3 Park Place, Suite 307
Annapolis, MD 21401-3722 USA
Phone: 301-731-4535
Fax: 301-731-4538
esa@entsoc.org
www.entsoc.org

Testimony of
Robert K.D. Peterson, PhD, President
Entomological Society of America
On
Fiscal Year 2020 Appropriations for the National Science Foundation
Submitted to the
Appropriations Subcommittee on Commerce, Justice, Science, and Related Agencies
United States House of Representatives

April 4, 2019

The Entomological Society of America (ESA) respectfully submits this statement for the official record in support of funding for the National Science Foundation (NSF). **ESA requests a robust fiscal year (FY) 2020 appropriation of $9 billion for NSF, including strong support for the Directorate for Biological Sciences (BIO).**

Research in entomology and other basic biological sciences provides the fundamental discoveries that advance knowledge and facilitate the development of new technologies and strategies for addressing societal challenges related to economic growth, national security, and human health. Basic research on the biology of insects has provided foundational insights across all areas of biology, including cell and molecular biology, genomics, physiology, ecology, behavior, and evolution. In turn, these insights have been applied toward meeting challenges in a wide range of fields, including conservation biology, habitat management, livestock production, and pest management.

Insects have long played an essential role as model organisms for understanding basic biological processes across all organisms, including humans. Insects are often ideal laboratory experimental subjects because they are generally small and inexpensive to obtain, they complete development rapidly, and they can be maintained without the special facilities required for vertebrate animals.

The common fruit fly, *Drosophila melanogaster*, for example, has been the subject of NSF-funded research that has profoundly transformed the understanding of human health in countless ways. Equally important, the ability to dramatically reduce the cost of sequencing genomes has played a critical role in advancing science in the last two decades. In 2018, entomologists were able to complete one of the first genome sequences by a single lab for under $1,000 using the fruit fly.[1] This breakthrough not only expanded the accessibility of genome sequencing, but also changed the way scientists understand the fruit fly itself as a model organism. Previously it was thought each fruit fly was essentially genetically identical. This study revealed there are

[1] Solares, Edwin A et al. "Rapid Low-Cost Assembly of the Drosophila melanogaster Reference Genome Using Low-Coverage, Long-Read Sequencing." G3 (Bethesda, Md.) vol. 8,10 3143-3154. 19 Jul. 2018, doi:10.1534/g3.118.200162

significant differences in the sequences of many important genes, indicating that genome variation is much greater than previously believed. This will likely have tremendous medical value to patients, health care workers, and scientists.

NSF is the only federal agency that supports basic research across all scientific and engineering disciplines, outside of the medical sciences. Each year, the foundation supports an estimated 300,000 researchers, scientific trainees, teachers, and students, primarily through competitive grants to approximately 2,000 colleges, universities, and other institutions in all 50 states. NSF also plays a critical role in training the next generation of scientists and engineers, including through programs like the NSF Research Traineeship, ensuring that the United States will remain globally competitive in the future.

One program, the NSF Graduate Research Fellowship, selects and supports science and engineering graduate students demonstrating exceptional potential to succeed in science, technology, engineering, and mathematics (STEM) careers. The NSF's Graduate Research Fellowship and Postdoctoral Fellows Programs have also been instrumental in supporting researchers at the forefront of soft robotics and space exploration. Recently, NSF funded several projects focused on soft robots, which are considered the best candidate for strong, mobile robots for exploration of harsh and dangerous environments. NSF funded successful projects to learn from insects to develop innovations in robotics. The results include a "robofly" with biologically inspired sensors for rapid flight stabilization,[2,3] the "RoboBee" project which pioneered an amphibious, micro-scale autonomous robot,[4] and vision-guided perching robots.[5] However, much is still unknown about the exact physical and biological mechanisms insects use to sense, move, and navigate through the world. For the United States to continue to be a world leader in robotics innovation, it is critical to fund research on the biology, physiology, and morphology of insects.

Through activities within the BIO Directorate, NSF advances the frontiers of knowledge about complex biological systems at multiple scales, from molecules and cells to organisms and ecosystems. In addition, the directorate contributes to the support of essential research resources, including biological collections and field stations. NSF BIO is also the nation's primary funder of fundamental research on biodiversity, ecology, and environmental biology.

