AUTHENTICATED
U.S. GOVERNMENT
INFORMATION
GPO

NATIONAL SCIENCE FOUNDATION PART I: OVERVIEW AND OVERSIGHT

HEARING

BEFORE THE

SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED FIFTEENTH CONGRESS

FIRST SESSION

MARCH 9, 2017

Serial No. 115–07

Printed for the use of the Committee on Science, Space, and Technology

Available via the World Wide Web: http://science.house.gov

U.S. GOVERNMENT PUBLISHING OFFICE

25–096PDF WASHINGTON : 2017

For sale by the Superintendent of Documents, U.S. Government Publishing Office
Internet: bookstore.gpo.gov Phone: toll free (866) 512–1800; DC area (202) 512–1800
Fax: (202) 512–2104 Mail: Stop IDCC, Washington, DC 20402–0001

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HON. LAMAR S. SMITH, Texas, *Chair*

FRANK D. LUCAS, Oklahoma
DANA ROHRABACHER, California
MO BROOKS, Alabama
RANDY HULTGREN, Illinois
BILL POSEY, Florida
THOMAS MASSIE, Kentucky
JIM BRIDENSTINE, Oklahoma
RANDY K. WEBER, Texas
STEPHEN KNIGHT, California
BRIAN BABIN, Texas
BARBARA COMSTOCK, Virginia
GARY PALMER, Alabama
BARRY LOUDERMILK, Georgia
RALPH LEE ABRAHAM, Louisiana
DRAIN LaHOOD, Illinois
DANIEL WEBSTER, Florida
JIM BANKS, Indiana
ANDY BIGGS, Arizona
ROGER W. MARSHALL, Kansas
NEAL P. DUNN, Florida
CLAY HIGGINS, Louisiana

EDDIE BERNICE JOHNSON, Texas
ZOE LOFGREN, California
DANIEL LIPINSKI, Illinois
SUZANNE BONAMICI, Oregon
ALAN GRAYSON, Florida
AMI BERA, California
ELIZABETH H. ESTY, Connecticut
MARC A. VEASEY, Texas
DONALD S. BEYER, JR., Virginia
JACKY ROSEN, Nevada
JERRY MCNERNEY, California
ED PERLMUTTER, Colorado
PAUL TONKO, New York
BILL FOSTER, Illinois
MARK TAKANO, California
COLLEEN HANABUSA, Hawaii
CHARLIE CRIST, Florida

SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY

HON. BARBARA COMSTOCK, Virginia, *Chair*

FRANK D. LUCAS, Oklahoma
RANDY HULTGREN, Illinois
STEPHEN KNIGHT, California
DARIN LaHOOD, Illinois
RALPH LEE ABRAHAM, Louisiana
DANIEL WEBSTER, Florida
JIM BANKS, Indiana
ROGER W. MARSHALL, Kansas
LAMAR S. SMITH, Texas

DANIEL LIPINSKI, Illinois
ELIZABETH H. ESTY, Connecticut
JACKY ROSEN, Nevada
SUZANNE BONAMICI, Oregon
AMI BERA, California
DONALD S. BEYER, JR., Virginia
EDDIE BERNICE JOHNSON, Texas

CONTENTS

March 9, 2017

	Page
Witness List	2
Hearing Charter	3

Opening Statements

Statement by Representative Barbara Comstock, Chairwoman, Subcommittee on Research and Technology, Committee on Science, Space, and Technology, U.S. House of Representatives	4
Written Statement	6
Statement by Representative Daniel Lipinski, Ranking Member, Subcommittee on Research and Technology, Committee on Science, Space, and Technology, U.S. House of Representatives	8
Written Statement	10
Statement by Representative Lamar S. Smith, Chairman, Committee on Science, Space, and Technology, U.S. House of Representatives	12
Written Statement	14
Statement by Representative Eddie Bernice Johnson, Ranking Member, Committee on Science, Space, and Technology, U.S. House of Representatives	16
Written Statement	18

Witnesses

Dr. France Córdova, Director, National Science Foundation (NSF)	
Oral Statement	20
Written Statement	22
Ms. Allison Lerner, Inspector General, National Science Foundation (NSF)	
Oral Statement	29
Written Statement	31
Discussion	41

Appendix I: Answers to Post-Hearing Questions

Dr. France Córdova, Director, National Science Foundation (NSF)	58
Ms. Allison Lerner, Inspector General, National Science Foundation (NSF)	70

Appendix II: Additional Material for the Record

Report and video link submitted by Dr. France Córdova, Director, National Science Foundation (NSF)	130

NATIONAL SCIENCE FOUNDATION PART I: OVERVIEW AND OVERSIGHT

THURSDAY, MARCH 9, 2017

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, D.C.

The Subcommittee met, pursuant to call, at 11:03 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Barbara Comstock [Chairwoman of the Subcommittee] presiding.

LAMAR S. SMITH, Texas
CHAIRMAN

EDDIE BERNICE JOHNSON, Texas
RANKING MEMBER

Congress of the United States
House of Representatives
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
2321 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515–6301
(202) 225–6371
www.science.house.gov

National Science Foundation Part I: Overview and Oversight

Thursday, March 9, 2017
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

Witnesses

Dr. France Córdova, Director, National Science Foundation (NSF)

Ms. Allison Lerner, Inspector General, National Science Foundation (NSF)

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HEARING CHARTER

Thursday, March 9, 2017

TO: Members, Committee on Science, Space, and Technology

FROM: Majority Staff, Committee on Science, Space, and Technology

SUBJECT: Research and Technology Subcommittee hearing
"National Science Foundation Part I: Overview and Oversight"

The Subcommittee on Research and Technology of the Committee on Science, Space, and Technology will hold a hearing titled *National Science Foundation Part I: Overview and Oversight* on Thursday, March 9, 2017 at 10:00 a.m. in Room 2318 of the Rayburn House Office Building.

Hearing Purpose:

The purpose of the hearing is to provide an overview of the National Science Foundation's (NSF) research and STEM education portfolio and priorities, and to update the Committee on oversight matters, including progress on implementation of accountability and transparency policies, a national interest requirement, large facilities management reform, and other provisions included in the American Innovation and Competitiveness Act (AICA).

Witness List

- **Dr. France Córdova,** Director, National Science Foundation (NSF)
- **Ms. Allison Lerner,** Inspector General, National Science Foundation (NSF)

Staff Contact

For questions related to the hearing, please contact Jenn Wickre of the Majority Staff at 202-225-6371.

Chairwoman COMSTOCK. The Committee on Science, Space, and Technology will come to order. Without objection, the Chair is authorized to declare recesses of the Committee at any time.

Welcome and good morning. I want to welcome a local class from Paul VI. Thank you for joining us today. They're here for their government day, and I imagine some of them might live in my colleague's district also, but a northern Virginia school with a lot of folks I know there. So great to have you here today.

Good morning, and welcome to today's hearing, which is entitled "National Science Foundation Part 1: Overview and Oversight." I now recognize myself for five minutes for an opening statement.

My district in Virginia is home to many research and technology companies on the forefront of technological innovation, so I'm very pleased that we're able to have this opportunity in this Committee. The innovative products and services they offer are often the end result of taxpayer-supported research conducted at universities and research laboratories.

The National Science Foundation is the primary source of federal funding for nonmedical basic research. NSF funds 12,000 competitive grants a year and supports the work of over 375,000 scientists, engineers, educators, and students across the country.

Basic and fundamental research is about good jobs and a secure future. Americans face enormous challenges, and NSF has a role to play in helping address them. Through research and activities supported by the NSF, we have the opportunity to boost our economy, enhance our national security, strengthen our cybersecurity infrastructure, and create a STEM-job-pipeline-ready workforce.

The purpose of today's hearing is to provide an overview of the National Science Foundation's research and STEM education portfolio and priorities, and to update the Committee on oversight matters. In January, the American Innovation and Competitiveness Act was signed into law, a bill that reauthorized many of the activities at NSF and reformed programs to maximize the nation's investment in research.

I am proud that the bipartisan law resulted from the work my Subcommittee and this Committee conducted last Congress, and I'm pleased that a bill I sponsored, the Research and Development Efficiency Act, who I worked with my colleague here Mr. Lipinski on, was included, which will help reduce the regulatory burden on scientists and universities. This bill also included a number of provisions to improve the coordination of STEM education programs across the federal government and promote inclusion in the STEM fields.

Last week, the President signed into law two additional STEM-related bills, which originated with this Committee, that will help the next generation of young women have greater opportunities to pursue careers in the STEM fields that are central to our 21st century economy. We had the INSPIRE Act, which authorizes NASA to encourage young women to study the STEM fields and to pursue careers that will further advance America's space missions. And the other bill was the Promoting Women in Entrepreneurship Act, which was authored by my colleague Ms. Esty, which promotes women and jobs in STEM fields through the NSF. And we are pleased to have finally gotten those through the Senate because we

passed them last Congress but they didn't make it through the Senate, so I am glad we were able to move forward with those.

Dr. Córdova, I look forward working together on these efforts, and particularly in STEM and cybersecurity. And, Ms. Lerner, I also greatly value the work of the Office of Inspector General. Your work and recommendations have led to millions of dollars saved, protecting the taxpayers' investment in research. I look forward to hearing more from both of you about your priorities for the coming year and about how we can work together to maintain our nation's leadership in innovation.

I know we all have innovative STEM initiatives in our districts that provide models for others. I just wanted to mention a few that I have had and recently visited in my district. K2M, which is a medical device company, has an Innovation Challenge Program that they're working on with their local schools. They're getting young people in ninth grade to have a semester-long program working with them and mentoring them; they pair up with somebody at the company to find out more about the engineering field of medical device technology. They particularly work on scoliosis and the sort of hardware that helps medically deal with that problem.

I have VISA, who is partnered with Women in Technology and the STEM for Her program, which are putting on programs in my district, specifically designed for young women to get engaged in STEM subjects.

So I encourage other members of this Committee to take these opportunities and all the opportunities that you all are providing through your good work to make sure we're getting all these programs out to our young people. And again, I'm pleased that we have a group of our young people here for this appropriate hearing for you.

[The prepared statement of Chairwoman Comstock follows:]

COMMITTEE ON
SCIENCE, SPACE, & TECHNOLOGY
Lamar Smith, Chairman

For Immediate Release
March 9, 2017

Media Contact: Kristina Baum
(202) 225-6371

Statement of Chairwoman Barbara Comstock (R-Va.)
National Science Foundation Part 1: Overview and Oversight

Chairwoman Comstock: My district in Virginia is home to many research and technology companies on the forefront of technological innovation.

The innovative products and services they offer are often the end-result of taxpayer-supported research conducted at universities and research laboratories.

The National Science Foundation (NSF) is the primary source of federal funding for non-medical basic research. NSF funds 12,000 competitive grants a year, and supports the work of over 377,000 scientists, engineers, educators and students across the country.

Basic and fundamental research is about good jobs and a secure future. Americans face enormous challenges, and NSF has a role to play in helping address them.

Through research and activities supported by the NSF, we have the opportunity to boost our economy, enhance our national security, strengthen our cybersecurity infrastructure, and create a STEM-job ready workforce.

The purpose of today's hearing is to provide an overview of the National Science Foundation's research and STEM education portfolio and priorities, and to update the Committee on oversight matters.

In January, the American Innovation and Competitiveness Act (AICA) was signed into law, a bill that reauthorized many of the activities at NSF and reformed programs to maximize the nation's investment in research.

I am proud that the bipartisan law resulted from the work my subcommittee conducted last Congress, and that a bill I sponsored, the *Research and Development Efficiency Act* was included, which will help reduce the regulatory burden on scientists and universities.

The AICA also included a number of provisions to improve the coordination of STEM education programs across the federal government and promote inclusion in the STEM fields.

Last week, the President signed into law two additional STEM related bills, which originated with this committee, that will help the next generation of young women have greater opportunities to pursue careers in the STEM fields that are central to our 21st century economy.

One was my bill, the INSPIRE Women Act, which authorizes NASA to encourage young women to study the STEM fields and to pursue careers that will further advance America's space missions. The other bill was the Promoting Women in Entrepreneurship Act, authored by my colleague Ms. Esty, which promotes women and jobs in STEM fields through the NSF.

Dr. Cordova, I look forward working together on these efforts, particularly in STEM and cybersecurity.

Ms. Lerner, I also greatly value the work of the Office of Inspector General. Your work and recommendations have led to millions of dollars saved – protecting the taxpayer's investment in research.

I look forward to hearing more from both of you about your priorities for the coming year and about how we can work together to maintain our nation's leadership in innovation.

I know we all have innovative STEM initiatives in our districts that provide models for others. I recently visited a global medical device company, K2M, for the kickoff of their Innovation Challenge Program.

The program hosts students in Loudoun County, and engages them in a semester long program where they solve engineering challenges. It also provides the students with mentors from K2M.

Others—including VISA, who partnered with Women in Technology and the "STEM for Her" program—put on programs in my area specifically designed for young women to get engaged in STEM subjects.

I encourage other members of this Committee to engage with the young people in their districts on STEM so that we, and they, have the brightest possible futures.

And with that, I look forward to hearing the testimonies of our guests.

###

Chairwoman COMSTOCK. And with that, I look forward to hearing the testimonies of our guests, and I now recognize the Ranking Member, the gentleman from Illinois, Mr. Lipinski, for an opening statement.

Mr. LIPINSKI. Thank you, Madam Chairwoman. And welcome to our distinguished panel. I'm glad we're having this hearing to get an update on the important work that's being done at the National Science Foundation. I want to thank Dr. Córdova for her leadership at the Foundation. A few weeks ago, we had a number of NSF grant recipients here, and we had a chance to hear about and see some of the breakthrough research and innovations. This was only a small sample but a great demonstration of the excellent work facilitated by funding from the NSF.

The federal government is uniquely positioned to fund world-class research, especially high-risk, high-reward research that leads to transformative discoveries and innovations that drive our economy forward. In doing so, the National Science Foundation plays a vital role not only advancing the U.S. scientific enterprise but also in shoring up our nation's ability to compete in an increasingly technology-driven and dynamic global economy.

Funding for NSF has not been what I would like to have seen in recent years. I think many of my colleagues agree. This Committee needs to push to make NSF funding a priority in this Congress as we face possible significant budget cuts. While we do this, we also need to make sure that NSF does the most possible with limited resources, and we'll get to some of that in today's hearing.

I believe it's also important that Congress does not make the mistake of changing the funding priorities of the scientists at the NSF. The social sciences in particular make key contributions to critical national and global challenges. You've heard this from me many times before, but it's worth repeating. Social scientists are showing us the human factors involved in developing effective cybersecurity. This Committee is working on strengthening cybersecurity in the federal government, and we need the input of social scientists to do this.

Additionally, NSF-funded social science research into cross-cultural nonverbal communication, which was presented to this Committee in 2011, helped the Army improve the way it trains its soldiers and lessen conflicts with foreign citizens. These are just a few examples of the value of social science research, which is only a small but very important portion of the NSF budget.

Regardless of the field of research, the work at the NSF does not stop at the laboratory bench. Programs like the NSF Innovation Corps or I–Corps and the SBIR STTR program aim to help scientists bring NSF-funded research to market. I–Corps provides researchers with the education, mentoring, and networking necessary to begin the process of commercializing their research. And SBIR STTR provides funding to help small businesses transition NSF innovations to commercial products. I was proud to help lead the effort to authorize the I–Corps program in the American Innovation and Competitiveness Act which passed last Congress and was signed into law in January. I am also a strong supporter of the SBIR.

As we review the important work going on at the NSF, I'd like to hear about NSF's plans for participation in the interagency working group on research regulation establishing the AICA legislation, as the Chairwoman mentioned. It doesn't make sense for eminent scientists to be spending 42 percent of their time complying with federal research regulations. I have been a champion of this issue for years and was glad to see some of the language from the bill I introduced last Congress incorporated in the AICA.

I look forward to hearing about the progress NSF has made in implementing a number of provisions of the AICA that address management challenges that have been the topic of hearings before this Committee. I'm confident that NSF will take the necessary steps to implement the policy changes in the law. This hearing is a good opportunity to check in and see how things are going, although I know it's very early.

Finally, I was pleased to learn that the NSF has made significant progress in increasing accountability in its management of large research facilities, lowering the cost of Intergovernmental Personnel Act appointments for rotating staff, and preventing research misconduct. I'm eager to learn more about how the agency is protecting our investment in research in these areas.

Thank you again to Dr. Córdova and Ms. Lerner for being here. I look forward to your testimony, and I yield back.

[The prepared statement of Mr. Lipinski follows:]

OPENING STATEMENT
Ranking Member Dan Lipinski (D-IL)
of the Subcommittee on Research and Technology

House Committee on Science, Space, and Technology
Subcommittee on Research and Technology
"National Science Foundation Part I: Overview and Oversight"
March 9, 2017

Thank you Madam Chairwoman and welcome to our distinguished panel. I'm glad we are having this hearing to get an update on the important work being done at the National Science Foundation. I want to thank Director Cordova for her leadership at the foundation. A few weeks ago we had a number of NSF grant recipients here and we had a chance to hear about and see some of their breakthrough research and innovations. This was only a small sample but a great demonstration of the excellent work facilitated by funding from the NSF.

The federal government is uniquely positioned to fund world-class research, especially high risk, high reward research that leads to the transformative discoveries and innovations that drive our economy forward. In doing so, the National Science Foundation plays a vital role, not only in advancing the U.S. scientific enterprise, but also in shoring up our nation's ability to compete in an increasingly technology-driven and dynamic global economy.

Funding for the NSF has not been what I would have liked to have seen in recent years; I think many of my colleagues agree. This committee needs to push to make NSF funding a priority in this Congress as we face possible significant budget cuts. While we do this, we also need to make sure that NSF does the most possible with limited resources; we will get into some of that today in this hearing.

I believe that it is also important that Congress does not make the mistake of changing the funding priorities of the scientists at the NSF. The social sciences, in particular, make key contributions to critical national and global challenges. Social scientists are showing us the human factors involved in developing effective cybersecurity. This committee is working on strengthening cybersecurity in the federal government and we need the input of social scientists to do this. Additionally, NSF-funded social science research into cross-cultural, non-verbal communication, which was presented to this committee in 2011, helped the army improve the way it trains its soldiers and lessened conflicts with foreign citizens. These are just a few examples of the value of social science research which is only a small but very important portion of the NSF budget.

Regardless of the field of research, the work at the NSF does not stop at the laboratory bench. Programs like the NSF Innovation Corps, or I-Corps, and the SBIR/STTR program, aim to help scientists bring NSF-funded research to market. I-Corps provides researchers with the education, mentoring, and networking necessary to begin the process of commercializing their research, and SBIR/STTR provides funding to help small businesses transition NSF innovations to commercial products. I was proud to help lead the effort to authorize the I-Corps program in the American Innovation and Competitiveness Act, which passed last Congress and was signed into law in January. I also supported SBIR reauthorization, which included annual increases in funding levels.

As we review the important work going on at the NSF, I would like to hear about NSF's plans for participation in the Interagency Working Group on Research Regulation established in the AICA legislation. It doesn't make sense for our eminent scientists to be spending 42 percent of their time complying with federal research regulations. I have been a champion of this issue for years and was glad to see some of the language from a bill I introduced last Congress incorporated into the AICA.

I look forward to hearing about the progress NSF has made in implementing a number of provisions of the AICA that address management challenges that have been the topic of hearings before this committee. I am confident that the NSF will take the necessary steps to implement the policy changes in the law. This hearing is a good opportunity to check in and to see how things are going.

Finally, I was pleased to learn that the NSF has made significant progress in increasing accountability in its management of large research facilities, lowering the cost of Intergovernmental Personnel Act appointments for rotating staff, and preventing research misconduct. I am eager to learn more about how the agency is protecting our investment in research in these areas.

Thank you again to Dr. Córdova and Ms. Lerner for being here. I look forward to your testimony. I yield back.

Chairwoman COMSTOCK. And I now recognize the Chairman of the full Committee, Mr. Smith, for his statement.

Chairman SMITH. Thank you, Madam Chairwoman.

For nearly 70 years, the National Science Foundation has served as the basis of taxpayer-funded basic research. Since its creation in 1950, NSF's mission has been to promote fundamental scientific discovery in the national interest, which helps make the United States a world leader in knowledge and innovation.

Our challenge this year is to set funding priorities that ensure America remains a leader in the global marketplace of ideas and products, while also recognizing budgetary limits. A full reauthorization of the science agencies under our jurisdiction, including NSF, will allow us to rebalance priorities and ensure that our nation's science agencies are on a trajectory to keep America at the forefront of scientific knowledge and discovery.

The Committee finished last year by completing work on the American Innovation and Competitiveness Act, which reauthorized some of NSF's activities. These include STEM education initiatives, entrepreneurship programs, the BRAIN Initiative, and others. In fact, on January 6, it was the last bill signed into law for the 114th Congress.

The new law also reforms federal science agency programs to increase the impact of taxpayer-funded research. It improves accountability and transparency, reduces administrative burden on researchers, enhances agency oversight, and improves research coordination.

I want to recognize Dr. Córdova for the steps NSF has taken to improve accountability over the last two years.

In the past, I have been critical of NSF for funding of too many projects that seem marginal or frivolous. My concern is that low-risk, low-priority projects detract from investments into groundbreaking research that includes biology, physics, computer science and engineering.

The new law makes permanent and enhances NSF's transparency and accountability policy so that it describes in nontechnical terms the research projects it funds. The law also improves the NSF grant-making process. It affirms that research funded through the merit-review selection process must be in the national interest by meeting one of seven broader impact goals. These goals include increasing economic competitiveness, enhancing the health and welfare of the American public, developing a STEM workforce, and supporting the national defense. I hope these reforms will prevent future cost overruns and the use of taxpayer funds for the wrong ideas and subjects.

I look forward to hearing from Dr. Córdova and Ms. Lerner about how the implementation of these reforms is proceeding and about the progress the NSF has made to be more accountable to taxpayers. I believe there has been noticeable improvement, but oversight challenges remain.

The Inspector General's last report to Congress identified several areas in need of improvement or monitoring. These include NSF's management of rotator personnel; the Foundation's move to a new headquarters building in Alexandria, Virginia; NSF's management of the U.S. Antarctic Program; and its efforts to improve grant ad-

ministration and encourage ethical conduct in research. I look forward to hearing more about these challenges and how we can work together to address them.

Finally, I want to acknowledge that, last week, President Trump signed into law two bipartisan Science Committee bills to promote the role of women in science: the INSPIRE Women Act, sponsored by Chairwoman Comstock; and the Promoting Women in Entrepreneurship, sponsored by Ms. Esty. These laws enable more talented young women to pursue their dreams and change the world with their ideas. NSF's support for groundbreaking basic research and STEM education can greatly help in making America prosperous.

Thank you, Madam Chairwoman, and yield back.

[The prepared statement of Chairman Smith follows:]

COMMITTEE ON
SCIENCE, SPACE, & TECHNOLOGY
Lamar Smith, Chairman

For Immediate Release
March 9, 2017

Media Contact: Kristina Baum
(202) 225-6371

Statement of Chairman Lamar Smith (R-Texas)
National Science Foundation Part 1: Overview and Oversight

Chairman Smith: Thank you, Chairwoman Comstock. And welcome Dr. Córdova and Ms. Lerner.

For nearly 70 years, the National Science Foundation (NSF) has served as the basis of taxpayer-funded basic research.

Since its creation in 1950, NSF's mission has been to promote fundamental scientific discovery in the national interest, which helps make the United States a world leader in knowledge and innovation.

Our challenge this year is to set funding priorities that ensure America remains a leader in the global marketplace of ideas and products while also recognizing budgetary limits.

A full reauthorization of the science agencies under our jurisdiction, including NSF, will allow us to rebalance priorities and ensure that our nation's science agencies are on a trajectory to keep America at the forefront of scientific knowledge and discovery.

The Committee finished last year by completing work on the American Innovation and Competitiveness Act, which reauthorized some of NSF's activities. These include STEM education initiatives, entrepreneurship programs and the BRAIN Initiative. In fact, on January 6 it was the last bill signed into law for the 114th Congress.

The new law also reforms federal science agency programs to increase the impact of taxpayer-funded research.

It improves accountability and transparency, reduces administrative burden on researchers, enhances agency oversight, and improves research coordination.

I want to recognize Dr. Córdova for the steps NSF has taken to improve accountability over the last two years.

I have been critical of NSF for past funding of too many projects that seem marginal or frivolous. My concern is that low-risk, low-priority projects detract from investments into groundbreaking research that includes biology, physics, computer science and engineering.

The new law makes permanent and enhances NSF's transparency and accountability policy so that it describes in non-technical terms the research projects it funds.

The law also improves the NSF grant-making process. It affirms that research funded through the merit-review selection process must be in the national interest by meeting one of seven broader impact goals. These goals include increasing economic competitiveness, enhancing the health and welfare of the American public, developing a STEM workforce, and supporting the national defense.

I hope these reforms will prevent future cost overruns and the use of taxpayer funds for liquor, lobbyists and foreign travel, which we have seen in the past.

I look forward to hearing from Dr. Córdova and Ms. Lerner about how the implementation of these reforms is proceeding and about the progress the NSF has made to be more accountable to taxpayers.

I believe there has been noticeable improvement but oversight challenges remain.

The Inspector General's last report to Congress identified several areas in need of improvement or monitoring. These include NSF's management of rotator personnel; the Foundation's move to a new headquarters building in Alexandria, Virginia; NSF's management of the U.S. Antarctic Program; and its efforts to improve grant administration and encourage ethical conduct in research.

I look forward to hearing more about these challenges and how we can work together to address them.

Finally, I want to acknowledge that last week President Trump signed into law two bipartisan Science Committee bills to promote the role of women in science: the INSPIRE Women Act, sponsored by Chairwoman Comstock, and the Promoting Women in Entrepreneurship Act, sponsored by Ms. Esty.

These laws enable more talented young women to pursue their dreams and change the world with their ideas.

NSF's support for groundbreaking basic research and STEM education can greatly help in making America prosperous.

I look forward to hearing from our witnesses today and yield back.

###

Chairwoman COMSTOCK. Thank you, Mr. Chairman.

And I now recognize the Ranking Member of the full Committee for a statement, Ms. Johnson.

Ms. JOHNSON. Thank you very much, and thank you, Ms.—Chairwoman Comstock and Ranking Member Lipinski, for holding this hearing. And I welcome back to our distinguished witnesses Dr. Córdova and Ms. Lerner.

This hearing is an opportunity to introduce some of our new Members to the mission and operations of the National Science Foundation and to review progress on some longstanding oversight issues.

The National Science Foundation was established by Congress in 1950 to promote the progress of science. Those very words are written into the enabling and enacted legislation. For more than six decades, America's scientists and engineers have been submitting their best and most creative ideas to the Foundation for funding. For more than six decades, the Foundation has required that every one of those proposals undergo merit review by scientific peers in order to select and fund the best of the best. This is the case for all fields of science and engineering supported by the Foundation, from physics and biology to Earth systems science to the social, behavioral, and economic sciences. The enacting legislation also established NSF to advance the national health, prosperity, and welfare and to secure the national defense.

These words also are central to NSF's mission. The intent was not that every grant would be required to meet those particular criteria. The guiding rule of basic research is that you should not be constrained to a particular path or a particular application. To be constrained in what research is pursued is to fail to ask the most fundamental and compelling questions in science and engineering. To fail to ask the most fundamental and compelling questions is to miss out on the truly transformative scientific and technological breakthroughs. The intent since 1950 has been just that, in the aggregate.

The taxpayers' investments in NSF would help contribute to a more secure and prosperous nation, and the record shows that they certainly have. This is as true for the social and behavioral sciences as it is for the physics and engineering.

This hearing is the first of two hearings this Committee will hold before moving legislation to authorize appropriations for the National Science Foundation and to take a fresh look at the Foundation's 1950 Organic Act.

While Congress has passed minor amendments to the 1950 act, the central mission of the Foundation and the Foundation's reliance on competitive peer review to identify and fund the best proposals have remained untouched. In short, the 1950 act has proven remarkably durable and worth preserving.

Over the last few years, we have had vigorous debates in this Committee about the National Science Foundation's mission and about the process for selecting and funding the best and most worthy grant proposals. In the bipartisan American Innovation and Competitiveness Act signed into law by President Obama in January, we arrived at a compromise that reaffirmed the National Science Foundation's gold standard merit review process, while en-

suring transparency and accountability in their grant decisions. This was a good outcome for U.S. science and for the taxpayer.

As we consider additional NSF legislation this Congress, I hope that all of us sitting here behind the dais will truly listen to the experts sitting before us, and perhaps more importantly, to the experts across the science and engineering community who constitute the lifeblood of U.S. innovation and competitiveness.

Once again, I want to welcome and thank the witnesses before us today, and I look forward to your testimony and to a fruitful discussion about NSF's progress on a number of oversight issues.

And I yield back. Thank you.

[The prepared statement of Ms. Johnson follows:]

OPENING STATEMENT
Ranking Member Eddie Bernice Johnson(D-TX)

House Committee on Science, Space, and Technology
Subcommittee on Research and Technology
"National Science Foundation Part I: Overview and Oversight"
March 9, 2017

Thank you Chairwoman Comstock and Ranking Member Lipinski for holding this hearing. And welcome back to our distinguished witnesses, Dr. Córdova and Ms. Lerner. This hearing is an opportunity to introduce some of our new Members to the mission and operations of the National Science Foundation, and to review progress on some longstanding oversight issues.

The National Science Foundation was established by Congress in 1950 to "promote the progress of science." Those very words are written into the enacting legislation. For more than six decades, America's scientists and engineers have been submitting their best and most creative ideas to the Foundation for funding. For more than six decades, the Foundation has required that every one of those proposals undergo merit-review by scientific peers in order to select and fund the best of the best. This is the case for all fields of science and engineering supported by the Foundation, from physics and biology, to earth systems science, to the social, behavioral, and economic sciences.

The enacting legislation also established NSF to "advance the national health, prosperity, and welfare" and "to secure the national defense." Those words are also central to NSF's mission. The intent was not that every grant would be required to meet these particular criteria. The guiding rule of basic research is that you should not be constrained to a particular path or a particular application. To be constrained in what research is pursued is to fail to ask the most fundamental and compelling questions in science and engineering. To fail to ask the most fundamental and compelling questions is to miss out on the truly transformative scientific and technological breakthroughs. The intent since 1950 has been that -- in the aggregate -- the taxpayers' investments in NSF would help contribute to a more secure and prosperous nation. And the record shows they certainly have. This is as true for the social and behavioral sciences as it is for physics and engineering.

This hearing is the first of two hearings this Committee will hold before moving legislation to authorize appropriations for the National Science Foundation and to take a fresh look at the Foundation's 1950 organic Act. While Congress has passed minor amendments to the 1950 Act, the central mission of the Foundation, and the Foundation's reliance on competitive peer-review to identify and fund the best proposals, have remain untouched. In short, the 1950 Act has proven remarkably durable and worth preserving.

Over the last few years, we have had vigorous debates in this Committee about NSF's mission and about the process for selecting and funding the best and most worthy grant proposals. In the bipartisan American Innovation and Competitiveness Act signed into law by President Obama in January, we arrived at a compromise that reaffirmed NSF's gold standard merit-review process while ensuring transparency and accountability in their grant decisions. This was a good outcome for U.S. science and for the taxpayer.

As we consider additional NSF legislation this Congress, I hope that all of us sitting here behind the dais will truly listen to the experts sitting before us and, perhaps more importantly, to the experts across the science and engineering community who constitute the lifeblood of U.S. innovation and competitiveness.

Once again, I want to welcome and thank the witnesses before us today. I look forward to your testimony and to a fruitful discussion about NSF's progress on a number of oversight issues, and I yield back.

Chairwoman COMSTOCK. Thank you. I'll now introduce our witnesses. Our first witness today is Hon. France Córdova, Director of the National Science Foundation. Dr. Córdova was sworn in as Director of the NSF in March 2014. She is President Emerita of Purdue University where she served as President from 2007 to 2012. From 1993 to 1996, she served as the Chief Scientist at NASA, and she is the recipient of NASA's highest honor, the Distinguished Service Medal. Dr. Córdova has a B.A. from Stanford University and a Ph.D. in physics from the California Institute of Technology.

Our second witness today is Ms. Allison Lerner, Inspector General for the National Science Foundation. Before joining NSF in April 2009, she served in many leadership positions at the Department of Commerce, including Counsel to the Inspector General. She has received several national awards for excellence, and in 2015 was appointed to serve as Vice Chair for the Council of Inspectors General on Integrity and Efficiency. Ms. Lerner received her law and undergraduate degrees from the University of Texas.

I now recognize Dr. Córdova for five minutes to present her testimony.

TESTIMONY OF DR. FRANCE CÓRDOVA, DIRECTOR, NATIONAL SCIENCE FOUNDATION (NSF)

Dr. CÓRDOVA. Thank you, Chairwoman Comstock, Ranking Member Lipinski, Chairman Smith, and Ranking Member Johnson, and Members of the Subcommittee. I'm pleased to speak to you today about the National Science Foundation.

From our beginning almost 70 years ago, NSF has operated in concert with the National Science Board under an extraordinary mandate: to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense.

NSF has an annual budget that is currently $7.5 billion. We operate as a lean agency with low overhead. Fully 93 percent of our budget goes to support research and education. Eighty-five percent of that goes to universities and colleges across the country, including community colleges, all of it decided by merit review.

While our annual budget represents just four percent of the total federal budget for research and development, it accounts for 1/4 of the total federal support for basic research conducted at U.S. colleges and universities. In some fields like computer science we're the predominant support for academic research. NSF is the only federal agency that funds fundamental science—high-risk, long-term, curiosity-driven research—over nearly all fields of science and engineering.

The history of NSF is a history of profound discoveries. Last year, the first detection on Earth of gravitational waves were made following NSF's sustained investment for 40 years and revealing the existence of large binary black holes. We have funded the research of 223 people who went on to win the Nobel Prize.

Our mission—to fund high-risk fundamental research—has yielded significant innovations with tremendous impact; for example, artificial intelligence, 3–D printing, technologies integral to the Internet and the iPhone, lifesaving tools and therapies essential to our

nation's hospitals, discoveries that have had a profound impact on our nation's economy, security, and health.

NSF's mission requires being responsive to the national needs and changing landscape of science and engineering, and this means having the flexibility to continue investing in fundamental research that creates new knowledge in critical areas such as cybersecurity. This also means sustained investment in developing a STEM-capable workforce, which can adeptly navigate the workplaces of the future. We don't know where the next groundbreaking discovery will come from, nor who will make it.

NSF and the National Science Board have worked closely with Congress, the Office of the Inspector General, the science community, industry, and outside experts to be responsive to priority-setting for our programs, to make internal improvements such as increased transparency and accountability, and to be focused increasingly on the management of our large, major user facilities.

The agency works closely with a wide array of partners to leverage its funding, as shown in this slide.

[Slide.]

Dr. CÓRDOVA. NSF recently fashioned a long-term research agenda to push the boundaries of knowledge in the form of 10 big ideas. It's a powerful vision that will ensure future generations continue to reap the benefits of fundamental science research. Investing in this strategic agenda, coupled with our sustained funding of current core programs, will ensure that our country leads in discovery, innovation, and impact.

And speaking of impact, I'd like to close with a short video that shows but a few of the impacts of NSF's contributions to society.

[Video shown.]

Dr. CÓRDOVA. I think you can see that NSF's mission of investing in scientific discovery and discoverers bolsters our economy and security and keeps us a great nation. Thank you. And I'd be happy to answer any questions.

[The prepared statement of Dr. Córdova follows:]

Testimony of

Dr. France Córdova
Director
National Science Foundation

Before the

House Committee on Science, Space, and Technology
Subcommittee on Research and Technology
U.S. House of Representatives

March 9, 2017

"National Science Foundation Part 1: Overview and Oversight"

Chairwoman Comstock, Ranking Member Lipinski, and Members of the Subcommittee, it is my privilege to be here with you today to discuss the National Science Foundation's (NSF) unique mission, significant impact on the economy and security of our nation. I will describe our efforts to implement provisions of the American Innovation and Competitiveness Act (AICA), and to strive for excellence in agency operations.

First, I would like to take this opportunity to thank this Committee for its work in developing the bicameral, bipartisan American Innovation and Competitiveness Act. This Act affirms NSF's long-standing, world-renowned merit review process; maximizes research opportunities; and promotes NSF's commitment to diversity in STEM fields. It also incentivizes NSF programs that encourage private-sector involvement and re-affirms NSF's commitment to entrepreneurship and commercialization.

NSF: Building a Foundation for Success

NSF is governed by the NSF Act of 1950, as amended, to "promote the progress of science." NSF supports close to 2,000 colleges, universities, and other institutions, and receives on the average of 50,000 proposals each year, of which it funds approximately 11,000 grant proposals each year. Over 200,000 proposal reviews are conducted annually. The estimated number of people directly supported by NSF at any given time is close to 300,000. This includes researchers, postdoctoral fellows, trainees, teachers, and students. NSF has also supported close to 50,000 graduate research fellows since 1952 through its flagship Graduate Research Fellowship Program. We are a lean agency with only 7% overhead. That means 93 percent of appropriated funds directly support research and STEM education, 85% of it at our nation's colleges and universities.

The Foundation's annual budget, $7.5 billion in fiscal year 2016, represents just four percent of the total federal budget for research and development, but accounts for 24 percent of the total federal support for

basic research conducted at U.S. colleges and universities, and this share increases to 60 percent when medical research supported by the National Institutes of Health is excluded. NSF is the primary source of federal academic support in many fields. For example, NSF provides 82% of the funding for academic computer science.

The cornerstone of NSF is the merit-based, competitive process that fosters the highest standards of excellence and accountability. The merit review process is one of NSF's critical business functions. Effective merit review recognizes high-quality research, including high-risk, high reward or potentially transformative ideas, empowers NSF to support such proposals, and retains the confidence and trust of NSF's external stakeholders. NSF has the latitude to support emerging fields, high risk ideas, interdisciplinary collaborations, and research that pushes – and even creates – the frontiers of knowledge. NSF uses two criteria as the basis for all proposal reviews: Intellectual Merit and Broader Impacts. The programs and practices which the hard-working and dedicated staff at NSF have created have been emulated around the world. NSF support has nurtured the creative talents of hundreds of thousands of scientists, engineers, students, and educators in every part of the U.S. NSF has supported the discoveries of some 223 American Nobel Prize winners. This represents about 70 percent of all the U.S. Nobel Prize winners since 1950.

As the nation's fundamental research funding agency, NSF is unique. Our mission is as broad as science itself. We support all fields of fundamental science and engineering (S&E), and STEM education in one agency, keeping our nation's scientific enterprise focused on the frontiers of research and education. We recognize and nurture emerging fields, encourage the most insightful ideas, and prepare future generations of scientists and engineers.

Reflection

In a few years, NSF will celebrate its 70th birthday. As we reflect on the enormous impact the agency has had on every facet of society, we can say with certainty that the results of frontier research funded by NSF have a long record of improving lives and meeting national needs. They are the very bedrock of economic growth; the path to sustainability in energy, agricultural, and environmental domains; the seeds of the next technology revolution; and the foundation for advances in medicine and national security.

From the beginning, NSF has focused on the frontier, where discoveries – and discoverers – begin. An example of frontier research is the first direct detection of gravitational waves by NSF's Laser Interferometer Gravitational-Wave Observatory (LIGO) just last year. This historic discovery first began to be funded by NSF in the 1970's as a transformational idea to test one of the predictions of Einstein's theory of General Relativity. The sources of the gravitational waves thus far discovered have been identified as the merger of large black holes in binary systems. This interpretation could not have been made without computer modeling and simulations, performed by NSF-funded researchers on NSF-funded supercomputers. The direct detection of gravitational waves is an example of high-risk, high-reward government funding of basic research. It illustrates the importance of NSF and its role in making transformative discoveries.

This discovery last year is a beginning, not an end. In much the same way as when Galileo first turned his telescope towards the night skies or when radio astronomy transformed our view of the universe, we now have a tool to probe the most violent phenomena in the furthest reaches of the cosmos.

The majesty of discovering our universe motivates ambitious experiments, but as with all fundamental science, LIGO offers other important benefits. This science will advance education, inspiring students and developing the workforce our society requires. It has, and will continue, to lead to collaborations in engineering, computer science, and other fields. This project has already led to other unpredictable

advances, enabling technology spin-offs ranging from vibration isolation to mirror coatings to vacuum technology, that make the Nation more competitive. Significantly, industrial manufacturers were crucial partners in an effort driven by the goal of making an unprecedented measurement.

NSF has several programs to create and expand partnerships with the business community. I will briefly touch on two of these programs. **The Industry–University Cooperative Research Centers (IUCRC) Program** was created in 1973 to develop long-term partnerships among industry, academe and government. NSF invests in these partnerships to promote research of mutual interest, contribute to the nation's research infrastructure base, enhance the intellectual capacity of the engineering and science workforce, and facilitate technology transfer. NSF currently supports 77 IUCRCs involving over 200 university sites. Each center has, on average, approximately 17 industrial partners. For every dollar provided to a center from the NSF IUCRC Program approximately seven dollars are provided by the industry members and other sources. More than 2,000 students conduct research at IUCRCs each year, and approximately 30% of those students graduating each year are hired by the center's member companies. **The NSF Innovation Corps (I-Corps™) Program** enables engineers and scientists to translate new discoveries into technologies with near-term benefits for the economy and society. Eight I-Corps Nodes and 56 I-Corps Sites form a National Innovation Network that stimulates the formation of I-Corps Teams that each include a technology expert, student entrepreneur, and a business mentor. The I-Corps Nodes then provide the training for those Teams. To date more than 900 Teams have completed the I-Corps Program resulting in the creation of more than 350 startups.

NSF provides a much-needed bridge between research and discovery that would otherwise be neglected and remain untapped by the commercial marketplace. In the 1970's, research on solid modeling by NSF-funded scientists at Carnegie Mellon University led to widespread use of Computer-Aided Design and Computer-Aided Manufacturing, which together have revolutionized much of the U.S. manufacturing industry. NSF encouraged investigations into design problems that neither private firms nor federal mission agencies were willing to address because of their long-term, high-risk nature. Many more examples of NSF returns on investments can be found in the addendum to this testimony.

Leadership

During my tenure as Director of NSF I have been witness to discoveries 40 years in the making, and I have had the privilege of meeting and interacting with talented researchers and students from all over the world. In addition, I have worked with a remarkable staff dedicated to the mission of NSF. It is a privilege to lead such an agile, capable organization.

For any organization to survive and thrive it needs responsible leadership. NSF has worked closely with Congress, the community, industry, and outside experts to be responsive to the changing priorities for science, engineering, and STEM education, as well as transparency and accountability in our award process, and the management of our multi-user facilities, among other things. We appreciate the opportunity to work with this committee and others to make NSF the best it can be, and look forward to continuing to make progress.

Leadership is about looking ahead, and that is why NSF came up with "10 Big Ideas" on the cusp of a breakthrough. NSF's 10 Big Ideas focus on: (1) pushing the existing boundaries of knowledge; (2) pinpointing new opportunities to seize; and (3) closing gaps – enabling these and more big ideas to move us beyond the minimum requirements needed to keep pace with other competitive nations. They are briefly described in an attached document.

Federal investments in fundamental science and engineering and STEM training are increasingly important to help establish U.S. leadership in next-generation technologies, especially as other nations intensify their support of research, development, and education. U.S. leadership is important in part because there is unprecedented global competition for the world-class talent who generate innovative scientific ideas and make up the technical workforce.

STEM Education and the AICA

NSF is unique among agencies in its integration of education and workforce development activities with fundamental research in all areas of science and engineering. The goals of the American Innovation and Competitiveness Act of 2017 align with this integrated mission, and implementation of the STEM education provisions are well underway. NSF's investment in STEM education is in the national interest, as it is designed to establish the evidence base for the most promising education practices for building the nation's STEM workforce at scale. NSF's implementation of the STEM education provisions in AICA emphasizes the improvement of STEM education to prepare tomorrow's workforce.

NSF administers programs that are key to the preparation of the STEM workforce in strategic areas of national need. The Cybercorps: Scholarships for Service prepares students to join the Federal, state, and local governments as cybersecurity experts. The Robert Noyce Teacher Scholarship program recruits STEM majors and prepares them to be highly effective elementary and secondary science and mathematics teachers in high-need local educational agencies. Diversity, inclusion, and broadening participation in science, technology, engineering, and mathematics (STEM) are essential to the development of a strong and innovative STEM workforce for our nation. NSF INCLUDES (Inclusion across the Nation of Communities of Underrepresented Discoverers in Engineering and Science) furthers NSF's commitment to building a diverse and well prepared STEM workforce by taking a comprehensive approach to fully engaging the nation's talent in STEM in order to secure our Nation's long-term economic competitiveness.

The integration of science and education is well illustrated in such programs as NSF's Advancing Informal STEM Learning (AISL) program. AISL provides opportunities for partnership between experts in learning and communication with scientists across the NSF directorates to design and study the most effective ways of engaging broad audiences with science and engineering outside of formal education settings. And, in the NSF-wide Improving Undergraduate STEM Education (IUSE) and Research Experiences for Undergraduates programs the education experts partner with researchers in the science and engineering disciplines to provide the most effective research experiences early in an undergraduate's tenure. Increasingly we are encouraging partnerships among 2-year and 4-year institutions, and studies of the effectiveness of different approaches. Projects with course-based research experiences in introductory/first-year courses are also funded by IUSE and provide another way for a beginning undergraduate to have a research experience. And, efforts to better understand how students come to learn the important skills of computer science and computational thinking are addressed across multiple programs.

AICA provides a useful blueprint for NSF's continued critical contributions to the development of a skilled and diverse STEM workforce, and we appreciate your recognition of the leadership role expected of the agency in providing an evidence base for the improvement of STEM education through continued integration of science and education, and coordination with colleagues across agencies.

Striving for Excellence

Transparency and Accountability – Working closely with our congressional authorizers and appropriators, especially this committee, NSF has taken up the charge in promoting transparency and accountability. Indeed, NSF transparency and accountability efforts are well-aligned to Section 102 of the AICA. They assure the public value of scientific research through clear communication of the merit review process, the resultant grants that are funded, and the potential impact for our nation that can accrue from these grants.

