



## Response to Senator Paul's "The Festivus Report 2020"

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 2020" illustrate examples of promising NSF-funded research awarded support through the merit review process.

***Determining the source of muscle power for suction feeding in ray-finned fishes;  
Rib kinematics and intercostal muscle function in amniotes; and  
Maintenance of the XMA/ZMA Portal video data management systems and XMA Lab video  
motion analysis software for the comparative biomechanics community***

NSF Awards 1120967, 1256065, 1661129, 165756

Festivus 2020: “Walked Lizards on a Treadmill”

Brown University

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The study of the fundamental science of biomechanics in animals is important because it often leads to practical applications of use to people, such as robotics and bio-inspired design. Biomechanics integrates physics, mathematics, engineering, and biology to understand how animals move, access food, and eat. The results from this type of research provide new knowledge about how muscle and bones interact and move during breathing, walking, running, and feeding. This knowledge leads to new engineering concepts that can be applied to designs for respiration or movement-assisting devices for people.

The four NSF awards highlighted in Sen. Paul’s report have resulted in more than 20 research articles on a variety of animals, of which the lizard is just one. The awards also resulted in the development of innovative technologies – X-ray Reconstruction Moving Morphology and Video Reconstruction of Moving Morphology – that have revolutionized the field of biomechanics and allowed researchers to answer long-standing questions about animal function and movement. This technology has been provided in an open-source format allowing data sharing among scientists to speed innovation. Advances like this promote U.S. economic competitiveness through technical innovation. The research also has provided critical training of the Science, Technology, Engineering, and Mathematics (STEM) workforce including postdoctoral fellows and doctoral students; contributed to K-12 education; and engaged underrepresented groups in STEM.

***Social Dynamics of Organizational Behavior in Temporary Virtual Teams***

NSF Award 1841374

Festivus 2020: “Studied how people cooperate while playing e-sport video games”

University of Colorado at Boulder

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Temporary teams are a useful way to develop new initiatives or undertake specific tasks by bringing together a range of stakeholders with varying perspectives. For example, a temporary team responding to a natural disaster like a flood might be comprised of first responders, city officials, law enforcement, and relief organizations.

This project studies the use of technology to support temporary teams using e-sports as a theoretical “laboratory”. The advantage of this approach is that e-sports allows for extensive data collection, from moment to moment, about how the teams succeed or fail to respond cooperatively to sudden challenges. Thus, as the researcher notes, "The need to understand the dynamics of how people form teams in the aftermath of disruptions and discover new innovations is arguably even more important in a post-COVID world and our research provides a unique empirical lens into how these processes unfold across time and cultures." Indeed, temporary teams have already proven critical in the nation’s medical response around COVID-19 testing, treatment, and vaccine distribution, and will continue to be invaluable in the development of technological tools for online teaching and learning. This project allows for an innovative way of better understanding behavior in virtual teams that can be used to inform future virtual teams in many mission-critical areas.

***RAPID: Examining Public Spatial Behavior During the COVID-19 Outbreak***

NSF Award 2027652

Festivus 2020: “Studied how New Yorkers abided by New York City COVID lockdowns”

New York University

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When a leader facing a pandemic in their state or city declares a curfew, closes businesses and schools, or mandates social distancing, the effectiveness — or ineffectiveness — of these actions hinges on our ability to accurately predict human responses at key moments and to plan accordingly.

Researchers are now carefully measuring human movement and interactions and comparing them to how people behaved before the pandemic. The project uses a novel method of data gathering to record the movements of individuals and, more importantly, why they took certain actions. Participants wear a GPS-enabled camera and “smart” watch that records where they are and what they see as they move through public places while complying with social distancing and other pandemic-related measures. The participants also make simultaneous audio recordings describing in real-time what they are doing and why. For example, choosing to jaywalk across a busy street because the sidewalk was too crowded to maintain social distancing. These highly detailed measurements are then used to build new computer models that better predict consequences of social distancing policies and other actions that can save lives during pandemics and other large-scale disasters.

This research has the power to inform our families, rural and urban communities, small businesses, public decision-makers and others about how to reduce the negative effects of the COVID-19 pandemic in stronger and more cost-effective ways. This knowledge can help inform decisionmakers as they look to speed the recovery of our economy and our nation. The results of this research are being made publicly available so people all over the country can use them to help vulnerable Americans who face challenges associated with their mobility— including wounded veterans, disabled children, and the elderly. Understanding how people move, particularly in times of crisis, is the key to designing and retrofitting built environments to increase safety while maximizing mobility for everyone.

There is also important social value in collecting data now — in the eye of the storm. The NSF RAPID award mechanism allows researchers to be in the field right now, gathering data that simply cannot be collected in calmer times. That data, and the project’s rigorous analytic approach, increase our national capacity to be more aggressive and more effective in confronting the current pandemic and crises yet to come.

*Understanding the Time- and State-Dependence of Climate Sensitivity*

NSF Award 1752796

Festivus 2020: “Taught students in Washington about disputed climate science”

University of Washington

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The open question addressed in this NSF-funded research is why climate sensitivity, meaning the change in global temperature caused by a given change in greenhouse gas concentrations, appears to increase as climate warms. If the increase is real, which is not yet known, it means that a "single, fixed sensitivity value" cannot fully represent the climatic effect of changes in greenhouse gas concentrations.

