Center for American Progress

Closing the Science Gap

Why We Need to Reinvest in Basic Research

By Harry Stein, Jennifer Erickson, and Alex Rowell September 2, 2014

The National Science Foundation, or NSF; the National Institute of Standards and Technology, or NIST; and the Department of Energy Office of Science, or DOE Science, provide a substantial amount of the country's basic research funding, which underpins much of the United States' technological progress. These three basic research agencies have a history of bipartisan support—President George W. Bush first called for doubling their funding in his 2006 State of the Union address, and a similar plan was endorsed by the bipartisan America COMPETES Acts of 2007 and 2010, as well as by President Barack Obama.[1]

Despite bipartisan agreement to double funding for basic research, Congress has not followed up with the appropriations necessary to meet this goal. In the three years after the America COMPETES Reauthorization Act of 2010 was passed, NSF, NIST, and DOE Science faced a gap of nearly $6 billion in funding; this can be thought of as "Science Gap 1.0." Given the huge return on investment from basic research, this lost funding has major economic implications and even risks eroding the science-based military advantage that serves as a cornerstone of our national security.

But the even more worrying reality is that we are about to face "Science Gap 2.0." The America COMPETES Act, which authorizes funding for these agencies, is once again due for reauthorization. Congress is currently considering several proposals to reauthorize the America COMPETES Act, and this issue brief analyzes the growth rates envisioned by the America Competes Reauthorization Act of 2014, as introduced in the House of Representatives. This act sets a course for substantial funding increases at all three agencies.[2] However, sequestration spending caps instituted by the Budget Control Act of 2011 make any significant increase in appropriations highly unlikely. So even if Congress authorized budget increases at NSF, NIST, and DOE Science using the growth rates in the America Competes Reauthorization Act of 2014, sequestration probably means these agencies will confront Science Gap 2.0: They will not receive more than $13 billion of their authorized funding between fiscal years 2015 and 2021.

If Congress creates Science Gap 2.0 by allowing sequestration to continue through 2021, the nation could potentially miss out on nearly 14,000 NSF research grants, 75 new NIST research institutes at U.S. universities, and 24,000 person-years—meaning one scientist's research for one year—of DOE Science research. Instead, Congress should reaffirm America's commitment to investment in research and development, or R&D, by reauthorizing the America COMPETES Act to place these three agencies back on a path toward doubling funding. Congress also should repeal sequestration spending restrictions so that it can fulfill this commitment with adequate appropriations. At a time when so much of the nation's economic competitiveness hinges on R&D, the cost of Science Gap 2.0 is simply too high.

Why is federal R&D investment important?

Estimates show that more than half of the United States' postwar economic growth has come from advances in science and technology.[3] Public investment in R&D, especially basic research—which focuses on advancing scientific knowledge "without specific applications in mind"[4]—provides crucial long-term economic benefits. For example, Google's search algorithm was developed while working under an NSF-funded Stanford University project[5] that used discoveries from federally funded research on social status and social networks from the 1970s.[6] Due in part to those modest public investments in past decades, Google became a major economic engine by 2013, with nearly $60 billion in revenue[7] and 26,559 American employees.[8]

Estimates of social returns from R&D range from 30 percent to more than 100 percent higher than private returns alone, suggesting that the market would not deliver the optimal level of R&D without public investment.[9] Federal investment also helps bring state-of-the-art products to the market. Fred Block, a sociologist at the University of California, Davis, examined *R&D Magazine*'s awards for the top 100 innovations and found that in 2006, 77 of the 88 U.S. product winners had received funding support from the federal government.[10] At NSF, for example, the Innovation Corps helps scientists maximize the economic value of their innovations by building entrepreneurial skills and developing a business plan, which frequently leads to the creation of a start-up company.[11]

The three agencies examined in this issue brief have a particularly important role in basic research activities, which is why they have received bipartisan support in past America COMPETES Act authorizations.

