



Response to Senator Ernst's March 2023 "Make 'em Squeal" Report

The National Science Foundation (NSF) has been the backbone of America's science and engineering research enterprise for over 70 years. In fact, NSF is the only federal agency that supports all fields of fundamental science and engineering research and education. NSF supports cutting-edge research projects — many of which serve as bellwethers for solutions to the myriad complex issues facing society. NSF programs also traditionally integrate research and education, fast tracking innovation excellence via hands-on learning to train our next generation of researchers and innovators.

Each year, NSF competitively awards thousands of grants that collectively advance our nation's scientific capabilities and engage the talents of hundreds of thousands of researchers, postdoctoral fellows, technicians, teachers and students in every field of science and engineering.

NSF is the primary source of federal funding for non-medical basic research, providing approximately 12,000 new awards annually. Through its merit review process, NSF ensures that proposals submitted are reviewed in a fair, competitive and in-depth manner. Competition for funding is intense, with only about one out of five proposals ultimately being approved.

Each proposal submitted to NSF is reviewed by science and engineering experts well-versed in their particular discipline or field of expertise. All proposals submitted to NSF are reviewed according to two merit review criteria: *Intellectual Merit* and *Broader Impacts*. NSF's merit review process is widely considered to be the "gold standard" of scientific review. Perhaps the best evidence of NSF's success is the repeated replication of its merit review model for discovery, education and innovation around the globe.

The results of this process — funding the best and brightest ideas through competitive merit review — have been profound. NSF-supported research has underpinned multitudinous discoveries leading to new inventions — the Internet, web browsers, Doppler radar, Magnetic Resonance Imaging, DNA fingerprinting, and bar codes — to name a few. These diverse examples underscore NSF's significant contributions to our nation's prosperity, health and wellbeing. NSF-funded discoveries have expanded our understanding of the world in which we live, led to life-saving medical advances, enhanced our national security, improved our everyday lives and yielded insights into the creation of the universe.

NSF's task of identifying and funding work at the frontiers of science and engineering requires keeping close track of research around the United States and the world; maintaining constant contact with the research community to advance the horizons of inquiry; and choosing the most promising people to conduct the research.

The following grants cited in the report illustrate examples of promising NSF-funded research awarded support through the merit review process.

In Search of Dolphin Language and Collaborative Research: Opening a Quantitative Window into the Mind and Communication of Dolphins

NSF Awards 1530544; 1606535; 1607280

March 2023 “Make ‘em Squeal” Report: “More money was sunk into creating a giant underwater touchscreen that can be used to play games like Whack-a-Mole...for dolphins!”

Rockefeller University and the City University of New York

The research conducted by these NSF-funded scientists resulted in the creation of innovative instrumentation and analysis methods capable of tracking the origin of propagating wave signals in an underwater environment with complex reflective surfaces. The scientists used machine learning algorithms to “learn” the acoustical geometry of the environment and accurately track signal origin. Among other results achieved by their research, their inventive method was published in [a peer-reviewed scientific journal in 2020](#). Their work also contributes indirectly to U.S. national security by improving our understanding of underwater communications.

The cognitive and communication prowess of large-brained mammals like the highly intelligent bottlenose dolphin is legendary. However, it is unknown whether dolphins are capable of learning and using complex symbol-based language, as humans do. To answer these questions the researchers needed to develop instrumentation and analysis methods capable of solving the problem of attribution of vocalizations to specific dolphins in diverse underwater environments. The solution to this problem has great potential for broad applicability in many fields, including underwater communication and signal origin identification. This solution harnessed the power of machine learning to map out and learn the properties of the acoustical environment; once the environment had been learned, the localization of acoustic signals can be both accurate and computationally fast even in an environment with complex reverberation.

These awards are consistent with NSF’s mission to advance fundamental knowledge, thus strengthening the U.S economy, enhancing our ability to compete with other countries and bolstering our position as a global innovation leader.

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IUCRC Phase I: Center for Environmental Sustainability through Insect Farming (CEIF)

NSF Awards 2052454; 2052565; and 2052788

March 2023 “Make ‘em Squeal” Report: “Like the millions of dollars being spent by multiple agencies to cook up crickets and other creepy critters into edible insect entrees for human consumption. Bug Appétit!”

