Response to Senator Flake's "Wastebook: The Farce Awakens"

The National Science Foundation (NSF) has been the backbone of America's science and engineering research enterprise for more than 60 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—including those deemed "wasteful" and "out-of-touch" in the "Wastebook: The Farce Awakens" report (authored by Senator Jeff Flake)—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. Nearly every proposal is evaluated by a minimum of three independent reviewers consisting of scientists, engineers and educators who do not work at NSF or for the institution that employs the proposing researchers.

On average, roughly 50,000 experts share the benefit of their knowledge and give their time to serve on review panels each year. NSF selects reviewers from the national pool of experts in each field, and their evaluations are confidential. NSF's merit review process is considered by some 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 in nations 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 well-being. 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.

Yet, a simple truth remains regarding fundamental scientific breakthroughs: Before these discoveries were made, these ideas, too, might have been considered novel or outside-of-the-box. Sometimes, based solely on the title of the project, these ideas might have even seemed impractical or inappropriate at first glance. However, if one used project titles instead of merit review to make funding decisions, Google® might not exist today. What was the original name of this search engine when it was funded as an NSF Digital Library project? BackRub.

Technical titles might also easily be misconstrued by anyone but a scientist or engineer versed in technical jargon. For example, a NSF-funded award titled, “Implementation of Maximum Likelihood Decoding for Trellis Codes and Trellis Coded Modulation,” actually led to the development of an electronic chip that enables mobile communications worldwide. Who knew “trellis codes” was slang for what would became one of the the most important technologies underpinning global wireless communication, an innovation vital to Qualcomm, a world leader in next-generation mobile technologies? These examples highlight the problem with discarding a project based solely on its title.

Moreover, the ripple effect of fundamental research can rarely be anticipated. Fundamental social and economic research on “game theory” revolutionized the way our nation apportions its airwaves, resulting in $60 billion for the U.S. Treasury derived from spectrum auctions. In this particular case, the link between fundamental research and direct application was unclear — until it offered the Federal Communications Commission a viable solution for partitioning our wireless bandwidth.

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 summaries of the 16 projects highlighted in “Wastebook: The Farce Awakens” illustrate examples of promising NSF-funded research that were awarded support through the merit review process.

The Effect of Latent Heating on the Hadley Circulation
NSF Award 0846641
Wastebook #5: "Koozies Keep it Cool"
University of Washington

This research was not about keeping drinks cool. The "cold drink can" paper referred to in the "wastebook" concerned a visual, hands-on experiment a team of researchers designed to demonstrate a complex weather phenomenon to students and the general public. The majority of the NSF project in question went into cutting-edge weather research.

The grant focuses on Hadley circulation, a weather phenomenon that plays a dominant role in Earth's climate system, influencing where rainfall occurs around the globe. Developing a greater understanding of Hadley circulation is a national priority, as that knowledge can help us better predict and prepare for drought. A northward expansion of the Hadley cell, for example, could have severe consequences for California or other parts of the U.S. Southwest, worsening the area's already-historic drought and causing further economic and ecological harm.

The study has produced an explanation for why climate and weather models incorrectly simulate this important phenomenon. The study also helped explain why rainfall shifted southward over the Atlantic Ocean and West Africa during the 1970s and 1980s – a change that resulted in devastating, prolonged drought for residents of the Sahel region of Africa. Long-term scientific benefits from this study include helping to explain and predict changes in water availability around the globe.

In addition to developing a greater understanding of Hadley circulation, the researchers designed a science experiment to translate this research into the classroom. The researchers provided instructions on how to recreate the experiment, using soft drink cans, giving teachers a resource that allows students to observe a latent heat phase change.