National Science Foundation

- Founded in 1950 in order "to promote the progress of science; to advance the national health, prosperity, and welfare; [and] to secure the national defense," this independent executive branch agency supports research through competitive grants and funding for high-tech facilities and equipment.[12]
- NSF support makes up approximately one-quarter of all federally supported basic research at U.S. colleges and universities,[13] and 212 Nobel Prize recipients since 1952 have received NSF funding at some point in their careers.[14]
- As part of its national defense mission, NSF is making major research investments through its Frontier program, which awards large grants to teams researching critical questions, in order to respond to the emerging national security threat from cyberattacks.[15]
- Innovations supported: web browsers, multitouch screens, and Google.[16]

National Institute of Standards and Technology

- Founded as the National Bureau of Standards in 1901 in order to unify local and regional standards, NIST's current mission is "[t]o promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life."[17]
- NIST conducts research at two large campuses in Maryland and Colorado. It also works with nearly 1,300 manufacturing specialists and staff at more than 400 facilities to bring innovative results from federal research directly to U.S. manufacturers through the Hollings Manufacturing Extension Partnership.[18]
- Innovations supported: the first atomic clock, which was crucial for GPS development, and closed captioning.[19]

Department of Energy Office of Science

- With origins in the Manhattan Project, DOE Science is dedicated to its mission of delivering "the scientific discoveries and major scientific tools that transform our understanding of nature and advance the energy, economic, and national security of the United States."[20]
- As the largest federal sponsor of physical science basic research, Office of Science funding goes to more than 300 U.S. academic institutions, DOE national laboratories, and user facilities that an estimated 28,000 researchers—roughly half from colleges and universities[21]—will use in fiscal year 2015.
- Innovations supported: lithium-ion batteries, organic superconductors, and carbon nanotubes.[22]

How large is the Science Gap?

The America COMPETES Reauthorization Act of 2010, which passed unanimously in the Senate and with bipartisan support in the House, authorized funding increases for key research agencies and reaffirmed the U.S. commitment to doubling their budget. However, the passage of the Budget Control Act of 2011, which set spending-cap levels over the next decade, meant that appropriations could not follow through with authorized funding, and Science Gap 1.0 was born as agencies were underfunded by nearly $6 billion in 2014 dollars. When Congress failed to reach an agreement on deficit reduction by 2013, sequestration lowered these budget caps even further, which devastated scientific research in the United States.[23] The Ryan-Murray budget deal replaced half of the planned discretionary sequestration cuts for FY 2014 but only replaced 20 percent of the cuts slated for FY 2015.[24]

Under current law, sequestration cuts are in full force from FY 2016 through FY 2021, which means that Congress cannot increase funding for the National Science Foundation, the National Institute of Standards and Technology, or the Department of Energy Office of Science without reducing other discretionary spending priorities, which have also been subject to deep cuts.[25] If these three agencies are funded at the same percentage of nondefense discretionary spending as FY 2014, sequestration and inflation will ensure that agency funding will enter a seven-year period of lost growth.

This issue brief uses Science Gap 2.0 to illustrate the magnitude of lost growth at NSF, NIST, and DOE Science by comparing their projected sequestration funding to the increases that would be provided under the framework of the America Competes Reauthorization Act of 2014, as introduced in the House. This bill authorizes funding at NSF, NIST, and DOE Science for the five-year period from FY 2015 to FY 2019, with an average annual increase of about 5 percent. Extrapolating that growth rate to FY 2020 and FY 2021 enables a full analysis of the remaining years of sequestration. From FY 2015 to FY 2021, sequestration likely will prevent $13.63 billion in 2014 dollars of investment at NSF, NIST, and DOE Science—investment that could otherwise be provided under the growth rates established by the America Competes Reauthorization Act of 2014. This would form Science Gap 2.0.