Since NSF provides information about its processes and awards in many different ways, we created a single Transparency and Accountability web page during the past year to link to a broad range of NSF activities (see https://nsf.gov/od/transparency/transparency.jsp). This page now provides links for the public to a diverse array of information including reports to the National Science Board on NSF's merit review process, our plan for public access to the results of NSF-funded research, budget and performance reports, Committee of Visitors reports, and more.

NSF's transparency and accountability initiative has focused on increasing the clarity of the language used to describe new awards in recognition of the fact that titles and abstracts are an important way to communicate with the public. Policies were put in place emphasizing the need for each award title and abstract to clearly convey, to a broad audience, the nature and importance of the funded activity. In support of the new policies, NSF enhanced its training and internal communications on the writing of titles and abstracts. The combination of the new policy and training has begun to improve the quality of the titles and abstracts, and NSF will continue to monitor results to ensure continuing improvement. We were pleased that the AICA recognized that "the Foundation has improved transparency and accountability of the outcomes made through the merit review process."

Management of Large Facilities – The members of this Committee, the NSF Inspector General (OIG), and the expert panel assembled by the National Academy of Public Administration (NAPA) have all been helpful to the agency in identifying areas where NSF can improve and make our oversight of critical science-support facilities even stronger. The NAPA report emphasized the need for heightened accountability and oversight, particularly with respect to large-scale research infrastructure, as NSF pursues its mission to support basic research at the frontiers of science and engineering. The agency is committed to improving the rigor and oversight of its processes and deploying appropriate levels of project, programmatic, and financial management expertise.

NSF has done a substantial amount of work over the past few years and the NAPA report has allowed us to sharpen our focus over the past year in particular. I'm very pleased to report to the Committee, that NSF has fully evaluated nearly all of the NAPA recommendations and fully implemented what we consider to be the highest priority items. Only a few are still undergoing internal discussion and will require a reasonable amount of additional time to implement. This effort, and our close coordination with your staff and our OIG, has made NSF nearly fully compliant with the requirements of the American Innovation and Competiveness Act related to major science facilities. We expect that we will only have to make minor procedural adjustments related to Independent Cost Estimates and the cadence of incurred cost audits. Those procedural adjustments are now underway and, as with the rest of the COMPETES requirements, will be implemented on all current and future projects.

Conclusion

Madam Chairwoman, NSF maintains its longstanding commitment to supporting research that drives scientific discovery, maintains America's global competitiveness, and builds the modern workforce that is critical for addressing the complex challenges that face the Nation. NSF's broad portfolio positions the agency to contribute productively and rapidly to important national challenges. NSF is vital because we invest in basic research and people who make the discoveries that transform our future.

With the continued support of this committee, the community, and outside experts, NSF will continue to thrive in its mission to "promote the progress of science."

Dr. France A. Córdova
Director
National Science Foundation

Photo by NSF/Stephen Voss

France A. Córdova is an astrophysicist and the 14th director of the National Science Foundation (NSF), the only government agency charged with advancing all fields of scientific discovery, technological innovation, and science, technology, engineering and mathematics (STEM) education. NSF is a $7.5 billion independent federal agency; its programs and initiatives keep the United States at the forefront of science and engineering, empower future generations of scientists and engineers, and foster U.S. prosperity and global leadership.

Córdova is president emerita of Purdue University, and chancellor emerita of the University of California, Riverside, where she was a distinguished professor of physics and astronomy. Córdova was the vice chancellor for research and professor of physics at the University of California, Santa Barbara.

Previously, Córdova served as NASA's chief scientist. Prior to joining NASA, she was on the faculty of the Pennsylvania State University where she headed the department of astronomy and astrophysics. Córdova was also deputy group leader in the Earth and space sciences division at Los Alamos National Laboratory. She received her Bachelor of Arts degree from Stanford University and her doctorate in physics from the California Institute of Technology.

More recently, Córdova served as chair of the Board of Regents of the Smithsonian Institution and on the board of trustees of Mayo Clinic. She also served as a member of the National Science Board (NSB), where she chaired the Committee on Strategy and Budget. As NSF director, she is an ex officio member of the NSB.

Córdova's scientific contributions have been in the areas of observational and experimental astrophysics, multi-spectral research on x-ray and gamma ray sources and space-borne instrumentation. She has published more than 150 scientific papers. She has been awarded several honorary doctorates, including ones from Purdue and Duke Universities. She is a recipient of NASA's highest honor, the Distinguished Service Medal, and was recognized as a Kilby Laureate. The Kilby International Awards recognize extraordinary individuals who have made "significant contributions to society through science, technology, innovation, invention and education." Córdova was elected to the American Academy of Arts and Sciences and is a National Associate of the National Academies. She is also a fellow of the American Association for the Advancement of Science (AAAS) and the Association for Women in Science (AWIS).

Córdova is married to Christian J. Foster, a science educator, and they have two adult children.

Chairwoman COMSTOCK. Now, we'll hear from Ms. Lerner, five minutes.

TESTIMONY OF MS. ALLISON LERNER,
INSPECTOR GENERAL,
NATIONAL SCIENCE FOUNDATION (NSF)

Ms. LERNER. Thank you, Chairwoman Comstock, Ranking Member Lipinski, Chairman Smith, and Ranking Member Johnson, and Members of the Subcommittee. As requested, my testimony will provide an oversight update, discuss continuing management challenges, and outline the Foundation's progress toward addressing OIG recommendations.

I will focus on three of NSF's top management challenges: ensuring accountability over large cooperative agreements, the management of the Intergovernmental Personnel Act program, and the need to ensure the ethical conduct of research.

With respect to the first challenge, NSF uses cooperative agreements to construct its largest and riskiest projects. Since 2010, my office has issued 28 reports containing more than 80 recommendations related to NSF's use and management of cooperative agreements. As a result of this work, NSF has developed new policies, procedures, and guidance which represent important steps towards accomplishing the goal of increased accountability over such projects.

While NSF's actions led to the removal of a significant deficiency on NSF's monitoring of large cooperative agreements from the agency's 2016 financial statement audit, the Foundation's work in this area is ongoing. My testimony will highlight recommendations related to incurred cost submissions, earned value management systems, lifecycle cost surveillance, and management fees, all of which remain open and are critical to NSF's ability to enhance accountability over its large facility projects.

Incurred cost submissions provide information that is critical for adequate stewardship of federal funds. We have recommended that NSF require these submissions annually for projects valued at $50 million or more. NSF has developed a tool to collect expenditure data, which is currently being tested. When awardees start using this tool, we will evaluate the data provided and NSF's actions in response to that information.

We have also recommended that NSF require awardees to certify their earned value management systems, which provide critical information about a project's schedule and cost and validate the data awardees submit to such systems. We are currently reviewing new guidance NSF has developed to address these recommendations.

Because our work has identified risk across the lifecycle of NSF's large facility projects, we recommended that NSF increase end-to-end cost surveillance for such projects, including obtaining current cost estimates and ensuring that awardees' accounting systems can properly handle federal funds. NSF has developed new policies and procedures to address these recommendations and has agreed to have a third-party evaluate their implementation.

With respect to management fees, our audits found that NSF did not obtain support from awardees to determine the need for such a fee and did not review the changes—charges awardees paid using

management fee. We have recommended that NSF require awardees seeking such fee to detail all the sources of revenue. NSF is revising its management fee policy but has not committed to implementing this recommendation.

Moving forward, we will examine how NSF is applying its new policies and procedures for both construction and operations awards and pay close attention to NSF's actions in response to new oversight requirements in the American Innovation and Competitiveness Act. A key contributor to the progress that has been made in this challenge has been the Stewardship Collaborative, which was established by OIG and NSF in 2010 as a collaborative effort to help accomplish the shared mission of proper stewardship of the taxpayers' investment in science.

The second challenge I will address relates to NSF's use of temporary personnel under the Intergovernmental Personnel Act. NSF regularly brings IPAs to NSF under rotational assignments of up to four years. Since IPAs serve in a temporary capacity, there is significant turnover in staff at NSF, especially in executive positions. The Foundation's use of IPAs also comes at a high cost. In 2015, NSF paid nearly $8.9 million for 27 executive-level IPAs.

Finally, because IPAs remain employees of their home institutions while at NSF, most come to the Foundation with known conflicts of interest, which must be identified, managed, and mitigated. We have made recommendations to reduce costs associated with IPAs and to strengthen controls over their conflicts. NSF has begun to take steps to reduce IPA costs and, among other things, no longer reimburses IPAs for lost consulting income. Moving forward, we plan to examine NSF's actions in response to our IPA-related recommendations, as well as its actions in response to the Competitiveness Act, which required the Foundation to report on its efforts to reduce IPA costs.

The third challenge relates to the need to ensure the ethical conduct of research. Research misconduct, defined as plagiarism, fabrication, or falsification in proposed or funded research, damages the scientific enterprise, is a potential use of—misuse of public funds, and undermines the trust of citizens in government-funded research. It is therefore crucial to the integrity of research funded with taxpayer dollars that NSF-funded scientists adhere to the highest ethical standards. NSF takes research misconduct seriously and has been responsive to our recommendations.

My office will continue to utilize the full range of our audit and investigative resources to exercise robust oversight of NSF stewardship of federal funds and to safeguard the integrity of the Foundation's operation. Public trust and confidence demand the highest level of accountability, and we look forward to working with NSF management, the National Science Board, and Congress to achieve this goal.

Thank you, and I am happy to answer your questions.

[The prepared statement of Ms. Lerner follows:]

STATEMENT OF ALLISON C. LERNER

INSPECTOR GENERAL

NATIONAL SCIENCE FOUNDATION

Before the

Committee on

Science, Space, and Technology

Subcommittee on Research and Technology

U.S. House of Representatives

Chairwoman Comstock, Ranking Member Lipinski, and Members of the Subcommittee, I appreciate this opportunity to discuss the Office of Inspector General's (OIG) work to promote the efficiency and effectiveness of the National Science Foundation's (NSF) programs and operations and to safeguard their integrity. My office is committed to providing rigorous, independent oversight of NSF, and I welcome the chance to discuss some of the challenges facing the Foundation, NSF's progress in addressing these challenges, and work that remains to further advance accountability and transparency at NSF.

Background

NSF is an independent federal agency and the funding source for approximately 24 percent of all federally supported basic research conducted by the nation's colleges and universities. In many areas, such as mathematics and computer science, NSF is the major source of federal backing. The Foundation funds approximately 12,000 new awards each year, thereby fulfilling its mission to promote the progress of science. Proposals for funding are assessed by panels of experts as part of NSF's merit review process.

Awards are made primarily as grants to individuals and small groups of investigators, as well as to research centers and facilities where scientists, engineers, and students undertake research projects. The Foundation also uses cooperative agreements and contracts to fund major research equipment such as telescopes, Antarctic research sites, and high-end computer facilities. In FY 2016, NSF was appropriated approximately $7.5 billion to carry out the Foundation's programs and operations.

The OIG is independent from NSF and reports directly to Congress and the National Science Board (NSB). Our mission is to conduct independent and objective audits, inspections, reviews and investigations of National Science Foundation programs and operations, and to recommend policies and corrective actions to promote effectiveness and efficiency and prevent and detect

waste, fraud, and abuse. Consistent with our statutory mandate, the OIG has an oversight role and does not determine policy or engage in management activities involving the Foundation or program operations. Thus, my office is not responsible for managing any NSF programs, nor do we attempt to assess the scientific merit of research funded by the Foundation.

The OIG has two main components: the Office of Audits and the Office of Investigations. The Office of Audits is responsible for auditing NSF's internal operations, as well as the grants, contracts, and cooperative agreements funded by the Foundation. Among its ongoing responsibilities are the annual audits of NSF's financial statements and the annual reviews of NSF's information system security program.

Through our audit work, we are able to monitor management functions that may pose significant financial or programmatic risks to the Foundation. In determining priorities for this work, we consider the results of prior audits and consult with the Foundation's senior management, the National Science Board and Congress, the Office of Management and Budget, and members of the research community supported by the Foundation. In selecting areas for audit, we assess factors such as the risk involved in the activity, the potential for monetary recovery for the government, and the greatest substantive benefit for NSF.

The Office of Investigations (OI) is responsible for investigating allegations of wrongdoing involving NSF programs and operations, agency personnel, and organizations or individuals who submit proposals to, receive awards from, or conduct business with NSF. OI also houses a team of investigative scientists responsible for investigating allegations of fabrication, falsification or plagiarism in NSF-funded research.

We focus our investigative resources on the most serious cases, as measured by such factors as the amount of money involved, the seriousness of the alleged criminal, civil or ethical violations, and the strength of the evidence. When appropriate, the results of these investigations are referred to the Department of Justice for possible criminal prosecution or civil litigation, or to NSF for administrative resolution.

Ongoing Management Challenges

NSF leads the world as an innovative agency dedicated to advancing science. Its awards have led to many discoveries that have contributed to the country and the world's economic growth. Beyond its scientific mission, as a federal agency NSF must be a responsible steward of taxpayer dollars and spend scarce research funds properly. Inattention to its fiscal and administrative responsibilities can compromise NSF's ability to reach its fullest potential.

In this vein, each September the OIG identifies the top management challenges facing the Foundation. I have attached a summary of the top challenges set forth in our most recent Semiannual Report to Congress to this document; the complete version can be found at:https://www.nsf.gov/oig/_pdf/FY17_Mgmt_Challenge.pdf

My testimony today will focus on three of NSF's continuing accountability challenges and the Foundation's progress toward addressing associated OIG recommendations. The challenges are:

- Establishing accountability over large cooperative agreements
- Management of the Intergovernmental Personnel Act (IPA) program, and
- Ensuring the ethical conduct of research

Effective responses to these challenges would help ensure the integrity of NSF-funded projects, and, in the case of the first two challenges, often also reduce their costs. I will discuss each of these three topics in greater detail below.

Establishing Accountability over Large Cooperative Agreements

While NSF fulfills its mission primarily through grants to researchers and institutions to advance promising science, the Foundation also uses cooperative agreements to construct and operate its large research facility projects. As of January 25, 2017, NSF had 459 active cooperative agreements totaling nearly $8 billion. Twenty-two of these agreements are valued at over $50 million each and add up cumulatively to more than $4.4 billion.

Since 2010, my office has issued 28 reports containing more than 80 recommendations to improve NSF's use and management of cooperative agreements for the construction and operation of its high-dollar, high-risk research facilities. As a result of these reports, NSF has developed new policies and procedures to strengthen its monitoring of such facilities.

Among other things, NSF's new guidance requires completion of a Cost Proposal Review Document (CPRD) for each large facility proposal to ensure that a thorough and well-documented record exists of NSF's determination that proposed costs are reasonable. The CPRD is NSF's analysis of whether an awardee's proposed costs are supported adequately and describes NSF's plans for oversight of the award. NSF's new guidance also requires the Grants and Agreements Officer to determine that a project's estimated costs are reasonable *prior* to making a construction award for a facility.

These new policies and procedures represent important steps by NSF toward the goal of increased accountability over the Foundation's largest and riskiest projects. These actions led to the removal of a significant deficiency on NSF's inadequate monitoring of large cooperative agreements from the agency's FY 2016 financial statement audit. While this progress is significant, NSF's work in this area is ongoing.

My testimony will focus on four major categories of recommendations (ones related to the need for annual incurred cost submissions, the validation and certification of awardees' earned value management (EVM) systems and data, the creation of policies requiring end-to-end surveillance of large cooperative agreements, and the oversight of management fees paid to large facility awardees). These recommendations remain open and which are central to NSF's ability to enhance accountability over cooperative agreements for large facilities. My office and NSF management continue to work together to resolve these recommendations.

Incurred cost submissions

Incurred cost submissions, which include certified schedules of direct costs by award and applied indirect expenses, provide information that is critical for NSF to properly discharge its administrative and fiduciary responsibilities as a steward of Federal funds. They are also

essential tools for the conduct of an incurred cost audit. In some cases, the absence of properly prepared incurred cost submissions has added months, and even years, to the time required for audits conducted by my office.

To address this problem, we recommended that NSF require awardees with large facility cooperative agreements in excess of $50 million to submit annual incurred cost submissions to ensure that costs are allowable, reasonable, and in compliance with Federal requirements.

In response to our recommendation, NSF has developed a tool to collect expenditure data from large facilities valued at $100 million or more. This tool and revisions in NSF's Large Facilities Manual are awaiting OMB approval, which NSF expects to receive this month. In addition, the contractor NSF is using to conduct incurred cost audits is testing this tool with one of the Foundation's current large facility awardees.

The effectiveness of this tool depends on the quality of its implementation. When awardees start submitting expenditure data using this tool, we will evaluate both the information being provided and the actions NSF takes in response to that information.

Certification and Validation of Earned Value Management Systems

Proper oversight of a large facility project includes certifying the EVM system used to track the project's schedule and cost as well as validating the information the awardee provides in EVM reports.

Certification of an EVM system is needed to ensure that an awardee maintains an acceptable system, which includes data to support scheduling of work and interim progress reports, among other things. Our examination of thresholds other Federal agencies use when determining whether an awardee's EVM system should be certified found thresholds ranging from $10 million and $50 million.

Although the large facility awardees we have audited receive hundreds of millions of dollars in NSF funding, to date NSF has not required that their EVM systems be certified. In 2017, NSF verified (a process it indicated is similar to certification) the EVM system for the $473 million Large Synoptic Telescope project and the $344 Daniel K. Inouye Solar Telescope, projects which had been under construction for several years.

Validation of the data submitted by an awardee is an important tool for monitoring a project's spending and progress. If data is not validated, there is an increased risk that the information is inaccurate and does not correctly reflect the project's progress. For example, monthly EVM progress reports for the NEON project were not accurate, which undermined NSF's ability to promptly identify problems that ultimately led to NSF having to significantly de-scope the project to avoid an $80 million cost overrun.

We recommended that NSF certify large facilities' EVM systems and validate the EVM data. NSF receives monthly reports from large facility awardees with earned value management information, which is used to measure project schedule and costs. If the EVM system is providing poor quality information, then an overrun may not be detected in a timely manner, as happened with the NEON project.

NSF has developed new guidance requiring verification of large facilities' EVM systems. It also developed new guidance related to the validation of large facilities' EVM systems and data, and

informed us that it has begun validating inputs into EVM systems. We are reviewing the new guidance to assess whether it is sufficiently robust to safeguard Federal funds and will provide feedback on that point to NSF.

End to End Cost Surveillance

Our audits and inspections of NSF's high-dollar large facility construction projects identified risks across the lifecycle of such projects. As a result, we recommended that NSF increase end-to-end cost surveillance for its largest and riskiest cooperative agreements valued at more than $100 million. At the pre-award stage, such surveillance would include obtaining updated cost estimates and audits of awardees' proposed budgets and cost accounting systems/estimating practices. At the post-award stage, the monitoring would include requiring annual incurred cost submissions and incurred cost audits.

In response to this recommendation, NSF issued new policies, procedures and standard operating guidance covering topics from reviewing proposal budgets to incurred cost audits and agreed to have a third party evaluate the implementation of the new procedures. The estimated completion date for the third party evaluation is September 30, 2017.

Management Fees

Management fees have long been provided to Federally Funded Research and Development Centers (FFRDCs) based on a recognition that these centers -- which are typically non-profit entities almost wholly dependent on government funding -- might need to incur costs that cannot be reimbursed by the government. Under such circumstances, management fee was created to enable an FFRDC to be reimbursed for "ordinary and necessary" but otherwise unallowable business expenses that were essential to maintaining the FFRDC's financial viability. Such expenses might include working capital and interest payments.

Audits of NSF's negotiation, award, and management fee for two large facility projects found, among other things, that NSF did not obtain supporting documentation to determine the need for management fee and did not review actual expenditures that awardees paid using management fees to determine if expenditures were for ordinary and necessary business expenses.

We recommended that NFS require that awardees seeking management fee submit a written assertion of need detailing all their sources of revenue. NSF could use such information to help it determine whether the awardee has insufficient access to non-Federal funding to cover otherwise unallowable expenses necessary to maintain its financial viability and thus should receive management fee.

In addition to our recommendations on this topic, the December 2015 National Academy of Public Administration report which examined NSF's use and management of large cooperative agreements recommended that NSF end its use of management fees in cooperative agreements as a means of eliminating the additional management burdens associated with monitoring the award and because of the potential that inappropriate expenses will be funded by such fees.

NSF indicated it will be revising its management fee policies but has not committed to requiring awardees to report on other sources of revenue. It also indicated that it would like to calculate management fee using weighted guidelines similar to those found in contracts. We plan to review the revised policy to assess whether it is consistent with the historical bases for such fees.

OIG's Ongoing and Future Work related to the Management of Large Cooperative Agreements

While the Foundation has made real progress in its management of large cooperative agreements, we will continue to monitor this area because of the unique challenges it poses to the Foundation.

Based on the serious nature of this challenge and the progress that has been made to date, our objective moving forward is to examine how NSF is applying its new policies, procedures and guidance to strengthen accountability for both construction and operations awards from the pre-award stage through the lifecycle of the award. Successful implementation will require sustained management attention, effective communication with the awardee community, clear award terms and conditions, and most importantly, a continuing commitment to change culture at NSF.

We are currently auditing NSF's application of its new policies and procedures in one of its large facility research projects that is nearing the end of the construction phase. We expect to issue that report in the next few months.

Additionally, we are auditing NSF's oversight of a sample of sub-recipients including large facility sub-recipients, in response to a provision in the American Innovation and Competiveness Act. Prior audit work disclosed that NSF could strengthen accountability over significant funding that is awarded to sub-recipients in large facility projects.

As we expand our work to examine NSF's oversight of the operation phase of large facilities, we recently started an audit to determine if NSF's internal controls are sufficient to ensure that the transfer of funds between construction and operation accounts follows applicable Federal requirements.

We will also pay close attention to the actions NSF takes in response to requirements in the American Innovation and Competitiveness Act. The Act contains a number of key oversight requirements related to NSF's large facility portfolio. For instance, it requires NSF to conduct a pre-award analysis of costs before making an award, obtain periodic external reviews on project management and performance, retain control over funds budgeted for contingency, and to establish guidelines regarding inappropriate expenditures associated with all fee types.

Management of the Intergovernmental Personnel Act Program

To further the agency's mission of supporting science and engineering research and education, NSF draws on scientists, engineers, and educators on rotational assignment from academia, industry or other eligible organizations. All of the non-permanent appointments are Federal employees with the exception of those who come to NSF under Intergovernmental Personnel Act (IPA) assignments. Individuals on IPA appointments remain employees of their home institutions. As a result, pay and benefits for IPAs are set by their home institutions and are not subject to limitations on Federal pay and benefits.

While there are benefits that come from having IPAs at NSF, there are also challenges. For example, because IPAs can serve in a temporary capacity only up to four years, there is

significant turnover in staff at NSF, especially in executive positions charged with leading the Foundation and setting its vision. As of December 2016, five of the seven Assistant Directors, whose primary responsibility is providing leadership and direction to the Foundation's scientific directorates, are IPAs (one Assistant Director slot is vacant). In addition, as of the same date, 20 out of NSF's 29 scientific divisions are led by IPAs (2 of those positions are vacant).

The Foundation's use of IPAs comes at a high cost and these costs are rising. In 2015, NSF paid nearly $8.9 million[1] for 27 executive-level IPAs, compared to $6.5 million for the same expenses for 21 executive-level IPAs in 2012. IPA salaries can also significantly exceed the salaries of the highest paid Federal employees. In 2015, the highest executive-level IPA salary was more than $440,000, up 45 percent from $301,247 in 2012. In 2015, the salaries for all but two executive level IPAs were more than the highest salary of a Federal employee at NSF. The number of IPAs has also increased--in 2009, there were 20 executive-level IPAs, whereas there were 29 executive-level IPAs in December 2016.

Finally, because most IPAs remain employees of their home institutions while at NSF and expect to return there after their tenure at the Foundation ends, most come to NSF with known conflicts of interests. In light of the Foundation's reliance on IPAs to make funding decisions, it is critical that strong controls be in place to identify and mitigate conflicts of interests that occur as a result of IPAs' own research activities or their connections with their home institutions. In June 2015 we issued a Management Implication Report (MIR), which disclosed a significant breakdown of numerous controls over an IPA's conflicts in one directorate.

Since 2010, we recommended that NSF evaluate ways to reduce IPA costs and have suggested, among other things, that the Foundation consider expanding the use of telework for IPAs and seeking greater cost sharing from IPAs' home institutions. Because IPA salaries and benefits are funded with program-related appropriations, savings in IPA costs would free up funds for additional research. We also made recommendations intended to enhance the Foundation's ability to manage IPA conflicts of interests.

In response to our recommendations related to the costs of IPAs, NSF no longer reimburses IPAs for lost consulting income; previously IPAs could receive up to $10,000 from NSF each year for consulting income they received while at their institutions. NSF also formed a steering committee in April 2016 to explore opportunities to reduce IPA costs. To this end, NSF indicated that it will pilot a required 10 percent cost sharing of IPAs' academic-year salary and fringe benefits in FY 2017.

In its August 2015 response to our MIR, NSF management asserted that existing controls were sufficient to address potential rotators' COIs. On March 3, 2017, the NSF Director issued a memorandum stressing how important it is for all employees and rotators to uphold the highest ethical standards. The memorandum also urged employees to take seriously their obligations to attend ethics training and to file timely financial reports.

Moving forward, we will continue to monitor NSF's actions in response to our IPA-related recommendations. We will also examine NSF's actions in response to the American Innovation

[1] Includes salary, fringe benefits, lost consulting, and per diem.

and Competitiveness Act, which required the Foundation to report on its efforts to cut costs associated with employing IPAs.

Finally, in the next few weeks we expect to release a report assessing NSF's controls over rotators' COIs with an emphasis on the Foundation's progress in addressing recommendations from our June 2015 MIR.

Encouraging the Ethical Conduct of Research

Research misconduct—defined as plagiarism, data fabrication, or data falsification in proposed or funded research--damages the scientific enterprise, is a potential misuse of public funds, and undermines the trust of citizens in government-funded research. Falsification and fabrication in NSF-funded projects can literally cost lives, while plagiarism in such work is dishonest (and potentially actionable). It is therefore crucial to the integrity of research funded with taxpayer dollars that NSF-funded scientists adhere to the highest ethical standards as they carry out their projects. For these reasons, we continue to pursue allegations of research misconduct by NSF-funded researchers.

In recent years, we have seen a significant rise in the number of substantive allegations of research misconduct associated with NSF proposals and awards. Over the past four years, we have reported 175 research misconduct cases in our semiannual reports to Congress

Examples of significant cases include plagiarism by a full professor who claimed that he did not know that he should use quotation marks when he copied text into his NSF proposal; falsification by a graduate student who lied to university officials and pursued a legal challenge to an OIG subpoena; and data fabrication by a graduate student who improperly manipulated data.

NSF takes research misconduct seriously, as do NSF's awardee institutions. During our most recent semiannual reporting period, institutions took actions against individuals found to have committed research misconduct, ranging from letters of reprimand to termination of employment. Over the past four years, NSF's actions in response to our recommendations ranged from a letter of reprimand to a 5-year government-wide debarment.

NSF and OIG recently developed a new system to track the Foundation's response to our recommendations related to our research misconduct investigations. This system provides increased transparency and helps both NSF and OIG track the status of the recommendations.

We also perform outreach to universities and others in the research community to provide training and preventing, detecting, and investigating research misconduct. These efforts include briefings with university investigation and inquiry committees, research administrators, and graduate school officials, among others. In addition, our website contains links to all research misconduct case close-outs, which illustrate the fact patterns from our cases that can be used for training.

We will continue our investigative and outreach efforts in this area. In addition, in the next few weeks, we expect to issue a report detailing the results of our survey of institutions' efforts to implement Responsible Conduct of Research training required by the American COMPETES Act of 2007.

NSF/OIG Efforts to Strengthen Accountability: The Stewardship Collaborative

In conclusion, I would like to highlight the joint efforts NSF and OIG have made to improve the stewardship of Federal funds. OIG and NSF established the Stewardship Collaborative in 2010 to help achieve a shared mission – the proper stewardship of taxpayers' investment in science, engineering, and education.

The Collaborative is comprised of staff from NSF's financial administration division and OIG's Office of Audits, and is chaired by Senior Executive leaders from both offices. It meets monthly to discuss current issues and identify possible upcoming barriers to resolution, as well as potential solutions. For example, it recently sponsored joint training to improve understanding of the audit resolution process, including participants' individual responsibilities.

In addition to increasing positive communication between NSF and OIG, the Collaborative has been instrumental in ensuring that management decisions are made by the right people within NSF. It has thus helped resolve a number of critical audit recommendations more efficiently. Most importantly, the Collaborative has facilitated accountability over the use of Federal funds without compromising OIG's independence, a fundamental tenet of the Inspector General Act.

Conclusion

Scientific research and discovery are the building blocks of the technological advances that are essential for our nation's economy to grow and to meet the challenges of the future, and NSF has an essential role to play in promoting scientific discovery. For the agency to achieve its mission, NSF must spend its research funds in the most effective and efficient manner while maintaining the highest level of accountability over taxpayer dollars.

NSF applies its highest level of attention and scrutiny to determine the scientific merit of the projects it decides to fund. It is imperative that NSF apply the same rigorous attention and scrutiny to its financial management of its programs and operations. My office will continue to utilize the full range of our audit and investigative resources to exercise robust oversight of NSF's stewardship of Federal funds and to safeguard the integrity of the Foundation's operations.

Public trust and confidence demand the highest level of accountability, and we look forward to working with NSF management, the National Science Board, and Congress to achieve this goal.

I would be happy to answer any questions.

Allison C. Lerner, Inspector General, National Science Foundation

Allison C. Lerner assumed the duties as Inspector General of the National Science Foundation (NSF) in April 2009. As head of the Office of Inspector General she recommends policies for promoting economy, efficiency and effectiveness of NSF programs and operations. She leads efforts to prevent and detect fraud, waste, and abuse; improve the integrity of NSF programs and operations; and investigate allegations of misconduct in science. Prior to becoming Inspector General at NSF, Ms. Lerner served in leadership positions at the Department of Commerce, including Counsel to the Inspector General.

In January 2015, Ms. Lerner was appointed to serve as Vice Chairperson for the Council of Inspectors General on Integrity and Efficiency (CIGIE). The Council is an independent Federal entity whose mission is to address integrity, economy, and effectiveness issues that transcend individual Government agencies. To accomplish its mission, CIGIE continually identifies, reviews, and discusses areas of vulnerability in Federal programs and operations with respect to fraud, waste, and abuse.

Ms. Lerner has received several national awards for excellence. Ms. Lerner received her law degree and her undergraduate degree from the University of Texas.

Chairwoman COMSTOCK. Thank you.

And I now recognize myself for five minutes for questions.

Dr. Córdova, as I mentioned in my opening statement, I'm very interested in the investments that NSF is making in cybersecurity research and education, and obviously, we are seeing that is a growing area where we need to make sure that our country is on the cutting edge so that we can protect all of our assets, whether they're financial, military, and otherwise.

I see there are some more students here, right? Do have some students here, another group, because we had one earlier? I wanted to recognize you and thank you. What school are you all from? Lake Braddock? Oh, great. So they might be yours, Mr. Beyer's, or some of Mr. Connelly's.

Okay. Great. Well, very nice to have you here. Cybersecurity is an area you can all study, right? Lots of good jobs there. Sorry, I'm off track here.

But anything you might be able to tell us on how NSF can best work with industry to make sure that cyber education programs match the workforce needs and to make sure that we are really responding to this, you know, great need and sort of the crisis we have in having a cyber workforce.

Dr. CÓRDOVA. Thank you for your question, Chairwoman Comstock. Let me take this opportunity to say welcome to the students, and I hope that eventually you will apply for an NSF grant.

Cybersecurity and all things cyber is really the theme of our age. When I was the student's age, we didn't have nearly so much cyber to utilize and do good things for us, nor to also pose the kinds of threats that it does today.

We were very pleased to see Congress' interest in some of the programs that we have like Computer Science for All and our CyberCore programs. Those are two of them. I just want to say a couple of words about each. Computer Science for All has the goal of preparing students for 21st century jobs. NSF has a plan with other agencies too. We do this through our education directorate and also our computer directorate to encourage teacher training in computer science in K–12, and to encourage all students to take computer science because we think that this—combined of course with English and reading and mathematics studies—will make them prepared to do anything.

As a consequence of these programs, NSF is investing in activities to advance effective teaching and learning of computer science. We are supporting the design of instructive materials and scalable and sustainable professional development models and resources.

We also have a program called CyberCorps, which we do with a couple of other agencies. We do it with the Department of Homeland Security and the Office of Personnel Management, and we work closely to monitor trends in the availability of positions in government and evolving needs in the preparation of cybersecurity experts. Every year we hold a jobs fair in January, and this was well attended by some Congressmen and a Senator as well. There we hear from agencies across the government about their needs, and we try to match students who are prepared to take these jobs with those availabilities. Those are just some of the indications.

Of course, you mentioned industry, Chairwoman Comstock, and we have a lot of programs with industry that are very excited about pioneering new methods of including cybersecurity grants to go along with their needs for their industries.

Chairwoman COMSTOCK. Great. Now, on another area in terms of veterans and transitioning them to STEM careers, I wanted to see how NSF is tracking veterans and the hiring of veterans, and if you are able to give us—can you add a box to the form so we know how many veterans are actually getting grants or how much they're involved in the STEM careers where you're working with veterans? Do you have an estimate on veterans' involvement?

Dr. CÓRDOVA. I can prepare a better answer for you that would follow this hearing because I don't know all the details.

I am aware of an event because I've participated in it where we fund veterans as graduate students and we bring them to the agency to talk about what they do how they're transforming their lives. This is a very special Veterans Day event to see the effect that it's had on graduate students, and to hear that one time when they were in the desert and looking up at the stars they decided that when I'm finished with my assignment I'm going to be an astronomer, that sort of thing. They are doing all sorts of STEM-related graduate studies. I know that we have other programs for veterans, and I'll be happy to supply that information later.

Chairwoman COMSTOCK. Great. Thank you.

And I now recognize Mr. Lipinski for five minutes.

Mr. LIPINSKI. Thank you. Dr. Córdova, I just want to—I'm going to ask a very sort of high-level question, but I think it's important to understand—for everyone to understand how the NSF develops—or how the research budget across the different directorates in the NSF—the offices in NSF is developed so we all have a good understanding of how the priorities are established within and across the directorates. Could you give the thumbnail sketch of that?

Dr. CÓRDOVA. There are many, many inputs in setting research priorities for each of the directorates and for the agency as a whole. Those inputs can come from Congress itself, from the White House, and clearly from the science and engineering communities. The National Academy plays a big role as well. In some cases they have studies which they call decadal or ten-year studies that take a year or more to do, and they set out the priorities for particular fields. We are very responsive to all the input that we get.

After that, we have to make decisions with the leadership and the staff about what directions look like they're current, and that we're getting a lot of input on, to pursue and weigh what the budget is that we have in order to look for a balance across the agency to support all fields of STEM engineering. Because, as I said in my opening remarks, we don't know where the next discovery will come from, nor who will make it, and so we want to be sure that we support all of science and engineering.

Mr. LIPINSKI. And in regard to—my understanding is there's much more that is being done now across directorates, across fields. Is that——

Dr. CÓRDOVA. Yes.

Mr. LIPINSKI. —accurate?

Dr. CÓRDOVA. Yes, absolutely. We do a lot of cross-directorate projects. A good example would be our food, water, energy systems studies because food, water, and energy are vital to our economy and the whole globe. Another cross-directorate initiative would be our Risk and Resilience Initiative. We have a lot of risks from earthquakes and floods and hurricanes, all kinds of phenomenon, and we want to be sure that citizens are prepared enough to perhaps mitigate or prevent some of these from happening with such devastating consequences.

I showed a slide of NSF's 10 big ideas, and all of those I would say represent cross-directorate pursuits of the really big research areas where we can make an impact on our future.

Mr. LIPINSKI. And finally, the impact that we see from research in the social and behavioral sciences—I know that's something, as you know, that I have often talked about here because the importance—even though it's a very small part of the NSF budget. Are there any of the—are there any grand challenges in social and behavioral sciences that you can talk about here?

Dr. CÓRDOVA. Well, I think we saw in the video a whole lot of them to do with national security. In any endeavor where there are people involved, either as individuals or as groups, the social sciences become very important. So cybersecurity has already been mentioned a number of times this morning, and I know you've had hearings on cybersecurity and you've learned that—we've all learned that much of our cybersecurity depends on individuals and their responses to make us secure.

I can't think of a sphere of human endeavor that doesn't really need social sciences to inform it. One of our big ideas is called the Human Technology Frontier. We know that, as we're speaking, that life is changing, the way that we work and we play, how we educate ourselves. It is changing because of technology. How do we confront that technology? How do we shape it in order to do good for us and to really make it useful and helpful depends a lot on social sciences and behavioral studies.

So I think it's actually perhaps one of the most important things that we invest in because it touches all aspects of our lives.

Mr. LIPINSKI. Thank you. I yield back.

Chairwoman COMSTOCK. Thank you. I now recognize Mr. Abraham, the Vice Chairman of the Subcommittee, for five minutes.

Mr. ABRAHAM. Thank you, Madam Chair. I thank the witnesses for being here.

I'm a physician by trade, and when I read a journal or a scientific article, unfortunately, the first thing I go to is the author and the research, whether he or she has in the past given a reliable data, and it goes back to our research integrity that, Ms. Lerner, you referenced that over the last four years there's been 175 cases of misconduct in NSF researchers, and that is a major concern because we base policy on this research.

My question is what recommendations have you made to the Secretary as to trying to clean up this research integrity or lack thereof?

Ms. LERNER. Thank you, sir. Each time our office conducts an investigation into research misconduct and determines that there actually was research misconduct, we make recommendations to the

foundation to try to protect its interest. Depending on the magnitude of the problem, the recommendations can range from requiring the individuals when they submit future applications to certify and ensure to NSF that they are not plagiarizing or falsifying or fabricating data. That can include requiring taking training and——

Mr. ABRAHAM. So I assume the last four years——

Ms. LERNER. —responsible conduct of research——

Mr. ABRAHAM. —you have made 75 recommendations?

Ms. LERNER. Yes.

Mr. ABRAHAM. Now——

Ms. LERNER. And sometimes——

Mr. ABRAHAM. —how many of those have been actually done?

Ms. LERNER. The agency has a very strong track record of affirming our——

Mr. ABRAHAM. Good.

Ms. LERNER. —recommendations, including debarring some of the worst offenders from receiving federal funding.

Mr. ABRAHAM. Doctor, do you want to comment or——

Dr. CÓRDOVA. We take this incredibly seriously. In fact, Ms. Lerner and I meet every month, at least once a month, and the very first thing we do is look at these research misconduct examples and say how well we're doing in responding to the recommendations.

Let me also just give a point of view from being a past President of two universities that at the university this is also taken——

Mr. ABRAHAM. Oh, I think it would be.

Dr. CÓRDOVA. —incredibly seriously. So we work in concert with the universities, as Ms. Lerner knows well, in order to make the punishment fit the crime if you know what I mean.

Mr. ABRAHAM. I do——

Dr. CÓRDOVA. We have to be careful there.

Mr. ABRAHAM. And I appreciate that perspective because it's not only in the NSF. It's unfortunately across all scientific borders. But again, because we are responsible for funding, it becomes a point of accountability.

So that'll transition us somewhat to the STEM discussion that is so important. We have students here. And we know the federal government for decades has been involved in STEM research, but unfortunately, we on the STEM side for our students seem to be falling further and further behind. We know private industry needs them, we know government needs a STEM student to step up and take the baton and do great things, as you mentioned in your video.

So my question to you, Doc, is, how can we assure the public that hopefully is listening to some of this that their investment in the NSF first in research is actually going to work?

Dr. CÓRDOVA. We are almost unique among agencies in really tying the research very closely with our educational mission. So that mission is really to encourage STEM education and development of a STEM workforce. We have—we spend over $1 billion a year on the educational mission, and we have programs in graduate school, undergraduate, K–12, teacher training programs, curriculum development programs in order to encourage it.

What we really need to do—and that was emphasized in the two bills that were recently passed——in Women in Science and Women in Entrepreneurship—is that we need to encourage women and underrepresented minorities in general to be role models and to encourage everyone to go into STEM careers.

Just this morning, I read in our NSF News Notes about a young woman at Stanford University, which is where I was an undergraduate, who went into a classroom to take a computer science course, to sit in there and see if she would stay, and there were only two other women in the class so she didn't stay in that classroom. And I had exactly the same experience when I was a student, went to a physics class. I was the only woman in the class. So it took me a long time to get back into physics.

These things really make a difference when you can see people who are like yourself, whether they're in the classroom, whether they're standing in front of you being a teacher or whether they're in informal learning programs that we have at museums and elsewhere, on television shows.

Mr. ABRAHAM. Okay. Thank you, Madam Chair.

Chairwoman COMSTOCK. Ms. Johnson is recognized for five minutes.

Ms. JOHNSON. Thank you very much.

Dr. Córdova, over the years there have been a number of questions about the peer-review process and the National Science Foundation has been very responsive in holding meetings and bringing groups in to listen to what processes it's used. And because of that, I've had hardly any questions recently about this gold standard, but I would like you to review that a little bit for the Committee, the process by which you use to determine the grants that you fund.

Dr. CÓRDOVA. Sure. Thank you. I think you all have a booklet in front of you. If you turn to page six of your booklet so that in case you forget everything I say here, it's there. So merit review is just so critical to everything the NSF does because all of our grants are given through a merit review process.

And so what does that look like? In short, it means that every proposal is reviewed by a minimum of three external people. And usually it's ten or a dozen people. And they're reviewed first separately, and then those reviewers most often come together in a panel meeting at NSF headquarters and talk with each other about the merits of the proposals. The merit reviewers go through a training course. Now, we have a new pilot program that has all kinds of things in it to up their game, to give better feedback to proposers of what—for example, may not be funded, and how to improve their proposals.

We take this process incredibly seriously. In fact, it was a surprise to me when I came to NSF that on any given day, between 200 and 600 visitors, external scientists and engineers, are coming in through the door, and if you just happen to come at the wrong time, know that you have to wait a long time for the elevator as I did this morning to go to these panel rooms and to talk about the individual proposals. They give them very serious consideration.

They then make a recommendation to the program officer, who takes these recommendations from all the proposals and all the dif-

ferent groups and has then to come up with a balanced program. That means one that's nonduplicative, that is really looking, at the national interest, according to the goals of that program officer's program and the larger goals of the whole division, and ask does the recommendation make sense in the context? Then it is the program officers' responsibility to forward a recommendation, or not, to the division director, who then signs off on the proposal.

This is a gold standard I have to underline. It has been so well reviewed. We have committees of visitors, 50 of them in all different subject matters in any given four-year period who come in and review the merit-review process itself and make suggestions for recommendations. It is widely copied by other countries.

Ms. JOHNSON. Thank you very much. Now, there's a hiring freeze on. How has this affected you so far or has it at all?

Dr. CÓRDOVA. Well, yes, it has affected us, especially because we're relocating soon. This summer, we're going to Alexandria where the headquarters will be moved. And so with or without a hiring freeze there is just a natural attrition that goes on when you move. Clearly—so that Mr. Beyer is not worried—we'll have others that come in and want to join NSF and will find Alexandria the very best place to live and work.

It does put a stress at this particular time because we have a hiring freeze, and so if we lose people, we can't backfill them unless they have emergency kinds of positions. So we do have concern about that.

But we have a good agency. If you looked at the Federal Employee Viewpoint Survey, you see that we made number 10 among all medium-size agencies this year on satisfaction of the workforce. By and large, we're good at holding onto people. It's a balance. Are we worried? Yes. Are we overly concerned? No. We're hopeful that we'll get past the hiring freeze and that we will be able to fill these positions, which are critical for science and engineering.

Ms. JOHNSON. Thank you very much. My time is expired.

Chairwoman COMSTOCK. Thank you. And actually, since we're on that topic, just if I can ask a little bit more on that area. What kind of outreach—because I do have constituents obviously who are there, too. And what kind of outreach are—is being done with folks as you have the transition and as people are maybe making that—if they're coming for my part of the area, that's a little further commute, so what are you seeing in terms of expectations?

Dr. CÓRDOVA. That's right. I really have to commend the group, our Office of Information and Resource Management, led by Joanne Tornow and Brian McDonald and her group in particular, who leads the relocation effort. The whole team has just really put a lot of effort into having weekly messages through our NSF weekly wire to staff to hosting workshops and open houses in-house. Recently, on Monday, they brought in a lot of the enterprises from Alexandria like the condos and restaurants et cetera with all sorts of information so that the staff could see that.

We have the head of our union here at this hearing, and he has worked very hard with the union to ensure that the negotiations go very smoothly over various important things, and we are just in the last phases of that now. And so I think the whole thing has gone on with a lot of effort and constant attention to the staff and

their needs and getting to pick out their offices, their space, and how that looks and so on. I think it's gone very, very well, and I'm just very, very proud of NSF. It's a very big deal to move 2,200 people or so, even if it is just 9 miles away. There's a lot of planning that's gone into it. It'll take six weeks in fact for us to fully do that move.

Chairwoman COMSTOCK. Okay. Thank you for letting me address that, a little bit of a parochial issue. Now, I will also recognize Mr. Webster for five minutes.

Mr. WEBSTER. Thank you, Madam Chair.

I was interested in what Mr. Abraham said about us spending lots of money over several decades trying to attract people into STEM. I guess this would be for Dr. Córdova. And yet we're always told we're way behind, keep falling further and further behind. Are there any studies being done to understand what works and what doesn't work? I mean, we were told here a couple weeks ago that every time there was a space launch, there would be lots of people headed towards a career just because of that. And one person told me, who's a Member of Congress, he was attracted by Star Wars movies. So I just wondered if there's any kind of proven way that we can draw new people into STEM fields?

Dr. CÓRDOVA. We have made big investments in trying to understand this better, and the best way to draw them in is to first provide access and to make sure that they can see, and talk with scientists, engineers, and have good curriculum, good teachers in their classrooms.

We are so concerned, Mr. Webster, with this question that when I came into the agency, we started a new program called INCLUDES, NSF INCLUDES. That's an acronym, but it's an acronym that means what it says. And we are now funding 40 pilot programs across the nation to try to move the needle in STEM and have communities of learners. This goes beyond universities. It extends to community colleges, citizens groups, mayors, the whole town getting together to address the particular needs of their communities and how they can bring all those who have not been exposed to STEM more in touch with it.

