OEBnews

2019–2020

Newsletter of the

Department of Organismic & Evolutionary Biology

HARVARD UNIVERSITY

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Welcome from the Chair

Elena Kramer
DEPARTMENT CHAIR
BUSSEY PROFESSOR OF ORGANISMIC AND EVOLUTIONARY BIOLOGY, HARVARD COLLEGE PROFESSOR,
INTERIM DIRECTOR, HARVARD UNIVERSITY HERBARIA

Dear Colleagues, Alumni, and Friends,

Wow. Well, where does one start to summarize an academic year like the one that just ended?

First, I want to say that I hope all of you and your loved ones are safe and well. I hope that you are taking care of yourselves, both physically and mentally. If you have suffered loss this year, I want to extend my personal condolences as well as those of the entire community.

Second, I want to let you know how proud I am of all of you. You have persevered with patience, fortitude, kindness, and generosity through unprecedented (aren't you tired of hearing that word?) times. We have all overcome challenges that we probably couldn't have imagined just a few short months ago. And while our challenges are not over, we will continue to implement everything we've learned about best practices to make sure that our community can continue its work while keeping each other safe.

Third, we must recognize the significance of this transformational period, as all aspects of our society seek to come to terms with centuries of systematic racism. This inflection point in history requires a sustained effort of self-education, serious introspection, and bold change. We look forward to working with the entire OEB community to shape a more inclusive future for our department, academia, and society writ large.

Saving the best for last, the good news – we do have things to celebrate. Although we missed honoring our IB concentrators and PhD graduates in person, we are enormously proud of all of them and look forward to a time when we can congratulate them face to face. We are also thrilled to recognize Prof. Ben de Bivort, who has been promoted to tenure in the department, and welcome our new Assistant Professor Benton Taylor, who will be starting at Weld Hill this summer. Even in tumultuous times, it is good to know that our academic rites of passage still endure. Our spirit of inquiry abides and we will continue to lift each other up to do our best work.

Please take some time to peruse the entire newsletter, there is more to celebrate within. Remember, you can follow all the latest news from OEB on our website, Instagram, and Twitter and we always welcome updates on your activities and accomplishments.

Best wishes,
Elena Kramer

Congratulations to our Graduates!

SEBASTIAN AKLE SERRANO

"Strategies for gene discovery and mechanistic insight using pleiotrophy and induced mutagenesis" (Michael Desai, Advisor)

CAITLIN BAKER

"Phylogenetics and biogeography of soil invertebrates across Gondwana" (Gonzalo Giribet, Advisor)

JACOB COHEN

"The ecophysiology of iron-oxidizing *Zetaproteobacteria*: Microbe-mineral interactions, transcriptomic responses, and biomineralization" (Peter Girguis, Advisor)

BLAKE DICKSON

"Evolution of the tetrapod forelimb and functional morphology of the humerus across water-land transitions" (Stephanie Pierce, Advisor)

NATHAN EDELMAN

"Evolutionary effects of hybridization" (James Mallet, Advisor)

HOLLY ELMORE

"Ecological population genomics in the emerging *Amanita* system" (David Haig, Advisor)

Congratulations to our Graduates!

JACOB GABLE

"The behavioral consequences and developmental genetic causes of whisker evolution in deer mice" (Hopi Hoekstra, Advisor)

ÉADAOIN HARNEY

"Exploring the human past during the ancient DNA revolution" (John Wakeley and David Reich, Advisors)

BRENT HAWKINS

"Latent developmental potential to form limb-like structures in fish fins revealed by mutations in the Vav2/N-WASP pathway" (James Hanken and Matthew P. Harris, Advisors)

MARA LASLO

"Evolutionary conservation of endocrine-mediated development in the direct-developing frog, *Eleutherodactylus coqui*" (James Hanken, Advisor)

AVANTIKA MAINIERI

"The sins of our kin: From genomic imprinting to ancient signaling systems" (David Haig, Advisor)

PAVITRA MURALIDHAR

"On the evolution of sex and its consequences" (David Haig and Jonathan Losos, Advisors)

NATHAN RANC

"The interplay between memory and resource preferences drives animal space-use patterns" (Paul Moorcroft and Francesca Cagnacci, Advisors)

Research Highlights

~ PhD candidates, **Sam Church** and **Bruno de Medeiros**, Research Associate **Seth Donoughe** ('18), and **Prof. Cassandra Extavour** disprove an old hypothesis and prove a new one. Their study published in *Nature* analyzed a large data set to challenge the untested assumptions about egg size in insects. Analyzing across all insects — which make up 80 percent of all animal species on Earth — the team found no universal scaling, no restriction of certain shape eggs to certain sizes and no evidence that larger eggs take longer to develop. Examining 3,000 papers dating back 300 years, the team was able to prove egg size and shape is more a product of the ecology the animal inhabits. In addition to the published study, *Nature* also featured an in-depth interview with Prof. Extavour.

~ Dolphin skin has long inspired research on drag reduction mechanisms due to the presence of skin ridges that could reduce fluid resistance. PhD candidate **Dylan Wainwright** and **Prof. George Lauder** collected in vivo three-dimensional surface data on the skin from five species of odontocetes (cetaceans that includes dolphins, porpoises, and whales possessing teeth) to quantitatively examine skin texture, including the presence and size of ridges. The team molded the skin of live dolphins to study the texture of their skin and how it might relate to flow around dolphins during swimming. Previously, scientists found dolphins have small ridges on their skin and there is some debate if the ridges somehow help dolphins swim more efficiently by changing how water flows around their bodies. The study published in *Biology Letters* also found ridges on dolphins; however, the ridges aren't present in all individuals and they are generally very small. Simple fluid mechanics equations revealed the ridges are too small to be changing water flow around dolphin bodies in any appreciable way.

~Crows are one of the few animals known to make tools. New Caledonian crows in particular stand out

Faculty Notable Awards

-Javier Ortega-Hernández and Research Associate Rudy Lerosey-Aubril awarded the William F. Milton Fund.

-Pardis Sabeti awarded the Merck Future Insight Prize.

-Hopi Hoekstra awarded the C. Hart Merriam Award from the American Society of Mammalogists.

-Naomi Pierce awarded the 35th International Prize for Biology of Japan Society in the field of Biology of Insects.

-Andrew Biewener named fellow of the American Association for the Advancement of Science (AAAS).

-Stephanie Pierce awarded the Fannie Cox Prize for Excellence in Science Teaching.