TABLE 1

Funding jeopardized by Science Gap 2.0

Difference between growth rates in the America Competes Reauthorization Act and projected sequestration levels from FY 2015 to FY 2021, in billions of 2014 dollars

Agency	Science Gap 2.0
National Science Foundation	$7.31
National Institute of Standards and Technology	$0.90
Department of Energy Office of Science	$5.42
Total	$13.63

Note: The America Competes Reauthorzation Act authorizes funding from FY 2015 to FY 2019. Funding levels for FY 2020 and FY 2021 are based on average annual growth rates during the five-year authorization period.

Sources: Authors' calculations based on FY 2014 appropriations and current law nondefense discretionary spending limits. *America Competes Reauthorization Act of 2014*, H.R. 4159, 113 Cong. 2 Sess. (2014); Congressional Budget Office, "The Budget and Economic Outlook: 2014 to 2024," Box 1.1 (2014), available at http://cbo.gov/sites/default/files/cbofiles/attachments/45010-Outlook2014_Feb.pdf; *Consolidated Appropriations Act*, H.R. 3547, 113 Cong. 2 Sess. (2014), available at https://beta.congress.gov/bill/113th-congress/house-bill/3547/text.

The critical role of the National Institutes of Health

NSF, NIST, and DOE Science are not the only drivers of basic research in the United States. The National Institutes of Health, or NIH, funded more than half of federal basic research in FY 2012.[26] The Center for American Progress studied the Budget Control Act's impact on biomedical research earlier this year, finding that the NIH will face a $6.3 billion cut from FY 2010 funding levels in FY 2019.[27]

What is the impact of the Science Gap?

Increased funding at the National Science Foundation would advance cutting-edge science in priority areas such as cognitive science and neuroscience, manufacturing and smart systems, and clean energy.[28] To better understand the importance of avoiding Science Gap 2.0, one can look to current NSF budget documents, which explain how NSF would handle new investment. NSF would receive an additional $542.7 million in 2014 dollars in funding in fiscal year 2015 under the president's Opportunity, Growth, and Security Initiative, adding 1,000 research grants and 3,000 traineeships for graduate students.[29] If NSF allocated future additional funding in a similar fashion, the $7.31 billion in funding growth prevented by Science Gap 2.0 would provide an additional 13,475 research grants over seven years.[30] Since fewer than 11,000 NSF grants were funded in FY 2013, eliminating Science Gap 2.0 would yield a substantial increase in research.[31] Expanding the NSF Research Traineeship program by a similar degree would lead to an additional 40,425 traineeship opportunities for graduate students over the next seven years.[32]

In 2013 alone, the sequester had a devastating effect on opportunities for young scientists to pursue their careers in the United States, with many switching careers or looking abroad for better prospects.[33] Losing more than 40,000 NSF traineeship positions due to seven more years of sequestration could put the United States at risk of losing many of the next generation's most promising researchers in science, technology, engineering, and mathematics, or STEM, fields. The United States Military Academy at West Point warns that, "The nation's worsening shortfall in STEM talent has clear national security implications."[34]

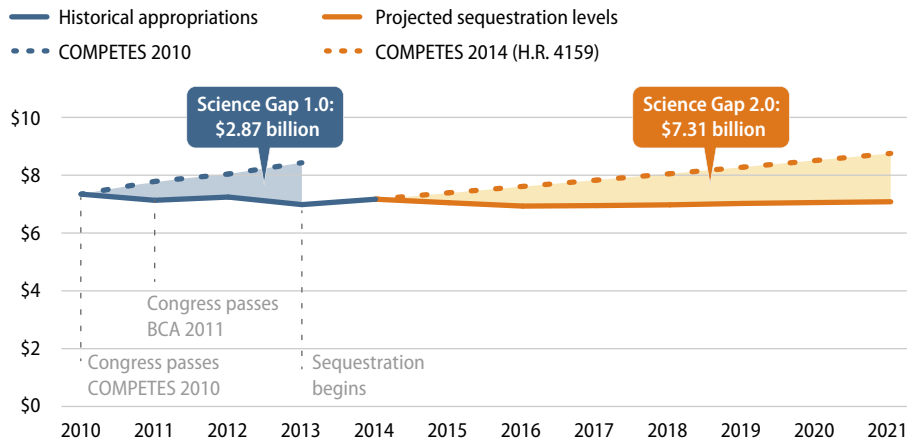
NSF Director Dr. France Córdova warned Congress about the long-term consequences of these budget cuts in her testimony before the Senate Appropriations Committee in April 2014:[35]

