

# Museum of Comparative Zoology



Harvard University

ANNUAL REPORT
2021 • 2022



The Museum of Comparative Zoology at Harvard University is a global center for research and education focused on the biology 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 students and researchers around the globe.

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# DIRECTOR'S MESSAGE

Life at the MCZ has returned to in-person interactions and is as vibrant as ever—a welcome sight after two years of distance and cautious measures.

Some of our colleagues who retired from the MCZ during the pandemic are back among us as research associates or have visited us at MCZ community lunches. We have been fortunate to have their positions filled by a new generation of colleagues full of energy and ideas. We have a new director of Collections Operations, new curatorial associates in Herpetology and Malacology, two new curatorial assistants in Invertebrate Zoology, new preparators in Invertebrate Paleontology and Vertebrate Paleontology, and several openings in other MCZ departments due to promotions and new grant-funded positions. This makes us look to the future with the hope that natural history collections continue to be viewed as a fundamental resource to study and document biodiversity and its change.

However, new challenges keep emerging for natural history collections, especially in relation to colonialist practices in the way such natural history collections were obtained. One important step for the MCZ and other museums must be to further increase access to the specimens in our collections to visitors from their countries of origin and make biodiversity "dark data" visible and transparent through our biodiversity databases.

Esteemed scientist and professor Edward O. Wilson passed away on December 26, 2021. Ed was a generous colleague who left a lasting impact in the scientific community and with the public, becoming one of the greatest public figures to support conservation biology. While continuing to champion biodiversity, we must acknowledge that, following his death, a set of documents that included letters exchanged with J. Philippe Rushton were released and ignited a discussion about Wilson and racism in academia, a controversy we cannot ignore. It is still debated whether his support to Rushton was about his fight for academic freedom, a hidden racist agenda, or a more complex set of interactions and motives that we must try to untangle. As the discussion continues, we must recognize the impact of Wilson's association with Rushton.

The MCZ also continues reckoning with its founder, Louis Agassiz. He was a brilliant scientist in some respects, but also a fierce anti-evolutionist who promoted ethnic cleansing and racial segregation. We need to think about how we got here. This will not be easy and much needs to be learned. As of today, all public busts and paintings of Louis Agassiz have been removed from MCZ public spaces while we continue to educate ourselves about the past and decide how to shape the future of our institution to provide an inclusive, welcoming environment that acknowledges its past and works toward a better future for all.

More than ever, we need to build an MCZ that welcomes and accepts everyone who wants to study zoology in all its forms. I hope you enjoy reading about all our activities in the following pages and join me in congratulating our students, staff, researchers and faculty for an incredible year.



Gonzalo Giribet
Director



About the cover: A brook trout (Salvelinus fontinalis) used to study locomotion in the Lauder lab. Photo by David Matthews

Opposite page: A whip coral goby (Bryaninops yongei) perches on its eponymous coral host in Sulawesi, Indonesia. Photo by David Matthews



# THE INDUSTRIOUS STEFAN COVER

During the last week of 1986, Stefan Cover moved to the Boston area and requested access to the MCZ's ant collection. But before obtaining access, he had to wait for a call by Prof. Edward O. Wilson—a call that he thought would never come—and then pass a test.



Stefan Cover

Veromessor lobognathus

Upper right: Formica ravida (MCZ ENT-552097)

(MCZ ENT-736315)

Prof. Wilson, curator in Entomology at the time, asked Stefan to visit him in the MCZ and bring a couple of boxes of his pinned ants. Only after examining these superbly mounted specimens did Prof. Wilson allow him into the ant collection.

A few months after this first meeting in the MCZ, Stefan was hired as a temporary staff member under a National Science Foundation collections improvement grant that Prof. Wilson had secured, and two years later he became a permanent curatorial assistant under Prof. Wilson and Assistant Prof. James Carpenter.

Stefan remembers those early days fondly, especially since his job included fieldwork every summer to keep the MCZ ant collection growing into what it is today. Stefan is the third top collector in the history of the MCZ—and the first among those alive today—having contributed



33,660 cataloged lots to MCZbase for an estimated total of 275,000 specimens.

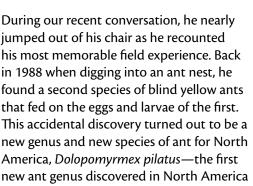
jumped out of his chair as he recounted his most memorable field experience. Back in 1988 when digging into an ant nest, he found a second species of blind yellow ants that fed on the eggs and larvae of the first. This accidental discovery turned out to be a new genus and new species of ant for North America, Dolopomyrmex pilatus—the first new ant genus discovered in North America since 1908.

Stefan also co-authored the book Ants of North America with Brian Fisher, a fauna that he knows extremely well.

Despite the North American fauna being the second best-known ant fauna in the world after Europe, Stefan discovered about 100 new species of North American ants and named 11 species in collaboration with colleagues.

Stefan was surprised when he learned how many ants he had contributed to the MCZ, to which he said, "I had no idea. I'm like an ant, I had no cosmic plan in mind." Stefan retired in 2021 but continues to work in collections as a visiting researcher, processing ants collected over the years many unknown to science, waiting to be described. Like the high mound an ant colony can make with single ants carrying one grain of sand at a time, he has built an enormous and valuable resource for the MCZ and for science.

—Gonzalo Giribet





# **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.

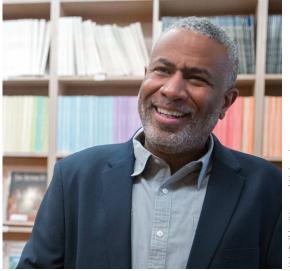


Scott V. Edwards

Professor of Organismic & 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*. On July 1, 2022, Prof. Edwards assumed the Chair of the parent department of the MCZ, the Department of Organismic and Evolutionary Biology.



Snibbe/Harvard University



### Brian D. Farrell

Monique & Philip Lehner Professor for the Study of Latin America Professor of Organismic & Evolutionary Biology Curator of Entomology 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, pests and pathogens, such as insects and other tiny consumers. His current projects include applying next-generation sequencing to speciation and phylogenetic studies of associated species of beetles and plants, 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**



# Gonzalo Giribet

Professor of
Organismic &
Evolutionary Biology
Alexander Agassiz
Professor of Zoology
Curator of
Invertebrate Zoology
Acting Curator of
Malacology
MCZ Director

Prof. Giribet's primary research focuses on the evolution, systematics and

biogeography of invertebrate animals, including biodiversity discovery as well as genomics.

Current projects in the Giribet lab include a comprehensive study of the harvestmen of New Zealand, their systematics and biogeography; characterizing a radiation of velvet worms in the Neotropics; 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 mollusks and arthropods, among other groups.



Hopi E. Hoekstra

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

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.



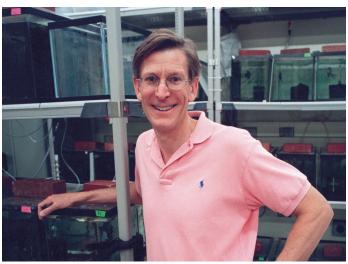
### James Hanken

Professor of Biology Alexander Agassiz Professor of Zoology Curator of Herpetology

Prof. Hanken utilizes laboratory-based analyses and field surveys to examine morphological evolution, developmental biology and systematics.

Current areas of research include the developmental basis of morphological novelty

and life-history evolution; the systematics and evolution of neotropical and Southeast Asian frogs and salamanders; and museum-based digital imaging technology.



Ponhani

George V. Lauder

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

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.



Stephanie E. Pierce
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.