The educational effort supported under the grant makes no assumptions regarding the ultimate outcome of the research. Instead the effort focuses on fundamental principles of climate science which are well established. The simple models are used to demonstrate, for example, that Earth's temperature is established by a balance between the amount of energy Earth receives from the sun and the amount of energy the earth emits to space. They also demonstrate concepts like feedback effects and the impact of natural climate variability on long-term records of global temperature.

The models developed for the educational effort are not intended to provide detailed answers to practical questions regarding climate change and its human impacts. The goal is rather to help students understand how the climate system works. In particular the models can help students understand why greenhouse gas increases cause warming and what factors influence how fast the world warms and how much warmer it ultimately gets.

### ***Scalable Insect Farming for Agriculture***

NSF Award 1831538

Festivus 2020: “Prepared bugs for you to eat”

Festivus 2020: “Subsidizes an insect ranching company’s R&D efforts”

Beta Hatch, Inc.

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This NSF award was made in 2018 under the Small Business Innovation Research (SBIR) Program. SBIR has been mandated by Congress to support American small businesses bringing new, breakthrough technologies to market. The SBIR program supports translational research to reduce technological risks behind promising innovations. The NSF SBIR program is particularly focused on supporting the national technology innovation ecosystem by identifying promising technology startups and preparing them for private investment.

NSF’s grant to Beta Hatch supports development of a more secure and efficient agricultural system for the nation. Specifically, this grant funds research and development of a cost-effective way to generate high-value protein nutrients for crop fertilizer as well as animal feed (e.g., chicken feed and farm-raised fish). The company’s innovative approach is to develop a scalable (i.e., mass-production) method for predictable, sustainable, year-round production of mealworms. The firm is creating new uses for underutilized spaces, such as warehouses and poultry barns. Furthermore, these ranches bring jobs to rural and HUBZone areas.

Because the company’s plan will effectively address needs in the US agricultural sector, private investors have invested \$12 million just in 2020. The company is putting these funds to use by launching what will be the largest insect farm in the U.S. – repurposing an underutilized 30,000 square-foot warehouse in Cashmere, Washington. Beta Hatch’s work will help advance American competitiveness and technological leadership within the \$400 billion global animal feed market.

***Smart Earpiece for Supporting Healthy Eating Behaviors***

NSF Awards 1565269 and 1835983

Festivus 2020: “Develops a wearable headset to track eating behavior”

Dartmouth College

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Low-power wearable devices that monitor personal health data are becoming increasingly integrated with daily life, with many individuals using them as a tool to engage with their own health and wellness information. Pacemakers and fitness monitors are but two examples in a broader range of devices that have the potential to positively effect health and life quality. Through this type of preventative monitoring, individuals develop a personal and direct connection with their daily health-related decisions, ultimately reducing the overall cost of long term health care.

This project seeks to design a low-powered wearable device that could help address one of the nation’s most pressing health challenges: obesity. The convenient, wearable sensors being developed through this project engage individuals with their own eating behaviors in the service of health and wellness. This work will not only better our understanding of behavioral factors involved in obesity, but also further our knowledge about how to use sensor-data processing algorithms to design new low-powered electronics that enable wearables with a long battery life. Ultimately, this work will result in scientific contributions that go beyond the specific device (a wearable earpiece) and context (obesity) and facilitate development of other practical wearables with sensing capabilities.

***Population Change and Gentrification in Urban Foodscapes***

NSF Award 1945132

Festivus 2020: “Studies how food options change when a neighborhood is revitalized”

University of North Carolina at Charlotte

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Proper nutrition is essential to human health. Deficiencies in nutrition contribute to many documented negative consequences including greater susceptibility to heart disease, diabetes and other conditions, impaired development and learning in children, decreased worker productivity and diminished economic competitiveness. Many communities in our country have experienced significant disruptions, which often result in “food deserts” where nutritious food cannot be acquired. That problem is caused by vulnerabilities in our food supply chains and is exacerbated by disruptions such as natural disasters, technology-fueled displacement of family farms and small businesses, and other economic changes. Strengthening and increasing the resilience of the food supply chains on which millions of American families depend is a challenge for citizens and communities in every state.

This NSF award supports researchers collecting vital data on how the types of challenges described above are affecting low-income communities. Their empirical focus in this project is on the ways that people can, and cannot, acquire food in urban areas. This research is designed to deliver a rigorous, data-driven understanding of the causes of such disruptions. The researchers’ methods draw from a number of scientific disciplines including spatial economics, choice modeling and regional planning. They will integrate and analyze substantial data sources including census data and property data to obtain a spatial model of food supply lines and their relationships to the communities and families that rely on them. That analysis will then be triangulated with data collected in the field from people involved in food production, distribution and consumption, to create a robust and highly detailed model.

This type of fundamental research has many potential applications and can help our nation improve access to healthy food in every part of the country. It can, for example, help family farms and other private-sector entrepreneurs improve their own capacity to better serve local and regional areas, while expanding their business. By funding this study, NSF seeks to provide a more reliable and actionable scientific basis for how cities— large and small — can avoid food deserts and thus enhance the health and wellbeing of people across the U.S.