-Peter Girguis awarded the Gordon and Betty Moore Foundation grant as part of the Symbiosis in Aquatic Systems Initiative investigator program.

-Scott Edwards and colleague Dr. Richard Kliman (Cedar Crest College) recipients of the inaugural Inclusiveness, Diversity, Equity, and Access (IDEA) Award bestowed by The Society for the Study of Evolution, The American Society of Naturalists, and the Society of Systematic Biologists.

-Mansi Srivastava appointed Editor-in-Chief of *EvoDevo Journal*.

-Cassandra Extavour named Harvard College Professor.

-Robin Hopkins awarded the Graduate School of Arts and Sciences Everett Mendelsohn Excellence in Graduate Mentoring.

-Pardis Sabeti and colleague Christian Happi (Redeemer's University, Nigeria) awarded TED's Audacious Project funding.

-Peter Girguis awarded the Petra Shattuck Excellence in Teaching by the Harvard Extension School.

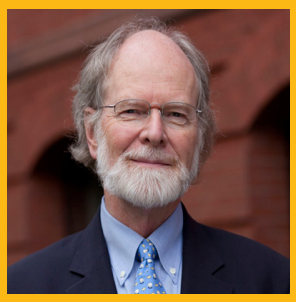
for manufacturing multiple complex tools and refining their designs. A study in *Current Biology* led by PhD candidate **Dakota McCoy** (Haig Lab) suggests the crows do it because it makes them happy. McCoy devised an experiment to test how optimistic the birds were feeling making and using tools. McCoy's findings suggests that in much the same way humans enjoy something like solving puzzles, the birds enjoyed simply using a tool. The study, including a video of crows using tools, was featured in the *Harvard Gazette*.

~ **Prof. L. Mahadevan's** study in *Proceedings of the National Academy of Sciences* offers insight into treatments for diseases like ALS, Alzheimer's, Parkinson's and other diseases in which protein aggregation (misfolded proteins clump together) is implicated. While the role of protein aggregation is not fully understood many current treatments target the aggregation process; however, finding the right treatment protocols for these drugs is challenging. Mahadevan and team developed a mathematical model to better understand how drugs inhibit the growth of protein fibrils and offered a guide to develop more effective strategies to target protein aggregation diseases.

~ Roopkund Lake is a small body of water nestled deep in the Himalayan mountains and is known colloquially as Skeleton Lake due to the remains of several hundred ancient human bones scattered around its shores. The skeletons have never been studied so little is known of their origins. PhD candidate **Éadaoin Harney** (Wakeley Lab) and an international team of researchers analyzed the remains using bioarcheological analysis and discovered three genetically distinct groups deposited at different times approximately 1000 years apart. Of the 38 skeletons examined, 23 are typical of present-day South Asians, 14 are typical of eastern Mediterranean. The study published in *Nature Communications* refutes previous suggestions that the skeletons were deposited in a single catastrophic event. Harney's study was covered by *National Geographic* and *The Atlantic.*

~ **Prof. L. Mahadevan** collaborated with the European Molecular Biology Laboratory (EMBL) to discover what controls the size of an embryo. The study published in *Nature* found that embryos maintain

In Memoriam



James J. McCarthy: January 25, 1944 - December 11, 2019

With profound sadness, we note the passing of our dear friend and colleague Jim McCarthy on December 11, 2019 after a protracted illness.

Professor McCarthy was a member of the Intergovernmental Panel on Climate Change (IPCC) which received the Nobel Peace Prize in 2001. In 2012 he was appointed to the U.S. Arctic Research Commission by President Barack Obama. He was honored as Scientist of the Year in 2009 by the Harvard Foundation and awarded the 2018 Tyler Prize for Environmental Achievement for his decades work on climate change.

Al Gore, Former Vice President of the United States, said of Jim, "Dr. James McCarthy was an amazing man, a loyal friend, world-class oceanographer, a passionate advocate for science and for our climate balance. Nobody communicated the importance of the climate crisis in the context of the oceans as eloquently and passionately as Jim. His dedication to better understanding our planet through its oceans will continue to enable and empower us as activists, citizens, and leaders fighting to solve this crisis."

Harvard University Center for the Environment posted an In Memoriam page with videos and podcasts featuring Jim, as well as kind words from the community.

Jim was a towering figure, whose impact as a scholar, policy advisor, and human being was extraordinary. The OEB community is greatly diminished by his loss, and we will all feel Jim's absence deeply.

an average size in early development through simple hydraulic pressure. During early stages of embryonic development, a fluid-filled cavity grows and expands. Using mouse embryos, researchers observed that the cavity repeated the process continuously, which allowed the embryo to maintain a steady, average size throughout initial stages of development. SEAS features a video of the process.

~ Tuna are highly efficient swimmers, migrating thousands of miles across the Pacific from California to Japan. They are also among the fastest fish in the water reaching speeds of nearly 50 miles per hour. **Prof. George Lauder** has been trying to understand how they are capable of both speed and efficiency by developing robots to model tuna's flexible underwater gait. Working with a team of researchers from the University of Virginia, Lauder developed Tunabot, the first robotic tuna that accurately mimics tuna's highly efficient swimming style and high speed. Tunabot is described in a paper published in *Science Robotics* and featured in the *Harvard Gazette*, which included a video of Tunabot in action.

~ **Prof. Pardis Sabeti** and researchers at the Broad Institute have turned a CRISPR RNA-cutting enzyme into an antiviral that can be programmed to detect and destroy RNA-based viruses in human cells. Many of the world's most common or deadly pathogens are RNA-based viruses. The study in *Molecular Cell* is the first to harness CAS 13 enzyme, or any CRISPR system, as an antiviral in cultured human cells.

~ PhD candidates **Nate Edelman** (Mallet Lab) and **Michael Miyagi** (Desai & Wakeley Labs) and researchers including **Profs. James Mallet** and **John Wakeley** have found evidence for widespread hybridization and gene flow between different species of Heliconius butterflies. The team, led by Nate Edelman, looked at a group of neotropical butterflies and found that different species have been hybridizing with each other throughout their millions-of-years-old history. They developed a new method to identify parts of the genome that were particularly impacted by hybridization and showed the process of recombination is widespread and important to the evolutionary process. The study published in *Science Magazine* shows the messiness of the speciation process and

Welcome Benton Taylor

Benton Taylor joined OEB as Assistant Professor of Organismic and Evolutionary Biology.

