Response to Senator Ernst's May 2021 "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.

RUI: Elevated environmental CO2 impairs acclimation to hypoxia in crustaceans
NSF Award 1147008
May 2021 "Make 'em Squeal" Report: "How fast can a shrimp run on a treadmill?"
College of Charleston

Crustaceans, such as shrimp and crab, are not only important in the ecology of estuarine systems, but are the basis for multi-million dollar local economies along the U.S. East Coast and Gulf of Mexico. Shrimp and crab landings have been in decline since the mid-1990s, and aquaculture production has been threatened by infection with bacterial, viral and fungal pathogens. Understanding marine ecologies is paramount to protecting the livelihoods of fishermen who depend upon the ocean's bounty. Many crustaceans, such as shrimp and crabs, live in coastal waters like the Gulf of Mexico, where they are important sources of income to entire communities and important sources of nutrition for all.

In many places, including the Gulf, shrimp and other shellfish are subject to significant environmental stresses, potentially threatening both the marine ecosystem and key elements of the fishing industry. Oxygen depletion, also known as hypoxia, is a primary concern for these crustaceans. Researchers at the College of Charleston aimed to find out how they cope with increased environmental stress. This research seeks to understand if bacterial infection affects the ability of crustaceans to take up oxygen from their environment, and how this in turn affects their metabolism and growth, and whether a decline in metabolism due to bacterial infection switches on genes associated with response to low dissolved oxygen levels in water (hypoxia), known to be a primary cause of mass mortality of marine life. Understanding the interaction between environmental stressors and pathogens will be relevant to managing an important U.S. industry.

This research was featured on the NBC Today Show in November 2008, where the two researchers explained how the research on these simple animals could help us learn about the impact of disease on important physiological functions. In their natural ocean environments, shrimp live in moving water, which requires them to move constantly in order to survive. So these scientists wanted to know how hypoxia, in combination with a decline in the shrimp's immune defense against bacteria, interferes with their ability to move. Of course, it is much easier to study shrimp in tanks, so researchers developed a "treadmill" to imitate flowing water and get shrimp to move the way they move in the ocean. This process is similar to doctors putting humans on a treadmill to test heart health.

Shrimp are the most heavily-cultured species for human consumption, with an annual global market of close to $9 billion in 2009. Unfortunately, the U.S. has been slow in growing its shrimp aquaculture industry. As a result, the U.S. imports over 90 percent of the shrimp consumed in this country, which is valued at $400 million. China has already invested heavily in research related to disease and disease resistance in crustaceans, but the U.S. invests comparatively very little in this area. This research will not only help improve our understanding of shrimp health and immune response in natural and farmed environments, but also aid in growing the nation's aquaculture industry, decreasing the seafood trade deficit, and creating new jobs. This research is also extremely important in predicting the present and future effects of increased pollution and other environmental changes on marine life, and in protecting the fishing industry from natural and man-made disasters.

Graduate Research Fellowship Program (GRFP)
NSF Award 1144153
May 2021 "Make 'em Squeal" Report: "Where does it hurt the most to be stung by a bee?"
Cornell University

The NSF award referenced was made through the NSF Graduate Research Fellowship Program (GRFP). Since 1952, NSF has funded over 60,000 graduate Research Fellows. Many of these Fellows have gone on to become leaders in their chosen fields and have made groundbreaking and important discoveries in STEM research. Over 450 GRFs have become members of the National Academy of Sciences, Engineering and Mathematics; and 40 Fellows have been honored as Nobel Laureates.

The purpose of the GRFP is to help ensure the quality, vitality and diversity of the scientific and engineering workforce of the United States. The NSF GRFP recognizes and supports outstanding graduate students in NSF-supported STEM disciplines who are pursuing research-based master's and doctoral degrees at accredited U.S. institutions. Fellows are selected annually from ~14,000 individual applications based on their demonstrated potential to make outstanding contributions to science and engineering. Fellows submit a brief statement of proposed research so reviewers may assess applicants' educational and research training, creativity, and promise. The Fellowship supports the individual student, not any specific research project in which they may participate during the course of their fellowship.

IGERT: Water SENSE - Water Social, Engineering, and Natural Sciences Engagement
NSF Award 1144635
May 2021 "Make 'em Squeal" Report: "Which tastes better: water from a bottle or out of the toilet?"
University of California-Riverside

The NSF award referenced was made through the NSF Integrative Education and Research Traineeship (IGERT) program, now succeeded by the NSF Research Traineeship (NRT) program. The IGERT program was an NSF-wide program developed to meet the challenges of educating U.S. Ph.D. scientists and engineers who would pursue careers in research and education, and who would have interdisciplinary backgrounds, deep knowledge in chosen disciplines, and the technical and personal skills to succeed.

As a part of their training, graduate students participated in and published research in the general interdisciplinary topic area of their IGERT project, as illustrated by the article referenced about recycled drinking water.[1]

[1] https://news.ucr.edu/articles/2018/03/13/toilet-tap-gross-think-about-how-does-it-taste-0

This contains links to non-government websites. NSF takes no responsibility for and exercises no control over the views expressed or the accuracy of the information contained on those sites. Also be aware that NSF's privacy policy does not apply to those sites.

Whether the issue is health, the economy, education, national security or climate, the extent to which we understand the "human factor" greatly influences whether our attempts to help others ultimately succeed or fail. The National Science Foundation supports experts who can uncover fundamental discoveries about human behavior. Those discoveries can provide an evidentiary basis for solutions to some of the most daunting challenges — including environmental changes due to climate — faced by leaders in government, business and the military.

The effectiveness of measures designed to reduce the impact of a changing climate, and protect our people and communities, is largely determined by human behavior and our willingness to adopt those measures. The research conducted in this project sought to understand how gender differences affect our adoption of behaviors related to the environment. On the small scale, such behavior can help predict decisions made by individuals doing particular activities. On the large scale, it can help predict the behavior of millions of people, such as energy usage for daily activities and if that usage can be more efficient and cost effective. Those important insights can inform policy at all levels of government and how those policies can best be implemented.

The research has helped to inform stakeholders who work on problems related to climate, such as the role of greenhouse gasses. This type of fundamental research has many potential applications and can help communities large and small improve their resilience to a changing environment, thus enhancing the health and wellbeing of people across the U.S.

CAREER: Locomotion Through Particulate Environments by Invertebrates and Vertebrates
NSF Award 1255127
May 2021 "Make 'em Squeal" Report: "How long does it take for a panda to poop?"
Georgia Institute of Technology

Biological systems have taught us how to design AI algorithms that outperform humans in many areas, ranging from medicine to self-driving cars. The NSF award 1255127 supports a theoretical project aimed at understanding how animals move in a particulate environment, which is the description of the everyday world around us.

The paper cited in Sen. Ernst's report is not a covered under the scope of this award. The PI has acknowledged the NSF award, but no funding has been allocated for the cited study. The paper is not listed in the annual and final project reports submitted by the PI for the NSF award.

The funded NSF project makes an attempt to use basic physics principles to understand the living world at the organismal and environmental level. As we think about clean air and how it influences human health and activities, it is our belief that the acquisition of fundamental understanding can be an important contribution to society. Dr Hu's projects funded by NSF awards, have resulted in new technologies e.g. a new technology for removing sand from the Mars Rover. In addition Dr. Hu has worked on educating the public about science on Good Morning America, National Public Radio, the Weather Channel, and Discovery Channel. His ant research was featured on the cover of the Washington Post in 2011 and also in the Economist, the New York Times, National Geographic, Popular Science and Discover.