Department of Ecology and Evolutionary Biology
University Museum of Zoology
University Herbarium

Self study for External Review

Contents

I. Mission and goals

The **Department of Ecology and Evolutionary Biology,** in collaboration with the **University Museum of Zoology** and the **University Herbarium,** has a primary mission to undertake research and education in the biological principles and processes that account for the origin and maintenance of the diversity and complexity of life.

Specifically:

- We conduct research, mentor students, and teach classes at levels of organization ranging from evolution at the molecular level to the ecology of the global biosphere.
- We play a unique role within the life sciences on campus through our expertise on the origin, evolution and ecology of diverse organisms throughout the tree of life and because of our focus on biological interactions in the context of heterogeneous natural environments.
- We link to many basic and applied disciplines in the broader biological and environmental sciences.
- We embrace the use of explicit learning goals as a way to develop appropriate assessment tools in our classrooms and continually improve our educational practices.
- We are dedicated to and promote one-on-one mentoring of research students in our laboratories and field sites, at levels from undergraduates to postdoctoral fellows.
- We incorporate computational and mathematical approaches into much of our education and research and are committed to helping students productively use quantitative approaches.
- We are committed to being a diverse, collegial, and collaborative community of faculty, staff, and students.

The **Museum of Zoology** is a community of scholars dedicated to studying the evolutionary origins, history, maintenance and conservation of the world's biota, to archiving and documenting changes in biodiversity through its research collections and to educating our students in this search for knowledge.

The **Herbarium** facilitates studies on the diversity of plants and fungi around the globe through the use of museum specimens and field studies. We act as a key resource for studies of the Great Lakes flora, as well as for other regions or taxonomic groups in which our staff and collections have strengths.

Both museum units interact with other LSA research museums as well as the Exhibit Museum to coordinate student mentoring and research in the collections and to supplement outreach to the wider community.

The collective goal of all three units is to be a national leader for research, graduate training and undergraduate education in ecology and evolutionary biology, by providing integration across these disciplines and through emphasis on organismal expertise as an essential component of addressing fundamental questions about the origin, history, and maintenance of biodiversity from the level of molecules to the global ecosystem.

In this joint report, we describe the current status of the three units in terms of research, education, organization and policies/procedures, and facilities. We also describe key ongoing or proposed initiatives in each area in the appropriate section; these are summarized in the concluding Section XIII. We provide a glossary for all the acronyms we use in Appendix A, previous long-term plans for each unit in Appendix B, and status reports and updates to those plans in Appendix C.

II. Academic profile

Research and education in the Department of Ecology and Evolutionary Biology (EEB), the Museum of Zoology (UMMZ), and the Herbarium span all aspects of biology, emphasizing the diversity and complexity of life (Appendix D, E). We study and teach about ecological interactions that contribute to the origin and maintenance of biodiversity and the functioning of ecosystems, and we explicitly address phenomena across levels of organization and scales of space, and time. We also address a wide range of evolutionary questions, including reconstructing the course of evolution (paleontology and phylogenetics) and elucidating the mechanisms of the key evolutionary processes, such as changes in genome complexity, speciation, and the origin and duration of complex phenotypes.

Our three units have historically been very strong in ecology and in phylogenetics and systematics, with comprehensive expertise in biodiversity. At the time of our last long-term plan in 2003, ecology remained strong but was extremely top heavy; since that time, we have successfullyrejuvenated and expanded our programs with four new faculty (Hunter, King, Ostling, and Rohani). We now have particularly outstanding groups in disease ecology and theoretical ecology (Pascual, King, Rohani, Ostling, Vandermeer) and in population and community ecology (the theorists plus Werner, Hunter, Goldberg and 0 fraction appointments Ibanez, Foufopoulos). In collaboration with other units on campus, including medicine, public health, engineering, and natural resources, we are developing a very strong interdisciplinary program in microbial ecology (Kling, Goldberg, and an ongoing search, 0 fraction appointment Zak). Biogeochemistry is also strong as an interdisciplinary group on campus, although relatively small within EEB (Nadelhoffer, Kling, 0 fraction appointments Zak, Blum). One conspicuous gap is large-scale ecology, from landscapes to the globe. Relative to other top EEB departments in ecology, we are perhaps within the top five; not nearly as large as UC Davis nor as elite as the small groups at Princeton and Stanford, but on a par with Cornell, UC Berkeley, and Duke.

In evolutionary biology, our traditional strength in phylogenetics and systematics has been waning due to retirements, although new hires in plants (Berry, Qiu) and fungi (James) include major players in NSF's "Assembling the Tree of Life" program—a flagship program to use advances in sequencing and informatics technology to reconstruct the evolutionary history of the tree of life on earth. Since 2001, we have been building strength in studying the mechanisms of evolution, with a number of new hires in 1.0 EEB positions (Zhang, Wittkopp, Qiu, and Tibbetts), faculty jointly appointed with the Museum of Zoology and Herbarium (Knowles, Dick, Duda, Berry, and James) , and one senior hire joint with the Life Sciences Institute (Kondrashov). Together with existing faculty (Tucker, OFoighil), these new hires have brought exceptional individual research programs in molecular evolution, evolutionary genetics and genomics, phylogeography, speciation processes, evolution of development, and evolution of behavior, all of which take advantage of the revolution in sequence data generation and bioinformatics capability. Nevertheless, we lack critical mass in any of these areas and remain behind top EEB departments such as the University of Chicago and Harvard in evolutionary biology.

Our current combination of research strengths uniquely positions us to address questions at the interface of ecology and evolution and understand how these interactions are constrained by evolutionary history. These questions include some of the most challenging issues in biology, such as the fundamental linkages among genotype, phenotype, and the environment; the role of selection; factors responsible for structure of communities, origin and preservation of biodiversity, emergence and dynamics of pathogens; and sustainability of managed ecosystems. We view this interface as a key area for future hires; it is already a strong theme in EEB research, e.g., work on the evolution of venoms and feeding behavior in snails (Duda), evolution of pigmentation in *Drosophila* (Wittkopp), the phylogenetic structure of communities (Dick), the evolution of the capacity for individual recognition in wasps (Tibbetts), and the evolution of bioluminescence in symbiotic bacteria (Dunlap).

A critical component of research and teaching in our units is that faculty jointly appointed in the Museum of Zoology and the Herbarium typically have more "vertically" oriented research and teaching programs. These integrate all aspects of the biology of particular groups, from molecules and genes to ecology, and therefore enable understanding of how these different levels of organization interact and feed back into each other. This approach is completely complementary to the more "horizontal" integration of many of the 1.0 EEB faculty. There, the focus is on one or a few levels of biological organization integrated across diverse taxa to understand both generalities and exceptions to general patterns. This focus on organismal expertise enabling vertical integration has become relatively rare, yet it is critical to forecasting biodiversity dynamics in a heterogeneous world. UC Berkeley and Harvard are the only universities on par with the organismal expertise at UM.

Finally, the subject matter of EEB represents the underlying basic science for some of the most pressing challenges of our time, and many of our faculty apply their expertise to research and education on these pressing challenges. These include the consequences of anthropogenic climate change and disruption of global biochemical cycles (Nadelhoffer, Kling, Hunter, Pascual, Goldberg, Myers, Badgley, Burnham); the emergence and spread of infectious disease (Pascual, Rohani, King);

sustainability of food production systems (Badgley, Vandermeer); and invasion biology, fragmentation, and conservation (Goldberg, James, OFoighil, Vandermeer, Werner).

The National Research Council ratings of graduate programs would be very helpful for assessing the relative strength of our overall programs; unfortunately, while these were due to be released last year, they are still not available. Without that highly quantitative source, we can only refer to the unreliable US News and World Report rankings based on general reputations. In the 2007 rankings (last time EEB was considered explicitly), EEB was tied for 11th; in 2006, we were tied for 6th.

Our faculty are highly productive and well-respected in the ecology and evolutionary biology research community. In the last five years, they have published a total of over 600 peer-reviewed papers. This total includes publications in Science (12), Nature (12), Proceedings of the National Academy of Sciences US (20), Current Biology (8) as well as in all the most distinguished disciplinary journals such as Evolution (14), Molecular Biology and Evolution (16), Ecology Letters (9), American Naturalist (8), Ecology (13), Systematic Biology (10), Proceedings of the Royal Society of London (11), Journal of Experimental Biology (27), and Global Change Biology (6). Collectively they hold 3 editor-in-chief positions of academic journals and serve on 23 editorial boards. Three faculty have been presidents of their professional societies and almost everyone has served on committees for their national or international professional society, many chairing important committees. Our faculty include a Howard Hughes Medical Investigator (Pascual), 2 Guggenheim Fellows, 2 Fulbright Fellows, a Sloan Research Fellow, 2 AAAS Fellows and 2 members of the Faculty of 1000 for Biology.

Within the University of Michigan, our faculty have won just about every award possible: we have five Collegiate Professors, one Thurnau Professor (for education), and one Distinguished University Professor. Patricia Wittkopp will be recognized during the External Review Committee's visit as the 2009 Russel Awardee; this is the highest honor the University bestows on a junior faculty member. Members of our faculty have won the Provost's Innovation in Teaching Award, the Rackham Distinguished Faculty Achievement Award, the Rackham Distinguished Graduate Mentoring Award, the Rackham Faculty Recognition Award, the LSA Excellence in Concentration Advising Award, the LSA Excellence in Education Award, the Sarah Goddard Power Award (for significant contributions to the betterment of women) and the University Distinguished Leaders in Diversity Award.

III. History

The organization of the basic biological sciences at the University of Michigan has followed a similar trajectory to that of many institutions in the United States. The Departments of Botany and Zoology were brought under a Division of Biological Sciences in 1974, the Division became a single Department of Biology in 1986, and in July 2001, the Departments of Molecular, Cellular, and Developmental Biology (MCDB) and Ecology and Evolutionary Biology (EEB) were established by fission of the Department of Biology. This split was endorsed by an external review of Biology in Fall 2000 (Appendix F). The undergraduate Biology concentration and curriculum that existed

under the former Department of Biology has been retained and is jointly administered by EEB and MCDB as an interdepartmental program, the Program in Biology.

The University of Michigan Museum of Zoology and the University Herbarium both began in 1837, when the newly recognized state of Michigan authorized a "Cabinet of Natural History" for the University. The Collections have grown over time as scientific expeditions by UM biologists and many others have entrusted archival research materials collected from nearly every region of the world to the university's care. The collections include representative specimens of extinct species and populations, providing records for studying effects of environmental change on the distribution, appearance, and genetic features of the world's animals, plants and fungi. The UMMZ and Herbarium reported directly to the Board of Regents or University President until 1956, when they were transferred to LSA. Curators/Professors then were jointly appointed in LSA academic departments. In 2000, the Herbarium and Museum of Zoology were both part of an external review of the four LSA research museums, together with the Exhibit Museum (see Appendix F). In 2004, faculty-curators took on an expanded role in departmental teaching (75%), while retaining their research and curatorial functions in the museum. In 2002, the Herbarium collections were moved from central campus to an off-campus facility on Varsity Drive; at the time the move was intended to be temporary but it has since been acknowledged as permanent. At the present time, intensive planning is underway for the move of most of the alcohol collections of the UMMZ to the Varsity Drive facility. The new EEB department presented a five-year plan in 2003 (Appendix B-1), which was approved by the College of Literature, Science, and the Arts (LSA) in April 2004. The faculty development component of this plan incorporated hiring strategies for faculty jointly appointed with the UMMZ and Herbarium and was fully supported by those units. The UMMZ and the Herbarium presented a joint plan in 2004 (Appendix B-2), which received mixed reviews from the College.

As a result of these plans LSA set a "target" resource allocation of 25 college-funded FTEs for EEB, 4 college-funded FTEs for UMMZ, and 2 for the Herbarium. This represented a net increase for EEB, but a decrease for UMMZ. The Herbarium had already lost several positions from its historic high of 4 college-funded FTEs; this new target formalized that reduction.

It is important to note that the actual FTEs in the three units will not correspond to the college-funded FTEs (CFFTEs) used in the target values. The latter do not include positions funded from other sources, such as Provost support for partner hires or the President's Interdisciplinary Junior Faculty Initiative, but they do include higher "costs" of senior faculty hires (1.5 CFFTEs rather than 1.0 CFFTE). Current CFFTEs in EEB alone are 21.5, with two additional positions already authorized but still open. Thus, EEB is still below its target and has room to expand (but has strong space limitations, see Section XII-A). However, UMMZ is exactly at target (CFFTE is 4) and the Herbarium is slightly under target (CFFTE of 1.75).