Taylor's research focuses on how terrestrial ecosystems respond to various global change drivers such as rising CO_2, nutrient pollution, human land use, and extreme weather events, and how these ecosystem responses, in turn, influence the trajectory of global change. His work spans from tropical rainforests to the tundra and encompasses scales from physiology to ecosystems. His work in particular focuses on the influence of symbiotic nitrogen-fixing plants on ecosystem dynamics, the below-ground responses of trees to elevated CO_2, and the processes that drive soil carbon storage. Taylor combines field and greenhouse experimental manipulations, large-scale observational studies, and global data analyses to illuminate the web of interactions between human activity, terrestrial ecosystem processes, and global change.

Benjamin de Bivort Promoted

Benjamin de Bivort has been promoted to Professor of Organismic and Evolutionary Biology. His work straddles the fields of neurobiology and behavior, driving pioneering discoveries about the biological bases of behavioral biases.

de Bivort largely invented the study of random variation in the brains and behaviors of individual animals whose genetic and environmental differences have been minimized.

Research Spotlight

Over the course of 18 months, **Prof. Javier Ortega-Hernández** has published five studies in an ongoing collaboration with Prof. Yu Liu (Yunnan University, China), visiting scholar in Javier's lab. Ortega-Hernández and Liu are studying, and often restudying, arthropod fossils from the early Cambrian Period in the Chengjiang biota in the Yunnan Province of China — which contains one of the most species-rich and well-preserved fossiliferous deposits for the early Cambrian — using microCT to reveal exceptional details of the preserved anatomy that are completely inaccessible through conventional preparation tools. Though species-rich and well-preserved, several Chengjiang arthropods have an unfamiliar morphology, are extremely rare, or are incompletely preserved, which often leads to many of these species being problematic, poorly known, or often both; thus hindering their contribution towards reconstructing the evolution of this major animal group. By focusing on the Chengjiang biota and using microCT Ortega-Hernández and Liu were able to produce highly detailed and informative virtual models in 3D that reveal similarities, ecology and evolutionary significance for the first time. Each publication tells a distinct story for the early evolution of arthropods while following the same overall goal and structure, and using similar techniques and methodology.

The first paper published in *Current Biology* examined the pancrustaceans (the most diverse animal group to ever exist, includes crustaceans and six-legged insects) revealing delicate details of the head and trunk limbs, such as antennae, mandibles and epipodites which are characteristic features observed in modern pancrustaceans. The second paper in *BMC Evolutionary Biology* examined the non-trilobite arthropod (the largest phylum in the animal kingdom, includes lobsters, crabs and spiders) *Sinoburius lunaris*. Though known for three decades, few details of its anatomy are understood due to its rarity within the Chengjiang biota and technical limitations for studying. Ortega-Hernández and Liu showed in great detail the limb anatomy revealing a substantial degree of antero-posterior limb differentiation, which is contrary to the traditional view that these early trilobite-like euarthropods were simple animals.

The third study in *Geological Magazine* discovered a new species of *Cambroraster falcatus,* a distant arthropod relative. The study described the occurrence of *Cambroraster* whose head bears an uncanny similarity to horseshoe crabs. This is the second instance of Cambroraster reported worldwide, as well as the oldest found, and indicates that these early euarthropods had acquired a complex benthic ecology (ocean floor or bottom of a lake) very early in their evolutionary history. In the fourth paper in *BMC Evolutionary Biology* Ortega-Hernández and Liu discover *Xiaocaris luoi*, a new species of *fuxianhuiid*, an important group of early branching arthropods that are central to discussions concerning the early evolution of this phylum. The study demonstrates that even specimens that appear to be poorly preserved and indistinct can preserve diagnostic features, suggesting that the biodiversity in Chengjiang may be even greater than currently understood. The fifth paper in *Current Biology* shows with unprecedented clarity the head morphology of the species *Leanchoilia illecebrosa* — a member of Megacheira, a major extinct group characterized by distinctively raptorial great appendages. Re-examination of Leanchoilia demonstrates the presence of a labrum (a flap-like structure overlying the mouth opening in most modern arthropods) and offers renewed support to the hypothesis that megacheirans are distant relatives of modern chelicerates (e.g. horseshoe crabs, scorpions and spiders). Ortega-Hernández and Liu expect the collaboration will continue yielding high-quality morphological information for several years. "We've only started to scratch the surface," said Ortega-Hernández. "We have several ongoing projects, including many new and exciting species, as well as re-descriptions of some old favorites and a few pleasant surprises."

that the definition of a species is more complicated than even Darwin had imagined! The impressive study was featured on the journal's coveted cover and was featured in *Harvard Magazine.*

~ Postdoctoral Researcher **Katrina Jones** and **Prof. Stephanie Pierce** tackled the question of biological complexity using the complex mammalian spine as an evolutionary example. Using phylogenetic modeling, Jones and Pierce were able to discover why the mammalian vertebral column became more complex over time. The study published in *Nature Communications* shows major shifts in spine complexity are associated with increases in aerobic capacity, thus supporting the hypothesis for stepwise shifts underlying evolutionary trends. The study was featured in the *Harvard Gazette*.

~ Postdoctoral Researcher **Ashesh Dhawale's** and **Bence Ölvecsky's** study in *Current Biology* suggests errors resulting from variability in motor function are a feature, not a bug, of our nervous system and play

Graduate Students Notable Awards

-Anju Manandhar (NM Holbrook) recipient of Harvard Center for Biological Imaging Simmons Award for her project, *"Structural mechanism of stomatal movement (How do leaves have pores that open and close?)".*

-Inbar Maayan (D Haig) recipient of Society of Systematic Biologists Graduate Student Research Award for her project, "*Testing species hypotheses in sympatric, wide-ranging Caribbean lizards*".

-Mark Wright (S Pierce) awarded Chapman Fellowship for research in vertebrate locomotion.

-Austin Garner (R Hopkins) recipient of American Society of Naturalists Student Research Award and Graduate School of Arts and Sciences (GSAS) Graduate Student Council Summer Research Award for his project, "*Revealing the evolutionary history of speciation by reinforcement through genetic variation in* Phlox *flower color*".