Pacific Northwest Viticulture and Oenology Education Collaborative
NSF Award 1501522
Wastebook #17: "Wine Classes for Minors"
Yakima Valley Community College

The "wastebook" mischaracterizes the nature of this award by alluding to wine glasses used in classes, referencing underage drinking and stating that "students don't have to fear a pop sobriety test" because of a Washington state law. In fact, the reason they don't have to worry about such tests is that this award did not involve any consumption of wine. This award is focused on the science that goes into agricultural production in a thriving area of the U.S. economy. Rather than utilizing stemware, the lessons involved grapevines, soil and farming equipment.

Currently, the United States is the fourth-largest wine-producing country in the world and grapes are the highest value fruit crop in the country with an estimated 61 percent increase in the number of wineries in production from 2007 to 2014. U.S. wine exports in 2014 were worth an estimated $1.55 billion. This expansion – together with rapid technological advances in growing, harvesting, and production techniques – has dramatically increased the demand for highly skilled workers. Yakima Valley Community College, located in the heart of Washington state's wine country, and its collaborating two-year colleges, are developing advanced education and training in oenology (the science of wine and winemaking) and viticulture (vine-growing and grape-harvesting) to students preparing to enter the workforce as skilled technicians in the field.

Oenology and viticulture rely heavily on the sciences, particularly biology and chemistry. Technical training includes laboratory skills such as monitoring pH, titratable acidity, sulfur dioxide levels, microbiological levels and identification, sanitation techniques and quality assurance, chromatography, enzymatic actions, titration, and volatile acidity measurement.

These laboratory skills are also vital in biofuel production, pharmaceutical production, and many food and beverage production facilities (examples include milk, cheese, pasta, fruit, juices, and sauces). Through this project community colleges and their industry partners are establishing best practices in curriculum design, professional development, and technical- and science-based training, including the use of online course delivery. These efforts, in turn, can lead to more efficient and affordable access to technician education in many sectors of the U.S. economy.

A Phylogenetic Evolutionary Psychological Approach to Human Mating
NSF Award 1243323
Wastebook #18: "Dating Secret of the Unattractive"
University of Texas at Austin

This research was not focused on dating, but on strongly attached partners, and the hormonal and psychological shifts they experience that help maintain and protect their bonds. The "wastebook" title and entry for this award misrepresents the work the researchers performed. This research explores how people in committed relationships can re-channel or control impulses that could otherwise lead them to disastrous decisions work that could yield profound new information for therapists and educators who work with couples.

Only by having a clear understanding of factors that influence how we make decisions and control impulses – and how we make bad decisions and act out to destroy pair bonds – can we have a positive impact on maintaining our closest social relationships. These findings could impact not only these social relationships, but also our well-being, security, and economy.

Whom we choose as our partner, also known as human-pair bonding, is a critical area for research. This bond is potentially the strongest we will make across the course of our lives. It can influence our well-being, capacity for cooperation and level of productivity, as well as that of our offspring. The research design integrates best practices from multiple disciplines, including anthropology and evolutionary psychology, and multiple methods to richly investigate human-pair bonding. The project expands on previous work in this field, exploring human pair bonding using techniques, including:

- Biological methods that assess hormone concentrations.
- Observational methods that capture live dyadic interactions.
- Social cognitive methods that examine moment-to-moment social judgments.
- Experimental methods that identify causes of interpersonal attraction.

Integrating Informal STEM and Arts-Based Learning to Foster Innovation
NSF Award 1224111
Wastebook #20: "Drought Sculptures"
Balboa Park Cultural Partnership

Many communities are experimenting with various approaches to encourage innovative thinking about the future of the economy via broad, collaborative participation and conversations amongst stakeholders – the public, the business community, and representatives from academia and not-for-profits. Science, technology, engineering and mathematics (STEM) knowledge and skills are critical to such efforts.

