Response to Senator Paul's "The Festivus Report 2022"

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 Festivus Report 2022" illustrate examples of promising NSF-funded research awarded support through the merit review process.

Collaborative Research: Collective intelligence and social brain evolution in ants

To understand the diversity among and within life on Earth and use solutions employed by different species to address societal challenges requires studies that span the tree of life. The field of comparative biology seeks to use natural variation and disparity to understand life at all biological levels – from genes to communities. The complexity of the brain across the tree of life necessitates studies of a variety of organisms to understand the organ’s evolution over time and across species. For example, the estimated 10,000 species of ants communicate via chemical signals processed in their brains but differ in brain size and energy use across species. In this research, biologists compared brain size and energy use across several species of ants with differing levels of organization and divisions of labor.

By learning how tasks and social organization affect both the size of an organism’s brain and how the organism manages energy use by the brain, the researchers created a novel model of social insect “intelligence” and its relationship to the brain: more socially complex species have bigger brains but may compensate for larger brain size with efficiencies in energy usage, task-specific organisms are associated with smaller regions of the brain comparable to parts in the human brain that conduct advanced information processing, and diversity in tasks is associated with changes in brain architecture. These results can be used to understand how the brain has evolved across the tree of life as a result social interaction of needing to accomplish certain tasks such as foraging, avoiding predators, and tool making. Findings from this research can be applied broadly to other species and provide new insights into how ant communities interact and partition labor. The research also provided training for students, many from underserved communities.

CAREER: Fast, Furious and Fantastic Beasts: Integrative principles, biomechanics and physical limits of impulsive motion in ultrafast organisms; and
Collaborative Research: Moving with muscles vs. springs: evolutionary biomechanics of extremely fast, small systems
NSF Awards 1941933, 2019371
Festivus 2022: "Researching if Thanos could snap his fingers wearing the infinity gauntlet"

Understanding how non-human organisms have evolved ultrafast movements, including those that provide protection from predators, provides an opportunity to apply these solutions to improve human movement and benefit society broadly.

While this particular finding was publicized with a reference to popular culture, the research project has also provided new knowledge on the components necessary to perform detailed finger movements and may aid in developing new prosthetics or robotic hands. This award has also resulted in [1]novel understanding of the collective movement of California blackworms that has been used to create swarming microrobots for potential use in munitions retrieval and could be used to develop engineered living materials. It has also supported research on certain forms of spider silk that could be put to use in robots or engineered materials.

In addition to its scientific merit, this research has engaged underrepresented groups in the United States in STEM, provided critical training to the next generation of biologists and bioengineers, and expanded the geography of innovation by creating connections between major research universities and primarily undergraduate institutions.

[1]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.