So we do rely on museums and others as part of this partnership. Every one of these 40 pilot projects is completely different. They're all over the country. We're studying it and we're going to be evaluating it very closely because what we're hoping is that we find programs that scale, that can be replicated, that are really making a difference. Every program has a goal and metrics and they're evaluated against that.

We want to ensure at the end of the day that these INCLUDES programs have done what they said they're going to do. They broaden the participation of people who have not yet know about STEM careers and bring them into that fold and then have something to offer in just the way you're talking about, lessons learned so that others can replicate those kinds of programs.

Mr. WEBSTER. So do we profile? I mean, do you profile what a potential STEM student might look like or be like or act like?

Dr. CÓRDOVA. I think that's impossible.

Mr. WEBSTER. I got an idea. I just thought of one. When I was at Georgia Tech as a freshman, all of us had to take composition,

and they spotted us a C because we only think out of the left side of our brain so maybe there's a start, I don't know. But anyway, go ahead.

Dr. CÓRDOVA. Well, I was an English major when I was in college because people like my parents and friends and teachers all thought that I would go to college to get married and, you know, that's a form of profiling, right? And so little did they know it would be harder to do that than to become a rocket scientist.

But I then discovered actually through television, public television, a show on stars, just like you're saying, you bring people to Florida to watch the space program. I saw the astronauts land on the moon. That was transformative. I saw scientists from MIT talk about dropping marshmallows onto a neutron star, hypothetical marshmallows onto a neutron star and how much energy that would liberate. And I said, wow, that really speaks to me. I've got to do that.

I was the most unlikely person to become a scientist according to anybody around me growing up, but it happened. And it happens because people have those moments of inspiration that really touch them and speak to them, and then they say there's nothing stopping them and they find the pathway.

Chairwoman COMSTOCK. Thank you. And thank you for your passion on that. I met a young student who had scored perfectly on all of his science and he was about 15, 16. He had taken all of these advanced tests already, so being a grandmother I did ask him, was there anything in particular you did or that your mom did? She said watching Little Einstein is what captured his imagination in science and STEM. So my granddaughter now is a big fan at two years old of the Little Einstein show. I think that goes to also capturing children's imagination at a very young age and having programs in school on STEM education, that they don't lose them in that elementary age transitioning into junior high, too. So sorry I'm editorializing along here.

But now let me recognize Ms. Bonamici for five minutes.

Ms. BONAMICI. Thank you very much, Madam Chair and Ranking Member Lipinski, and thank you to our witnesses.

And I'm so glad we're having this conversation. I'm just going to follow up on this briefly. And I'm glad the students are here as well.

I also serve on the Education Committee—Education and Workforce Committee, and I'm the founder and the co-Chair of the bipartisan STEAM Caucus. And STEAM integrates arts and design into STEM learning. It is not detract from it. It enhances it. And we've seen the benefits of STEAM in schools that are using that approach. It's hands-on learning, things like makerspaces, integrating arts and design into STEM learning. It has a lot of benefits.

You mentioned left brain. It engages more students. It also educates both halves of the brain and results in more creative students who are better communicators. And I think your English degree probably has something to do with the fact that you are a great communicator today. There is research that shows that the Nobel Laureates in sciences are much more likely to be engaged in arts

and crafts in their spare activity than other scientists, and they're—the brain research is there to support this as well.

We have model STEAM schools across the country, and I encourage all of my colleagues on this Committee to join the bipartisan STEAM caucus and learn more about the benefits of STEAM.

Dr. Córdova, you outlined the critical ways that the NSF supports research at universities. Oregon State University in my home State is one example. They've really leveraged NSF funding, particularly geoscientists directorate, funding to study the oceans' primary production and food web, as well as to study the coastal impacts of the 2015, '16 El Nino and the consequences for coastal flooding and ongoing beach erosion. So these studies and discoveries are critical not only for coastal communities but also for our global ocean health and food supply.

And I know NSF is a critical funder of basic research in ocean sciences, along with NOAA, but NSF is critical. That research is supported from within the geosciences directorate, which we know has often been the target of attempted cuts. So can you please discuss the importance of those investments to our economic and national security? And I think I'll have time for another question as well.

Dr. CÓRDOVA. First of all, can I just make a STEAM comment——

Ms. BONAMICI. Absolutely.

Dr. CÓRDOVA. —because of students here?

Ms. BONAMICI. You're welcome to.

Dr. CÓRDOVA. Those iPhones or whatever kind of smartphones that you have, students, are the result of a STEAM-like approach——

Ms. BONAMICI. Absolutely.

Dr. CÓRDOVA. They have incredible technologies, all of them, interestingly first funded by the federal government to people in universities, including like the lithium iodide battery and the touchscreens and the microprocessors and all. And GPS of course. Somebody like Steve Jobs and company put all that together with an eye towards very creative design, and then we have something that's amazingly useful and creative to use. So——

Ms. BONAMICI. That's a great example.

Dr. CÓRDOVA. Yes. So on ocean science, yes, of course. Seventy-some percent of the planet is covered by oceans, and it's vital to life. It may have been the source of life on this planet, the beginnings of it itself. It's important for transportation and it's important for the health of our food supply. We, you know, eat fish. We have lots of plants that grow in the ocean.

The science that can be yielded by understanding with our ships, our vessels, our explorers in the oceans, understanding the life in the ocean and the health of the ocean is just so important to our own health and to jobs and to national security and as well as our own security of our coastal communities and so forth.

So it's just very, very important that we have good monitoring of our oceans.

Ms. BONAMICI. Absolutely.

Dr. CÓRDOVA. Yes.

Ms. BONAMICI. I want to get another question in. I'm sorry. I don't mean to interrupt. But NSF has proposed to build a new regional class of research vessel as a cutting-edge platform for scientists to address ocean science questions that are a priority of the National Academies decadal report for ocean sciences. And it's my understanding that the project is on hold because we're operating under a partial fiscal year 2017 continuing resolution. So if Congress approves these vessels, how will they contribute to the advancement of ocean sciences?

Dr. CÓRDOVA. Yes. Everything is still going along as you know, with Oregon State University's leadership, and they will make a recommendation in another month or two about shipyard selection and so forth. Our fleet is aging, and it just simply must be replaced. These vessels have the newest kinds of technologies, and we can actually have fewer ships. The end goal by 2022 is to have something like 15 vessels instead of 18 in the academic research fleet, and that's much more than just NSF. But these RCRVs, research-class research vessels, are integral to that because they do have more technology; they can do more science on them, be more efficient. They can replace the old ships, and we can retire more ships and utilize those with all the latest science.

Ms. BONAMICI. Terrific. Well, we support efficiency. So thank you very much, and I yield back the balance of my time.

Chairwoman COMSTOCK. Thank you. And I now recognize Chairman Smith for five minutes.

Chairman SMITH. Thank you, Madam Chairwoman.

And, Dr. Córdova, let me address a couple questions to you. The first one is I want to thank you for doing your best to implement the national interest standard that we've discussed over the last couple of years. But my question is how are you going to enforce that national interest goal on a grant-by-grant case? What are you doing individually?

Dr. CÓRDOVA. So we have the criteria, as you know, intellectual merit and the broader impact criteria, and this feeds into broader impacts, of course. And we are asking all of our proposers to, in their abstracts, which we now require a nontechnical abstract as well as the——

Chairman SMITH. Right.

Dr. CÓRDOVA. —technical abstracts that are sometimes a little harder for the public to understand. The nontechnical abstract should say what is the importance of this project and which of those many things——

Chairman SMITH. Right.

Dr. CÓRDOVA. —that you mentioned earlier does it address?

Chairman SMITH. And each individual grant applicant gets that guideline, right?

Dr. CÓRDOVA. Gets that guideline, yes.

Chairman SMITH. Okay. And then their grant is evaluated by another individual, and that individual is looking to make sure that standard is met, right?

Dr. CÓRDOVA. The general answer is yes. The person who has the particular responsibility is the program officer. Those program officers are our staff and they have the training.

Chairman SMITH. Do you have any metrics yet as to how many grants have succeeded in meeting that standard and how many have not?

Dr. CÓRDOVA. No.

Chairman SMITH. Just in general. I'm just wondering if——

Dr. CÓRDOVA. Yes. Well, we have been looking with these corrective lenses that you've given us if you call it that since January of the past year, not this year but last year, and so, we are doing what we said we were going to do. And we—in order to be recommended to—remember that only 1/5 of the proposals we get—we get 50,000 proposals a year. We can only fund one out of every five of them at most: those that go up for recommendation to the division leader——

Chairman SMITH. Right.

Dr. CÓRDOVA. That's the kind of thing that would be looked at. I have a person, as I have promised, in my office—his name is Jim Hamos—who works closely with the process and what the guidelines are, and are they being followed, and watches that in a general sense. But we certainly believe, because they go up to the division leaders, who are also trained and are educated about how important this is——

Chairman SMITH. Okay.

Dr. CÓRDOVA. —that they wouldn't go up without that being apart of it. And a proposal can go back to the proposer for corrections, and we do that all the time just so you know, Chairman Smith, that the title is not clear. It doesn't make sense. The abstract doesn't make sense. You haven't addressed this, you haven't addressed that. And ultimately, we've given the program officer the wherewithal to—if it still is not coming back in a good form——

Chairman SMITH. Right.

Dr. CÓRDOVA. —for the public to review, that the program officer, that's his or her responsibility.

Chairman SMITH. All right. Thank you for that. In regard to the occasional—though I understand they may be increasing—research misconduct and fraud, what are you doing to try to correct that prospectively?

Dr. CÓRDOVA. Well, there are official standards about research misconduct and plagiarism and falsification of data, and we are working—you know that most of our grantees are universities and colleges, say 85 percent of them, so we work closely with them. We make sure that they know what the law is and what the guidelines are——

Chairman SMITH. Right. If I could——

Dr. CÓRDOVA. —and then they're judged against them.

Chairman SMITH. If I can interrupt you just real quickly——

Dr. CÓRDOVA. Yes.

Chairman SMITH. —because I don't know the answer to this question. Are there any sanctions to be imposed on individuals who might——

Dr. CÓRDOVA. Oh, yes.

Chairman SMITH. —engage in fraud?

Dr. CÓRDOVA. Oh, absolutely.

Chairman SMITH. What are the sanctions other than denial of a grant or something?

Dr. CÓRDOVA. Well, there's a full spectrum of sanctions, and Ms. Lerner can give you more detail on that. They go all the way from not letting the person submit grants for a few years to debarment. Sometimes, as I mentioned earlier, the punishment has to fit the crime, so if you forget quote marks but you do have the reference there, that is different than intentionally copying something and not giving credit.

Chairman SMITH. Madam Chairwoman, could I have an additional 30 seconds only real quickly for a last question, and this is in regard to dyslexia funding. Not everybody on the Committee may know it, but NSF is spending $2.5 million a year. And I just wonder what you envision the next steps to be in research that will benefit those with dyslexia?

Dr. CÓRDOVA. Yes, I'm glad you asked that. It's part of the READ act. As you know, that's mostly in our 2017 budget, which is on a continuing resolution. Ahead of that that we have been funding the good proposals that we get on dyslexia. I just made a trip to Florida State University to see the MagLab there this week and had a really good talk with their dyslexia folks there.

The challenges for NSF are to find out what its particular role in dyslexia research should be, and that should be very upstream. It should be the fundamental research because we have the National Institute of Child Health Care and Development that funds a lot of research on learning disabilities, and there's also an institute in the Department of Education. The NSF wants to do something where nobody else is touching it in this space.

So to answer your question, Chairman Smith, I think that we need to bring to D.C. in the fall a workshop in which I hope that you will give a keynote and bring together the scholars and workers in this field and talk about what should be NSF's special contribution in this area.

Chairman SMITH. Okay. Thank you, Dr. Córdova.

Chairwoman COMSTOCK. Excellent. Thank you. I now recognize Mr. Beyer for five minutes.

Mr. BEYER. Yes, thank you, Madam Chair, very much.

I often find myself offering respectful disagreement with my Chairman, so I'd like to heap praise on him for his leadership on the dyslexia issue, so thank you, Mr. Chairman.

The—Ms. Lerner, you expressed concern about the increase in the number of IPAs in the executive-level positions and the fact that it's—that they're significantly more expensive because they're paid at the rate of the university, and that it's gone from 20 in 2009 up to 29 in 2016. And it's like seven out of nine of the senior-level positions and—what's the right balance? How do we figure out how many should be long-term permanent government employees at the GS-type rates and how many should be IPAs pulled from the university?

Ms. LERNER. Thank you. Striking the balance is more of the agency's call than mine. I would point out in making the determination as to how to strike that balance you certainly need to consider the strengths and the bench expertise that scientists who have ongoing research practices bring to the Foundation and to the merit-review process, but you have to balance that against the costs and the fact that those costs are paid for out of research fund-

ing. So I would defer to the agency in determining what the right number is, but I think you certainly have to consider both the good and the challenge that comes with the IPAs when you do that.

Mr. BEYER. Thank you. Shifting to the Chairman's question about fraud, plagiarism, things like that, I know that 175 cases over four years with 12,000 grants a year is a little more than 3 cases per 1,000 grants, which I would argue is actually better than our ethical record in the U.S. House. But it's up from where we used to be. So, Dr. Córdova, why do you think that's increasing?

Dr. CÓRDOVA. That's because of the talented Ms. Lerner in her group one could say. Why do we find more cancer? Got better analytical tools. So that certainly could have a bearing on it.

Mr. BEYER. Okay. So it's not necessarily that there is more but it's just we're discovering more.

And, Ms. Lerner, in her long testimony, talked about the big four things she was concerned about and, you know, one by one, number one was incurred cost submissions, awaiting on OMB approval, earned value management systems. You guys have begun validating inputs, end-to-end cost surveillance, third-party evaluation by September 30. Everything looks very responsive on the part of leadership's part. The one question you said that was—the National Science Foundation indicated it will be revising its management fee policies but has not committed to requiring awardees to report on other sources of revenue. And, Dr. Córdova, why have—why is that a hurdle, the notion of asking your grantees to report on other sources of revenue with respect to management fees?

Dr. CÓRDOVA. I'm not sure I'm the best person to answer that so I'll get you a more complete answer after this.

We did make changes in the management fee policy—I'll start with that—as a result of the NAPA recommendations and the recommendations of the OIG. I will say that our group in budget and finance respectively tortured themselves over the question of management fee and how to do it right and looked at a lot of other government agencies and how they do it and adopted the government-wide model of how to handle management fees with the one added change that we do have a list of things that our management entities should not do with the fees.

Asking the kinds of questions that you just said and close monitoring of it, we don't really have the workforce to do this because once you say you're going to do something and monitor it, then you actually have to be responsive to that, responsible, and continually, you know, do it, and that would take a kind of workforce, the type—and a number that we simply don't have. So what we're doing instead are spot checks on where think that the risk is higher because of the cost of the project or because of its sensitivity, any number of reasons, and doing spot checks on utilization of the management fee.

Mr. BEYER. Okay. Great. So—because I think the most painful hearing we've had yet has been the management fees for the alcohol in the Christmas parties. Yes.

Dr. CÓRDOVA. Well, that's on the no-no list.

Mr. BEYER. Okay. Thank you very much. I yield back, Madam Chair.

Chairwoman COMSTOCK. I now recognize Ms. Esty for five minutes.

Ms. ESTY. Thank you, Chairwoman Comstock and Ranking Member Lipinski. Thank you again to Ms. Lerner and to my good friend Dr. Córdova.

I think you can guess where I'm going to be going, Dr. Córdova, given our shared passion around inclusion in STEM. I have a STEM Advisory Committee, and we've been working hard to find ways to encourage underrepresented populations, particularly girls and children of color, to get them excited. I know you've talked about the initiatives in NSF, and I do want to note the President has signed two bipartisan bills, and both of them or on women in STEM coming out of this Committee, which I think is a testament that the Chairman and I sponsored those. And I think that's a testament to the importance of these provisions.

Chairwoman COMSTOCK. And I owe you a pen. I've got it.

Ms. ESTY. Oh, I'll take the pen. Thank you.

So I wanted to ask you a little bit—and this came up in my STEM Advisory Committee recently with a woman, Kelly Johnson, who administers STEM grants and who was talking about sort of the disturbing research that's out there about how early girls self-identify as not being, quote, "smart enough" for math and science and how also I think you've presented some of this information of how when MIT changed its course description for one of its computer science classes to have the subject matter be around social issues and health issues, they found that the participation of women in that course skyrocketed to over 50 percent.

Can you talk a little bit about what you—whether you think NSF has a role and how we could help design curricula in elementary and middle school that would incorporate that growing body of knowledge about what tends to get girls more involved in science and maybe broaden not just experiential work, as my colleague Ms. Bonamici has talked about, but also even subject matters of how are you taking these powerful tools of math and science and applying them to maybe somewhat different issues, maybe broader issues, clean water in Africa, health issues in our inner cities. Could you talk a little bit about that, please?

Dr. CÓRDOVA. We do fund development of course curricula in K–12, and we would welcome proposals that went along those lines, as a result of your Women in Entrepreneurship—because it's all related. It goes back to when you're little—that I think I would be tempted to recommend to my colleagues at NSF that we issue a dear-colleague letter to encourage the submission of that kind of curriculum. I think it could truly make a difference to be exposed those young ages to that kind of curriculum.

I talked earlier about our INCLUDES program, and that we funded 40 pilots in the first round, and we have another round coming up here. That kind of thing would make a wonderful INCLUDES project, too, and I'm sure there are people listening who would be inspired to do that.

Ms. ESTY. Could you talk a little bit about the scaling up? I know that the key part of what you're looking at. And how does NSF propose or what do you think is going to be necessary once you identify programs that can be scaled up? How are we going to dissemi-

nate that information? Because that's a question I've been asked a lot. I think there are a lot of innovative programs around the country and I find even in my own State of Connecticut, in my own district, people in the same field don't even know about projects occurring, you know, two towns away. Do you think—what role do you think NSF or we can play in helping to disseminate information once we identify programs that are really working?

Dr. CÓRDOVA. Yes. Well, it's on all of us to do that of course, but we—we've determined that in the INCLUDES program that we will not only carefully evaluate how these projects are going but we will also take the best practices. And we are bringing together periodically the leaders of these programs to give talks, as they did in January, to each other about how things are going. We do need to remember that documenting the results of a study and putting it in the open—in an open literature, an open website is just incredibly important.

And I know you've mentioned this at our previous hearing, too. I think that this gives us a new start, having this INCLUDES program. It's a great place to see how successful we can be with documenting these programs, putting the lessons learned on a website so that everybody can learn from the experiments of others and can extract what's most valuable from those programs. I think you are really on the leadership edge of this, Congresswoman Esty, and we can do something so that by the next hearing I'll have a better answer.

Ms. ESTY. Thank you very much, and I yield back.

Chairwoman COMSTOCK. Thank you. And I thank the witnesses for their testimony and the Members for their questions. The record will remain open for two weeks for additional written comments and written questions from Members.

And again, I thank our witnesses, both of you, for all of your great work in this very important field and how important it is and appreciate again the students being here. We did share the book you gave us today. We shared it with students so they can bring it back. And I don't know if the students were here when Dr. Córdova showed the video, but that is also on the website. So if you'd like to see that and share that with your other classmates, as well as the book, we hope we will see more of all of you in the STEM and STEAM fields.

So with that, this hearing is adjourned. Thank you.

[Whereupon, at 12:31 p.m., the Subcommittee was adjourned.]

Appendix I

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Dr. France Córdova

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

"National Science Foundation Part I: Overview and Oversight"

Dr. France Córdova, Director, National Science Foundation

Questions submitted by Chairwoman Barbara Comstock, House Committee on Science, Space, and Technology

1. I have many veterans in my district who are interested in transitioning to STEM careers. It is difficult to know how many veterans NSF funding is reaching, as NSF does not track funding of veterans the way it tracks gender, race, and ethnicity, is that correct? All it takes is adding a box to a form. Is that something you would consider doing? How much are current veteran programs being utilized? Do you have any ideas about how we can better reach out to veterans who want to go into STEM careers?

Answer: NSF is very proactive in reaching out to veterans. This is especially evident in the Graduate Research Fellowship (GRFP), the nation's flagship fellowship program, funding Graduate Fellows in all fields of science, technology, engineering, and mathematics. The GRFP has been tracking veteran applicants since 2012, and includes veterans as a targeted group in its program goals. The program goals are: 1) to select, recognize, and financially support, early in their careers, individuals with the demonstrated potential to be high achieving scientists and engineers, and 2) to broaden participation in science and engineering of underrepresented groups, including women, minorities, persons with disabilities, and veterans. NSF especially encourages women, members of underrepresented minority groups, persons with disabilities, veterans, and undergraduate seniors to apply. GRFP has awarded fellowships to 155 veterans since 2012, when we added veterans to our Solicitation and program goals. NSF tracks the veteran status of GRFP applicants and GRFP awardees.

In addition to recognizing the importance of veterans' service and training to the nation, past and present, opening up opportunities to veterans in STEM also provides greater access for women, underrepresented minorities, and persons with disabilities. The percentages of members of these groups among veterans (U.S. Department of Veteran Affairs) are strong and projected to increase.

From FY 2012 through FY 2016, the number of self-identified veteran applicants to the GRFP totaled 587, about 1% of applicants each year. The total number of veteran awardees over the same years is 155. There are currently 137 active Fellows who are veterans.

The importance of supporting veterans in graduate degree programs was highlighted in NSF's Veterans Day Event, *Saluting Veterans in STEM*, held on November 5, 2014. NSF

selected 11 Graduate Fellows who are veterans to come to NSF and present their research. The eleven represented both the enlisted and officer corps in the Navy, Army, Marine Corps, Coast Guard, and Air Force. The veterans included Sergeant First-Class Joshua Jarrell, a third year doctoral candidate in Applied Physiology at the Georgia Institute of Technology, who was the keynote speaker for the NSF Veterans Day Event. He was the senior medic on a Special Forces team in the 1st Battalion 20th Special Forces Group, in the Alabama National Guard. Joshua has recently completed sixteen years of military service, including 8 years in Special Forces, and two combat tours to Iraq. He served in Balad, Iraq in 2003-2004 as a construction equipment operator during the first year of the war, and in Bayji, Iraq in 2011 as a Green Beret medical sergeant during the final year of the conventional war. At Georgia Tech, he studies osseointegration of limb prostheses. Osseointegration is the procedure of anchoring a prosthesis into the residual long bone at the site of amputation, bypassing the need for traditional attachment sockets and vacuum suspension. Joshua is investigating the effects of implant porosity on bacterial resistance in an osseointegrated limb prosthesis.

During the NSF visit, program directors met with the veteran Fellows to discuss their experiences as graduate students and to get their ideas on what NSF could do to help them and other veterans succeed in STEM careers.

Please see some more examples below of some current efforts to engage veterans.

A 'Dear Colleague Letter' detailing supplemental funding available to Principal Investigators to engage veterans in engineering research (Veterans Research Supplement Program) is still active, and is supported by NSF's Engineering Education Center Division (within NSF's Engineering Directorate).
https://www.nsf.gov/pubs/2014/nsf14124/nsf14124.pdf

In addition, NSF's Mathematical and Physical Sciences Directorate released its own 'Dear Colleague Letter' announcing funding supplements for Veterans https://www.nsf.gov/pubs/2015/nsf15024/nsf15024.jsp and NSF's Directorate for Computer and Information Science and Engineering also released a 'Dear Colleague Letter' detailing supplemental funding available for groups underrepresented in computing, including U.S. Veterans.
https://www.nsf.gov/pubs/2017/nsf17021/nsf17021.jsp?WT.mc_ev=click

There is also a NSF-wide 'Dear Colleague Letter' -- Improving Graduate Student Preparedness for Entering the Workforce, Opportunities for Supplemental Support https://www.nsf.gov/pubs/2016/nsf16067/nsf16067.jsp that specifically addresses Veterans' participation in the NSF Graduate Research Fellowship Program.

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

"National Science Foundation Part I: Overview and Oversight"

Dr. France Córdova, Director, National Science Foundation

Questions submitted by Ranking Member Daniel Lipinski, House Committee on Science, Space, and Technology

1. The I-Corps program was reauthorized and expanded in a bill that was signed into law this January. That bill included calls for expansion of entrepreneurship and commercialization training programs, partnerships with federal and state agencies to expand I-Corps training, and funding for proof-of-concept development. Can you provide us with an update on how NSF is working to implement these recommendations? What are your plans for the current I-Corps nodes? In what ways is NSF partnering with other federal agencies to expand the I-Corps model?

   Answer: Since the start of the I-Corps Program in 2011, NSF has funded 8 I-Corps Nodes, 57 I-Corps Sites, and more than 900 I-Corps Teams. NSF currently has an open solicitation, with proposals due March 14, 2017, to fund up to 7 new or renewal I-Corps Nodes. Proposals were received in February 2017 for new or renewal I-Corps Sites with up to 15 expected to be funded. Proposals for I-Corps Teams are received in three time windows each year.

   NSF supports the Partnerships for Innovation – Accelerating Innovation Research (PFI-AIR) Program that provides grants of up to $200,000 for up to 18 months to perform prototyping or proof-of-concept development. Proposals to PFI-AIR are accepted from I-Corps Team participants as well as investigators who have been previously supported by NSF for basic research.

   The State of Ohio was the first state to launch a statewide region of I-Corps - I-Corps@Ohio - where state funds are used to support Ohio university-based teams to go through the I-Corps Program. The third year of the Ohio program is ongoing now. A workshop was held last fall, and representatives from all states were invited to participate and learn more about the I-Corps Program. Multiple states are now evaluating launching a program similar to the program in Ohio. NSF is now planning additional outreach to the states.

   NSF provides training on the I-Corps program to personnel from a number of agencies and makes the I-Corps training available to Teams funded by each agency. NSF has a Memorandum of Understanding (MOU) in place with each of the Department of Homeland Security, National Security Agency, Advanced Research Projects Agency – Energy (ARPA-

E), National Institutes of Health, Small Business Administration, Department of Agriculture, NASA, Department of Energy, and the Department of Defense.

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

"National Science Foundation Part I: Overview and Oversight"

Dr. France Córdova, Director, National Science Foundation

Questions submitted by Representative Don Beyer, House Committee on Science, Space, and Technology

1. The Inspector General has expressed concern about the increasing number of IPAs in executive level positions. There is also concern about the fact that IPAs are significantly more expensive than Federal employees and that those costs are paid with research funding. What is the right balance between long-term Federal employees and IPAs pulled from academia to ensure the best use of NSF's research budget?

   Answer: As of the end of FY 2016, NSF had a total of 170 IPAs with assignments of 10 or more months. The number of NSF IPAs has remained relatively stable over the past few years.

   Data has demonstrated that the costs of IPAs are not significantly more expensive than Federal employees. The use of IPAs varies across NSF directorates and offices, ranging from a low of 11% to a high of 23%, and we are constantly aware of the need to try to strike the right balance. The directorates in which IPAs make up the highest percentages of IPAs also have the highest percentage of IPAs serving as executives (38%-40%), as well as the highest percentages of scientific staff (35%-38%). The total personnel compensation and benefit cost for the NSF workforce (both federal employees and IPAs) in FY 2015 was $247.5 million. Within that, the total cost of the agreements with the 176 IPAs on board at the end of FY 2015 (including grants for salary and benefits reimbursement and payments to IPAs for lost consulting and per diem) was $41.4 million[1]. Considering the compensation and benefit cost of an equivalent number of federal employees during the same time period ($35.7 million), the marginal additional cost for IPAs was $5.7 million. This translates into an addition of approximately 2.3% to the Foundation's overall personnel costs.

   To better manage our IPA program and to further our goal of conducting our IPA program in the most effective and efficient manner, NSF has established a Steering Committee for Policy and Oversight of the IPA program. Under the auspices of this Committee, in FY 2017, NSF began piloting a mandatory 10% cost-sharing toward new IPAs salaries by their home institutions. Historically, NSF requested a voluntary 15% cost share and received an approximate 6% average cost share. NSF has also implemented two new policies to curb IPA costs: the elimination of lost consulting payments and limiting travel reimbursement for trips to the IPA's home institution. NSF is in the process of conducting an evaluation to

explore the consequences of requiring home institutions to share IPA costs within a context of other IPA program changes. The purpose of the evaluation is to determine to what extent the new IPA policy changes impacted the quality of IPAs who are successfully recruited to the NSF workforce during the pilot period, if NSF is missing opportunities to hire strong IPAs because of these changes, and if there is a change in the burden imposed on the NSF recruitment process.

By way of the establishment of the IPA Steering Committee and putting into place an evaluation of the cost elements associated with the IPA program, the NSF Office of the Inspector General has recognized our efforts and closed the sole open audit recommendation on IPAs, which was directed to cost.

1. This estimate includes those IPAs whose assignments in FY 2015 were for 10 or more months. The total cost of all IPAs in FY 2015, including those on assignments of less than 10 months, was $41.9 million

2. IPAs, being at the top of their field, are often placed in supervisory positions within the NSF. Since IPAs are by definition from the private and university sector, which operate very differently from the public sector in both goals and implementation, the relationship between IPAs and career NSF employees is sometimes described as a "clash of cultures." This dynamic can lead to dysfunctional program teams and dissatisfied employees of the NSF. How is NSF working to improve these relationships and ensure IPAs are equipped with managerial tools and skills they need to lead teams?

   Answer: Executive IPAs generally have significant administrative and supervisory experience, having served as department chairs, center directors, and deans at their home institutions. NSF offers a number of resources to Executive and supervisory IPAs new to NSF to help them quickly understand the NSF culture and how to apply supervisory requirements in the Federal context.

   New executives, including IPAs, generally attend a four-day Executive Leadership Retreat (ExLR) during their first 6 months at NSF. There is a segment in the first day of that retreat which explicitly covers the NSF culture and how it differs from academia, the private sector and even other Federal agencies. The ExLR covers how NSF and NSF executives fit within the federal context. There is also an entire day of the ExLR which addresses Oversight of Merit Review for Division Leaders to ensure that incoming Executive IPAs in science directorates have a clear understanding of their roles and responsibilities in NSF's Merit Review process.

All new executives and executive IPAs have the opportunity to work with an Executive Coach who is familiar with NSF, the NSF culture and the role of the executive within the Federal sector. All new supervisors (including Executive IPAs) are required to attend the 3-day Federal Supervision and NSF course which covers all aspects of federal human capital management, including employee relations, performance management, diversity and inclusion, federal labor relations, employee engagement, etc. A separate, full-day Federal Labor Relations course is also a one-time requirement for all new supervisors, including Executive IPAs.

In addition to the learning opportunities above, NSF also offers a number of other supervisory workshops on performance management and coaching, federal hiring and selection, leadership and problem solving skills, and other topics which help supervisors become more effective in their roles.

NSF is continuously expanding and improving the training and resources available to support all supervisors, including IPAs with supervisory responsibilities. NSF has conducted IPA and Executive Engagement Interviews to identify factors that impact recruitment, selection, and retention of a high-performing executive and program director workforce. As a result, NSF is taking action to implement the following:

- Developing guidance on individual check-in meetings. Regular and meaningful check-ins with supervisors are one of the most effective ways to improve a supervisor-employee relationship, drive performance, and foster engagement. The tool will help supervisors conduct effective one-on-one check-in meetings with their staff and serve as a resource for new supervisors.
- Our agency employee engagement action plan calls for enhancing employee-supervisor relationships. As a part of the action planning, we are asking all directorates and offices to include a meaningful action to enhance employee-supervisor relationship. We are currently collecting the plans so we do not have input into what specific actions have been identified.

3. The National Science Foundation has indicated that it will be revising its management fee policies but has not committed to requiring awardees to report on other source of revenue. Why has NSF not asked its grantees to report on other sources of revenue with respect to management fees?

Answer: NSF considered requiring organizations to provide information on other sources of revenue as part of the development of Management Fee policy that was initially published in the Federal Register in December 2014. Public comment received at that time indicated that information specific to other sources of revenue including unencumbered funds such as fees

is generally considered by organizations to be proprietary. Further, based on analysis by the agency, it was determined that the availability of other sources of revenue to an organization should not be set as a determinative factor in NSF decisions to provide a fee. Organizations, including non-profit organizations, often require receipt of a reasonable fee to perform work on large, complex awards. Refusing payment of a fee to an organization based on the fact that the organization has other sources of income would not incentivize highly qualified organizations to compete for NSF large facility awards. NSF's goal is to ensure that awards are made to organizations that are financially viable, and have the technical and business capacity to successfully fulfill complex requirements regardless of whether or not they have other sources of income. NSF plans to implement a revised fee policy to be more consistent with provisions of fees by other federal agencies, which do not collect information on other sources of revenue from awardees

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

"National Science Foundation Part I: Overview and Oversight"

Dr. France Córdova, Director, National Science Foundation

Questions submitted by Representative Jacky Rosen, House Committee on Science, Space, and Technology

1. As a former systems analyst and software developer who worked in the computer science field when women were not a huge part of the tech workforce, I know firsthand the challenges facing women pursuing careers in STEM. When I began my career in the 1970s, I experienced numerous barriers- from wage discrimination to prejudices about women's capabilities in science, technology, engineering, and math. We have thankfully made some improvements since then, but there is still much work to be done.

    a. Please detail some of the work NSF's INCLUDES program is doing to encourage women, and young girls in particular, to get involved in STEM. Are there specific projects within the INCLUDES program that focuses on involving girls in computer science?

    Answer: Broadening participation in science, technology, engineering and mathematics (STEM) is a core value of the National Science Foundation, which employs numerous strategies in order to more fully engage the U.S. population in STEM. NSF INCLUDES is a new program (the first competition was in 2016) whose underlying rationale is that broadening participation in STEM is a national challenge that requires a national solution. The fresh approach of this new research and development program is to develop networks and partnerships that involve organizations and consortia from different sectors committed to a common agenda. While this multi-stage, multi-year initiative is just beginning, several awards have already been made that focus on girls and women. For example, in one project, a group of diverse organizations will collaborate to design and implement a short-term intensive training opportunity in computer science for women ages 16-34 who are unemployed or underemployed. The project includes a custom curriculum, internships or job shadows, and information, coaching, and exposure to college and career opportunities, with the goal of job placement in STEM careers (Linda Christopher, UC-Irvine, award 1649377). Other NSF INCLUDES awards focus on indigenous women (April Lindala, Northern Michigan University, award 1649082), Hispanic women (April Marchetti, Randolph-Macon College, award 1649289), and women in mathematics (Judy Walker, University of Nebraska-Linclon, award 1649365).

One of the initial awards (Lori Pollock, University of Delaware award 1649224) addresses minority youth in grades 5-8 and their access to computer science; this pilot project will be situated in community-based organizations including Boys and Girls Clubs. While NSF INCLUDES awards necessarily focus on particular disciplines or underrepresented groups, the intent is that each will be able to share lessons learned across projects, for the benefit of all

2. In order to remain competitive in today's global workforce, it is imperative that we increase women's participation in STEM fields. We must engage girls at an early age and provide inspiring moments that crystallize into a lifetime dedicated to technological research and advancement. We don't fly to the moon anymore. We don't have these big events that connect us as a nation and impart to these young girls, better than any classroom experience can, that yes, you can achieve if only you dream large enough. That is precisely the sort of thinking we need to be fostering.

    a. What specific actions can Congress take to encourage and inspire the next generation? What can we do to improve STEM outreach for young children, specifically girls? How have NSF grants accomplished this goal in the past?

    Answer: Congress can continue to provide flexibility in NSF research and education programs so that they continue to provide the maximum opportunities for all Americans. NSF employs a full spectrum of approaches to engage girls in STEM, through both informal and formal venues. NSF has a long history of funding out-of-school STEM experiences for youth, especially girls and underserved communities. For example, SciGirls includes a Public Broadcasting Service Emmy Award-winning series that builds on gender research suggesting best practices for engaging girls of ages 9-13 in STEM to change the way that girls think about STEM. SciGirls reaches girls, educators and parents across all digital platforms (including a television show, destination website, outreach activities, and professional development activities with games, problems to solve, and materials for educators). SciGirls is funded by NSF, and its success has attracted funding from nongovernmental organizations as well including the Northrup Grumman Foundation, Infor, The Mosaic Company Foundation and the PPG Industries Foundation and is produced by Twin Cities Public Television. In its 12-year history, SciGirls has reached over 28 million girls, educators, and families (http://national.tpt.org/engagement/scigirls-engagement/).

    Another successful informal learning activity at the K-12 level is "Inspiring the Next Generation of Cyberstars (GenCyber)," a collaboration between NSF and the National Security Agency, that provides summer cybersecurity camp

experiences for K-12 students and teachers. In 2016 there were 30 teacher camps and 80 student camps, including several camps for girls only. The large camp at California State University-San Bernardino was organized with the collaboration of the Girl Scouts of America. In another kind of camp, middle and high school girls were introduced to a computer on a single circuit board (MagLab SciGirls Coding Camp, award 1157490).

Engaging more girls in STEM, including the computer sciences, is supported by NSF both inside and outside the classroom as informed by research on the important factors for the success of girls in STEM education. For example, NSF-funded research, through the Directorate for Social, Behavioral and Economic Sciences, the EHR (Directorate for Education and Human Resources) Core Research program and others, investigates how early interest and confidence in the STEM fields begins as well as strategies for teaching girls computer sciences in a way that attracts them to this field. EHR and the Computer and Information Science and Engineering Directorate (CISE) collaborate on the Computer Science for All program, which utilizes partnerships between researchers and K-12 teachers to help provide all U.S. students the opportunity to participate in computer science and computational thinking education in their schools at the K-12 level. EHR and CISE also collaborate on the STEM + Computing Partnerships program, which advances the integration of computational thinking and computing activities into STEM teaching and learning from the early grades through high school to develop the essential skills, competencies, and dispositions needed to succeed in a computationally-dependent world. The NSF Innovative Technology Experiences for Students and Teachers (ITEST) program, funded with H-1B Visa receipts, supports projects to help understand how to foster preK-12 student interest in and capacity to pursue occupations in STEM, particularly in information and communications technologies. ITEST has funded numerous projects focused on girls in STEM, including on stimulating the interest of girls in computer science (Jody Clarke-Midura, Utah State University, award 1614849).

Research has shown that role models are important, so strong female role models both inside the classroom and outside are important at every educational level. Teacher preparation is supported by NSF's Noyce Teacher Scholarship program; NSF's ADVANCE program promotes gender equity in academic STEM careers. NSF's competitive scholarship and fellowship programs, e.g. the Graduate Research Fellowship program; Bridges to the Doctorate program; CyberCorps®: Scholarship for Service program, provide funding to eligible applicants so that they can earn advanced degrees if they choose. NSF funds Women in Cybersecurity, a continuing effort to recruit, retain, and advance women in

cybersecurity (Ambareen Siraj, Tennessee Technological University, award 1303441).

Responses by Ms. Allison Lerner

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

"National Science Foundation Part I: Overview and Oversight"

Ms. Allison Lerner, Inspector General, National Science Foundation

Questions submitted by Ranking Member Daniel Lipinski, House Committee on Science, Space, and Technology

1. In your testimony you stated, "In recent years, we have seen a significant rise in the number of substantive allegations of research misconduct associated with NSF proposals and awards. Over the past four years, we have reported [75] research misconduct cases in our semiannual reports to Congress." Can you expand on this statement?

   OIG RESPONSE: The 75 research misconduct (RM) cases (attached) cited in testimony were reported in our Semiannual Reports to Congress from March 2013 through September 2016. They represent all the referrals that OIG made to NSF recommending findings of RM for plagiarism, fabrication, and/or falsification in those eight semiannual periods. These cases illustrate the range of RM cases OIG referred to NSF.

   a. At the time of your testimony, which was prior to your office having compiled and organized the historical data on research misconduct, on what basis did you conclude there had been a "significant rise" in substantial allegations? Now that you have compiled the historical data and shared it with the Committee, what statistical trends, if any, would you calculate or qualitatively conclude from the data, and on what basis?

      OIG RESPONSE: In answer to your first question, the statement about an increase in the number of substantive allegations of research misconduct was based on the increase we saw in the number of allegations of data falsification and fabrication by graduate students or postdocs over the period from FY 2004 through FY 2016. There were more than twice as many such allegations in the period from FY 2011 through FY 2016 than there were in the period from FY 2004 through 2010.

      With respect to your second question, now that we have compiled statistics over a 12-year period for research misconduct allegations received, research misconduct investigations opened, and the outcomes of research misconduct investigations (including debarments), we have more data about the types of allegations we have received over time, the number of investigations that resulted from those allegations, and the impact of those investigations. As noted on the chart we prepared and in our response to question 1c, however, even with this expanded

body of information there are real limits as to the conclusions that can be drawn from it, especially with respect to the data related to allegations.

In addition, the conclusions you draw from the data can vary depending upon the way in which you look at it. If you look at the number of investigations into fabrication or falsification that were opened over the 12 years covered by the chart, for example, you can find support for the idea that such investigations have been increasing over time (there were 46 such investigations from 2005 through 2010, while there were 100 such investigations from 2011 through 2016). Similarly, if you look at the percentage of investigations opened that were related to fabrication or falsification versus plagiarism for FYs 2012-2016, you see that the percentage steadily increased from 13% to 38%. However, if you look at the number of allegations of fabrication and falsifications for the past five years, you will see that the number of such investigations varied from year to year and did not steadily increase.

Our goal in creating this chart, which we plan to update at the end of each semiannual reporting period, is to provide as much transparency as possible about the makeup of our research misconduct investigative caseload. We will also strive to make the limits of the data clear. Most importantly, the data contained in the tables only reflects matters that have come to our office's attention; it should not be construed as representing *all* occurrences of research misconduct in proposals received and/or funded by NSF.

b. What is the significance of the reported number of 75 research misconduct cases that you cited in your testimony? Specifically, what types of cases are and are not included, and how, if at all, does it align with the statistical table you later provided?

OIG RESPONSE: As noted above, the 75 research misconduct cases cited in testimony were reported in our Semiannual Reports to Congress from March 2013 through September 2016. They represent all the referrals that OIG made to NSF recommending findings of RM for plagiarism, fabrication, and/or falsification in those eight semiannual periods and illustrate the range of RM cases OIG referred to NSF. As noted on the attached document, there were a couple of exclusions for cases related to suspensions or voluntary settlements.

The 75 referrals reported in the Semiannuals do not align with the information contained in the tables, which, as noted previously, report on allegations received, investigations opened, and investigative outcomes. A referral is an investigative step that occurs when we have completed our review of a matter and determined what actions to recommend to the agency.

c. What, if any, limitations are there to the data and/or trend analysis of the 12-year data history that Congress should be aware of?

OIG RESPONSE: As we note on the tables themselves, there are substantial limits on a user's ability to identify trends in the allegations we have received over time because of the varying ways we collected allegation-related data over the 12 years reflected in the tables. A further limitation on the ability to identify such trends arises from the fact that we ran several proactive assessments looking for plagiarism over the years encompassed in the tables, which inflated the number of plagiarism allegations we had in some years. We ran the last such proactive in 2013, but allegations resulting from it were still being identified in 2014.

Finally, differences in the way we counted allegations before and after moving to our new investigative case management system further undermine the ability to identify trends in this area. Prior to moving to the new case management system, we counted allegations by the number of individuals who could have been responsible for the violation at issue, so if a PI, a co-PI and a grad student could have been responsible for plagiarism in a proposal, we counted three allegations. Under our new system such a situation would be coded as one allegation. Our hope is that, moving forward with our new system we will have consistent allegation-related data that can be more useful.

A further limitation of the data in the tables results from the time it takes to conclude a research misconduct investigation. Because it can take a year or more for us to complete our investigation and for NSF to make a finding, the tables showing allegations and investigations by FY cannot be directly correlated to the table of findings by FY.

Finally, the tables only provide information about allegations that come to our office's attention and cases we open. Accordingly, they do NOT reflect the total universe of research misconduct related to NSF proposals or awards, only a subset. Based on our previous experience running plagiarism-focused proactives, we could easily increase the number of such allegations and cases if we ran another proactive. It is also quite likely that there are fabrication and falsification cases that do not come to our attention. Given the many different ways data can be fabricated or falsified, and the fact that the evidence for such violations often resides at NSF awardees, and not NSF itself, we have not yet identified a way to run a fabrication/falsification-focused proactive and test this assumption.

Breakdown of 75 "cases" reported from our Semiannual Reports

SAR	# Reported RM Cases	Comments
Sep-16	6	
Mar-16	5	
Sep-15	5	
Mar-15	12	1 case in the SAR was for suspension of an award, not RM (pg. 18)
Sep-14	10	
Mar-14	12	
Sep-13	13	2 of the write-ups described 2 separate cases within them (pgs. 40-41)
Mar-13	12	1 case in the SAR was for a voluntary exclusion (pg. 46)
Total	75	

The number of reported RM cases represents the referrals that OIG made to NSF for RM Findings. In the count, we did not include any referrals for other than RM, or other actions taken, such as a voluntary exclusion.

NSF OIG Research Misconduct Statistics for FY05 through FY16

Allegations and Investigations

FY	RM Allegations Received[1]				RM Investigations Opened[2,3]			
	P	Fab	Fal	Total	P	Fab	Fal	Total
2005	86	11	3	**100**	66	3	2	**71**
2006	67	8	7	**82**	48	3	5	**56**
2007	90	8	6	**104**	67	6	0	**73**
2008	132	7	10	**149**	99	5	6	**110**
2009	108	0	11	**119**	83	0	10	**93**
2010	90	4	10	**104**	70	3	3	**76**
2011	85	17	15	**117**	58	15	8	**81**
2012	96	9	8	**113**	80	7	5	**92**
2013	84	10	11	**105**	80	8	10	**98**
2014	37	7	5	**49**	35	7	5	**47**
2015	64	9	11	**84**	64	9	11	**84**
2016	35	10	11	**56**	24	6	9	**39**
Totals	974	100	108	**1182**	774	72	74	**920**

Notes:

1. Key to allegations: P = Plagiarism; Fab = Fabrication; Fal = Falsification. Allegations were made against both funded and declined NSF proposals.

Over the reporting period FY05-16, we used 3 different methods of capturing allegation data. The periods were: FY05 through FY12; then FY13, when we were granted Statutory Law Enforcement authority, through FY15; and finally FY16 onward, when we switched to a new Investigative case management system. For this reason, you cannot make a meaningful comparison or identify trends related to allegations across the entire reporting period.

