

The 2022-2027 Entomology Strategic plan

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Department Overview. Entomology, a full member of the College of Computer, Mathematical, and Natural Sciences (CMNS), gets half of its budget through, and also participates in, the research and extension programs of the College of Agriculture and Natural Resources (AGNR), especially those relating to integrated pest management (IPM).

The mission of the Entomology department is to improve the quality of life of the people of Maryland and the world by generating and applying information about insects. A recent (2021) departmental review highlighted the past success of the Entomology department. As part of the preparation for the review, the Department engaged in a series of planning exercises to develop a departmental strategy that will build on our past successes and identify current and anticipated gaps in departmental capacity in order to ensure we continue to meet those societal needs which can be addressed through the study of insects. We identified various needs to enhance programming and activities, set out goals for accomplishing those needs and make specific suggestions about how to achieve those goals. Those discussed here are considered the most vital to advance Entomology and the University of Maryland's agenda.

We note that this strategic plan, like the University-wide strategic plan "Fearlessly Forward: In Pursuit of Excellence and Impact for the Public Good", attempts to reimagine what our department does to uphold and expand our mission of service to humanity. Like the university plan, ours is underpinned by a commitment to values-driven excellence, diversity, equity and inclusion, impact, innovation, collaboration, and service to humanity. It is meant to help give direction to the department's next leadership, and act as the foundation for innovative new hires who will help us bring novel directions and creativity to our research, extension, teaching, and administration. We see as central to this aim a focus on developing cross-discipline collaborations aimed at addressing societal problems from multiple and diverse approaches.

Over the next decade, our vision for the future of the Department of Entomology is to support and sustain continued excellence in research, training, extension and outreach in insect science and its application within a department that is proud of its accomplishments and culture. This will be achieved through the encouragement of bold approaches to solve difficult problems, the training of students who become leaders in their field, and the production of valuable and trusted information for all our stakeholders. Our bridge-building efforts, and our own emphases within the broad spectrum of insect science, will strongly support the strategic initiatives of both Colleges with which we work, as well as those of the University in partnering to advance the public good, investing in people and communities, and taking on humanity's grand challenges. Reflecting its public service orientation, the department also has a strong effort in public outreach, with participation by many faculty, staff and students. Our insect zoo exhibits are a leading attraction of the annual campus open house (Maryland Day). Our insect summer camp gets national visibility. Our "Bug of the Week" outreach site averages 10,000 viewers per month. We have strong desire and justification for expanding our public outreach, given its

alignment with University priorities and the seemingly inexhaustible demand. We will focus on outreach opportunities in which exceptional potential for impact coincides with availability of resources, and actively advocate and seek for resources when they are missing.

Core values

- ❖ Be leaders in Entomological research, basic and applied, that improves quality of life.
- ❖ Excel in educational activities with a focus on conceptual basics and experiential learning.
- ❖ Serve our stakeholders locally, nationally and internationally.
- ❖ Foster a scientific world view that is sensitive to the needs of society.
- ❖ Create a collegial, respectful, and welcoming place, where members can thrive professionally, regardless of race, gender, or philosophy.
- ❖ Promote the synergism that comes from interdisciplinary interactions.
- ❖ Invest in, engage, and value our people so that they can be productive and engaged.
- ❖ Work hard and have fun doing what we love to do.
- ❖ Provide value for resources invested in Entomology.
- ❖ Take advantage of our location close to Washington DC, a major governmental and biotech hub, and in Maryland, which is in the front line of both climate change impacts and research advances (e.g., at the Chesapeake Bay).

Research and Extension goals

We view driving the integration of Research and Extension in the broad sense as crucial to our purpose. From this perspective, and despite separate treatment in this document, there is an expectation that the coming years will see an increase in sharing and translation of scientific knowledge produced in the Department to the different audiences that could benefit from it (in agriculture and beyond). Such an integration would also facilitate the alignment of our departmental mission with the four pillars of the University's strategic plan.