IV. Structure and interactions among EEB, UMMZ, and the Herbarium

All the faculty with appointments in the Museum of Zoology and the Herbarium, as well as one faculty member in the Museum of Paleontology, have appointments in EEB (Appendix D); these

joint appointments, however, are quite different from standard joint appointment between two academic departments. For faculty jointly appointed with a museum unit, tenure resides in EEB, graduate students are admitted only through the department, all formal teaching duties are through the departments, and most committee service is in the departments. The intellectual disciplines in the museum units are well integrated within the disciplinary scope of EEB, and the three units effectively operate as a single unit for undergraduate teaching, the graduate program, and in the hiring, mentoring and promotion of faculty. To facilitate these operations, the Chair of EEB and the Directors of UMMZ and the Herbarium meet regularly (at least monthly). The EEB Executive Committee always includes representatives of the museum units, as do all key committees such as Promotions and Merit, Graduate Admissions, and Undergraduate Curriculum.

On the other hand, curatorial and outreach responsibilities in the museum units are quite distinct from duties in an academic department; these are described briefly in Section VI-A and in more detail in the updated UMMZ and Herbarium long-term plans (Appendix C-2, 3). The collection-related aspects of the mission of the UMMZ and the Herbarium require quite different administration and staff expertise such as overseeing specialized database procedures, management and hiring of properly trained collection management personnel, and knowledge of accessioning procedures and their legal ramifications. Although no longer the case in EEB, many members of the former Department of Biology did not appreciate this distinctive mission and set of responsibilities, which resulted in considerable conflict.

These simultaneous convergences and divergences in functions between EEB and the two museum units could operate under a number of alternative administrative structures. The current structure has all three units with their own faculty lines, separate budgets, and separate reporting lines to LSA. The Dean's office is interested in the possibility of incorporating the museum units into academic departments. The directors of all the museums in LSA (also including Paleontology, Anthropology, and the Exhibit Museum, as well as UMMZ and the Herbarium) have proposed an alternative model that combines administrative functions of the museums to create a single, more efficient and cost-effective structure, as well as to increase the synergies springing from museum-related activities. This plan is still being refined at the time of this writing and has not been thoroughly discussed by the faculty of all relevant units. Each of these different administrative structures has its own costs and benefits, and the three units under review have begun serious conversations to evaluate them in anticipation of discussing these issues with the review committee and the Dean's office.

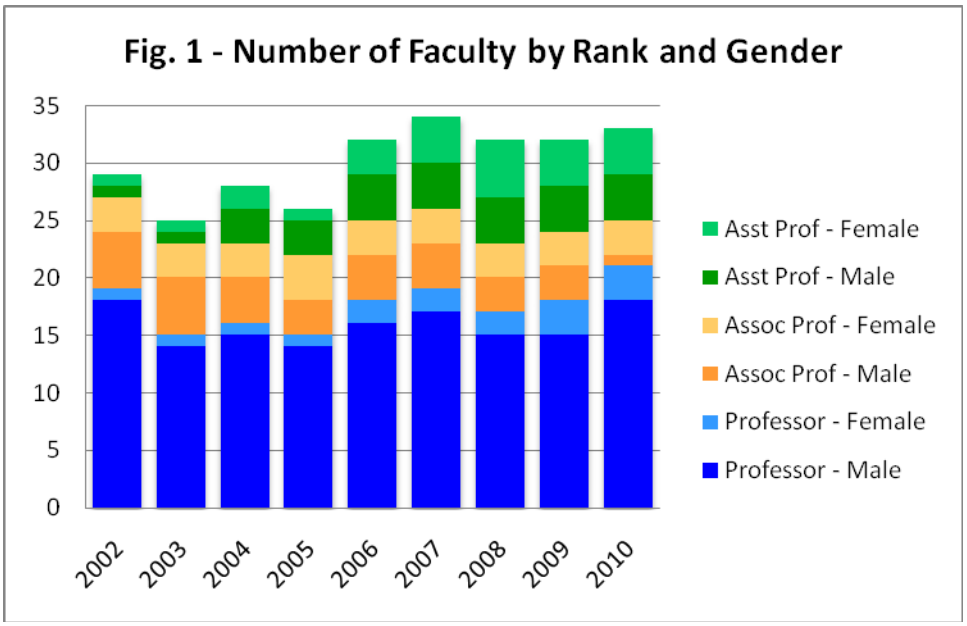
V. Faculty demography, hiring goals, and interdisciplinarity

A. Faculty demography

In 2001-2, when EEB was first created, the department and the two museum units had a combined total of 25.55 FTEs and 28 faculty (Fig. 1; Appendix G). By 2009, the combined faculty was somewhat larger, with 29.5 FTE and 33 faculty. However, the balance among the units shifted, from 73% of the combined FTEs in EEB in 2001 to 81% in 2009. This was a consequence of an increase in EEB (from 18.55 to 24 FTE) combined with declines in UMMZ (from 5 to 4 FTE) and the

Herbarium (from 2 to 1.5 FTE). EEB also has one faculty member jointly appointed with the Museum of Paleontology (Burnham) and typically has 1.5-3 FTEs jointly appointed with other academic units (Appendix G).

In 2001-2, the three units were very top-heavy with 65% full professors and only 7% assistant professors (Fig. 1). However, a wave of retirements of senior faculty, especially in the UMMZ and the Herbarium, and subsequent hiring led to a large turnover, with the consequence that nearly half of the faculty currently in the three units are new since 2001. Most of these 17 hires have been assistant professors (12), but 5 have been full professors. Five of the 17 hires were joint between EEB and a museum unit, two involving UMMZ (both assistant professors: Duda, Knowles), and three involving the Herbarium (two assistant professors: Dick and James and one professor: Berry).



Thus, we have successfully rejuvenated the three units as a whole, more than tripling (to 25%) the percentage of assistant professors (Fig. 1). However, one assistant professor is currently in the tenure/promotion process (approved by the department) and three others are starting the process this summer. In the absence of further hiring, only 10% of our faculty will be assistant professors one year from now, with none in the Museum of Zoology. The percent of women faculty has almost doubled since 2001, from 17% to 30%. Most of this increase has been in the assistant professor (now ca. 50% women) and associate professor (ca. 75% women) ranks; only three women are full professors (compared to one in 2001) (Fig. 1). Faculty diversity is discussed in more detail in Section X-B.

Over the past two decades, the Curator/Professor component of the UMMZ has seen steady erosion due to retirement, mostly without replacement, from 13 individuals in 1980 to 8 presently (2 in Insects, 1 in Fishes, 1 in Amphibians and Reptiles, none in Birds, and 2 each in Mollusks and Mammals; total of 4 FTEs). Two of the current curators (Knowles in Insects, Duda in Mollusks) were hired since 2000. The curators in the Amphibian and Reptile division and in the Fish Division are both relatively senior and their retirement without replacement would leave these collections, along with the Bird Division, without a faculty curator to provide scholarly direction and oversight (see Section VI-A for a discussion of the curatorial role).

In the case of the Herbarium, the loss of Curator/Professors occurred earlier than in the UMMZ, and areas traditionally overseen by a curator have gone for long periods without one (e.g., fungi, mosses, ferns). The Herbarium has therefore stopped conceptualizing their collections in terms of divisions, and curators have been hired more recently based on criteria such as the need for an experienced director, opening a phylogeographic line of research, and filling an endowed position in mycology. In 2000, at the last external review of the Museums by the College, the Herbarium had four Curator/Professors; these declined to only one in 2003, but subsequent hires and one further retirement led to the current status of three Curator/Professors, occupying 1.75 of the 2.0 CFFTE positions (1.5 actual FTE).

B. Hiring goals and strategies

Based on the analysis of strengths and weaknesses in Section II and the demography of the three units, as well as extensive department discussions on the most exciting emerging fields in ecology and evolutionary biology and the recognition that we cannot do everything well, we have reached a consensus that evolutionary biology and its interface with ecology is our highest priority, followed by large-scale ecology. While searches will be conducted at this very broad level, specific research areas of interest will be noted in position descriptions. These research priorities are described below.

The study of the origin, evolution and diversity of life is an integrative science requiring an understanding of relationships at multiple levels of biological organization, e.g., how changes in genome structure and gene regulatory networks influence developmental differences, how these differences produce phenotypes that respond to selection in an ecological context, and how genetic and environmental factors interact to give rise to species and to large-scale patterns of biotic diversity. Priority research areas for new hiring include the evolution of these genotype-phenotype-environment relationships, a field that draws from the subdisciplines of evolutionary genetics and genomics, evolutionary ecology, experimental evolution, and evolutionary theory.

In ecology, it has proved an extraordinary challenge to scale up the powerful understanding of local-scale processes that population, community, and ecosystem ecologists have developed to include entire landscapes, regions, or the globe. The solutions to this challenge will have particular applications for society, for example in the ecology of pandemic diseases or the rapid spread of invasive species, as well as in the response to synoptic changes in weather as driven by global climate change. The importance of developing understandings of large-scale processes has been recognized in funding initiatives such as the request in President Obama's budget for $433M to NSF to build a National Ecological Observatory Network (NEON). Given this great emphasis on ecology at this level in both intellectual and funding arenas, it is a stark realization that we currently have no faculty whose primary research is in large-scale ecology, making this area a high priority for hiring.

These research priorities are also teaching priorities, representing major gaps in our upper-division undergraduate and graduate-level curriculum that include evolutionary ecology, evolutionary genetics and genomics, phylogenetic theory, evolutionary theory, physiological ecology, landscape ecology, and global change biology. As well, we lack sufficient faculty to teach courses on scientific

writing, grant writing, and graduate-level statistics for biologists, and we simply need more field courses. The increasing interactions of ecologists and evolutionary biologists with other disciplines throughout the University means increasing enrollments of non-EEB or Biology students in our upper division/graduate courses. We are also always in need of faculty to fit into our rotations in the large enrollment introductory courses in biology, genetics, evolution, and ecology and to teach in the EEB concentration capstone course, which is capped at 20 students a section (see Section VIII-B).

The department is committed to integrating research and education in the areas above with expertise in organismal diversity--gaining insights into questions in ecology and evolutionary biology requires fundamental knowledge of the basic biology and evolutionary history of the organisms being studied in the same way that asking fundamental questions in, say, anthropology or sociology, requires deep knowledge of the historical and linguistic context of the geographic area and time being studied. As a consequence of this broadly-recognized need, in 2009 the EEB faculty voted unanimously that "*When partial lines that belong in the Museum of Zoology or the Herbarium become available, those faculty lines should be used for searches that directly strengthen key curatorial and research needs of the associated units. These should be defined as broadly as possible given those needs*." Thus, we expect that searches for jointly appointed faculty will **be defined very broadly in conceptual terms and with the same priority research areas specified above**, but oriented towards a particular taxonomical group to ensure research, teaching, and curatorial expertise in biodiversity. For example, two specific searches likely in the near future are "evolution and evolutionary ecology of birds" and "evolution and evolutionary ecology of plants and fungi". The first of these new faculty would teach an ornithology course and become curator of the Bird Division in UMMZ, and the second would contribute to our curriculum and concentration in plant biology and help establish a critical mass of plant evolutionary biologists in the Herbarium and EEB. Both would also teach in one of the conceptually-oriented courses described above.

Finally, because of the unique value of the collections of the UMMZ and Herbarium for many kinds of research and the need for curatorial leadership (see Section VI-A), the EEB faculty also voted unanimously to add the following language to all faculty position advertisements that are 1.0 FTE in EEB: "*Opportunities also exist for using the large research collections of the Museum of Zoology and Herbarium; curatorial opportunities in these units may replace some teaching.*"

Notably missing from the list of research areas of emphasis for new hires is functional organismal biology, including physiology, functional morphology, and behavior of individual organisms. As we did in the 2003 long-term plan, we made this decision with considerable reluctance. We recognize the importance of the integration of analyses of function at the molecular and cellular levels with analyses at the population and community level, and that such functional or integrative biology has declined nationally as many departments of biology split into departments such as MCDB and EEB. Aspects of functional biology are inevitably included in the teaching and research of EEB faculty, especially as they merge with evolutionary and ecological questions. Nevertheless, we recognize a need for a more comprehensive approach to organismic biology, which is often the nexus for reintegration of biology sub-disciplines (advocated as a goal in the National Research Council's

recent 2009 report, *A New Biology for the 21st Century)*. Part of the challenge of re-investing in organismic functional biology is that work in the area has become distributed over many disciplines in various Schools and Departments. Therefore, we are beginning an effort to coordinate with other units across campus, such as the School of Kinesiology, MCDB, College of Engineering, Medical School and School of Dentistry, with the goal of improving teaching and research in organismic function. We hope to develop an interdisciplinary group focused on organismic functional biology, perhaps leading to a proposal for a cluster hire in this area for the President's Interdisciplinary Junior Faculty Initiative.

C. Interdisciplinarity

The highly interdisciplinary nature of ecology and evolutionary biology is reflected both in the strong connections of EEB faculty to formal units across campus and in the great variety of collaborations with researchers in other disciplines. Over half the appointments in EEB are joint with other units. In addition to the joint positions with the UMMZ and the Herbarium, EEB faculty currently have joint appointments (one each) with the Museum of Paleontology, the Life Sciences Institute, the School of Natural Resources and Environment (SNRE), the Center for the Study of Complex Systems and the UM Biological Station (the Director of UMBS is an EEB faculty member) (Appendix H-1).