2. We define an investigation as any case in which investigative activity occurred, including case activity defined as "Inquiry" in the RM regulation.

3. There are a small number of allegations involving RM which result in Criminal or Civil investigations. We have not included those allegations in this report at this time.

Research Misconduct Investigations

Research Misconduct damages the scientific enterprise, is a potential misuse of public funds, and undermines the trust of citizens in government-funded research. It is imperative to the integrity of research funded with taxpayer dollars that NSF-funded researchers carry out their projects with the highest ethical standards. For these reasons, pursuing allegations of research misconduct (plagiarism, data fabrication, and data falsification) by NSF-funded researchers continues to be a focus of our investigative work. In recent years, we have seen a significant rise in the number of substantive allegations of research misconduct associated with NSF proposals and awards.

NSF takes research misconduct seriously, as do NSF's awardee institutions. During this reporting period, institutions took actions against individuals found to have committed research misconduct, ranging from letters of reprimand to termination of employment. NSF's actions in research misconduct cases ranged from letters of reprimand to a proposed five-year debarment. In each case below, we recommended that NSF make a finding of research misconduct, issue a letter of reprimand, and require the subject to complete a Responsible Conduct of Research (RCR) training program. We also recommended additional significant actions as summarized below. Unless otherwise specified, NSF decisions on our recommendations are pending.

(1) *Associate Professor Falsifies and Fabricates Research*

An associate professor at a university falsified data and fabricated results in a published article, a submitted manuscript, a draft manuscript, and a meeting abstract that were all supported by an NSF award. The university initiated an inquiry into allegations of research misconduct against both the associate professor and his collaborator/ spouse, and both immediately departed the country and ceased communication with the university. The university concluded the associate professor's acts were intentional and constituted research misconduct; however, it found there was insufficient evidence to support a finding against the spouse. The university prohibited both individuals from returning to the university and contacted the journal, resulting in a retraction of the published article.

We concurred with the university's findings and recommended that NSF debar the associate professor for five years. We further recommended that, for five years after the debarment period, NSF require certifications and assurances; require submission of a detailed data management plan with annual certifications of adherence for any resulting awards; and bar him from participating as a peer reviewer, advisor, or consultant for NSF.

(2) *Graduate Student Falsifies Experiments*

In NSF-supported research, a graduate student falsely portrayed numerous experimental procedures and falsified data. After multiple attempts failed to replicate the student's data, the student's mentor retracted two papers. The student returned

to her native country prior to the university investigation. The university investigation concluded that the student falsified fourteen figures in the two papers. However, the committee felt a lack of physical evidence precluded them from drawing any conclusions on whether the student had falsely portrayed the experiments.

We concurred with most of the university's conclusions; however, we found that a preponderance of the evidence indicated that the graduate student falsely portrayed the experimental procedures. We recommended that NSF debar the graduate student for five years and require the graduate student to submit certifications and assurances for three years after the debarment.

(3) *Manuscript from NSF-Funded Center Almost Entirely Plagiarized*

A university faculty member's seven page manuscript was almost entirely plagiarized from two law review articles. In response to a journal's query, the faculty member attributed the plagiarism to "a tragic sequence of mistakes and honest errors," and said her two co-authors submitted the manuscript to the journal without her approval.

The university investigation concluded that the faculty member intentionally committed plagiarism, and the university placed a letter of reprimand permanently in the faculty member's file; required that a senior faculty member monitor her written work for two years; placed her on probation for two years; and removed her from the NSF-funded center projects for no less than two years.

We concurred with the university's report and recommended that NSF debar the faculty member for one year. We also recommended that, for three years following the debarment period, NSF bar her from serving as an NSF peer reviewer, advisor, or consultant and require that she submit certifications and assurances.

(4) *Assistant Professor Submits Others' Research for Funding*

Our investigation found that an assistant professor submitted nine proposals to NSF with plagiarized text; six of the proposals also proposed to do work that had already been completed and published by other researchers. We recommended that NSF debar the assistant professor for two years. We also recommended that, for two years after the debarment ends, NSF bar the assistant professor from serving as a reviewer, advisor or consultant, and require submission of certifications and assurances.

(5) *Students Fabricate Data on a PhD Student's NSF-Funded Project*

A PhD candidate hired several students to work as hourly employees to code data related to her dissertation research. Two of the students entered copied data they claimed they had individually coded. The university learned of their conduct, examined it in the context of the school's student code of conduct, terminated the students from the project, informed our office of the misconduct, and credited the students' salaries to the NSF award (approximately $2,300).

We conducted an investigation to examine the students' actions in relation to research misconduct. We concluded that the students fabricated data, and that these actions were a significant departure from the standards of the research community and therefore constituted research misconduct. We provided our investigative findings to NSF along with recommendations for findings of research misconduct, debarment, mandatory responsible conduct of research training, and imposition of certifications and assurances for future documents submitted to NSF.

(6)

Assistant Professor Falsifies Data in NSF proposal

An assistant professor at a university falsified data in an NSF proposal. The university's Investigation Committee determined that the assistant professor's acts of mislabeling figures in a published manuscript, poster, and NSF proposal met the definition of falsification of data. The Investigation Committee did not make a research misconduct finding, because they concluded the preponderance of the evidence did not establish that the acts were committed intentionally, knowingly, or recklessly. The university agreed with the Investigation Committee's conclusion that research misconduct did not occur. The university implemented the recommended actions, which included a correction of the publication, remedial training courses, and oversight by a mentoring committee for a period of three years.

We disagreed, in part, with the university's findings. We did not find that the mislabeled figure in the manuscript constituted an act of data falsification but rather was a mistake generated during the manuscript publisher's formatting process. We did conclude that the other two acts of data falsification were committed recklessly, fit a pattern of research misconduct, and were a significant departure from accepted practices. We recommended that, for one year, NSF require certifications and assurances; require submission of a detailed data management plan for any resulting awards; and bar the assistant professor from participating as a peer reviewer, advisor, or consultant for NSF.

Actions by NSF Management on Previously Reported Research Misconduct Investigations

NSF has taken administrative action to address our recommendations on ten research misconduct cases reported in previous Semiannual Reports. In each case, NSF made a finding of research misconduct, issued a letter of reprimand, and required RCR training. NSF also took additional significant actions in response to our recommendations, as summarized below:

- In the case of the graduate student who submitted eleven NSF proposals in order to receive funding for work he had already completed[19] and manipulated his published manuscripts to hide it, NSF proposed a three-year debarment.

19. March 2016 Semiannual Report, p.24.

- In the case of a university professor who fabricated data and falsified the status of manuscripts in NSF documents,[20] NSF imposed a one-year debarment followed by three years of certifications and assurances. NSF did not impose requirements following the debarment period for a data management plan or prohibit the professor from participating as an advisor or consultant for NSF, as we had recommended.
- In the case of a university professor who plagiarized material from three sources into an awarded proposal where he was the listed co-PI,[21] NSF required certifications and assurances for three years, and barred the professor from serving as peer reviewer, advisor, or consultant for NSF for one year.
- NSF proposed to debar for five years a graduate student who falsified her dissertation data.[22]
- In the case of the full professor whose awarded proposal was found to contain plagiarized text,[23] NSF required that he submit certifications and assurances for two years, and barred him from serving as an NSF reviewer, advisor, or consultant for two years.
- In the case of a PI who copied a portion of another scholar's research goals into a declined NSF proposal and copied a substantive portion of the methodology into another declined NSF proposal,[24] NSF required that the PI submit certifications and assurances for two years, and certify compliance with requirements imposed by his university.
- NSF required a PI who plagiarized material in an NSF proposal[25] to submit certifications and assurances for two years, and barred him from serving as a reviewer, advisor, or consultant for two years.
- In the case of a PI who plagiarized material in a proposal for a funded NSF award, which was suspended and subsequently closed while suspended,[26] NSF required the PI to submit certifications and assurances for three years and certify compliance with university-imposed requirements.
- NSF required that a graduate student who plagiarized text into an NSF grant's annual report[27] certify compliance with university-imposed requirements.
- NSF required a PI who plagiarized material in multiple NSF proposals[28] to submit certifications and assurances for one year, and barred him from serving as a reviewer, advisor, or consultant for two years.

20. March 2015 Semiannual Report, pp.27-28.
21. September 2015 Semiannual Report, p.31.
22. September 2015 Semiannual Report, p.29.
23. March 2015 Semiannual Report, p.30.
24. March 2016 Semiannual Report, p.27.
25. March 2015 Semiannual Report, p.30.
26. March 2015 Semiannual Report, pp.31-32; March 2016 Semiannual Report, pp.26-27.
27. September 2015 Semiannual Report, p.30.
28. September 2015 Semiannual Report, p.30.

RESEARCH MISCONDUCT INVESTIGATIONS

Research misconduct damages the scientific enterprise, is a potential misuse of public funds, and undermines the trust of citizens in government-funded research. It is imperative to the integrity of research funded with taxpayer dollars that NSF-funded researchers carry out their projects with the highest ethical standards. For these reasons, pursuing allegations of research misconduct (plagiarism, data fabrication, and data falsification) by NSF-funded researchers continues to be a focus of our investigative work.

NSF takes research misconduct seriously, as do NSF's awardee institutions. During this reporting period, institutions took actions against individuals found to have committed research misconduct, ranging from letters of reprimand to termination of employment. NSF's actions in research misconduct cases ranged from letters of reprimand to a proposed three-year debarment.

In every case discussed below, we recommended that NSF make a finding of research misconduct, issue a letter of reprimand, and require the subject to complete a Responsible Conduct of Research (RCR) training program. We also recommended additional significant actions as summarized below; unless specified, NSF's decisions are pending.

(1) *Student Fabricated Data in Order to Perform More Interesting Research*

After being confronted by her advisor, a doctoral student at a Massachusetts university admitted that she fabricated data in an NSF-funded research project that was published in a journal article. The student said she fabricated the data in order to move on to research that was more scientifically interesting to her. The university immediately dismissed her, informed the journal, and retracted the published article. The university's investigation determined that the student intentionally and knowingly fabricated a figure in the published article, which it deemed a significant departure from accepted practices.

We concurred with the university's conclusion, and recommended that NSF debar the student for three years, and require certifications and assurances for six years.

(2) *Plagiarism Leads to Funds Put to Better Use*

A PI from a Puerto Rico university plagiarized material in a funded NSF proposal, which was suspended and subsequently terminated, resulting in over $150,000 of funds put to better use. As described previously,[19] the PI included plagiarized material in a funded NSF proposal and an unfunded proposal.

The PI's university concluded that she committed research misconduct. The PI asserted during the investigation that student assistants prepared portions of the proposal; however, she had no evidence regarding student involvement. The university reprimanded the PI and required that her writing be monitored for three years, that she successfully complete a university course regarding proper citations practices within one year, and that she complete a refresher workshop the following year.

19 March 2015 Semiannual Report, pp.31-32.

Our investigation concluded the PI committed research misconduct by knowingly plagiarizing material in two proposals, constituting a significant departure from accepted practices. We also identified plagiarism in the PI's dissertation. We recommended that NSF require the PI submit certifications and assurances for three years and certify compliance with university-imposed requirements.

(3) *PI Plagiarized Portions of His Proposed Research Work*

A PI from a New York university copied a portion of another scholar's research goals into a declined NSF proposal and copied a substantial portion of the methodology into a second declined NSF proposal. The university's investigation concluded that, although the PI's act was a significant departure from accepted practices, the PI did not commit research misconduct because he acted with careless intent. The university required the PI to take or teach a responsible conduct of research course, and to use proper citation practices in his writings.

Our review of the university's report found that the university incorrectly interpreted the reckless standard of intent, determining erroneously that recklessness requires a conscious or purposeful element. Our investigation concluded that the PI acted recklessly and thus committed research misconduct. We recommended that NSF require the PI to submit certifications and assurances for two years, and certify compliance with university-imposed requirements.

(4) *PI Asserts Numerous Reasons to Explain Plagiarism Allegation*

A PI at a Michigan university submitted an NSF proposal containing three pages of apparently copied text in the proposal's five-page literature review. The PI asserted that he had used the American Psychological Association (APA) citation style, that common language use was coincidence, and that he used the author's words to avoid misinterpretation. We determined the PI's citation practices did not meet APA standards, found his other responses contradictory, and referred the investigation to his institution.

The PI asserted that: 1) NSF policies are nuanced and in conflict with his own literal interpretation; 2) NSF's requirements for quotation use conflict with other disciplines' standards; 3) his field is eclectic and not addressed by NSF policy; and 4) the research proposal is not really research. The university refuted all of these assertions and concluded that the PI committed plagiarism, at least recklessly, which was a significant departure from accepted practices. The university required the PI to participate in a supervisory meeting to discuss the seriousness of his actions, identify steps to prevent future occurrences; take training about plagiarism prevention; and submit all grant proposals to a university official for review for two years.

Our investigation determined that the PI knew his actions constituted plagiarism, knew NSF proposals required attention to citation, and was not unfamiliar with the grant writing process. Consequently, we determined he acted knowingly. We recommended that NSF require the PI submit certifications and assurances for two years, and certify compliance with university-imposed requirements.

(5) *Assistant Professor Recklessly Plagiarizes in NSF Proposal*

An assistant professor in Alabama submitted an NSF proposal in which most of the first page, as well as a few other paragraphs, were apparently copied from other sources. She stated she copied and pasted text from her source documents without any notation into the same computer document where she was also composing original text for the proposal–over months of composition, this practice led to her inability to distinguish copied from original text. The university determined that she recklessly plagiarized and terminated her employment. We agreed with the university's conclusions and recommended that NSF require certifications for one year.

Actions by NSF Management on Previously Reported Research Misconduct Investigations

NSF has taken administrative action to address our recommendations on seven research misconduct cases reported in previous Semiannual Reports. In each case, NSF made a finding of research misconduct, issued a letter of reprimand, and required RCR training. NSF also took additional significant actions in response to our recommendations, as summarized below.

- In the case of a former graduate student who falsified data appearing in his submitted PhD dissertation and in multiple publications,[20] NSF debarred the individual for three years and imposed three years of subsequent certifications and assurances.
- Previously, we reported on a graduate student at a Rhode Island university who provided falsified data to his NSF-funded advisor who included it in a journal article that has been retracted.[21] NSF made a finding of research misconduct and imposed a three-year debarment.
- In the case of a professor at a Florida university who submitted multiple proposals containing plagiarism to NSF over a period of four years,[22] NSF imposed a one-year debarment and four years of certifications and assurances. NSF also took final action against a postdoctoral research associate involved in this case, imposing a one-year debarment and four years of certifications and assurances.
- In the case of a PI at a Pennsylvania university who plagiarized material from a colleague's declined proposal into her own NSF proposal,[23] NSF imposed a one-year debarment followed by three years of certifications and assurances. NSF also barred the PI from serving as a peer reviewer, consultant, or advisor for NSF for a year.
- In the case of a post-doctoral scholar at a Pennsylvania university who falsified NSF-funded research data in a manuscript submitted to a journal,[24] NSF imposed a one-year debarment and four years of certifications and assurances.
- In the case of a PI who claimed that the wrong version of his proposal was submitted to NSF, and that the use of quotation marks around directly copied text in his proposals was not required by the standards of his research community,[25] NSF imposed three years of certifications and assurances.

20 September 2014 Semiannual Report, p.26.
21 March 2015 Semiannual Report, p.27.
22 September 2014 Semiannual Report, pp.26-27.
23 March 2015 Semiannual Report, p.28.
24 March 2015 Semiannual Report, p.28.
25 March 2015 Semiannual Report, p.29.

- In the case of a Missouri PI who submitted annual and final project reports that misrepresented the publications supported from his grant,[26] NSF required certifications and assurances for three years.
- In the case of a professor at a Virginia university who submitted two NSF proposals containing plagiarism,[27] NSF imposed two years of certifications and assurances.
- In the case of a professor at a Georgia university who submitted two NSF proposals containing plagiarism,[28] NSF imposed two years of certifications and assurances.
- In the case of an associate professor at a Massachusetts university who plagiarized material into multiple NSF proposals,[29] NSF imposed one year of certifications and assurances.
- In the case of an Illinois professor who plagiarized materials into four NSF proposals,[30] NSF imposed two years of certifications and assurances.

26 March 2015 Semiannual Report, pp.28-29.
27 March 2015 Semiannual Report, p.29.
28 March 2015 Semiannual Report, p.30-31.
29 March 2015 Semiannual Report, p.31.
30 March 2015 Semiannual Report, p.30.

Research Misconduct Investigations

Research misconduct damages the scientific enterprise, is a potential misuse of public funds, and undermines the trust of citizens in government-funded research. It is imperative to the integrity of research funded with taxpayer dollars that NSF-funded researchers carry out their projects with the highest ethical standards. For these reasons, pursuing allegations of research misconduct (plagiarism, data fabrication, and data falsification) by NSF-funded researchers continues to be a focus of our investigative work. In recent years, we have seen a significant rise in the number of substantive allegations of research misconduct associated with NSF proposals and awards.

NSF takes research misconduct seriously, as do NSF's awardee institutions. During this reporting period, institutions took actions against individuals found to have committed research misconduct, ranging from letters of reprimand to revocation of doctoral degrees. NSF's actions in research misconduct cases ranged from letters of reprimand to a proposed five-year debarment. In every case, we recommended that NSF make a finding of research misconduct, issue a letter of reprimand, and require the subject to complete a Responsible Conduct of Research (RCR) training program. We also recommended additional significant actions as summarized below.

(1) ***Graduate Student Falsifies Dissertation Data***

A Texas university concluded that a former graduate student manipulated her dissertation research data. The university's investigative panel heard testimony from the PI, IT experts, and the student, about the data and the student's methodology for collecting the data. Based on the evidence the PI presented during the hearing, the former student eventually agreed the data were falsified, and blamed the falsification on an ex-roommate. The panel concluded the former student committed research misconduct by falsifying and fabricating data in her dissertation, and recommended that the university revoke her Ph.D. She appealed the decision, but the university president, and the state's board of regents upheld the finding and action.

We concurred with the university that the student committed research misconduct. Furthermore, we concluded that the student failed to take responsibility for her actions. She tried to conceal her falsification by lying to the university and pursuing legal challenges to the university's authority to investigate and our ability to obtain evidence from the university about the investigation. We recommended that NSF debar her for five years, and for five years prohibit her from serving as a peer reviewer, advisor, or consultant for NSF.

(2)

Graduate Student Fabricates and Falsifies Research Data in Multiple Publications

A graduate student at a Texas university fabricated and falsified data in three publications describing NSF-supported research and multiple other publications supported by other external funding. The university investigation committee concluded that she committed research misconduct. We determined that her actions included the improper manipulation of data, and publishing a description of a synthetic reaction and its products when the reactions were never carried out. We recommended that NSF: debar the student for three years; bar the student from serving as a peer reviewer, advisor, or consultant for NSF during the debarment period; and require three years of certifications and assurances thereafter.

(3)

Plagiarism in a Proposal Requesting Support to Write a Textbook

We determined that a proposal from a California professor requesting support to write an undergraduate-level textbook contained plagiarized text and references. The sources for the copied text and references included a Ph.D. dissertation, college job advertisements, and college mission statements. During our investigation, the professor described the dissertation author as a "consultant to the project", but the proposal does not describe the author as a consultant and did not list her as a collaborator. We recommended that NSF require two years of certifications and assurances, and bar the professor from serving as a peer reviewer, advisor, or consultant for NSF.

(4)

PI Exonerated, Graduate Student Committed Plagiarism

A Texas university PI who submitted an annual report to NSF that contained plagiarized text asserted that a graduate student wrote the plagiarized part. The university found that the PI checked the report prior to submission with plagiarism software, which did not detect the bulk of the copied text was not flagged. The PI provided evidence that he had asked the graduate student to increase citations and rewrite portions flagged by the software. The student rewrote the flagged portions, but concealed that a large amount of copied text was not flagged. The institution found that the student committed plagiarism, for which the PI did not share culpability. We concurred that the graduate student knowingly plagiarized and recommended that NSF ban the student from serving as an NSF reviewer, advisor, or consultant for two years.

(5) *Co-PI Plagiarizes in Proposal*

An awarded proposal submitted by a North Carolina university contained material plagiarized from three sources. The university's investigation determined the co-PI alone knowingly plagiarized the material into the proposal. The university implemented corrective actions that included remedial training and plagiarism screening of all forthcoming proposals. We agreed with the university's conclusion and recommended one year of certifications and assurances, and a one-year bar from serving as a peer reviewer, advisor, or consultant for NSF.

Actions by NSF Management on Previously Reported Research Misconduct Investigations

NSF has taken administrative action to address our recommendations on three research misconduct cases reported in previous semiannual reports. In two of the cases NSF made a finding of research misconduct, issued a letter of reprimand, and required RCR training. NSF also took additional significant actions in response to our recommendations as summarized below:

- In the case of a former PI at a California university who intentionally fabricated and falsified data,[20] NSF imposed a five-year debarment. NSF also barred the PI from serving as a peer reviewer, advisor, or consultant for NSF for five years. However, NSF did not impose any certification requirements for proposals submitted, and data management plans entered into, following the debarment period, as we had recommended.

- In the case of a former postdoctoral researcher and his mentor at a Colorado university who committed falsification and fabrication,[21] NSF imposed a government-wide suspension for both pending a final resolution of the case. Ultimately, NSF debarred each for one year.

- In the case of an Illinois PI who committed plagiarism,[22] NSF required three years of certifications and assurances, and banned the PI from serving as a peer reviews, advisor, or consultant for NSF for three years.

- NSF declined to make a finding of research misconduct in the case of two professors and a graduate student at a North Carolina university who omitted experimental details and overstated their experimental results in a published article,[23] concluding that their actions were significant departures from accepted research practices, but were

20 September 2014 Semiannual Report, p.25.
21 March 2014 Semiannual Report, pp.21-22.
22 September 2014 Semiannual Report, p.30; March 2014 Semiannual Report, pp.23-24.
23 September 2013 Semiannual Report, p.21.

not committed with a culpable level of intent. NSF issued a letter of reprimand, and declared all three ineligible for future NSF funding, relying on statutory authority to do so when it has concluded that investigators have violated NSF policy on dissemination and sharing of research results.[24] NSF would reinstate their eligibility if they took specific actions to correct publications containing the misleading results. This prohibition applies only to the receipt of NSF funds and does not affect awards from other federal agencies.

Assessing Intent in Verbatim Plagiarism Investigations[25]

One approach for assessing intent in verbatim plagiarism cases examines the acts of copying, pasting, and integrating (CPI) text into a document. CPI draws on the copy-and-paste description of plagiarism, and isolates the physical actions of copying and pasting to the levels of intent to start the analysis. The intent level derived from CPI may then rise or fall according to other evidence.

Copy: Selecting and copying text and figures from electronic sources has become the digital equivalent of manual note-taking. But maintaining bibliographic information for citation purposes is still necessary. Copying without preserving information for proper attribution can be unnecessary and because a reasonable person would recognize the increased risk of plagiarizing the copied material without attribution.

Paste: The act of pasting copied material into a document is inherently a knowing, conscious act. Because it generally requires manual highlighting followed by executing a copy command, changing documents, and executing a paste command. Thus, a knowing level of intent is inherent in the act of pasting the material into the new document, and the act becomes knowing plagiarism in the conscious absence of subsequent steps to provide quotation marks, citation, and reference. The recurrence of matching typographical errors, existing conventions, and erroneous citations or objects into the new document are common evidence of the copy-and-paste method of plagiarism demonstrating knowing intent.

Integrate: Additional specific steps to integrate the copied material into the body of a new document can help mislead the reader into concluding that the new document is the subject's original work. These steps can elevate the intent level to intentional. Examples include: deleting or paraphrasing attributed citations to reflect a missing attribution; changing verb tenses to suggest work completed by another is to be performed in the future by the subject. Each of these specific steps on its face shows intent to achieve the specific purpose of making the copied material appear to be original. Evidence of integration of the copied material often supports findings of intentional plagiarism.

24 42 U.S.C. § 1862o-3.

25 We introduced the Quotation-Citation-Reference (QCR) method for assessing the act of plagiarism in our March 2009 Semiannual Report, p.43.

NSF Proposed Termination of Two Employees

In a previous Semiannual Report[18], we described the actions of two NSF employees: a supervisor who lied to OIG, his supervisors, and his staff and colleagues; and a program officer who released a sensitive document to the press. Based on an analysis of all the facts, NSF proposed termination of both employees, and both retired.

Research Misconduct Investigations

Research misconduct damages the scientific enterprise, is a potential misuse of public funds, and undermines the trust of citizens in government-funded research. It is imperative to the integrity of research funded with taxpayer dollars that NSF-funded researchers carry out their projects with the highest ethical standards. For these reasons, pursuing allegations of research misconduct (plagiarism, data fabrication, and data falsification) by NSF-funded researchers continues to be a focus of our investigative work. In recent years, we have seen a significant rise in the number of substantive allegations of research misconduct associated with NSF proposals and awards.

NSF takes research misconduct seriously, as do NSF's awardee institutions. During this reporting period, institutions took actions against individuals found to have committed research misconduct, ranging from letters of reprimand to termination of employment. NSF's actions in research misconduct cases ranged from letters of reprimand to a proposed three-year debarment. In every case, we recommended that NSF make a finding of research misconduct, issue a letter of reprimand, and require the subject to complete a Responsible Conduct of Research (RCR) training program. We also recommended additional significant actions as summarized below.

Narrative

Proactive Review Identifies Plagiarism in Multiple Proposals

As part of a proactive review, we analyzed over 8,000 proposals awarded by NSF in FY 2011 for evidence of plagiarism. We processed these proposals using commercial plagiarism software, and ranked them by the amount of apparently-copied text. We determined that many proposals contained some amount of copied text, but opened cases only on the more apparently serious violations that might constitute research misconduct.

We opened 34 plagiarism investigations, ten of which have resulted in NSF making findings of research misconduct. From these cases we have recovered $357,602 in federal funds to date. We issued questionable research practice letters in six cases in which the copying

18 September 2014 Semiannual Report, p.17

was considered plagiarism, but did not rise to the level of research misconduct. Ten cases are still pending. One of the pending plagiarism investigations uncovered significant financial issues, and is being pursued for possible civil/criminal prosecution.

Overall, less than one half of one percent of the funded proposals contained enough plagiarism to constitute research misconduct. This percentage is less than the results from our earlier proactive reviews which included declined proposals.

(1) ***Graduate Student Misrepresents Data to Advisor Who Published It***

A graduate student at a Rhode Island university provided falsified data to his NSF-funded advisor, who included it in a journal article. A reader of the article first identified the problems with the data presented in a figure, and reported to the advisor his inability to repeat the reported calculations based upon that data. The advisor and a colleague were unable to reproduce the student's results when asked to review the data, and the advisor retracted the article.

The university initiated its investigation, but shortly thereafter the student returned to his home country. Other than two written explanations for how he had arrived at his results, the student did not participate further in the investigation. The university concluded that the student knowingly falsified the curve-fitting results that ultimately appeared in the article, retroactively dismissed the student from the university, and prohibited him from readmission.

We concurred with the university that the student committed research misconduct and we recommended NSF debar the student for 3 years.

(2) ***Professor Fabricates Data and Falsifies Status of Manuscripts***

A professor at a Maryland university fabricated data and falsified the status of manuscripts in NSF proposals. The university's investigation determined the professor intentionally fabricated data in one NSF proposal and intentionally misrepresented the status of manuscripts in several NSF proposal and award documents. The university concluded the professor's acts constituted research misconduct and the university's disciplinary actions included oversight, remedial training, and prohibition of applying for funds.

Our further investigation established that the professor falsified the status of manuscripts in four NSF proposals and four annual reports. We concluded that the professor's fabrication of data and falsification of manuscripts' status were intentional acts, representing a pattern of research misconduct. We recommended that NSF debar him for

one year and that for three years after the debarment, NSF: require certifications and assurances; require submission of a detailed data management plan with annual certifications of adherence for any resulting awards; and bar him from participating as a peer reviewer, advisor, or consultant for NSF.

(3)

PI Plagiarizes from Former Colleagues in NSF Proposal

A PI at a Pennsylvania university plagiarized a significant amount of material from a colleague's declined proposal submitted to another agency into her own NSF proposal. The university declined to conduct an investigation because it did not have a research misconduct policy. The PI admitted to us that she knowingly plagiarized material from a former advisor and another colleague, blaming time constraints and inexperience in proposal writing. We concluded that the PI committed plagiarism and recommended that NSF debar her for one year, require certifications and assurances for three years after the debarment, and bar her from participating as a peer reviewer, advisor, or consultant for NSF.

(4)

Postdoc Falsifies Data To Make Results "Look Better"

A post-doctoral scholar at a Pennsylvania university falsified NSF-funded research data in a manuscript submitted to a journal. When confronted by his mentor, the postdoc admitted that he had changed the data because it "would make the results in the paper look better."

The university concluded that the post-doc knowingly committed research misconduct, but found mitigating circumstances. It sent the postdoc a letter of reprimand and required his lab director to monitor his research; however, the postdoc left the university and returned to his home country. We concurred with the university's assessment and recommended NSF debar the post-doc for one year, and require he provide certifications and assurances for four years.

(5)

PI Falsifies Accomplishments under Grants

A Missouri university's investigation determined that a PI's annual reports were inaccurate and misrepresented the publications supported from his grant. It concluded that the PI's extensive misrepresentations constituted falsification, made a finding of research misconduct, and required the PI to provide quarterly progress reports for all externally-funded projects for one year. In addition, for three years he must have all annual reports reviewed by the university.

We concurred with the university's finding of research misconduct. The PI overwhelmingly misrepresented his accomplishments in his publications listed in his progress reports to NSF. For one grant, more than 90% of the publications listed in his first annual report and 80% of the publications in his second annual report were falsified; the publications were either inaccurate or not attributable to his NSF-funded research. Further, approximately 90% of the publications listed in the annual and final reports for a second NSF grant were also falsified, establishing a pattern of misrepresenting his publications. We recommended that NSF require the PI to provide certifications and assurances for three years.

(6) ***Texas Professor Claims Wrong Version of Proposal Submitted to NSF***

Our investigation determined that a Texas PI plagiarized in two NSF proposals. The PI told us he mistakenly submitted a version of the proposal in which he used placeholders for copied text, and that proper citations and references were present in a "final" version. The "final" version that he provided showed changes only to the text which we had originally identified, suggesting that the final version was created after we contacted the PI. The PI's university determined that plagiarism also existed in a proposal submitted by the PI to another agency. Because the proposals were used as support in his tenure package, the university dismissed the professor. We recommended that NSF require certifications and assurances for three years, and a concurrent prohibition from service to NSF as a reviewer, consultant, or advisor.

(7) ***Professor Copies Portions of His Proposal's Proposed Research Plan***

A professor at a Virginia university submitted two NSF proposals containing plagiarism. One of the proposals contained copied text in the research plan taken from another researcher's proposal. The professor told us that his citation was adequate, and that he "had no intention of taking the author's technical idea or copying his writing without giving him full credit."

The university investigation concluded the professor plagiarized and that his actions represented a pattern of plagiarism. It required him to submit all of his proposals, papers, and manuscripts for plagiarism review for five years.

We concurred with the university's conclusions and recommended that NSF require the professor to provide certifications and assurances for two years, and require he certify compliance with the university-imposed requirements.

(8)

Full Professor Claims Ignorance of Quotation Marks

A full professor at a Michigan university who plagiarized text into an NSF proposal asserted that he was unaware of the need for quotation marks, stating, "I really didn't know actually when you copy, you need to put quotation." The university rejected this excuse after finding the professor attributed text properly in 22 of his other papers, also noting the professor had already completed RCR training. They imposed three years of certifications and assurances, and required him to attend in-person remedial training at his own expense.

The NSF program officer determined that the plagiarized text would have been material to the funding decision. We concluded that the professor knowingly plagiarized and recommended that NSF terminate the award early, recover funds already spent, impose two years of certifications and assurances, and impose a ban of the same length on serving as an NSF reviewer, consultant, or advisor.

(9)

Professor's Claim of Technically-Constrained Language Dispelled

An Illinois PI plagiarized into four NSF proposals. The PI claimed that the copied text was technically constrained, or that he had permission to use the text verbatim without citing its source. The university investigation determined the PI knowingly committed plagiarism in two of the four proposals. The university concluded that the copied text in the other two proposals was technically constrained — that is, it could only be expressed in a limited number of ways. The university also determined that the permission the PI described was solicited after we initiated our investigation.

The university required that for one year the PI's department chair must certify that his submitted proposals are free of plagiarism. Additionally, the PI was directed to write a report to the investigation committee on proper citation practices. We recommended that NSF impose a two-year period of certifications and assurances, and a concurrent prohibition from service to NSF as a reviewer, consultant, or advisor.

(10)

University Removes Professor from Funded Project Due to Plagiarism

A professor at a Georgia university submitted two NSF proposals containing plagiarism, one of which NSF funded. The university investigation concluded that the professor committed plagiarism, removed her from the awarded project, excluded her from receiving or applying for federal funding for one year, and required her to implement a university-approved responsible conduct of research plan.

We concurred with the university and found that a journal article the professor authored also contained plagiarism, which directly contradicted statements she made to her university. We recommended NSF require the professor to provide certifications and assurances for two years, and require that she certify compliance with university-imposed requirements.

(11) ***Professor Claims Quotation Marks Not Needed for Directly Copied Text***

A Mississippi PI plagiarized in multiple NSF proposals. He explained to us that his community standards allowed verbatim copied text to be attributed by including a reference to the author at the end of the block of text, and did not require quotation marks. The university committee which investigated the matter disagreed with that interpretation of professional standards, and identified numerous examples of copied text appearing in the NSF proposals without reference attribution.

The university concluded that the PI committed research misconduct and imposed a formal reprimand, a prohibition from writing and submitting grant proposals for one year, completion within one year of courses on ethics in scientific research, responsible conduct of research, and scientific writing, three-years monitoring of grant activities by a university Dean, and enlistment of the services of a professional editor. We recommended that NSF impose certifications and assurances for two years, and a concurrent prohibition from service to NSF as a reviewer, consultant, or advisor.

(12) ***PI Responsible for Copied Text in Funded NSF Proposal***

An associate professor at a Massachusetts university was solely responsible for plagiarism in multiple NSF proposals. The university investigation concluded that the PI recklessly engaged in acts constituting a pattern of plagiarism. The university required the PI to develop, obtain approval, and then present a workshop related to responsible conduct of research in STEM proposals; and, for three years, to submit external research proposals to the university's research administration office three days before the internal deadlines. We concurred that the PI recklessly committed plagiarism and recommended that NSF require the PI to provide certifications and assurances for one year.

Alleged Plagiarism Leads to Award Suspension

A PI from a Puerto Rican university included a significant amount of apparently copied material in a funded NSF proposal. We interviewed the program officer, who concluded that the allegedly plagiarized

text was material to her decision to fund the award. Based on our recommendation, NSF suspended the award — with $150,637 unexpended — pending completion of our investigation.

Actions by NSF Management on Previously Reported Research Misconduct Investigations

NSF has taken administrative action to address our recommendations on 7 research misconduct cases reported in previous semiannual reports. In each case, NSF made a finding of research misconduct, issued a letter of reprimand, and required RCR training. NSF also took additional significant actions in response to our recommendations as summarized below.

- In the case of a Florida PI and co-PI who plagiarized material into multiple NSF proposals[19], NSF proposed a one-year debarment for each, and four years of certifications and assurances. The co-PI appealed the action, and NSF's decision is pending.

- In the case of an associate professor at a California university who plagiarized text into four proposals to NSF, one of which was awarded[20], NSF imposed two years of certifications and assurances and also barred the professor from service to NSF as a reviewer, consultant, or advisor for two years.

- In the case of a professor at a Florida university who plagiarized text in eight proposals to NSF[21], NSF imposed a one-year debarment followed by three years of certifications and assurances. For three years NSF also barred the professor from service to NSF as a reviewer, consultant, or advisor.

- In the case of an assistant professor in Maine who plagiarized text into five NSF proposals[22], NSF imposed three years of certifications and assurances, and a ban on serving as an NSF reviewer, consultant, or advisor.

- In the case of a Missouri graduate student who falsified data that appeared in multiple (now retracted) publications[23], NSF proposed a five-year debarment and three subsequent years of certifications and assurances.

19 September 2014 Semiannual Report, p.26.
20 September 2014 Semiannual Report, p.29.
21 March 2014 Semiannual Report, p.23.
22 September 2014 Semiannual Report, pp.28-29.
23 September 2014 Semiannual Report, p.26.

- In the case of a Kansas professor who extensively plagiarized in two review articles citing NSF support[24], NSF required two years of certifications and assurances.

- In the case of a New York PI who plagiarized[25], NSF required certifications and assurances for three years, and prohibited the PI from serving as a reviewer, consultant, or advisor for three years.

24 September 2014 Semiannual Report, p.28.
25 September 2014 Semiannual Report, p.28.

Research Misconduct Investigations

Research misconduct damages the scientific enterprise, is a potential misuse of public funds, and undermines the trust of citizens in government-funded research. It is imperative to the integrity of research funded with taxpayer dollars that NSF-funded researchers carry out their projects with the highest ethical standards. For these reasons, pursuing allegations of research misconduct (plagiarism, data fabrication, and data falsification) by NSF-funded researchers continues to be a focus of our investigative work. In recent years, we have seen a significant rise in the number of substantive allegations of research misconduct associated with NSF proposals and awards.

NSF takes research misconduct seriously, as do NSF's awardee institutions. During this reporting period, institutions took actions against individuals found to have committed research misconduct, ranging from letters of reprimand to termination of employment. NSF's actions in research misconduct cases ranged from letters of reprimand to a proposed five-year debarment. In every case, we recommended that NSF make a finding of research misconduct, issue a letter of reprimand, and require the subject to complete a Responsible Conduct of Research (RCR) training program. We also recommended additional significant actions as summarized below.

1

PI Fabricates and Falsifies Research Results

A PI at a California university fabricated and falsified results that were included in an awarded NSF proposal, a published article, a declined NSF proposal, and a submitted manuscript. The university's investigation determined the PI committed fabrication and falsification in numerous data figures, and issued a research misconduct finding. The PI left the university, the journal retracted the published article, and the submitted manuscript was declined for publication.

We concurred with the university's finding that the PI inappropriately manipulated the research images, and concluded that the PI intentionally committed fabrication and falsification. We recommended that NSF debar him for five years, and for the five years after the debarment period: require certifications and assurances; require submission of a detailed data management plan with annual certifications of adherence for any resulting awards; and bar him from participating as a peer reviewer, advisor, or consultant for NSF.

(2)

Graduate Student Falsifies Data to Support Favored Hypothesis

A student entered into a voluntary settlement agreement with another federal agency for three years, based on an admission of data falsification in his graduate work that resulted in the retraction of three research publications. The individual was supported by an NSF graduate fellowship as well as other federal funding. The university expelled the student under its academic integrity policy, based on his admission of wrongdoing, and then completed an investigation under its research misconduct policy, concluding that the student intentionally falsified data. The university failed to notify NSF of the investigation, as required.

We obtained the university's investigation report, and the student declined to provide any comments or additional information to us. We concluded that the student intentionally falsified the data, and we recommended that NSF debar the student for five years, and require certifications and assurances for three years thereafter.

(3)

Professor's Proposals Routinely Prepared by Graduate Students and Postdocs

Our investigation determined that a professor at a Florida university submitted multiple proposals to NSF over a period of four years that contained plagiarism. The university investigation established that the professor had minimal involvement in the preparation of the proposals. He asked his graduate students and postdocs to write the proposals, and he then submitted them without review or evaluation. The university concluded that the professor plagiarized from his students and postdocs in six proposals. The university investigation also established that the proposals inaccurately listed research publications as "in press" and inaccurately listed the professor's current and pending support. The university removed the professor from sole supervision of graduate students, prohibited him from submitting proposals to external funding agencies for a specified period, and mandated RCR training.

Our further investigation established the professor was the PI on four additional NSF proposals that contained copied text. We concluded that the professor's plagiarism in a total of ten proposals established a pattern of research misconduct. We recommended that NSF impose a one-year debarment and for the following five years require certifications and assurances, and prohibit service to NSF as a reviewer, consultant, or advisor.

One of the postdocs identified as an author of the plagiarized proposals was the focus of a previous case in which NSF made a finding of research misconduct based on plagiarism in multiple NSF proposals. Our investigation established that in this case the postdoc was the primary author of the four additional proposals considered in our further investigation. We recommended that NSF impose a one-year debarment and a subsequent five-year period of certifications and assurances, and prohibit service to NSF as a reviewer, consultant, or advisor.

(4) ***Assistant Professor Resigns From University During Investigation***

An assistant professor at a Florida institution submitted three NSF proposals containing extensive plagiarism. The copied text comprised the majority of the proposals' introduction, background, and proposed research sections. He acknowledged the material was inappropriately cited and attributed the act to "miscommunications, fatigue and time constraints."

The university conducted an investigation, but the assistant professor resigned prior to his scheduled interview, accepted a teaching position outside the country, and did not respond to requests for information. Based on the evidence we provided and student interviews, the university concluded the assistant professor committed repeated acts of plagiarism, which constituted a pattern of plagiarism.

The assistant professor also did not respond to our request for additional information. Our investigation concluded that he knowingly committed repeated acts of plagiarism. We recommended that NSF debar the assistant professor for one year, require he provide certifications and assurances for three years following the debarment, and bar him from participating as a peer reviewer, advisor, or consultant for NSF for four years.

(5) ***PI Submits Inaccurate Annual and Final Reports***

Our investigation determined that a Missouri PI's annual reports were inaccurate because most of the publications listed in the reports were either inaccurate or were not related to his NSF-funded research. The first annual report we reviewed cited fifty papers, but only eight of those had appropriate attribution. We referred the matter to the PI's university, which concluded that the PI's misrepresentations constituted falsification in his annual reports and made a finding of research misconduct. It required the PI to complete RCR training, and to provide quarterly

progress reports for all externally-funded projects for one year. In addition, for three years he must provide all annual reports he plans to submit to any funding agency for advance review by the university.

We concurred with the university's finding of research misconduct. For one grant, more than 90% of the publications listed in his first annual report and 80% of the publications in his second annual report were falsified, in that they were inaccurate or not attributable to his NSF-funded research. Furthermore, approximately 90% of the publications listed in the annual and final reports for a second NSF grant were also falsified, establishing a pattern of misrepresentations in his publications. We recommended that NSF require the PI to provide certifications and assurances for three years.

(6)

PI Plagiarized Text and Figures; $79,000 Put to Better Use

Our proactive review identified a funded proposal, authored by a PI in New York, that contained text copied without appropriate attribution. Our investigation identified additional proposals with unattributed copying. Based on our recommendation, NSF suspended the grant, and we referred the allegation to the awardee institution for investigation. The PI subsequently withdrew all pending proposals from all funding agencies.

The awardee found the PI plagiarized a total of 444 lines and five figures into four proposals. It made a finding of research misconduct and required the PI to: receive formal supervision for two years, which includes reviewing her proposals or manuscripts prior to submission; watch a training video on plagiarism and certify she understood it; and take a writing course. We concured with the awardee's finding and recommended that NSF require the PI to provide certifications and assurances for three years and prohibit the PI from serving as a peer reviewer, advisor, or consultant for three years. The suspended award has since expired, resulting in $79,050 put to better use.

(7)

Assistant Professor Intentionally Plagiarized in Five Proposals

An assistant professor at a Maine university plagiarized text into an NSF proposal for a collaboration between him and a researcher at another university. The copied text comprised two-thirds of the professor's technical portion and half of his broader-impacts section. The university determined that he intentionally plagiarized in the proposal to convey a false sense of his capabilities to reviewers. The university recommended that the assistant professor repay the money, but he resigned his

position and returned to his home country. As discussed previously,[22] the university terminated the grant, resulting in $40,000 of funds put to better use, and the university repaid the $26,000 already spent.

During our investigation, we found that the professor also copied text into four additional NSF proposals. We recommended NSF impose three years of certifications and assurances, and a ban on serving as an NSF peer reviewer, advisor, or consultant.

(8) ***California Professor Plagiarized in Four NSF Proposals***

An associate professor at a California university copied text into four proposals submitted to NSF, one of which was awarded. During the university investigation, the professor acknowledged copying without attribution. The university found that the professor recklessly plagiarized in four proposals to NSF and required the professor to participate in training and provide internal assurances for three years. The professor was also issued a formal reprimand.

We concurred with the university that the professor committed research misconduct. We recommended that NSF require two years of certifications and assurances, and bar the professor from serving NSF as a reviewer, advisor, or consultant.

(9) ***Adjunct Faculty Plagiarizes in Proposal***

An adjunct professor in Massachusetts copied portions of a literature review without attribution in a funded NSF proposal. The NSF program officer stated she had used the literature review as an indication that the professor was qualified to perform the work on the award. As reported previously,[23] the institution terminated the grant early, resulting in more than $162,000 of federal funds put to better use. We recommended that NSF require two years of certifications and assurances, and bar the professor from serving NSF as a reviewer, advisor, or consultant.

(10) ***Professor Plagiarizes in Research Reviews***

Our investigation determined that a Kansas university professor committed plagiarism in two research publications supported by NSF. The professor copied large sections of text verbatim from publications of others, and did not use quotation marks around the copied text, although he usually cited the source. The professor claimed that he provided

22 March 2014 Semiannual Report, p.29.
23 March 2014 Semiannual Report, p.29.

adequate attribution. The university investigation committee did not agree; the publications were subsequently retracted, and the university issued a public censure. We recommended that NSF require two years of certifications and assurances, and bar the subject from acting as a reviewer, advisor, or consultant for NSF.

Actions by NSF Management on Previously Reported Research Misconduct Investigations

NSF has taken administrative action to address our recommendations on ten research misconduct cases reported in this semiannual and in previous semiannual reports. In each case, NSF made a finding of research misconduct, issued a letter of reprimand, and required RCR training. NSF also took additional significant actions in response to our recommendations as summarized below.

In the case of a former graduate student at a Michigan university who intentionally fabricated and falsified data and research materials,[24] NSF finalized a three-year debarment. NSF also barred her from participating as a peer reviewer, advisor, or consultant for three years, and required three years of certifications and assurances as well as certifications of adherence to a detailed data management plan for any new proposals.

In the case of a PI at an Illinois university who committed plagiarism by copying ideas and text from an awarded proposal,[25] NSF proposed to debar the PI for one year. It also required three years of certifications and assurances, and banned the PI from serving as an NSF reviewer for three years.