Research

Increase Entomology research success and respond to new challenges

The 2021 departmental review committee recognized that outstanding, cutting-edge research is our hallmark and the core strength that underlies excellence in our instruction, extension and outreach. We aim to capitalize on this core strength to increase Entomology research efficiency and creativity. Our internationally-recognized research must rise to meet the challenges of climate change, the rising number of invasive species reaching major pest status, the rise of new insect-transmitted diseases with impacts at local, national and international levels, and the alarming decline in insects that perform important ecosystem services such as pollination, pest control, and nutrient cycling. These challenges demand innovative interdisciplinary research to lead the way. We seek to build upon our existing expertise to grow and expand our research foci and our ability to flexibly respond to emerging issues and research opportunities.

Strategies to achieve goal

- ❖ Recruit new and retain current faculty who have outstanding research programs. We are down three tenure track faculty positions compared with 2012, and there are several upcoming retirements in the time frame covered by this plan.
- ❖ Promote, support and reward research success.
- ❖ Target critical global issues with research led by our faculty and their collaborators, and train others to do the same.
- ❖ Foster and enhance collaborations in the department, college and across campuses; strongly support both college and campus-wide initiatives; and further strengthen ties with local partners such as NIH, John Hopkins, USDA, the Smithsonian Institution and others.
- ❖ Strengthen research infrastructure, including administrative support staff, maintaining and upgrading facilities, and providing appropriate University resources (e.g., equipment, computational) to researchers.
- ❖ Maintain excellent mentoring of faculty, and increase nominations of faculty for awards.

Actions to achieve goal

- ❖ Establish and lead interdisciplinary teams to address global challenges.
- ❖ Reward faculty and staff achievement with merit raises and promotions.
- ❖ Support faculty success and promotion through targeted nominations for awards and fellowships.
- ❖ Recruit faculty in areas with strong extramural funding prospects and with high impact potential in areas such as: addressing the biodiversity crisis, food (in)security, invasive species, insect (phylo)genomics and systematics, insects of medical importance, science literacy, cross disciplinary scholarship, and interdisciplinary integration of entomological and social equity research.
- ❖ Increase efficiency of grant submission and management.
- ❖ Invest in infrastructure with maintenance and upgrades to the building physical plant.
- ❖ Facilitate access to the shared equipment and other resources that we support. An urgent requirement is to improve access to resources and services available through the DeepThought3 Cluster so as to accommodate new research programs or faculty with funding. Improved access includes capacity to provide a reasonable baseline allocation to researchers and changes in the management of wall times and access requests.

Inputs needed to achieve the goals

- ❖ Receive approval and funding for at least four research faculty searches over the next five years
- ❖ Provide competitive compensation and resources for hiring, retention and promotion.
- ❖ Provide resources needed for successful submission and management of externally-funded research.
- ❖ Repair or replace shared research equipment (e.g., autoclaves, growth chambers).
- ❖ Petition for maintenance and upgrades to the building physical plant including new walk-in cold rooms and a new roof, improvement/updates of water and HVAC systems.
- ❖ A flexible system for researchers to gain access time on the DeepThought3 Cluster for needs intrinsic to the analysis of biological data, which include difficulty in predicting computing times. On this, a Life Sciences-specific sub-cluster could be established.

Extension

Entomology as a hub for IPM (Integrated Pest Management) work and outreach

The departmental review committee noted that Entomology's cooperative extension and research programs have garnered national and international recognition for their development and deployment of new strategies with large impacts on the economy, environmental protection, and society. Our capacity to create a premier U.S. center for IPM research, education, and Extension is currently incomplete but, if fulfilled, would attract major funding, the best scientists, science, and students of IPM, and would generate solutions to society's pressing needs for safe and secure food and healthy environments. In addition, expanding our extension and outreach capacity to better reach underserved populations in the state of Maryland would lead to increased science literacy, environmental protection, and improved health.

Our goal for the next ten years is to build on our strengths to make UMD Entomology a premier center for IPM research, education, outreach, and Extension providing leadership and advancing the science as well as its application and implementation. In so doing, we will educate a generation of students that will face daunting food security, safety, and environmental challenges posed by land use changes, pests and pest-related risks.