> *If reduced funding levels for NSF were to become a reality, the tangible impacts would be significant: fewer teachers would be trained in high quality math and science education; fewer students would graduate with real-world research experiences under their belts, and less research would occur throughout the country in critical areas such as cybersecurity, disaster resilience, and robotics. What is much more difficult to measure is what we will miss by leaving many of the most innovative ideas on the cutting room floor.*

FIGURE 1

The Science Gap at the National Science Foundation

Funding in billions of 2014 dollars



Note: Both COMPETES lines are only funding authorizations, and do not reflect actual appropriations. Authorization levels for FY 2020 and FY 2021 are projected for COMPETES 2014 based on average annual growth rates during the five-year authorization period.

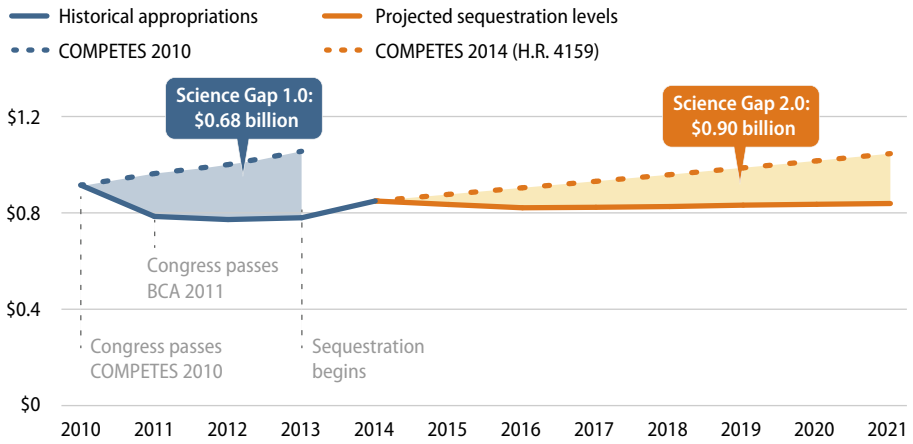
Sources: Congressional Budget Office, "The Budget and Economic Outlook: 2014 to 2024," Box 1.1 (2014), available at http://cbo.gov/sites/default/files/cbofiles/attachments/45010-Outlook2014_Feb.pdf; National Science Foundation, "NSF Requests and Appropriations by Account: FY 1951 - FY 2015," available at http://dellweb.bfa.nsf.gov/NSFRqstApproHist/NSFRequestsandAppropriationsHistory.pdf (last accessed August 2014); *America COMPETES Reauthorization Act of 2010*, H.R. 5116, 111 Cong. 2 Sess (2010), available at http://www.gpo.gov/fdsys/pkg/BILLS-111hr5116enr/pdf/BILLS-111hr5116enr.pdf; *America Competes Reauthorization Act of 2014*, H.R. 4159, 113 Cong. 2 Sess. (2014), available at https://beta.congress.gov/bill/113th-congress/house-bill/4159.