In the case of a Tennessee professor who copied text in three NSF proposals and received duplicate reimbursements from his university for his service as an NSF review panelist,[26] NSF debarred the professor for two years; he filed an appeal which is pending.

In the case of an Illinois graduate student who falsified microscope images,[27] NSF imposed a one-year debarment followed by two years of certifications and assurances, and prohibition from service as an NSF reviewer, advisor, or consultant.

24 March 2014 Semiannual Report, pp.22-23.
25 March 2014 Semiannual Report, pp.23-24.
26 March 2014 Semiannual Report, p.23.
27 September 2013 Semiannual Report, p.20.

In the case of a Kentucky graduate student who fabricated data,[28] NSF debarred the student for one year, followed by one year of certifications and assurances, and prohibition from serving as a reviewer, advisor, or consultant.

NSF finalized the one-year debarment proposed of a former post-doctoral fellow at a Washington university who intentionally falsified data.[29]

In the case of a professor at a Texas university who plagiarized in his NSF proposal,[30] NSF required that he provide certifications and assurances for three years.

In the case of a student in Pennsylvania who plagiarized text into his NSF-funded dissertation,[31] NSF required two years of certifications and assurances, and submission of a corrected dissertation to his own university's library as well as the national repository. NSF also required the student to take RCR training.

In the case of a North Carolina professor who plagiarized a modest amount of text from multiple sources into his NSF proposal,[32] NSF required him to submit certifications for one year.

In the case of a team leader in Illinois who recklessly plagiarized,[33] NSF required RCR training.

28 September 2013 Semiannual Report, pp.20-21.
29 March 2014 Semiannual Report, p.26.
30 March 2014 Semiannual Report, p.24.
31 March 2014 Semiannual Report, p.25.
32 March 2014 Semiannual Report, p.26.
33 March 2014 Semiannual Report, p.26.

This page intentionally left blank

RESEARCH MISCONDUCT INVESTIGATIONS

Research misconduct damages the scientific enterprise, is a potential misuse of public funds, and undermines the trust of citizens in government-funded research. It is imperative to the integrity of research funded with taxpayer dollars that NSF-funded researchers carry out their projects with the highest ethical standards. For these reasons, pursuing allegations of research misconduct (plagiarism, data fabrication and data falsification) by NSF-funded researchers continues to be a focus of our investigative work. In recent years, we have seen a significant rise in the number of substantive allegations of research misconduct associated with NSF proposals and awards.

NSF takes research misconduct seriously, as do NSF's awardee institutions. During this reporting period, institutions took actions against individuals found to have committed research misconduct, ranging from letters of reprimand to termination of employment. During this reporting period, NSF's actions in research misconduct cases ranged from letters of reprimand to a proposed five-year of debarment. In every case, we recommended that NSF make a finding of research misconduct, issue a letter of reprimand, and require the subject to complete a Responsible Conduct of Research training program. We also recommended additional significant actions as summarized below.

1

Postdoc and Mentor Perpetuate Data Falsification and Fabrication In a Series of Published Articles

A former postdoctoral researcher and his mentor at a Colorado university perpetuated the apparent validity of research data after the postdoc had intentionally falsified and fabricated the original study. After coauthors on the original study were unable to replicate the postdoc's research results, the mentor's college—without informing university-level administration—conducted an informal inquiry and recommended that the issue be worked out in the literature rather than through a formal investigation. Although the mentor's lab members had been able to repeat the results when the postdoc was there, after he left they could not do so.

As a result of the inadequacy of the college's informal inquiry, we conducted our own on-site inquiry. We recommended that the university conduct an investigation, which it agreed to do. The university investigation focused on the postdoc's reported isolation of four compounds and the mentor's continued use of the resulting data over several years, despite mounting evidence of research misconduct presented by lab members and other faculty members.

The mentor's failure to require lab notebooks or to maintain instrumental data in his own lab complicated the investigation; however, his coauthors, students, and other university collaborators maintained

sufficient records to enable the investigation to proceed. The university ultimately concluded that the postdoc had intentionally fabricated data with respect to the four compounds he claimed to have isolated as natural products. Because the postdoc was no longer an employee, the university could take no direct actions against him.

The university also concluded that the mentor was "reckless in his use of highly suspect data" in the face of the "loud chorus of voices challenging the original" work. The investigation committee recommended the retraction of eight publications and required that the mentor receive instruction "in proper scientific laboratory protocols to document techniques and procedures."

We agreed with the university's findings and recommended that NSF: debar the postdoc for five years and the mentor for three years; terminate the former postdoc's active NSF awards; and require retraction of the papers identified by the university and completion of training.

Additionally, until five years after the end of their respective debarment periods, we recommended NSF require certifications and assurances; require submission of detailed data management and mentoring plans with annual certifications of adherence to those plans for new NSF awards; and bar both from serving NSF as a peer reviewer, advisor, or consultant.

Certifications and Assurances

In many of our research misconduct cases, we recommend that NSF require the subjects to submit certifications and/or assurances with every proposal and report they submit to the agency. Certifications are letters from the subject stating that they certify that the document they submit does not violate NSF's research misconduct regulation. Assurances are letters from a responsible official of the subject's employer assuring NSF that they have reviewed the document and that its contents do not violate NSF's research misconduct regulation.

(12)

Graduate Student Admits Fabricating Data

A graduate student who conducted NSF-funded research at a Michigan university fabricated the existence of biological sample collections and the performance of experiments, and also fabricated and falsified data. The student admitted to the research misconduct and the university dismissed her from the graduate program.

When we interviewed the student, she accepted responsibility for the research misconduct. We concluded that she intentionally fabricated and falsified data and the research record, and recommended that NSF debar her for three years. After the debarment period, we recommended that for three years NSF: require certifications and assurances; require submission of a detailed data management plan with annual certifications of adherence for any resulting awards; and bar her from participating as a peer reviewer, advisor, or consultant for NSF.

③ ***Finding of Research Misconduct and Debarment Recommended for Professor***

Our investigation identified copied text in three NSF proposals submitted by a professor from a Tennessee university. A university investigation found that the professor committed plagiarism, but that his actions were careless and did not constitute a significant departure from the standards of his research community. Our investigation concluded that the professor acted recklessly and that his actions did constitute a significant departure from the standards of his research community, and therefore that he did commit research misconduct.

Our investigation also determined that between 2004 and 2011 the professor served as an NSF review panelist six times. On each occasion, NSF provided him a flat rate to cover expenses for lodging and meals; nonetheless, he also requested and received duplicate lodging and meal reimbursements from his university. Based on his plagiarism and deceptive conduct, we recommended that the professor be debarred for two years and that NSF require him to complete an ethics course within one year.

④ ***Florida Professor Plagiarizes in Eight NSF Proposals***

A Florida university determined that a professor intentionally committed extensive plagiarism in several proposals, including two proposals he submitted to NSF as PI. Despite the professor's claim that no other proposals contained copied text, our investigation found substantial plagiarism in six additional NSF proposals. We recommended that NSF debar the professor for one year, followed by three years barring the professor from serving as a reviewer, advisor, or consultant; and three years of certifications and assurances.

⑤ ***Lab Director Commits Plagiarism***

A lab director in Illinois plagiarized text, ideas, and structure from an awarded NSF proposal she had obtained from the proposal's PI. During our inquiry, she told us she thought the PI had given her permission to copy text and ideas from the proposal, which was aimed at the same NSF program as hers. Her institution investigated, found that she violated its code of ethics, and imposed sanctions.

The awarded proposal's PI told us she had voluntarily offered the director a copy of her proposal, but had not given permission for the director to use her text or ideas. We concluded that the lab director knowingly plagiarized and we recommended that NSF debar the lab director for one year, require three years of certifications and assurances, and bar her from serving as a consultant or reviewer for NSF for three years.

(6)

PI Plagiarizes in Funded Faculty Early Career Development (CAREER) Proposal

A professor at a Tennessee university plagiarized in a CAREER proposal submitted to NSF. The professor asserted that he was rushed in preparing the proposal and did not have time to properly edit his submission. However, the same copied text appeared in proposals he later submitted to other federal agencies, seeking support for the same research that was already funded by the NSF CAREER award. The university made a finding of research misconduct, required training in the responsible conduct of research, and placed the professor under the mentorship of a senior faculty member. We agreed with the university's conclusions, and recommended that NSF impose a three-year period of certifications and assurances, and a concurrent prohibition from service to NSF as a reviewer, consultant, or advisor.

(7)

Professor Asserts that Rushed Deadline Resulted in Extensive Plagiarism

A professor from a Texas university plagiarized about three pages of material in his NSF proposal. Claiming that he was rushed by deadlines, the professor accepted full responsibility for his actions. His university determined that he committed research misconduct in failing to properly attribute the work of others within his proposal. We concurred with the university's assessment and recommended that NSF require certifications and assurances for three years and bar the professor from serving as a reviewer for two years.

(8)

Professors and Postdoctoral Researcher Plagiarize in Two NSF Proposals

Two Washington professors and their postdoctoral researcher plagiarized materials from ten separate sources into two NSF proposals. Based on its investigation, the university required that the professors' grant proposals be reviewed for five years, that they develop an ethics workshop within three years, and that their dean and department chair be responsible for monitoring their work. The university concluded there was sufficient evidence to substantiate the postdoc's direct involvement in the plagiarism, but in lieu of a full investigation it entered into a settlement agreement that precludes the postdoc from seeking employment from the university for seven years.

Based on our further investigation, we determined that the postdoc was responsible for a large portion of the plagiarized text. While the actions taken against the professors adequately protected the interests of the federal government, we recommended that NSF require the postdoc to provide certifications and assurances for three years.

(9)

Professor Plagiarizes from Graduate Students' Dissertations

A professor at a Pennsylvania university plagiarized material from the dissertations of two former students, and from an article by another author summarizing the professor's own work, into four NSF proposals. The university investigation revealed that the professor copied text from the dissertation of one former student, which itself contained plagiarized text. The university accepted the professor's assertion that no other proposals contained improperly copied text and the university found that no research misconduct occurred.

Our investigation determined that the professor had submitted two more NSF proposals with text copied from a second former student's dissertation, which also contained plagiarized text, as well as from an article by another author summarizing the professor's research. We concluded that the professor knowingly committed plagiarism and recommended that NSF require two years of certifications and assurances, and bar the professor from serving NSF as a reviewer, advisor, or consultant for two years. NSF accepted our recommendations.

(10)

Graduate Student Plagiarizes in NSF-Funded Dissertation

A graduate student working under an NSF award at a Pennsylvania university plagiarized a large amount of text into his dissertation. The university concluded it was plausible that the student, who had been educated in another country, was unaware of proper citation or paraphrasing standards for reviewing other research. Further, the student admitted that he was in a hurry and reckless in putting his dissertation together. The university determined he recklessly plagiarized and required him to replace the official version of his dissertation with a revised version.

We concurred with the university's conclusions, and we recommended that NSF require two years of certifications and assurances, and bar the student from serving NSF as a reviewer, advisor, or consultant for two years.

(11)

Team Leader Recklessly Plagiarizes in NSF Proposal

A university team leader in Illinois both contributed to and compiled two NSF proposals in which plagiarized text appeared. The university determined that the team leader recklessly plagiarized "since proper checking of citations and appropriate attributions were not provided." We agreed with the university's assessment and recommended that NSF require certifications and bar the professor from serving NSF as a reviewer, advisor, or consultant for one year.

(12)

Professor Plagiarizes From Four Sources Into an NSF Proposal

A North Carolina professor plagiarized a modest amount of text from multiple sources into his NSF proposal. Because the professor claimed that he placed the copied text into his draft proposal as a place holder, the university concluded that he had no structured process to prevent the insertion of plagiarized text into his proposals. We concurred with the university that the professor plagiarized recklessly and recommended that NSF require the professor to submit certifications for one year.

Actions by NSF Management on Previously Reported Research Misconduct Investigations

NSF has taken administrative action to address our recommendations on fifteen research misconduct cases reported in this semiannual and previous semiannual reports. In each case, NSF made a finding of research misconduct, issued a letter of reprimand, and required the subject to complete a Responsible Conduct of Research training program. NSF also took additional significant actions in response to our recommendations as summarized below.

- In the case of a former doctoral student at a Minnesota university who intentionally fabricated and falsified data on which his dissertation advisor relied in an NSF proposal, NSF finalized the five-year debarment proposed previously.[12]
- NSF took action against a graduate student in Kentucky who fabricated data[13] by proposing a one-year debarment, imposing one year of certifications, and barring the student from serving as a reviewer, advisor, or consultant for NSF for one year.
- In the case of a former postdoctoral fellow at a Washington university who intentionally falsified data,[14] NSF proposed a one-year debarment, barred him from participating as a reviewer, advisor, or consultant for three years, and required three years of certifications and assurances as well as certifications of adherence to a detailed data management plan in each new proposal.

12 September 2013 Semiannual Report, p.24.
13 September 2013 Semiannual Report, p.20.
14 September 2013 Semiannual Report, p.20.

- In the case of a professor who plagiarized from a proposal that she reviewed for NSF,[15] NSF imposed certifications and assurances for three years, and prohibited the professor from serving as a reviewer, consultant, or advisor to NSF for three years.
- In the case of the assistant professor at an Arizona university who plagiarized text in two NSF proposals and blamed it on software,[16] NSF required certifications and assurances for approximately two years, and barred him from participating as a reviewer, advisor, or consultant for NSF for approximately two years.
- NSF required a small business owner who knowingly plagiarized text in two NSF proposals to submit certifications for two years.[17]
- NSF required a PI employed by an Idaho company, who knowingly plagiarized material in an NSF proposal, to submit certifications and assurances for two years.[18]
- In the case of a PI in South Carolina who plagiarized into three NSF proposals,[19] NSF required that for two years the PI: certify compliance with his university-imposed sanctions; provide certifications and assurances; and be barred from serving as a reviewer, advisor, or consultant for NSF.
- NSF required a PI, formerly at an Illinois university,[20] who plagiarized text into two grant proposals, to provide certifications for one year. We also identified $42,641 of inappropriate expenditures that were returned by the university during the last semiannual period and the current one.
- In the case of a PI in Georgia who falsified five letters of collaboration, NSF required certifications for one year and prohibited the PI from serving as a reviewer, advisor, or consultant for NSF for one year.
- In the case of an associate professor at an Illinois university who plagiarized material into an NSF proposal,[21] NSF required one year of certifications.
- In the case of an assistant professor at a Pennsylvania university who knowingly plagiarized in a proposal,[22] NSF required that he certify compliance with his university's sanctions and required certifications and assurances for one year.
- In the case of a PI at an Ohio institution who submitted a collaborative proposal containing extensive plagiarism, NSF required certifications and assurances for one year.[23] The Ohio institution subsequently terminated the award, resulting in $50,000 put to better use.

15 September 2013 Semiannual Report, p.22.
16 March 2013 Semiannual Report, p.29.
17 September 2013 Semiannual Report, p.22.
18 September 2013 Semiannual Report, p.21-22.
19 September 2013 Semiannual Report, p.22.
20 September 2013 Semiannual Report, pp. 23-24.
21 September 2013 Semiannual Report, p.23.
22 September 2013 Semiannual Report, p.24.
23 September 2013 Semiannual Report, p.23.

NSF required a South Carolina co-PI who plagiarized to provide certifications for one year.

- NSF declined to make a finding of research misconduct against a professor at a Colorado university who plagiarized in his CAREER proposal that NSF awarded with ARRA funds.[24] We recommended a finding of reckless plagiarism, but NSF concluded that the professor acted carelessly.

ADMINISTRATIVE INVESTIGATIONS

Panelist Violates NSF's Conflict of Interests Rule in Reviewing Proposal

A panelist submitted a written review for a proposal, with which he had a conflict of interests (COI), even though he was not one of the panelists assigned to provide a written review of that proposal. We verified the panelist was a recent collaborator and co-author with both the PI and co-PI of the proposal. The panelist acknowledged that although he had a conflict of interests with both the PI and co-PI, he rated the proposal "Excellent" and was a strong oral advocate of the proposal during the panel discussion.

He claimed that he did not recognize the PI's and co-PI's names because he had not physically met with them and wrote the manuscript with them via email. NSF requires panelists to disclose potential COIs, so the program officer can make informed decisions about the objectiveness of reviewers' opinions. Therefore, we recommended NSF ban the panelist from participating as a reviewer, advisor, or consultant for NSF for two years. NSF's decision is pending.

NSF Panelist Breaches Confidentiality by Asking His Staff to Review Proposals for Him

A Texas professor knowingly breached reviewer confidentiality by sharing six NSF proposals assigned to him for panel review with subordinates at his institution. Panelists reviewing proposals for NSF sign a non-disclosure form and agree not to disclose material from any proposal they are asked to review. During our investigation, the panelist admitted that he shared the confidential proposals with his postdoctoral researchers, but asserted he had not done this before.

Concurrent with our investigation, the National Institutes of Health (NIH) reviewed a similar allegation involving the panelist's disclosure of proposals during his participation on NIH study sections. NIH's

24 March 2013 Semiannual Report, pp.29-30.

Non-Profit Improperly Spends NSF Funds

Our investigation of an NSF cooperative agreement with an Alaskan non-profit organization revealed that the PI and the organization spent NSF funds on expenses incurred by other Arctic researchers on non-NSF research, requested duplicative reimbursement of the same expenses, and failed to maintain adequate documentation of expenses. We recommended that NSF debar the PI and the non-profit organization for three years, and NSF's decision is pending.

Former Professor and His Company Proposed for Debarment for Ten Years for Theft of Award Funds

We previously reported[10] that a former professor of an Indiana university used NSF grant funds to purchase items for personal use, and as a result he was: suspended government-wide by NSF; indicted and pled guilty to criminal conversion; sentenced to probation and home confinement; and ordered to make restitution to NSF due to his misuse of NSF grant funds. Based on our recommendation, NSF proposed debarment of the individual and his company for ten years. NSF also prohibited the individual from serving as an NSF reviewer, advisor, or consultant to NSF during the period of debarment.

Research Misconduct Investigations

Research misconduct damages the scientific enterprise, is a misuse of public funds, and undermines the trust of citizens in government-funded research. It is imperative to the integrity of research funded with taxpayer dollars that NSF-funded researchers carry out their projects with the highest ethical standards. For these reasons, pursuing allegations of research misconduct by NSF-funded researchers continues to be a focus of our investigative work. In recent years, we have seen a significant rise in the number of substantive allegations of research misconduct associated with NSF proposals and awards. The NSF definition of research misconduct encompasses fabrication, falsification, and plagiarism.

NSF takes research misconduct seriously, as do NSF's awardee institutions. During this reporting period, institutions took actions against individuals found to have committed research misconduct, ranging from letters of reprimand to termination of employment. During this reporting period, NSF's actions in research misconduct cases ranged from letters of reprimand to one year of debarment.

10 March 2011 Semiannual Report, p.22, September 2011 Semiannual Report, p.9, and March 2013 Semiannual Report, p.24.

We referred thirteen cases of research misconduct to NSF, which are summarized below. In every case, we recommended that NSF make a finding of research misconduct, send the subject a letter of reprimand, require the subject to complete a Responsible Conduct of Research training program, and other actions as described below. NSF's decisions are pending in all cases.

(1)

Post-Doctoral Fellow Admits Falsifying Data

A post-doctoral fellow who conducted NSF-funded research at a Washington university admitted that he manipulated images in a manuscript submitted to a journal. The university's investigation determined that he intentionally committed falsification, but found that the image manipulations did not affect the conclusions of the manuscript. The university issued a research misconduct finding and terminated the fellow's employment. The journal rescinded its acceptance of the manuscript for publication.

We concurred with the university's findings and recommended that NSF debar the fellow for one year. We further recommended that, for three years after the debarment period, NSF: bar him from participating as a peer reviewer, advisor, or consultant for NSF; require certifications and assurances for all proposals or documents submitted to NSF; and require submission of a detailed data management plan with annual certifications of adherence for any resulting awards.

(2)

Graduate Student Fabricates Microscope Images

A graduate student at an Illinois university twice fabricated microscope images, misrepresenting his research abilities. The student admitted to his actions and was expelled from the university. We recommended that NSF debar the student for one year, require two years of certifications and assurances after the period of debarment, and bar him from serving as a consultant or reviewer for NSF for two years.

(3)

Graduate Student Expelled for Fabricating Data

A graduate student at a university in Kentucky committed research misconduct when he fabricated research data. The student's advisor became suspicious when the student provided new data so soon after returning from vacation. The advisor checked the lab equipment on which the student supposedly conducted the experiments and found it had not been used. When the advisor confronted the student, the student admitted he fabricated the data. The department chair conducted an investigation, concluded the student fabricated, and dismissed him from the program.

We concurred with the university's conclusions and recommended that NSF debar the student for one year, require him to submit certifications and an assurances for one year following the debarment period, and bar the student from serving as a reviewer, advisor, or consultant for NSF.

(4) ***Research Team Omission of Experimental Details and Overstatement of Results Constitutes Falsification***

Our investigation determined two faculty members and a graduate student at a North Carolina university recklessly omitted experimental details and overstated their experimental results in a published article, to an extent that constituted falsification.

The university's investigation concluded that at least one of the faculty members had falsified but had done so carelessly, which did not constitute research misconduct. Nevertheless, the university requested that the authors retract the article. When the authors disregarded that request, the university sent the request directly to the journal — which did not retract the article.

We continued our investigation with additional interviews and examined the laboratory records. The student's lab notebooks, which described some experiments in great detail, lacked documentation to support the pertinent claim discussed in the article. Although both faculty members claimed to have reviewed the raw data, we concluded that the minimal raw data that existed in fact contradicted the pertinent claim in the article. We also reviewed subsequent articles that the coauthors asserted constituted corrections to the original paper, but we found that these articles did not address the deficiencies in the original article.

We concluded that collectively the coauthors recklessly falsified their work in the original article. We recommended that NSF require retraction of the article and three years of certifications and assurances for each author, and bar each author as an NSF reviewer, advisor, or consultant for three years.

(5) ***Extensive Plagiarism Found in PI's Proposal***

Our investigation found plagiarism in a proposal submitted by a PI. The PI and the president of the Idaho company did not dispute that the proposal contained copied text, but explained that the PI neglected to finish the proposal because of "extenuating circumstances," specifically a visit from his fiancé, whom he had not seen in a year. Subsequently, another company employee submitted the proposal without consulting the PI.

Our investigation, however, also found extensive plagiarism in a proposal submitted to another federal entity, casting doubt on the claim the NSF plagiarism was due to "extenuating circumstances." We concluded that the PI knowingly committed plagiarism and recommended that NSF require certifications and assurances for three years.

(6)

Professor Copies from NSF Proposal She Reviewed

Our investigation determined a North Carolina professor retained copies of NSF proposals she reviewed and shared them with her students without approval by the NSF program officer. She also copied a figure from one of the proposals and used it in a conference presentation without attribution to its author. Our investigation concluded that the professor committed plagiarism and violated NSF reviewer rules. We recommended that NSF require that the professor provide certifications and assurances for three years, and be barred from service as a reviewer or consultant to NSF for three years.

(7)

Small Business Owner Plagiarizes in Two NSF Proposals

A small business owner plagiarized in an NSF proposal but claimed the plagiarism was a result of computer software. Our investigation found that the owner had submitted another NSF proposal a year earlier, contrary to his contention, and that this proposal also contained plagiarism.

The owner ultimately accepted responsibility for the copied text while claiming he misunderstood the definition of plagiarism. This claim was not plausible in light of his extended experience at large U.S. research institutions and U.S. research companies. We concluded that the owner knowingly committed plagiarism and recommended that NSF require the owner to provide certifications for two years.

(8, 9)

Proactive Review Identifies Two Incidents of Plagiarism

We routinely carry out proactive reviews to identify fraud, research misconduct, and other wrongdoing in NSF awards. As a part of an ongoing proactive review, we have been looking for plagiarism by reviewing all proposals funded by NSF in 2011. In one case that arose from that review, a South Carolina PI plagiarized in his NSF proposal. The university investigation found additional plagiarism, concluded the PI intentionally plagiarized, and took several actions in response. Our investigation identified more plagiarism, revealing a pattern. We concurred with the university's findings, and we recommended that NSF require the PI to submit certifications and assurances, and bar the PI from participating as a peer reviewer, advisor, or consultant for NSF for two years.

In a second case, we determined that a South Carolina co-PI plagiarized in an NSF proposal. During our investigation, we found no additional instances of copied text. We recommended that NSF require the co-PI to provide certifications for one year.

16, 11

PIs Submit Proposals without Noticing Plagiarism by Others

In two cases we recommended that PIs be found to have committed plagiarism because they submitted proposals in their names which had been significantly plagiarized by others. In the first case, a PI at an Ohio institution submitted a collaborative proposal in which almost nine of twelve pages were plagiarized. The NSF U.S.-Egypt program announcement states that proposals "should be jointly developed ... and reflect a true intellectual collaboration," and it includes explicit language about plagiarism. The PI admitted that his collaborator, an Egyptian scientist with whom the PI was unfamiliar, prepared virtually all of the proposal.

Our investigation concluded that the PI recklessly committed plagiarism. Although the PI authored only one small section of the proposal, he submitted a document provided to him by a foreign scientist, whom he admittedly did not know professionally or personally, without performing any due diligence such as carefully reviewing the document — despite having engaged in email correspondence in which it was clear the Egyptian scientist has a very limited command of English. We recommended that NSF require certifications and assurances for one year.

In the second case, an associate professor at an Illinois university recklessly plagiarized material into an NSF proposal. An inexperienced graduate student wrote the proposal and the professor submitted it with minimal review. He claimed that family matters affected his ability to exercise due diligence and compromised his judgment when deciding to submit the proposal. We recommended that NSF require certifications and assurances, and bar the professor from serving NSF as a reviewer, advisor, or consultant for one year.

12

PI Plagiarizes in Two Awards

A PI at an Illinois university plagiarized text in two awards from ten sources. The PI claimed he paraphrased and prominently referenced sources to support the text; however, the identified text was not demarcated by quotation marks or indentation. The university inquiry determined the PI committed plagiarism, but the university did not conduct an investigation because the PI subsequently obtained employment elsewhere. We agreed with the university's findings that

the PI plagiarized and recommended that for one year NSF require certifications for all proposals or documents submitted to NSF and bar him from participating as a peer reviewer, advisor, or consultant for NSF.

13

Assistant Professor Blames Software for Deleting Citations

A Pennsylvania professor plagiarized text into an NSF proposal and claimed that the software he used to merge components of the proposal somehow caused citations to disappear. A university committee with expertise in the same software examined the original proposal components and found no indication that attribution was ever present. The committee also noted that the professor made slight modifications to the copied text to fit his subtly different research area, and that copying such a large amount of text would be inappropriate for quotation marks or even a large indented block. The committee concluded that his actions constituted research misconduct, and we agreed and recommended that NSF require certifications and assurances, and bar him from serving NSF as a reviewer, advisor, or consultant for one year.

Actions by NSF Management on Previously Reported Research Misconduct Investigations

NSF has taken administrative action to address our recommendations on nine research misconduct cases reported in previous semiannual reports. In each case, NSF made a finding of research misconduct, issued a letter of reprimand, and required the subject to complete a Responsible Conduct of Research training program. NSF also took additional significant actions in response to our recommendations as summarized below.

- NSF proposed a five-year debarment for a former doctoral student at a Minnesota university who intentionally fabricated and falsified data.[11] NSF will then require certifications and assurances and bar him from serving as a consultant or peer reviewer for five years.
- NSF debarred a former graduate student at an Illinois university, who fabricated and falsified data in a publication and his Ph.D. thesis dissertation,[12] from participating as a peer reviewer, advisor, or consultant, for three years, followed by three years of certifications and assurances as well as certifications of adherence to a data management plan. NSF also required him to retract the publication.
- NSF proposed a three year debarment for an ex-professor and co-owner of a small business, and the business itself, in California for plagiarism,[13] submitting duplicative proposals, misrepresenting research capabilities, and providing false certifications to NSF

11 March 2013 Semiannual Report, pp.26-27.
12 March 2013 Semiannual Report, p.27.
13 March 2013 Semiannual Report, p.34.

- NSF debarred three New York professors[14] for one year, required certifications and assurances from them for three years following the debarment, barred them from participating as NSF peer reviewers,advisors, or consultants for three years following the debarment, and required certification of compliance with the requirements imposed by their institution.
- NSF barred a PI who plagiarized in proposals submitted from two SBIR companies[15] from participating as a peer reviewer, advisor, or consultant for NSF, and required certifications and assurances, for two years.
- NSF barred a Texas PI who copied text without citation or quotation[16] from participating as a peer reviewer, advisor, or consultant for NSF for one year, and required certifications and assurances for two years.
- NSF required a research scientist at a small business in Maryland, who plagiarized text into an awarded NSF proposal,[17] to submit certifications, and barred him from participating as a reviewer, advisor, or consultant, for one year.
- NSF required a professor at a Colorado university, who recklessly plagiarized in the proposal for his ARRA-funded CAREER award,[18] to provide certifications, and barred him from serving NSF as a reviewer, advisor, or consultant, for one year.
- NSF required an Ohio PI, who recklessly plagiarized in his NSF proposal,[19] to provide certifications for one year.

Administrative Investigation

Significant Abuse of Transit Subsidy

Our investigation found that an NSF employee used her transit benefit 938 times for personal trips and 51 times for parking over three years. During this period, the employee replaced her Metro card four times but did not transfer the subsidy balance to the new card, thereby leaving almost $1,000 of federal funds on the old card accounts. She also applied for and received an almost $1,000 cash reimbursement for transit expenses that she had not incurred.

During our interview, the employee admitted that she had given her son the cards, obtaining new cards as he lost or broke them and registering them with NSF to continue the subsidy. Because the employee's

14 March 2013 Semiannual Report, pp.27-28.
15 March 2013 Semiannual Report, p.28
16 March 2013 Semiannual Report, p.28.
17 March 2013 Semiannual Report, p.30.
18 March 2013 Semiannual Report, pp.29-30.
19 March 2013 Semiannual Report, p.30.

This page intentionally left blank.

NSF Suspends Two Companies, the PI, and Former Controller Government-Wide Pending Further Investigation

Our investigation revealed a Connecticut for-profit company filed false financial reports and cash requests with NSF and that the PI misused NSF award funds. Based on our recommendation, NSF suspended the PI, the company's former controller, the company, and the associated non-profit company government-wide pending the conclusion of our investigation. The U.S. Attorney's Office accepted this case and is pursuing appropriate remedies.

Research Misconduct Investigations

Research misconduct damages the scientific enterprise, is a misuse of public funds, and undermines the trust of citizens in government-funded research. It is imperative to the integrity of research funded with taxpayer dollars that NSF-funded researchers carry out their projects with the highest ethical standards. For these reasons, pursuing allegations of research misconduct by NSF-funded researchers continues to be a focus of our investigative work. In recent years, we have seen a significant rise in the number of substantive allegations of research misconduct associated with NSF proposals and awards. The NSF definition of research misconduct encompasses fabrication, falsification, and plagiarism.

NSF takes research misconduct seriously, as do NSF's awardee institutions. During this reporting period, institutions took actions against individuals found to have committed research misconduct, ranging from letters of reprimand to termination of employment. During this reporting period, NSF's actions in research misconduct cases ranged from letters of reprimand to one year of debarment.

We referred eleven cases of research misconduct to NSF, which are summarized below. In every case except the first one, we recommended that NSF make a finding of research misconduct, send the subject a letter of reprimand, require the subject to complete a Responsible Conduct of Research training program, and other actions as described below. NSF's decisions are pending in nine of the eleven cases.[10]

10 Pursuant to NSF's regulation, NSF strives to issue decisions on allegations of research misconduct within 120 days of receiving the OIG's recommendations. 45 C.F.R. § 689(c)(2)(iii). NSF is still within this 120-day timeframe in each of the nine pending cases.

V.E

Professor Enters into a Voluntary Exclusion Agreement to Resolve Data Falsification Allegations Spanning More than a Decade

A former professor at a Massachusetts university agreed to voluntarily exclude himself from federal funding for eighteen months as a result of a university investigation that concluded that he had falsified data in eight different projects. The university report described the professor's pattern of falsifying data and misrepresenting his methodology in published and unpublished manuscripts since the late 1990s, some of which involved NSF funding. The resulting changes either enhanced the significance of the statistics supporting his hypotheses or increased the credibility of his reported results. The university investigation concluded with the retraction of one NSF-supported publication and the publication of corrections to two others. The professor took a one-year leave of absence from the university and later resigned.

During our investigation, the professor negotiated a voluntary exclusion agreement with NSF under which he acknowledged that NSF has sufficient evidence to make a finding of research misconduct and excluded himself from federal funding for eighteen months. He agreed to complete training in the responsible conduct of research, and for three years after the exclusion period to provide certifications, assurances, and detailed data management plans for any NSF-funded work in which he participates.

(1)

Graduate Student, Given a Second Chance, Falsifies and Fabricates Additional Data

A doctoral student at a Minnesota university intentionally fabricated and falsified data used by his dissertation advisor in an NSF proposal. The student previously admitted to his advisor that he had fabricated apparently successful data, and the advisor gave the student a second chance to complete the work. Several months later the student again reported successful results, which the advisor included in proposals to NSF and NIH, conference presentations, and two published articles. When another member of the advisor's group was unable to replicate the results, the student admitted that he had fabricated and falsified the data. The advisor immediately dismissed the student from his group and began an investigation outside of the formal university process, with the assistance of the student's peers.

Shortly after the university investigation began, the student alleged that the advisor had knowingly used the fabricated data in the NSF proposal, but the university found no evidence to support this allegation. In addition to the admission the student made to his advisor and two others, copies

of spectra and chromatographs in the student's desk showed manual manipulation of the data. The university concluded the student committed research misconduct when he intentionally fabricated and falsified data.

We were concerned about the advisor's dismissal of the student and *ad hoc* investigation, but concluded that the university's formal investigation was fair, and we concurred with the university's findings. We recommended NSF debar the student for five years. After the debarment period, we recommended that for five years NSF: bar the student from serving NSF as a reviewer, advisor, or consultant; and require certifications and assurances for all proposals or reports submitted to NSF.

(2) ***NSF-Supported Graduate Student Admits to Data Fabrication and Falsification***

A former graduate student who conducted NSF-funded research at an Illinois university admitted that he fabricated and falsified data in a publication and his Ph.D. dissertation. Based upon the admission, the university revoked the student's Ph.D. and requested the publication be retracted. The student accepted responsibility for the fabricated and falsified data.

We concluded that he intentionally fabricated and falsified data, a significant departure from accepted practices. We recommended that NSF debar the student for three years. After the debarment period, we recommended that for three years NSF require certifications and assurances for all proposals or documents submitted to NSF, require submission of a detailed data management plan with annual certifications of adherence for any resulting awards, and bar him from participating as a peer reviewer, advisor, or consultant for NSF.

(3) ***PI and Co-PI Plagiarize Almost Entire Project Description in NSF Proposal***

Our inquiry determined that a declined NSF proposal submitted by a New York PI and two co-PIs contained text apparently copied from twelve sources comprising nine of the nearly fourteen pages of the project description. The university investigation concluded that the PI and one of the co-PIs committed plagiarism—and that while the second co-PI did not commit plagiarism, he was careless because he did not identify the extensive plagiarism in a proposal bearing his name. The university required the PI and both co-PIs to complete online training and attend a responsible conduct of research workshop. It also assigned a mentor to the PI and first co-PI to assist them with grant proposals for at least three years.

Our investigation concluded that the first co-PI, who wrote the proposal and carried out the copying, plagiarized intentionally, and that the PI acted knowingly, because he was aware of the co-PI's copying but did nothing to address it. We also concluded that both exhibited a pattern of plagiarism in a published article and an internal university proposal. We recommended that NSF: debar them for one year; require certifications and assurances from them for three years following the debarment; and bar them from participating as NSF peer reviewers, advisors, or consultants for three years following the debarment.

(4)

Plagiarism Follows PI from Company to Company

Our investigation determined that a PI submitted multiple SBIR proposals from two companies that contained substantive plagiarism. The PI denied that she plagiarized, claiming that her proposals had been edited, changing her words to match text in the source documents. However, most of the plagiarized text was in a proposal on which she was sole PI and there was evidence of direct copying-and-pasting from the sources. We recommended NSF require two years of certifications and assurances and bar the PI from participating as a peer reviewer, advisor, or consultant for NSF for two years.

(5)

Faculty Member Plagiarizes in Multiple NSF Proposals

A PI at a Texas university plagiarized in multiple NSF proposals. The PI admitted to copying in one proposal, asserting that he had believed citation alone was sufficient. The university's investigation did not make a finding of research misconduct because the sources were cited and quotation marks or other demarcation of verbatim text is "a matter of style", commonly omitted. We disagreed and conducted our own investigation.

We determined that only one of the three source documents was cited, and that citation was not proximal to the text copied from it. We also found that the style guide of a major journal in which the PI publishes clearly requires verbatim text to be quoted or offset, demonstrating that the standards of his research community are the same as other science disciplines. In addition, we consulted two experts in the PI's discipline who independently concluded that the proposal text was inappropriately copied, lacking both correct citation and demarcation.

During our investigation, we found two other proposals submitted to NSF by the PI that contained significant plagiarism, establishing a pattern of plagiarism. We recommended that NSF require certifications and assurances for two years and bar the PI from participating as a peer reviewer, advisor, or consultant for NSF for one year.

(6)

Assistant Professor Blames Software for Deleting Attribution

An assistant professor at an Arizona university plagiarized text in two NSF proposals. The assistant professor stated that the software he used deleted quotation marks, citations, and other punctuation. After the university investigation revealed unattributed copying in a second NSF proposal, he asserted that he was unaware of the need for quotation marks, despite having two doctoral degrees. The university determined that he committed research misconduct.

Our review of previous drafts of the first proposal, in which the assistant professor had appropriately cited and quoted a statement that was deleted during editing demonstrated his awareness of proper citation methods. More importantly, none of the previous drafts properly demarcated the plagiarized passages in question or contained the supposedly deleted citations/punctuation. We concluded that he committed research misconduct and recommended that NSF, for two years, require certifications and assurances, and ban him from serving NSF as a reviewer, advisor, or consultant.

(7)

PI Plagiarizes in Two NSF proposals

Our investigation found that a PI at a company in Virginia plagiarized more than 150 lines of text from eighteen different sources in two proposals, one of which NSF awarded. In response to our recommendations, NSF required the PI to submit certifications and assurances for his NSF proposals for two years, and barred him from serving as an NSF reviewer, advisor, or consultant for one year.

(8)

Professor's Incomplete Citation Practices Result in Plagiarism

A professor at a Colorado university recklessly plagiarized in his CAREER proposal that NSF awarded with ARRA funds. The professor cited most of the published papers, but did not distinguish the copied text by quotation marks or indentation. Additionally, he did not cite his colleagues' unpublished manuscripts from which he also copied text.

The university investigation found that the professor committed plagiarism, but because the university concluded that the professor was merely careless, it did not make a finding of research misconduct. However, the university implemented corrective action including a training requirement and internal certifications for two years.

We agreed that the professor committed plagiarism but disagreed with the university's finding with respect to intent, because such extensive plagiarism from so many sources could not be less than reckless. We

recommended that for one year NSF: bar the professor from serving NSF as a reviewer, advisor, or consultant; and require certifications and assurances for all proposals or reports submitted to NSF.

(9)

Professor Plagiarizes in Two Proposals

Our investigation determined that a PI at an Ohio university recklessly committed plagiarism in his NSF proposal. The PI admitted that he plagiarized, but asserted that in his native culture plagiarism is, in certain circumstances, encouraged, and that persons who plagiarize in such circumstances are considered well-educated and knowledgeable. We concluded that, regardless of whether his statement accurately reflected the practice in his native culture, when submitting a proposal to NSF he is required to abide by U.S. standards of scholarship and NSF policy. We recommended that NSF require certifications for one year.

(10)

PI Falsifies Letters of Collaboration

Our investigation concluded that an owner of a small business in Georgia submitted a proposal that included falsified letters of collaboration. The owner falsified five letters he had received for a previous SBIR project by removing the text related to the original project and subsequently submitted them in a proposal to a different program. He did not add text relevant to the new program, but just left white space in the letters, which led to inquiries from merit reviewers.

We contacted the authors of the letters and learned that the PI had not informed them of the alterations or sought permission from them to alter and reuse their letters for the second proposal.

We concluded the alteration of the letters meets NSF's definition of falsification since the PI intentionally altered them to more broadly support his research. We recommended that NSF: require for one year that the PI certify that any documents submitted to NSF do not contain plagiarism, falsification, or fabrication; and bar the PI from serving as a reviewer, advisor, or consultant for NSF for one year.

(11)

PI from a Small Business Accepts Responsibility for Plagiarism

Our investigation found that a PI at a small business in Maryland knowingly plagiarized text in an awarded NSF SBIR proposal. We recommended that NSF require certifications for one year and bar him from serving NSF as a reviewer, advisor, or consultant for one year.

The Importance of Accurate Information in Biosketches and Letters of Collaboration or Support

An NSF proposal consists of multiple sections, and PIs have a responsibility to ensure that each section contains accurate information. Our office regularly receives allegations where key information was omitted, or information was fabricated, in the proposal's biographical sketch ("biosketch") and letters of collaboration or support. NSF instructions for preparing a biosketch state that the section should contain a "list, in reverse chronological order, of all the individual's academic/professional appointments beginning with the current appointment." This includes foreign appointments, non-salaried appointments, or appointments of limited term. In a case reported herein, a professor resigned his position after it was discovered that he failed to acknowledge his appointments at foreign universities on his conflict of interests forms.

NSF also provides clear instructions about relevant publications that can be included in the biosketch:

A list of: (i) up to five products most closely related to the proposed project; and (ii) up to five other significant products, whether or not related to the proposed project. Acceptable products must be citable and accessible including but not limited to publications, data sets, software, patents, and copyrights.[11]

Unpublished documents, manuscripts described as "to be submitted" or "in preparation" should not be listed, and publications listed as "submitted" or "in press" must actually exist.

Similarly, NSF states that letters of support "must be unique to the specific proposal submitted and cannot be altered without the author's explicit prior approval."[12] We have seen several cases where PIs recycled old letters of collaboration or support and either put a new date on the letter or simply removed the original date. In a case discussed herein, a PI went a step further and removed several sentences from letters of collaboration because they related to a program to which a proposal had previously been submitted.

Padding one's biosketch and altering letters of collaboration or support are a violation of the standards of scholarship; in an NSF proposal, such actions may constitute civil and criminal false statements and false claims.

11 NSF Proposal & Award Policies & Procedures Guide, Grant Proposal Guide, II.C.2.f(i)(c).
12 NSF Proposal & Award Policies & Procedures Guide, Grant Proposal Guide, II.C.2.j.

(12)

Former University Official Wrote Plagiarized Proposals for Staff

We ascertained that two proposals nominally submitted by different PIs from the same institution contained nearly identical text, and both proposals contained text apparently copied from an awarded NSF proposal submitted by another institution. Based on statements from the PIs, we determined a university official no longer employed by the first institution wrote and submitted the two proposals. We contacted the university official, who accepted responsibility for writing and submitting the proposals. Because her university was very small and had no procedures in place for handling research misconduct investigations, we investigated this matter and concluded that she committed plagiarism and recommended that NSF make a finding of research misconduct, require certifications for one year and bar her from serving as a reviewer, advisor, or consultant for one year.

Actions by NSF Management on Previously Reported Research Misconduct Investigations

NSF has taken administrative action to address our recommendations on six research misconduct cases reported in previous semiannual reports. In each case, NSF made a finding of research misconduct, issued a letter of reprimand, and required the subject to complete a Responsible Conduct of Research training program. NSF also took additional significant actions in response to our recommendations as summarized below.

- In the case of a doctoral student at a Texas university who copied over 1,200 lines of text and supporting data into his dissertation from another student's dissertation,[13] NSF debarred the student for three years, followed by five years of certifications and assurances. NSF also barred him from serving NSF as a reviewer, advisor, or consultant for five years.

- In the case of an Ohio university faculty member who copied almost 500 lines of text into four proposals,[14] NSF required certifications and assurances for three years, and barred the faculty member from participating as a peer reviewer, advisor, or consultant for NSF for three years.

- In the case of an assistant professor at a New Jersey university who committed plagiarism in eleven unfunded NSF proposals,[15] NSF required certifications and assurances for three years, and barred him from serving as a reviewer for three years.

13 September 2012 Semiannual Report, pp.21-22.
14 September 2012 Semiannual Report, p.22.
15 September 2012 Semiannual Report, p.23.

- In the case of a small business official who plagiarized in eighteen proposals and four final project reports,[16] NSF required certifications for two years.

- In the case of an assistant professor at a Texas university who copied text in two NSF proposals,[17] NSF required certifications and assurances for one year.

- In the case of an assistant professor at a Maryland university who plagiarized large amounts of text into an NSF proposal,[18] NSF required the PI to provide certifications and assurances for one year.

Administrative Investigations

PI Alleges Retaliation for Whistleblowing under ARRA Award

ARRA provides whistleblower protections to awardee employees who reasonably believe that they are being retaliated against for reporting allegations of misuse of ARRA funds received by their non-federal employers. Under the Act, we investigate such allegations and submit a report to NSF management, the complainant, the awardee, and the Recovery Accountability and Transparency Board (RATB). NSF then determines whether there is sufficient basis to conclude that the awardee subjected the complainant to a prohibited reprisal.

We investigated an allegation that a professor had been removed as PI by an Arizona university from an NSF recovery act award, in retaliation for filing a complaint with the university alleging misuse of ARRA award funds. The allegations included inappropriate travel expenses and fraudulent undergraduate intern hours charged to the award by the graduate student who ran the program under the supervision of the PI. The university conducted a full financial audit of the award and determined that there had been no misuse of award funds. The university also determined that, in his role as supervisor of the graduate student, the PI was not engaged in the award to the extent expected by the university of a PI, and therefore the university decided to remove him as PI and replace him with the co-PI.