Strategies to achieve goal

- ❖ Recruit faculty and staff able to and interested in reaching both traditional and underserved populations at state, national, and international levels.
- ❖ Create a fertile and interdisciplinary environment for the translational work needed to support IPM.
- ❖ Plain communities (e.g., Amish, Mennonites etc.) are an example of an important underserved audience in our area that may not be reached with the web. We therefore need to maintain excellence in both our in person and web-based initiatives, as well as utilize developing technologies to enhance and elevate our reach and visibility, expanding support for extension and outreach.
- ❖ Ensure facilities and their staffing are maintained and upgraded to strengthen and grow Extension programs and improve the functioning of the RECs (Research and Education Centers).
- ❖ Develop a plan that coordinates and promotes classes we offer for different IPM and outreach paths (e.g. integration into the Extension Major offered by AGNR).

Inputs needed to achieve the goal

- ❖ Receive approval and funding for at least three searches for faculty with extension components to their programs (these are in addition to the research hires).
- ❖ Provide competitive hire packets.
- ❖ Request and support improvements of the UME website, making it more user-friendly, and improve integration of established and developing communication platforms.
- ❖ Increase our ability to support and improve the quality of extension activities that integrate all members of the Department, and maintain and strengthen associations with USDA and other partners.

- ❖ Petition UME and MAES to encourage investment in the RECs, and to make sure they effectively function and meet Extension needs.
- ❖ Recruit faculty and staff with expertise in communication and outreach to serve underserved communities, including non-commodity stakeholders such as low-income urban and suburban populations.

Teaching

The level and intensity of teaching in our department was highlighted by the review. In fact, the current teaching portfolio offered by our department is very strong at the undergraduate level, and our graduate program is also among the top in the country. However, the latter could further grow. In particular, there is a clear need for more specialized conceptual (e.g. advanced evolution, phylogenetics, bioinformatics), and analytical (e.g., advanced statistics, modelling) classes. Failure to further expand on these could lead to a reduction in graduate enrollment levels and graduation success, and reduce student ability to succeed post-graduation.

Train the next generation of successful entomologists

It is our overall teaching goal to provide a high-quality educational experience, resources and mentoring to allow students to discover, explore and pursue their interests in Entomology and develop intellectually, socially and professionally to their fullest potential. A well-recognized team of commodity and subject area experts such as ours provides many different training opportunities to students, and our students eagerly participate in these unique experiences that develop skills in real-world situations. We do this through our participation in Graduate and Undergraduate programs.

Overall expected outcomes

- ❖ Students receive a superior and well-rounded education.
- ❖ Curricula that meet the evolving needs of our students and gives them a competitive advantage.
- ❖ Continue to make significant contributions to University core outcomes by providing high quality and engaging instruction in the areas of Science, Technology and Society.
- ❖ Growth in interest in entomology as a career in industry, government agencies and academia.
- ❖ Increased recruitment and retention of a diverse student cohort.
- ❖ Ensured funding availability to support students throughout their graduate studies.

Graduate Program. The graduate program was recognized in the review as one of the main successes of the department, providing a diverse graduate training portfolio, which reflects our role as a “bridge” department between disciplines and colleges, and shows a fundamental commitment to both the advancement of scientific knowledge and the University’s Land Grant Mission. Yet, funding for students is unpredictable and increasingly deficient, which threatens future recruiting and the long-term success of the program. Only 14% of our current students receive Departmental Gahan Fellowships, and TAs support 26% of our students. The largest single funding source now is via faculty grants/startups (~42%). To attain the desired situation

of increasing our yearly enrollment from seven to ten or more fully-funded students, doubling funding from stable sources is needed. Other challenges the program faces include mixed results from efforts to increase the recruitment of graduate students from diverse backgrounds.