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

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



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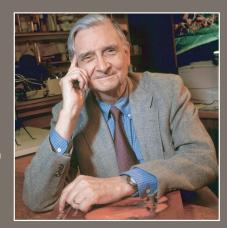
developed as a new acoel model system. Acoels represent an understudied phylum that is distantly related to other well-studied regenerative species, which allows her group to study genetic mechanisms from a comparative perspective. Current projects in the lab range from identifying gene regulatory networks for regeneration to determining the embryonic origins of pluripotent stem cells to understanding the evolution of centralized nervous systems.

# **EMERITUS PROFILES**

# In Memoriam: Edward O. Wilson

Edward O. Wilson, Honorary Curator in Entomology and Pellegrino University Professor, passed away on December 26, 2021, at the age of 92. He received his PhD in entomology from Harvard in 1955, joined the faculty the next year and remained at Harvard for the rest of his career.

Wilson's early field work focused on the classification and ecology of ants in Cuba, Mexico, New Guinea and other Pacific islands, leading to the discovery of how ants communicate through pheromones. He developed the theory of species equilibrium in islands as a function of island size and distance to the mainland with Robert MacArthur, and they published *The Theory of Island Biogeography* in 1967, which served as a foundational work in the field of island biogeography. In 1975, Wilson's *Sociobiology: The New Synthesis* explored the genetic and evolutionary roots of animal behavior and posited that genes shape human behavior, as well,



ideas that culminated in On Human Nature in 1978, which received a Pulitzer Prize and launched evolutionary psychology.

In the 1980s, Wilson's writing and advocacy turned to efforts to protect nature. He established the E.O. Wilson Biodiversity Foundation and received the TED Prize in 2007, where he articulated the concept of the Encyclopedia of Life. His 2016 book Half-Earth launched a global project to set aside half of the world's land for species conservation. He also worked to restore the devastated Gorongosa National Park in Mozambique and established a new park in the Alabama delta near his boyhood home.

Wilson was a prolific writer, publishing more than 400 scientific papers and 20 books, including his second Pulitzer Prize—winner *The Ants* with Bert Hölldobler in 1990. He received more than 150 awards and honors in recognition of his research, creative literature and environmental activism.

The MCZ acknowledges the controversy generated by Wilson's correspondence with J. Philippe Rushton, which were among the papers given by Wilson to the Library of Congress. While analysis and interpretation of these letters will continue, the MCZ reaffirms its mission to foster a diverse and vibrant community of active zoologists who feel supported, respected and able to do their best work as we are committed to diversity, equity and inclusion.



**A. W. "Fuzz" Crompton**Fisher Professor of Natural History,
Emeritus

Prof. Crompton, former curator in 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.



Robert M. Woollacott

Professor of
Biology, Emeritus
Former Curator
of Marine
Invertebrates
Prof. Woollacott
joined the
faculty in 1972
and retired in
2018. During
his tenure at

Harvard, he served as the first Chair of the Department of Organismic and Evolutionary Biology. His teaching and research focus on the reproduction of marine invertebrates and human impacts on life in the sea.

# Courses Led by Faculty-Curators

Academic Year 2021–2022



OEB 190: Biology and Diversity of Birds

# Organismic and Evolutionary Biology

# OEB 10: Foundations of Biological Diversity

Brian D. Farrell, Mansi Srivastava (and Elena Kramer, Ann Pearson)

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 56: Geobiology and the History of Life

Javier Ortega-Hernández (and David Johnston, Nadja Drabon)

Within our solar system, Earth is distinguished as the planet with life. Living organisms are complex entities that originated from planetary processes, have been sustained by the same processes for approximately four billion years, and have fundamentally affected the functioning and composition of the Earth's surface and atmosphere. In this course we will investigate the ways that Earth and life interact with each other, focusing on the biogeochemical cycles of major elements, and the interplay between complex organisms and their ever-changing environment. This will provide a framework for interpreting the fascinating history of life reconstructed from a comprehensive understanding of the rock

record, the diversity of life through time, and evolutionary biology.

### **OEB 57: Animal Behavior**

Naomi E. Pierce (and Bence P. Ölveczky)

A review of the behavior of animals under natural conditions, with emphasis on both mechanistic and evolutionary approaches.

# OEB 112: Arthropod Biology: Arachnids and Myriapods, Their Biology and Evolution

Gonzalo Giribet

This course introduces the evolutionary history and biology of arachnids, myriapods and related groups, learning their taxonomy and anatomy as well as their role as model organisms to understand phenomena such as segmentation or appendage specification.

# OEB 115: The Developmental Basis for Evolutionary Change

Mansi Srivastava (and Clifford Tabin, Matthew Harris)

A lecture course in evolutionary developmental biology. This course will focus on the molecular and cellular bases of how embryos generate adult body plans in order to understand how form, physiology and life history strategies are modulated over the course of evolution. We discuss insights from both invertebrate and vertebrate animal model systems as well as

OEB 155R: Biology of Insects



Protogoniomorpha parhassus





OEB 207: The Fishy Aspects of the Human Body

plants and investigate the forces driving change at both micro- and macro-evolutionary time scales. Particular emphasis will be placed on how changes in development underlie major evolutionary transitions and the origin of innovation in organismal evolution. The course will also emphasize learning of experimental design, molecular tools, and phylogenetic methods currently used by researchers in the field of evolutionary developmental biology.

# **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 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. Through lectures, seminar discussions and student presentations based

on readings, students are introduced to topics related to biomechanical performance.

# 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, higher-level systematics and field characters of the ~27 orders, speciation processes, nesting and courtship behavior, vocalizations, mating systems and sexual selection, cooperative breeding, demography and conservation. Optional field trip during spring break. Laboratories will consist of gross anatomy, bird watching excursions in the Cambridge area, field techniques and specimen preparation, and systematic study of avian groups using the collections of the Museum of Comparative Zoology.

# OEB 207: The Fishy Aspects of the Human Body Stephanie E. Pierce

Exploration of how the human body evolved through an analysis of the non-fiction book Your Inner Fish by Neil Shubin. Students discuss how the author communicates complicated scientific concepts and whether they do it effectively, as well as the scientific content of the book. Each chapter discussion is supplemented with both an in-person, specimen-based lab and a specially designed (bespoke!) virtual 3D specimen website that conveys information from the book using an alternative science communication medium.

### 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 52L: Life and Death Lessons from the Fossil Record

Javier Ortega-Hernández

Explores the rich world of paleontology and its bearing on human activities, including how cutting-edge scientific research informs

OEB 56: Geobiology and the





our understanding of the main processes that have influenced the evolution of life on Earth for approximately four billion years, including episodes of global warming/ cooling and mass extinction events.

# **Life Sciences**

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

Hopi E. Hoekstra (and Andrew Berry, Pardis Sabeti)
How are observable characteristics of organisms influenced by genetics? How do genomes change over time to produce the differences we see among species?
This course takes 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. In covering Mendelian genetics, quantitative genetics and population genetics, this course will emphasize

# LIFESCI 2: Evolutionary Human Physiology and Anatomy

developments involving our own species.

Andrew A. Biewener, George V. Lauder (and Daniel E. Lieberman, Joanne Clark Matott)

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

# Graduate Courses of Reading and Research

# 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 56: Geobiology and the History of Life

# 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

OEB 173: Comparative Biomechanics



# HIGHLIGHTS OF FACULTY-CURATOR GRANTS

In addition to their teaching responsibilities, curatorial duties and research efforts, MCZ faculty-curators obtain grants for and lead long-range, often multi-institutional research projects.

"Faculty-Curator grants constitute the basis for a large component of the research happening in the MCZ," says Director Giribet. "They showcase the cutting-edge nature of the work our faculty-curators and their students and postdocs undertake. The competitive grants highlighted here are examples of such diverse research on regeneration, evolution and biogeography, paleobiology, and biologically inspired design."