-Jacob Suissa (W Friedman) recipient of New England Botanical Club Graduate Student Research Award for his abstract, "*The effects of stelar architecture on hydraulic integration in fern rhizomes".*

-Sang Il Kim (B Farrell) recipient of Graduate Student Research Enhancement Award from The Coleopterists Society for his project, "*Target enrichment phylogenomics of longhorned beetle genus Anoplophora Hope, 1839 (Cerambycidae: Lamiinae) with emphasis on their adaptation to the temperate zone*".

-Ryan Hulett (M Srivastava) recipient of Ruth L. Kirschstein National Service Award Individual Predoctoral Fellowship to Promote Diversity in Health-Related Research for his project, "*Identifying genetic pathways and cellular sources for neural regeneration in adult animals*".

-Min Ya (E Kramer) awarded GSAS Merit Fellowship in recognition of her academic talent and promise.

-Kari Taylor-Burt (A Biewener) recipient of Dean Shinagel Exceptional Teaching Assistant Award from Harvard Extension School.

-Julian Kimura (M Srivastava) recipient of QBio Student Fellowship supported by the NSF-Simons Center for the Mathematical & Statistical Analysis of Biology at Harvard University.

- **Zachary Morris** (S Pierce) awarded NSF Earth Sciences Postdoctoral Fellowship for his project, "*Unraveling the convergent origins of secondary palates in amniotes*".

- **Pavitra Muralidhar** (D Haig) awarded NSF Postdoctoral Research Fellowship in Biology: Integrative Research Investigating the Rules of Life Governing Interactions Between Genomes, Environment and Phenotypes for her project, "*The role of sex chromosomes in sexual conflict*". Pavitra was also a finalist for the James F. Crow Early Career Research Award from the Genetics Society of America.

- **Meghan Blumstein** (NM Holbrook) awarded NSF Postdoctoral Research Fellowship in Biology: National Plant Genome Initiative (NPGI), "*Untangling the environmental and genetic drivers of phenological timing in red oak (Quercus rubra) to improve climate predictions*".

- **Nikhil Chari** (B Taylor) awarded Skaff Environmental Fellowship from Harvard University Center for the Environment.

-Dakota McCoy (D Haig) awarded Chapman Fellowship for research in vertebrate locomotion for her project, "*Cooperation and Conflict in House Mouse Huddles*".

-**Sam Church** (C Extavour), **Ben Goulet-Scott** (R Hopkins), **Dakota McCoy** (D Haig) and **Jacob Suissa** (W Friedman) awarded funding from the Office for Sustainability to plant native plants on the Harvard campus for their proposal, "*Native plants at Harvard: Ecosystem, education, community*".

a critical role in learning. The study addresses the issue of how the brain regulates variability which is necessary for learning, but not useful when a successful action needs repeating. Dhawale and Ölvecsky looked at data from approximately three million rat trials and found that rats regulate their motor variability based on the outcomes of the most recent 10 to 15 attempts at a task. Depending on the outcome of previous trials, rats will either increase their variability if trial has gone poorly, or limit their variability if trial has gone well. They also studied performance-dependent variability by training rats to press a 2D joystick towards a target angle. The researchers discovered rats that were regularly rewarded had low variability and if they performed less well in later trials their variability increased. The study was featured in the *Harvard Gazette.*

~ Artificial muscles will power the soft robots and wearable devices of the future, but the underlying mechanics is not well known. **Prof. L. Mahadevan's** study in *Physical Review Letters* uncovers some of the fundamental physical properties of artificial muscle fibers. The thin soft filaments can stretch, bend and twist into extreme deformations. Mahadevan's study explains the theoretical principles underlying the transformations.

~ PhD candidate, **Richard Childers** and **Prof. Naomi Pierce** teamed with researchers at Columbia University to examine the wings of Lepidoptera. Butterfly wings contain a matrix of living cells whose function requires appropriate temperatures. However, given their small thermal capacity, wings can overheat rapidly in the sun. In the study published in *Nature Communications*, the team analyzed wings across a wide range of simulated environmental conditions and found regions containing living cells are maintained at cooler temperatures. The wings act like temperature sensors, which allows butterflies to respond swiftly to changes in sunlight and prevent overheating. The study was featured in *The Economist* and *Harvard Magazine.*

~ Postdoctoral Researcher **Katrina Jones** and **Prof. Stephanie Pierce** joined researchers at the Field Museum of Natural History to find out how and when changes happened in the spine of mammals during evolution. First author Jones says the study published in *Nature Ecology & Evolution* tries to answer a fundamental evolutionary question, "How does a relatively simple structure evolve into a complex one that can do lots of different things?" A combination of developmental changes and adaptive pressures led to the diversity of backbones in mammals today. In a previous study from 2018, Jones and Pierce showed that though vertebrae looks very similar in early mammal ancestors, there are subtle differences that create distinct developmental regions. In this study, they reveal that those distinct regions provided the raw material that facilitated functional differentiation. The study was featured in the *Harvard Gazette*.

~ For a decade **Prof. Cassandra Extavour** pitched a project to students to understand whether horizontal gene transfer — the process of passing genes between organisms without sexual reproduction — might be responsible for part of the makeup of a gene, known

Welcome 2020 G1s!

- Lucrecia Aguilar (Davies Lab)
- Katherine Angier (N. Pierce Lab)
- Nikhil Chari (Taylor Lab)
- Maoting Chen (Zhang Lab)
- Sarah Dendy (Mallet Lab)
- Sophie Everbach (Holbrook Lab)
- Landen Gozashti (Hoekstra Lab)
- Misha Gupta (Desai Lab)
- Calvin Heslop (Taylor Lab)
- Yunha Hwang (Girguis Lab)
- Josefine Just (Extavour Lab)
- Arianna Lord (Giribet Lab)
- Catherine Ressijac (Davies Lab)
- Jared Richards (Ortega-Hernández Lab)
- Yuttapong Thawornwattana (Mallet Lab)
- Michael Voysey (Davies Lab)
- Justin Williams (Davis Lab)
- Maya Woolfolk (Hoekstra Lab)

Faculty Spotlight

When COVID-19 sent students home and halted lab research, Scott Edwards, Professor of Organismic and Evolutionary Biology and Curator of Ornithology in the Museum of Comparative Zoology, decided to fulfill his lifelong dream of cycling from the Atlantic to Pacific. Two weeks before his departure on June 6, nationwide protests broke out over the murder of George Floyd by a police officer. On the same day a video of a racist encounter in Central Park involving a Black birder and white woman went viral. As a result of that incident, a group of Black birders and naturalists launched Black Birders Week, a social media campaign that elevates Black voices in birding and takes on racism in the outdoors.