The National Institute of Standards and Technology's FY 2015 budget justification shows that a funding boost would forward research goals in advanced manufacturing, cybersecurity, advanced communications, and forensic science.[36] Examining additional investment in NIST under the American Reinvestment and Recovery Act of 2009, or ARRA, provides a way to see how additional dollars might be spent. NIST allocated the equivalent of $191.9 million in 2014 dollars of ARRA funding to construction grants to assist in building 16 university and nonprofit research facilities that furthered NIST research interests.[37] These facilities, such as the University of Maryland's Laboratory for Advanced Quantum Science and the University of Maine's Advanced Nanocomponents in Renewable Energy Laboratory, give researchers the tools they need to pioneer new scientific research.[38] As an illustrative example, if the funding included in Science Gap 2.0 were to go entirely to new research facilities, NIST could build an additional 75 scientific research facilities at universities and research organizations across the United States.[39] To be sure, NIST could also build fewer new facilities and instead invest more in grants, fellowships, and new high-tech equipment.

FIGURE 2

The Science Gap at the National Institute of Standards and Technology

Funding in billions of 2014 dollars



Note: Both COMPETES lines are only funding authorizations, and do not reflect actual appropriations. Authorization levels for FY 2020 and FY 2021 are projected for COMPETES 2014 based on average annual growth rates during the five-year authorization period.

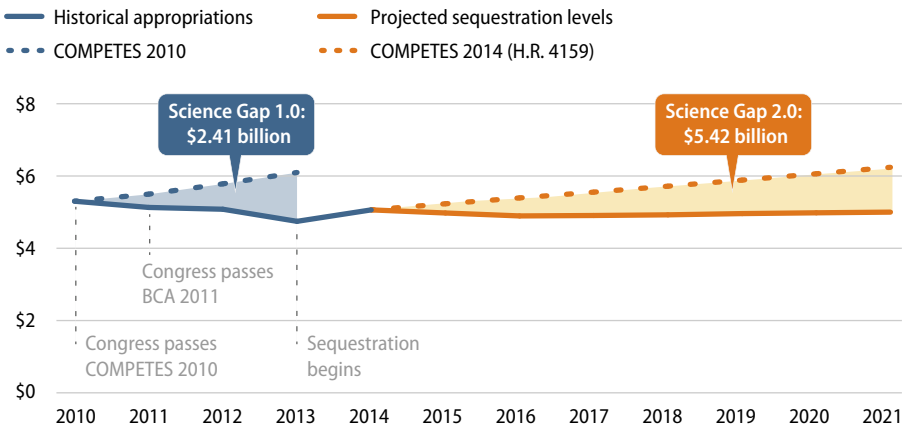
Sources: Congressional Budget Office, "The Budget and Economic Outlook: 2014 to 2024," Box 1.1 (2014), available at http://cbo.gov/sites/default/files/cbofiles/attachments/45010-Outlook2014_Feb.pdf; National Institute of Standards and Technology, "Budget, Planning and Economic Studies," available at http://www.nist.gov/public_affairs/budget/index.cfm (last accessed August 2014); *America COMPETES Reauthorization Act of 2010*, H.R. 5116, 111 Cong. 2 Sess (2010), available at http://www.gpo.gov/fdsys/pkg/BILLS-111hr5116enr/pdf/BILLS-111hr5116enr.pdf; *America Competes Reauthorization Act of 2014*, H.R. 4159, 113 Cong. 2 Sess. (2014), available at https://beta.congress.gov/bill/113th-congress/house-bill/4159.

The Department of Energy's FY 2015 budget allocates increased funding to programs that focus on advanced scientific computing, clean energy, and materials research, but Science Gap 2.0 means that $5.42 billion of new investments might not be made to support this work during the remaining seven years of sequestration. To get a better sense of what this funding can do, the Office of Science FY 2015 budget requests $5.02 billion in 2014 dollars, which would support the work of about 22,000 researchers for that year.[40] The funding to prevent Science Gap 2.0 could therefore provide for about 24,000 person-years—one person performing research for one year—of researchers working at national laboratories and academic institutions nationwide.[41] Increased funding would also ensure that more researchers would have access to the up-to-date technology they need for basic research, such as improved supercomputing centers and particle accelerators.