The goals of this research and development project are to explore how art-based learning methods – some developed for industry – can be integrated with STEM to foster collaborative initiatives around critical community-identified challenges. Three city-wide "innovation incubators" have been set up in San Diego, California, Chicago, Illinois, and Worcester, Massachusetts. Over 50 organizations (including organizations such as General Electric, Qualcomm and the University of California, San Diego) and hundreds of individuals have been associated with the effort. The project has generated exploratory ideas for 28 cross-disciplinary products, processes, services and curriculum – resulting in innovation prototypes that address the critical STEM-related civic challenges of **water resources** (San Diego), **urban nutrition** (Chicago), and **alternative transportation** (Worcester). This project has been breaking new ground with interdisciplinary approaches that could improve how such efforts might be organized nationwide, and uncover new ways to maximize outcomes.

Research and development in informal STEM learning is positioned to contribute to important national economic and societal challenges and opportunities and foster a climate of innovative thinking and group problem solving. The current literature on possible synergies between STEM learning and arts-based innovation methods is in the early stages of development. This project includes both education research and evaluation studies that can contribute to the knowledge base about how arts-based learning can be applied to develop the STEM skills needed by the 21st century workforce.

The Impact of Online Technologies on Interpersonal Communication and Perceptions
NSF Award 1520723
Wastebook #23: "Love at First Swipe"
Wayne State University

The "wastebook" title and entry oversimplify the research to the point of misrepresentation. This grant offered a fundamental shift in how scientists model online behavior. Whereas past work has investigated online activity from the perspectives of communication, psychology or information science, this research combined all of those approaches to provide a more nuanced, comprehensive view of why people act certain ways when interacting with technology.

This type of research enhances our knowledge about how technology influences decision making and interpersonal relationships. At a time when human relationships are changing, due to the increasing presence of social apps, Internet communications and other "third parties," this is an essential area of study. The researchers used the context of online dating to address core questions facing society today. Those include how basic social psychological and judgmental processes change in a situation where the algorithms built into apps and social media sites play a part in communications and people receive information solely through computers, without the social cues provided in person-to-person contact.

Much of the scientific community's understanding of basic social psychological and judgmental processes, from how we decipher the motivations of others to how we distinguish truth from deception, comes from studying "offline" behavior. But those premises may have to be rethought in the context of online, mediated contact. These new forms of communication and human interaction have in some cases upended our understanding of judgmental processes that we knew quite a bit about in the offline world. As technology becomes increasingly embedded in society, scientists must establish that same level of knowledge in the online world to understand and solve the socio-technical cyber security challenges that are becoming more prevalent with increased human interaction with technology.

Design Principles for Information Networks Supporting the Social Production of Knowledge
NSF Award 0910664
Wastebook #28: “A Perfect Tweet”
Cornell University

This pioneering project aims to understand the dynamics of new forms of online communication media, at a time when they are surging in popularity and significance for users around the world. This work has produced a wealth of scientific publications and **developed design principles that incentivize more productive behavior by participants – providing fundamental insights that help our nation's innovative information technology sector stay ahead in the global marketplace**.

The large research team, composed of leading scientists in several fields, was able to go far beyond exploring communications in one particular online system. It tested formal hypotheses, developed prototype information technologies, and achieved valuable insights about technology design across a variety of online media, including consumer review sites, massive open online courses, and collaborative information resources such as Wikipedia.

This project included the participation of a large number of unfunded scientists who collaborated with the team funded by the grant. Together, incredibly vast and diverse data were collected, analyzed, and published in a wide range of professional venues. Several graduate students co-authored the studies, thus launching their own scientific careers. The timely nature of the research topic also allowed the many researchers to share their discoveries with numerous undergraduate students, undoubtedly inspiring many to seek careers in computer science and the information technology sector.

The Evolutionary Mechanics of Rapid Movement
NSF Award 1439850
Wastebook #33: “Shrimp Fight Club”
Duke University

When engineers look for solutions to build stronger or more flexible products and designs, nature often serves as inspiration. Mantis shrimp are among the fastest and most powerful animals on Earth. Their claws are incredibly strong and do not easily break, even though shrimp use them with extreme force to crack thick clam and snail shells. A human would need to use a hammer to perform the same task. This research aims to understand how mantis shrimp generate and store such extreme force, uncovering basic biomechanical principals that apply across the species.

