839 (Hymenoptera, Formicidae) in Madagascar	$1,500
Pamela Yesenia Sánchez Vendizú	Universidade Federal do Pará, Brazil	Systematic revision of the spiny tree rat *Mesomys* (Rodentia: Echimyidae)	$1,500
Emily L. Sandall	Pennsylvania State University	Phylogeny of *Ophiogomphus* (Odonata: Gomphidae)	$882
Aluska Tavares dos Santos	Universidade Federal do Paraná, Brazil	Taxonomic revision of *Acanthoscelides*, the largest Neotropical genus of seed-beetles (Chrysomelidae: Bruchinae)	$1,500
Josenilson R. Santos	Universidade Federal do Rio de Janeiro, Brazil	A taxonomic review of the New World genus *Microcerella* Macquart, 1851 (Diptera, Sarcophagidae)	$1,500
Wildio Ikaro da Graça Santos	Universidade Federal do Paraná, Brazil	Taxonomic review of *Eurybia* [Illiger], 1807 and phylogenetic analysis of the subtribe Eurybiina Reuter, 1896 (Lepidoptera: Riodinidae)	$1,500
José Eduardo Serrano-Villavicencio	Universidade de São Paulo, Brazil	Taxonomic revision of the genus *Pithecia* Demarest, 1804 in the eastern Peruvian Amazon	$1,500
		Total Awards	**$39,754**

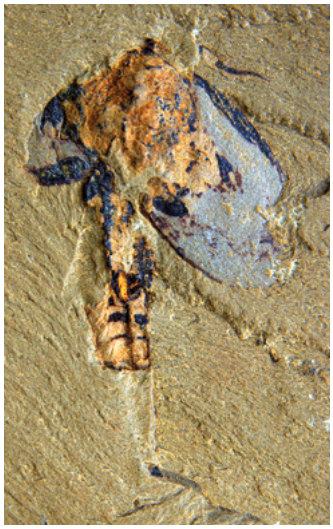
Emily L. Sandall

Emily L. Sandall

Alexander B. Orfinger

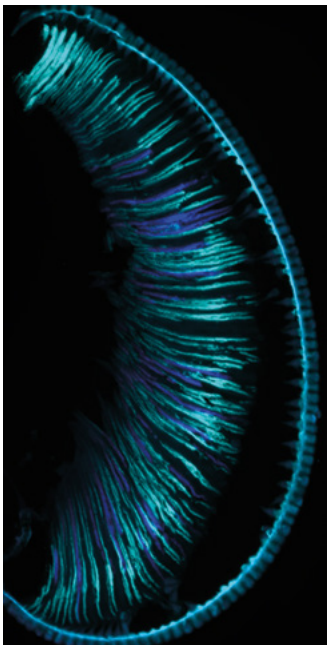
André L. Martins

Publications in 2019



Dayou Zhai

Samuel Church and Seth Donoughe



Marjorie Liénard

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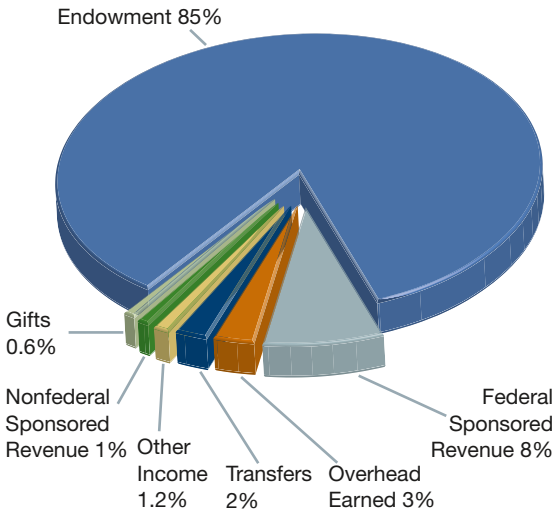
Financial Data

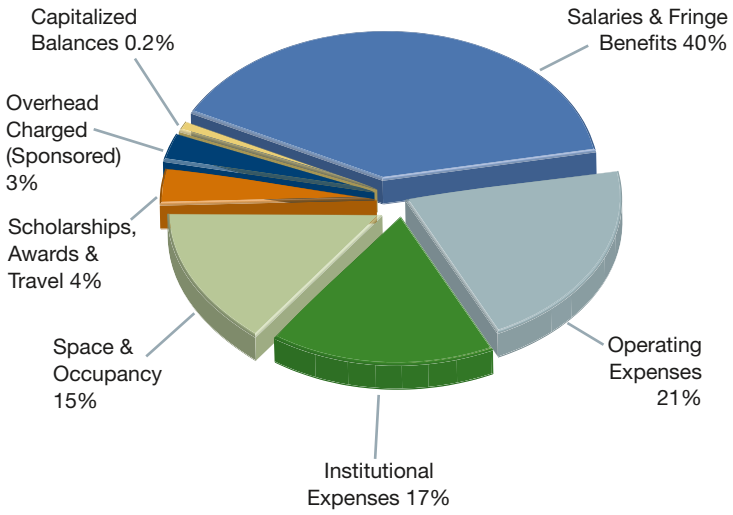
These charts describe the income and expenses of the Museum of Comparative Zoology in fiscal year 2020.

Endowment income funds much of the Museum's activities, such as acquisition and maintenance of collections, faculty and staff salaries, capital projects, facilities renovation and maintenance. It includes the annual distribution (payout) and endowed funds decapitalized per donor request. **Nonfederal Sponsored Revenue** does not include HHMI funds awarded to Prof. Hoekstra. **Gifts** are donations received in support of Museum activities that are available for current use; it does not include donations for endowed funds. **Transfers** include financial support for the Ernst Mayr Library and other Harvard-funded activities. **Other Income** comprises miscellaneous income from publication subscriptions, royalties, sales and fees, and cost recovery from other MCZ-sponsored activities. **Overhead** is funds paid from sponsored projects to cover associated facilities and administrative costs. It is shown as both income (**Overhead Earned**) and expenses (**Overhead Charged**). **Accumulation of Unrestricted Reserves** indicates net growth of balances in unrestricted gifts and endowments from, for example, interest payments and unspent portions of the current year's endowment payouts. **Accumulation of Restricted Reserves** indicates net growth of balances in highly restricted gifts and endowments. Building expenses such as maintenance, facility improvements and utilities are captured in the **Space & Occupancy** category. **Operating Expenses** consist of equipment purchases, supplies, and consultant and conference fees, as well as annual subventions to the Department of Organismic and Evolutionary Biology (OEB) for administrative services and MCZ support for faculty-curator research. Support for MCZ-affiliated graduate students in OEB is included in **Scholarships, Awards & Travel**. **Institutional Expenses** are support for other University activities outside the MCZ, including FAS and University initiatives and general operating support to the Harvard Museums of Science and Culture.

INCOME



EXPENSES & NON-OPERATING FUNDS



Income

Endowment	$16,975,583
Federal Sponsored Revenue	$1,525,650
Overhead Earned	$579,254
Transfers	$403,783
Other Income	$242,974
Nonfederal Sponsored Revenue	$143,532
Gifts	$111,067
Accumulation of Unrestricted Reserves	($362,813)
Accumulation of Restricted Reserves	($254,072)
Total	**$19,364,958**

Expenses

Salaries & Fringe Benefits	$7,695,344
Operating Expenses	$4,040,458
Institutional Expenses	$3,272,435
Space & Occupancy	$3,005,982
Scholarships, Awards & Travel	$731,341
Overhead Charged (Sponsored)	$579,254
Capitalized Balances	$40,144
Total	**$19,364,958**

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