In addition to these budgeted joint appointments, EEB welcomes non-budgeted ("dry") appointments in the department (total of 10), and ten of the EEB faculty have dry appointments in other units. While these formal interactions are important, a much better description of the interdisciplinarity of the three units is its network of actual research collaborations on campus, involving 8 different colleges and schools and 17 distinct departments or centers within the University (Appendix H-1). The most common partner is the School of Natural Resources and Environment, but a number of faculty also collaborate with the College of Engineering, School of Public Health, and the Medical School as well as many other departments or centers within LSA.

Disciplines with which EEB faculty collaborate include other biological sciences (e.g., neuroscience, plant pathology, oceanography, epidemiology, medicine), physical sciences (e.g., physics, environmental engineering, atmospheric sciences, geochemistry, hydrology, remote sensing), social sciences (e.g., psychology, economics, Latino studies, education), mathematics, statistics, computer sciences, and even theater. Finally, research collaborations and field work are worldwide, involving 113 institutions in 44 countries on all continents except Antarctica (Appendix H-2).

Future hiring will continue to add to these interdisciplinary linkages both within and outside the University. For example, our two current searches, in computational evolutionary biology and microbial ecology, are both part of the President's Interdisciplinary Junior Faculty Initiative, which funds cluster hires across departments and schools and colleges. These cluster hires involve 4-6 faculty in the same interdisciplinary area in multiple units (each person hired will be 1.0 in one unit), typically with an addition of an interdisciplinary steering committee that serves as a mentoring committee for the new faculty in the cluster and initiates interdisciplinary activities such as joint symposia, journal clubs, and training grant proposals. In the first year of this program, EEB was involved in 2 out of the 6 successful proposals in the entire University. We also have two

cluster proposals currently under consideration, focused on sustainable food systems and on water resources.

VI. Museum-specific issues

A. Curatorial roles

Joint Curator/Professor appointments in the UMMZ and the Herbarium differ from 100% EEB faculty appointments by their curatorial duties. A Curator in these units is expected to have world-class expertise in the biology of a particular group of organisms and curatorial duties include the following: a) provide leadership and vision about where the respective field is headed so that collections can be made or prepared to meet those needs; b) be conversant in best practices of curation procedures and technologies, c) provide or maintain resources for the wise use of collection objects and associated data; d) teach undergraduate and graduate students about the care and maintenance of major biodiversity collections and resources; e) oversee staff who do the routine work of preparing loans, specimens, and cataloguing; f) be aware of legal issues regarding their particular collection and instruct staff and students about these requirements; g) increase the scope and diversity of the collection through targeted acquisition and exchanges with other museums around the world; and h) communicate museum-oriented biodiversity research to the broader community by developing online resources for the public and for various research and educational communities, as well as through tours for UM classes, public lectures or tours, and collaboration with UM Exhibit Museum staff in the development of visitor exhibits.

Every Curator in the UMMZ and all but one in the Herbarium have a 0.5FTE appointment in the museum unit and 0.5FTE in EEB. In addition, one faculty member in EEB has a 0.5 FTE appointment in the Museum of Paleontology (the four other members of the Museum of Paleontology have joint appointments with Geological Sciences, two of whom also have dry appointments in EEB). Tenure of curators jointly appointed with EEB resides in EEB, but curatorial duties figure into annual salary evaluations, as do service, teaching, and research. (The Chair of EEB and the Director of the Herbarium or UMMZ meet to decide on a joint salary recommendation.) In 2002, the entire faculty of EEB, including all the jointly appointed curators, unanimously agreed that the teaching expectation for the jointly appointed faculty with the UMMZ and Herbarium should be 75% of that expected of 1.0 EEB faculty, rather than the 50% expected based on the distribution of FTE (Appendix I-1). This expectation is averaged across all curators over a 3 year period; this allows adjustments due to increases in curatorial load (e.g., when large projects on databasing are being initiated or major collections are being accessioned).

Curatorial accomplishments are evaluated according to how well they match the expectations just listed. These include the broad areas of development and scholarly use of the organismal collections and genetic resources for biodiversity studies, biodiversity informatics and outreach activities. Curator/Professors provide the UMMZ or Herbarium Director with documentation of these activities on a yearly basis as part of their salary review. Among other things, evaluations can include staff oversight duties (including collection managers, graduate student research assistants, undergraduate students and volunteers). Curator/Professors are expected to coordinate and

encourage use of the collections by the international scientific research community as well as University of Michigan scientists and students; this includes biodiversity informatics efforts. Curator/Professors also are expected to, as needed, seek and administer external funding for improvement and upkeep of collections facilities (e.g., new specimen cases, salary for assistance with collections databasing).

B. Specialized support staff

A special level of staffing in the museum units comprises the Collection Managers. This category is unique to the museum units and includes specialized professionals who directly oversee and care for the collections on a daily basis, but generally do not engage in research activities on their own. They may be involved, however, in infrastructure improvement and informatics grants. Since this work requires expertise in organismal diversity and because different groups of organisms require drastically different methods of preservation and care, Collection Managers are not interchangeable and often reflect years or decades of dedication to particular groups or curation practices.

C. Museum informatics

With the other LSA research museums, the UMMZ and Herbarium emphatically need to strengthen our position in the digital arena. Each unit has its own amalgamation of databases and websites, but with no overall coordination or vision of consolidating and improving our digital presence. We manage enormous quantities of data and specimens, which require creative ways to present and analyze them. We aim to hire a high-level informatics expert who can focus on the strategic development of the Museums' varied forms of data and specimens to advance their research and education missions. This person will be responsible for envisioning and designing the institutions' informatics approaches to best leverage existing intellectual strengths and information resources by bringing collections and associated data into national and international museum networks and initiatives. It is expected that the hire will actively pursue external funding for new informatics initiatives working in collaboration with curatorial and research staffs.

D. Outreach, service, and support functions

Besides the teaching and research missions that are the focal points of the EEB Department, the Herbarium and Museum of Zoology also fulfill a broader function to the university community and beyond, namely a significant role in outreach and service activities. This is best illustrated with a few examples. The Museum of Zoology has a very successful and popular Animal Diversity Web site that reaches a broad constituency across the nation, as well as within the university. The Herbarium is the home of the Michigan Flora project, which is being updated by a new upcoming book and associated web site. It is the to go-to place for anyone requiring greater knowledge or advice about plants that occur in Michigan and the Great Lakes region. A consequence of these and similar activities is that each of the museum's staff handle numerous inquiries from faculty, graduate and undergraduate students, professionals outside the university, and the general public. In short, people from a broad slice of society come to the Herbarium and Museum of Zoology, either virtually or in person, to obtain expertise and definitive answers about major taxonomic groups of organisms. The large size of our collections (1.7 million specimens at the Herbarium, for example) requires that the staff devote considerable time to databasing and cataloguing and applying for

grants that support the infrastructure and informatics needs in both museums. Further, both museums maintain an active loan and exchange program with peer institutions to facilitate interchange of research materials.

E. Relationship to other museum units

The Herbarium and UMMZ are just two of six museum units within the college that have common themes and issues that could benefit greatly from closer integration. Recently, the Ruthven Museums (Exhibit Museum, Anthropology, Paleontology, and Zoology), in conjunction with the Herbarium and the Kelsey Museum of Archaeology (the latter as an observer), have begun developing a plan for a collaborative organizational structure that will enable expansion of interdisciplinary collaborations and synergies among the museums. This plan would allow us to better establish the museums as a nexus for interactions across campus, consolidate administrative functions, and enhance our ability to dynamically respond to emerging needs and opportunities for undergraduate education, research, and collections curation.

F. Off-campus location of the Varsity Drive facility

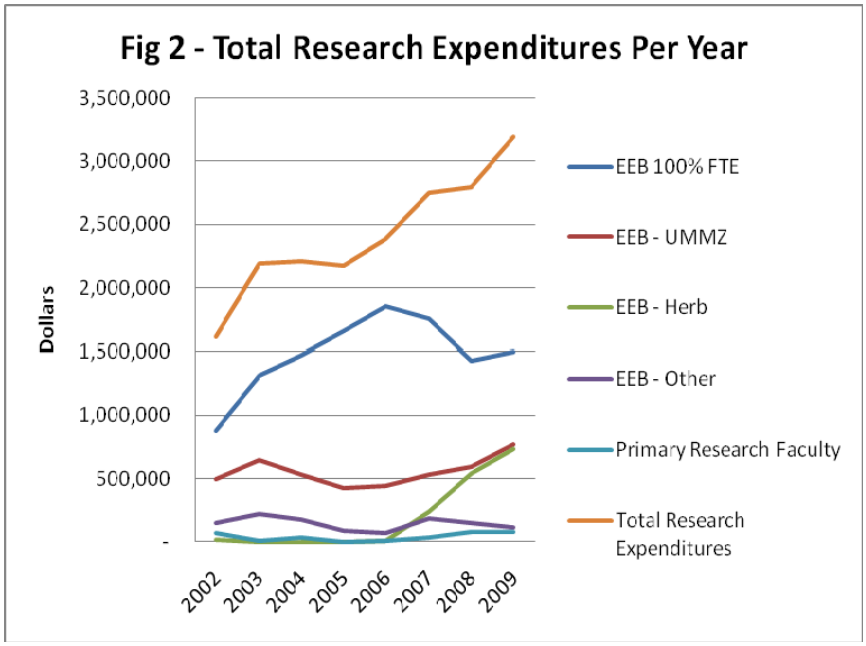
Herbarium is currently located at a facility approximately 15-20 minutes by car from central campus and the alcohol collections of the UMMZ are slated to be moved to this facility in the next year. However Herbarium faculty laboratories and offices are located in the Kraus Natural Science Building on campus, along with the 1.0 EEB faculty. According to the climate survey of Herbarium staff, those who work full-time at Varsity Drive are generally content (Appendix J-4), but for Curator/Professors and others who need to travel regularly between campus and Varsity Drive, the extra driving and parking time and requirement to have a car on campus are problematic. The Herbarium has found so far that the best solution is to have business "hang tags" that allow us to use specially designated parking spots on campus. We have recently made an arrangement whereby the College pays for three hang tags each year (@$750 each); this is adequate for the director (who needs one on a near daily basis) and for the rest of the staff, who have more occasional transportation needs. Parking and transportation are especially difficult for students; two Ann Arbor bus lines currently pass within a half mile or so each of the facility, but this can be a hazardous walk in the wintertime or in bad weather, because there is no continuous sidewalk. One alternative for students who either work as temporary staff or who are engaged in research at Varsity Drive may be for the university to offer to pay their cab fares, if they do not have independent means (an automobile) to get there.

VII. Research funding

Funding from sponsored projects in the combined units has increased continuously since 2001, to a total of over $3 million in the last fiscal year (Fig. 2). Research for the current fiscal year is slightly up as of December 2009. In addition to the research funding shown in Fig. 2, the three units have considerable funding in educational grants and infrastructure/informatics grants, with a total of over $7 million in expenditures since 2000 and over $400,000 in 2009 (Appendix K-1). Of particular note is the major funding by Professor Phil Myers, joint between EEB and UMMZ, for development of and educational research using the Animal Diversity Web

(http://animaldiversity.ummz.umich.edu/site/index.html). We have also just received a $600,000 S-STEM grant for undergraduate scholarships in biology, as part of the Biology Academy Scholars program to increase retention and success of diverse students. All grants active in the current fiscal year (2009-2010) are listed in Appendix K-2.

Average per-capita research funding in 2008-9 was ca. $96,000 in annual expenditures (direct + indirect) per tenure-track FTE for the three units combined (Appendix K-3). Total per-capita external funding including infrastructure and educational funding was ca. $113,000 (Appendix K-3).



The percent of the total faculty with significant (estimated as >$20,000) external funding is low for a department of our quality, running 60-65% in all but one of the last five years (Appendix K-4). The faculty without external funding divide into four roughly-equal size categories: assistant professors, all of whom are submitting multiple proposals, getting good reviews and we expect to be funded in the near future; senior faculty on retirement furlough or close and winding down their research programs; faculty with mostly consistent funding, submitted proposals and quite active research programs but in temporary gaps; and faculty who either do not submit grants or have been submitting grants unsuccessfully over a period of at least four or five years. This last group is of the most serious concern, but it is also worth noting that most of this group is nonetheless publishing an average of at least 2-3 scholarly papers a year.