Scott V. Edwards is the Principal Investigator for Dimensions US-BIOTA-São Paulo: Collaborative Proposal: Traits as Predictors of Adaptive Diversification Along the Brazilian Dry Diagonal, a \$419,334 (\$1,994,393 total) five-year research grant from the National Science Foundation. The Brazilian Dry Diagonal is a broad region of diverse and unique habitats between the wetter Amazon basin and the moist tropical and subtropical Atlantic Forest, and its arid landscape harbors many unique species in the most endangered set of habitats in Brazil. Using a diverse set of approaches to study a variety of animals, plants and fungi that today inhabit this broad swath of dry habitats in central Brazil, this research will be the first to synthesize information from species' traits, communities and genetics to understand how the unique traits and communities of organisms living in the region originated, evolved and diversified. The project engages a large team of experts from the United States and Brazil and provides interdisciplinary research training opportunities for undergraduate students, graduate students and postdoctoral researchers. The results will improve scientists' ability to predict the impacts of a changing world on biodiversity.

Gonzalo Giribet is the Principal Investigator for Collaborative Research: The Opiliones of New Zealand: Revisionary Synthesis and Application of Species Delimitation for Testing Biogeographic Hypotheses, a five-year research

grant for \$752,233 from the National Science Foundation. New Zealand offers an ideal setting in which to combine the study of evolution and biogeography—the distribution of living beings in space and time. The archipelago has been shaped by isolation from other landmasses since it split from Gondwana approximately 80 million years ago and subsequently experienced drastic flooding, massive mountain building and changing climate, all of which left a signature on its biota. This research aims to study these historical processes while conducting a revision of the arachnid order Opiliones—harvestmen or daddy long-legs—witnesses of these geological changes throughout their evolutionary history. The research team combines classic taxonomic methods with cutting-edge molecular approaches to understand their diversity and evolutionary history. The research will also contribute to disseminating evolutionary



research in islands through museum exhibits and train the next generation of evolutionary biologists able to combine genomics with biodiversity discovery and analysis.

Mansi Srivastava is the Principal Investigator for the CAREER Grant The Evolution of Gene Regulatory Networks for Regeneration, a \$950,000 six-year grant from the National Science Foundation. Regeneration is a fascinating phenomenon whereby an adult animal makes new cells and structures in response to injury, but how does the animal know that it has lost organs and how does



Thraupis sayaca. Photo by Kelsie



Aoraki denticulata major. At right, Pantopsalis coronata



it make the right cells in the right places? This project focuses on understanding, at the cellular level, how the earliest responses upon injury lead to correct regeneration of missing tissues. Although many animal species can regenerate, the details of the underlying molecular pathways and how these pathways compare across species remain unknown. Biological pathways acquire changes in all species over the course of many generations, but evolution tends to preserve pathways that are essential. By studying two species of distantly-related worms that both have impressive regeneration abilities, this project will reveal which aspects of regeneration are shared, and hence essential.



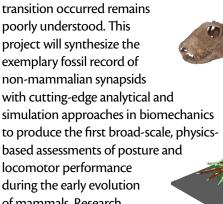
Hofstenia miamia

The general principles of regeneration identified through this work will have relevance to regenerative medicine.

George V. Lauder is a Principal Investigator for IntBIO Collaborative Research: Deep Time, Development, and Design: Evolution of Shark Skin Teeth from Genotype to Phenotype to Prototype, a three-year research grant from the National Science Foundation for \$431,276. The skin of sharks is unique among vertebrate animals because it contains tooth-like scales, called dermal denticles, that create a hard external armor. These denticles evolved over millions of years and equip the shark with hydrodynamic skin that reduces the cost of moving through the water. Working in collaboration with co-Pls Prof. Gareth Fraser (University of Florida) and Dr. Elizabeth Sibert (Yale University), this

project aims to provide a complete integrated understanding of shark denticles: how they form in embryonic sharks, how denticle shape has changed over years of evolution, and which denticle types are the best for drag-reduction and further design advances. This knowledge will enable better use of shark skin technology to make advanced design solutions that contribute to a more environmentally friendly world, such as the development of surface structures on airplanes or boats that reduce drag and decrease fuel emissions.

Principal Investigator Stephanie E. Pierce and postdoctoral fellow Peter Bishop were awarded Integrating the Fossil Record with Computer Simulation to Reconstruct Posture and Locomotor Evolution in the Ancestors of Mammals, a three-year research grant from the National Science Foundation for \$544.317. Modern mammals display remarkable locomotor diversity, including running, hopping, digging and flying. This diversity was facilitated by profound transformation in anatomy, stance and gait in the extinct ancestors of mammals, the non-mammalian synapsids. Fundamental to this was a shift away from a reptilian-like "sprawled" limb posture and movement pattern to the "erect" posture and movement pattern used by terrestrial mammals today. Despite its pivotal role in shaping modern mammals, exactly how and when the "sprawling-to-erect"



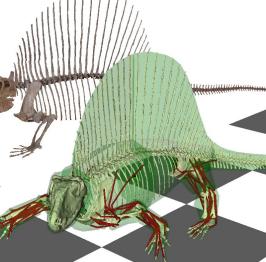
during the early evolution of mammals. Research outcomes will showcase

interdisciplinary research in paleontology and biomechanics and provide the foundation for a strong program of outreach focused on increasing diversity in the sciences.





Shark eye and denticles. Photos by the Lauder Lab



3D musculoskeletal model showing the sprawling posture of *Dimetrodon milleri* (MCZ VPRA-1365) by Peter Bishop



# Research Making Headlines

# Sweet Song, Sweet Taste



Phylidonyris novaehollandiae. Photo by Gerald Allen/Macaulay Library 340326621

Songbirds originated in Australia around 50 million years ago and have radiated worldwide, with around 4,000 known species. Was their success due in part to the plentiful high-energy carbohydrates of those ancient forests—nectar in flowers, sweet sap from eucalyptus trees, and lerp and honeydew excretions from insects? However songbirds, like all birds, descended from carnivorous dinosaurs, which are not thought to have been able to taste sugars. To

investigate this conundrum, **Scott V. Edwards**, **Maude W. Baldwin**, **Simon Yung Wa Sin** and colleagues undertook a six-year study to examine songbirds' ability to taste sugars and how, and when, they developed this capability.

First, the researchers offered a choice of sucrose and plain water to songbirds that prefer nectar (honeyeaters) and those that dine on

# receptors from honeyeaters, canaries and other songbirds that usually consume insects and grains and determined that, regardless of dietary preference, the birds could perceive sweetness. Next they synthesized and tested receptors inferred to have been present in the songbird ancestor and confirmed that early songbirds could respond to sugars, and because the molecular basis for acquiring this ability is complex, it is likely that it developed early in songbird evolution and was retained.

grain (canaries), finding that both preferred

the sugar water. Then, in the laboratory, the

team experimentally isolated and tested taste

Surprisingly, while songbirds and their distant relatives hummingbirds convergently evolved to detect sweetness by repurposing a savory (umami) receptor, the researchers found that they did so by modifying different parts of the receptor to achieve the same ends.

Toda Y, Ko M-C, Miller ET, Rico-Guevara A, Nakagita T, Sakakibara A, Uemura K, Sackton T, Hayakawa T, Sin SYW, Ishimaru Y, Misaka T, Oteiza P, Crall J, Edwards SV, Buttemer W, Matsumura S, Baldwin MW (2021) Early origin of sweet perception in the songbird radiation. *Science* 373:226–231 DOI: 10.1126/science.abf6505



Hofstenia miamia

# Glow, Worm, Glow

Transgenesis is the method by which researchers introduce a foreign substance into an organism's genome to study how tissues or cells work within an animal's body. Researchers at Harvard have used transgenesis to introduce DNA molecules that enable certain types of cells to glow in *Hofstenia miamia*, the three-banded panther worm. Over the last ten years, *H. miamia* has been developed by **Mansi Srivastava** as a model organism for the study of whole-body regeneration.