One NSF BIO-supported project that illustrates the broad reach of basic entomological research is focused on fundamental insect physiology. The investigators are testing a hypothesis about the mechanism insects use to transport blood, nutrients, and gases throughout their bodies.[6] Their research on these transport processes will inform our understanding of insects' success as agricultural pests and disease carriers as well as our ability to mitigate those traits. A deeper

---

[2] Paul Yu Oh. Robotic Insect Flight Stabilization Using Biomimetic Sensors. Award Number: 0412541

[3] https://www.nsf.gov/news/news_videos.jsp?cntn_id=138802&media_id=80678&org=NSF

[4] https://www.ien.com/product-development/news/20781982/robobees-may-lead-to-autonomous-robotic-insects

[5] https://news.psu.edu/story/532491/2018/08/21/research/mechanical-engineering-faculty-studies-flying-insects-create-better

[6] Socha, John; Harrison, Jon; Miller, Laura; and Pendar, Hodjat. A New Hypothesis for Cardio-respiratory Mechanics in Insects. Award Number: 1558052

knowledge of these transport systems will also provide insights into those possessed by other animals and impact the design of new mechanical systems. This investment has already led to the breakthrough discovery of proteins found in carabid beetles with valuable applications in bioengineering and biomedical technology. Carabid beetles are special in their ability to produce caustic chemicals that they spray as a defense mechanism against predators. Due to the toxic nature of these chemicals, carabid beetles must have a way of producing and, more importantly, storing these chemicals without harming their own body. Using novel microscopy techniques, NSF-funded researchers discovered that the gland system that produces, stores, and propels these chemicals is comprised of an elastomeric protein called resilin.[7] In addition to furthering our understanding of the natural world, the discovery of resilin in carabid beetle caustic chemical secretory glands has biomedical and bioengineering applications due to its impermeability, resistance to chemicals, and flexibility.

NSF BIO also supports the development of technologies that directly impact economic sectors that are highly dependent on entomology. NSF recently awarded funding for a Small Business Innovation Research (SBIR) Phase I project aimed at ensuring healthier honey bee populations through data analysis and modeling.[8] The project seeks to build newer and more robust algorithms capable of autonomously analyzing data generated by networked sensors placed in beehives. The information derived from the resultant data sets could then be used to develop models capable of predicting the infiltration of pests and disease in hives before it actually occurs. Ultimately, the successful commercialization of this technology could revolutionize an entire agricultural sector that has suffered significantly because of honey bee colony collapse.

In addition to funding research, NSF BIO plays a critical role in the curation, maintenance, and enhancement of physical-biological collections. These collections and their associated data sets serve a variety of purposes, and while they are particularly important to the field of entomology, their value to the broader scientific enterprise cannot be overstated. Physical collections enable the rapid identification and mitigation of costly invasive pests that affect agriculture, forestry, and human and animal health. This is only achievable because such collections are continuously being updated to reflect environmental changes, evolutionary developments, and shifting migratory patterns of invasive species around the world. NSF also supports workshops designed to provide hands-on training in collections curation and management, with a particular emphasis on students and early-career researchers.[9] Workshops like this, across numerous disciplines, help ensure the long-term availability of a STEM-trained workforce.

While collections-focused awards like that mentioned above are encouraging, ESA is concerned by the continued downward trend of federal funding for biological collections. Recent advancements in imaging, digitization, and data collection and storage technologies have caused some to question the necessity of continued support for existing biological collections. This uncertainty has previously prompted the suspension of the NSF Collections in Support of Biological Research (CSBR), which supports scientifically valuable collections that contribute to

---

[7] https://www.sciencedirect.com/science/article/pii/S146780391830183X

[8] Symes, Ellie. SBIR Phase I: Data Analytics on Honebee Hives Using IoT Sensor Data. Award Number: 1746862

[9] Song, Hojun and Shockley, Floyd. Towards a Sustainable Management of Insect Collections in the U.S. through the Entomological Collections Management Workshop. Award Number: 1640919

domestic homeland security, public health, agriculture and food security, and environmental sustainability. ESA recognizes that technological development is spurring substantive discussion about the future of biological collections, but given their continuing relevance and broad application, ESA firmly supports continued federal investment in these collections.

Given NSF's critical role in supporting fundamental research and education across science and engineering disciplines, ESA supports an overall FY 2020 NSF budget of $9 billion. ESA requests robust support for the NSF BIO Directorate, which funds important research studies and biological collections, enabling discoveries in the entomological sciences to contribute to understanding environmental and evolutionary biology, physiological and developmental systems, and molecular and cellular mechanisms.

ESA, headquartered in Annapolis, Maryland, is the largest organization in the world serving the professional and scientific needs of entomologists and individuals in related disciplines. As the largest and one of the oldest insect science organizations in the world, ESA has over 7,000 members affiliated with educational institutions, health agencies, private industry, and government. Members are researchers, teachers, extension service personnel, administrators, marketing representatives, research technicians, consultants, students, pest management professionals, and hobbyists.

Thank you for the opportunity to offer the Entomological Society of America's support for NSF research programs. For more information about the Entomological Society of America, please see http://www.entsoc.org/.