VIII. Undergraduate Program

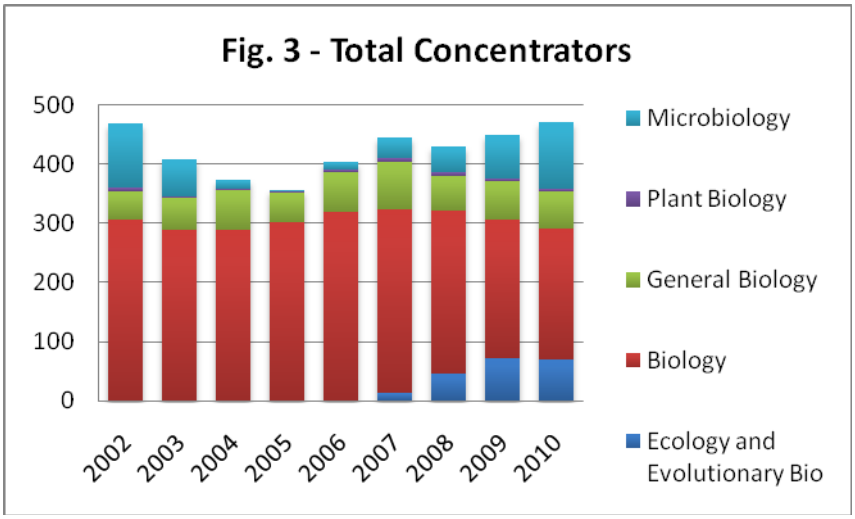
A. Management and organization

The undergraduate concentrations in the biological sciences are managed jointly by EEB and MCDB through the Program in Biology. The Associate Chairs for Undergraduate Education in the two departments are responsible for the Program in Biology and meet weekly, together with the student administration manager of the Program and a Lecturer IV who serves as curriculum coordinator and coordinator of concentration advising.

All 100 and 200-level undergraduate courses taught by EEB and MCDB faculty are labeled as Biology courses and are the joint responsibility of the two departments, while 300- and 400-level courses are the responsibility of the separate departments and labeled as EEB or MCDB. The Program in Biology thus includes all non-major courses, often taken by students to satisfy natural science distribution requirements in LSA, and the introductory and core biology courses often required for multiple concentrations. (In UM terminology, "concentrations" are equivalent to "majors" at most other institutions.) In all data on enrollments and student credit hours reported by the College and below, Biology courses are split between EEB and MCDB.

B. Concentrations and advising

EEB is involved in five different concentrations: EEB, Biology, General Biology (designed for pre-professional students and double majors), Plant Biology, and Microbiology. Together, these programs typically have 400-450 total concentrators (Fig. 3). All but the EEB concentration are jointly managed with MCDB, which also has a Cell and Molecular Biology concentration and a Neuroscience concentration that they share with the Department of Psychology and the Medical School. The Microbiology concentration also involves two departments in other colleges: Microbiology and Immunology in the Medical School, and Epidemiology in the School of Public Health, and is run by an intercollegiate steering committee. EEB also contributes substantially to teaching and advising in the intercollegiate Program in the Environment (PitE), jointly managed by LSA and SNRE and involving a wide range of natural and social science departments, as well as the College of Engineering, School of Public Health, and College of Architecture and Urban Planning. PitE has been growing very rapidly and currently has 291 concentrators. Thus, as with research, our teaching is part of a network of linkages across campus.



When EEB was established in 2001, we did not develop a separate EEB concentration for two reasons. First, philosophically, the department felt strongly that a broad-based biology curriculum was the best training for further work in any specific area of biology. In addition, a new intercollegiate concentration, Program in the Environment or PitE, began around the same time and it was unclear whether the audience for that would include those more interested in the biological aspects of environmental studies. However, it became clear that many students interested in EEB areas felt lost among the many pre-health students in the Biology concentration, who often focused on cell and molecular biology. On the other hand, these students were unable to get sufficient background for graduate studies in EEB within the PitE program. Therefore, we initiated an EEB concentration in 2007 that grew quickly in the first two years and now seems to be stabilizing at

about 70 students (Fig. 3). The Microbiology concentration was put on hiatus in 2003 while it was reconfigured as an intercollegiate concentration; after its reestablishment, it also has begun to rapidly increase and is now similar in size to EEB. As we expand our program in microbial ecology and therefore collaboration with microbiologists throughout campus, we expect our participation in this concentration will continue to grow.

Important aspects of the EEB concentration include the following: 1) a required research experience, 2) a required course that focuses on biodiversity of a particular group (courses that meet the requirement are marked in bold in Appendix M), and 3) enrollment in the EEB Capstone Seminar. Co-taught by an ecologist and an evolutionary biologist each term, students in the Capstone read and discuss primary literature on the scientific underpinnings of areas of broad societal concern such as climate change, sustainable agriculture, emerging diseases, and human evolution. The goal is to integrate ecological and evolutionary principles in understanding the natural world and its interactions with human affairs and expand students' ability to articulate their understanding of these issues. The students read primary literature, write essays addressing focused questions arising from the discussions, and write and present a literature-based research paper expanding on a topic discussed in the seminar. The course has been extremely popular such that we now must teach it both semesters; one concern is whether we will have sufficient faculty to staff the course (currently capped at 20 students to maximize discussion) if the concentration continues to grow.

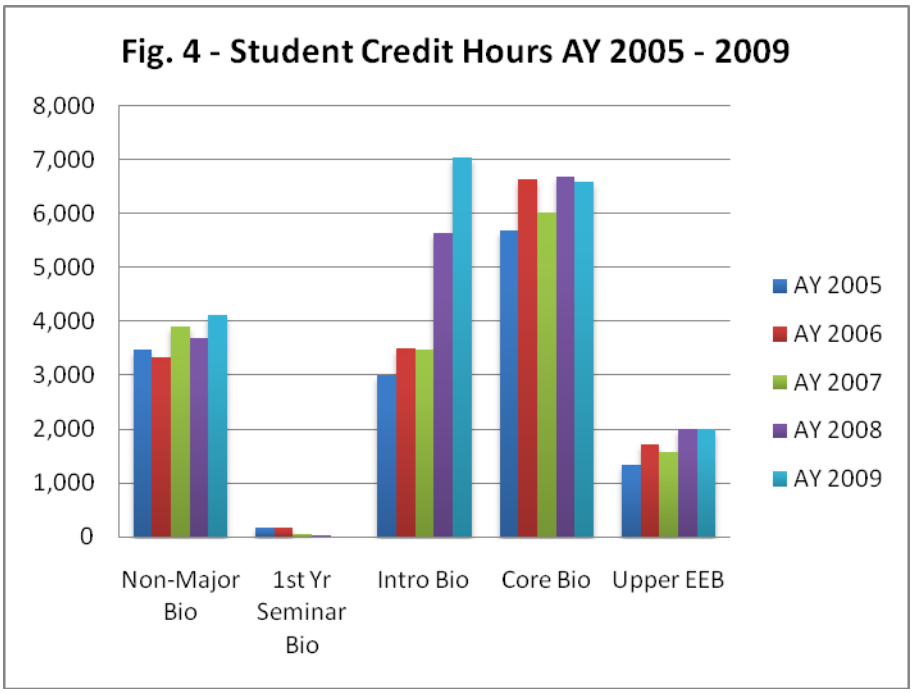
Requirements of all of the concentrations are in Appendix N. The Program in Biology also offers several minors including in Biology and EEB; their requirements are available at http://www.lsa.umich.edu/biology/minors.asp .

All EEB faculty contribute to undergraduate concentration advising. Starting three years ago, we also hired a Lecturer IV (joint with MCDB) who coordinates curriculum and advising for the entire Program in Biology. This includes keeping all web content and advising materials up to date and ensuring coordination across the curriculum, as well as walk-in and scheduled advising time for concentrators and general advising fora. The coordinator also teaches one course a semester. This position has greatly improved the quality of advice on routine issues such as concentration requirements, and it has freed up faculty to focus more of their advising time on research opportunities, graduate school, and career options.

C. Curriculum

The curriculum taught by EEB faculty includes courses for non-science concentrators (100 level), introductory biology courses for concentrators (Biology 163, 171, 173), core courses for concentrators (mostly 200 level), and advanced concentration courses for the Biology, EEB, Microbiology, and Plant Biology concentrations (300-400 level) (Fig. 4; and see complete list of courses with enrollment history in Appendix M). We also teach first year seminars for students not yet committed to a concentration. All categories except first year seminars have been increasing over time; the particularly sharp increase in introductory biology in 2007 corresponds to the expansion from a one term introductory course to a three term introductory sequence (two involving EEB).

Courses for non-scientists: The United States citizenry is insufficiently literate about ecology and evolution to make informed decisions about many of the issues facing the country, and ultimately, the world, with climate change and the evolution and spread of disease as two particularly timely and critical examples. The University of Michigan has responded, in part, to these developments by establishing the Program in the Environment, and EEB contributes heavily to this concentration. However, we are also firmly committed to contributing to science literacy within the Biology Program. To do this, EEB faculty now offer ten 100-level courses for non-concentrators that can be used to satisfy the natural science distribution requirement. They meet our goals of increasing scientific (specifically, biological and environmental) literacy and of providing a basic understanding of the process of critical thinking and scientific discovery. These courses are Biology for Non-Scientists; Energy, Food and the Environment (formerly Biology and Human Affairs); Biology of Sex; Practical Botany; Biology of Human Nutrition; Animal Diversity; Animal Behavior; Evolution of Life, Global Change; and Ecological Knowledge and Environmental Problem Solving (Appendix M). Collectively, these courses are popular (accounting for 4,120 student credit hours in AY 2009, Fig. 4). While we would like to increase this amount still further, maintaining our teaching in core concentration courses (see below) is a higher priority given limited faculty.



First –year seminars. Although they reach far fewer students than the large lecture classes, these seminars offer the benefits of small classes and the opportunities for close contact with a faculty member. Over the last three years, only 0-1 first-year seminars per year have been taught by EEB faculty. We would very much like to increase this to at least one a semester, and as we fill out our faculty in the next few years, we expect that will be possible.

Introductory biology. In 2005, EEB and MCDB formed a taskforce to re-envision the Biology curriculum for undergraduate science majors. Following two years of detailed study and discussion, we completely revised the introductory Biology courses, which now include full semester treatments of EEB- and MCDB-oriented topics and a separate laboratory course reflecting both. The laboratory course is designed with project-oriented modules that build towards integration across levels of biological organization. These three courses, first offered in fall 2007, now enroll over 1900 students per semester during the regular academic year and are also offered in the

Spring and Summer terms. These changes to introductory biology required us to make substantial changes to several of our next tier of courses (core courses in Genetics, Evolution, and Ecology), which were implemented beginning in Fall 2008. The EEB faculty have strongly supported these changes and continue to support our policy of having most teaching done at these levels done by research-active, tenure-track faculty. Dr. Jo Kurdziel, Lecturer IV in EEB, has begun a three year project to evaluate the changes in introductory biology, with funding from IDEA Institute (a joint LSA-School of Education institute to investigate science learning and pedagogy) (see Section VIII-E below for details).

Core concentration courses. Courses taught by EEB faculty at the 200-level fulfill key requirements in five of the biological sciences concentrations and include Ecology, Microbiology, Plant Biology, Chordate Anatomy and Phylogeny, Animal Diversity, and Plant Diversity. All of these have associated laboratories. Also included in the core courses are two 300-level courses required by all Biology, General Biology and EEB concentrators: Genetics (Biology 305; co-taught with MCDB) and Evolution (EEB 390). Many of these courses must be taught both semesters to accommodate the large numbers of concentrators and pre-health students (many of whom are not concentrators).

Advanced concentration courses and graduate courses. We offer a wide range of advanced courses in ecology and evolutionary biology. These include courses that focus on conceptual areas (e.g. , molecular evolution, evolution of development, ecosystem ecology, etc.) and courses that examine vertical integration of these conceptual areas across levels of organization, through the lens of focus on particular groups of organisms (e.g., fungi, insects, or fishes; Appendix M). However, as noted in the section on hiring plans, we also have some substantial gaps that should be taught in a top EEB program for both undergraduate and graduate students. In conceptual areas, we are lacking courses in evolutionary ecology, evolutionary genetics and genomics, phylogenetic theory, evolutionary theory, physiological ecology and evolutionary physiology, landscape ecology, global change biology, as well as courses on scientific writing and grant writing and advanced statistics appropriate for biologists. In biodiversity courses, the biggest gaps are in ornithology (study of birds) and in invertebrate biology. The audience for these courses includes EEB and other Program in Biology concentrators, Program in the Environment concentrators, EEB graduate students, students from the rapidly growing professional masters programs in SNRE and SPH, and Ph.D. students from SNRE, Epidemiology, Human Genetics, Bioinformatics, and Civil and Environmental Engineering.

University of Michigan Biological Station (UMBS). Field classes taught at UMBS (see Section XII-B) are an important part of our curriculum; 10-11 advanced courses in EEB (300-400 level) are typically taught every summer term, with introductory ecology also usually taught in the smaller spring term. Total enrollments are ca. 100-150 each year and 30-45% of UMBS students identify themselves as concentrating in Biology or EEB. All of the courses have a significant component of independent research, and the students present their results in a station-wide symposium at the end of each term. Many of these courses fulfill important core requirements (introductory ecology, introductory evolution), the EEB requirement for a biodiversity course, and the EEB requirement for a research experience.