Suddenly, Scott's adventure turned into a much larger mission. He created a Twitter account to participate in Black Birders Week and strapped Black Lives Matter signs to his bike. Along the way Scott met up with fellow researchers as well as met many new people who are cheering him on in his quest.

In his interview with *Audubon*, Soctt said, " A bicycle trip is in some ways a good metaphor for a journey in science. You will run into hills and roadblocks and flat tires. Just don't let that stop you. We need more diversity in science and we need more success stories. It's a matter of hard work and creating your community. Don't let anyone tell you you're not supposed to be doing this."

Scott's journey has been covered by *Audubon Magazine* of the National Audubon Society, the *Boston Globe*, the *Harvard Gazette*, CBCRadioOne in Canada, *Ames Tribune*, Iowa Public Radio, and *The Christian Science Monitor*. Scott also joined Harvard Museums of Science & Culture for live conservation where he told everyone if he could be a bird he'd be an Albatross because they are graceful, can fly huge distances, and have amazing sensory skills.

Quickfire Q&A!

- **Most challenging thing about your trip?** Soft, stony gravel roads in Iowa and Illinois
- **Most rewarding?** The generosity of random people I've met
- **What are you most looking forward to when you return?** Being with my family
- **Do you miss us in OEB as much as we miss you?** Yes!

Image of Scott courtesy of James Deshler, a friend and former colleague at NSF.
Albatross courtesy of Oregon State University on Flickr.

as oskar, that plays a critical role in the creation of germ cells in some insects. PhD candidate **Leo Blondel** (Extavour Lab), a first-year student in the Molecules, Cells, and Organisms (MCO) program, rose to the challenge. Blondel provided the strongest suggestive evidence yet that at least part of oskar actually came from bacterial genomes. Oskar appeared suddenly in evolution and in 480 million years became one of the most essential genes in the reproduction of insects. Blondel performed a phylogenetic analysis to find from where the gene came. The study published in *eLife* shows part of oksar's sequence is closely related to a sequence found in bacteria. Animals and bacteria are thought to not reproduce with each other, so Extavour determined it must occur through horizontal gene transfer. Extavour and Blondel measured codon use in oskar four different ways and discovered many of the sequences that appear to be closely related to the [oskar] domain came from bacteria that are sometimes endosymbionts — bacteria that live inside insects. Many insect endosymbionts live in the cytoplasm of the germ cells, which suggests horizontal gene transfer from bacteria living inside the cell that contains the DNA to the next generation's genome. The study was featured in the *Harvard Gazette*.

~ Postdoctoral Researcher **Elsa Ordway** (Moorcroft Lab) and Greg Asner, Director of Arizona State University's Center for Global Discovery and Conservation Science investigated the impact of edge effects on forest structure and tree canopy characteristics along boundaries between lowland rainforests and oil palm plantations in Malaysian Borneo. One of the many consequences of tropical deforestation includes forest fragmentation, a process that involves dividing forests into smaller and smaller pieces, creating new borders between habitats. These borders are exposed to different environmental and biological conditions, called "edge effects", less favorable than conditions within forest interiors. In their study, published in *Proceedings of the National Academy of Sciences*, Ordway and Asner found widespread evidence of major changes in forest structure along forest edges, as well as changes to three important canopy traits related to a tree's ability to capture sunlight and grow. Tropical forests hold approximately 25% of the world's carbon in their trees and plant species; when they are burned, all of that carbon is emitted into the atmosphere. The vegetation that acts as carbonsinks disappears causing important global implications. Without rainforests, climate scientists warn, the global-warming consequences could be catastrophic. The study was featured in *Harvard Magazine*.

~ Professors **Stephanie Pierce** and **George Lauder** partnered with University of Detroit paleontologist, Nizar Ibrahim, to decipher how Spinosaurus aegyptiacus would have used newly found tail vertebrae fossils. Ibrahim's team discovered Spinosaurus fossils in Morocco in 2014 that included tail vertebrae with

Postdoc Notable Awards

- **Jesse Marshall** (B Ölveczky) received NIH/NINDS Pathway to Independence Award for his project, "*Neural and computational mechanisms underlying the assembly of motor skills*".
- **Shahan Derkarabetian** (G Giribet) awarded Museum of Comparative Zoology Putnam Expedition Grant for his project, "*The unknown triaenonychid harvestmen of Australia. Expedition II: Queensland*".
- **Elizabeth Sibert** (A Knoll & G Lauder) awarded support from NSF and the International Ocean Discovery Program to study the response of pelagic ecosystems to global warming events 50 million years ago.
- **Aaron Hartmann** (G Giribet) awarded: NSF Belmont Forum for his project, *"ARMS to reefs: A new tool to restore coral reef biodiversity, fisheries yield, and human health in Madagascar*"; U.S. Department of Defense Environmental Security Technology Certification Program for his project, "*Coral Reef Arks: a cost-effective and high-return tool for restoration and conservation of coral reef resources on DoD submerged lands*"; Harvard Culture Lab Innovation Fund for the collaborative project," *Inclusive undergraduate science research labs and research opportunities*".
- **Katrina Jones** (S Pierce) awarded the Royal Society University Research Fellowship for her project, "*Putting their back into it: A whole body perspective on the evolution of mammalian running*".
- **Rudy Lerosey-Aubril** and Javier Ortega-Hernández) awarded the William F. Milton Fund.

meter-long spines that appeared to form a paddle. Ibrahim reached out to Pierce who worked with fish bio-mechanist, Lauder, to create a robotic model of the tail, complete with the top fin that would cover the meter-long bone spines. The study published in *Nature* proves the Spinosaurus, one of the largest known carnivorous dinosaurs, was aquatic. Pierce and Lauder's robotic modeling shows a large, flexible tail fin that would have given the giant predator a deadly propulsive thrust in the water, similar to a salamander or crocodile tail. Combined with the dinosaur's center of gravity, the paper lays to rest the argument over whether Spinosaurus was aquatic. The study was widely covered in *The New York Times*, the *Harvard Gazette*, *Newsweek*, *National Geographic* and *Science News*.

