



THE UNIVERSITY OF MICHIGAN  
DEPARTMENT OF ECOLOGY AND EVOLUTIONARY BIOLOGY

# NATURAL SELECTIONS

VOLUME 9 NUMBER 1

FALL 2011

## A DECADE OF POSITIVE CHANGES

**T**he Department of Ecology and Evolutionary Biology was “born” July 1, 2001 with the split of the former Department of Biology into EEB and the Department of Molecular, Cellular, and Developmental Biology. The undergraduate Program in Biology was created to have a home for the concentrations jointly managed by the two new departments and the introductory courses taken by all concentrators. Since those initial major changes, EEB’s first decade has continued to be eventful and exciting in multiple ways.

“We’ve become a much more vibrant place in the last 10 years,” said Asa Gray Distinguished University Professor of Ecology and Evolutionary Biology and Arthur T. Thurnau Professor John Vandermeer. He thinks part of the reason stems from what he called “a really good divorce.” He said, “a lot of the tensions that existed in the old biology department have largely disappeared. We’ve just had really positive growth for the entire ten years.”

Perhaps the most dramatic change over the decade has been the turnover in the faculty: over 60 percent of the faculty in the department was hired since 2001. Accompanying this has been significant movement into new areas of research. For example, “we’ve become one of the premier departments in theoretical ecology,” said Vandermeer. “In 2001, we had Mercedes (Pascual) and myself who were interested in theoretical ecology. Then we hired Aaron (King), Annette (Ostling), and Pej (Rohani). So, we now have one of the most extensive collections of theoretical ecologists in the country.”

We have also increased our programs in ecosystem ecology and in molecular ecology. In evolutionary biology, we

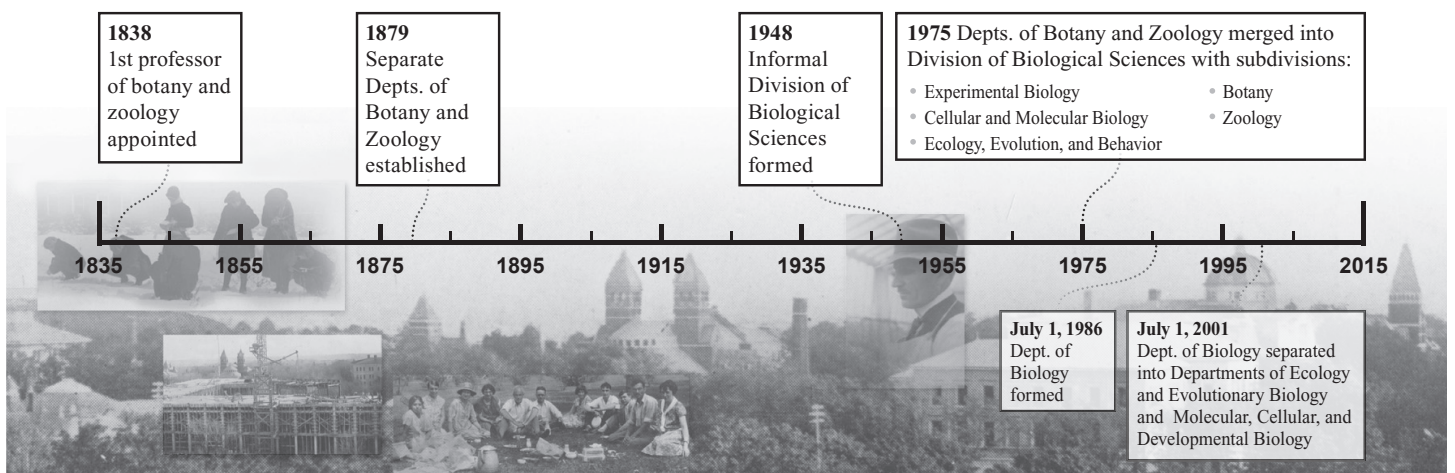
have added to our traditional strength in systematics and phylogenetics, by adding outstanding faculty who study the mechanisms of evolution, from molecular genetics to the evolution of behavior.

Another important theme over the last decade has been interdisciplinary. EEB has been awarded four new positions as part of a presidential initiative at U-M to hire groups of faculty (“clusters”) across multiple departments and colleges to promote interdisciplinary scholarship. In 2010, EEB hired Dr. Vincent Denef as part of a cluster with the Schools of Medicine and Public Health in microbial ecology, as well as Dr. Stephen Smith as part of a cluster with the College of Engineering in data mining. Upcoming searches include a cluster in biological networks from genes to social systems and a cluster in food sustainability that involves the Schools of Business, Public Health, Natural Resources and Environment, Architecture and Urban Planning.