Strategies to achieve goal

- ❖ Encourage faculty external funding requests to include funds for RA-ships.
- ❖ Establish a plan to have all PhD students apply for at least one fellowship, scholarship, or extramural award (e.g., pre-doc USDA, NSF GRFP, Ford) during their time in the program.
- ❖ Establish formal student internships with local industry, government agencies, non-profit organizations and other entities.
- ❖ Leverage the department's small size and unique bridging between two Colleges to implement and test innovative new administrative approaches.
- ❖ Petition for increased funding from UMD for TAs for undergraduate courses taught by Entomology faculty.
- ❖ Improve recruitment using new paths to reach new populations (e.g., professional listservs such as evoldir and eco-log, social media).
- ❖ Identify reasons for low application rates among underrepresented groups and seek remedies.
- ❖ Promote and further support student and faculty presentations at ABRCMS (Annual Biomedical Research Conference for Minority Students), SACNAS (Society for Advancement of Chicanos/Hispanics & Native Americans in Science) and similar conferences, and participate in UMD programs oriented to underrepresented groups (e.g., SOARE).
- ❖ Continue to improve our graduate program through providing strong, relevant courses, which contribute to better training of students, and increases attractiveness of our programs.

Inputs needed to achieve the goal

- ❖ Faculty effort in trainee proposal development and running funded programs.
- ❖ Faculty effort in increasing extramural grant funding with support for RAs.
- ❖ Faculty and departmental effort in recruiting and mentoring diverse students.
- ❖ Increase efforts to establish donor-based student endowments.
- ❖ Attractive brochures, displays for meetings and websites.
- ❖ Continue offers to waive application fees for underrepresented minorities and socio-economically disadvantaged backgrounds.
- ❖ Increase number of advanced classes taught, which could include the hiring of new teaching faculty focused only on teaching these classes.
- ❖ Promote genuine connections and collaborations with SACNAS, ABRCMS and other organizations, and involve Faculty in UMD-based programs such as SOARE.
- ❖ Promote mentoring trainings for faculty and students, which will likely improve attractiveness to non-traditional students and their retention and success in the programs.
- ❖ Promote faculty setup of Google Scholar profiles and/or lab websites to improve the ability of prospective students to learn about our Department's research programs.

Undergraduate program. The department has grown its connections with undergraduates, and this was also recognized in the review. The Department offers a Minor in Entomology, an Honors program, and Entomology courses offered in the Biology program. Our Entomology Student Organization (ESO) also now includes entomology-minded undergraduates from campus, expanding our undergraduate service. It is our goal to continue to grow our reach with our undergraduate education, assisting this population to properly identify and succeed at career paths in Entomology.

Strategies to achieve goal

- ❖ Reach a larger number of undergraduates through improved promotion of our Minor and Honors program.
- ❖ Increase the number of undergraduates that complete an Honor's thesis in Entomology labs.
- ❖ Establish an expectation for Faculty with active research to host at least one undergraduate in their labs per year.
- ❖ Promote the presentation of undergraduate research at local, regional, national, or international meetings, aiming for allowing at least half of the undergraduates participating in our research programs to do so.
- ❖ Continue and grow partnerships with other related departments and programs (e.g., Biology) to promote the preparation of undergraduates to apply for graduate programs and competitive fellowships (e.g., NSF GRFP).

Inputs needed to achieve the goal

- ❖ Funding to support more undergraduate research (e.g., growing Cory fellowships).
- ❖ Expanded communication with faculty on avenues for university or college support for undergraduate research.
- ❖ Early engagement with undergraduates and faculty advisors on the advantages of completing an Honor's thesis project.

Departmental Hiring Needs

Departmental Chair

A new departmental chair will be recruited in 2023. The department strongly favors selecting a new chair from among a large pool of external candidates. The optimum candidate will have a deep appreciation for interdisciplinary thinking as it relates to the tripartite mission of the department, will be a team builder across colleges, disciplines, and within the department, and will provide a fresh perspective that emphasizes not just discovery but also social change.