D. Undergraduate Research

The Department, UMMZ, and Herbarium together engage over 100 undergraduate students a year in research projects through a variety of mechanisms. We participate heavily in the University-wide award winning Undergraduate Research Opportunities Program (UROP). UROP facilitates matches between faculty research projects and first and second year undergraduates interested in conducting research, as well as provides workshops in aspects of conducting research and peer mentoring for participating students. Many EEB students also conduct independent research for academic credit, carry out honors thesis research, and/or work as volunteers or as paid research assistants in laboratories or UMMZ and Herbarium collections during the academic year or summer. In addition, many of our laboratory courses, including all of those taught at the UM Biological Station, incorporate an independent research project component.

To further encourage research, we hold a research open-house at the beginning of each term for students to meet with potential faculty mentors. This program has been successful in attracting students to faculty labs and collections where they are given first-hand experience in a variety of research projects. We also teach a Biodiversity research seminar (EEB 335) every semester, in which the students attend EEB-sponsored seminars and then meet with the faculty instructor for discussion and evaluation of the material presented. These discussions enable the students to address the learning goals described in the next section in a great variety of actual research settings.

Despite these mechanisms of engaging students in research, there are always more students who would like to participate in research than faculty available. Research experience is extremely effective way to get students involved in science and likely to continue on to a career in science. In 2006, with funding from an internal UM grant, we developed a program to fund graduate students to mentor undergraduates (10% additional appointment on top of a graduate student instructorship (GSI) or research assistantship (GSRA)) and to support these new mentors with a seminar course called "Entering Mentoring," developed originally by a HHMI-funded program at the University of Wisconsin. We are seeking funding to renew this formal program, perhaps in conjunction with the Undergraduate Research Opportunities Program. Although many of our graduate students and postdoctoral fellows continue to mentor undergraduates in research, their ability to do so at a high professional level would be enhanced by renewing availability of this training.

E. Learning goals and assessment

In academic year 2009-10, the department began an initiative to specify and formalize learning goals for courses taught by EEB faculty and for the department as a whole. Faculty members are being asked to develop specific learning goals for each course in which they are involved, and the faculty has approved the following as general learning goals for the EEB program:

Students will:

- explain key concepts in ecology, genetics, and evolution

- understand how ecological, evolutionary, and genetic processes interact with each other and the environment to influence current, historical, and future patterns of biodiversity
- understand the myriad ways humans interact with the rest of the biosphere and the consequences for biosphere functioning and for human well-being
- develop a robust understanding of how science works and be able to practice quantitative and scientific reasoning
- develop the scientific skills needed to embark on a career in the health professions, science education, biological research, natural resource management, or science policy
- intelligently and critically discuss scientific issues and bring a scientific perspective to relevant societal concerns

During the next few years, we expect all EEB faculty members to develop specific learning goals for their courses that will address the department-wide goals above. The department has also begun formulating methods of assessing how well the program as a whole, as well as individual courses, is meeting these goals. In this, we are making use of the talents of two EEB lecturers, Drs. Jo Kurdziel and Laura Eidietis, both of whom have backgrounds in science education. Dr. Kurdziel has recently been awarded a grant from the IDEA institute entitled, "Injecting assessment in the introductory biology curriculum to improve student learning and teaching." The long-term goals of this project are to 1) develop assessment instruments to measure students' understanding of key biological concepts and their conceptions of the nature of science and the processes of scientific inquiry; 2) measure students' understanding of key concepts, nature of science and process of science skills as they enter the introductory biology sequence, and measure the changes in students' understanding and skills when they complete the introductory sequence (BIO 171,172 and 173); and 3) develop classroom materials and strategies that will help students master key biology concepts as well as develop a more robust understanding of how biological research is done. We have begun implementing goal 2 this current winter semester (2010) in our large enrollment, introductory course covering EEB subjects (Biology 171) with the application of survey instruments to determine the level of students' understanding both before and after completion of the course.

To address the third goal, we have already begun implementing aspects of the "Blooming Biology Tool" developed by Crowe et al. (2008), which is based upon Bloom's taxonomy of cognitive domains (Bloom et al. 1956). Through this process, the students, who are primarily first and second year concentrators in biological sciences, and the graduate student instructors are introduced during the first discussion session to the different levels of cognition: knowledge, comprehension, application, analysis, synthesis and evaluation. Throughout the semester, both GSI's and students practice implementing the different levels of cognition through writing questions based upon lecture material and discussion readings. Students evaluate each other's work during small group discussions. Assessment tools used in the course include examinations, with questions covering the different levels of cognition, and periodic surveys of the students.

We intend to extend the application of these methods to other courses in the department through interactions among faculty members who will become more familiar with such methods of assessment. We plan to assess the overall learning goals of the program in the EEB capstone seminar course (EEB 410), which is a required course for senior EEB concentrators and is open to

others as well. Students in this course read and discuss primary literature and are evaluated based on writing assignments and oral presentations. The EEB curriculum committee is also designing a questionnaire that can be used in all of our courses to evaluate how well the learning goals are being met.

Finally, we have begun discussions with MCDB about developing learning goals for all of our joint concentrations and applying the ideas above to all the Biology courses. They are enthusiastic, but it will take some time to work through these together.

F. Faculty teaching efforts and assignments

In an effort to make teaching assignments more transparent and equitable, the department has devised a set of rules for defining and monitoring teaching effort for each faculty member. Faculty with 1.0 appointments in EEB are expected to teach two course equivalents a year (this may increase with less participation than expected in mentoring, grant submission, or administration (Appendix I-2)). Faculty are expected to teach in one large enrollment, lower division class and one smaller, more specialized upper division course. Course equivalencies are defined in terms of enrollment, number of credits, presence of laboratory components, and whether jointly taught throughout the semester. Despite these efforts, as noted above, only half the faculty agree that teaching assignments are distributed fairly. One source of concern among faculty about inequitable teaching assignments may spring from the fact that from 2001-2004, new junior faculty were offered a lower effort of 1.5 course equivalents per year until they achieved tenure. This turned out to be untenable because it resulted in insufficient teaching experience for tenure evaluation , especially for joint appointments with the museum unit where faculty were also expected to do some curation in place of teaching. Another possible source of dissatisfaction could be due to the differential teaching effort for faculty appointed 1.0 in EEB or 0.5 in EEB. Faculty with 0.5 FTE in a museum unit are expected to teach, on average, 75% of the full 1.0 FTE effort, or 1.5 course equivalents (Appendix I-1); other joint faculty have teaching efforts prorated by their appointment fraction. In fact, UMMZ and Herbarium senior faculty have taught 30% more than this expectation over the last 5 years.

G. EEB contributions to undergraduate education in the College

The Key Performance Indicators (Appendix L) provided by LSA show that in 2009, compared to the other natural sciences in LSA, EEB has the highest number of student credit hours per tenure-track FTE and the second highest number of concentrators per tenure-track FTE (MCDB has the highest). Although the relative ranking of EEB, MCDB, and Chemistry in these metrics has fluctuated over the last several years, EEB clearly contributes a very significant share of undergraduate education in the natural sciences. Our biggest concern is lack of space and support for building a community of these many concentrators. Every term, the three staff in the 600 square foot Program in Biology Office handle all advising for concentrations involving EEB and MCDB (>800 concentrators); scheduling and assignment and hiring of >100 Graduate Student Instructors for all Biology, EEB, and MCDB courses; secretarial support for the introductory biology sequence, which enrolls over 2000 students per term; and initiate all paperwork involving modifications of courses and curriculum. We have a remarkably effective and dedicated staff and the program runs quite well.

However, the lack of any space for students to look over materials, e.g., on career options and research opportunities, do peer advising or talk more informally with each other, meet with faculty or GSI's or advisors informally, etc. means that it has been very difficult to create a community of undergraduate students to enhance their learning and engagement in our disciplines, whether the broader field of biology or the narrower fields of EEB, microbiology, and plant biology.

IX. Graduate Program

Graduate students are admitted through EEB and advised by faculty in all three units. The department offers a Ph.D. program, a very small traditional masters program (0-2 students a year), and a new masters program called the Frontiers Masters Program, which is a fully-funded program designed to increase diversity in ecology and evolutionary biology. We describe each of these programs in a separate section below; formal policies for each are in Appendix O and more information can be found at our website (http://www.eeb.lsa.umich.edu/eeb/graduates/index.html).

A. Ph.D. Program

The goal of the EEB Ph.D. program is to train independent scientists for positions in research- or teaching-oriented universities and colleges, research museums, governmental or independent research agencies, and other such institutions. Ideally, our students will acquire knowledge of the subject matter of our area and the ability to devise and carry out independent research (including design and data analysis), to find and obtain research support, and to communicate effectively, verbally and in writing. They should also acquire the ability to teach effectively, as well as self-confidence and a sense of membership in the community of their scientific peers. Career goals vary among students, and these differences are respected. Relatively few of our faculty follow an apprenticeship model, with students working almost entirely on aspects of their advisor's research program with general directions set by existing grants.

Recruiting. We get relatively high numbers of applications to our PhD program (Table 1), but very few of these applicants are from under-represented minorities (< 5%) so we have focused recruiting efforts on these populations. In addition to attending conferences such as SACNAS and McNair, our major effort has been a partnership with biology departments in institutions that historically have high undergraduate populations of under-represented minorities (currently Howard University, Morehouse College, Spelman College, and University of Puerto Rico at Mayaguez). This program brings 2-4 students from each of those institutions to participate in a weekend of our advanced field ecology course and sends 2-3 current UM graduate students to visit each institution, give seminars on their research and meet with potential applicants. The program, carried out in partnership with SNRE, is now in its fourth year. It has been extremely successful in giving positive experiences to the students we bring in and many have kept in touch with our faculty and graduate students. Unfortunately, it has not yet resulted in an increase in applications to our Ph.D. program by under-represented minorities. We nevertheless want to keep this program to continue to build long-term relationships with these institutions. The initial funding (from the

National Center for Institutional Diversity) is ending and we are working with Rackham to find other sources.

Table 1. *Demography of Ph.D. cohorts from application to the program through completion of degree since the first year of the full-funding package in 2002. Completion of Ph.D. can only be calculated for the first three cohorts. Also see Rackham data (Appendix P-1).*

Cohort	# students applied	Selectivity (% admitted)	Yield (% enrolled)	Initial cohort	% cohort candidacy in 2 years	% cohort achieve candidacy	% cohort Ph.D. in 5 years	% cohort Ph.D.	% cohort MS degree only	% cohort no degree
2002	91	27%	52%	13	46%	69%	23%	62%	31%	8%
2003	94	19%	61%	11	91%	91%	18%	91%	0%	9%
2004	82	24%	55%	11	91%	91%	82%	n/a	18%	n/a
2005	69	33%	57%	13	85%	92%	n/a	n/a	8%	n/a
2006	114	21%	54%	13	54%	77%	n/a	n/a	8%	n/a
2007	80	30%	38%	9	44%	n/a	n/a	n/a	33%	n/a
2008	100	31%	58%	18	n/a	n/a	n/a	n/a	n/a	n/a
2009	136	10%	43%	6	n/a	n/a	n/a	n/a	n/a	n/a

Admissions. Students are admitted to the department, not to individual laboratories, although we require that a student have at least one prospective mentor among the faculty before admission. Files are assigned to several faculty to review and then the Graduate Admissions Committee uses these evaluations and their own to narrow down the list to ca. 20-30 prospective admits. These students are then invited to a recruitment weekend, where they are hosted by current graduate students, meet with individual faculty and students, attend a faculty symposium/student poster session, and attend a party typically held at the Chair's house. International students are interviewed by phone by at least two faculty. We consider that all the students invited to the recruitment weekend are admissible, but use this event to make sure they are indeed good fits for the department. The number of applications varies considerably over time (Table 1) and accordingly the selectively also varies, but overall is fairly high (mean of 26% of applicants are offered admissions). Yield (enrollment as a percentage of admits) is also fairly high with a mean of 52% (Table 1).

Training program. Appendix O-1 describes the Ph.D. policies and procedures. The only courses required of our Ph.D. students are independent study (EEB 700 or 730) during both terms of their first year. Typically, this is one term with their potential advisor and a second term with a likely committee member or alternative advisor. One of the terms must result in a written paper, which often is a proposal for summer research. Depending on the field of the 700/730 advisor, these independent study courses can be largely reading/discussion or focused on learning laboratory methodologies. Almost all of our students also take two "core" courses their first year: Population and Community Biology (EEB 485) and Principles of Evolution (EEB 516). Typically all of the first year ecology and many of the evolution students also take Field Ecology (EEB 477), which is jointly

taught with the School of Natural Resources and Environment and meets every weekend for the first six weeks of fall term. This very intense course incorporates seminars and field projects led by the course instructors and other faculty who rotate through the course, analysis and presentations of day-long field projects.