Understanding the systems that allow these animals to exert such force, and the material properties of their exoskeletons, enables researchers to apply that knowledge to human-engineered systems. This knowledge could lead to innovations in defense technology or manufacturing: faster and stronger robots, for example, or new materials as tough and lightweight as the shrimp's exoskeleton. In fact, the mantis shrimp has already inspired a new design structure for composite materials, one more impact resistant and tougher than the standard currently used on airplanes.

This research also analyzes differences between different species of mantis shrimp, which will help identify fundamental rules about how the species applies force and stores elastic energy. Understanding broad, unifying biological principals like these will teach us more about the basic physics of all organisms, even humans.

Fluctuations and Phase Transitions in Iron Pnictide Superconductors
NSF Award 1305637
Wastebook #37: "Back to the Future Day"
Ithaca College

This grant studies phase transitions in unconventional superconductors. Research on various aspects of superconductivity is of central importance to modern condensed matter physics, and the results have broad applications. For example:

- Magnetic resonance imaging (MRI) techniques widely used in modern diagnostics of cancer.
- Magnetic levitation of trains (MAGLEV technology utilizing superconducting magnetic coils).
- Detection of mines and submarines by the U.S. Navy by using superconducting SQUID technology.

NSF has two merit review criteria for reviewing proposals: Intellectual Merit and Broader Impacts. The Intellectual Merit of the award focus is to improve the existing scaling analysis and apply it to the measurements of the critical dynamics of the 122-type iron-pnictide superconductors. There have been no measurements of the normal-superconducting phase transition in this material before, and the researcher is leading the way in determining the nature of the transition.

The Broader Impact component contains an impressive and remarkable outreach program provided by YouTube videos that have attracted the attention of national television and press. Educational and outreach efforts help attract quality students to STEM disciplines, ensuring the U.S. can secure its future in the modern science and technology market.

The demonstrations in physics provided by the researcher include that of the Meissner effect, based on the expulsion of magnetic field by a superconductor, which leads to levitation of magnets above superconductors. Demonstrations of Meissner effect attract the attention of students and provide a most useful educational tool.

Exploring the Relation between BMI and Visual Appearance of Face and Body
NSF Award 1450620
Wastebook #48: "Fat Detector"
West Virginia University

Obesity is a national epidemic and a major contributor to some of the leading causes of death in the U.S., including heart disease, stroke, diabetes and some types of cancer. **The annual medical expenditures attributable to obesity have doubled in less than a decade, reaching $147 billion, according to a recent survey by the Centers for Disease Control**. Many obesity intervention programs rely on patients' understanding their own body mass indices (BMI). A patient's ability to identify as overweight has been shown to correlate with the patient's desire to lose weight. Thus, it is critical to raise the awareness of BMI and measure and track BMI variations.

To facilitate the ability to easily monitor BMI, researchers at West Virginia University are exploring the relationship between BMI and visible human body parameters. Their work can aid in the development of a low-cost, portable, reliable, and convenient BMI assessment system, which could enable better awareness and response to fight obesity. This system could be deployed in rural communities or on tribal lands – locations that face unique healthcare access challenges – where healthcare delivery reforms can play a critical role in improving care while containing costs.

This research explored the hypothesis that a relationship exists between BMI and visible human body parameters. Initial studies indicate a correlation between BMI and facial features, such as cheekbone-to-jaw width. The team can use this knowledge in concert with advances in computer vision and machine learning technologies to prototype a visual analysis system that can provide convenient estimates of BMI anywhere and anytime. An increased awareness of BMI has the potential to not only positively impact individuals' health, but could potentially impact healthcare costs, and thus, the nations' economy.

National Science Board Alan T. Waterman Award Dinner
NSF Award 1542281, 1542282, and Solicitation Number DACS15Q1009
Wastebook #55: "Swanky Science Soiree"
National Science Board

The National Science Board's (NSB) annual awards ceremony honors some of the nation's greatest researchers and public service contributors. As a steward of the U.S. science and engineering innovation enterprise, the NSB recognizes the remarkable achievements of individuals and organizations whose research achievements inspire others and help ensure that America remains a global leader in these fields.