In their study, Srivastava and postdoctoral researcher **Lorenzo Ricci** used microinjection to introduce genes into the tiny worm's embryos that cause the targeted cells to fluoresce under blue or green light. Because the life cycle of *H. miamia* is completed within two months, and adults produce an average of four embryos a day that hatch within eight or nine days as juvenile worms, several

generations of multiple stable transgenic lines were created within six months. The various lines have fluorescent muscle, digestive or epidermal cells, allowing these cells to be observed *in vivo* and during the regeneration process. The researchers have already determined that *H. miamia* muscle cells have extensions that interlock in columns, creating a tightly interwoven grid that provides support for the worm, much like a skeleton.

The development of transgenesis in *Hofstenia* will provide a toolkit for the study of cells and particularly neoblasts, pluripotent stem cells in adult worms that can develop into any cells in the body, eventually contributing to the understanding of the regenerative process in humans.

Ricci L, Srivastava M (2021) Transgenesis in the acoel worm Hofstenia miamia. Dev Cell 56:3160–3170 DOI: 10.1016/j. devcel.2021.10.012



# **Trilobite Titillation**

Trilobites were one of the earliest large complex organisms and have a long evolutionary history spanning from the Cambrian to the Permian, encompassing some 250 million years. Trilobites are abundant in the fossil record because of their calcium-based exoskeleton, but this exoskeleton also obscures ventral and internal features that could provide clues about their biology, such as how they reproduced. In a paper in Geology, graduate student Sarah R. Losso and Javier Ortega-Hernández reveal how an exceptionally preserved, uniquely broken fossil specimen of a trilobite sheds light on its mode of reproduction.

The specimen of the trilobite Olenoides serratus from Toronto's Royal Ontario Museum was collected from the Burgess Shale of British Columbia, Canada, a site of exceptional fossil preservation that provides information about soft tissues, such as legs, that are not usually recorded in the fossil record. The exoskeleton of this particular specimen is broken in a way that

reveals some of these rarely seen underlying appendages.

A detailed analysis of the fossil showed specialized clasper-like appendages in the mid-body, which the researchers theorize were used by the male to grasp the female's spines and place it in the appropriate position to fertilize eggs released by the female in external

fertilization analogous to that of the modern horseshoe crab. While there were most likely a variety of reproduction methods in the more than 20,000 described species of trilobites, the existence of claspers for positioning shows that complex mating strategies developed relatively early during the Cambrian explosion.

Losso SR, Ortega-Hernández J (2022) Claspers in the mid-Cambrian Olenoides serratus indicate horseshoe crab-like mating in trilobites. Geology 50:897-901 DOI: 10.1130/G49872.1



Reconstruction of mating by Holly Sullivan



Olenoides serratus

# A Reason to Love Leeches

Wildlife protected areas often have conservation as their goal, but surveying the animals within the area can be resource-intensive and logistically challenging. In a study in Nature Communications, Naomi E. Pierce, Christopher Baker, Yuanheng Li, Zhengyang Wang, Douglas W. Yu and colleagues demonstrate the effectiveness of using environmental DNA to map vertebrates in the Ailaoshan National Nature Reserve in Yunnan, China.

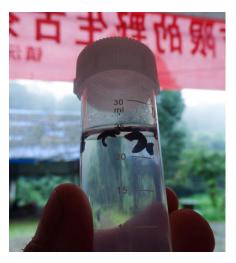
In the 260-square-mile Ailaoshan Reserve, researchers worked with 163 volunteer park rangers to collect more than 30,000 leeches that had fed on wildlife across the reserve. The team extracted DNA from the blood meals of the leeches to look for DNA found only in vertebrates, and because leeches don't move around much, they were able to use multi-species occupancy modeling to map species within the reserve. The team identified 86 vertebrate species including amphibians, mammals, birds and squamates, some of which are listed as threatened or near-threatened by

IUCN, and determined that species richness increases with elevation and distance from the reserve's edge. They also found the DNA of

cows, sheep and goats predominantly along the edge of the reserve, suggesting that domestic animals from surrounding farms are grazing on the reserve, potentially degrading it and competing with the wild animals for resources.

In addition to using environmental DNA on a large scale as a costeffective, real-world conservation tool in tropical or subtropical areas, this method shows promise as a way to track zoonotic reservoirs of disease by also screening leech blood meals for viruses.

Ji Y, Baker CM, Popescu VD, Wang J, Wu C, Wang Z, Li Y, Wang L, Hua C, Yang Z, Yang C, Xu CCY, Diana A, Wen Q, Pierce NE, Yu DW (2022) Measuring protected-area effectiveness using vertebrate distributions from leech iDNA. Nat Commun 13:1555 DOI: 10.1038/s41467-022-28778-8





# Keel Yong Lee, Sung-Jin Park, Kit Parker

# A Tiny Fish with Heart

A miniscule biohybrid fish that swims by recreating the muscle contractions of a beating heart may ultimately contribute to developing an artificial heart that could grow along with a child. Created by a team from Harvard, Emory and Georgia Tech Universities that includes George V. Lauder and lab member David Matthews, it is the first autonomous biohybrid device made from cardiac muscle cells derived from

human stem cells.

Inspired by the shape and swimming motion of a zebrafish, the device has two layers of muscle cells on each side of the tail fin so that when one side contracts, the other stretches in a mechanoelectrical process that moves the fish though the water in a way that mimics a beating heart. The researchers also engineered an autonomous pacing node, like a pacemaker, which controls the frequency

and rhythm of contractions, allowing the fish to swim by itself for up to 100 days. Interestingly, the researchers found that the biohybrid fish gets more robust as it ages. Muscle contraction strength, maximum swimming speed, and muscle coordination all improved during the first month as the cardiac cells matured, allowing the device to eventually reach the swimming speed of a living zebrafish in the wild.

In future research, the team plans to build even more complex biohybrid systems from human heart cells in their quest to create more complex artificial pumps and provide a platform to study human diseases like cardiac arrhythmias.

Yong Lee K, Park S-J, Matthews DG, Kim SL, Antonio Marquez C, Zimmerman JF, Ardoña HAM, Kleber AG, Lauder GV, Parker KK (2022) An autonomously swimming biohybrid fish designed with human cardiac biophysics. *Science* 375:639–647 DOI: 10.1126/science.abh0474

# Long in the Tusk

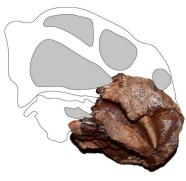
Tusks are an extreme example of evolutionary specialization. They evolved independently in a variety of mammals, from small hyraxes to massive elephants, and are used for burrowing, defense and sexual selection. But to investigate the ancient origins of mammal tusks, Megan Whitney and colleagues had to first define tusks as continuously growing incisors or canines that can be replaced when broken, are composed of dentine, and are attached to the jaw with flexible soft tissue ligaments that can accommodate the growth process. Teeth, on the other hand, are dentine covered in tough enamel so that they cannot grow continuously and are attached without ligaments.

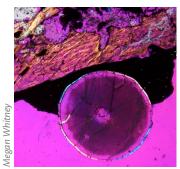
With this distinction in place, the researchers focused on Dicynodontia, an abundant premammalian clade that lived 270 to 210 million years ago, which are distinguished by two tusks extending from turtle-like beaks.

By analyzing wafer-thin slices of dicynodont tusks from ten different species and using micro-CT scans to examine tusk attachment to the jaw, the researchers determined that some species of dicynodonts developed the first true tusks. However, they were surprised to find that not all dicynodonts had tusks—some were just large teeth.