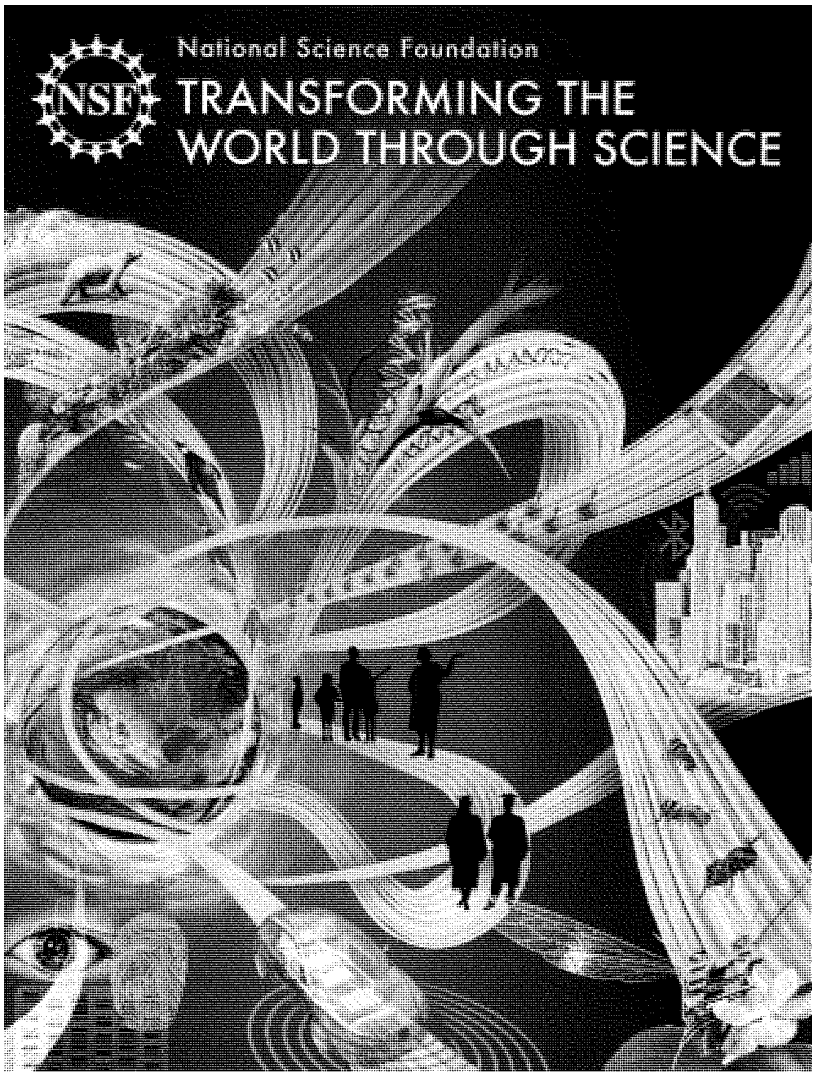
As required by ARRA, we submitted a report of investigation and NSF's decision is pending.

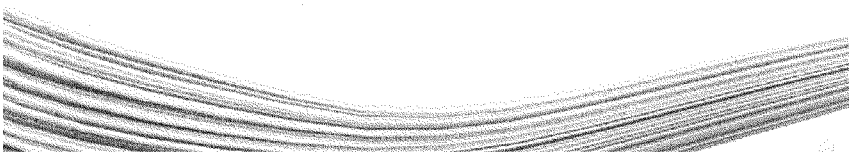
16 September 2012 Semiannual Report, pp.23-24.
17 September 2012 Semiannual Report, p.24.
18 September 2012 Semiannual Report, p. 23.

Appendix II

Additional Material for the Record

DOCUMENTS SUBMITTED BY DR. FRANCE CÓRDOVA





DIRECTOR'S LETTER

The National Science Foundation's (NSF) decades-long investment in science and engineering (S&E) research helped build the backbone of the U.S. scientific enterprise and transformed universities and colleges into centers of scientific innovation, creativity, knowledge and discovery. It also brought about the benefits of scientific discovery—new technologies, products and knowledge—that have fueled the economy, strengthened national security, enhanced the well-being of millians of Americans and shaped the nation as a world leader in science and technology.

Today, NSF-funded research continues to advance the nation's prosperity, welfare and leadership. As these pages reflect, outcomes from basic research across multiple scientific disciplines are transforming entire industries, from transportation to computing to manufacturing and agriculture.

Scientific breakthroughs start with a big idea—a question about the nature of things that leads to a fundamental shift in thinking. The ability to pursue and investigate that question, and to innovate along the way, is what enables the discoveries that ultimately transform the world.

Recently, NSF debuted a set of Big Ideas. These are bold, long-term research questions that look at critical societal challenges and aim to catalyze new breakthroughs fram the S&E communities. They identify new frontier areas for basic research, from the Arctic to the quantum world, yet also underscore where greater investments are needed; for example, in the S&E infrastructure and workforce.

If one factor unites these Big Ideas, it's that they must be shared with the public by the entire scientific community committed to moving them forward. The Big Ideas also serve as invitations to other federal agencies, nonprofits, private-sector collaborators, industry partners and the public to help expand, develop and turn them into reality.

As the only agency that supports all areas of S&E, NSF is committed to maving these ideas and the S&E enterprise of the nation forward. As highlighted in this book, this involves investing in people—the cornerstone of the scientific endeavor—through programs that ensure science, technology, engineering and mathematics education and careers are accessible ta all citizens. And it invalves supporting a vast physical infrastructure, from telescopes and polar stations to ecological sites to cyberinfrastructure/supercomputers capable af advancing the frontiers af science.

With bold leadership and an eye toward the future, the U.S. will remain at the forefront of scientific exploration.

France A. Córdova
Directar, National Science Foundation

AN EXTRAORDINARY MANDATE

"The pioneer spirit is still vigorous within this Nation. Science offers a largely unexplored hinterland for the pioneer who has the tools for his task. The rewards of such exploration both for the Nation and the individual are great. Scientific progress is one essential key to our security as a nation, to our better health, to more jobs, to a higher standard of living, and to our cultural progress."

-Science, The Endless Frontier, 1945

Vannevar Bush wrote those words in response to a commission from President Franklin D. Roosevelt to plan the nation's scientific future after the massive—and successful—research and development (R&D) mobilization following World War II. Roosevelt envisioned a postwar world with a brighter future than the preceding decades, one in which science and technology (S&T) could create more productive, more fulfilling lives for all Americans. Bush, as Roosevelt's "General of Science," proposed the nation's first science agency to transition the wartime R&D experience—which yielded new discoveries such as penicillin, radar and the atom bomb—to peacetime.

In 1950, Congress passed, and President Harry S. Truman signed, the National Science Foundation Act to "promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes" to continue this legacy.

More than 60 years since, many aspects of S&T, as well as social and political shifts, have altered the research landscape, but NSF has adapted and held firmly to its core mission: belief in the value of basic research. It is indeed "where discoveries begin."

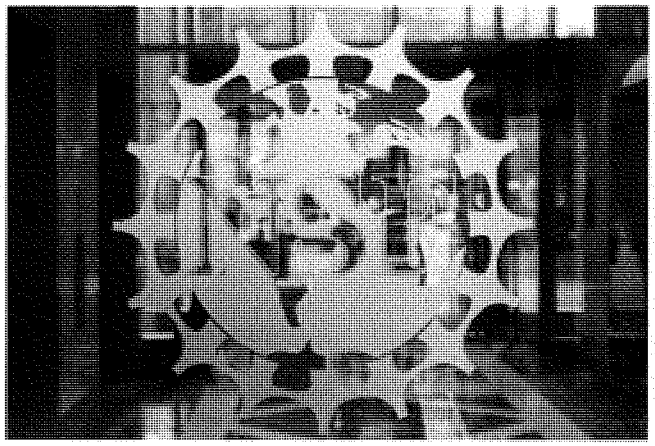


TABLE OF CONTENTS

Director's Letter i

An Extraordinary Mandate ii

The Arc of Science: Research to Results 2

Investing in the Future 4

Broadening Participation 5

Merit Review 6

NSF by the Numbers 7

Supporting the Infrastructure of Basic Research 8

U.S. Centers, Sites, Labs and Infrastructure 10

Directorate for Biological Sciences 14

Directorate for Computer and Information Science and Engineering 18

Directorate for Education and Human Resources 22

Directorate for Engineering 26

Directorate for Geosciences 30

Directorate for Mathematical and Physical Sciences 34

Directorate for Social, Behavioral and Economic Sciences 38

Office of Integrative Activities 42

Office of International Science and Engineering 46

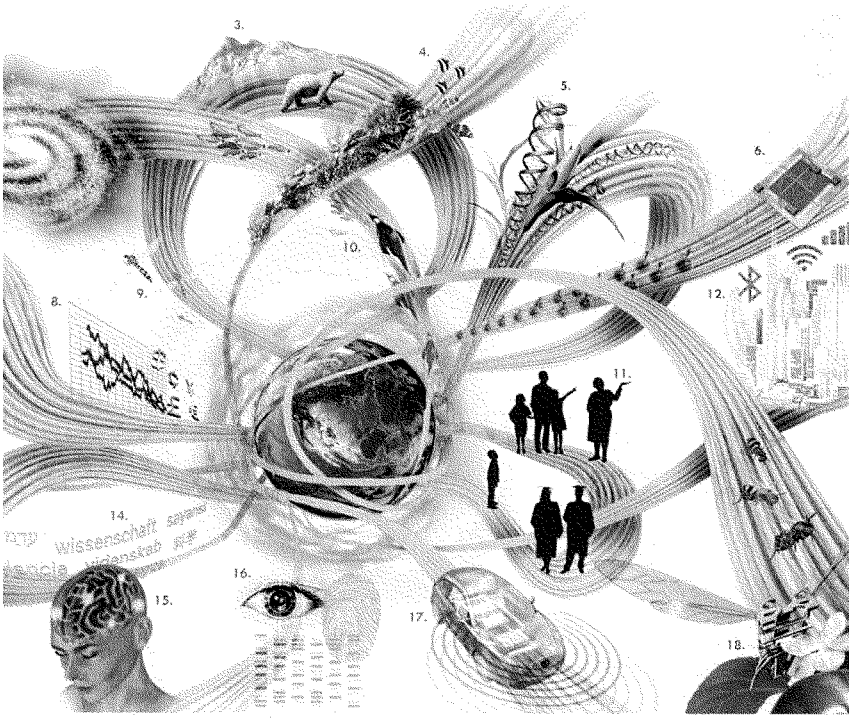
Resources and Social Media 50

Image Credits 50

THE ARC OF SCIENCE: RESEARCH TO RESULTS

Science has revolutionized the way we live our lives. As the only federal agency specifically mandated to support fundamental research across all fields of science, technology, engineering and mathematics (STEM), NSF has supported discoveries and innovations that have transformed the way we live, sparked and expanded the limits of our curiosity, opened the world to entirely new occupations and industries and enriched our quality of life. NSF plays a vital role in keeping the United States at the forefront of discovery and innovation.

1. WILDFIRE: NSF funds research that takes a multifaceted approach to understanding wildfires from prevention and prediction of the fire's path to expanding wireless communication needed for responders to studying subsequent re-growth.
2. ASTRONOMY: NSF-funded facilities house some of the world's most powerful telescopes, providing new ways to peer into space to survey distant galaxies, detect cosmic particles and monitor the sun's magnetic field and solar flares.
3. ARCTIC: Establishing a network of mobile and fixed observation platforms and tools across the Arctic will enable NSF to understand the far-reaching consequences of changing Arctic temperatures and sea-ice levels on the climate, weather and ecosystems.
4. OCEAN: The oceans are a complex and dynamic environment that houses tremendous diversity and promise for improving our quality of life. NSF addresses multiple dimensions of ocean research from mapping evolving ecosystems and forecasting sea-level changes to tracking and remediating oil spills to developing new ways to harness energy from ocean waves and clean contaminated water.
5. AGRICULTURE: With NSF funding, researchers have developed nutrient-rich vegetables, vertical farming, and methods to monitor pest levels, and sought to better understand the relationship among food, water and energy, thus protecting and improving the food supply.
6. QUANTUM COMPUTING: Harnessing the power and potential of quantum mechanics and the interaction of matter and energy at extremely small and discrete dimensions enables smaller, faster, more efficient sensors and computing. Looking ahead, NSF is prepared to lead the next computing revolution by addressing fundamental questions about quantum behavior and systems.
7. WEATHER: NSF-funded researchers are enabling a better understanding of weather patterns and more accurate weather predictions, through Doppler Radar, the Doppler on Wheels vehicle, airborne GPS technology, tornado trackers and computer modeling.
8. ECONOMICS: Understanding how U.S. goods and services are exchanged is vital for growth and sustainability, a mission NSF knows well. Fifty-five of the 78 Nobel Prize winners in Economic Science were NSF-funded.
9. EMERGING PANDEMICS: Zika, Malaria, West Nile. When and where will the next outbreak strike? NSF-funded researchers study vital aspects of the mosquitoes, ticks, fleas and fruit bats that corry viruses harmful to humans. Researchers track their movement, life cycles as well as what attracts and repels them, to determine and limit the spread of infectious diseases.
10. ANTARCTIC: NSF-funded research includes ice-shelf monitoring, cosmic neutrino detection, studies of the cosmic microwave background, and life in extreme environments. NSF also operates several important components of Antarctic research: the Amundsen-Scott South Pole, McMurdo and Palmer stations. The management of these facilities, as well as NSF's unique relationship with the Department of Defense to support flight and vessel operations, play an indispensable role for the international research community to carry on their work.
11. EDUCATION: NSF is dedicated to STEM education, from educating teachers and cybersecurity experts and funding students to supporting tribal colleges and universities, with a special focus on workforce development and broadening participation by underrepresented groups. NSF also funds research to improve STEM education.



12. CYBERTECH: Imagine a connected world with a safe, fast, and accessible internet; cutting-edge anti-virus software; more energy-efficient information technology systems and software; cloud computing; and global accessibility to data. NSF is poised to make major transformations, driven by the combination of machine learning, artificial intelligence, the Internet of Things and robotics.

13. NATURAL DISASTER: From seismic shaking models and earthquake-resistant water pipelines to search and rescue robots to understanding the human response to emergencies to collecting data, NSF funding encompasses all aspects of natural disasters and increases preparedness and resilience.

14. LINGUISTICS: NSF funds research to understand the science of linguistics, including the psychological processes involved in the use of language; how children acquire language; the social and cultural factors in language use, variation and change; and the biological basis of language in the brain.

15. BRAIN: Understanding the brain, the most intricate organ in the body, requires the integration of multiple approaches and methods. NSF-funded researchers study how individual brain cells function and communicate with each other and how neural networks are formed and maintained, which will advance the understanding of the way neurophysiological systems operate and relate to behavior.

16. POLICING: Thanks to NSF research involving stronger bulletproof vests, DNA fingerprinting, retinol scans, improved explosive devise detection, work in cryptography and nonverbal communication education, our military and police are able to better perform their work and do so more safely, enhancing national security.

17. CAR: NSF drives the automotive field forward with reseorch on advanced manufacturing; safer, more fuel-efficient cars and airplanes; and self-driving car technology.

18. ROBOTICS: From insect-sized robots to health and education assistance to robots working in tandem with humans, NSF is propelling forward the field of robotics.

INVESTING IN THE FUTURE

Today's technologies were once just ideas. In most cases it took years of research and funding to bring them to market. The advances that will change our lives require careful cultivation and NSF is a central player in this effort. Through basic research funding and educational initiatives that tap into the nation's economic drivers, NSF contributes to every step of the U.S. research enterprise.

Across—and among—its seven directorates, each one representing a broad field of science, engineering and education, NSF funds ideas that push the boundaries of innovation and productivity. With the power to transform daily life, from increasing crop yields to high-speed communication networks, these ideas are critical to moving the nation forward. Grants span all parts of the research and innovation pipeline, from fundamental research to transition to practice of research innovations. Researchers are encouraged to apply at all levels of their careers. Specific awards can assist young researchers with establishing their scientific and teaching trajectory—cementing research pathways that can transfer to commercial arenas.

Through its education programs, NSF prepares students from kindergarten through post-graduate school to become the new champions for scientific exploration. These efforts also provide evidence-based resources and learning experiences for K-12 teachers to strengthen the skills they need to nurture these budding scientists and engineers.

Advancing U.S. technological leadership also requires strong collaborations between industry and academia. Acutely aware of this need, NSF supports initiatives that complement the needs of industry, helping to transition new scientific knowledge to commercialization. Other programs work with community colleges and job training programs to strengthen the skills of technicians in high-tech fields from biotech to optics to cybersecurity, strengthening the U.S. workforce and keeping the country safe. Small businesses also benefit from these collaborations. Grants that foster entrepreneurship and provide R&D funding help them refine ideas and bring innovative products to market across all scientific fields. NSF's decades of collaboration across industry, academia and government have facilitated some of the nation's most groundbreaking and important discoveries.

DID YOU KNOW?

According to NSF's National Center for Science and Engineering Statistics (NCSES), the federal government provides 45 percent of the total national investment in basic research. This funding provides a pipeline of new ideas and innovations that are later used to bolster the economy, secure our nation and maintain our position as a global leader.

BROADENING PARTICIPATION

The brightest minds offer the best hope for solving the diverse challenges facing the world today and in the future. But who has the brightest minds? Some require a lunch subsidy. Others communicate with assistive devices. Still others live in Alaska's villages. Building a pathway for these students to share their talents is at the heart of NSF's efforts to broaden participation in STEM and to develop well prepared diverse STEM leaders.

These efforts give all students, regardless of background, gender, economic status, race, or physical ability, the opportunity to engage in STEM discovery. Through educational and informal settings, students from kindergarten through graduate school experience a range of possibilities they may otherwise never encounter. Participation builds critical thinking skills and often energizes these students to pursue further STEM opportunities. Their choices can lead to high-paying jobs with strong growth potential.

Since its inception, NSF has funded the development of STEM talent with the goals of furthering scientific discovery and ensuring the nation's security, economy and ability to innovate. NSF's recent endeavor is NSF INCLUDES. The goal of this integrated, national initiative is to develop STEM talent from all sectors and groups in society to help grow our economy.

NSF's broadening participation programs change individual lives and often entire communities. They strengthen the U.S. research enterprise and sharpen its competitive edge. Through these programs, keen minds are empowered to change the world.

DID YOU KNOW?

According to the National Center for Science and Engineering Statistics, women make up over 50% of the college-educated workforce but only 28% of individuals working in science and engineering occupations. The disparities for certain minority populations, including Blacks and Hispanics, are even larger. These numbers underscore why NSF invests in a number of programs designed to understand and broaden participation in STEM at the educational and professional levels.

MERIT REVIEW

Every year, NSF receives over 50,000 research proposals. To evaluate which proposals have the greatest potential tc promote the progress of science, a rigoraus merit review process was established by the National Science Board that seeks to identify two key factors in every proposal:

- Intellectual merit: the potential to advance scientific knowledge.
- Broader impacts: the potential to benefit saciety and contribute to the achievement of specific, societal outcomes.

Evaluating proposals on the basis of these key factors assures that the Foundations' activities are in the national interest. As reviews affirm, all proposals funded by NSF are of high quolity, advance scientific knowledge and address societal needs.

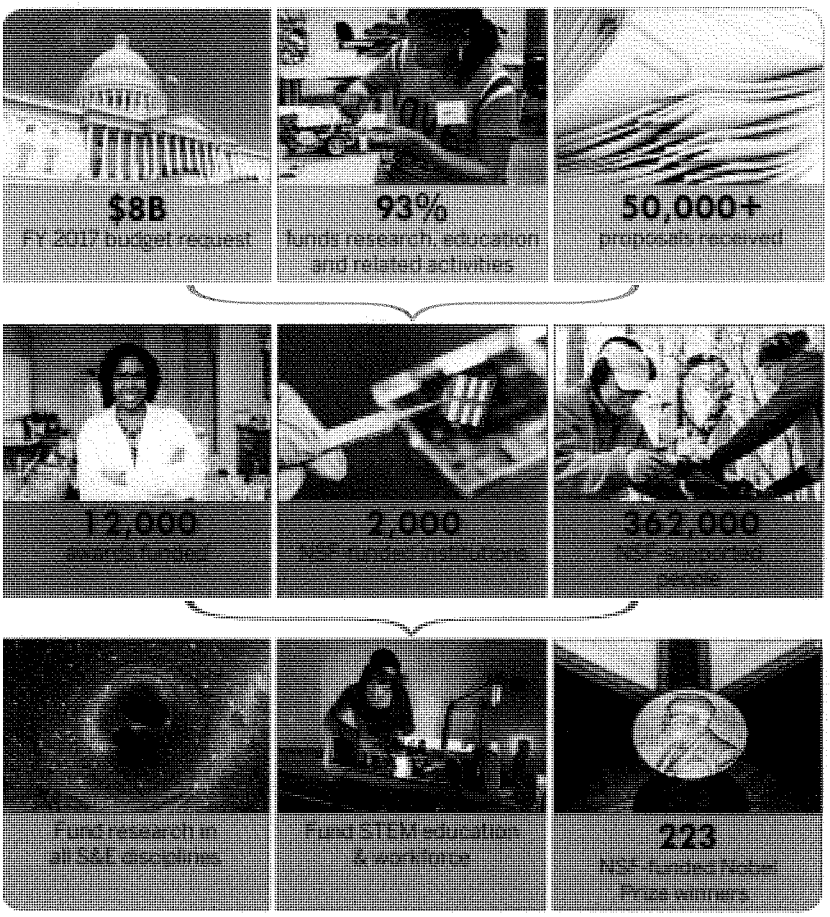
For this globally-recognized gold standard for evaluation to work, NSF relies on its program directors to assemble experts to evaluate every proposal eligible for funding, either individually, an a panel coordinated by NSF, or a combination of both. Every eligible proposal is reviewed by multiple experts in that proposal's discipline(s), who provide confidential feedback, which is crucial to ensuring that unbiased, independent assessments are received. Multiple analyses of a proposal's strengths and weaknesses provide a diversity af viewpoints across all dimensions of intellectual and societal benefits.

Pragram directors—experts in their disciplines—use reviewers' feedback and proposal rankings to determine which proposals are most likely to achieve their stated goals and advance the nation's scientific and societal endeavors. The merit review process is one of checks and balances through multiple reviews, strict conflict of interest rules and concurrence from directorote leadership. High-level oversight groups such as committees of visitors and advisory committees provide portfolio reviews and assess the quality and integrity of NSF's decision-making processes. Information on every award is publicly accessible via the NSF website.

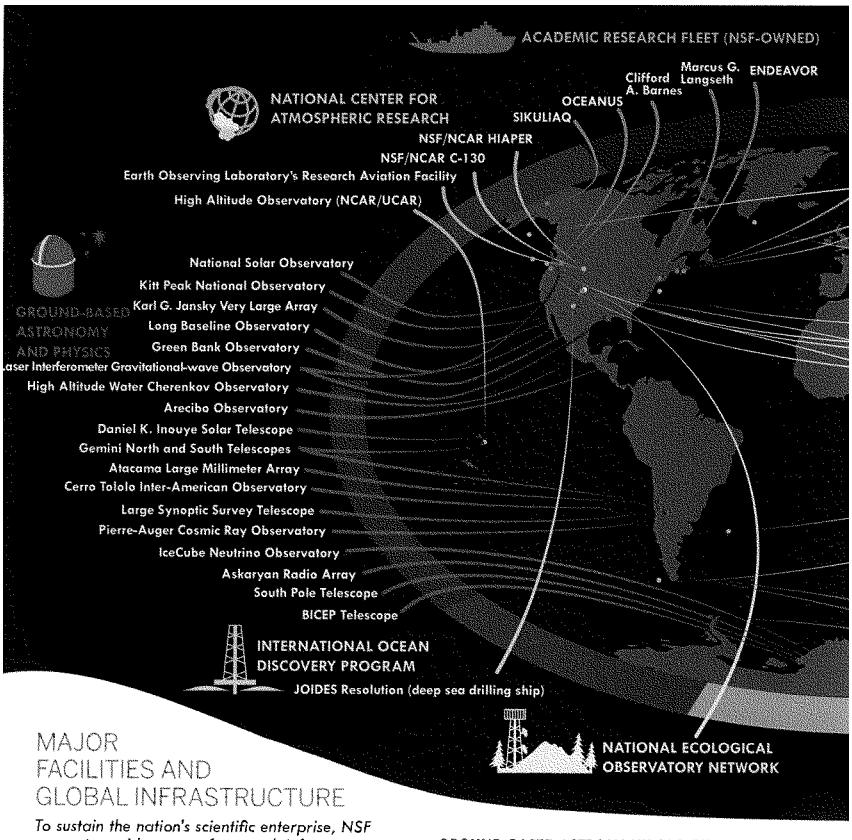
NSF has limited resources and is only able to award a fraction af the propasals it receives annually. Review feedback is provided to every grant proposer, whether they are funded or not. This feedback is constructive informatian that provides guidance towards refining the scientific ideas or proposal.

NSF's merit review pracess wauld nat be what it is without the participation of nearly 34,000 reviewers each year, who provide their time and expertise to give back to their science and to the nation. This willingness to serve allows NSF ta use almost all of its funds—93 percent of its total budget—to support over 362,000 researchers, teachers, postdoctoral fellows, trainees and students each year.

NSF BY THE NUMBERS



Other than the FY 2017 budget request, numbers shown are based on FY 2016 activities



MAJOR FACILITIES AND GLOBAL INFRASTRUCTURE

To sustain the nation's scientific enterprise, NSF supports a wide array of research infrastructure throughout the country and around the world, from polar research stations and telescopes to a fleet of research vessels. These include:

ACADEMIC RESEARCH FLEET

NSF, in partnership with other federal agencies, supports a robust fleet of 18 academic research vessels that serve as floating laboratories, including the NSF-owned vessels featured on the map.

NATIONAL CENTER FOR ATMOSPHERIC RESEARCH (NCAR)

NCAR is devoted to understanding and transferring knowledge about the behavior of the atmosphere and related Earth and geospace systems.

GROUND-BASED ASTRONOMY AND PHYSICS

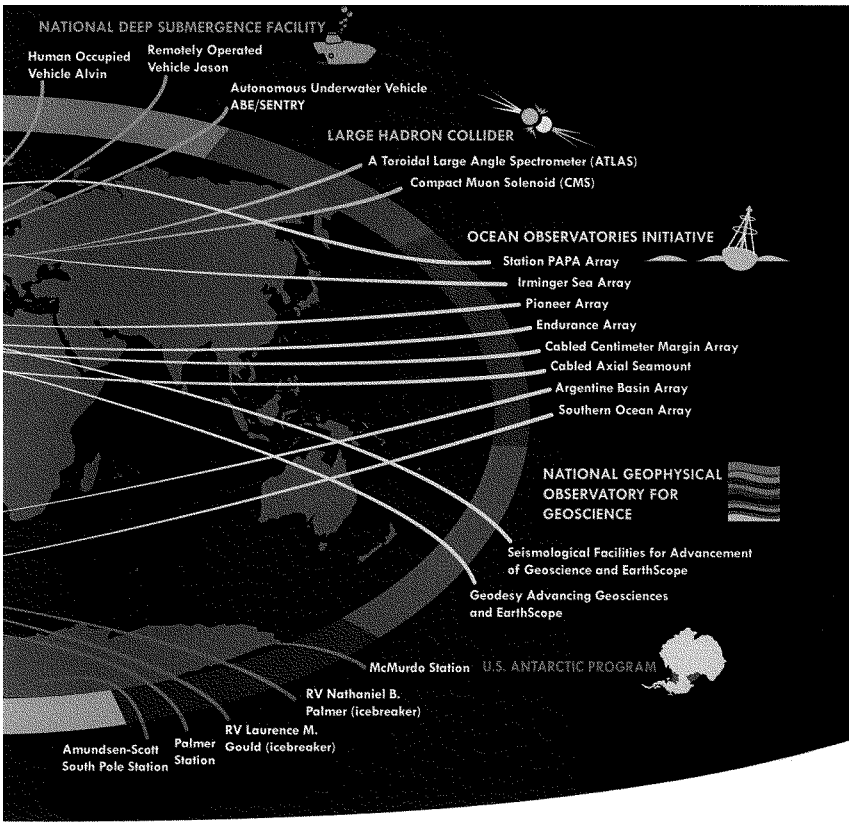
NSF funds a suite of ground-based telescopes and observatories that use cutting-edge technology to explore the universe and advance astronomical research. Many of the world's most renowned telescopes are operated by NSF.

INTERNATIONAL OCEAN DISCOVERY PROGRAM (IODP)

The JOIDES Resolution, an ocean-drilling research vessel that is part of the IODP, conducts sea drilling to study Earth's oceans and paleoclimate and maintains a number of ocean drill sites around the world.

NATIONAL ECOLOGICAL OBSERVATORY NETWORK (NEON)

NEON is a continental-scale ecological observatory that enables fundamental research on biological responses to



shifting environmental conditions, land-use changes and invasive species.

NATIONAL DEEP SUBMERGENCE FACILITY

With funding from NSF, the Woods Hole Oceanographic Institute operates three deep-sea exploration vehicles: one human-pilated vehicle, one remote-controlled vehicle, and one fully autonomous vehicle.

LARGE HADRON COLLIDER (LHC)

NSF supports two particle physics detectors—ATLAS and CMS—at the LHC in Switzerland, the world's largest, most powerful particle accelerator.

OCEAN OBSERVATORIES INITIATIVE (OOI)

NSF installed fixed and mobile instruments, undersea cables and instrumented moorings that span the Western Hemisphere and measure physical, chemical, geological and biological phenomena in key coastal, regional and global areas.

NATIONAL GEOPHYSICAL OBSERVATORY FOR GEOSCIENCE (NGEO)

Within NGEO, NSF funds a suite of community-governed, multi-user facilities that seek to transform understanding of Earth's systems and hazards.

U.S. ANTARCTIC PROGRAM (USAP)

Through USAP, NSF manages all U.S.-related logistics in Antarctica for scientific research, including deep-space exploration, particle physics, Earth's atmospheric chemistry and more.

U.S. CENTERS, SITES,
LABS & INFRASTRUCTURE
CENTERS FOR CHEMICAL INNOVATION
CENTERS FOR ENVIRONMENTAL IMPLICATIONS OF NANOTECHNOLOGY
CENTERS FOR NANOTECHNOLOGY IN SOCIETY
CENTERS OF RESEARCH EXCELLENCE IN SCIENCE AND TECHNOLOGY
CORNELL HIGH ENERGY SYNCHROTRON SOURCE
DECISION MAKING UNDER UNCERTAINTY CENTERS
ENGINEERING RESEARCH CENTERS
HIGH PERFORMANCE COMPUTING RESOURCES (HPC)
LONG-TERM ECOLOGICAL RESEARCH SITES
NATIONAL ECOLOGICAL OBSERVATORY NETWORK
NATIONAL HIGH-MAGNETIC FIELD LABORATORY
NATIONAL NANOTECHNOLOGY COORDINATED INFRASTRUCTURE
NATIONAL SUPERCONDUCTING CYCLOTRON LABORATORY
NETWORK FOR COMPUTATIONAL NANOTECHNOLOGY
SCIENCE AND TECHNOLOGY CENTERS
SYNTHESIS CENTERS

NSF support makes possible a network of science and engineering (S&E) centers, long-term ecological sites, laboratories, supercomputers and other infrastructure across the U.S. These resources foster scientific discovery.

BIOLOGICAL FIELD STATIONS AND MARINE LABORATORIES (FSML)

FSMLs are off-campus facilities for research and education conducted in the natural habitats of terrestrial, freshwater and marine ecosystems. NSF has provided infrastructure support to more than 300 sites across the U.S. and the world. (Sites not shown on map.)

CENTERS FOR CHEMICAL INNOVATION (CCI)

CCIs focus on solving major, long-term fundamental chemical research challenges, partnering with researchers from industry, government laboratories and international organizations. Centers include:

- Center for Aerosol Impacts on Climate and the Environment (CA)
- Center for Chemistry at the Space-Time Limit (CA)
- Center for Enabling New Technologies through Catalysis (WA)
- Center for Chemical Evolution (GA)
- Center for Selective C-H Functionalization (GA)
- Center for Solar Fuels (CA)
- Center for Sustainable Materials Chemistry (OR)
- Center for Sustainable Nanotechnology (WI)
- Center for Sustainable Polymers (MN)

CENTERS FOR ENVIRONMENTAL IMPLICATIONS OF NANOTECHNOLOGY (CEIN)

CEINs perform fundamental research and education on the implications of nanotechnology for the environment and living systems at all scales and address interactions of the living world with naturally derived, incidental and engineered nanoparticles and nanostructured materials, devices and systems.

- Center for the Environmental Implications of NanoTechnology (NC)
- University of California Center for Environmental Implications of Nanotechnology (CA)

CENTERS FOR NANOTECHNOLOGY IN SOCIETY (CNS)

NSF supports two CNS sites—at Arizona State University and University of California, Santa Barbara—which focus on the ethical, legal, economic and policy implications of nanotechnology. (AZ /CA)

CENTERS OF RESEARCH EXCELLENCE IN SCIENCE AND TECHNOLOGY (CREST)

CREST enhances the research capabilities of minority-serving institutions through the establishment of centers that effectively promote the development of new knowledge, strengthen the research productivity of individual faculty, and expand the presence of students historically underrepresented in STEM disciplines. Centers include:

- Advanced Center for Laser Science and Spectroscopy (VA)
- Bioenergy Center (NC)
- Center for Advanced Functional Materials (CA)
- Center for Cellular and Biomolecular Machines (CA)
- Center for Climate Change and Carbon Sequestration (CA)
- Center for Energy and Environmental Sustainability (TX)
- Center for Energy and Sustainability (CA)
- Center for Environmental Neuroscience (Puerto Rico)
- Center of Excellence in Nanobiomaterials derived from Biorenewable and Waste Resources (AL)
- Center for Explaitation of Nanostructures in Sensors and Energy Systems (NY)
- Center for Forest Ecosystems Assessment (AL)
- Center for Functional Nanoscale Materials (GA)
- Center for Gravitatianal Wave Astronomy (TX)
- Center for Innovative Information Systems Engineering (FL)
- Center for the Integrated Study of Coastal Ecosystem Processes and Dynamics (MD)
- Center for Nano & Bop-Inspired Materials and Devices (VA)
- Center for NanoBiotechnology Research (AL)
- Center for Physics and Chemistry Materials (TN)
- Center for Research and Education in Optical Sciences and Applications (DE)
- Center for Research on Complex Networks (TX)
- Center for the Sharing of Cyber-Resource to Advance Science and Education (TX)
- Center in Tropical Ecalogy and Evolution in Marine and Terrestrial Environments (HI)
- Center for Water and the Environment (NM)
- Computational Center far Fundamental and Applied Science and Education (NC)
- Interdisciplinary Center for Nanotoxicity (MS)
- Interdisciplinary Center of Research Excellence in Design of Intelligent Technologies for Smartgrids (NM)
- Nanotechnology Center for Biomedical, Environmental and Sustainability Applications (Puerto Rico)

CORNELL HIGH ENERGY SYNCHROTRON SOURCE

This NSF-funded synchrotron radiation facility supports research in physics, chemistry, biology and environmental and materials science. (NY)

DECISION MAKING UNDER UNCERTAINTY CENTERS (DMUU)

DMUUs are centers that support teams of researchers that will advance fundamental understanding of decision making under uncertainty. Centers include:

- Center for Climate and Energy Decision Making (PA)
- Center for Robust Decision Making on Climate and Energy Policy (IL)
- Decision Center for a Desert City (AZ)

ENGINEERING RESEARCH CENTERS (ERC)

ERCs help the U.S. meet its engineering demands and prepare the engineering workforce by integrating research and education with technological innovation. Centers include:

- Center for Advanced Self-Powered Systems of Integrated Sensors and Technologies (NC)
- Center for Bio-mediated and Bio-inspired Geotechnics (AZ)
- Center for Biorenewable Chemicals (IA)
- Center for Future Renewable Electric Energy Delivery and Management Systems (NC)
- Center for Integrated Access Networks (AZ)
- Center for Lighting Enabled Systems & Applications (NY)
- Center for Nanomanufacturing Systems for Mobile Computing and Energy Technologies (TX)
- Center for Nanotechnology Enabled Water Treatment Systems (TX)
- Center for Power Optimization for Electra-Thermal Systems (IL)
- Center for Quantum Energy and Sustainable Solar Technologies (AZ)
- Center for Re-Inventing the Nation's Urban Water Infrastructure (CA)
- Center for Revolutionizing Metallic Biomaterials (NC)
- Center for Sensorimotor Neural Engineering (WA)
- Center for Translational Applications of Nanoscale Multiferroic Systems (CA)
- Center for Ultra-wide-area Resilient Electric Energy Transmission Networks (TN)

★ GROUND-BASED ASTRONOMY AND PHYSICS

NSF supports a suite of ground-based telescopes and observatories that use cutting-edge technology to explore the universe. They include:

- Arecibo Observatory (Puerto Rico)
- Gemini Observatory (HI)
- Green Bank Observatory (WV)
- LIGO (LA/WA)
- Long Baseline Observatory (CA, NM, HI, IA, TX, WA, AZ, NH, Virgin Islands
- National Optical Astronomy Observatory (AZ)
- National Radio Astronomy Observatory (NM/VA)
- National Solar Observatory (NM, AZ, HI)

HIGH PERFORMANCE COMPUTING RESOURCES (HPC)

NSF supports HPCs throughout the U.S. that enable academic and industrial researchers, regardless of discipline or funding agency, to perform advanced analysis and simulations on everything from atoms to the structure of the early universe. They include:

- Blue Waters: National Center for Supercomputing Applications (IL)
- Bridges: Pittsburgh Supercomputing Center (PA)
- Comet: San Diego Supercomputer Center (CA)
- Gordon: San Diego Supercomputer Center (CA)
- Jetstream: Indiana University Pervasive Technology Institute (IN)
- Stampede: Texas Advanced Computing Center (TX)
- Wrangler: Texas Advanced Computing Center (TX)
- Yellowstone: NCAR-Wyoming Supercomputing Center (WY)

LONG-TERM ECOLOGICAL RESEARCH (LTER) SITES

The LTER program supports 25 sites across the country, each of which represents a major ecosystem type or natural biome and allows for the study of ecological phenomena over long periods of time. They include:

- Andrews Forest (OR)
- Arctic (AK)
- Baltimore Ecosystem Study (MD)
- Bonanza Creek (AK)
- California Current Ecosystem (CA)
- Cedar Creek Ecosystem Science Reserve (MN)
- Central Arizona-Phoenix (AZ)
- Coweeta (GA)
- Florida Coastal Everglades (FL)
- Georgia Coastal Ecosystems (GA)
- Harvard Forest (MA)
- Hubbard Brook (NH)
- Jornada Basin (NM)
- Kellogg Biological Station (MI)
- Konza Prairie (KS)
- LTER Network Communications Office (CA)
- Luquillo (Puerto Rico)
- McMurdo Dry Valleys (Antarctica, not shown on map)
- Moorea Coral Reef (Moorea, not shown on map)
- Niwot Ridge (CO)
- North Temperate Lakes (WI)
- Palmer Antarctica (Antarctica, not shown on map)
- Plum Island Ecosystems (MA)
- Santa Barbara Coastal (CA)
- Sevilleta (NM)
- Virginia Coast Reserve (VA)

✳ MATERIALS RESEARCH SCIENCE AND ENGINEERING CENTERS (MRSEC)

The MRSECs are an NSF-funded network of university-based centers that support materials research and education and address fundamental problems in S&E important to society. Centers include:

- Bioinspired Soft Materials Center (MA)
- Center for Emergent Materials (OH)
- Center for Materials Science and Engineering (MA)
- Center for Nanoscale Science (PA)
- Center for Photonic and Multiscale Nanomaterials (MI)
- Center for Precision Assembly of Superstratic and Superatomic Solids (NY)
- Chicago Materials Research Center (IL)
- Cornell Center for Materials Research (NY)
- CRISP Center for Research on Interface Structures and Phenomena (CT)
- Harvard Materials Research Center (MA)
- Materials Research Laboratory (CA)
- Materials Research Science and Engineering Center on Structured Interfaces (WI)
- Next Generation Materials for Plasmonics and Organic Spintronics (UT)
- Northwestern University Materials Research Science and Engineering Center (IL)
- NYU Materials Research Science and Engineering Center (NY)
- Princeton Center for Complex Materials (NJ)
- Research Triangle MRSEC (NC)
- Saft Materials Research Center (CO)
- The Laboratory for Research on the Structure of Matter (PA)
- UMN Materials Research Science and Engineering Center (MN)
- UNL Materials Research Science and Engineering Center (NE)

NATIONAL ECOLOGICAL OBSERVATORY NETWORK (NEON)

NEON is a continental-scale network of sites that enable fundamental research on biological responses to shifting environmental conditions, land-use

changes, and invasive species. NEON's twenty core terrestrial sites are shown on the map.

- Caribou Creek - Poker Flats Watershed (AK)
- Central Plains Experimental Range (CO)
- Guanica Forest (Puerto Rico)
- Harvard Forest (MA)
- Konza Prairie Biological Station (KS)
- LBJ National Grassland (TX)
- Niwot Ridge Mountain Research Station (CO)
- Oak Ridge (TN)
- Onaqui-Ault (UT)
- Ordway-Swisher Biolagical Station (FL)
- Pu'u Maka'ala Natural Area Reserve (HI)
- San Joaquin Experimental Range (CA)
- Santa Rita Experimental Range (AZ)
- Smithsonian Conservation Biology Institute (VA)
- Talladega National Forest (AL)
- Toolik (AK)
- UNDERC (MI)
- Wind River Experimental Forest (WA)
- Woodworth (ND)
- Yellowstone Northern Range (WY)

NATIONAL HIGH MAGNETIC FIELD LABORATORY (NHMFL)

The NHMFL is the largest and highest-powered magnet laboratory in the world. (FL/NM)

NATIONAL NANOTECHNOLOGY COORDINATED INFRASTRUCTURE (NNCI)

The NNCI are university-based facilities that advance research in nanoscale science, engineering and technology by providing researchers from academia, industry and government with access to leading-edge tools and expertise. They include:

- Center for Nanoscale Systems (MA)
- Cornell Nanoscale Science and Technology Facility (NY)
- Kentucky Multi-Scale Manufacturing and Nano Integration Node (KY)
- Mid-Atlantic Nanotechnology Hub (PA)
- Midwest Nanotechnology Infrastructure Corridor (MN/ND)
- Montana Nanotechnology Facility (MT/MN)
- nano@Stanford (CA)
- Nanotechnology Collaborative Infrastructure Southwest (AZ)
- National Center for Earth and Environmental Nanotechnology Infrastructure (VA)
- Nebraska Nanoscale Facility (NE)
- Northwest Nanotechnology Infrastructure (WA/OR)
- Research Triangle Nanotechnology Network (NC)
- San Diego Nanotechnology Infrastructure (CA)
- Soft and Hybrid Nanotechnology Experimental Resource (IL)
- Southeastern Nanotechnology Infrastructure Corridor (GA/NC)
- Texas Nanofabrication Facility (TX)

NATIONAL SUPERCONDUCTING CYCLOTRON LABORATORY

This nuclear science research facility allows researchers around the world to explore the inner workings of atoms and their role in the universe. (MI)

NATURAL HAZARDS ENGINEERING RESEARCH INFRASTRUCTURE (NHERI)

NHERI centers are university-based, experimental facilities that provide researchers with state-of-the-art tools to investigate earthquake, wind and water hazards, and test ground-breaking concepts to protect individuals, communities and critical infrastructure. Different components will provide:

- Boundary Layer Wind Tunnel, Wind Load and Dynamic Flow Simulators, and Pressure Loading Actuators (FL)
- Computational Modeling and Simulation Center (CA)
- Cyberinfrastructure (TX)
- Geotechnical Centrifuges (CA)
- Large, High-Performance Outdoor Shake Table (CA)
- Large, Mobile Dynamic Shakers for Field Testing (TX)
- Large-Scale, Multi-Directional, Hybrid Simulation Testing Capabilities (PA)
- Large Wave Flume and Directional Wave Basin (OR)
- Network Coordination (IN)
- Post-Disaster, Rapid Response Research Facility (WA)
- Twelve-Fan Wall of Wind (FL)

NETWORK FOR COMPUTATIONAL NANOTECHNOLOGY (NCN)

NCN is a multi-university network that develops models and simulation tools to predict behavior at the device, circuit and system level for nanoelectronics, nanoelectromechanics and nanobio systems. NCN serves as a virtual laboratory to the nanotechnology community through online simulation and education.

