REPORT FROM NATIONAL CASE STUDY

United States

Deliverable 12.1
Work Package 12

Project title:	Responsible Research and Innovation in Practice (RRI-Practice)
Grant Agreement no:	709637
Funding Programme:	Horizon 2020
Project Coordinator:	Hogskolen I Oslo Og Akershus (HIOA), Norway
Project website:	www.rri-practice.eu
Organization responsible for the deliverable:	Arizona State University
Author(s):	Tess Doezema and David Guston
Date of delivery:	27.07.18
Dissemination level:	PUBLIC

Abstract

This report assesses the national context of Responsible Research and Innovation (RRI) in the United States, and takes Arizona State University's Biodesign Institute as a case study for a closer examination of the dynamics of different elements of Responsible Research and Innovation in one particular U.S. research conducting organization. The research seeks to identify best practices in areas of interest in the RRI framework, as well as barriers and drivers to change in these areas. Although RRI is not a term that is used in policy debates or throughout much of the research conducting enterprise in the U.S., each key highlighted by the European Commission as integral to RRI is deeply engaged in the U.S. research space and the topic of lively and ongoing debate and development. This report examines those debated and considers the present and potential future of RRI in the U.S.

Contents

1. Executive summary 4
2. Introduction: about the report..6
3. Methodology 6
3.1 National mapping 6
3.1.1 Document analysis..6
3.1.2 Interviews 7
3.1.3 National workshop 7
3.2 The organizational studies...7
3.2.1 Document studies..7
3.2.2 Interviews for Reviews 7
3.2.3 Focus groups 7
3.2.4 Outlook process 8
4. The context for RRI: the national science policy system 8
4.1 General country information..8
4.2 Legal and other binding normative frameworks 9
4.3 Political and cultural values and discussions related to STI..13
5. Aspects of responsibility in national science policy 14
5.1 The conceptualizations of responsibility in national science policy 14
5.2 The notion of 'RRI' in national science policy discussions..15
5.3 Ethics in the national science system 15
5.4 Societal engagement strategies in research...19
5.5 Gender equality and diversity strategies in the science system 24
5.6 Open access and open science strategies in the national science system........................31
5.7 Science education as integrated in research...38
5.8 Incorporation of AIRR dimensions into science policy discussions 41
5.8.1. Diversity and inclusion..41
5.8.2. Anticipation and reflexivity...42
5.8.3 Openness and transparency 44
5.8.4 Responsiveness and adaptation 44
5.8 The integrated or fragmented nature of different responsibility related aspects 45
6. Organizational reviews and outlooks: Research conducting organization...........................46
6.1 Mapping of the organization 46
6.2 Aspects of responsibility in organizational policy and practice 48
6.2.1 The conceptualizations of responsibility in the organization 48
6.2.2 Ethics in the organization..49
6.2.3 Societal engagement strategies in organization 53
6.2.4 Gender equality and diversity strategies in the organization 57
6.2.5 Open access and open science strategies in the organization.......................................62
6.2.6 Science education as integrated in research 65
6.2.7 Incorporation of AIRR dimensions into policies...67
6.2.8 Other concepts used to characterize responsibility in the organization 70

6.3. Reflection on Review findings, Outlooks developed and ways forward 71
6.3.1 The integrated or fragmented nature of different responsibility related dimensions 71
6.3.2 Common barriers or drivers 71
6.3.3 Final reflections and plan for follow-up 71
7. Discussion of findings 72
8. Conclusions 74
8.1 Policy recommendations to national policy makers 74
8.2 Policy recommendations to European policy makers 74
8.3 Recommendations to research conducting and funding organizations 74
8.4 Best practices scalable to European or national level 75
9. Annex 1: Reviewed documents 77
10. Annex 2: Matrices 80

1. Executive summary

Examining the research system of the United States through the lense of Responsible Research and Innovation, this report presents data and findings on the state of U.S. policy and discourse around issues in including ethics, science education, open access, gender, and public engagement. Additionally, the report seeks to understand how diversity and inclusion, anticipation and reflexivity, openness and transparency, as well as responsiveness and adaptation, inform science and innovation policy, administration, and practice.

The report interrogates these areas of interest both at the U.S. national level and in an in-depth case study of one research conducting organization, the Biodesign Institute (BDI) at Arizona State University. The Project's researchers engaged executive leadership, scientists, and administrators at the Institute on questions of current practice and potential areas of change in pursuit of ever-more socially responsible research and innovation. The research relies on data gleaned through extensive document analysis, interviews, a national workshop, a pair of focus groups, and several follow-up meetings with the case study organization's leadership.

U.S. national discourse on these policies is active, with a long history of engagement with the key RRI-dimensions. Nevertheless, a principal finding is that RRI does not function as a shared concept or organizing premise at the national level or within the research conducting organization examined by this research. The various RRI dimensions are sometimes interrelated in the U.S. national landscape, but as a general rule they tend to be the subject of separate areas of analysis and resource allocation. Recent political developments have complicated the trajectories of many of the RRI-dimensions, especially gender and diversity, open data, and science education, rendering the trajectory of national policy and practice uncertain in these areas.

As the case study organization, the Biodesign Institute is well situated in the national context, with orientations and priorities toward the RRI dimensions existing within the organization similar to those found in policy documents and analyses at the national level. The priority action areas, the ways in which the keys were seen as fitting together, and the plausible actions going forward all mapped clearly between the organization and the national discourse. While recent events have complicated the national context, the ambiguities and even reversals that national leadership has introduced at the Federal level do not seem to have penetrated at the level of the Biodesign Institute. Values and concerns consistent with past agendas in science policy continue to drive priorities and possibilities at BDI.