The study suggests that in order to develop evergrowing tusks, soft tissue ligament attachment had to become a permanent condition and the rate of tooth replacement had to be reduced. These findings may help explain how and why tusks evolved independently in so many lineages of mammals and inform the evolutionary development of tusks in extant animals.

Whitney MR, Angielczyk KD, Peecook BR, Sidor CA (2021) The evolution of the synapsid tusk: Insights from dicynodont therapsid tusk histology. *Proc R Soc B* 288:20211670 DOI: 10.1098/rspb.2021.1670







# HIGHLIGHTS FROM THE COLLECTIONS

# **Flight of Fancy**

Jeremiah Trimble (2)

The Ornithology collection acquired four dioramas of 69 mounted specimens from the 1800s as a gift from Amy Krell. According to Curatorial Associate Jeremiah Trimble, "The specimens are very diverse and are mounted in lifelike positions and postures. The vast majority of species are from New England, but since there are no collections data associated with the specimens, they could have been acquired from further afield. There is at least one tropical species, the Brazilian tanager (Ramphocelus bresilius), but the most interesting birds are certainly the passenger pigeon (Ectopistes migratorius) and a heath hen (Tympanuchus cupido cupido), both extinct."

The specimens were prepared by Samuel Jillson, who lived from 1827 to around 1887. Although little is known about who collected the specimens, where they were collected or for whom the dioramas were created, some specimens may have been collected by Jillson himself. He was one of the earliest and best-known

taxidermists in the region and was even visited by Henry David Thoreau. As Thoreau noted in his journal: "Called at the shop where lately Samuel Jillson, now of Feltonville, set up birds, — for he is a taxidermist and very skillful; his own birds and with blow-guns, which he makes and sells, some seven feet long, of glass, using a clay ball. Is said to be a dead shot at six rods!" The specimens will be

used for research and education.



# **Anything but Boring**



Ruth Dixon Turner, one of Harvard's first tenured female professors, was the world's expert on Teredinidae—shipworms—which are not worms at all, but marine bivalve mollusks that damage submerged wood by boring into it. Turner played a significant role in building the MCZ's collection of teredos and pholads, also known as piddocks, which burrow into mud or clay. Turner collected mollusks from 1953 to 1993, contributing organisms in 243 different families as well as many other non-mollusk invertebrates, including a type specimen of a deep-sea echinoderm, Xyloplax turnerae, that is associated with wood timbers and was named for her. This creature was so bizarre that it was initially considered as a sixth class of echinoderm, but now it is recognized as an aberrant sea star.

"Turner's collecting methods included submerging boards and various species of wood, or wood treated with deterrents, for specific durations—generally years and subsequently extracting the boring species inside," says Curatorial Associate Jennifer Winifred Trimble. "Many of the wood boards that she used remain in the Malacology collection, even though they were broken up to extract the teredos." In the collection, nearly all of the teredos and pholads are preserved in ethanol to allow for continued morphological and molecular research, extending the life and value of her scientific and collections contributions far beyond Turner's own lifetime. Today MCZbase, the collections database, has 3,830 Pholadidae records and 11,908 Teredinidae records.



# Staff Highlight

Breda Zimkus, the new director of Collections Operations, has a long history with the MCZ. She first became associated with the Museum as a graduate student working on African amphibians with James Hanken and remained as a postdoctoral researcher. Wanting to use her degree and continue working with natural history collections, she accepted a project manager position to research and design the MCZ's Cryogenic collection, which was launched in 2012.

As director of Collections Operations, her mission is to help the MCZ embrace the vision of a 21st-century natural history museum. "The MCZ is a world-renowned center for research and education," says Zimkus. "Our specimens are at the center, but our people are the heart of the MCZ. I'm really lucky to have a great team in Collections Operations.



1elissa Aj

We coordinate the shared laboratories and facilities and manage MCZ-wide initiatives." One of these initiatives is the redesign of MCZbase, which will enrich the museum-wide collections database to improve functionality and accessibility. Zimkus is also focused on initiatives that will make the MCZ a more diverse and welcoming place.

But despite her familiarity with the MCZ, it still inspires wonder. "Any time I go into one of our collections, especially if I'm with a visitor, I feel like I'm seeing things for the first time. Our curatorial associates never cease to amaze me with something new or specimens with remarkable histories, such as birds owned by George Washington or fossils collected by Charles Darwin." Another impressive aspect of the MCZ's collections are the number of types, which are the actual specimens used to name and describe a species. "If you walk through Herpetology, for example, they're marked by ribbons around the jars. You look around and see red and blue ribbons everywhere, and it's absolutely incredible."

# Mutually Beneficial Relationships



Natural history museums and zoos/aquariums are repositories of biological specimens—museums hold preserved specimens while zoos and aquariums care for living animals—and these organizations generate a wealth of valuable data about their collections. Museum records contain information such as when and where the animal was collected and by whom, and they make these specimens and related data available for researchers studying taxonomy, genetics, biogeography, ecosystems and biodiversity. Zoos, on the other hand, have extensive records on the animals in their care, such as life history, illnesses and treatments, behavior, breeding, blood chemistry and genetics. Partnerships between these organizations, if they exist at all, are often informal and information sharing ad hoc, but there is increasing interest in developing official, mutually beneficial partnerships.

The MCZ has received specimens from zoos and aquariums across the country and around the world. Some specimens, like a Caribbean monk seal provided by the New York Aquarium, are now extinct. The earliest donation on record is from 1929, when an American black bear was received from the Stone Zoo in Stoneham, Massachusetts, highlighting the long cooperation between the MCZ and Zoo New England, made up of Stone Zoo and Franklin Park Zoo in Boston, Massachusetts. "I think that as wild populations continually decrease, the benefits of zoo-museum partnerships will be increasingly important," says Mark Omura, curatorial associate in Mammalogy. "Because of these population declines and increasing regulation, it is becoming more difficult and less desirable to collect animals in the wild. And in addition to being used for anatomical and other studies, modern specimens contribute tissue samples that are cryogenically preserved to keep DNA viable for genetic research long into the future." This gives the animals a very long life, indeed, and could contribute to the conservation of the species and benefit society as a whole.

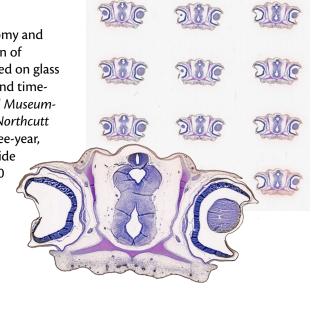
# **PROJECTS & INITIATIVES**

# **Bringing Data into Focus**

The MCZ has received National Science Foundation funding for three digitization grants that will create and serve specimen records, benefitting both science and society.

# The Evolution and Development of the Vertebrate Brain

The R. Glenn Northcutt Collection of Comparative Vertebrate Neuroanatomy and Embryology is the world's largest and most taxonomically diverse collection of histological preparations of developing and adult vertebrate brains mounted on glass microscope slides, but the slides are fragile and access to them is difficult and timeconsuming. James Hanken is the Principal Investigator for Creating a Novel Museum-Based Resource for Neuroscience: Mass Whole-Slide Imaging of the R. Glenn Northcutt Collection of Comparative Vertebrate Neuroanatomy and Embryology, a three-year, \$651,747 grant. The project will use a high-throughput, semi-automated slide scanner to make high-resolution digital images of the approximately 33,000 glass microscope slides in the Northcutt Collection. According to Hanken, "By utilizing a whole-slide-imaging workflow developed in collaboration with Harvard's Center for Brain Science, the project will allow professional scientists, educators and students to easily and routinely access the slides' content via high-resolution digital images."