We expect our students to complete a preliminary exam by their third term, achieve candidacy with a complete dissertation proposal by their fourth term, and complete and defend a dissertation by the end of five years.

The preliminary exam is given to all students in a given cohort during the same term. Each student's performance is evaluated by members of a departmental standing committee plus the student's advisor. Each student prepares a synthetic review paper, a public seminar on research, and undergoes an oral exam that starts from the specific content of the review paper and seminar, but can explore any area of ecology and evolutionary biology. The components are designed to mimic professional activities and to facilitate progress towards the dissertation (e.g., the review paper could be part of a dissertation proposal, the seminar could be based on preliminary research towards the dissertation project.)

Achievement of candidacy involves completion of a dissertation proposal and successfully defending that proposal to a dissertation committee. Time to candidacy varies enormously among cohorts with 91% of students meeting the two-year target in some years, but only 44-54% in the most recent two cohorts (Table 1). Nevertheless, this target is not missed by much: all students in the last two cohorts achieved candidacy within three years.

The average time to degree is difficult to estimate because only three cohorts since the founding of EEB and the establishment of a full funding package (see below) have had at least five years to complete their degree. On average, 41% of students in those three cohorts achieved a Ph.D. in five years (Table 1) and at least 77% in 6 years. For cohorts starting in the 1990s, mean time to degree was typically close to 7 years, so it is clear changes in the funding package as well as in departmental policies have had a substantial effect.

To prepare our students for teaching as a component of their career, we require all our students to act as a Graduate Student Instructor for at least one year, and we offer an extensive GSI training program before and during the fall term each year; the program is run under the auspices of the Program in Biology and shared with MCDB. First-time GSIs attend a series of evening seminars and workshops to prepare them to teach. Early sessions tackle first day issues, course policies and lesson planning; later sessions address more subtle subjects such as grading, learning styles, and professional responsibilities. Two classroom peer observations and mid-semester feedback from students are incorporated into the training program. We also encourage our students to benefit from the many workshops offered by the University's Center for Research on Learning and Teaching (CRLT). EEB students tend to be highly dedicated and effective teachers. We regularly nominate students for Rackham's Outstanding GSI Award, and in many years have had 2 of our students win out of only 20-25 awarded throughout the entire University.

We strongly encourage our students to teach during their first year rather than use their pre-candidate fellowship term (see next section) because we have found anecdotally at least that students who teach their first year are better prepared for their preliminary exam both in terms of broad biological knowledge and their confidence and ability to speak in front of groups.

Funding. During the first year of EEB, a new full funding package for Ph.D. students was negotiated with LSA, so this funding began for the cohort starting in fall 2002. The current model (first line, Table 2) has five years of guaranteed support, including summers. Sufficient funds are provided by LSA and Rackham Graduate School to guarantee two terms of fellowship (one precandidate and one

Table 2. Funding sources for EEB graduate students based on academic year funding only (includes tuition and health insurance). The "model" is based on the number of students we can support for 5 years with two academic terms of departmental fellowship (standard package), four summers of departmental support, and an expected one year of GSRA support from student advisors.

Cohort (year of fall start)	Number of Starting Students	Total Terms to date	Dept. fellow (standard package)	GSI	Internal Fellow	Museum GSRA	Training Grant	External Fellow	External GSRA
MODEL	**14**	**140**	**20%**	**60%**	**0**	**0**	**0**	**0**	**20%**
2002	8	94	13%	37%	9%	13%	6%	16%	6%
2003	9	98	17%	53%	10%	2%	8%	3%	7%
2004	9	90	15%	49%	7%	4%	0%	7%	18%
2005	12	114	15%	61%	4%	4%	4%	0%	12%
2006	12	89	15%	56%	0%	7%	4%	1%	17%
2007	9	45	7%	60%	0%	0%	19%	9%	5%
2008	18	66	17%	65%	3%	0%	0%	5%	10%
2009	6	12	0%	83%	17%	0%	0%	0%	0%

after achieving candidacy). We also expect faculty mentors to provide one full year of support as a Graduate Student Research Assistant (GSRA). Thus, the maximum number of terms students should be acting as a Graduate Student Instructor (GSI) is 6, or 60% of total graduate funding. In reality, many of our students receive competitive external and internal fellowships such as NSF or EPA-STAR fellowships, so that students in most cohorts teach less than the 60% (Table 2). We also have substantial training grant support for students, including NIH-funded grants for Genome Science and in Genetics, and an NSF-funded IGERT in Biosphere-Atmosphere Research based at the UM Biological Station (Table 2). A new IGERT in microbial ecology is at the final review stage at NSF. We strongly encourage first year students to teach rather than use their precandidate fellowship or even other fellowships; therefore the percent of GSI terms for first and second year students in Table 2 is much higher than the model predicts over the entire five years of guaranteed

funding. Students who take longer than 5 years to complete their Ph.D. can usually obtain GSIships if they don't have other funding, although these are not guaranteed.

Our graduate student funding package from LSA is based on a $20,000 annual stipend, including two fellowship terms with tuition. This package was highly competitive when it was initiated in 2002, but is no longer so. Because the total stipend amount has been fixed, as the academic year Graduate Student Instructor (GSI) rate has increased consistent with agreements with the Graduate Employees Organization, the spring-summer stipend declined. In response, in 2008, we froze the spring-summer rate at about $5000 for the four month period; this is still considerably below the academic year stipend of $8,347 per term. Thus, the total stipend now increases annually and is currently $21,944. Our goal is to match the spring-summer stipend to the academic term stipend and we are evaluating options to change the current funding package to allow this

For research funding, students have a number of options besides depending on their faculty advisors. We allocate a total of about $45,000 per year, from Rackham Graduate School block grants and income from our endowments, to graduate student research. Students must write proposals to receive these funds and they are awarded competitively. We also strongly encourage students to write proposals for external funding, and they have been quite successful, receiving grants from NSF (Dissertation Improvement), the Smithsonian, American Museum of Natural History, Sigma Xi, American Philosophical Society, and numerous professional societies.

Mentoring. The climate survey (Appendix J-2) revealed that the great majority of graduate students (88%) were satisfied or very satisfied with the academic advice they have received from their mentors and strongly felt (98%) that this was the most important kind of support they needed from their mentors. Students were less satisfied with advice about careers (59% were satisfied or very satisfied) and the level of social/emotional support (53%). The lack of satisfaction with career advice is particularly noteworthy because 90% of students stated it was important to receive this support from their mentors. Other aspects of the climate survey also emphasize the need of graduate students in the department for greater discussion and support for a diversity of career options and work/life balance. The postdoc climate survey (Appendix J-3) also emphasized a desire for more information on career options and advice. We have had career workshops for graduate students in the past that were not well attended and so were not continued. The results suggest that we need to find a way to improve these workshops so that they fill this clear need for students and postdocs in the department. The department diversity committee will be charged with this task.

Further, women were less likely than men to agree that faculty members were readily available and that they were satisfied with interactions between faculty and graduate students. Women also reported less support and respect from their advisors than did male students and were overall less satisfied with the advice they received. These differences suggest a need to improve mentoring for women in particular; the department diversity committee will also be charged with this task. Diversity in the grad program is discussed in more detail in Section X-B.

Climate and diversity. As is the case nationally in the biological sciences, we have slightly more women (mean over 2005-2009 =54%) in the Ph.D. program. We have unacceptably low numbers

of under-represented minority students (6-8%) and about 29% international students. In response to the low representation of minorities, we have instituted the Frontiers Masters Program described below as well as the recruiting activities described above.

The climate survey of the PhD students shows a moderately positive and tolerant environment, significantly more so than other biological and health sciences in a broader survey conducted by the Rackham Graduate School (see Appendix J-2, EEB student climate survey). However women students reported a significantly less positive and tolerant environment than did men, and EEB students overall were less likely to agree that the department environment is one in which female graduate students feel comfortable and included than were students in the larger biological and health science student survey. This differential in perception of the environment relative to gender was not found in an earlier (2006) survey of the climate for EEB graduate students, but is nevertheless an important concern. Still fewer students overall felt that the environment was one such that international students felt comfortable and included, and even fewer reported that under-represented minorities, sexual minorities, and disabled student felt comfortable and included. The international student data are consistent with the earlier survey in EEB and therefore of particular concern. These reports are disturbing and we will be working with ADVANCE to interpret the data and to conduct focus groups with graduate students to understand the source of these concerns and how to address them. The Diversity Committee will also be charged to investigate these concerns and develop approaches to address them.

In addition, the climate survey found that half of the graduate students expressed unhappiness with interactions among department faculty members, which is consistent with the reduced amount of collaboration reported by faculty themselves (Section X - C).

Placement of Ph.D. students. As noted in the 2006 Rackham Review (Appendix P-2), our placement record is good, but not outstanding in terms of the standard goal of having our students be just like us with careers at top ranked research institutions. As a department, we respect that some of our students prefer other options, such as to work in government agencies or nongovernmental organizations or at smaller primarily teaching colleges. Nevertheless, many of the students finishing their Ph.D. since 2001 have moved to assistant professorships at comprehensive doctoral universities (e.g., Duke University, Arizona State University, University of New York at Stony Brook, Michigan State University) and to postdoctoral fellowships (e.g., UC Berkeley, Yale University, Cornell University, Duke University, Emory University, Fred Hutchinson Cancer Institute) (complete lists in Appendix P-3). The great majority of our students find academic or other positions in the fields in which they were trained.

B. Traditional Masters Program

The Department admits relatively few traditional masters students, with only 0-6 at any time, one of whom on average goes on to our Ph.D. program. Most of these students do a thesis rather than course work masters, although both options are possible. We do not guarantee funding for traditional masters students. Further information can be found in Appendix O-2 and the department website.

C. Frontiers Masters Program

In 2008, we started a new, fully-funded masters program (see Appendix O-3) designed to attract students from non-traditional backgrounds who might not have considered a degree in ecology and evolutionary biology. Our long term goal is to increase the diversity of the graduate student body, and ultimately the diversity of the workforce, in the fields of ecology and evolutionary biology. The immediate goal for students in the Frontiers Program is to become fully prepared to be admitted and be successful in top-ranked Ph.D. programs, especially that at the University of Michigan. The two year program enrolls four students each year and thus has eight students at steady state.

The program starts with a summer transition program of classes and research at the University of Michigan Biological Station. At UMBS, students receive one-on-one training with a research mentor, take foundational classes in ecology or evolution, and participate in weekly professional development workshops. On their return to campus in fall, students take courses including the intensive field ecology class and a laboratory rotation. These experiences are designed to help them choose a permanent research mentor and a long-term research project. They also gain experience teaching and mentoring undergraduates and, by the end of their first year, Frontiers students are well integrated into our larger graduate student body. They are expected to finish a thesis masters in two years and thus are guaranteed GSI appointments for two years and a stipend for two summers, as well as all costs at UMBS. To date, the program is supported by NSF (AGEP) funds through the Rackham Graduate School, LSA, and EEB funds, but we are very actively searching for long-term sources of support.

Our first cohort is just finishing the program this semester so we cannot yet evaluate effectiveness in terms of student success in a Ph.D. program, but we have succeeded in diversifying the graduate program and all four students do plan to apply to Ph.D. programs.

X. Faculty mentoring, diversity, and climate

A. Faculty mentoring, retention and promotion

EEB, UMMZ and the Herbarium have joint mentoring (Appendix I-3) and promotion policies and procedures (http://www.eeb.lsa.umich.edu/documents/tenure_promotion-final-9-22-08.pdf). These appear to be very successful to date; all promotions from assistant to associate professor (4) and from associate to full professor (7) since the creation of EEB have been successful. Mentoring of junior faculty includes assignment of two senior faculty mentors to each new assistant professor (named in consultation with the new hire) who are strongly encouraged to meet at least once a semester (the Department pays for lunch) and who read and give feedback on grant proposals and manuscripts, discuss service and teaching expectations and concerns, and advise on broader career development issues. Mentors are also asked to attend classes and review teaching materials the first time a new assistant professor teaches a course, following the protocol used by the department for third year and tenure reviews (Appendix I-3). Assistant professors are given first choice in hosting seminar speakers and strongly encouraged to invite senior scientists in their fields who can give advice on research and be a significant addition to their professional networks. The department initially organized monthly assistant professor lunches for peer mentoring; these

have been somewhat erratic because they rely on grass roots enthusiasm which has not been continuous. All assistant professors receive a term off teaching during their first year and another "nurturance leave" in their fourth year.