~ **Prof. L. Mahadevan** and researchers have developed a framework to quantify the fate and dynamic organization of cells into tissues from imaging data by applying techniques of fluid dynamics and chaos theory to embryogenesis — how an organism arises from a single cell and one of the most mysterious and complex processes in nature. The large-scale, coordinated and collective movements of cells in a tissue during embryogenesis resemble the complex and chaotic flows of fluids in the ocean or atmosphere. How the movements determine which cells are destined to become part of the brain, the gut or the limb is unknown. The study published in the *Proceedings of the National Academy of Sciences* helps in predicting the fate of cells, making it possible to spot pathologies in the earliest stages of development.

- Trees typically experience mid-day water depressions due to water evaporating out of the plant's stomata (a tiny opening or pore in plant leaves that intakes carbon dioxide, which is needed for photosynthesis). To understand how the water stress influences carbon's movement from the leaves (where production begins) to the roots, trunk and shoots (where the water is needed), PhD candidate **Jessica Gersony** (Holbrook Lab) measured carbon and water traits of five mature red oak trees over the course of 24 hours at Harvard Forest. Working with Holbrook lab members, Gersony discovered the midday water depression does not impede carbon movement and that carbon that does not immediately leave the leaf aids in preventing the leaf from wilting. The study published in *Plant Physiology* is important for understanding the robust carbon transport and phloem functioning (the vascular tissue in plants that transports sugars and other metabolic products from the leaves) during mature trees' water depressions.

~ Pollination is often a mutual relationship between flowering plants and insects. Understanding how these plants entice diverse insects to pollinate has major implications across evolutionary, ecological, organismal and conservation biology. One mechanism that can provide a window into ancient insect pollination, before the rise of flowering plants, are

Derek Bok Certificate of Distinction in Teaching

SPRING 2019

-Certificates of Excellence for Lecturers and Preceptors: Andrew Berry (LIFESCI 1B and OEB 53).

-Certificates of Distinction for Teaching Fellows (TFs), Teaching Assistants (TAs) and Course Assistants (CAs): Vanessa Knutson (OEB 11), Shoyo Sato (OEB 51), Abagail Burrus and Catherine Chamberlain (OEB 52), Avantika Mainieri (OEB 53), Nathaniel Edelman (OEB 55), Kadeem Gilbert (OEB 57) Jacob Suissa (OEB 103), Jennifer Austiff (OEB 115), Laura Clerx (OEB 240R), Blake Dickson and Zachary Morris (OEB 207), Éadaoin Harney and Benjamin Rice (OEB 242), Tyler Wooldridge (OEB 278), Nicole Bedford (MCB 146).

FALL 2019

-Certificates of Excellence for Lecturers and Preceptors: Collin Johnson (OEB 10)

-Certificates of Distinction for TFs, TAs and CAs: Abagail Burrus and Alyssa Hernandez (OEB 10), Austin Garner, Brock Wooldridge and Tianzhu Xiong (OEB 50), Richard Childers (OEB 54), Sarah Losso (OEB 56), Min Ya (OEB 106), Brianna Weir (OEB 114), Jessica Mitchell (OEB 119), Sang Il Kim (OEB 275R), Ava Mainieri (OEB 399).

Graduate Student Spotlight

When Harvard classes moved online during COVID-19, PhD candidate and teaching fellow **Phil Fahn-Lai** (S. Pierce) used his background in graphic and web design to tackle the online challenges for students in OEB 126: Vertebrate Evolution. The course's labs involve hands-on observation of the MCZs Vertebrate Paleontology collection. Determined to make the classroom experience meaningful for the remote students, Phil approached the Derek Bok Center's Learning Lab to design a custom web app for the course. In collaboration with members of the Pierce lab, Phil used photogrammetry to scan and create 3D models of as many fossil specimens as possible. With the images, Phil built the app Lab 3D, OEB 126's online platform for conducting labs. We reached out to Phil for a Q&A.

OEB: What inspired you to develop the virtual lab?
Phil: I had been thinking about digitizing some of the content for OEB126 before COVID-19 and the university shutdown. One of the cool things about the course is it gives students hands-on experience with rare fossil specimens. The hands-on time is great from a pedagogical point of view, but it does cause some problems with specimen wear and tear (the students are trained on how to properly handle fossils, but we've seen a few breakages in the past). The other issue is a lot of the most scientifically important fossils are kind of a mess to the untrained eye—the contrast between fossilized bone and the surrounding rock matrix is often quite low, and a lot of the bones are broken and jumbled up, so the whole thing looks pretty different from the idealized diagrams the students are familiar with from class. Also, some of the fossils are about the size of a thumbnail, and having eight undergrads all crowd around something that small isn't ideal. For a while I've thought a digital viewer for fossil specimens would be a nice supplementary teaching tool. A way for students to interact with fossils up close without risking damage, and give contextual information to help guide them in their learning.

OEB: Do you see your app working in other OEB courses, as well as courses within Harvard and other schools?
Phil: I think something like this could be pretty widely applicable—any course that deals with physical specimens (i.e. OEB specimen-based courses) or material culture (Archaeology and Anthropology) could find this useful. The app is not specific to OEB 126. At its core, the app is a way to display web content (primarily 3D models hosted on the Sketchfab service, but also public-domain images and videos) alongside explanatory text, organized into meaningful taxonomy. OEB 126 content happens to be vertebrate fossils, but this could just as easily be pottery organized by period or friezes organized by region…the sky's the limit really. I had ease of use in mind when I developed this. Think of it as a pseudo-publishing platform; the whole back end of the website where the data lives basically runs on Google Sheets and Google Docs, which makes the barrier to reproducing this for some other subject area potentially pretty low.

Big congratulations to Phil who has been appointed to an OEB TF position that is directed at providing advice and support for the transition to online teaching for the 2020 Summer/Fall semesters.

Cycads. Cycads are primary seed-producing plants and represent one of the oldest lineages of seed plants. These plants rely on insect pollination, yet do not display the colorful visuals that signals to pollinators, which is common to flowering plants and a major mechanism in pollination biology. In a study in *Science* led by **Shayla Salzman** ('19, N. Pierce & Hopkins), Postdoc **James Crall** ('17, N. Pierce), and **Professors Naomi Pierce** and **Robin Hopkins** teamed with Damon Crook (USDA) to uncover the mechanism by which these ancient endangered plants entice pollinators to service their brood site (deceptive breeding sites for insects that are housed in the pollen cone). Using a combination of chemical ecology and insect behavior, researchers found that a push-pull mechanism of alternating attraction and repulsion, coinciding with heat producing plants, acts to move pollinators between pollen and the female cones of the plant, which when fertilized by pollen, become seeds.