# **Watching Out for the Bees**

While bees and other insects pollinate most wild plants and are critical to a large proportion of global food production, our understanding of the factors driving their declines is limited without data on the distribution of bee species and the behavioral and anatomical traits that make them vulnerable or resilient to human-induced environmental changes. Naomi E. Pierce and Crystal Maier are the lead investigators for the three-year, \$177,103 grant Extending Anthophila Research through Image and Trait

Digitization (Big-Bee), which will digitally capture data and images from historic specimens in natural history collections, develop tools to measure bee traits from these images, and generate a comprehensive bee trait and image dataset to measure changes through time. In partnership with 13 institutions and US government agencies, the Big-Bee Thematic Collection Network will create over one million high-resolution 2D and 3D images of bee specimens representing over 5,000 worldwide bee species and engage the general public in crowdsourcing trait measurements and data transcription from images.

# Fast as Lightning

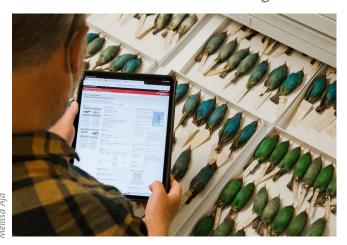
Insects are the largest and most diverse class of animals and they play essential roles in ecosystems and the resulting services to society. Natural history museum entomological collections provide critical information about the past from which scientists can assess current and future global change impacts. Naomi E. Pierce and Crystal Maier are the lead investigators for the three-year, \$111,116 grant LightningBug, an Integrated Pipeline to Overcome the Biodiversity Digitization Gap, which seeks to facilitate data acquisition from pinned insects in collections. "At present, only 5% of specimens have transcribed labels and less than 1% of specimens are imaged," says Pierce. "The LightningBug project will break through this digitization bottleneck by establishing a semi-automated workflow involving advancements in robotic multiview imaging, information extraction and 3D reconstruction." The results will also have applications in areas like computer graphics, product imaging, motion pictures, 3D animation, virtual and augmented realities, and education.



Colleagues from Yale University



# **MCZbase Redesign**



MCZbase, the Museum's centralized specimen database, contains records associated with specimens in ten research collections. It is currently undergoing a redesign to rework the web-based user interface, enhance access for users, improve digital accessibility and add new capabilities. Originally deployed in 2007, the code grew organically based on needs across the Museum. The redesign is unifying how the system works, facilitating the addition of new features, and improving usability across a variety of devices and screen sizes. Because it can be more easily used from mobile devices, the new MCZbase provides instantaneous and up-to-date access to data for researchers in the field, staff in the collections and students in their classes, making it much easier to discover and explore information about MCZ collections.

The redesign project has been a long-term effort by Collections Operations staff, including Paul Morris, biodiversity informatics manager; Michelle Kennedy, collections information and database specialist; Brendan Haley, senior database manager; Breda Zimkus, director of Collections Operations, and her predecessor, Linda Ford. Other collections operations team members, including Jonathan Woodward, Jeremy Kisala, and Emily Blank, have been involved in the design process and tested redesigned components. The most visible and utilized public-facing pages—specimen search, specimen results and specimen details—went live in August 2022 and users have reported that MCZbase's new presentation has greatly improved readability while delivering a higher density of information about the specimens.

"The redesign effort has illuminated the enormous advantage of maintaining a database and data interface that can keep up with ever-changing standards, regulations and community concepts, as well as evolve with staff workflows and curatorial practices," says Zimkus. The new and improved platform allows for deeper and more complex connections to external data aggregators, data authorities and other museums and increases the presence and importance of MCZ data in an ever-evolving extended specimen network.

# **Ernst Mayr Library**



The Ernst Mayr Library supports the people and collections of the MCZ and the educational mission of the University by sharing print collections, archives and digital assets on site and online through the website, library guides and social media. After closing in March 2020, the library returned to regular visiting hours this year and course-related visits resumed. The staff answered over 2,500 research and reference queries, participated in orientation tours, and presented a new display in the library, *The Art of Alexander Wilson and Titian Peale*, featuring original artwork, books and archives from Special Collections. The library continues to enhance Biodiversity Heritage Library content while focusing on unique EML/MCZ collections, with 92 volumes added to BHL (9,603 pages) and over 5,000 digitized pages of handwritten MCZ archives transcribed in the past year.

This year library collections supported the development of exhibits and recognitions of notable people. In March, the Concord Museum opened the *Alive with Birds* exhibit that includes two items, William Brewster's 1886–1887 *Journal* and his *Field Notes on New England Birds*. Images from library collections appeared in the exhibit *Pasteur, Marcou & Co* at the Grande Saline Museum in Salins-les-Bains, France, honoring Jules Marcou, the MCZ's first librarian and lifelong friend of Louis Pasteur, and former MCZ Director **James Hanken** 

spoke about Marcou at events celebrating the 200th anniversary of Pasteur's birth. As part of reviewing the public spaces in the library and ensuring the images presented are welcoming, portraits of Louis Agassiz were replaced with items from the Museum's art collections, including portraits with signage describing the history of the people portrayed and their connections to the MCZ and the library.

# **Spotlight on MCZ Faculty-Curators**



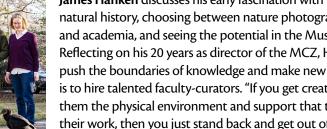
In the HMSC Connects! podcasts, Stephanie E. Pierce talks about growing up in fossil-rich Alberta, Canada, and how she is paving the way for diversity in the maledominated field of paleontology. "It's really important that we break old historical patterns and diversify the field so that everyone can have access to fossils, to knowledge, and follow their passions."

MCZ Director Gonzalo Giribet recounts scouring the beach for shells while growing up south of Barcelona, Spain, which led to his career as a scientist. "Museums are a library for biodiversity," Giribet says. "The specimens that we have in museums are an amazing resource, and in some places, this resource is untapped." His vision for the MCZ is to bring these untapped resources to the forefront for both researchers and the public.



James Hanken discusses his early fascination with natural history, choosing between nature photography and academia, and seeing the potential in the Museum's collections. Reflecting on his 20 years as director of the MCZ, Hanken says that to push the boundaries of knowledge and make new discoveries, the key is to hire talented faculty-curators. "If you get creative people and give them the physical environment and support that they need to do their work, then you just stand back and get out of their way."

Listen to these podcasts at hmsc.harvard.edu/podcast.



The second half of the 19th century saw the first marine laboratories in Europe, which were a new breed of research centers. In 1873, Louis Agassiz started a summer school on Penikese Island, Massachusetts, as an experiment that is now considered the predecessor of the first marine biological labs in the US. Soon after he died, his son Alexander became director at Penikese and of the MCZ.



The Penikese school closed in 1875 following a fire, and Agassiz acquired a small peninsula in Newport, Rhode Island, where he built a summer residence



Alexander Agassiz in his lab

and a private laboratory. This facility, later referred to as the Newport Marine Laboratory, is now considered one of the very first modern marine laboratories in the US, preceding the established labs of the East Coast (including the Marine Biological Laboratory at Woods Hole) and the big three of the West Coast (SCRIPPS, Hopkins and Friday Harbor). The details and facilities of Agassiz' laboratory were listed in the MCZ's annual report of 1877.

A peculiarity of Agassiz' laboratory is that it combined research following the MCZ tradition and instruction following the Penikese experiment, and thus hosted both

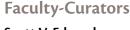
students of the MCZ and teachers. He provided "facilities for work to half a dozen teachers (three ladies and three gentlemen)" and as Agassiz himself described "it is my intention hereafter to divide the facilities at my command between students of the Museum and teachers of our common schools."



# **AWARDS & RECOGNITION**



Stephanie E. Pierce



Scott V. Edwards was elected as a member of the Royal Physiographic Society of Lund in honor of his scientific achievements and collaboration with University of Lund researchers.

Hopi E. Hoekstra was elected to the 2021 class of the American Association for the Advancement of Science Fellows in Biological Sciences, honoring her outstanding scientific contributions.