To showcase the exciting changes in the department and to give our graduate students and faculty the opportunity

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***“We’ve become a much more vibrant place in the last 10 years.”***



Dear Friends,

As you'll see, this issue of *Natural Selections* is dedicated to the 10th anniversary of EEB. We had a good time looking through photo archives and dusting off some of the old photos from years gone by. See who you can recognize. John Vandermeer is our faculty member with the longest tenure at 41 years and as such, he was a great reservoir of information and memories for our articles. Thanks, John, and to everyone else who contributed to this special issue.

I have been in the department for 28 years and have seen many positive changes over that period of time. It is my great pleasure to work with an exceptional faculty, whom you'll read more about in this issue. Even though we can't name them all here, each and every member of our faculty makes a contribution to who we are and what gives us strength in a wide variety of research areas and in educating our next generation. I am proud of our promising postdoctoral fellows, creative graduate students, enthusiastic undergrads and a staff that keeps many, many wheels running smoothly and efficiently. We have been fortunate to add to the administrative ranks a graduate program assistant and recruiter to help us with our outreach and diversity efforts and a communications specialist who keeps us informed via our wonderful website and newsletters and has helped to get our research publicized much more widely than ever before, both in the national media and within the university.

Be sure to read our cover story, "A decade of positive changes" for information about how our department has changed in the last 10 years. As chair, I have been lucky enough to be closely involved in hiring 20 new faculty and they represent an extraordinary collection of cutting-edge researchers and teachers. For example, we have revitalized plant evolutionary biology after a number of retirements in the 90s and early 2000s, by hiring Professor Paul Berry as director of the Herbarium, as well as Professors Yin-Long Qiu in phylogenetics and evolution of early land plants, Chris Dick in molecular ecology and population genetics of tropical trees, and Stephen Smith in "mega" phylogenetics.

We have made a series of spectacular hires in the study of evolutionary processes: Professor George Zhang in molecular and genomic evolution, Professor Lacey Knowles in speciation and phylogeography, Professor Patricia Wittkopp in the evolution of development, Professor Alex Kondrashov in evolutionary and population genetics, Professor Elizabeth Tibbetts in evolution of behavior, Professor Tim James in the evolution of mating systems and Professor Dan Rabosky in macroevolution. Professor Catherine Badgley, paleontologist and paleoecologist, has given us a deep time perspective on evolution. In ecology, in addition to the theoreticians noted in our cover story, we have added Professor Knute Nadelhoffer, who is also director of the Biological Station, and Professor Mark Hunter, who integrates ecosystem ecology with population dynamics and chemical ecology.

Other stories in this issue focus on students then and now, changes in the Museum of Zoology and the Herbarium, and ways in which the disciplines of ecology and evolution have changed, driven in part by major improvements in technology, such as DNA sequencing capacity and computational speed.

Don't miss our back cover, where we provide some comparisons of our department statistics now and then that show what our graduates are doing now and how our student body and faculty have become increasingly diverse, a better reflection of the community at large. We have a ways to go in that regard, but there's always the next decade and the next.

Finally, I wanted to add a personal note on my 10 years as chair of EEB. One of the mythologies in academia is that becoming an administrator is "going over to the dark side!" But for me, it has been a tremendous privilege to work with not only the wonderful people within the department but with the faculty and staff across the great college of LSA and, indeed, all of U-M. This is a truly great university, with tremendous commitment to the core values of scholarship, lifelong learning, and inclusiveness.

We hope you enjoy this journey back in time and the glimpse at what lies ahead. Stay in touch and I wish you a happy and healthy new year!