- Nano-Engineered Electronic Device Simulation Node (IN)
- NanoBIO Node (IL)
- nanoHUB (IN)

SCIENCE AND TECHNOLOGY CENTERS (STC)

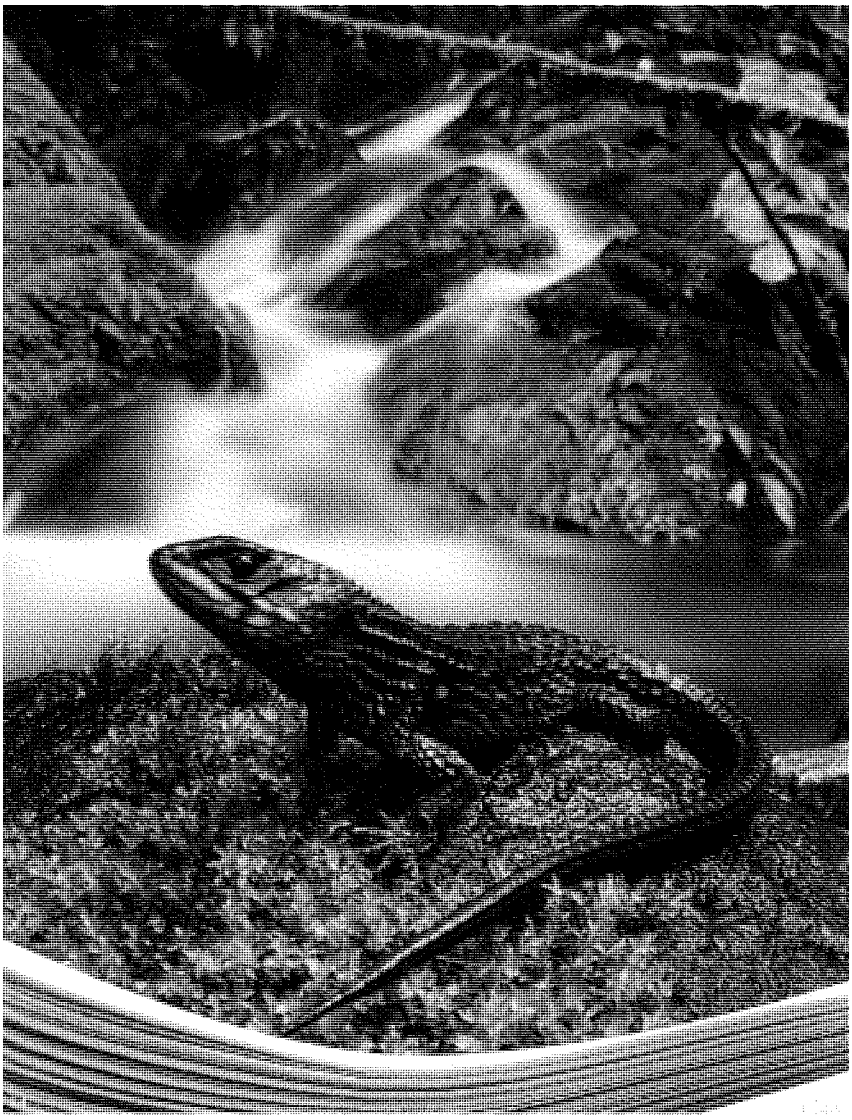
STCs integrate education and research and provide a rich environment that encourages future scientists, engineers and educators to take risks in pursuing discoveries and new knawledge. Centers include:

- Center for Biology with X-Ray Free Electran Lasers (NY)
- Center far Brains, Minds, and Machines (MA)
- Center far Integrated Quantum Materials (MA)
- BEACON Center for the Study of Evolution in Action (MI)
- Center for Dark Energy Biosphere Investigations (CA)
- Center for Energy Efficient Electronics Science (CA)
- Center for Emergent Behaviors af Integrated Cellular Systems (MA)
- Center for Science of Information (IN)
- Center for Bright Beams (NY)
- Center for Cellular Construction (CA)
- Center for Engineering MechanoBiology (PA)
- Center on Real-Time Functional Imaging (CO)

SYNTHESIS CENTERS

Synthesis centers accelerate scientific understanding in the development of new tools and standards for managing data, new analysis capabilities with broad utility, and foster interdisciplinary collabarations in both educational and prafessional contexts.

- National Institute far Mathematical and Biological Synthesis (TN)
- National Socio-Environmental Synthesis Center (MD)



DIRECTORATE FOR BIOLOGICAL SCIENCES

INTRODUCTION

Understanding life at all scales and degrees of complexity—from the sub-cellular level to the biosphere—is central to the health and well-being of humans, and to the resilience of the planet.

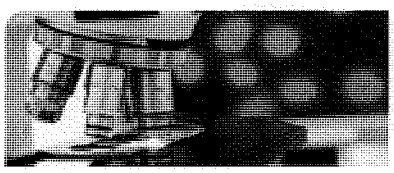
Basic research supported by NSF's Directorate for Biological Sciences (BIO) seeks to understand how humans and other animals, plants and a host of microorganisms persist and interact with one another, and how they respond and adapt to a variety of environmental conditions. Identifying the basic biological rules that have led to the existence and diversity of life on Earth can reveal mechanisms and inspire tools to prevent and treat diseases, improve agricultural practices or conserve precious natural resources.

In addition, new technologies have transformed biology into a "big data science," one that engages researchers from all areas of STEM to store, manage and analyze data. These data promise to enrich knowledge and address fundamental questions about everything from molecular interactions to the behavior of organisms.

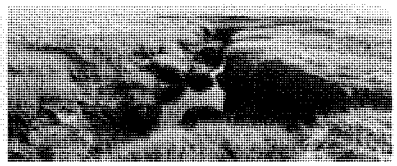
Furthermore, the BIO Directorate invests in the infrastructure, tools and theories needed to advance the biological sciences and ensure the U.S. remains at the forefront of discovery, with all the technological, societal and economic benefits that a competitive edge affords. Outcomes from BIO-funded research have the ability to transform human health, food security, biodiversity conservation and more, making biology an engine for innovation in the 21st century.

Opposite page: NSF-funded researchers discovered this new species of aquatic lizard, the *Potamites erythrocularis*, while conducting a survey of a national park and its buffer zone.

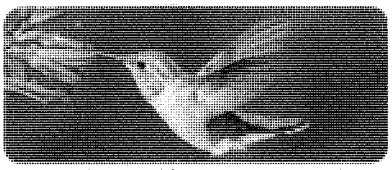
BIO DIVISIONS



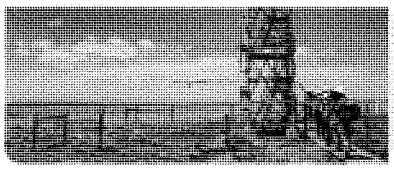
Molecular and Cellular Biosciences seeks to understand complex living systems at molecular and cellular scales.



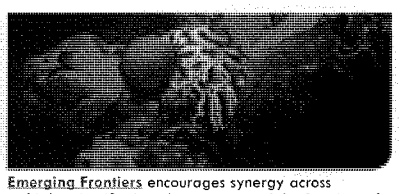
Environmental Biology supports fundamental research on populations, species, communities and ecosystems across all spatial and temporal scales.



Integrative Organismal Systems supports research to understand the simple and complex structures and functions of different organisms in evolutionary and ecological contexts.



Biological Infrastructure invests in people and infrastructure needed to advance all areas of biological research, including everything from new instrument development to advanced cyberinfrastructure.



Emerging Frontiers encourages synergy across multiple scientific disciplines to expand the frontiers of biological research.

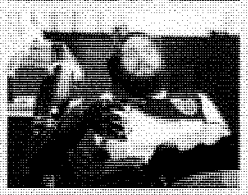
DID YOU KNOW?

- NSF supports 25 LTER sites—each representing a major ecosystem type or natural biome—across the continental U.S., Alaska, Antarctica and islands in the Caribbean and the Pacific. Researchers have monitored five of the sites for more than three decades.
- There are an estimated 1 trillion microbial species on Earth, of which only one-thousandth of 1 percent are known to scientists. That's according to an NSF-funded study that combined datasets from government, academic and citizen science sources.
- Stanley Falkow—considered the father of molecular microbial pathogenesis, which investigates diseases at the molecular level—was supported by NSF early in his career through a series of grants. Today, Falkow is a professor of microbiology and immunology at Stanford University's School of Medicine.

IMPACTS

NEXT-GENERATION FORESTRY AND CROP MANAGEMENT

In the Western U.S., NSF-funded researchers deployed a unique set of instruments, called the Internet of Trees Microenvironmental System, to monitor how trees respond to repeated droughts at the cellular level and across ecosystems. The researchers refined the instrumentation during the study and, with funding from NSF's Small Business Innovation Research (SBIR) and I-Corps programs, began rolling it out for commercial use. The new technology, called Arable, will help farmers and natural resource managers collect data on rainfall, microclimate, etc. Pilots are underway with large growers, including California-based Driscoll's and Australian-based Treasury Wine Estates.

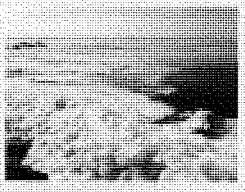


TOUCH-SENSITIVE PROSTHETICS

From borrowing a shirt to grasping a cup, the ability to manipulate objects is aided by the sense of touch, which is why traditional prosthetics limit patient function. Earlier this year, however, a quadriplegic man experienced the sense of touch again through a robotic arm connected to a brain computer interface (BCI) implanted in his head that allowed him to "feel" pressure on the robotic hand. The blueprint for the BCI-robotic arm system came from NSF-funded basic research that looked at the neural activity of monkeys as they manipulated objects. The advancement is paving the way for future touch-sensitive prosthetics.

NEW GENE-EDITING TOOL

NSF-funded researchers studying how a bacterium's immune system fights off viruses uncovered a powerful new gene-editing technique called CRISPR-Cas9. CRISPR-Cas9 acts like a pair of molecular-sized scissors that researchers can wield to snip a segment of DNA, for example, to edit a segment that codes for a particular trait in an organism. Biomedical researchers are exploring CRISPR-Cas9's potential use for everything from treating genetic disorders and developing targeted cancer therapies to preventing vector-borne infectious diseases. The agricultural industry is also exploring whether CRISPR-Cas9 can help enhance crop production and livestock survival.



RAPIDLY WARMING LAKES

More than half of the world's fresh water supply is warming rapidly, according to an NSF- and NASA-funded study. Using satellite data and ground measurements collected from 235 lakes on six continents over a period of 25 years, scientists determined the world's lakes are warming on average 0.61 degrees Fahrenheit each decade, with potential impacts ranging from drinking water to crop production. Toxic algal blooms are also projected to increase by 5 percent and methane emissions by 4 percent over the next decade. Some species face possible extinction, as the rapid temperature increase disrupts aquatic ecosystems.

WINDOW INTO THE BRAIN

Until recently, the composition of brain tissue limited researchers' insights into the brain's neural circuitry and function. NSF-funded scientists developed a technique called CLARITY to chemically dissolve opaque elements and replace them with a hydrogel, essentially rendering the brain transparent. When used with fluorescent markers, CLARITY lets researchers precisely reconstruct the brain's neural circuitry in 3-D and analyze how changes to the brain may underlie certain disorders such as autism or depression. The technique has been hailed as a breakthrough in neuroscience.

DIRECTORATE FOR COMPUTER & INFORMATION SCIENCE & ENGINEERING

INTRODUCTION

Advances in computer, communication and information S&E have rapidly and profoundly transformed our lives. They have changed the way we work, the means by which we communicate and the way in which many of us spend our free time. These innovations help us to be more efficient and productive, and drive economic growth.

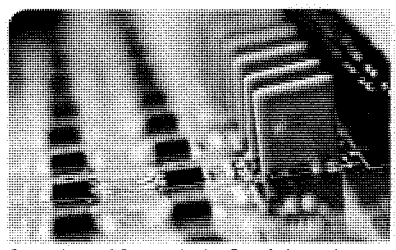
Research supported by NSF's Computer and Information Science and Engineering (CISE) Directorate has enabled many transformative innovations. From the internet and web browsers to assistive robotics and driverless cars, CISE-funded research has resulted in many technologies that touch our daily lives.

Research supported by CISE also addresses national priorities. For example, exploring the integration of physical infrastructure with "cyber" capabilities will improve the function and quality of cities and communities, revitalizing them for the 21st century. Efforts to maximize the benefits of advanced cyberinfrastructure, including high-performance computing research, development and deployment will accelerate scientific discovery and advance all sectors of the economy. And building the knowledge base and capacity for computer science education will expand its access to all students across the nation.

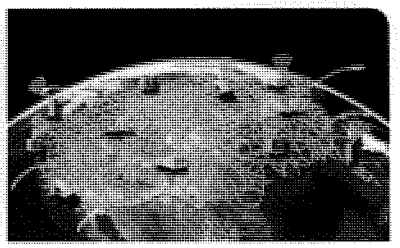
The computing field requires continued investment to enable more efficient and secure devices, systems, networks and computational abilities. Cantinued investments are needed to provide advanced cyberinfrastructure resources that enable discovery across the entire U.S. S&E enterprise. They will also enable education that provides skills essential for success in the new era of data and computation.

Opposite page: Data is accelerating the pace of discovery and innovation across all fields of inquiry. Here, sensors measure environmental data in a city to scientifically investigate solutions to urban challenges ranging from air quality to transportation flow.

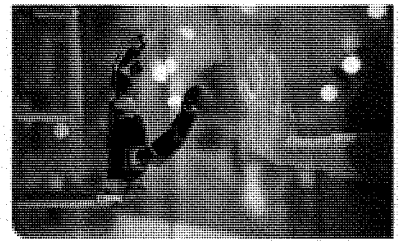
CISE DIVISIONS



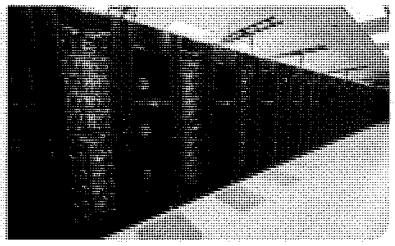
Computing and Communication Foundations advances computing and communication theory, algorithms for computational and data science, and the design of novel hardware and software for future computing systems.



Computer and Network Systems invests in new computing and networking technologies, while ensuring their security and privacy, and finds new ways to make use of current technologies.



Information and Intelligent Systems studies the interrelated roles of people, computers and information to increase the ability to understand data, as well as mimic the hallmarks af intelligence in computational systems.

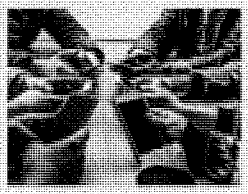


Office of Advanced Cyberinfrastructure supports and coordinates the development, acquisition and provision of state-of-the-art cyberinfrastructure resources, tools and services essential to advance and transform S&E.

DID YOU KNOW?

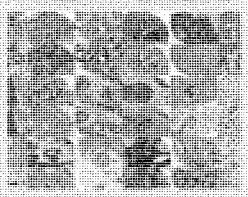
- NSF supports 82 percent of U.S. academic computer science research. This funding enables research throughout the entire range of computing from fundamental theory to improving human-computer interfaces.
- The Blue Waters supercomputer at the National Center for Supercomputing Applications at the University of Illinois at Urbana-Champaign is the fastest supercomputer on a university campus in the U.S. Researchers across the U.S. use Blue Waters to address a wide range of challenges, from predicting the behavior of complex biological systems to simulating the evolution of the cosmos.
- NSF-funded researchers worked with The College Board to launch a new Advanced Placement® (AP®) computer science course that aims to engage a greater number and diversity of students in computer science.

IMPACTS



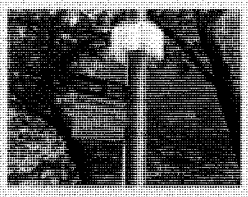
ADVANCING WIRELESS COMMUNICATIONS

The growing U.S. wireless industry, which reached nearly $192 billion in 2015, relies on advances in wireless communications technologies made possible by NSF-funded research. One such advance is a discovery made in 1992 that enables wireless devices to simultaneously receive multiple input and multiple output (MIMO) data streams. MIMO technology dramatically increases the performance of wireless systems, allowing both higher data rates and wider coverage areas, and underlies today's wireless (WiFi and LTE) networks. In addition, the breakthrough was the basis for two companies that pioneered 4G wireless communications and WiMax technologies and advanced the wireless communications sector over the last decade.



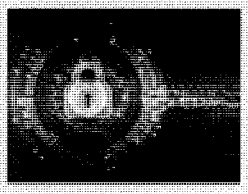
TRAINING COMPUTERS TO ANALYZE CANCER

Advances in data analytics and machine learning are helping to diagnose illnesses and personalize treatments. For example, scientists developed a new model to teach computers how to analyze breast cancer. By assessing numerous novel morphological features visible in images of breast cancer tissue, the model can more accurately determine cancer diagnosis and prognosis than trained clinicians. An astounding outcome of this work was that the cellular features that were the best predictors of patient survival were not from the cancer tissue itself, but rather from adjacent tissue—a finding that had gone undetected by medical teams.



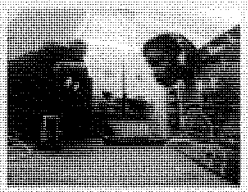
INSTRUMENTING A CITY TO TRACK LIVABILITY

New sensors, together with advanced networking capabilities, are paving the way for smart cities and communities. In Chicago, Illinois, researchers are working with the city to deploy an urban-scale instrument that can assess the livability of areas by measuring environmental data. Sensor boxes are mounted to street light poles that measure factors such as weather and air quality, and then analyze those data on the spot in order to help protect privacy. The information collected through this network of sensors is open and free to the public and is being used by individuals to guide everyday decisions. For example, an individual with asthma may plan to take the bus instead of walk on a day when the air quality is poor.



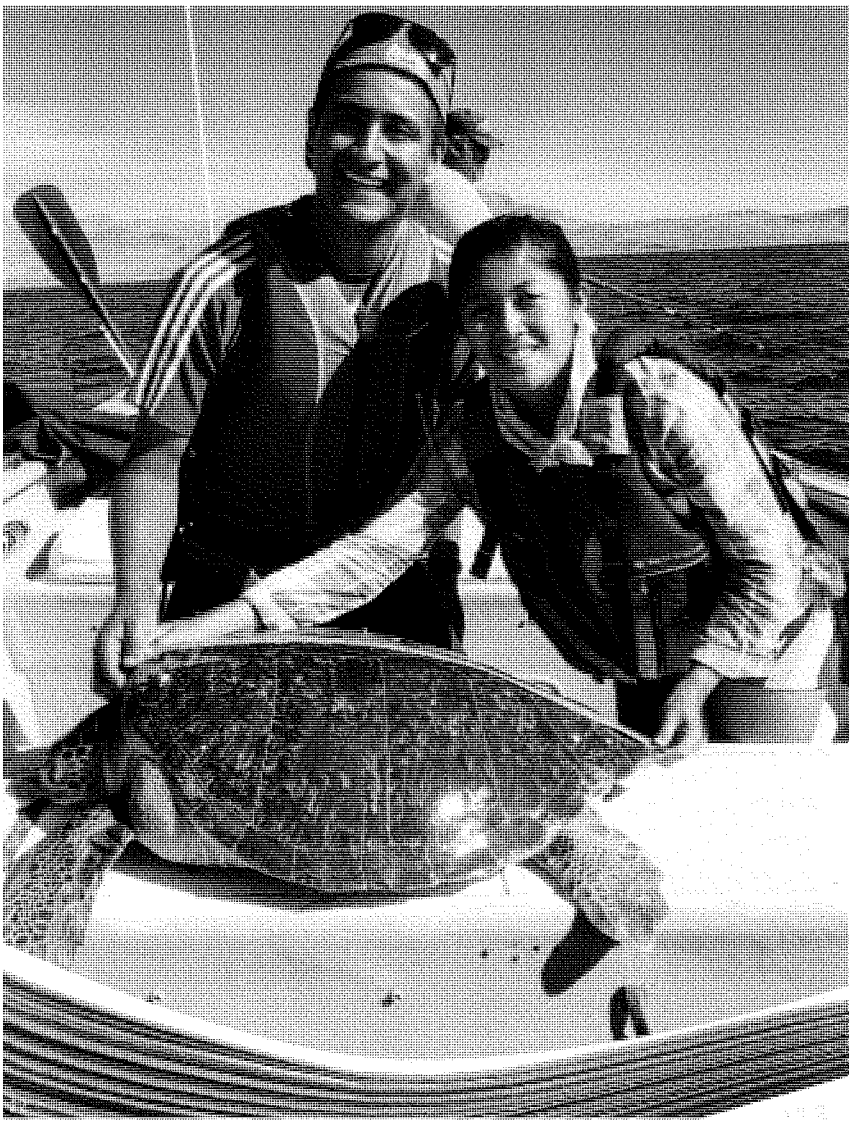
REDUCING SPAM AND STOPPING INTERNET SALES OF COUNTERFEIT PRODUCTS

In recent years, spam emails marketing products for everything from pharmaceuticals to software have begun flooding our inboxes. Sophisticated firewalls can filter out these messages but some still slip through, with some recipients unknowingly buying the advertised—often counterfeit—products. Researchers performed a detailed analysis tracking the financial trail of these sales and showed that only a handful of banks process these transactions. Uniting those transactions disrupted the spam networks, substantially reducing emails advertising the sale of such products. As a result of this work, the International AntiCounterfeiting Coalition launched a program to help banks identify and halt payments from spammers selling counterfeit products.



ENGAGING STUDENTS THROUGH PERSONALIZED ROBOTS

A furry, brightly colored robot named Tega is helping to teach Boston-area. The robotic system was designed and piloted with NSF funding to enable long-term interactions with children by integrating the emotional response of an individual and, based on those cues, create a personalized motivational strategy. It uses an Android device to process movement, perception and thinking and respond appropriately to children's behaviors. Tega was more engaging than other non-personalized learning robots. The researchers hope to make improvements to the personalized educational assistive robot so that it can be used in a variety of contexts, including assisting students with learning disabilities.



DIRECTORATE FOR EDUCATION AND HUMAN RESOURCES

INTRODUCTION

People are the backbone of the nation's S&E enterprise. The success of that enterprise relies on scientists, technicians, engineers, mathematicians and educators who engage in science every day, combined with a well-informed public.

To sustain U.S. leadership and excellence in STEM, and to meet the high-technology workforce needs of today and tomorrow, the U.S. must maintain a vigorous investment in its STEM human capital.

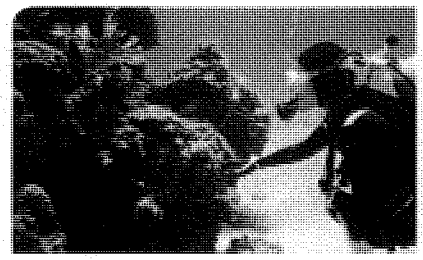
NSF's Education and Human Resources (EHR) Directorate supports STEM education and education research from early childhood learning to doctoral work and beyond. EHR supports and promotes evidence-based innovations in teaching practices, instructional tools and programs that advance STEM education and prepare the next generation of STEM professionals.

The directorate further works to ensure that STEM education and career opportunities are available to all Americans, regardless of race, creed or gender. Accordingly, EHR-based programs support broadening participation and the development of talent among groups that have been traditionally underrepresented in STEM, including women, minorities, persons with disabilities and veterans.

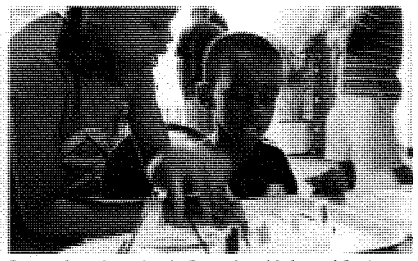
The short-term impact of this investment is to expand the STEM education research knowledge base and develop tools and practices that inform efforts toward improvement. The longer-term impact of this investment is a workforce that is diverse, innovative and prepared to lead in S&E, along with a science-literate U.S. public.

Opposite page: San Diego's Ocean Discovery Institute provides a tuition-free program to low-income youth that incorporates education, scientific research and lessons on environmental stewardship. NSF, on behalf of the White House, recognized the institute with a Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring award.

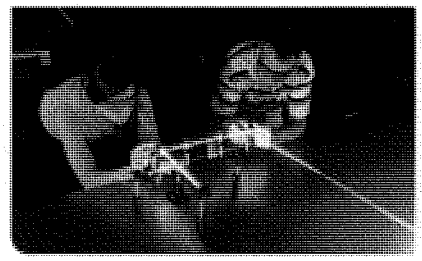
EHR DIVISIONS



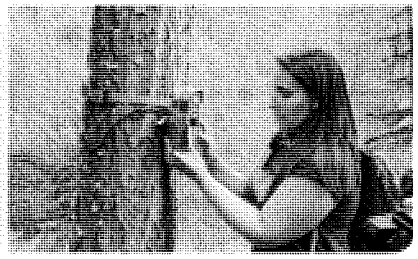
Graduate Education manages innovative, NSF-wide programs to support U.S. citizens ond permanent residents to become leading scientists and engineers.



Research on Learning in Formal and Informal Settings supports advances in cutting-edge knowledge and practices in formal and informal educational settings to advance STEM learning for people of all ages.



Undergraduate Education promotes excellence in undergraduate STEM education at two- and four-year colleges and universities by investing in R&D to produce effective instructional approaches and materials; research experiences; and support for diverse students and institutions to prepare tomorrow's STEM workers.

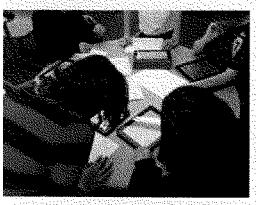


Human Resource Development enhances excellence in S&E education and high-quality research by broadening participation in STEM to include historically underrepresented groups such as minorities, women and persons with disabilities.

DID YOU KNOW?

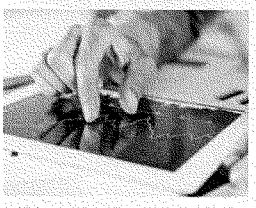
- NSF has supported 53,800 graduate student researchers through its Graduate Research Fellowship Program (GRFP) since it launched in 1952. More than 40 of those fellows went on to become Nobel Laureates.
- Since the Sept. 11 terrorist attacks, NSF has supported the training of 2,200 cybersecurity experts through the CyberCorps®: Scholarships for Service program, which seeks to recruit and train the next generation of information technology professionals.
- Active participation in science labs not only helps students learn and earn higher test scores, but also shows a lasting physical impact on the sensorimotor regions of the brain.

IMPACTS



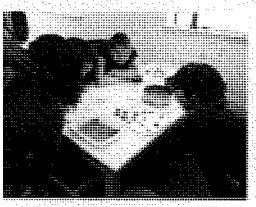
MATH ASSIST

Web-based platforms enhance teaching and learning in the classroom. Today, 100,000 schools across the U.S. use an online mathematics tutoring and assessment program developed by an NSF-funded researcher 15 years ago. Called ASSISTments, the innovative platform helps students with their mathematics coursework and teachers with their mathematics instruction. In Maine, a recent study of more than 2,800 students at 43 public schools using ASSISTments found that students scored 75 percent higher on a standardized test of mathematics achievement than students at schools without the program.



NSF FELLOWS MAKE DISCOVERIES

Through its GRFP, NSF has funded thousands of graduate researchers, many of whom have made important discoveries while still in graduate school. For example, an NSF Graduate Research Fellow developed a touch screen to recognize multi-finger gestures for computer input—using two fingers on a screen to zoom in and out—a breakthrough technology that is now ubiquitous in smartphones and other mobile devices. Since 1952 this program has supported 42 students who went onto win Nobel Prizes.



NATIVE STUDENTS GRADUATING WITH ADVANCED SCIENCE DEGREES

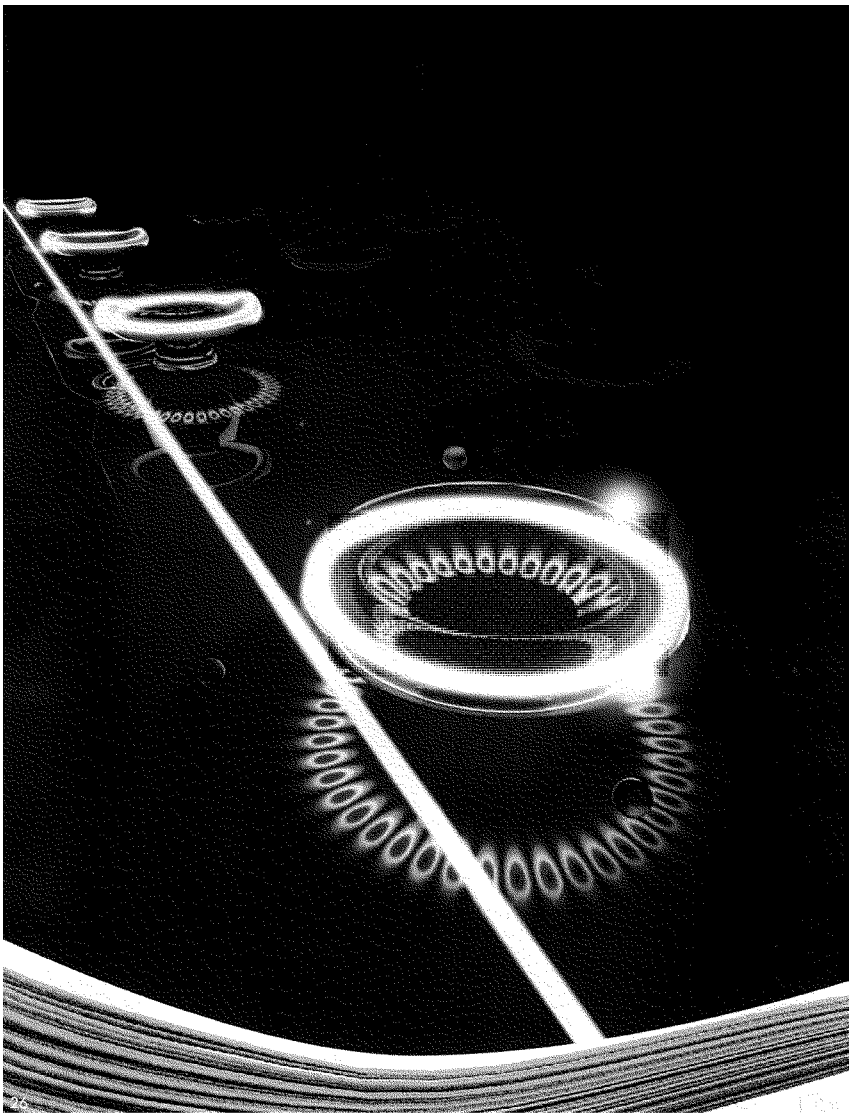
Northwest Indian College in Washington state offers one of the few bachelor of science in Native environmental science programs in the world. Supported by NSF's Tribal Colleges and Universities Program (TCUP), the first student enrolled in the program graduated in 2009. Since then, 51 students have graduated from the program, with 10 more on track to graduate in 2017, and another 81 currently enrolled. Six of the 2016 graduates are pursuing advanced degrees and the first Ph.D. graduate will return to the college as a faculty member.

VISUALIZING DATA

The U.S. Census Bureau's Census Explorer is an online, interactive mapping tool that enables members of the media and public to visualize census data at the state, county and neighborhood levels. The web-based platform is built on a data visualization tool, called Social Explorer, developed by an NSF-funded researcher to help undergraduate sociology students studying demography better visualize U.S. census data. Census Explorer users can create maps on a range of data, including median household income and home ownership rate. Within the first few months of its launch, more than 100,000 users had created 4 million data maps.

TOMORROW'S COMPUTER PROGRAMMERS

To increase the appeal of computer programming for young people, a team of NSF-funded researchers created a visual computer programming language, called Scratch, that allows users to develop software graphically instead of tediously typing lines of code. Launched in 2007, Scratch helps children improve their mathematics, computation and problem-solving skills, even as they create games, animations and other fun projects. More than 800,000 students have shared their projects through the Scratch website and in 2009, NSF-funded researchers launched ScratchEd, an online resource for Scratch educators used by teachers all over the world.



160

DIRECTORATE FOR ENGINEERING

INTRODUCTION

Engineering is essential to create a future where people thrive. Today, engineers are making this future a reality through research in areas such as advanced manufacturing, health care, sustainability and infrastructure.

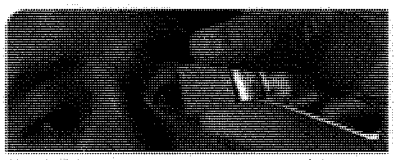
Engineering researchers create new knowledge, concepts and designs that become technological breakthroughs and solve real-world problems. They create innovations for clean water, the electric grid, agriculture and other national challenges. They make economic opportunities in areas such as 3-D printing and secure wireless communication. Engineers improve people's lives with everything from smart transportation to prosthetic devices to faster computers.

NSF's Directorate for Engineering (ENG) supports discovery across all these areas and more. To speed innovations to the market, ENG also spurs entrepreneurship, small business growth and industry collaboration. To prepare the engineers and leaders of tomorrow, the directorate supports engineering education and introduces the exciting possibilities of engineering to the next generation.

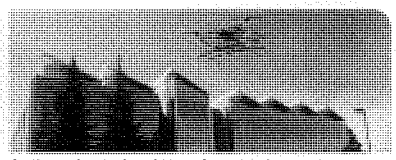
Investments in engineering are critical building blocks for the nation's future prosperity, security and global competitiveness.

Opposite page: When visitors whisper by an arch in New York's Grand Central Terminal, sound waves travel to the arch's opposite side and are easily heard. Using the geometry of whispering galleries with light waves, new sensors magnify the effects of airborne particles and detect molecules and viruses with unprecedented sensitivity.

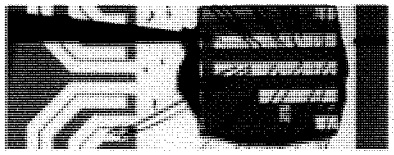
ENG DIVISIONS



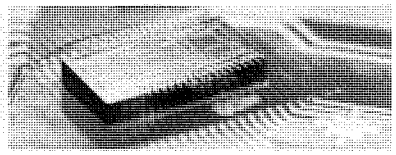
Chemical, Bioengineering, Environmental and Transport Systems supports discoveries in chemical and biochemical engineering; fundamental engineering inquiries into energy and matter; environmental engineering and sustainability; and the engineering of health care technologies.



Civil, Mechanical and Manufacturing Innovation advances the future of manufacturing; the design of innovative materials and building technologies; the creation of resilient and sustainable infrastructure; and high-performance systems from robotics to health care.

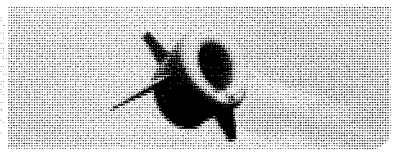


Electrical, Communications and Cyber Systems promotes fundamental research in device and component technologies, power, controls, computation, networking, communications and cyber technologies for the intelligent systems of the future.



Emerging Frontiers and Multidisciplinary Activities supports research on cutting-edge opportunities and long-term challenges that address national needs, such as secure, next-generation communication and electronics; and supports studies and facilities at the intersection of engineering and other disciplines.

Engineering Education and Centers invests in the creation of 21st century engineers and technologies through center-based research; research in education and student inclusion; and research opportunities for students and teachers.

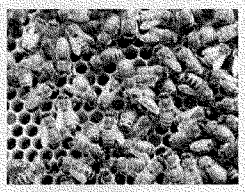


Industrial Innovation and Partnerships invests in high-tech, small businesses and collaborations between academia and industry to transform discoveries into innovative commercial technologies with societal benefits.

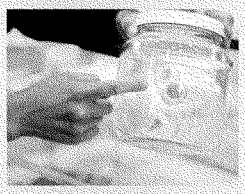
DID YOU KNOW?

- Since 2013, the small business innovation research (SBIR) program funded nearly 1,300 high-tech startups and small businesses, and acquisitions and initial public offerings of NSF-funded companies totaled a published dollar value of $700 million.
- Between the years 1985 and 2016, NSF-funded ERCs received 789 patents.
- NSF's Innovation Corps (I-Corps) program has immersed 800 teams of scientists and engineers from 192 universities in 44 states in entrepreneurial training to extend their focus beyond the lab and consider the commercial potential and broader impact of their research. As a result, I-Corps participants have launched 320 startups, which have raised an additional $93 million in follow-on funding.

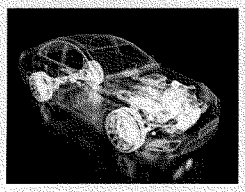
IMPACTS



HONEY BEE RESEARCH SETS GLOBAL SERVER MARKET ABUZZ
Researchers mimicked the food foraging behavior of honey bees to vastly improve how computer programs and devices work together in a rapidly growing global market worth over $50 billion. Just as honey bees perform various tasks in a highly synchronized and adaptable manner to benefit the colony, the researchers designed a novel set of step-by-step instructions to assign tasks to multiple computer servers. Major web hosting companies use the algorithm to analyze images, recognize objects and text, retrieve documents, and more. The algorithm also affects statistics, machine learning, data mining and other areas of computer science and engineering.

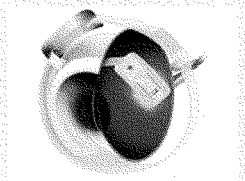


MINNESOTA COMPANY TARGETS FUTURE ORGAN REPLACEMENT
Miromatrix Medical, a small business funded by NSF, developed a technology to create bioengineered organs for human transplant. More than 120,000 people are on the U.S. organ transplant waiting list. The technology removes all cells from existing human or animal organs while preserving the material's architecture, leaving the decellularized organ ready to receive new cells from the recipient, thereby minimizing potential rejection. FDA approved Miromatrix's proprietary technique for use in a commercially-available, biological mesh for hernia repair. The company's goal is to engineer replacement hearts and other organs. It currently is developing a cardiac patch to repair damage from heart disease.

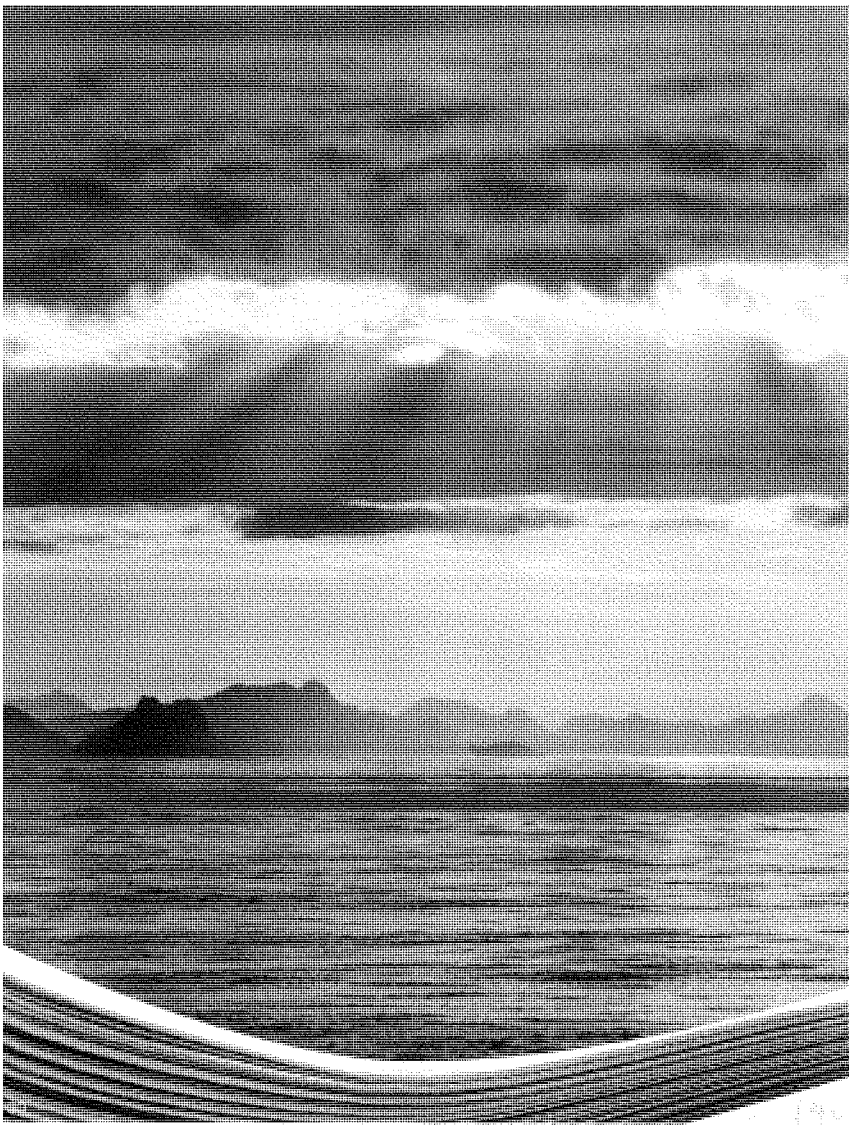


MORE RELIABLE TRANSMISSION USED IN 30 MILLION VEHICLES
Automatic transmissions allow cars and trucks to travel at sustained speeds. Their core technology, the one-way clutch, at one point failed more than any other component in Ford automobiles. Los Gatos, California based Epilogics, a small business funded by NSF's SBIR program, developed a newer Mechanical Diode One-Way Clutch and licensed it to Means Industries. Means used it to replace the older one-way clutch, and it became the most successful, active, driveline component. The Mechanical Diode One-Way Clutch has been installed more than 30 million times.

ECONOMIC WIN FOR SOLAR ENERGY CONSUMERS
SolarBridge, an Austin, Texas-based company founded by NSF-funded researchers, engineered an elegant solution that drives down homeowner costs for solar panel installations. Solar panels need devices called "inverters" to transform direct current electricity from sunlight into alternating current for home and commercial use. Usually, these inverters look like bulky boxes mounted on roofs or the sides of buildings. SolarBridge fits small inverters right onto individual solar panels. In 2014, SunPower Corp, a billion-dollar solar company, acquired SolarBridge. Today, the majority of SunPower solar panels for residential use include SolarBridge microinverters that drive down costs and installation time.



BIONIC EYE SEEING MORE USE
The first bionic eye approved for people in the U.S. has been implanted more than 200 times, a 150 percent increase from 80 successful implants overall, recorded in 2014. The Argus® II Retinal Prosthesis System allows patients to perceive light, sense movement and navigate their surroundings. Developed in part with NSF support, Argus® II wirelessly transmits images from an eye-glass-mounted camera to a tiny antenna implanted on a patient's damaged retina. From there, electrical signals are sent via the optic nerve, and the brain interprets a visual image. Argus® II is the basis for the Orion™ I Visual Cortical Prosthesis, a next-generation wireless visual cortical stimulator that was successfully implanted and activated in a human in October 2016.



DIRECTORATE FOR GEOSCIENCES

INTRODUCTION

The Geosciences (GEO) Directorate supports research that reveals what goes on beneath the Earth's crust, across its landmasses and oceans, amid the atmosphere and inside its ice floes. GEO-funded researchers seek to understand the many processes that affect the global environment.

Some of these efforts rely on NSF's fleet of research vessels while others rely on highly-equipped laboratories. Researchers travel to the South Pole, the North Pole and down deep into the world's oceans. They identify the forces behind natural hazards such as earthquakes, tornados and tsunamis. Their findings provide data for models and other tools that save lives and protect property. Solar studies illuminate the impact solar eruptions can have on Earth, disrupting everything from electrical grids to wireless communications.

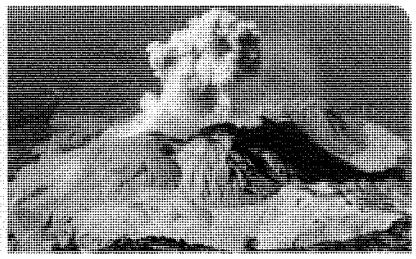
The GEO Directorate also has multiple education and outreach programs to help build a strong scientific workforce, including weather forecasters, groundwater specialists, oceanographers, glaciologists, seismologists and engineers and scientists in the oil, gas, petroleum and mining industries.

Relationships with outside partners also leverage and extend the reach of GEO-funded research. The directorate is a key player in multiple activities including the Antarctic Treaty System, the U.S. Global Change Research Program, the Ocean Research Priority Plan and the Global Seismic Network.

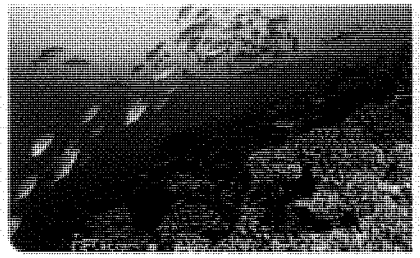
Opposite page: NSF research in the geosciences examines the Earth's atmosphere, landmasses, oceans and polar regions.

GEO DIVISIONS

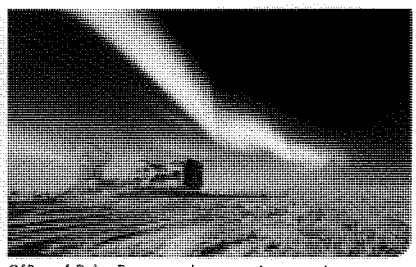
Atmospheric and Geospace Sciences extends understanding of the behavior of Earth's atmosphere and its interactions with the sun.



Earth Sciences examines the structure, composition and evolution of the Earth, the life it supports and the processes that control them.



Ocean Sciences advances understanding of oceans across the globe and their interactions with people, the Earth and the atmosphere.

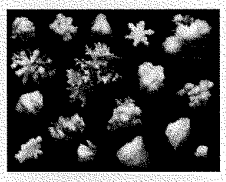


Office of Polar Programs has two science sections—one for the Arctic and the Antarctic. A third section manages the logistics and support operations including field stations, camps, laboratories, ships, and airplanes.

DID YOU KNOW?

- For 60 years, NSF has maintained an uninterrupted presence in Antarctica. NSF's U.S. Antarctic Program oversees all U.S. scientific research and logistics at the South Pole.
- In Southern California, NSF-supported scientists recently discovered and mapped the Salton Trough Fault, a potentially significant fault that lies along the eastern edge of the Salton Sea and runs parallel to the San Andreas Fault.
- The IceCube Neutrino Observatory is built into a cubic kilometer of ice under the South Pole. It searches for particles from the most violent sources in the universe such as exploding stars, gamma-ray bursts, black holes and neutron stars to tell us about the nature of the universe.

IMPACTS

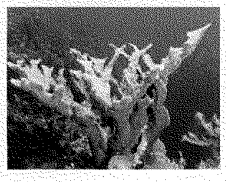


SAFER WINTER DRIVING WITH SNOWFLAKE IMAGING
Falling snow makes winter driving a challenge. Transportation planners, road crews and emergency managers can now estimate real-time accumulations with active imaging from multi-angle snowflake cameras (MASC). NSF-funded research led to development of MASC, which images snowflakes down to the diameter of a human hair and simultaneously measures how fast they fall. These data have been critical for verifying snowfall predictions and winter precipitation algorithms for weather radars.