The study's fossil evidence and phylogenetic analysis show that this push-pull mechanism is likely ancestral in this group of plants and represents one of the earliest insect pollination mechanisms, well before the rise of flowering plants.

~Isolating and studying the movements of live fish is difficult and scientists often use robotic models instead. Most robotic fish models, however, are either passive, flapping models that are simple but don't actively swim, or active, hard models that actively swim but take forever to construct. PhD candidate **Zane Wolf** (Lauder Lab) worked with lab members and colleagues at Max Plank to study fish undulatory locomotion using a soft, pneumatically-activated robot called the Pneufish, which falls somewhere between the two previously studied models. The study published in *Bioinspiration & Biomimetics* yields valuable insights into how fish can modulate their own biomechanics to swim efficiently at higher or lower speeds.

~ For 75 years, adaptive radiations — the relatively fast evolution of many species from a single common ancestor — have been considered as the major cause of biological diversity, including the origins of major body plans and new lineages. However, past research examining these rapid rates of evolution was largely constrained by the methods used and the amount of data available. Postdoctoral Researcher **Tiago Simões**, **Prof. Stephanie Pierce** and colleagues from University of Alberta tackled the longstanding question of how adaptive radiations have shaped reptile evolution. The team examined the largest available data set of living and extinct major reptile groups using DNA information from modern species and hundreds of anatomical features from both modern and fossil species for statistical analysis. The study published in *Nature Communications* detected that periods of fast anatomical change during the origin of reptile groups often predate when those groups diversified into hundreds or thousands of species: contradicting long-held ideas of adaptive radiation in evolution biology. The results also showed that reptiles that evolved similar protective armour had radically different rates of evolution and that the origin of snakes is characterized by the fastest rates of anatomical change in the history of reptile evolution.

REU: Evolution, Ecology, Environment (E3)

OEB completed its first successful year of the NSF Research Experiences for Undergraduates (REU). The E3 REU is aimed at training highly motivated young scientists and preparing them for successful careers in the broad fields of evolution, ecology, and environmental biology. OEB hosted seven undergraduates from around the world.

2019 Participants:

- Alissandra Ayala, University of Texas at Austin
- Aundrea Koger, Western Washington University
- Nicole Márquez-Reyes, University of Peurto Rico, Cayey
- Macy Petrula, California State University, Sacramento
- Emma Riccardi, Northestern University
- Alyssa Vanerelli, University of North Carolina at Asheville
- Kierra Wilk, Rensselaer Polytechnic Institute

Integrative Biology

IB Student Spotlight

Rewan Abdelwahab, one of 20 graduating IB concentrators, took four trips to five countries during her time at Harvard. Rewan's adventures were featured in *The Harvard Gazette* student profiles. In addition to her IB concentration in OEB, Rewan has a secondary concentration in the humanities in two languages, Spanish and Somali. We reached out to Rewan with a Q&A about her time in OEB and her experiences as an IB concentrator and world traveler!

OEB: What led you to concentrate in IB?
Rewan: The collaborative nature of OEB students and the amazing faculty I met! Even though I came from a humanities and math background, I felt welcomed in OEB. I especially appreciated that I had the opportunity to explore a lot of different fields of biology all under the umbrella of OEB. I studied botany, geobiology, neurobiology, and genetics and felt truly enthralled by each and every class I took!

OEB: What was most rewarding about being an IB Concentrator?
Rewan: Learning how scientific literature, writing, and labs could differ so much among the sciences. I truly felt I could get a wide breadth and depth in whatever topic I desired, without sacrificing my interest in any particular field of science. I was able to learn as much as I wanted from top scientists in many fields.

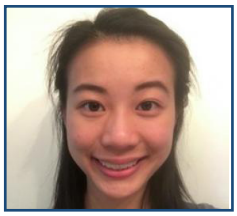
OEB: Tell us about your travels and how they relate to your IB studies?
Rewan: Exploration was central to my experience in OEB. Many classes had fieldwork or field trips to supplement and lock-in what I learned in class. I was genuinely interested in many different fields of science and being able to explore so many of my interests solidified that medicine was my path. With the support of OEB, I was able to secure summer funding to work in a mental health clinic that serves low-income Egyptians and refugees in Alexandria, Egypt, my city of birth!

OEB: Where are you headed and how did IB help in making those plans?
Rewan: I will be a medical student at Mayo Clinic in my home state of Minnesota. My introduction to the sciences through OEB and all of the research and advising support I received was instrumental in building my experience and knowledge of the medical field. My OEB advisor supported my endeavors to create the Minority Association of Premedical Students for first-generation, underrepresented or low-income students entering the field of medicine. When a fire destroyed parts of my home, OEB faculty gave me tremendous support and advice on support networks. I am so lucky that I chose OEB as my concentration. My time in OEB has changed me for the better!

IB Awards

Congratulations to the following IB Concentrators awarded the 2020 Hoopes Prize in Faculty of Arts and Sciences:

Dylan Ryals (Farrell Lab) for his project, "*Of mites and men: Using spatially explicit sampling and genetic sequencing to uncover disease dynamics of honeybee parasite Varroa destructor in migratory apiculture*".



Allison Shu Ting Law (Giribet Lab) for her project, "*Consider the lobster ectocommensal, Symbion americanus: Phylogeographic analysis reveals spatial niche partitioning on host mouthparts*".

Chinmay Sonawane (Haig Lab) for his project, "*A defence of the queens of Africa: The public health and economic benefits of spotted hyenas (Crocuta crocuta)*"**.**

Adele Woodmansee (Davis Lab) for her project, "*It is pure Criollo Maize': Subsistence agriculture and ideas of locality and contamination in San Miguel del Valle, Oaxaca*".

- **Chinmay Sonawane** (Haig Lab) awarded the Captain Jonathan Fay Prize by the Radcliffee Institute for his project, "*A defence of the queens of Africa: The public health and economic benefits of spotted hyenas (Crocuta crocuta)*"**.** The prize is awarded to the graduating senior who has produced the most outstanding imaginative work or piece of original research in any field.

- **Adele Woodmansee** winner of the Taliesin Prize for Distinction in the Art of Learning.

Congratulations IB Graduates!