Warm regards,




**Deborah E. Goldberg**  
Elzada U. Clover  
Collegiate Professor  
and Chair, Ecology  
and Evolutionary  
Biology



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Olivia P. Maynard, Goodrich

Andrea Fischer Newman, Ann Arbor  
Andrew C Richner, Grosse Pointe Park  
S. Martin Taylor, Grosse Pointe Farms  
Katherine E. White, Ann Arbor  
Mary Sue Coleman (ex officio)

Editors: Deborah Goldberg, Nancy Smith  
Writer, editor: Gail Kuhnlein  
Production, illustration: John Megahan  
Photographer: Dale Austin



## Students then and now

{now}

**Emily Moran** is a postdoctoral fellow at the National Institute for Mathematical and Biological Synthesis (NIMBioS) in Knoxville, Tenn., where she is investigating the impact of increasing CO<sub>2</sub> and ozone on inter-genotype competition and plant-insect interactions in aspen forests in order to develop modeling frameworks that could be applied to other forest communities. She earned her doctorate degree in biology from Duke University in 2010.



2005 U-M biology graduate

{then}

Moran began her undergraduate biology program in 2001 at the University of Michigan. She spent several years in Professor and Chair Deborah Goldberg's lab, working on various plant community ecology research projects. Other undergraduate research experiences included field courses at the U-M Biological Station, and the Smithsonian Institution Research Training Program. She also studied abroad in Melbourne, Australia where she took wildlife biology and plant physiology courses.

"As a freshman, I already knew I wanted to major in biology, and had been thinking of pursuing a research career," said Moran. "The research experience during the semester, together with summer research opportunities, convinced me that this was the right path for me."

"Although at the time I didn't enjoy them as much as my ecology courses, I am very glad that I took statistics, math up to linear algebra, and several genetics classes," she said. "Math has always been important for theoretical biology, but there are so many exciting new directions that you can take in ecology and evolution if you have quantitative skills and/or can use molecular tools."

{looking  
ahead}

"There is a growing recognition among biologists of the ways that ecology and evolution may interact on similar timescales," she said. "For instance, the genetic diversity of hosts can strongly influ-

ence the diversity and performance of herbivores or pathogens, dispersal can positively or negatively affect local adaptation. We are even beginning to see widespread evidence of epigenetic effects, in which parental environment can affect phenotype for several generations without changes in DNA sequences – just gene expression!

"Because of the large amounts of data that are becoming available due to data-sharing and large-scale projects like NEON (National Ecological Observatory

Network), the development of new methods for dealing with large datasets is going to be just as important in ecology as it is in genomics. I also think that, given high rates of climate change, habitat loss, and other environmental changes, the role of ecologists in providing guidance for conservation, management, and policy, will only become more important. Unfortunately, many of us interested in the basic science were not trained in how to connect with policymakers and managers, and therefore struggle with it a bit, although there are more opportunities now for students to get into that world earlier in their careers."

***"There is a growing recognition among biologists of the ways that ecology and evolution may interact on similar timescales."***

Read more about Moran's work: <http://www.nimbios.org/press/Moran> and watch a video interview with her on changing forests: <http://www.nimbios.org/videos/moran>

{now}

**Nick Perri** is an undergraduate at U-M in the Program in Biology. He recently worked with EEB graduate student Brian Sedio in Professor Chris Dick's lab investigating community ecology of Panamanian *Psychotria*, a genus of tropical trees. Perri spent the summer of 2011 in the Upper Peninsula at the Huron Mountain Club assisting graduate student Alexa Unruh from Professor Phil Myers' lab, with her research investigating shrew populations.

As an undergraduate teaching assistant for Biology 171, he leads weekly classroom discussions, attends lectures, and proctors and grades exams and essays. Perri is applying for a research assistant position to explore various research opportunities in order to narrow his focus for graduate school.

"The only downside to being in EEB is that there are an incredible amount of interesting concentrations within the field, which makes it really hard to choose a focus," he said. "My educational goal is to attain a Ph.D., however I do not have a specific school in mind as I would like to pick one with a



**Nick Perri**  
Current U-M biology senior

## U-M Herbarium and Museum of Zoology

### *A look back, but mostly forward*

The past decade was bookended for both EEB-associated museum units (U-M Herbarium and U-M Museum of Zoology) by the launch of the Department of EEB in 2001 and the formal merger of both units with EEB in 2011.

The **U-M Herbarium** began the decade with a move from its long-term location in the North University building to a new facility at Varsity

Drive, south of central campus. The new facility greatly expanded the space for the collections and added a research laboratory and high quality office space.