Javier Ortega-Hernández was awarded a collaborative Human Frontier Science Program Early Career award to study the water-to-land transition in euarthropods. Ortega-Hernández and Research Associate Rudy Lerosey-Aubril were awarded the Harvard Dean's Competitive Fund for Promising Scholarship to support investigating a new Cambrian site with exceptional fossil preservation.

**Stephanie E. Pierce** was awarded tenure in January 2022. Pierce, along with postdoctoral fellows **Megan Whitney** and **Peter Bishop**, received

Australian Synchrotron competitively allocated beamtime for their project "Unlocking the microanatomy of the early tetrapod *Ossinodus* to reveal how vertebrates colonized the land."

# **Postdoctoral Researchers**

Jenny Chen received a National Institutes of Health Pathway to Independence Award to support her postdoctoral work on the genetics of social behavior evolution.

**Amandine Gillet** was awarded the Marie Sklodowska-Curie Fellowship.

Jean-Marc Lassance received the Ulysse Incentive Grant for Mobility in Scientific Research supported by the Fund for Scientific Research.



Sarah R. Losso, Javier Ortega-Hernández and Karma Nanglu during field work in Morocco

**Sarah R. Losso** received the Sylvester-Bradley Award from the Palaeontological Association.

# **Graduate Students**

Jenni Austiff, Molly Gabler-Smith, Landen Gozashti, Richard J. Knecht, Arianna Lord, Katy Loubet-Senear, Sophie MacRae Orzechowski, David Matthews, Shoyo



Amandine Gillet

Sato (2), Connor White (2), Brock Wooldridge, Maya Woolfolk and Mark Wright each received a Certificate in Distinction in Teaching from the Derek Bok Center.

Landen Gozashti received a National Science Foundation Graduate Research Fellowships Program Honorable Mention.

Olivia Harringmeyer was a Society for the Study of Evolution W. D. Hamilton Award Talk Finalist and received the Best Student Talk Award (2nd place) at the Population Genetics Group Conference.



Catie Strong

Olivia Harringmeyer, Connor White, and Mark Wright each received a Robert A. Chapman Memorial Scholarship for Vertebrate Locomotion from the Harvard Faculty of Arts and Sciences.

Catie Strong received the Winifred Goldring Award, presented to an outstanding female student pursuing a career in paleontology, which is administered by the Association for Women Geoscientists and the Paleontological Society.

Maya Woolfolk was awarded a Gilliam Fellowship for Advanced Study from the Howard Hughes Medical Institute, a National Science Foundation Graduate Research

Fellowship, and a Genetics Society of America Presidential Membership.

# **Undergraduate Students**

Sorcha Rae Ashe was awarded a Hoopes Prize for her thesis project "Flying Colors: The Evolution of Wing Color and Color Vision in the Hyperdiverse Eumaeini Butterfly Tribe (Family: Lycaenidae)."

Graham L. Friedman was inducted into the Harvard chapter of the Phi Beta Kappa honor society.

### Staff

Many staff members celebrated long-term service anniversaries: Adam Baldinger, curatorial associate in Invertebrate

Zoology (25 years); Paul Morris, biodiversity informatics manager (15); Jennifer Winifred Trimble, curatorial associate in Malacology (10); and Murat Recevik, curatorial assistant in Malacology (20).

Jennifer Winifred Trimble was elected as a Society for the Preservation of Natural History Collections Member at Large.



Jennifer Winifred Trimble



Maya Woolfolk

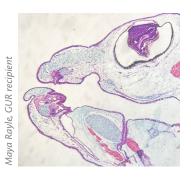




Beatrice H. Youd, GUR recipient



Maya Rayle, GUR recipient



Ambystoma mexicanum

# GRANT RECIPIENTS

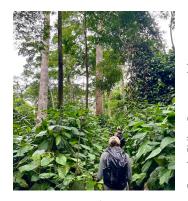
# Grants-in-Aid of Undergraduate Research

**GUR 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.



Copelatus briviori

Recipient	Academic Dept./ Faculty Sponsor	Project Title	Amount
Ella M. Bradford	OEB/Andrew Davies	Understanding the role of forest clearings in promoting biodiversity in rainforest ecosystems	\$1,000
Henry Cerbone	Engineering & Applied Sciences/Robert Wood	Studying the spatial dynamics of ant colony distribution in a semiarid landscape	\$6,000
Karen E. Cortina	OEB/Hopi Hoekstra	Investigating the role of the motor cortex on the dexterity of deer mice	\$1,000
Karen E. Cortina	OEB/Hopi Hoekstra	Exploring the role of the motor cortex on the fine motor skill of deer mice	\$1,000
Julia Doan	OEB/George Lauder	The hydrodynamic advantages of fish school swimming formation as it relates to energy expenditure	\$5,000
Katherine M. Enright	History of Science/ Janet Browne	From natural history to national heritage: The politics and museum display of colonial-era natural history objects in Singapore	\$4,357
Naomi Kaye Hegwood	OEB/Paul Moorcroft	Using spaceborne Lidar data to explore the effects of environmental factors on maximum canopy height	\$1,000
Magdalen M. Mercado	OEB/Stephanie Pierce	A quantitative analysis of forelimb morphology in extant quadrupeds and modern implications	\$1,000
Magdalen M. Mercado	OEB/Stephanie Pierce	A quantitative and functional analysis of humeral morphologies across tetrapoda and implications for the evolution of mammals	\$5,000
Logan T. Qualls	OEB/Javier Ortega- Hernández	Using parametric modeling to demonstrate the evolutionary pathways of Radiodonta	\$5,000
Maya Rayle	OEB/James Hanken	The evolution of salamander dentition	\$5,500



Beatrice H. Youd, GUR recipient



Katrine Worsaae and Sandra Garcés



GUR recipient Ella Bradford (second from left)

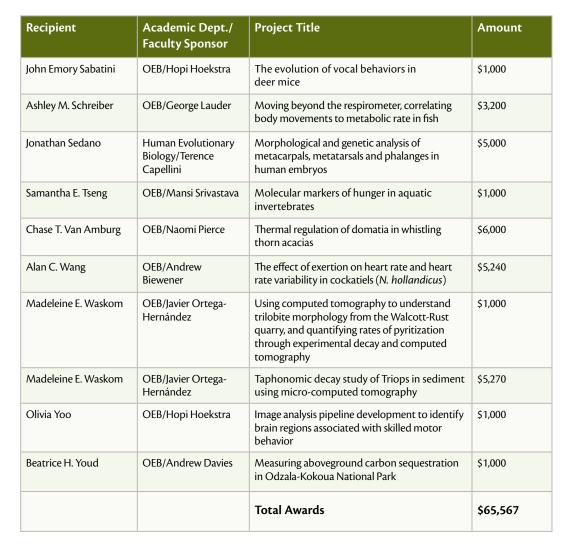




Salvelinus fontinalis by Ashley M. Schreiber, GUR recipient



Aratus pisonii by Jonas Geburzi, Putnam recipient









Henry Cerbone, GUR recipient



Crystal Maier, Jocelyn Wang, Richard J. Knecht, Chase T. Van Amburg (GUR recipient) and Nina Chung