Faculty Hires (Research)

Given the campus-wide interest in fostering interdisciplinary programs, any of the Faculty hires proposed here could be coupled with hires in other departments. For instance, connections could be established with departments in the schools of Public Health, BSOS, Biology, Education and Arts, where the impact of the entomological research can be coupled with action-

oriented outcomes (thus, actively integrating our Research and Extension missions). Given the clear connection between entomology topics and human and ecosystem welfare, the department is well placed to emphasize natural and social sciences working together.

Arthropod vectors of disease. We urgently encourage the replacement of the recently-vacated vector biologist position, and thereby also provide a new leader for the “state-of-the-art” Insect Transformation Facility (ITF). The ITF mission is to be an international resource for the creation of genetically modified insects, a developer of new insect genetic modification technologies, and a source of training in the use of these technologies.

Research in arthropod vectors addresses pathogenesis, genetics of vector-host biology, insect-virus interactions, and host resistance mechanisms of human and animal disease organisms. This position is also ideal to accomplish work on integrating these research areas with social equity, a major global challenge that also aligns with the UMD strategic plan. This position would generate research-based knowledge for improved management and application, increase research grant support from nationally competitive sources; provide leadership and collaborations that advance research, instruction and extension/outreach. Such a position would also allow developing translational medical efforts targeting human and animal health, contribute opportunities for spin-off biotechnology companies and/or large pharmaceutical companies through the design and development of antimicrobials, chemotherapeutics, and novel vaccines and vaccine delivery platforms. The importance of insects for disease transmission (mosquito and tick-borne diseases) makes of this hire a central axis to address global and local health needs.

Phylogenomics and Biodiversity. The Department of Entomology has been recognized as a hub for molecular insect systematics and this vacated position ought to be retained. A new hire on this topic to replace retired faculty would allow us to maintain and expand critical expertise in insect evolutionary biology, biodiversity and systematics. Today, Entomology has no faculty fully-focused on insect molecular systematics and biodiversity, and a person with this expertise can support all areas of entomology and college initiatives through production, storage, analysis, and interpretation of complex biological data sets. Such a position would allow considerable increase in funding from several federal agencies, and would strengthen the department’s connections with, for instance, the Smithsonian Museum of Natural History and the USDA labs. Given the biodiversity crisis, its complex interactions with human-actions on the environment, and the very large potential negative impacts of this on all living organisms, it is critical for this position to be filled as soon as possible. Also, given the impact on human and environmental health, this position would also represent an ideal interdisciplinary path to work towards public good and improving equity and inclusion in research and its applications. Importantly, this addresses a critical research area for the future and builds upon past and existing strength in our department.

Insect genetics. As insect management solutions are increasingly genetic, knowledge of insect population genetics and insect-plant interactions at the cellular and molecular level are needed for future solutions. Further, and related to this, *Drosophila* and other insects such as honeybees and the caterpillar *Manduca sexta* currently represent exceptional models used for the study of the genetics of ubiquitous developmental processes. Studies covering these arrays of knowledge underpin crop entomology, resistance management, the generation of biodiversity and the development of pest management solutions, thus complementing and expanding

existing departmental strengths. From a funding perspective, a hire on insect genetics would offer stronger linkages with MOCB, Shady Grove, USDA, NSF and NIH.

Chemical ecology. The field of chemical ecology in the broad sense represents one of the leading fronts in science, with chemical ecologists in a unique position to bridge divides between disciplines. For example, chemical ecology allows understanding species interactions within complex phytochemical landscapes, describes and explains insect chemical products/metabolites and communication, traces nutrient movement and track food networks in ecosystems, and discovers novel toxins and other chemistries. Besides advancing their own fields, this hire would fill a current gap in departmental expertise while being extremely complementary to many ongoing research programs in the Department. Such a position would also allow increasing federal and other funding resources. Given our goal of increasing interdisciplinarity, the high impact research that can be accomplished through the integration of such an expertise to our department, this hire has the potential to open completely new research avenues in our group. Further, the high importance of chemical compounds in agriculture would expand the integration of extension work with the investigation of ecological and evolutionary aspects of the chemistry of life.