Paul Berry

Timothy James

Chris Dick

Three long-term curators retired over the decade, including former Director Bill Anderson, phycologist Mike Wynne, and Bob Fogel, fungal ecologist, but the Herbarium bolstered its ranks with three exceptional new curators. Professor Chris Dick investigates the evolutionary processes that underlie the rich diversity of tree species in tropical forests, examining genetic structure on both biogeographical and local scales. Professor Tim James studies the evolution of mating systems in fungi and the molecular systematics of early diverging fungal lineages. Professor and Herbarium Director Paul Berry studies systematics and evolution of large genera and floristics and biogeography of tropical floras. All three combine molecular methods in their research along with the use of herbarium and living material.

Over the last decade, many smaller herbaria in the U.S. have been consolidated into larger ones, and the U-M Herbarium has acquired some of these collections, especially ones of interest to Michigan or the Great Lakes. During this time, there has also been an increased emphasis on databasing and digitizing specimens. Through a grant from the Andrew W. Mellon Foundation, the Herbarium has completed high-resolution scans of 20,000 of their most valuable specimens, those known as "types" because they are ones that new species are based on. Beyond that, Herbarium personnel have databased about 350,000 of

their 1.7 million specimens. The Herbarium is currently collaborating on several projects supported by the National Science Foundation to digitize portions of their moss, lichen, and fungal collections.

Many other exciting projects are in the works at the Herbarium and beyond. Dr. Anton Reznicek, research scientist and curator of vascular plants, is publishing a one volume update and condensation of the three volume "Michigan Flora." The Herbarium recently launched a website called "Michigan Flora Online," incorporating maps and images at <http://michiganflora.net>. Berry is the lead investigator of an NSF-funded project that is providing a new phylogenetic and taxonomic framework for *Euphorbia*, one of the largest genera of flowering plants in the world.

Because the Herbarium is located six miles south of campus, Berry emphasizes that they need to find ways of more closely connecting the Herbarium with the rest of EEB on campus. There are more than 1.7 million reasons to make the trip worthwhile!



Tom Duda

Lacey Knowles

Dan Rabosky

**For the U-M Museum of Zoology (UMMZ)**, the past decade has been characterized by a number of very positive developments and some major challenges, according to Professor Diarmaid Ó Foighil, director of the Museum of Zoology.

Three superb new curatorial appointments were made: Professors Tom Duda, Lacey Knowles, and Dan Rabosky (joining EEB in 2012). Knowles is an outstanding evolutionary biologist who is a global leader in the development of probabilistic methodologies for both phylogeographic and phylogenetic analyses and whose main taxonomic focus is *Orthoptera* (grasshoppers and crickets). Duda is an innovative marine evolutionary biologist who has developed a highly integrative research



## The ever-evolving sciences

In the year 2000, the first human genome sequence was announced – the result of a decade of collaborative effort between many labs across the world. In stark contrast, now, an individual lab can sequence the genome of 100 and more individuals in a few weeks.

“In the past, it was such a heroic effort to sequence the genome of a human, a fly, a mouse, or whatever your favorite organism is,” said Professor Patricia Wittkopp. “It led to a static view of what the genome was for that species. Of course, we know that’s not true. There’s lots of variability between individuals of a species. Now that the cost of sequencing has come down, it’s reasonable to sample deeply in virtually any organism. There’s a goal of resequencing a human genome for \$1,000 and we’re not that far away from it.”

“I think that arguably one of the greatest technological advances that impacts ecology and evolution and different areas within those fields is the massive increase in DNA sequencing capacity,” Wittkopp said. “This has led to an accumulation of knowledge that can be leveraged to address many questions that previously couldn’t be asked. Experiments are possible that weren’t before,” she said, even 10 years ago, when she was a graduate student.

For example, microbial ecology samples from various environments are being sequenced ranging from the human gut to sea water and soil. These experiments can identify what microorganisms are present, providing an approach to what used to be an impossible undertaking. In an evolutionary context, there are now complete genome sequences from many different organisms, allowing researchers to better understand their phylogenetic relationships to each other. The new capabilities allow scientists to make predictions about which genes or types of genes have contributed to the evolution of different phenotypes. One of the major questions in evolution is to understand how population level variation relates to differences between species and how those differences have evolved. It’s now possible to do extensive sampling genetically at the population level, which is one way to make these connections.

***There’s an increasing recognition that the academic discipline of ecology needs to engage with societally important issues.***

Even as we are looking forward, we are able to see more clearly back in time. Because of technological advances, it is now possible to perform DNA sequencing on extinct organisms, such as on Neanderthals and other fossils. We can also use the sequences of extant species to reconstruct their evolutionary history, including the genomes of long extinct common ancestors. As we approach having a true “tree of life”, evolutionary biologists can shift to the even more complex task of understanding the evolution of the enormous diversity of traits that characterize species, from the major adaptations such as the ability to live on land instead of the sea to the more subtle differences among closely-related species living in a single habitat.