Henry Cerbone (front), GUR recipient



# Gunnar Kramer, Putnam recipient

Baeolophus ridgwayi

Aluska Santos, EMG recipient



Mustela macrodon



Marília Pessoa Silva, EMG recipient

# **Ernst Mayr Travel Grants in Animal Systematics**

Ernst Mayr Grants (EMG) 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
David Chamé-Vázquez	Biological Research Centre of the North- West, Mexico	The spider family Plectreuridae Simon, 1893 (Araneae) in North America	\$1,940
Adaiane C. M. Jacobina	Federal University of Paraná, Brazil	Cladistic analysis of <i>Leptoschoinina</i> Lacordaire, 1865 (Coleoptera: Curculionidae: Baridinae)	\$2,000
Adrian Gómez Jácome	National Autonomous University of Mexico	Review of <i>Bittacus</i> Latreille (Mecoptera: Bittacidae) from North America, including Mexico	\$1,800
Bryan Jennings	University of California, Riverside	Taxonomic revision of two species complexes in the scincid lizard genus <i>Lerista</i>	\$2,000
Gabrielle Jorge de Melo	National Institute for Research in the Amazon	Taxonomic revision of S <i>cirtes</i> Illiger, 1807 (Coleoptera: Scirtidae) from Brazil	\$2,000
Lech Karpiński	Polish Academy of Sciences	Longhorned beetles (Coleoptera: Cerambycidae) of the tribes Trachyderini, Callidiini (Cerambycinae), and Dorcadionini (Lamiinae) of Central Asia	\$1,750
Lawrence Kirkendall	University of Bergen, Norway	The missing piece of the puzzle: The Chapuis Platypodinae in the Royal Belgian Institute of Natural Sciences	\$1,600
Natalia Ladino	Federal University of Paraná, Brazil	Taxonomic revision of <i>Prionopelta</i> Mayr, 1866 (Formicidae: Amblyoponinae)	\$2,000
Aline Lira	Rural Federal University of Pernambuco, Brazil	Systematics and natural history of <i>Udeus</i> Champion, 1902 (Curculionidae: Curculioninae: Eugnomini)	\$2,000
Yesenia Marquez Lopez	Metropolitan Autonomous University, Mexico	Taxonomic revision of owlflies of the subfamily Ascalaphinae (Neuroptera: Myrmeleontidae) of Mexico	\$1,500
Omar Ojeda Gómez	Metropolitan Autonomous University, Mexico	Taxonomy and systematics of the family Eulimidae (Mollusca: Gastropoda) in the tropical Eastern Pacific	\$2,000
Olivia Olson	Middlebury College	Sea minks ( <i>Neovison/Neogale macrodon</i> ) in context: Ecology, phylogeny, and extinction	\$950
Marília Pessoa Silva	University of São Paulo, Brazil	Cladistic analysis of the genus <i>Pseudopilanus</i> Beier, 1957 (Pseudoscorpiones: Chernetidae), with phylogeographic analysis of Brazilian populations	\$1,750
Jordan Rainey	Montana State University	Revision of the West Indian <i>Belonuchus</i> (Coleoptera: Staphylinidae Staphylininae) and an analysis of their phylogenetic placement in relation to mainland species	\$1,897
Aluska Santos	Federal University of Paraná, Brazil	Taxonomic revision of <i>Acanthoscelides</i> , the largest Neotropical genus of seed-beetles (Chrysomelidae: Bruchinae)	\$1,000
Natalie Saxton	Case Western Reserve University	Study of historic Australasian Scarabaeinae holdings in the Museum of Comparative Zoology, Harvard	\$1,700



Eodorcadion spp. by Lech Karpiński, EMG recipient

Recipient	Institutional Affiliation	Project Title	Amount
Sayali Sheth	National Centre for Biological Sciences, Tata Institute of Fundamental Research	A study of Himalayan <i>Copelatus</i> Erichson 1832 (Coleoptera: Dytiscidae) deposited in National Museum, Czech Republic	\$2,000
Itzahi Silva Morales	The College of the South Border, Mexico	Revision of aspidosiphonids (Sipuncula: Aspidosiphonidae) deposited at the Museum of Comparative Zoology, Harvard	\$1,900
Geusivam Soares	State University of Campinas, Brazil	Revision of genera <i>Chauhanellus</i> Bychowsky & Nagibina, 1969 and <i>Hamatopeduncularia</i> Yamaguti, 1953	\$2,000
Jack Stack	Virginia Polytechnic Institute and State University	The paleobiology of ancient ray-finned fishes (Actinopterygii) implies that jaw mobility evolved in the Late Paleozoic	\$2,000
		Total Awards	\$35,787



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
Brian D. Farrell	Entomology	The genomic basis of insect-plant coevolution: The Tetraopes-Asclepias arms race	\$12,816
Jonas Geburzi	Invertebrate Zoology/ Gonzalo Giribet	Up to the North and down from the trees: Genetic signatures of a century-long range expansion in mangrove tree crabs	\$5,157
Gunnar Kramer	Ornithology/Scott Edwards	Untangling the roles of genetic and regulatory mechanisms in adaptive responses to climate change	\$1,200
Sophie MacRae Orzechowski	Ornithology/Scott Edwards	Understanding regulatory and adaptive processes shaping neo-sex chromosome evolution in Australian honeyeaters	\$9,400
Naomi E. Pierce	Entomology	Bees from East Africa	\$10,000
Paula Rodríguez Flores	Invertebrate Zoology/ Gonzalo Giribet	Diversity screening of mutualism: Collecting crustacean samples and symbiotic data from the Marianas, Guam	\$13,775
Diego F.B. Vaz	Ichthyology/George Lauder	Taxonomic review of fish species of <i>Eviota</i> from Guam, Micronesia	\$10,440
		Total Awards	\$62,788



Paula Rodríguez Flores, Putnam recipient



Gunnar Kramer, Putnam recipient, and Nicole Mejia



Eviota prasites



Jack Stack, EMG recipient





### BIOLOGY LETTERS







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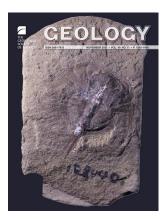
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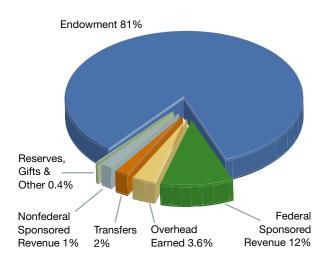
# FINANCIAI DATA

These charts describe the income and expenses of the Museum of Comparative Zoology in fiscal year 2021.

**Endowment** income funds much of the Museum's activities, such as acquisition and maintenance of collections, faculty and staff salaries, capital projects, and facilities renovation and maintenance. It includes the annual distribution (payout) and endowed funds decapitalized per donor request. 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. Draw on Restricted Reserves indicates restricted fund balances utilized to fund operations. 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 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**

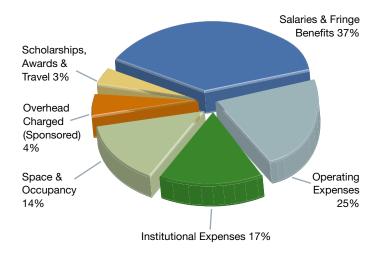


# Income

Total	\$20,054,209
Accumulation of Unrestricted Reserves*	(\$2,334,277)
Gifts	\$19,600
Other Income	\$25,014
Drawdown of Restricted Reserves	\$43,772
Nonfederal Sponsored Revenue	\$350,703
Transfers	\$394,677
Overhead Earned	\$814,645
Federal Sponsored Revenue	\$2,651,915
Endowment	\$18,088,160

<sup>\*</sup>Accounts for income received but not spent in FY22

### **EXPENSES & NON-OPERATING FUNDS**



### **Expenses**

\$2,869,963 \$814,645 \$516,760
, -,,-
\$2,869,963
\$3,322,214
\$5,010,983
\$7,519,644



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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

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The MCZ deeply appreciates the additional support and contributions of numerous interns and undergraduate students during the 2021–2022 academic year.

# **MCZ Faculty**

The MCZ's charter, signed in 1859, mandates that the Museum's activities will be overseen by a governing board, the Faculty of the Museum of Comparative

Mr. George Putnam III Mr. Jeff Tarr

Dr. Barbara Jil Wu President Lawrence S. Bacow

# **Acknowledgements**

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