The event's formal setting pays tribute to the recipient of NSF's congressionally-created Waterman Award – which recognizes exceptional accomplishments by a young researcher – and to the winner of the NSB's prestigious Vannevar Bush Award, which honors lifelong leaders in science and technology who have substantially advanced the welfare of our nation. Conferring the awards at a dinner in the State Department's Diplomatic Reception Rooms, as NSF has done for over 30 years, enhances the recognition value of the awards.

Zero taxpayer dollars paid for alcoholic beverages at the event. NSF's trust fund — consisting of donations from private individuals — covered these expenditures. The black-tie dinner May 5 was $63 per person. Total catering costs were $34,790, (not $74,590, as alleged in the "wastebook") including food, personnel, equipment, floral arrangements, trash removal and recycling. Logistical costs included managing pre-event and on-site logistics and amounted to $17,133. NSF reimburses the State Department through an interagency agreement for use of the room ($15,000) and security ($3,900) and, as required, uses the department's caterer.

Teaching Engineering Concepts to Harness Future Innovators (TECHFIT)
NSF Award 1312215
Wastebook #58: "Life-Size Pac-Man"
Purdue University

The "wastebook's" focus on a single aspect of this project at a single school is unfortunate, as this is just a small part of a larger effort. The TECHFIT Project combines a pressing economic need (a tech-proficient U.S. workforce) with a proven strategy for fostering a passion for learning in children (reaching them in informal environments outside the classroom). Furthermore, the wastebook seems to have mistaken this award's primary purpose as being the combination of gaming and exercise. This was not the intent, or the execution of the award. TECHFIT exists to impart students who might otherwise never get the opportunity with a basic background in computer science – the students may have fun playing the games, but they pick up practical skills designing them.

Effective, evidence-based programs to encourage student interest in science, technology, engineering and math (STEM) careers specifically related to technology design and innovation are of benefit to society. The nation needs a workforce that understands how technology works in order to create and design new technologies as well as use existing technologies to their full potential. Fitness-driven technology, for example, is a multi-billion dollar industry that has important employment and health-related outcomes for the public. This emerging frontier in computer science and technology design will need a workforce capable of understanding the underlying infrastructure of current technologies to create the next generation of health and fitness tools.

TECHFIT provides teachers with professional development resources and curriculum materials to engage their students in after-school programs focused on programming, technology design, and engineering activities and to teach them about careers in STEM. Students learn to code and design sensors within fitness applications. These activities provide an engaging platform for technology skills development. TECHFIT personnel work with middle school teachers during the summer, helping them to develop expertise in areas such as computer programming, electricity, wiring, safety, and fitness. The teachers then return to their schools to organize their own afterschool programs and design projects to work on with their students. The Pac-Man exercise was just one of such projects. So far the project has reached students and teachers in Indiana and South Carolina, most in low-income, Title I schools with large numbers of students from populations traditional underrepresented in computing and technology careers, including girls and minorities.

Increasing the number of students with quality experiences in computational thinking, computing design, and STEM innovation is a national challenge that requires both a teacher workforce prepared to design and teach with technology along with creative curricula that is engaging to students.

I-Corps: Automated Attendance Check by Using Smartphone Cameras
NSF Award 1521289
Wastebook #72: "Truancy App"
Missouri University of Science and Technology

This research focused on developing technology to detect, track and recognize multiple faces in videos. Previous facial recognition research and technology development has largely centered on verification through a single image or a single live feature. This project advances previous computer science research funded by NSF to create an improved video-based identity and access management system through technology that verifies an individual's identity through unique facial expressions, rather than by a single images or feature.