Texas A&M; Indiana University; and Mississippi State University

NSF created the IUCRC program in 1973 to foster long-term partnerships among industry, academe and government. IUCRCs are designed to help corporate partners and government agencies connect directly and efficiently with university researchers to achieve three primary objectives.

- Conduct high-impact research to meet shared industrial needs in companies of all sizes;
- Enhance U.S. global leadership in driving innovative technology development, and;
- Identify, mentor and develop a diverse high-tech, exceptionally skilled workforce.

The IUCRC program provides a structure for academic researchers to conduct fundamental, pre-competitive research of shared interest to industry, government, and other organizations. These organizations pay membership fees to a consortium so that they can collectively envision and fund research, with at least 90% of member funds allocated to the direct costs of these shared research projects. IUCRCs typically involve multiple university sites, which each address distinct, unique needs for the center overall.

Before an IUCRC is established, it must successfully complete an IUCRC planning phase funded by an NSF planning grant. During this year-long phase, prospective Center leaders learn best practices for developing and maintaining a center, perform customer discovery, and recruit center members from industry and government entities, which ultimately leading to the submission of a Phase I IUCRC proposal. NSF uses a rigorous [merit review process](#) to ensure that submitted proposals for all IUCRC awards are reviewed in a manner that is fair, competitive, and transparent.

The Center for Environmental Sustainability through Insect Farming (CEIF) is an NSF Industry-University Cooperative Research Center (IUCRC) established in 2021 through a set of collaborative awards to Texas A&M AgriLife (award #[2052454](#)), Indiana University-Purdue University in Indianapolis (award #[2052565](#)), and Mississippi State University (award #[2052788](#)). The total intended NSF award amount for the 5-year Phase I IUCRC period is \$2,237,956.

CEIF brings together leading industry and academic experts to create ways in which insect-derived components such as proteins can enhance the environmental sustainability of products intended for commercial use. Research results can potentially decrease environmental pollution and resource competition for human-grade food, increase quality assurance and quality control of products, and improve efficiency in production and reduce cost. CEIF’s collaborative research leads to new strategies for improving production and increasing the safety and overall environmental sustainability of this emerging industry. In collaboration with its 16 member organizations, the Center has selected transdisciplinary research topics that require the engagement of expertise from across academia, industry, nonprofits and philanthropic organizations, government, and communities of practice.

CEIF aims to decipher and harness the natural biology of insects that can convert waste to protein and other products of value. Its research efforts focus on making the most of industrially relevant insect traits to increase production efficiency, promote quality assurance, and expand the number and diversity of products that benefit from insect agriculture. Projects include the study of animal feed supplemented with insect protein, the usefulness of microbiomes for feed and waste conversion, and genomics for trait selection and breeding strategies, as well as surveys for quality assurance and quality control. Findings from this research will yield insights for developing quality standards and for regulatory bodies seeking independent research as insect agricultural activity continues to grow. Given that the industry is new relative to other agricultural sectors, there are opportunities to diversify products and technologies in areas such as food/feed formulations, energy production, waste recycling, bioremediation, and bio-products development.

In addition, CEIF provides the infrastructure for training a diverse, high-tech workforce in research, knowledge and skills that are important to industry. The center also provides a forum for startups and small businesses to engage with larger industrial organizations and develop a rich network of partners. This will enable the use of corporate, academic, and public resources to accelerate knowledge transfer and technology translation towards addressing national needs.

Advances in sustainable insect agriculture from CEIF will open an entirely new job market for people with a range of skill sets, support the economic growth of local communities and the nation, and impact US competitiveness in a multi-billion-dollar industry space. CEIF research will facilitate current industry expansion in insect agriculture, build a larger U.S. footprint for the industry, and support the growth of new companies entering the sector. Co-locating with other businesses (for example, food processing with by-product streams) has the potential to leverage agricultural development for wider benefits in terms of generating rural economies, food waste recycling, and food security. Food waste recycling through insect agriculture for feed production can decrease the amount of waste otherwise being received into landfills, thus reducing the climate change vulnerability of both urban and rural areas. The recent global pandemic highlighted vulnerabilities in supply chains, and insect agriculture reduces such vulnerabilities by generating a circular economy not reliant on imports.