FIGURE 3

The Science Gap at the Department of Energy Office of Science

Funding in billions of 2014 dollars



Note: Both COMPETES lines are only funding authorizations, and do not reflect actual appropriations. Authorization levels for FY 2020 and FY 2021 are projected for COMPETES 2014 based on average annual growth rates during the five-year authorization period.

Sources: Congressional Budget Office, "The Budget and Economic Outlook: 2014 to 2024," Box 1.1 (2014), available at http://cbo.gov/sites/default/files/cbofiles/attachments/45010-Outlook2014_Feb.pdf; Deparetment of Energy Office of Science, "Budget," available at http://science.energy.gov/budget/ (last accessed August 2014); *America COMPETES Reauthorization Act of 2010*, H.R. 5116, 111 Cong. 2 Sess (2010), available at http://www.gpo.gov/fdsys/pkg/BILLS-111hr5116enr/pdf/BILLS-111hr5116enr.pdf; *America Competes Reauthorization Act of 2014*, H.R. 4159, 113 Cong. 2 Sess. (2014), available at https://beta.congress.gov/bill/113th-congress/house-bill/4159.

Conclusion

Sen. Lamar Alexander (R-TN) was right when he testified before the Senate Committee on Commerce, Science, and Transportation in November 2013 that Congress should "finish the job" to double major research budgets.[42] Making sure that the United States remains at the forefront of scientific research is a goal on which politicians on both sides of the aisle can agree. Congress should come together to reauthorize the America COMPETES Act in a manner that sets our key basic research agencies—the National

Science Foundation, the National Institute of Standards and Technology, and the Department of Energy Office of Science, among others—back on track to meet this goal in the near future. Congress should also repeal sequestration so that the necessary appropriations can be made.

Failure to fund key basic research agencies could mean that the next breakthrough in clean energy or supercomputing occurs elsewhere or not at all. Science Gap 1.0 was enough of a blow to our nation's research agencies; there is no need for a repeat performance. Our economy needs this basic research as a driving force toward increased prosperity. Short-sighted sequestration budget caps should be removed so that research can be properly funded.

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Endnotes

1 Brandon Keim, "Obama Answers Your Science Questions," *Wired*, September 2, 2008, available at http://www.wired.com/2008/09/obama-answers-y/.

2 *America Competes Reauthorization Act of 2014*, H.R. 4159, 113 Cong. 2 sess. (2014), available at https://beta.congress.gov/bill/113th-congress/house-bill/4159. While Congress is also considering other proposals to reauthorize the America COMPETES Act—such as S. 2757 and H.R. 4186—H.R. 4159 is the most appropriate bill for the purposes of this analysis, since it covers all three agencies examined in this report.

3 Michael J. Boskin and Lawrence J. Lau, "Generalized Solow-Neutral Technical Progress and Postwar Economic Growth." Working Paper 8023 (National Bureau of Economic Research, 2000), available at http://www.nber.org/papers/w8023; Robert M. Solow, "Technical Change and the Aggregate Production Function," *The Review of Economics and Statistics* 39 (3) (1957): 312–320, available at http://www9.georgetown.edu/faculty/mh5/class/econ489/Solow-Growth-Accounting.pdf.

4 National Science Board, "Science and Engineering Indicators 2014," Chapter 4 (2014), available at http://www.nsf.gov/statistics/seind14/content/chapter-4/chapter-4.pdf.

5 National Science Foundation, "On the Origins of Google," available at http://www.nsf.gov/discoveries/disc_summ.jsp?cntn_id=100660 (last accessed August 2014).

6 Stephen E. Fienberg, "The Federal Research Portfolio: Capitalizing on Investments in R&D," Testimony before the Senate Committee on Commerce, Science and Transportation, July 17, 2014, available at http://www.commerce.senate.gov/public/?a=Files.Serve&File_id=6b8be86e-c286-4845-a10b-3b222341cd40.