- Rewan Abdelwahab (Yee Lab, U MN, A Berry)
- Sarah Alam (Arbel Lab, MGH)
- Elizabeth D'Haiti (Srivastava Lab)
- Mary Katherine DeWane (Kramer Lab)
- Jessica Diaz (Carmody Lab, HEB)
- Brandon Duffy (Kim Lab, MEEI)
- Stephanie Dufresne (Pepperberg Lab, PSYCH)
- Kevin Eappen (Carmody Lab, HEB)
- Skye Fenton (Moorcroft Lab)
- Justina Hewitt (Haig Lab)
- Annina Kennedy-Yoon (N.Pierce Lab)
- Allison Law (Giribet Lab)
- Mattia Mah'moud (Rexrode Lab, BWH)
- Elena Moncada (Giribet Lab)
- Dylan Ryals (Farrell Lab)
- Chinmay Sonawane (Haig Lab)
- Dexter Summers (Lauder Lab)
- Rory Wakeford (Schamberg Lab, HEB)
- William Wang (Ölveczky Lab)
- Adele Woodmansee (Davis Lab)

IB POSTER SESSION:

The 2020 Senior Thesis Poster Session took place on Zoom!! Fifteen senior thesis posters -- 5 minutes and 2 slides!

Field Trips!

OEB 11: Introduction to Tropical Biology

Instructor: Gonzalo Giribet

OEB 11 spent J-Term in Australia together with undergraduates from Sydney University. The course focused on Australian biodiversity. The trip started with marine work at the One Tree Island Research Field Station in the Great Barrier Reef in Queensland, followed by terrestrial, salt marsh and rocky shore ecology work in Warrah in New South Wales. The students were able to experience first-hand the local biodiversity and research related to aspects of diversity, ecology and evolution, while interacting with their Australian counterparts and learning about the local culture. This was the second time the field course was offered and many students saw this as a great educational experience to learn about coral reefs to fish ecology, forest diversity to rocky shore ecology, and a great deal about the local fauna and flora.

Event Highlights

OEB Seminar Series

The 2019-2020 seminar season had a successful fall and early spring with an incredible lineup of speakers from all over the world.

Fall 2019: Robin Hopkins, OEB, Harvard University; **George Lauder**, OEB, Harvard University; **Mansi Srivastava**, OEB, Harvard University; **Doug Altshuler**, The University of British Columbia; **Martha Muñoz**, Yale University; Adrienne Roeder, Cornell University; **Cassie Stoddard**, Princeton University. **Spring 2020: Neil Shubin**, The University of Chicago; **Benjamin de Bivort**, OEB, Harvard University; **Jeannine Cavender-Bares**, University of Minnesota; **David S. Hibbett**, Clark University; **Peter Wilf**, Pennsylvania State University; **Catherine Aime**, Purdue University.

PBI Symposium

Due to COVID-19, the 15th Annual Plant Biology Initiative Symposium *"Fungi and Plants: Ecology and Interactions"* scheduled to take place May 4-5 has been postponed to May 2021. The event will be hosted by Prof. Donald Pfister and feature the same speakers.

Invited Speakers:

- **Catherine Aime**, Purdue University
- **Elizabeth Arnold,** The University of Arizona
- **Greg Bonito**, Michigan State University
- **Kevin Boyce**, Stanford University
- **David Hibbett**, Clark University
- **Timothy James**, University of Michigan
- **Peter Kennedy**, University of Minnesota
- **Teresa Pawlowskat**, Cornell University
- **Kabir Peay**, Stanford University
- **Anna Rosling**, Uppsala Universitet
- **Matthew Smith**, University of Florida

Upcoming Events 2020-2021

OEB Seminar Series

- **September 3**: Erica Bree Rosenblum, University of California, Berkeley
- **September 17**: John Silvanus Wilson Jr., Harvard University
- **October 1**:Paul Shamble, Harvard University
- **October 15**: Donna Maney, Emory University
- **October 29**: Iñaki Ruiz-Trillo, Universitat de Barcelona
- **November 12:** TBD
- **December 3:** TBD
- **January 28**: Kristen Koenig, Harvard University
- **February 11**, Andrew Biewener, Harvard University
- **February 25:**TBD
- **March 11:** TBD
- **March 25**: Julia Clarke, University of Texas at Austin
- **April 8**: PatriciaWhittkopp, University of Michigan
- **April 22**: Marie Dacke, Lund University

Commencement 2020

Harvard held the 2020 Commencement ceremonies online this year due to COVID-19.

We were very sorry our amazing graduating PhDs were unable to walk and celebrate with their mentors, peers and OEB community. To honor their work and tremendous achievement, OEB faculty sent videos of well wishes and congratulations which were combined with a montage of each student's image and dissertation title to create a celebatory video. Congratulations graduates! We are so very proud of you!

OEB Staff News

Welcome New Staff!

- **Fengyun Duan**, Zhang Lab
- **August Easton-Calabria**, de Bivort Lab
- **Charles Hale**, Hopkins Lab
- **Sade McFadden**, Hoekstra Lab
- **Monica Schreiber**, Sabeti Lab
- **Greta Wong**, Lauder Lab

Promotions:

- **Megan McHugh** promoted to Human Resources Administrator

Community Outreach

OEB participated in the 2019 Mayor's Summer Youth Employment Program (SYEP). Building on Harvard's longstanding tradition of partnering with Boston and Cambridge to hire local teens, SYEP offers a unique six-week experience for hiring managers and students alike. OEB Administrative offices hosted Mary Lyon Pilot High School juniors, **Daniella Santana** and **Elior Danan.**

For the sixth year in a row, OEB participated in the School-to-Work (STW) program, a collaboration among the HUCTW, the Cambridge Office of Workforce Development, Harvard University and Cambridge Rindge Latin School. OEB Administrative offices hosted CRLS junior **Nadira Chowdhury** for 2019 STW (Due to COVID-19, the 2020 session was not held).

Milestones In Service

30 Years of Service:

- **Lydia Carmosino**, OEB

25 Years of Service:

- **Rebecca Chetham**, OEB

15 Years of Service:

- **Julie Knippa Colby,** OEB

10 Years of Service:

- **Sarine Der Kaloustian,** OEB
- **Maggie Starvish,** OEB

5 Years of Service:

- **Michael Barrett**, OEB

Notable Awards

Congratulations to **Christian Flynn**, Administrative Coordinator in OEB, recipient of the 2020 FAS Dean's Distinction Award!

Acknowledgements and Credits:

Editor
Wendy Heywood

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Wendy Heywood
Catherine Musinsky

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HARVARD UNIVERSITY

2019–2020