As a result of this research, a patent application was submitted for improved facial recognition technology. Through this project, the researcher expanded the original technology application domain to include new markets, including online education, financial systems, and medical institutions – all organizations with a strong need for facial recognition technology. Transitioning this research through the I-Corps program into commercial products has the potential to benefit the U.S. government and American citizens and businesses, contributing to our economic vitality and national security.

I-Corps Program Background

The mission of the National Science Foundation's (NSF) Innovation Corps (NSF I-Corps™) program is "to foster entrepreneurship that will lead to the commercialization of technology that has been supported previously by NSF-funded research."

Through I-Corps, researchers learn the entrepreneurial skills required to successfully translate university-based, complex and fundamental research into the marketplace. The NSF I-Corps program is geared towards scientists and engineers who have, through NSF basic-research funding, discovered something in their laboratory that has commercial appeal that may benefit the U.S. economy. This program has been supported by federal legislators and is currently being emulated at other federal agencies, and around the world.

Combining Crowdsourcing and Computational Creativity to Enable Narrative Generation for Education, Training, and Healthcare

NSF Award 1350339

Wastebook #76: "Artificial Story Time"

Georgia Tech

Narratives play an important role in society – they are a fundamental means through which humans organize, understand and explain the world. If computer systems could create effective narratives, they would be better able to interact with people. This research aims to produce novel algorithms and software in order to create "intelligent" systems with the potential to impact broad societal problems, such as education, healthcare, and workforce development. The award also furthers study into computer-human interaction, with the possible economic benefit of smarter computing systems.

Artificial intelligence approaches to automated story generation and interactive storytelling could have tremendous impact in a number of industries. For example, some of the many research studies already published on the basis of this unfinished five-year grant address the ability of intelligent tools that would allow caregivers to create training routines and social skill scenarios for young adults with autism.

The project also includes an educational plan to develop a sustainable, annual summer hack-a-thon camp, wherein high school students work alongside K-12 teachers to create interactive narratives that motivate and guide classroom inquiry based learning.

The International Situations Project

NSF Award 1528131

Wastebook #77: “The World at 7 O’Clock”

University of California, Riverside

This research involves an intensive, international effort to address the question of how culture is reflected and transmitted through the experience of ordinary, real-world situations. In a fundamental way, understanding how we express who we are as humans -- helpful or violent, innovative or passive, fearful and anxious or pleased and proud -- means understanding the situations that drive human behavior. An individual may be proficient at understanding those expressions within his or her own culture, while the cues other cultures use are foreign and incomprehensible. But society’s increasing interconnection through economics, politics and technology routinely puts people from multiple cultures in direct contact. Misunderstandings can result in harms ranging from confusion to danger, making cross-cultural understanding more important than ever.

In order to collect information about how people behave across cultures in real-world situation, the research team created a website that allows scientists from around the world to enter data using a set of nearly 100 descriptive features. Researchers involved with this project are spread out across every continent around the world. This extensive network of scientist volunteers collect data from their countries, which will be of considerable importance to scientists due to its breadth of measures, and large and diverse sample.

This project has the potential to produce transformative information about how culture, as instantiated in situations, affects our behavior. By understanding the features that characterize situations in which an individual is acting the researchers can use these situational assessments to understand human behavior. Having an enormous sample of data allows examinations of whether the differences and similarities in situations are associated with the personalities of the individuals involved, differences in economic state of the country, or cultural differences.

No one has previously addressed these issues at such a large scale. This is very important for science: whereas scientists once believed behavior was primarily determined by biology, as dictated by genes, or determined by personality as dictated by early upbringing, researchers have come to understand that variation and commonalities in momentary behavior are better predicted by *what situations people are in*. **Understanding cross-cultural differences in situations and whether these foster prosocial or destructive behaviors can affect our national security. Indeed, cross-cultural misunderstanding about behavioral situations can endanger our security. Knowing what situational variations are associated with economic variation can also inform our own economy.**

Graduate Research Fellowship Program
NSF Award 1321851
Wastebook #79: "Hyper Dogs"
University of Pennsylvania

The "wastebook" entry for this award grossly distorts the size of this grant. It cites NSF's contribution at $10 million, when in fact the Foundation has only provided the researcher in question with $138,000 – and it wasn't directed toward funding "hyper dogs" or any specific research project.