7 U.S. Securities and Exchange Commission, "Form-10k for Google Inc.," available at http://www.sec.gov/Archives/edgar/data/1288776/000128877614000020/goog2013123110-k.htm#s19D7370DAB1A284191372E71A9AA23E1 (last accessed August 2014).

8 Google Inc., "2013 Employer Information Report, Consolidated Report – Type 2," available at https://static.googleusercontent.com/media/www.google.com/en/us/diversity/2013-EEO-1-consolidated-report.pdf (last accessed August 2014).

9 Charles I. Jones and John C. Williams, "Measuring the Social Return to R&D" (Washington: Board of Governors of the Federal Reserve System, 1997), available at http://www.federalreserve.gov/pubs/feds/1997/199712/199712pap.pdf.

10 Fred Block and Matthew R. Keller, "Where Do Innovations Come From? Transformations in the U.S. National Innovation System, 1970-2006" (Washington: Information Technology and Innovation Foundation, 2008), available at http://www.itif.org/files/Where_do_innovations_come_from.pdf.

11 National Science Foundation, "About I-Corps," available at http://www.nsf.gov/news/special_reports/i-corps/about.jsp (last accessed August 2014).

12 National Science Foundation, "NSF at a Glance," available at http://www.nsf.gov/about/glance.jsp (last accessed August 2014).

13 France Córdova, "Driving Innovation through Federal Investments," Testimony before the Senate Committee on Appropriations, April 29, 2014, available at http://www.appropriations.senate.gov/sites/default/files/hearings/Testimony%20-%20The%20Honorable%20France%20Cordova,%20NSF.pdf.

14 National Science Foundation, "Fact Sheet: National Science Foundation" (2014), available at http://www.nsf.gov/about/congress/reports/nsf_factsheet.pdf.

15 National Science Foundation, "NSF invests $20 million in large projects to keep the nation's cyberspace secure and trustworthy," Press release, August 15, 2013, available at http://www.nsf.gov/news/news_summ.jsp?cntn_id=128679.

16 Córdova, "Driving Innovation through Federal Investments."

17 National Institute of Standards and Technology, "Mission, Vision, Core Competencies, and Core Values," available at http://www.nist.gov/public_affairs/mission.cfm (last accessed August 2014).

18 National Institute of Standards and Technology, "NIST General Information," available at http://www.nist.gov/public_affairs/general_information.cfm (last accessed August 2014); National Institute of Standards and Technology and National Technical Information Service, *Fiscal Year 2015 Budget Submission to Congress* (U.S. Department of Commerce, 2014), available at http://www.osec.doc.gov/bmi/budget/FY15CJ/NISTandNTISFY2015CJFinal508Compliant.pdf.

19 Peter L. Singer, "Federally Supported Innovations: 22 Examples of Major Technology Advances That Stem From Federal Research Support" (Washington: Information Technology and Innovation Foundation, 2014), available at http://www2.itif.org/2014-federally-supported-innovations.pdf.

20 U.S. Department of Energy Office of Science, "About," available at http://science.energy.gov/about/ (last accessed August 2014).

21 Ibid.

22 U.S. Department of Energy Office of Science, "Accomplishments: Discoveries," available at http://science.energy.gov/bes/news-and-resources/accomplishments/discoveries/ (last accessed August 2014).

23 Sam Stein, "Sequestration Ushers in a Dark Age for Science in America," HuffPost Politics, August 14, 2013, available at http://www.huffingtonpost.com/2013/08/14/sequestration-cuts_n_3749432.html.

24 Office of Management and Budget, *Opportunity for All* (Executive Office of the President, 2014), available at http://www.whitehouse.gov/sites/default/files/omb/budget/fy2015/assets/opportunity.pdf.