We separate mentoring from our annual feedback and evaluation process (see Appendix I-3). The latter involves an annual meeting of each assistant professor with the Promotion and Merit Committee. The PMC writes a report to the Chair (and Director for those assistant professors jointly appointed with a museum unit), who then meets with each assistant professor to discuss that report, as well as ways in which the department (and museum unit) could provide better support. This meeting results in a joint report that both the chair (and director) and the assistant professor agree covers all the issues discussed. In the third year, the PMC review is expanded to include a peer teaching evaluation by the EEB Curriculum Committee (protocol in Appendix I-3) and internal letters from colleagues and students. While the recent climate survey (Appendix J-1) reports that the great majority of assistant professors indicate they have received adequate mentoring, 14% state that they have not. Thus, we have more work to do to ensure that all junior faculty receive not just adequate but extremely helpful career advice. Two years ago, the Department instituted an annual meeting of the Chair with all senior mentors to discuss any concerns about the junior faculty. This has been very helpful in identifying institutional changes needed in department processes as well as a strong source of support for the mentors in formulating their role.

Promotion processes are described in detail in documents on our webpage (http://www.eeb.lsa.umich.edu/documents/tenure_promotion-final-9-22-08.pdf ; http://www.eeb.lsa.umich.edu/documents/promo_fullprof-final-9-22-08.pdf) and we do not repeat them here except to emphasize that it is a highly layered process, involving review of the complete file by a three person panel, which writes an initial report and recommendation, a chance for the candidate to read and correct the report, a "voting body" of eight faculty who make a recommendation to the college, a divisional committee of faculty from other natural sciences departments, the LSA Executive Committee, and finally a Provost committee. As noted above, all promotions initiated by EEB since the department was formed have been successful.

We also have been generally successful in retaining faculty, successfully keeping three senior faculty heavily recruited elsewhere. One senior faculty member was recruited but returned to his original institution within two years, another left to become a Dean elsewhere, and one switched an appointment from 0.5 FTE to "dry" (0 FTE). All other departures of faculty present in 2001 were retirements.

B. Faculty and pipeline diversity

The three units combined have nearly doubled the percentage of women faculty since 2001, from 17% to 30%. However, this is still under-representation relative to the percentage graduating with undergraduate degrees in biology at UM (54%) and entering and completing the Ph.D. program (ca. 55% over the last five years in EEB). National data on the postdoc pool are difficult to obtain, but the current postdoc pool in the three units combined is 42% women. Thus, the applicant pool for assistant professorship positions over the last few years (23% women) is

shockingly low compared to the graduate and postdoc pool. However, the pool ranges from 15% to 41%, with values under 20% for the most narrowly defined searches we have conducted and 41% for the most broadly defined search (in evolution and evolutionary ecology). All searches going forward will be defined as broadly as possible. Despite the low percentages of female applicants to assistant professor positions in the last few years, we have a very equitably distributed assistant professor group (50% women) and a female-dominated associate professor group (75%). However, there are still only 3 women full professors (14% of rank); while a tripling since 2001, it is still obviously too low.

Under-represented minorities are just that in the faculty of the three units: we still have **only one** faculty member who is a U.S. citizen from an under-represented group. The proportion of under-represented minorities completing an undergraduate degree is only about 8% on average, with a further decrease in the graduate program (about 5%). Postdocs are similarly of low diversity (7% from under-represented groups), although highly diverse in terms of nationality. The faculty applicant pool appears to be somewhat higher (11%) but this value includes many international applicants and is therefore inflated relative to the graduate and postdoctoral pools where the data are strictly underrepresented minorities who are US citizens. Twenty eight percent of the faculty are international.

The Department has a mandate and guidelines for faculty search committees on expanding the diversity of the applicant pool, and all members of search committees are required to attend a STRIDE workshop focused on explaining evaluation bias and how to minimize its impact. Nevertheless, we clearly have much more work to do to ensure a diverse faculty and the excellence it brings.

C. Climate for faculty

The ADVANCE survey of the EEB faculty (Appendix J-1, combined over the three units) reported moderate-high scores on questions concerning collegiality, positive and tolerant environment, gender egalitarianism, job satisfaction, and sense of being valued for their contributions by colleagues; results were similar for the smaller subset of the UMMZ faculty curators (the Herbarium was deemed too small for an anonymous survey of faculty). Almost all of these metrics were significantly more positive than those of the broader group of Natural Sciences departments in the campus-wide survey. Interestingly, EEB ranks higher in collegiality than in collaborativeness, suggesting that the strong mutual respect and friendliness is not necessarily translating into research and other collaborations. The department chair ranked high in terms of commitment to racial-ethnic diversity and being an effective administrator and lower in terms of giving faculty useful feedback about their performances, articulating a clear vision for the department, and helping faculty obtain the resources they need.

Despite the generally quite positive climate, several issues emerged in the EEB survey. One quarter of the faculty reported that they do not have a voice in decision-making that affects the department's direction. They also stated that colleagues can make discussion of important departmental issues, especially hiring, difficult. Only half of the faculty reported that the allocation of teaching assignments was fair and equitable to all and a third of faculty felt that the department

does not try hard enough to recruit strong graduate students in their research area. In addition, while EEB faculty are generally quite satisfied with their positions, sources of dissatisfaction included the balance between personal and professional lives, time for scholarly work relative to administrative and committee responsibilities, and salaries relative to UM colleagues.

These are all concerns that require attention, although the values are not significantly different than other natural science departments in LSA. As a first step to address them in EEB as a whole, the Diversity Committee will be charged with examining the climate report in detail and making recommendations to the EEB Executive Committee on how to modify departmental processes to improve these aspects of the climate.

XI. Management and organization

A. Faculty governance

EEB is managed by a chair, currently Deborah Goldberg, two associate chairs, one for undergraduate affairs, currently Barry OConnor, and one for graduate affairs, currently George Kling and a full complement of committees (Appendix I- 4). An elected Executive Committee meets regularly and faculty meetings are held as needed (typically once a month). We have formal Rules of Governance and written policies for most departmental activities, including teaching assignments and efforts, space allocation, mentoring, and promotions; these are meant to provide transparency but inevitably sometimes verge on the bureaucratic. All policies, as well as executive committee and faculty meeting minutes, are available on the departmental web site (http://www.eeb.lsa.umich.edu/internal/index.html). All committees except the Promotion and Merit Committee have a graduate student member, who is elected through the graduate student government and who is a full voting member.

All committees, including the Executive Committee, include representatives from the museum units and all policies (other than space-related) explicitly incorporate how they are applied to faculty jointly appointed in one of the museum units. In addition, the EEB Chair and UMMZ and Herbarium Directors meet together at least monthly to ensure that all activities are fully coordinated and concerns are addressed promptly.

UMMZ and the Herbarium are each managed by a Director, currently William Fink (UMMZ) and Paul Berry (Herbarium). Both are governed by a committee of the whole for decision making, although some committees are tasked with issues such as awarding student fellowships.

B. Staff support

EEB currently has 12 staff members fully appointed in EEB (9.75 FTE), including a "key administrator" and 12 additional staff shared with MCDB (10.25 FTE; Appendix Q-1). The EEB staff handle all administrative aspects of the department, including finances, personnel, sponsored research submission and administration, communications, computing, photography, and graphics. The EEB business manager and grant administrator provide both pre- and post-award grant administration for EEB, the Herbarium, and some pre-award services for the UMMZ. The EEB graduate program is also coordinated by the EEB staff. The Biology staff shared with MCDB work

mainly in the undergraduate Program in Biology, with three staff handling all administration and secretarial support for the program (including all GSI assignments and paperwork for both Departments as well as the Program) and five staff providing technical support to the laboratory courses. In addition, two shared staff members handle facilities and maintenance in the Kraus Building that houses both EEB and MCDB faculty and two shared staff members handle safety, purchasing, shipping and receiving for all faculty in the Kraus Biology. We had planned to hire an additional grant administrator in EEB because of the increasing sponsored research in the department; however that position is currently on hold and will probably not be filled due to the economic situation. In the absence of additional staff, we are working to find ways to streamline processes without reducing services provided to faculty.

The UMMZ has 5 administrative and clerical staff (including the key administrator, a scientific illustrator and graphic designer who is shared with EEB) and six collection managers (Appendix Q-2). The Herbarium has a single administrative staff person, in addition to a full time curator/assistant director (Anton Reznicek), three collection managers, and a plant mounter (Appendix Q-3). Until 2007, the administrative position in the Herbarium was defined as a "key administrator" who reported directly to LSA, but because of the small size of the unit was by necessity a jack of all trades and a master of none. When that person left in 2007, EEB took over administrative supervision and financial management, including grant administration, freeing up the Herbarium Administrative Specialist to focus more on managing on-site operations, and increasingly outreach/education.

The EEB, UMMZ, and Herbarium administrative staff cooperate routinely, including sharing data and best practices, communications and website maintenance and development and providing backup when one of the units is short-handed, for example, due to medical emergencies. EEB and MCDB staff also provide backup services for each other within the Kraus Building.

Overall, EEB and Herbarium staff members reported a positive climate and relatively high satisfaction with their jobs and work conditions, with high levels of respect from their co-workers and confidence in the unit leadership (Appendix J-4). This is also largely true within the UMMZ (Appendix J-4), but there is some degree of perceived discrimination among staff; these issues are already known to the Director and are being addressed as possible. Some concerns also appear about the amount of communication among curators and staff; this will be a main focus of discussions to be held with the UMMZ curators, collections managers, and staff in the coming weeks.

C. Budget

The current general fund budget allocations for EEB, UMMZ, and the Herbarium, as well as for the Program in Biology, are shown in Appendix R. As is true at almost all public and private universities, the recession is leading to cutbacks and all units in LSA have been asked to plan for a total 6% decrease from the Fiscal Year 2009 operating budgets over the next three years. For EEB this represents a cut of $425,000, of $87,000 in UMMZ, and of $43,700 in the Herbarium. Although large, these cuts are considerably less than most other academic institutions because of the highly conservative fiscal management in place at UM. Our current expectation is that we can achieve

these reductions without severe damage to our core missions of education and research, although obviously we will lose some programs and services for faculty and students. The specifics of the budget reduction plan for each unit will be formulated during February in anticipation of discussion of the underlying principles and priorities with the review committee.

XII. Space and facilities

Limitations on the amount of space, the quality of current space, and, the way in which the faculty and research facilities, including the collections, are dispersed across campus and town are all highly significant impediments to faculty productivity and to recruiting the best new faculty for all three units. On the other hand, many of the shared facilities available to faculty are outstanding, including core campus facilities such as sequencing, microscopy, bioinformatics, and computing, and off-site field facilities.

A. Faculty laboratories and UMMZ and Herbarium Collections

The 33 EEB, UMMZ, and Herbarium tenure-track faculty office and laboratory spaces are primarily distributed between the Kraus Natural Science Building (35,995 sq ft for EEB's portion of the bldg, Appendix S-1) and the Ruthven Museums Building; the latter also includes the Museum of Zoology collections (65,985 sq ft, Appendix S-2). For faculty curators who are jointly appointed in the Herbarium, their main laboratory space is on campus in Kraus, but they also have access to a shared laboratory at the Varsity Drive facility, as well as individual offices there. Kraus is shared with MCDB, and Ruthven is shared with the Museums of Anthropology and Paleontology (which includes one EEB faculty member) and with the Exhibit Museum of Natural History. One additional faculty member is located in the Museum Annex adjacent to Ruthven, one in the Life Sciences Institute, also near Ruthven, and one in the Center for the Study of Complex Systems in West Hall. Kraus and Ruthven are within five minutes of each other, and faculty and students move between the buildings routinely; nevertheless the interactions among faculty and students that take place by daily meetings in the hall and the mailroom, or the easy visiting between offices and laboratories simply cannot be duplicated by any formal mechanisms of interaction imposed on inhabitants of different buildings.

The collections and staff of the Herbarium are now located at the Varsity Drive facility, originally considered to be temporary (29,000 sq ft, Appendix S-3). The Herbarium collections occupy a total of 16,400 sq ft in a single room of this former warehouse facility, with the remaining space consisting of the Herbarium library, a wet lab, a meeting/lunch room, preparation and shipping rooms, and offices and cubicles for the faculty and staff. Varsity Drive is about 20 minutes drive from central campus, necessitating travel of the faculty and students between their laboratories and the collections. Planning is considerably advanced for the move of the alcohol collections of UMMZ to this facility in 2011, which will mean increased travel time for the collection managers and professor/curators in the UMMZ as well (see Section VI-3 for further discussion of this issue).

In Kraus, faculty are typically allocated ca. 1000 sq ft for office plus laboratory, although exact space depends on type of program (e.g. primarily computational or primarily collections-based programs have smaller allocations), as well as size of program. In 2001, 11 EEB faculty were

housed in Kraus; this number has now grown to 20 through replacement of classroom or storage space with laboratory space and downsizing of space available for some faculty. However, we have reached a limit, with space available for the two faculty positions currently being filled but no more. Thus, we have no further room for any current programs to expand or for offices for visiting faculty or for postdoctoral fellows. In Ruthven, faculty are typically allocated about 700 sq. ft. for office plus laboratory, with some having more and some less depending on funding activity and need. The Director manages space and considers that all laboratory space should be distributed flexibly.