Insect behavior/Neurobiology. Insects are model systems in research on the neural basis of simple and complex behaviors and animal cognition. We propose an interdisciplinary hire who addresses the astonishing diversity of insect activities and ecological interactions at the behavioral and neurological level. This hire could be linked with other hires by studying the genetics of behavior or the behavior of biomedically important insect species, or with chemical ecology and other aspects of the various responses of insects to environmental hazards such as temperature, humidity, parasites, and toxins. The department already has extensive expertise working with *Drosophila* and honey bees that are key model systems for behavioral studies. A hire that specifically focuses on behavior could fully leverage that expertise as well as the opportunities offered by the unparalleled diversity of insect lifestyles. This hire would offer stronger linkages with Biology, NSF and the NIH.

Faculty Hires (Extension)

IPM in urban landscapes. Maryland is a highly urbanized state with additional development anticipated as the population grows. This urban population also manages the landscape and needs IPM-related knowledge, all of which can be offered through serving our University's Land Grant Mission. For instance, expertise in urban food production and other urban pest management issues such as structural pests would benefit Maryland stakeholders. Further, additional expertise is needed to meet the increasing demand for sustainable pest management programs in urban landscapes and for populations that have been historically underserved (e.g., Latinx, urban poor) by traditional entomology-related extension programming in our state. Beyond private land managers, urban communities are directly related to the Green Industry, which is formed of diverse stakeholder groups, requires us to serve. This position builds upon existing departmental strengths, as well as others within AGNR and UME programs, in particular, a proposed dedicated urban forestry position within UME.

Climate change research and literacy. Climate change extension work is critical to maintain the livelihoods and health of our population, and this is of direct relevance to our Department's focus. Climate change is expected to increase the spread of zoonotic diseases, pest

problems, the spread of invasives, and impact people's livelihoods. From a conceptual perspective, the fact that insect development is dependent on temperature renders them optimal systems for studying the impacts of climate change. Research topics in this area could include the impacts of climate change on insect biodiversity, plant-insect and tritrophic interactions, range expansion of pests and outbreaks, food security, vector-borne diseases, and others. Many in the department broadly address issues associated with climate change in their research and Extension programs, however, specific expertise on this critical topic would enable us to expand and complement this expertise and provide the focus needed for such an important topic. Importantly, the two faculty who contribute to current extension work on these topics in the Department have or will soon retire, making this hiring essential. This is a position that could also represent a potentially-rich interaction with other departments at UMD, which could bring the development of new expert classes, and which clearly aligns with UMD strategic goals.

Geospatial science and statistical approaches (big data analysis and modeling), climate modeling, and meta-analysis. Has numerous applications in invasive species, land use change, climate, open environmental data science, precision agriculture etc. Already, farmers and nursery growers in Maryland are moving towards the use of precision agriculture in their management plans. This line of research includes the use of optical and remote sensing, drones for pest surveys and natural enemy releases for biological control, and the use of sprayers that turn on and off based on pest monitoring / survey maps. CMNS has major strengths in computer science and artificial intelligence (AI), and seeking to build upon that expertise, we aim to hire a faculty member who can collaborate with the engineering college, while serving Extension and applied Research program areas. Support of a hire with these skill-sets would help Maryland growers stay at the forefront of best management practices on their farms and nurseries. From a funding perspective, NSF and USDA are expanding their funding in the area of precision agriculture.

Plant Diagnostics. Diagnosis and identification of the causal agent of plant problems are the crux of successful IPM programs. Knowing the cause of the problem(s) allows for the development of best management practices. Our department is fortunate to house the University of Maryland Plant Diagnostic Laboratory which diagnoses abiotic and biotic (disease and insect) plant problems. We will seek to replace the current director of the laboratory if as expected she retires during the period covered by this strategic plan. This position reflects our department's 100+ years of dedication to the Land Grant mission of the University of Maryland. Over the years, and in part motivated by a goal of increasing our connection to and impact on the life sciences as a whole, we have deliberately broadened our subject matter. We have done so in part by adding faculty whose background and research interests are non-traditional for an Entomology department, but who strongly share our commitment to integrative biology and to research and outreach that address public needs.