The NSF Graduate Research Fellowship Program (GRFP) awards fellowships to the nation's most outstanding graduate students pursuing degrees in science, technology, engineering, and mathematics (STEM) disciplines. Annually, 2,000 applicants are selected as Fellows, from an applicant pool that currently exceeds 16,000. Applicants are evaluated by independent experts in their academic fields who make recommendations to NSF, which selects the awardees. Each individual Fellow receives a stipend and a cost of education allowance totaling $138,000 over three years. Fellowships support the graduate student's education, as opposed to an award designed to fund a specific research project development. By awarding bloc grants to universities, NSF administers this large and important program in a cost efficient manner. NSF has awarded a $9.2 million to the University of Pennsylvania, but it supports all of the GRFP Fellows currently attending the school. The research referred to in the wastebook is that of only one NSF Graduate Research Fellow.

Furthermore, the "wastebook" misstates the purpose of the research. It was not intended to measure how "hyper" dogs are, but to find more efficient ways to evaluate and train dogs as **guide dogs**. As stated above, NSF's support is for the Fellow's graduate education. The Fellow's research, however, is also supported by grants from the Office of Naval Research and the National Institutes of Health, and concerns the early environmental factors affecting the development of canine cognition and behavior. This study has a broad societal impact by helping to determine which variables, at which points in development, should be targeted for improvement so that in the future, guide dogs can be as effective as possible. This research includes a longitudinal study of guide dog puppies with *The Seeing Eye*, the world's oldest guide dog school. The project's ultimate goal is to link early observations to later program outcomes (failure, continued training, or placement), as currently only 60-70 percent of the dogs will ultimately be successful. Improving that percentage will save money and time when it comes to training these important animals – dogs that support blind and visually impaired individuals – including the approximately 157,000 Veterans in the United States who are legally blind.

GRFP supports individuals proposing comprehensive, holistic plans for their graduate education that take into account individual interests and competencies. By underwriting the training of graduate students with the demonstrated potential to be high-achieving scientists and engineers, the GRFP makes long-range investments for the future of society.

Genetic Architecture and Proximate Mechanisms Underlying Indirect Genetic Effects on Cooperative Antipredator Behavior

NSF Award 1453536

Wastebook #92: "Guppy Fishing"

Stonehill College

Understanding the relationship between an organism's genes (genotype) and its physical form, behavior, or even disease state (phenotype), is one of the grand challenges of biology and a goal of much of the NSF-funded research into organisms. This project integrates several levels of analysis and seeks to make a direct connection between genes, gene expression (the production and sensitivity of hormones), behavior (cooperation) and population genetics to help us understand better how evolution works, how organisms interact cooperatively, and how behaviors are modified. Scientists have theorized that a relationship exists between these factors, and this particular project is one attempt at uncovering those connections through experimentation with a model organism.

Researchers have discovered that the expression of complex social behavior in one individual often depends on the expression of genes in its social partner. What is unique about this research is that it studies the role of interactions in affecting gene expression and hormone physiology (amounts and sensitivity) and how those interactions affect both individual level and population level responses in different environmental settings (e.g., high and low predation). Guppies are a great model because the cooperative anti-predator behavior is predictable and reliable. In addition to the physical interactions, hormones are excreted into the water so one guppy's physiology can directly influence another guppy, there are numerous populations with similar streams but different predation environments, and the tools are available to manipulate the endocrinology and genetics.

Solving many modern social problems will rely on cooperation between individuals and groups, and understanding what genomic and endocrine factors favoring cooperation in a vertebrate may give us new insights into the mechanisms of cooperation in general and how cooperation arises over evolutionary time. Ultimately, many people want to understand human cooperation, and manipulation of fish endocrinology and genetics serves as a model to inform other organism interactions.