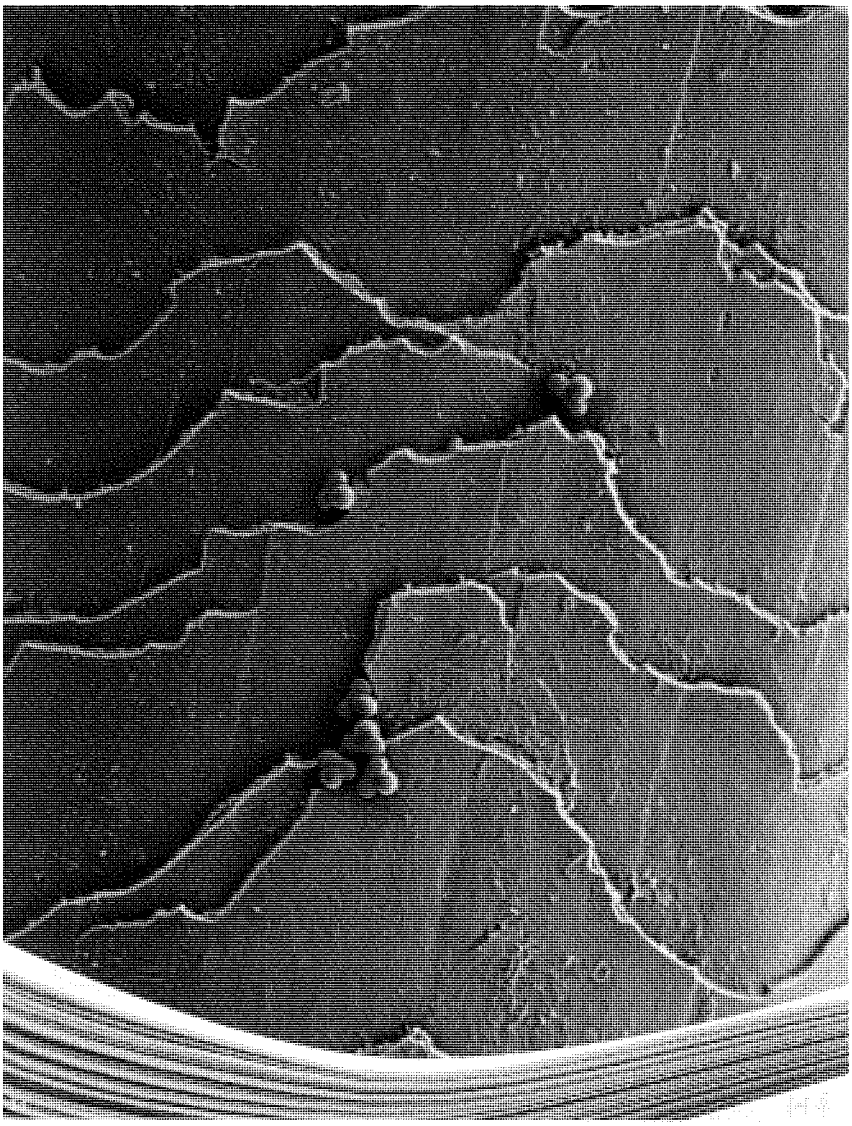
REDUCING AIRLINE ICING EVENTS
Each year in the U.S., 20 to 40 aircraft accidents are linked to in-flight icing. Hazardous conditions that set up these events cost the aviation industry an estimated $20 million annually in injuries, aircraft damage and fuel. Icing forecast products developed by NSF-funded scientists and used by the Federal Aviation Administration (FAA) are credited with preventing an average of eight airline accidents a year and reducing airline operating costs by $60 million annually. Online icing maps, developed at the request of the FAA, represent a major advance in the nation's effort to ensure safe flying.

TRADING WATER RESOURCES ONLINE
By 2025, two-thirds of the global population could face water shortages. Conflicts over water resource management are increasing, with large sums spent on litigation. To ease these challenges, Mammoth Trading launched an online market system to lease water rights. Mammoth grew out of NSF-funded research on the economic and environmental effects of groundwater pumping rights. It provides new risk management tools for farmers, reduces the cost of water reallocation, and leads to an increase in agricultural productivity and profits, while maintaining or improving environmental conditions and resource sustainability. The approach could extend to other natural resources as well.

3-D GEOLOGIC MAP LEADS TO PRECIOUS METAL DISCOVERY
Using technology for 3-D electronic mapping originally developed by scientists working in the McMurdo Dry Valleys of Antarctica, NSF-funded researchers discovered one of the world's largest precious metal deposits in northern Minnesota. The Nokomis Deposit is estimated to contain metal resources of approximately 10 billion pounds of copper, 3.1 billion pounds of nickel, 165 million pounds of cobalt, 4 million ounces of platinum, 9 million ounces of palladium and 2 million ounces of gold.



LEARNED FROM AGING CORALS
Using genetics to estimate the age of corals, NSF-funded researchers have found that while some species have lasted thousands of years, their ability to continually adapt to changing conditions may be limited. Elkhorn corals found in Florida and the Caribbean were pegged at more than 5,000 years old. Their resilience attests to their abilities to adjust to sea-level changes, storms and sedimentation events. The research findings could help shape future approaches to coral reef preservation to protect these robust invertebrates.



DIRECTORATE FOR MATHEMATICAL AND PHYSICAL SCIENCES

INTRODUCTION

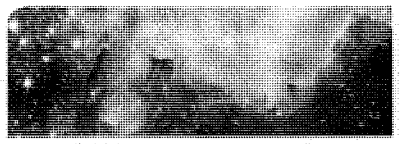
Gravity, light, sound and energy. These basic physical phenomena lie at the heart of research supported by the Mathematical and Physical Sciences (MPS) Directorate. Through its five divisions, which cover astronomy, chemistry, materials, mathematics and physics, MPS-funded scientists explore how physical phenomena impact matter. They deepen awareness of mathematical concepts and develop new tools to study the physical world.

MPS is NSF's largest directorate and its research ranges across the entire scale of the universe from spinning subatomic particles to colliding black holes in space. Its award portfolio extends from large facilities, such as telescopes, to research grants for individual scientists. It includes education programs to help students pursuing careers in mathematics and the physical sciences as well as initiatives to improve science literacy.

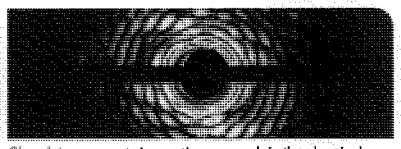
The discoveries from this research advance the understanding of the world around us and provide the critical information needed to create technologies to improve our quality of life. Computers run faster, threats are detected sooner, water is cleaner and surgery is more precise because of fundamental studies supported by the MPS Directorate.

Opposite page: Shown in color, microscopic particles are building blocks used to create synthetic materials. NSF-funded researchers developed a process that transforms the particles from inflexible Lego-like pieces into supple, shape-shifting units.

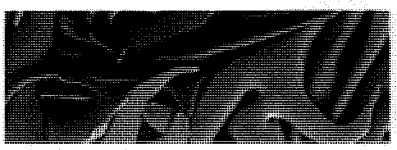
MPS DIVISIONS



Astronomical Sciences supports research in all areas of astronomy and astrophysics as well as related multidisciplinary studies.

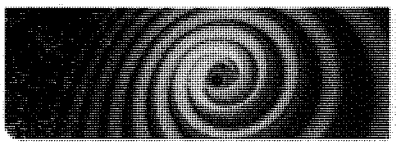


Chemistry supports innovative research in the chemical sciences to understand the composition, energetics and interactions of molecules.

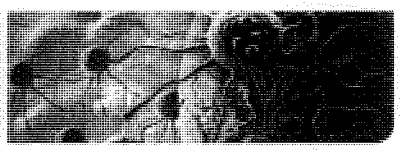


Materials Research enables new experimental and theoretical discoveries about the behavior of matter and materials. The division supports the creation of new materials and new instrumentation to investigate materials phenomena, while also preparing the next generation of materials researchers.

Mathematical Sciences supports a wide range of projects aimed at developing and exploring the properties and applications of mathematical structures.



Physics sponsors research across a broad range of topics including atomic, molecular and optical physics, gravitational physics, particle physics, astrophysics and cosmology, accelerator science, plasma science, nuclear physics, and the physics of living systems.



Office of Multidisciplinary Activities facilitates and supports opportunities that cross traditional disciplinary boundaries. The office is a focal point for external partnerships, interdisciplinary research and innovative experiments in education that may lead to new paradigms in graduate and undergraduate education in the mathematical and physical sciences.

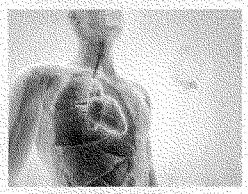
DID YOU KNOW?

- Since 1950, NSF has funded 123 Nobel Prize winners in physics and chemistry.
- Once complete, NSF's Large Synoptic Survey Telescope will contain the world's largest digital camera, with over 3 billion pixels of solid-state detectors.
- The Laser Interferometer Gravitational-Wave Observatory (LIGO) detected ripples in the fabric of spacetime originating over a billion light years away. This is the dawn of a new era of observations whose increasing number will extend our knowledge of the universe.

IMPACTS

ARTIFICIAL INTELLIGENCE MEETS BIG DATA

By 2019, big data and business analytics sales are expected to pull in $187 billion worldwide. Already making waves in this sector is Ayasdi, a company founded by a renowned mathematician and NSF award recipient. The Menlo Park, California, company analyzes large datasets using advanced algorithms. Ayasdi's analysis tools help hospitals deliver better care, health insurers streamline claims and global banks model risk. In 2015, FastCompany named Ayasdi one of the top 10 most innovative companies in Big Data.



SMART MATERIALS THAT RECOGNIZE PATTERNS

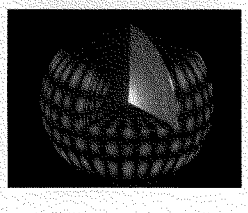
Gloves that monitor an injured hand for progress of recovery; footwear that onalyzes the gait in people at risk for early onset Alzheimer's disease; and shirts that chart cardiovascular activity in people at risk of heart disease and stroke may all be possible thanks to a new material designed by NSF-funded researchers to recognize simple patterns. The hybrid gel material works by converting its own chemical reactions into electrical energy. This aspect also makes the material useful as skin for a robot or other device.

MORE ECONOMICAL FERTILIZERS

The Haber-Bosch process produces 100 million tons of fertilizer a year. This production helps feed almost a third of the world's population. Currently, the process consumes 3 to 5 percent of the world's natural gas production, about 1 to 2 percent of the world's annual energy supply. NSF-funded scientists are developing new molecular receptors that could help reduce dependence on this energy-hungry process. The receptors serve as nitrogen sensors to provide for more efficient and economical application of fertilizers, while minimizing wastewater runoff from agricultural fields.

ULTRASENSITIVE DETECTOR FOR PHYSICS AND MEDICINE

NSF-funded research to discover new fundamental particles and forces has led to a new tool with multiple applications including brain research, diagnosis of abnormal heart rhythms and pre-surgical imaging. Originally built to precisely measure very faint magnetic fields for basic physics experiments, the ultrasensitive detector, called an atomic spin magnetometer, has validated fundamental theories about the symmetry of space. Furthermore, the device's ability to sense magnetic fields 1000 times weaker than those in the human brain made it a candidate for additional applications in medicine and neuroscience. Two startup companies, TwinLeaf Precision Sensors and QuSpin, are advancing the technology for commercial use.



SOLAR RESEARCH PROTECTS CIVIL INFRASTRUCTURE

Space weather can disrupt radio and satellite communications, civil aviation and even pose a threat to the electrical grid. But solar storms are highly unpredictable. To develop salar storm forecasts, the national Space Weather Prediction Center now uses data supplied by the Global Oscillation Network Group (GONG), an NSF-funded project. The worldwide network of six telescopes monitor subtle oscillations of the sun 24 hours a day. GONG research has developed an understanding of the sun's internal structure that is used to monitor and predict activity that will lead to solar storms, even when that activity is on the side of the sun facing away from the Earth.

DIRECTORATE FOR SOCIAL, BEHAVIORAL AND ECONOMIC SCIENCES

INTRODUCTION

There are close to 7.5 billion people on the planet, each interacting with family members, friends, co-workers, communities and the environment. New technologies and forms of communication have further connected people with one another around the world at an unprecedented scale. Every day, people shape, and are shaped by, the economic, political, social, cultural, technological and environmental forces that surround them.

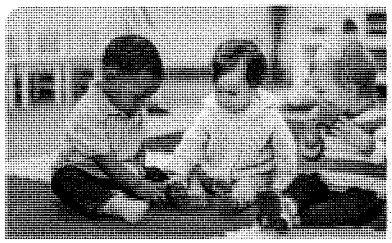
The social, behavioral and economic sciences collectively examine this confluence of forces on people and illuminate the fundamental principles underlying human behavior—from how we think and learn to how we interact individually and in groups. They help to better navigate relationships, build stronger and safer communities, run businesses efficiently and effectively, and create the technologies that enrich our lives.

NSF's Social, Behavioral and Economic Sciences (SBE) Directorate coordinates insights from the various disciplines to generate a comprehensive understanding of human behavior in all of its complexity. SBE-funded scientists study people and their behavior at scales ranging from cells to society and across space and time. They explore the mysteries of the brain—how it produces perception, action, cognition and language—and help make sense of the many political, social and economic challenges that confront communities, including energy use, migration, inequality, disaster response and warfare.

Ultimately, findings from the social, behavioral and economic sciences provide crucial insights into the self and society that strengthen the U.S. economy, improve health and well-being, enhance national security, and continue to position the nation as a leader of innovation and discovery.

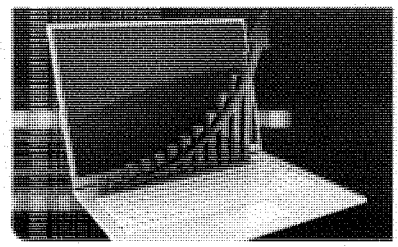
Opposite page: The NSF-funded Center for Nanotechnology in Society at Arizona State University is dedicated to helping the public become a voice in nano and other emerging technologies. This helps scientists and engineers think deeply about where technologies are headed and how to make them work effectively for everyone; for example, when designing more liveable cities.

SBE DIVISIONS

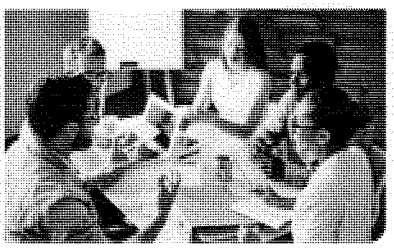


Behavioral and Cognitive Sciences supports basic research in the psychological, linguistic, anthropological and geographic sciences to better understand how people interact at the biological, cultural and social levels, leading to new knowledge in everything from how the brain forms memories to how the use of resources changes the environment.

Social and Economic Sciences supports basic research in economic, social, political and organizational behavior that looks at everything from decision making to social capital development. Outcomes from this research provide insights into how social networks evolve, how cybercrime spreads and the optimal functioning of markets.



National Center for Science and Engineering Statistics is one of 13 principal federal statistical agencies and the nation's leading provider of statistical data on the U.S. science and engineering (S&E) enterprise.



Office of Multidisciplinary Activities supports interdisciplinary research and training in the social, behavioral and economic sciences, including SBE's intersections with other S&E fields.

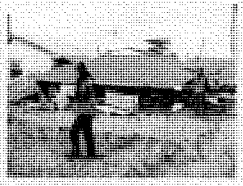
DID YOU KNOW?

- An NSF-funded economist applied the principles of game theory to the problem of matching kidney recipients with donors, laying the groundwork for today's national kidney exchange program. To date, the program has saved more than 4,000 lives in the U.S.—a number that continues to grow.
- NSF has funded 55 Nobel Laureates in the economic sciences since 1969, including every U.S. winner since 1997.
- NSF-Funded researchers developed a computer-brain interface that allowed a patient with "locked-in syndrome" to vocalize sounds for the first time. This technology may also help others, such as veterans with severe paralysis.

IMPACTS

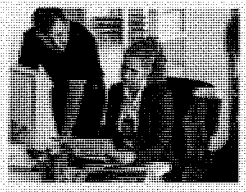
DETECTING READING PROBLEMS EARLY

Reading disabilities affect millions of Americans and can have long-term effects from childhood into adulthood. Dyslexia alone affects 5 to 10 percent of the U.S. population. An NSF-funded researcher has developed a tool that uses a child's brain waves to predict reading problems before they start. This is important because interventions for children are effective, but they need to start early. The researcher is now developing a diagnostic tool that can double or even triple the time window for implementing an intervention.



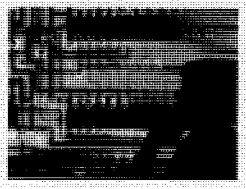
BETTER WARNING SYSTEMS, BETTER DISASTER RESPONSE

When a severe storm approaches, how a person responds can be a matter of life and death. Human response in the face of disaster greatly depends on how weather experts communicate the risks. NSF-funded scientists worked with the National Oceanic and Atmospheric Administration (NOAA) and their National Weather Service emergency responders to improve the communication of risks related to weather emergencies. For example, storm surge—rather than wind speed—is typically the deadliest and costliest force in a hurricane. Informed by NSF's research, NOAA now uses dynamic displays of storm surge presented visually to better communicate hurricane risks.



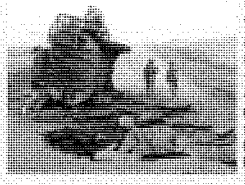
EYEWITNESS TESTIMONY THAT IS ROBUST AND RELIABLE

Crime investigators often rely on eyewitness testimony, yet misidentification is a primary cause of convictions of innocent people. NSF-supported scientists showed that changing how investigators conduct eyewitness procedures can reduce misidentification. Showing witnesses photos one at a time (not side by side) and telling them the suspect may not be pictured are ways to reduce false positives. Additionally, having an officer who is unaware of the suspect's identity conduct these procedures reduces misidentification as the officer is less likely to unintentionally convey information via tone of voice or posture. The research led many states to reevaluate their eyewitness procedures and the Department of Justice to adopt new guidelines.



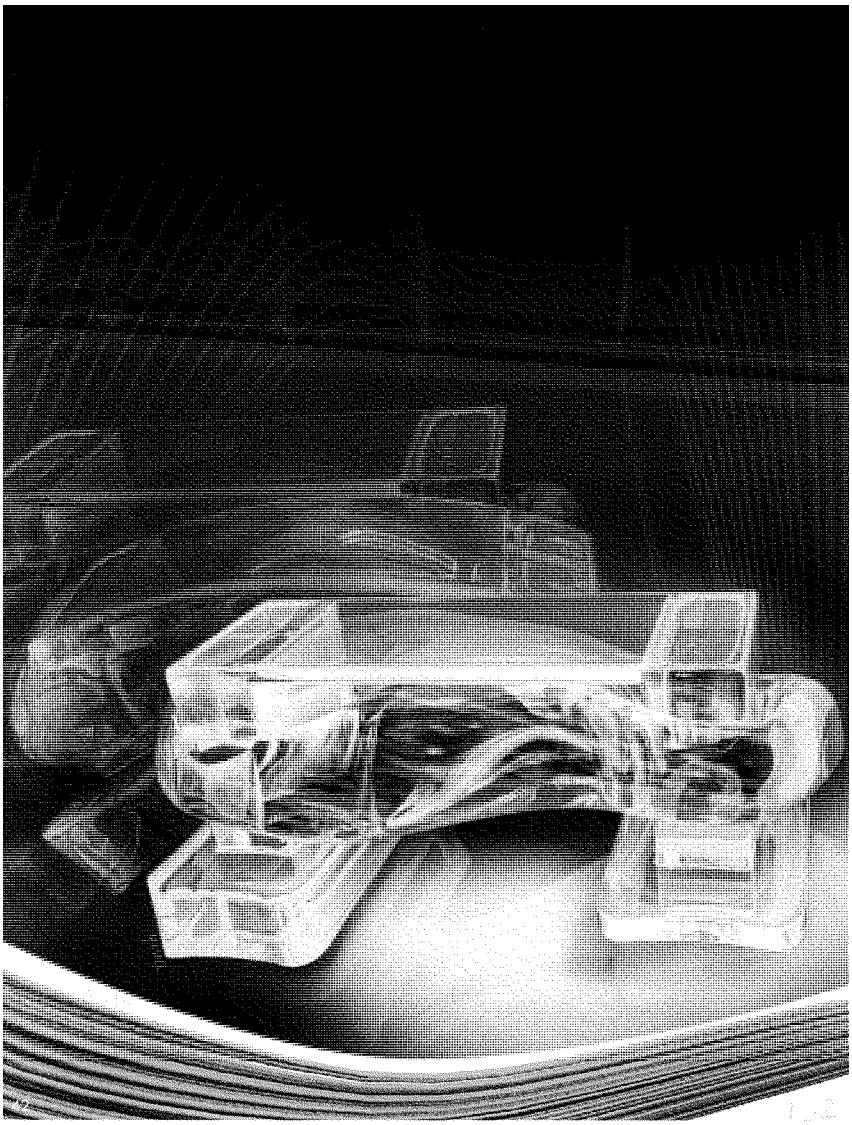
BEHAVIORAL SCIENCE HELPS TRACK CRIMINALS, STOP CRIME

From hackers who steal identities to terrorists looking for new recruits, many criminals use the Internet to achieve their goals. NSF-funded scientists have studied the way criminals organize and support each other's efforts and how they choose targets and implement plans. This research led to two major programs to stop crimes and arrest perpetrators. COPLINK is used by over 3,500 police agencies in the U.S. and in 25 NATO countries to trace criminal activity. CIA and FBI analysts use the Dark Web project to understand terrorist targets, recruitment activities and large-scale hacking efforts.



COUNTERING VIOLENT EXTREMISM

Why are extremist groups like ISIS so successful in recruiting new fighters? Many attribute extremism as psychopathy or people seeking to achieve personal gain. Based on interviews with extremists in war zones, an NSF-funded researcher found the truth is more complicated. New recruits are often motivated by ethical and moral beliefs, suggesting that strategies designed to disrupt recruitment must include moral alternatives to violent extremism as much as material ones, such as access to economic opportunities. This research is informing efforts by the Department of Defense and other agencies to better counter violent extremism at home and abroad.



OFFICE OF INTEGRATIVE ACTIVITIES

INTRODUCTION

Basic discovery research often does not stay in a single lane; it frequently crosses disciplines. A physics researcher may need an engineer or a computer scientist to help test a theory or solve a problem. To address complex problems like this, NSF's Office of Integrative Activities (OIA) crosses boundaries to form unique partnerships between researchers and experts who need each other to carry out societally relevant initiatives.

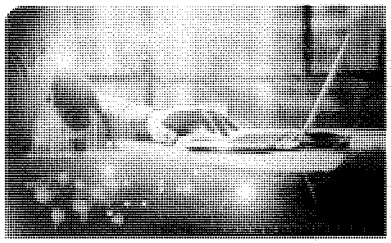
OIA focuses on initiatives such as:

- NSF INCLUDES, an integrated, national initiative which develops STEM talent from all sectors and groups in society to help grow our economy.
- Science and Technology Centers (STCs), which conduct world-class research through partnerships among academic institutions, national laboratories, industrial organizations and others.
- Presidential Early Career Awards for Scientists and Engineers, which recognize scientists and engineers who show exceptional potential in the early stages of their independent research careers.

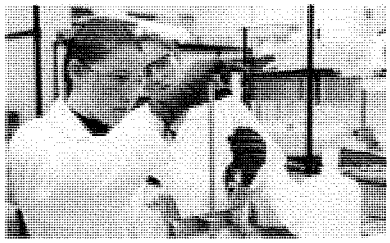
OIA's activities advance research excellence and innovation, develop human and infrastructure capacity critical to the U.S. S&E enterprise, and promote engagement of scientists and engineers at all career stages.

Opposite page: This artistic image represents tiny biological machines called "bio-bots." A fusion of biology and engineering, bio-bots are powered by skeletal muscle cells controlled by electrical impulses. This work was funded through a STC grant to the MIT, in collaboration with the University of Illinois, the Georgia Institute of Technology and other partner institutions.

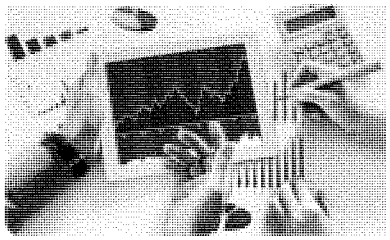
OIA SECTIONS



Integrative Activities administers major interdisciplinary programs across the foundation and supports the NSF director's office through policy analysis and special projects that address NSF priorities.



Established Program to Stimulate Competitive Research (EPSCoR), which recently changed its name from "Experimental" to "Established," promotes sustainable increases in scientific research, education, training capacity and competitiveness in states and territories that have not historically benefited from federal research grants.



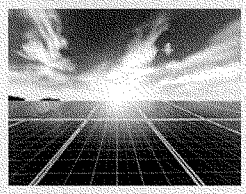
Evaluation and Assessment Capability provides centralized support and resources for data collection, analytics and the design of evaluation studies and surveys that enable NSF to more consistently evaluate the impacts of its investments, and to make more data-driven policy decisions.

DID YOU KNOW?

- Research Infrastructure Improvement awards were granted 313 times to date to stimulate sustainable R&D in EPSCoR jurisdictions.
- The 2004 Alan T. Waterman Award recipient, chemical and biological engineer Kristi Anseth, is designing new bioscaffolds, or temporary structures, upon which biological tissues can form to heal fractures, engineer new cartilage or even construct replacement heart valves.
- To date, NSF administered the selection of 506 recipients of the congressionally mandated National Medal of Science.

IMPACTS

UNDERWATER GPS CHANGES THE MAP
In Guam, researchers developed a new method for mapping underwater areas that is transforming how oceanographers observe the seafloor. Data from global positioning satellites are the primary method for mapping the Earth, but it's impossible for global positioning system (GPS) signals to pass through water, making detailed mapping of underwater features very difficult. By synchronizing underwater cameras with GPS buoys and using computer software to geo-tag—assign graphical location—photographs, NSF-funded researchers mapped for the first time all of Guam's Pago Bay and Apra Harbor.

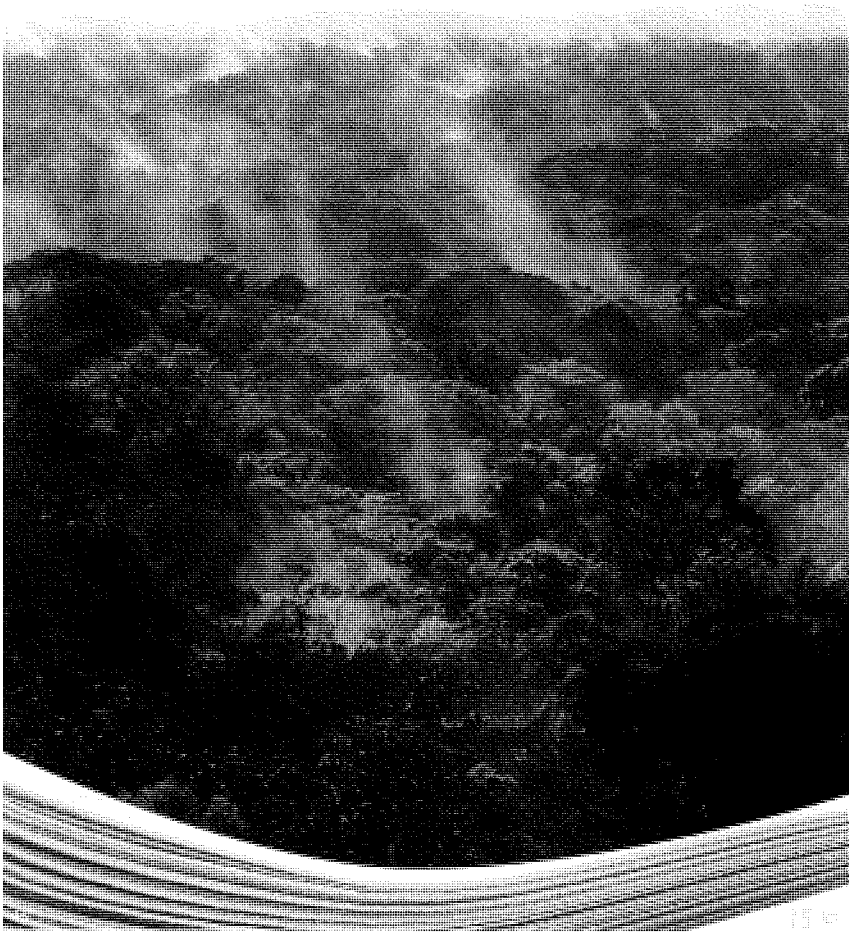


NSF PROGRAM PROVIDES LIFT-OFF FOR STARTUPS
Administered through the Arkansas Economic Development Commission, NSF ESPCoR helped launch several startup companies in Arkansas, each tackling different challenges that impact everything from public health and manufacturing to energy use. One startup, WattGlass LLC, which developed a nanoparticle coating, produces antireflective coatings for solar panels that boost light absorption and increase electrical output by at least 8 percent. Another start-up, GeneCoMe Biotech LC, is addressing the alarming rise in multidrug-resistant bacteria by developing a plant-based alternative—cytokine—in place of the antibiotics currently injected into livestock to prevent disease.

BUILDING UP THE STEM WORKFORCE WITH A UNIQUE PAY STRATEGY
The STC for Emergent Behaviors of Integrated Cellular Systems (EBICS) increased the probability that local students from low socioeconomic backgrounds could earn a college education. EBICS expanded its Engaging New Generations at Georgia Tech through Engineering and Science program to MIT and other partner institutions. The program now pays high school students, most of whom are black from Title I schools, $10 an hour for their contributions to scientific research. The pay helps student families, while improving the quality of their college applications.

HAND-DISABILITY RESEARCH PROPELS INDUSTRY
No-pressure keyboards, widely-used in Apple products, were originally developed by a University of Delaware researcher with support from NSF's EPSCoR program. To help people with hand disabilities, he imagined a keyboard that required a softer touch. His innovation led to the startup company FingerWorks that created some of the world's first tablet computers with multi-touch technology. Apple acquired FingerWorks and the rest is history. As of August 2016, Apple has sold more than 1 billion iPhones and 308 million iPads equipped with touch keyboards.

WATERSHED IN UNDERSTANDING SEA LEVEL
The NSF-funded STC for Remote Sensing of Ice Sheets (CReSIS) developed image-gathering and data-retrieval technologies that vastly improve how we understand the physical features of the Antarctic and Greenland ice sheets. These ice sheets hold 99 percent of the world's fresh water in the form of ice. If they were to melt, they would cause enormous global sea-level rise. CReSIS' unique radar for ice sounding and imaging technology increased knowledge of how climate pressures might cause the ice sheets to behave. In fact, the technology produced 80 percent of the critical data used to make the new map of the Greenland Ice Sheet.



OFFICE OF INTERNATIONAL SCIENCE & ENGINEERING

INTRODUCTION

NSF's Office of International Science and Engineering (OISE) establishes and maintains strategic relationships with the Foundation's international peers. The Office funds U.S. scientists and engineers to pursue unique international research opportunities while providing research experiences for U.S. students to create a globally-engaged U.S. science and engineering workforce. For example:

- With Australia, a collaborative program is developing containers small enough to be injected directly into the bloodstream to deliver medicines.
- With South Korea, U.S. researchers are cooperating to create artificial muscles for use in soft robotics.
- With South Africa, students from the United States work with peers from the University of KwaZulu-Natal to improve water decontamination and provide basic sanitation to underserved populations.

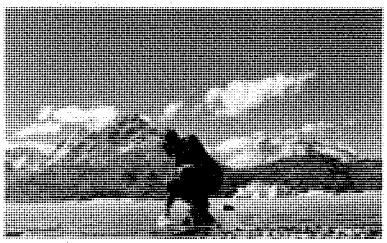
The Office's specialized research programs prepare U.S. students to become members of the global STEM workforce. For example:

- Students from the University of Michigan conducted collaborative research with the South African National Space Agency to understand the impacts of solar disturbances on the Earth.
- Rice University's TerraNano program, a coaperative endeavor with Japan, provided undergraduates the opportunity to develop and study novel nanomaterials with electronic and vibrational properties in the terahertz range.

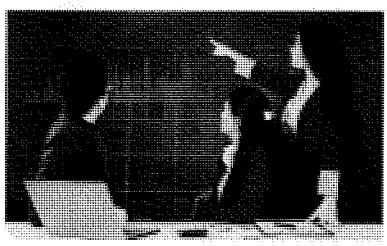
Opposite page: PIRE researches used three cameras set up on different towers to photograph individual tree crowns, discovering a pattern of leaf growth and death that helps us understand seasonality.

OISE CLUSTERS

Country and Regions establishes and maintains relationships with counterparts in foreign countries. In addition, the cluster is the primary interface with interagency partners who also focus on international relations (i.e. State Department, White House Office of Science and Technology Policy, etc).



Programs and Analysis develops, implements and monitors OISE programs. These programs seek to catalyze international science and develop a globally competitive U.S. scientific workforce. The cluster also develops foresight products for NSF leadership—a new capability expected to be fully operational in Fiscal Year 2018.

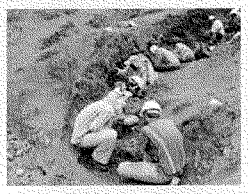


The Administrative cluster ensures consistent implementation of the Foundation's policies and procedures within the Office. The team ensures programmatic activities receive appropriate review, develops and implements the Office's budget, and assists Office leadership in human capital actions.

DID YOU KNOW?

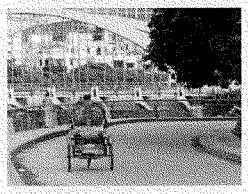
- Permafrost regions occupy about 25 percent of the Northern Hemisphere and students from Tennessee and Russia are exploring 2-3 million-year-old permanently frozen sediments in the Kolyma lowland in Siberia to expand understanding of life at low temperatures.
- NSF-supported students gain international research experience in 37 countries and regions.
- NSF's Partnerships International Research and Education (PIRE) program supports high-quality research and education projects for U.S. researchers in 19 countries: U.S., Brazil, China, Czech Republic, France, Germany, India, Ireland, Italy, Japan, Korea, Mexico, Norway, Poland, Russia, Spain, Switzerland, Taiwan and Turkey.

IMPACTS



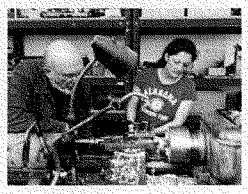
FOSSIL FIND REVEALS EARLY INTERCONTINENTAL MOVEMENT

A 21-million-year-old monkey fossil unearthed by NSF-funded researchers in Panama upended conventional thinking about when and how species moved from South America into North America. The researchers discovered the fossil, which is related to modern South American monkeys, on the North American landmass in rock strata exposed by the Panama Canal's expansion. While scientists long thought species moved northward via a 4-million-year-old land bridge—called the Isthmus of Panama—the fossil finding suggests species made the trek 17 million years earlier, before the bridge formed. NSF's PIRE program funded the once-in-a-century research opportunity.



RESEARCH SPURS GLOBAL, GEOHAZARD KNOWLEDGE INCREASE

An OISE-developed partnership is raising the Bangladesh government's awareness of potential natural hazard dangers there. Bangladesh, which is about the size of Iowa, with almost 170 million people, is vulnerable to huge earthquakes. To design stable, earthquake-resistant infrastructure, the partnership—composed of researchers from the U.S., Bangladesh, Germany, India and Italy—is working to understand Earth's structural features beneath Bangladesh. Data from the project drew the attention of the Bangladesh parliament and resulted in more than 15 peer reviewed papers in widely respected publications like *Nature Geoscience, Tectonophysics,* the *Journal of Geophysical Research* and others.

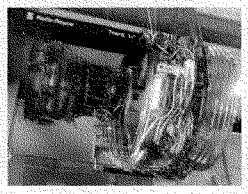


STUDENT TRAINEES SET TO REVOLUTIONIZE NANOFIBER MANUFACTURING

A novel method developed by student trainees could transform manufacturing of nanofibers for biomedicine, energy, filtration, high-rate fiber-production and more. Teams from the University of Alabama at Birmingham and the Czech Republic's Technical University of Liberec discovered that strong alternating electric fields produced on liquid polymers could be used to manufacture nanofibers much quicker and in more volume than current processes. The new process has an ability to generate continuous thread-like materials 100 nanometers or less in diameter at astonishing rates when compared to current fabrication processes.

PROTECTING CENTRAL AFRICA'S RAINFORESTS

The rainforests of Central Africa are tremendously important to the health of the planet. However, habitat loss occurs there at a rapid rate due to tree clearing, environmental change and growing human populations. This project, comprised of researchers and students from the U.S., Cameroon, Gabon, the United Kingdom, Germany, France and the Netherlands, is developing a framework for conserving Central African biodiversity. To help ease the effects of habitat loss and climate change, the researchers regularly meet with decision-makers to provide the latest scientific information on meaningful conservation measures.



ROLLS-ROYCE AND BOEING GET STUDENT ASSIST

More than 20 students from Virginia Tech and the University of Nottingham designed a replacement for the hydraulic and gear power transfer systems on the Rolls-Royce Trent 1000 turbofan engine. Working with Rolls-Royce in Derby, U.K., their design would replace the existing system with modern electronics, improving jet propulsion on Boeing Commercial Airplanes' 787 Dreamliner. Boeing purchases Trent 1000 engines from Rolls-Royce. The students are part of an OISE-led and supported—with additional funding from Boeing—international program that provides research experiences for students interested in future electric transportation systems.

RESOURCES AND SOCIAL MEDIA

National Science Foundation	nsf.gov
Directorate for Biological Sciences	nsf.gov/BIO
Directorate for Computer and Information Science and Engineering	nsf.gov/CISE
Directorate for Education and Human Resources	nsf.gov/EHR
Directorate for Engineering	nsf.gov/ENG
Directarate for Geosciences	nsf.gov/GEO
Directorate for Mathematical and Physical Sciences	nsf.gov/MPS
Directorate for Social, Behavioral, and Economic Sciences	nsf.gov/SBE
Office of Integrated Activities	nsf.gov/OIA
Office of International Science and Engineering	nsf.gov/OISE
Established Program to Stimulate Competitive Research	nsf.gov/EPSCoR
NSF and Congress Toolkit	nsf.gov/toolkit
Science360	science360.gov
Social Media	nsf.gov/social

IMAGE CREDITS

Cover: Nicolle Rager Fuller, NSF

Page i: NSF, Stephen Voss

Page ii: (top) Carnegie Institution of Washington; (bottom) NSF

Pages 2-3: Nicolle Rager Fuller, NSF

Page 4: The National Center for Optics and Photonics Education (OP-TEC)

Page 5: John C. Williams, Humanoid Engineering & Intelligent Robotics (HEIR) Lab, Marquette University

Pages 6: NSF

Page 7: (top row) ©iStock.com/tupungato; Sara Parks, NSF Iowa EPSCoR, Iowa State University; ©iStock.com/fatesun; (center row) Amanda Padbury, North Carolina State University College of Textiles; Amy Simmons, Padture Lab, Brown University; J.E. Doll, Michigan State University; (bottom row) Simulating eXtreme Spacetimes (SXS) project (http://www.black-holes.org); from *ATE Centers Impact 2016-2017* (www.atecenters.org); superjoseph/Shutterstock.com

Pages 8-10: Nicolle Roger Fuller, NSF

Page 14: Alessandro Catenazzi, Southern Illinois University Carbondale

Page 16: (top) ©iStock.com/Sage78; John Angell, UMass Boston; (center) Steve Byland/Shutterstock.com; (bottom) Abraham Karam, NEON, Inc.; David Gruber, Baruch College, City University of New York

Page 17: (top to bottom) Arable Labs, Inc.; University of Pittsburgh Medical Center/Pitt Health Sciences; Jennifer Doudna, University of California, Berkeley; T. Noges; Deisseroth Lab

Page 18: Douglas Pancoast and Satya Mark Basu, School of the Art Institute of Chicago/Array of Things

Page 20: (top) Computer Science and Engineering Division of Electrical Engineering and the Computer Science Department, University of Michigan; Nicolle Rager Fuller, NSF; (bottom) Andrew Kelly, NY Hall of Science; Texas Advanced Computing Center

Page 21: (top to bottom) pixelrain/Shutterstock.com; Daphne Koller; Douglas Pancoast & Satya Mark Basu, School of the Art Institute of Chicago/Array of Things; (c)iStock.com/KrulUA; Personal Robots Group, MIT Media Lab

Page 22: Ocean Discovery Institute

Page 24: (top) Kristian Dzilenski; Science Museum of Minnesota; (bottom) from *ATE Centers Impact 2016-2017* (www.atecenters.org); Rob Margetta, NSF

Page 25: (top to bottom) ASSISTments; ©iStock.com/Ridofranz; Marco Hatch, Western Washington University; Aisha Hassan, Queens College, CUNY; Georgia Computes! Georgia Tech

Page 26: Nano/Micro Photonics Laboratory, Electrical and Systems Engineering Department, Washington University, Saint Louis

Page 28: (top) Craig Chandler, University Communications, University of Nebraska-Lincoln; Michael Shafer; (center) Paul Prucnal, Department of Electrical Engineering, Princeton University; Shayan Mookherjea, University of California, San Diego; (bottom) Eve Syrkin Wurtele, William Schneller, Paul Klippel, Greg Hanes, Andrew Navratil and Diane Bassham, Iowa State University; Altaeros Energies

Page 29: (top to bottom) ©iStock.com/bbraley; Miromatrix Medical; ©iStock.com/Henrik5000; ©iStock.com/roberthyrons; Second Sight Medical Products

Page 30: ©iStock.com/Jacques van Dinteren

Page 32: (top) Jacob DeFlitch; Jeffrey Johnson, Department of Geosciences, Boise State University; (bottom) Jennifer Smith, Scripps Institution of Oceanography; Keith Vanderlinde, NSF

Page 33: (top to bottom) Tim Garrett, University of Utah; ©iStock.com/Chalobala; Ian Kluft, CC BY-SA 3.0; Ruth Schulte, USGS; ©iStock.com/johnandersonphoto

Page 34: Stefono Sacanna, New York University

Page 36: (top) Gemini Observatory/AURA; Andrey Vilesov, Chemistry Department, University of Southern California, Los Angeles; (center) Pupa U.P.A. Gilbert and Christopher E. Killian; Richard Palais and Luc Benard, University of California, Irvine; (bottom) LIGO/T. Pyle; ThinkStock

Page 37: (top to bottom) ©iStock.com/Maxiphoto; ©iStock.com/cosmin4000; NSF; © iStock.com/Pitju; John W. Harvey, National Solar Observatory

Page 38: The Center for Nanotechnology in Society at Arizona State University

Page 40: (top) ©iStock.com/FatCamera; Thinkstock; (bottom) Mmaxer/Shutterstock.com; ©iStock.com/shironosov

Page 41: (top to bottom) Sarah Laszlo, Brain and Machine Laboratory, Binghamton University; Ning Lin, Princeton University; Photographee.eu/Shutterstock.com; Jupiter Images; U.S. Army

Page 42: Janet Sinn-Hanlon, DesignGroup@VetMed for Dr. Rashid Bashir, Department of Bioengineering, University of Illinois

Page 44: (top to bottom) ©iStock.com/Pinkypills; University of Maine; ©iStock.com/Ridofranz

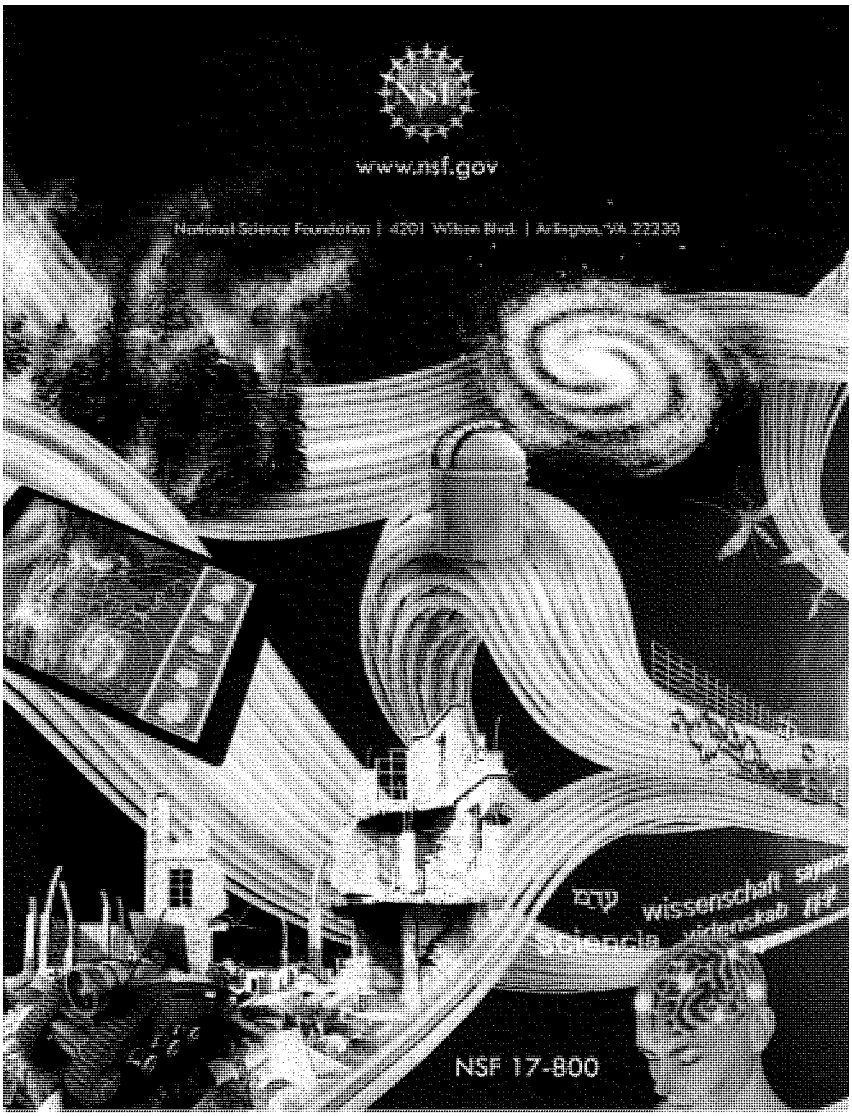
Page 45: (top to bottom) Jason S. Biggs, University of Guam Marine Laboratory; Thinnapob Proongsak/Shutterstock.com; ©iStock.com/asiseeit; ©iStock.com/Anatoliy Babiy; Bruce Vaughn, INSTAAR, University of Colorado

Page 46: Aline Lopes, National Institute of Amazon Research, Manaus

Page 48: (top to bottom) Central African Biodiversity Alliance; Alia Khan, University of Colorado Boulder; ©iStock.com/CreativaImages

Page 49: (top to bottom) Jason Head, University of Cambridge; eGuide Travel, CC BY 2.0; Douglas Pecot, Department of Materials Science and Engineering at the University of Alabama, Birmingham; jbdodane, CC BY-NC 2.0; Dentonyoder, CC BY-SA 4.0

Written by: Susan Reiss, NSF; Kathleen Garrigan, NSF; Bobbie Mixon, NSF; Dana Hunter, NSF; Brittany Quade, NSF; Denise Zaninno, NSF
Design by: Adrian Apodaca, NSF
Illustrations by: Nicolle Rager Fuller, NSF
Image research by: Mornie Briggs, NSF; Anne Du Vivier, NSF


www.nsf.gov
NSF 17-800

Dr. France Córdova Video:

Title: *NSF Helps Safeguard America's Security*

Published By: National Science Foundation

Date: March 10, 2017

https://www.youtube.com/watch?v=S6PWX-I4zoY