As a result of these new capabilities dealing with millions, and approaching billions of short DNA sequences, the computational analysis downstream is significantly more demanding than it was in the past, not to mention the challenges of data storage. On the other hand, advances in computer speed paved the way for the development of more user-friendly software tools in the past decade, making it possible to simulate complex models in ecology and evolutionary biology over large spatial and temporal scales using only a few lines of computer code.

On the ecology side, computational and molecular tools are also essential, along with other technology such as Global Positioning

Systems (GPS), which make it possible for researchers

to acquire accurate spatial and tracking information and Geographic Information Systems (GIS) that allow layering of many different types of data. “We’re moving away from simply testing hypotheses to more quantitative methods of determining which models provide the best fit, meaning that

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**Brian Sedio extracting DNA from leaf tissue.**

**Peter Kilham reading computer data.**





**Beverly Rathcke**



**Anton Reznicek**

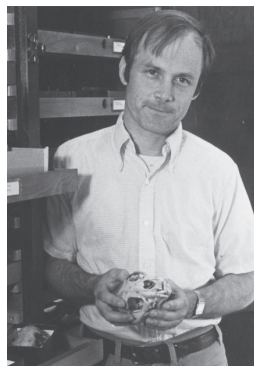


**John Vandermeer**

**BioKids 2011 field trip**



A decade of change from page 1 to interact with outstanding researchers from around the globe, in 2006, EEB launched the annual Early Career Scientists Symposium. Rather than inviting well-established and often-invited senior scientists to speak on particular topics, the speakers are chosen to present the most exciting work being done by the upcoming generation of ecologists and evolutionary biologists. The ECSS has grown into a prestigious annual event focusing on a different topic each year that attracts researchers from across the globe and a growing number of regional attendees.



**Phil Myers**

For undergraduates, a big change has been the launch of a concentration in EEB and the revival of concentrations in microbiology and in plant biology, in addition to the older biology and general biology concentrations. Together with MCDB, we completely overhauled the teaching of introductory biology from a single course to three courses that better prepare students for more advanced courses in biology. Teaching in the department has also changed considerably in response to pedagogical research that focuses on how students learn rather than just how faculty can improve their lecture style. Many of the faculty use much more active learning techniques that directly engage students, even in classes of over

300 students. The department has also increased the number of small

classes for undergraduates, with more first year seminars and a required senior capstone seminar for EEB majors. In using technology for education, Professor Phil Myers has led the way, not only at U-M, but nationally, with the Animal Diversity Web as a tool for inquiry-based learning.



EEB has also taken to heart the importance of making our department and our science more reflective of the diversity of the country. "Under Deborah's leadership, our department has stepped up to the plate, in a very major way, when the University of Michigan started moving in the direction of being more responsible about serving all the people in society," Vandermeer said. Programs in EEB range from elementary school (the BioKIDS project with Detroit Public Schools), to early college (Michigan Biology Academy Scholars, EDQUE<sup>2</sup>ST), to graduate students (Frontiers Masters). And indeed, the number of women on the faculty has nearly doubled and the proportion of underrepresented minorities in the graduate program has increased nearly eightfold. 🌱



**Bill Fink**



**George Kling**

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strong program in my focus that has yet to be decided. Ideally, I would really enjoy sharing my knowledge with others through teaching."

What most excites Perri about the field of EEB is the immense diversity of topics. "EEB has a lot to offer to our understanding of the natural world, and the necessity of this knowledge is becoming increasingly transparent as we attempt to address some of the environmental issues the world is facing today."

**Looking ahead**

In terms of where the field is heading, he thinks significant emphasis will be placed on evolution because the ability to evaluate and understand evolutionary processes greatly increases as our technology increases. "In addition there are a lot of hot topics such as global warming, invasive species, and loss of biodiversity which draw heavily upon EEB principles, so I would expect there to be an increase in projects focusing on these topics." 🌱



museum from page 4

program involving predatory *Conus* species (cone snails) that links evolution at specific genes (paralyzing conotoxins) to organismal ecological performance. Rabosky is currently a Miller Fellow at the University of California, Berkeley and is an emerging star in macro-evolutionary studies. His research addresses fundamental aspects of among-lineage differences in species richness and phenotypic diversity and his main taxonomic focus is the Australian lizard and snake fauna.