25 Harry Stein, "The Fiscal Debate in Context," Center for American Progress, March 12, 2014, available at http://www.americanprogress.org/issues/budget/news/2014/03/12/85684/the-fiscal-debate-in-context/.

26 National Science Foundation, "Table 7. Preliminary federal obligations for research and development, by agency and character of work: FY 2012," available at http://www.nsf.gov/statistics/nsf13326/pdf/tab7.pdf (last accessed August 2014).

27 Kwame Boadi, "Erosion of Funding for the National Institutes of Health Threatens U.S. Leadership in Biomedical Research" (Washington: Center for American Progress, 2014), available at http://www.americanprogress.org/issues/economy/report/2014/03/25/86369/erosion-of-funding-for-the-national-institutes-of-health-threatens-u-s-leadership-in-biomedical-research/.

28 National Science Foundation, "Opportunity Growth and Security Initiative" (2014), available at http://www.nsf.gov/about/budget/fy2015/pdf/60_fy2015.pdf.

29 Ibid.

30 Ibid. Authors' calculations are based on estimated additional funding of $7.31 billion from closing Science Gap 2.0 from 2015 to 2021 and research grants that would be supported under the Opportunity, Growth, and Security Initiative.

31 Ibid.

32 Ibid. Authors' calculations are based on estimated additional funding of $7.31 billion from closing Science Gap 2.0 from 2015 to 2021 and traineeships that would be supported under the Opportunity, Growth, and Security Initiative.

33 Stein, "Sequestration Ushers in a Dark Age for Science in America."

34 United States Military Academy at West Point, "About CSE," available at http://www.usma.edu/cse/SitePages/About.aspx (last accessed August 2014).

35 Córdova, "Driving Innovation through Federal Investments."

36 National Institute of Standards and Technology and National Technical Information Service, *Fiscal Year 2015 Budget Submission to Congress*.

37 National Institute of Standards and Technology and National Technical Information Service, *Fiscal Year 2013 Budget Submission to Congress* (U.S. Department of Commerce, 2012), available at http://www.osec.doc.gov/bmi/budget/13CJ/NIST-NTIS_FY_2013_Congressional_Justification.pdf.

38 National Institute of Standards and Technology, "NIST Awards $123 Million in Recovery Act Grants to Construct New Research Facilities," Press release, January 8, 2010, available at http://www.nist.gov/public_affairs/releases/20100108_cgp_awards.cfm#umaine.

39 Authors' calculations are based on estimated additional funding of $900 million from closing Science Gap 2.0 from 2015 to 2021. ARRA investments are from National Institute of Standards and Technology and National Technical Information Service, *Fiscal Year 2013 Budget Submission to Congress*.

40 U.S. Department of Energy, *FY 2015 Congressional Budget Request* (2014), available at http://www.energy.gov/sites/prod/files/2014/04/f14/Volume_4.pdf.

41 Authors' calculations are based on estimated additional funding of $5.42 billion from closing Science Gap 2.0 from 2015 to 2021 and the number of personnel supported by the FY 2015 budget at current funding levels. See U.S. Department of Energy, *FY 2015 Congressional Budget Request*.

42 Physics Frontline, "U.S. Sen. Alexander to Congress: 'Finish the job' of doubling research budgets outlined in America COMPETES," November 7, 2013, available at http://physicsfrontline.aps.org/2013/11/07/u-s-sen-alexander-to-congress-finish-the-job-of-doubling-research-budgets-outlined-in-america-competes/; Senate Committee on Commerce, Science, and Transportation, *America COMPETES: Science and the U.S. Economy: Hearings on H.R. 5116*, 111th Cong., 2d. sess., 2013, available at http://www.commerce.senate.gov/public/index.cfm?p=Hearings&ContentRecord_id=69d33a64-afaf-491f-852f-5f8788c7a530&ContentType_id=14f995b9-dfa5-407a-9d35-56cc7152a7ed&Group_id=b06c39af-e033-4cba-9221-de668ca1978a.