Major renovation of laboratories is required for almost all new faculty hires located in either Kraus or Ruthven. Because of the age of the buildings, this cost is substantial, typically greater than $500,000.

The upcoming move of the UMMZ ethanol collections to the Varsity Drive site will open considerable space in the building, but much of it, the sub-basement of the 1964 wing and the basement of the main building, is not suitable for laboratories or offices. It is expected that some of the dry collections will be moved to the basement, freeing up space in other areas of the building, but problems with air handling, flooding, and vibration will remain. The Museum of Zoology has been cooperating with EEB in planning office/laboratory space for future EEB hires.

Ruthven (constructed in 1928) and Kraus (constructed in 1915) have long been recognized as the buildings in LSA and, in fact, in the University, most in need of drastic renovation. External reports commissioned by LSA in 2001 and 2002 conclude that in their current state they cannot adequately support modern science laboratories. Some of these problems can be dealt with by major renovation (e.g., electrical infrastructure, lack of auxiliary emergency power) but others are intractable given the age of the buildings, including weight-bearing limits, lack of head space between floors for adequate air-handling and problems with vibration. Ruthven has serious issues with the foundation of the main building and flooding of the basement is common. The entire building lacks modern fire alarms and sprinkler systems, although this is being remedied as part of the alcohol move. The Kraus report further concluded that complete renovation of Kraus could do no better than an upgrade to 1995 levels of science laboratories and thus would be 15 years out of date by completion. The central administration of the University recognized these limitations by initiating planning in 2003 for a new building for MCDB, which shares Kraus with EEB. However, this idea was shelved after two years of detailed planning, and there is currently no specific plan for new construction for either MCDB or EEB. An $8 million proposal to NSF to provide emergency auxiliary power and cooling and automatic resets for air cooling to core equipment rooms and plant and animal growth room for Kraus (as part of an AARA-funded infrastructure program) received very positive reviews but we have just received word that insufficient funding is available to make an award.

In 2007, EEB, MCDB, UMMZ, and the Herbarium submitted a joint white paper to LSA on a long-term plan for space and interdisciplinary interaction; while the report was viewed favorably at the College level, it is clear that funds are not going to be available for such an expansive vision at the current time and that the move of the UMMZ alcohol collections to Varsity Drive will be carried out without the context of a long-term space plan for the museum units and EEB. The lack of long-term

planning for the life-science units in LSA is a major source of frustration and represents a substantial constraint on our long-term success.

B. Shared facilities

Kraus and Ruthven: Facilities available for faculty and student use in Kraus include preparation rooms, equipment rooms on each floor, and five growth chambers. The preparation rooms each contain one or more large autoclaves, a glassware washer, a glassware dryer, an ice machine, a deionized water still, and a sink. The equipment rooms, which have been renovated in recent years to provide better cooling, house the larger heat and noise generating equipment from individual laboratories, especially ultra-low temperature freezers. At this time, no additional equipment room space is available in Kraus, including space for back-up freezers, which places a major constraint on new and growing faculty research programs. Access to walk-in growth chambers is very limited in EEB, although they are an important resource for experiments under controlled conditions with plants and with small animals such as insects and zooplankton. EEB currently has five growth chambers in a common room in Kraus; these are quite old, and frequent breakdowns have resulted in significant loss of research materials over the last several years. Upgrades in the last year have, we hope, improved the situation but they are hardly a state-of-the-art research facility. Cold room space for sample storage is also very limited in Kraus, and EEB currently has no access to cold room or warm room work space. In addition to these facilities, the UMMZ houses the shared-use Genomic Diversity Laboratory (GDL), which provides access to equipment for DNA-based analyses by students and faculty who do not have this equipment in their laboratories.

Core facilities on campus: Many EEB faculty and students rely on fee-for-service core facilities on the U-M campus to support their research. Major use is made of the DNA Sequencing Core, which provides high quality, low-cost standard Sanger sequencing via Applied Biosystems DNA 3730XL sequencers and Next-Gen sequencing via an Illumina Genome Analyzer IIx and a Roche 454FLX Genome Sequencer. Computing clusters include the Center for Advanced Computing (CAC), which provides high performance computing and very large working-set data storage, and the Michigan Academic Computing Cluster (MACC), which houses high density platforms requiring energy-consuming power and cooling capacity in a robustly networked and secure, managed location. Other core facilities include the Microscopy and Image Analysis Laboratory, which provides a wide variety of light, fluorescence, and electron microscopy services and training; the Core Assay Facility for analysis of hormones; the Flow Cytometry Core, which provides flow cytometry instrumentation and expertise; the Molecular Biology Core Laboratory, for microarray analysis via the Affymetrix GeneChip system and real-time quantitative PCR; the Marine Hydrodynamics Laboratories (MHL) Gravity/Capillary Wind Wave Facility; the CEE Hydrodynamics lab; and the SNRE Aquatic Labs.

Matthaei Botanical Gardens and Nichols Arboretum: The Matthaei Botanical Gardens consists of a 350-acre site on Dixboro Road, along with two other research and teaching areas comprising an additional 250 acres (Mud Lake Bog and Horner-McLaughlin Woods). The Dixboro site includes four large greenhouses for research and teaching, a laboratory-classroom building and service and utilities buildings. The Botanical Gardens is a critical component of EEB research, especially in plant ecology

and evolution, and is also where the laboratories for introductory ecology (Biology 282) and the non-majors botany course (Bio 102) are taught, enabling access to both field sites and greenhouse space for laboratory work. Many EEB faculty and students routinely use the greenhouses for small-scale pot experiments (with excellent support by the Gardens horticultural staff) and protected areas of the grounds have been used for common garden experiments. The Botanical Gardens also represents a rich diversity of habitats for field research close to the Ann Arbor campus. The Nichols Arboretum consists of a 123-acre site on the eastern edge of central campus that includes wetland, prairie, and woodland ecosystems.

Edwin S. George Reserve: The E. S. George Reserve (ESGR) is a 1400-acre tract of land located 25 miles northwest of Ann Arbor, currently administered by EEB and directed by Earl Werner. The ESGR includes a wide variety of natural habitats, an extensive experimental pond facility used by Professor Werner's research program, living quarters, laboratory and storage space, and a weather station. Other than the experimental pond facility, which was constructed in 1986, most of the infrastructure in ESGR is badly in need of renovation and a more regular maintenance schedule. Responsibility for maintenance of the ESGR has recently been transferred from Plant Department to LSA and we are currently searching for a facility supervisor, which should improve the regular maintenance of the Reserve. The main portion of the ESGR is fenced to permit the safe conduct of experimental programs that otherwise would be sensitive to public intrusion. The ESGR is becoming increasingly important to our faculty and students as a research facility, as undisturbed sites for ecological research near Ann Arbor diminish and interest in biodiversity research increases. Currently 6 EEB faculty, 11 EEB and SNRE graduate students, and two EEB postdocs have active field projects at ESGR, along with 12 researchers from other institutions.

The University of Michigan Biological Station (UMBS): The UMBS, near Pellston in northern lower Michigan, is a unit of the College of Literature, Science and the Arts with close links to EEB. It is dedicated to education and research in field biology and environmental science. The Director, Knute Nadelhoffer, is a professor in EEB. The UMBS administers approximately 10,000 acres of mostly forested land that includes several first-order streams, wetlands and ~7 miles of undeveloped shoreline on Douglas and Burt Lakes. It also has easy access to various habitats on public lands (federal, state and county forests) and Great Lakes shorelines. The UMBS also administers the ~3,000 acre Chase Osborne Preserve on Sugar Island, which provides access to shoreline habitats in the straits between Lake Superior and Lake Huron. Research facilities at UMBS include greenhouses; a soil Biotron for study of belowground environments; three highly instrumented towers for measuring forest-atmosphere gas exchanges (CO2, ozone, oxides of nitrogen, volatile organics); an experimental stream laboratory allowing for manipulation of stream substrate, flow rate, chemistry, light levels, etc.; an analytical chemistry facility with an isotope ratio mass spectrometer; and a well-equipped stock room with field and laboratory supplies.

About 280 students, faculty, staff, scientists and families can be accommodated in summer, and 40 people in winter. Between 100-150 students take Biology and EEB classes at UMBS every summer, with many of them Biology and EEB concentrators. Five current EEB faculty have major components of their field research programs centered at UMBS (Nadelhoffer, Goldberg, Hunter, Myers, Webb) and 5-

10 EEB graduate students are conducting all or most of their dissertation research there. UMBS is entering the final year of a second 5-year funding cycle of an NSF IGERT program entitled the Biosphere-Atmosphere Research and Training Program (BART; PI Professor Mary Anne Carroll, UM Dept of Atmospheric, Oceanic and Space Science, co-PI, Nadelhoffer and 3 others), which brings PhD students from institutions across the US to conduct interdisciplinary research on site for two or more summers. Approximately ¼ of BART Fellows have been UM students, including 4 current EEB students. UMBS has also hosted a site-based REU program during summers (funded through 2013) which provides research opportunities for EEB undergraduates as well as undergrads from other US institutions.

XIII. Conclusions and future directions

The years since EEB became a separate department in 2001 have been enormously productive and exciting for all three units. Over half the faculty have turned over since 2001 and these new faculty have brought exciting world-class research programs, along with innovative approaches to teaching and curation. The working relationships between the UMMZ and Herbarium and their academic affiliate have improved enormously with the advent of EEB, and we have greatly expanded interdisciplinary linkages with other units on campus such as Geological Sciences, MCDB, Human Genetics, Natural Resources and the Environment, Public Health, Engineering, and the Medical School. The relationship between EEB and MCDB has also improved tremendously since we were in a single department; for example, together we successfully evaluated and completely renovated the way we teach introductory biology.

The three units together have great strengths in disease ecology and theoretical ecology, as well as strong groups in population and community ecology, in phylogenetics and systematics, and in tropical biology. We participate actively in strong interdisciplinary groupings in microbial ecology and biogeochemistry. On the other hand, despite some excellent recent hires, we are weak relative to other top EEB departments in many areas of evolution, including evolutionary genetics and genomics, evolutionary theory and phylogenetics theory. While many of our faculty incorporate both ecology and evolution in their research, we also have few research programs that take the interface between ecology and evolution as their explicit focus. We also have conspicuous gaps in landscape to global scale ecology and in functional organismal biology**. Therefore, we propose to focus hiring in the next five years primarily on evolutionary biology and evolutionary ecology, along with large-scale ecology**. All searches will be defined very broadly with these research priorities listed within position descriptions. Joint positions between EEB and the UMMZ or the Herbarium will be defined similarly, except with orientation towards particular taxonomic group as required by curatorial needs. For functional organismal biology, we propose to collaborate with other units across campus to develop an interdisciplinary group focused on the functioning of whole organisms.

In teaching, a number of faculty now use active learning approaches in their classrooms, and we are beginning an initiative to define learning goals for all of our courses, make more effective use of formative assessments to improve classroom learning, and better align evaluation of student learning

with these goals. We also need to add upper division courses to cover gaps in core areas as well as newly emerging fields such as in genomics and global biology.

We have been expanding programs designed to increase diversity in ecology and evolutionary biology, including our Frontiers Masters program, and, with MCDB, are developing a proposal for a transition program from high school through the first two years of college for students interested in biology but at risk of not succeeding in their initial courses (the Michigan Biology Academy Scholars). Further developing these programs and solidifying their funding is a very high priority.

The relationship between EEB, UMMZ, and the Herbarium is strong, with a commitment from EEB on the importance of maintaining biodiversity expertise and the collections as an integral part of research in ecology and evolutionary biology. **We will continue to work together and with the College on defining and implementing the best possible administrative structure to enhance the missions of all three units; coming to a conclusion on this very serious issue is key to enable effective long-term planning for all three units.**

We will continue to expand our interdisciplinary linkages, integrating ecology and evolution more explicitly with both basic and applied disciplines such as public health, atmospheric sciences, medicine, and environmental engineering. A pending IGERT on microbial ecology is one such initiative; taking the lead on coordinating organismal functional biology on campus is another. We had been strongly involved in a past proposal for the Mathematical Biology Synthesis Center (reaching the site review stage) and are now actively engaged in developing a proposal for the recently announced NSF competition for an Environmental Synthesis Center.

Our biggest limitation besides the great need to build our faculty in evolutionary biology is in the quantity and quality of space that we oversee: both Kraus and Ruthven are outdated buildings that are not up to standards for modern science. There is no room for expansion even for existing programs, and the dispersion of laboratories and offices between Kraus and Ruthven, as well as the off-campus location of the Herbarium at Varsity Drive, are ongoing impediments to maximizing the synergies among our research programs. We recognize that we live in difficult times and that a new building or complete renovation is extremely unlikely. However, we strongly urge initiation of a planning process for the long-term space needs of the biological sciences in LSA and their linkage to the broader research communities in the life sciences and the environmental sciences at UM.

XIV. Appendices

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