UMMZ collections development and upgrading have continued apace over the past decade. The most extensive growth has been in Professor Barry O'Connor's extraordinary Acari (mite) collection. Major new electronic databasing initiatives have involved the Orthopteran insect and freshwater mollusk holdings. Most of the vertebrate collections are now electronically linked to multi-institutional networks: the Mammal Networked Information System (MaNIS) and its bird (ORNIS) and fish (FishNet) equivalents. These linkages maximize the utility of UMMZ holdings for basic research and for conservation and climate-change studies.

"As museum research incorporates new molecular techniques, there is a need for high-quality preservation of specimen biomolecular structure," said Ó Foighil. "Our ability to

do this is being significantly enhanced by the construction of our first liquid nitrogen storage facility, funded by Professor Priscilla Tucker's recent National Science Foundation grant."

"The UMMZ has continued to engage in extensive local and global outreach," he said. The Animal Diversity Web or ADW (<http://animaldiversity.ummz.umich.edu/site.html>), a premier source of educational biodiversity information, founded by Professor Phil Myers, is a prime example. It is heavily used – currently five million page views and half a million unique users/month – and recently received new NSF support to further enrich its classroom teaching capabilities. ADW also feeds content into the Encyclopedia of Life (<http://eol.org/>).

A major challenge faced by the UMMZ is common to zoological museums worldwide. Changing fire codes put ethanol-preserved collections in violation of new safety standards. These collections are being relocated to an extensive new collection facility adjacent to the Herbarium that meets current safety standards. "This ensures their long-term viability as research collections and also of biodiversity studies as a central component of EEB research," said Ó Foighil. 🌿



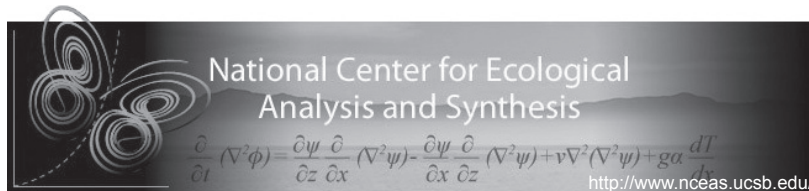
**Animal Diversity Web**  
<http://animaldiversity.ummz.umich.edu>

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researchers need much more sophisticated analytical tools," said Professor Deborah Goldberg, chair of EEB. Theoretical ecology has expanded its range to

use models to extract and understand patterns in long-term data sets, exemplified by the work of EEB Professors Mercedes Pascual, Pej Rohani, and Aaron King on the dynamics of diseases such as cholera and whooping cough.

In addition, Goldberg cites "a growing compilation and use of databases with information about species, communities, and organismal traits that enable us to search for patterns and test hypotheses with really large sample sizes, spanning the globe instead of having to rely only on the data that an individual or team of researchers can collect. Just as the GenBank sequence database and now collections of entire genomes has changed evolutionary biology, ecology is being changed by the ability to mine data collected and assembled by others."



The National Center for Ecological Analysis and Synthesis (NCEAS) has played an integral role in stimulating the development of databases, team research, data mining, new approaches to synthesis, as well as in developing tools for ecological informatics. The newer National Evolutionary Synthesis Center (NESCent) is now playing that same role in evolutionary biology.

"The pace of technological changes enabling major advances in understanding over the past decade has been unprecedented; I can't wait to see what the next decade will bring," said Goldberg. 🌿



## EEB by the numbers

### Graduate students

*149 graduates since 2001 (103 Ph.D./46 M.S.)*

#### Where are they now?

- 34 university - tenure track faculty positions
- 23 university - non-tenure track positions
- 28 postdoctoral fellows
- 15 government/non-profit positions
- 11 continuing graduate education
- 5 private sector positions

#### Who are they?

- 2001: 67 graduate students total  
(44% female, 9% international, 3% underrepresented minority)
- 2011: 75 graduate students total  
(55% female, 27% international, 23% underrepresented minority)

### Faculty

#### 2001

29 total: (17% female)

#### 2011

35 total: (27% female)

#### Hired since 2001

20

#### Retired/left dept. since 2001

16

#### Research funding

##### FY 2002

\$2,004,627

##### FY 2011

\$3,612,036

