Response to Senator Paul's "March 2017 Waste 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 grant cited in the "March 2017 Waste Report" illustrates an example of promising NSF-funded research awarded support through the merit review process.

The goal of this project was to understand the molecular mechanisms that generate flavor and nutritional quality of tomato fruits; this has implications for sustaining U.S. agriculture and limiting food waste and created a tool for further analysis of tomato genomes, including in studies to enhance their robustness to pests and climate change.

Flavor is a complex trait, controlled by numerous genes, making it very hard for breeders to systematically change or improve the trait. This project conducted pioneering work into complex traits and identified the genes that control flavor in tomato fruits. The results from this work contributed to 23 peer-reviewed publications in top journals, such as Science, Nature Genetics, and Cell. Some of these publications were widely covered by the media, such as The New York Times[1] and PBS[2], demonstrating a broad interest of the public in this research.

The first step in understanding flavor is to determine the chemicals that are causing flavor. This was achieved through an interdisciplinary approach using analytical biochemical methods to identify flavor molecules and asking consumer taste panels to evaluate flavor. It turned out that sugars and certain volatile chemical were responsible for "tasty" tomatoes. Because of this work, tomato is one of the few fruits where we now have a good understanding, which chemicals generate the flavor of the fruit and provides a model that can be used to investigate other fruits and vegetables.

In a next step, a technique called a genome-wide association study was used to identify the genes that control synthesis of all the "tasty" chemicals, generating tomato flavor. For this the genetic information in 725 cultivated and closely related wild tomatoes was sequenced and combined into a so-called pan-genome. This resulted in the discovery of 4,873 new genes and identified a rare version of one gene that can make tomatoes tastier. We are now able to replace undesirable versions of a gene in modern tomato varieties with more desirable versions of this gene from their heirloom parents. Meaning, we can make tomatoes that taste noticeably better. This project has benefits that go beyond tomato flavor. The tomato pan-genome provides a resource for breeders to explore previously unidentified genes, and potentially use them to improve any property of tomatoes.

[1]https://www.nytimes.com/2017/01/27/science/better-tasting-tomatoes-genes.html#:~:text=In%20this%20week's%20issue%20of,most%20modern%20varieties%20of%20tomatoes.&text=The%20researchers%20are%20using%20traditional,engineering%20would%20be%20much%20quicker

[2]https://www.pbs.org/newshour/science/quest-grow-better-tomato-breeders-forgot-taste