One central, common driver for progress across RRI dimensions is the shared concern among the global scientific community, creating momentum for progress in creating transparency and inclusion. The work that has been done to broaden these concerns from national policy to areas for global collaboration and shared visions for science governance are instrumental in creating consistent progress even in the face of contentious national politics. In general, in the U.S., the impetus for change within the research landscape has come from above—congressional directives and executive orders that change the funding landscape and create incentives for scientists through their funding to engage the public and increase transparency in findings and data. Requirements in grant application by the National Institutes of Health (NIH), the National Science Foundation (NSF) and other public funding agencies around open science, inclusion, ethics training, science education and public engagement have done much to shape the U.S. landscape for RRI issues.

Barriers to progress in these areas are varied. While the rich history that underlies such areas as ethics and gender equality in the U.S. provides a strong basis and even legal precedent for a level of consistency and stability across institutions and political administrations, these structures also tend to resist change in important ways. For example, increasing diversity in science is an articulated priority of research-conducting institutions and science education facilities across the U.S., but quota systems and hiring strategies that target particular demographic groups are not a viable option within the framework of U.S. civil rights law, as they may be in other national contexts. Similarly, well-institutionalized systems of institutional review boards and well-developed legal frameworks for ethical scientific behavior may largely stabilize and ensure a baseline level of ethical practice, but these fixed infrastructures (and their concomitant norms) tend to compartmentalize ethical deliberation and render ethics more of a narrowly construed box-ticking practice than an active area of engagement for many scientists. As these brief examples Illustrate, drivers of and barriers to progress tend to be conflicting and contradictory, rather than cleanly divisible from one another.

This research identifies some best practices across RRI-dimensions and makes a variety of recommendations for different actors. Some key recommendations are as follows.

At the level of the European Union:

- Increase global scale collaborations
- Target international outreach at levels below the executive branch

For the U.S. national government:

- Expand public engagement possibilities
- Create mechanisms for assessment and institutional memory for programs such that successes can be emulated and lessons can be learned in funding agendas relevant to RRI-dimensions.
- Reinstate critical technology assessment capacities at the federal level
- Encourage universities and other grantees to create significant capacities for RRI

Research conducting organizations:

- Conduct organizational assessments of RRI-dimensions to identify areas of potential improvement and interest
- Collaborate with social scientists on areas of mutual interest

2. Introduction: about the report

This report seeks to assess and analyze Responsible Research and Innovation in Practice in the United States. The report also examines a particular case study, with a more in-depth investigation into the Biodesign Institute (BDI) at Arizona State University (ASU). Through these descriptions and analyses, the report aims to identify drivers, barriers and best practices for RRI in the U.S. context. The research included interviews, a workshop, focus groups and extensive document analysis in the service of these goals.

The primary challenge for such an endeavor in the U.S. is an overabundance of information and the multiplicity and wide distribution of initiatives, documents, projects, databases, etc., with relevance to the broad range of concerns encompassed by RRI. In the U.S. context, RRI is not recognized as a particular area of policy, research, or research funding. Each element of RRI has a rich history, is surrounded by diverse and even conflicting attitudes, experiences fluctuations in political salience, and has produced such a proliferation of documents and engagements that to claim to present a definitive snapshot of RRI in the U.S. would be hubris.

With this challenge in mind, our research has sought primarily to focus on RRI undertakings at the federal level, particularly those associated with research funding agencies. While there is some discussion of individual research projects and private sector activities, the landscape of such examples so vast and contains such diversity that, to generalize about them is outside of the scope of this research project. As such, the report offers an account of the state of RRI in the U.S. at the level of federal policy and analysis, but it does not account for innovative projects that may be leading the charge in these areas and have yet to be recognized or highlighted at that level.

The case study, of ASU's Biodesign Institute, offers a much more fine-grained understanding of one particular research-conducting organization, embedded in and responsive to the broader contextual elements discussed as part of the national context. The case study thus provides insight on how researchers engage with broader national science policy requirements and aspirations. Further, the "interventionist" nature of this project has produced some insights on potential organizational change in U.S. research and innovation, where sites of resistance to change are located, and where areas of potential transformation exist.

3. Methodology

This research followed the RRI-Practice methodological guidelines.[1] Details on particularities of this research in the context of existing methodological framework of the project are described in the following.

3.1 National mapping

3.1.1 Document analysis

The national mapping is based largely on the document analysis. We analyzed 45 documents to understand the national landscape with respect to RRI aspects (See appendix 1). These documents were identified through searches of publications by key players in the national science policy landscape, including Federal government websites, government funding agencies, national science academies, and news organizations. The search was roughly bounded by date, with a focus on documents after 2009, but it does include some key documents published before this date that have an oversized influence on the current state of policy and practice in a particular area. Further, when multiple documents by the same actor existed, such as yearly reporting on a

[1] RRI-Practice project description, Part B. Available: www.rri-practice.eu. Accessed: June 28, 2018.

particular initiative, the most recently published of those documents was chosen in order to minimize repetition and keep the number of analyzed documents reasonable in scope.

3.1.2 Interviews

We conducted four semi-structured interviews and a collection of more informal conversations that were particularly useful for fact finding, background, and the identification of key documents in the national mapping. The interviews were not used as analytical objects, since the number of interviews within the scope of this project were best suited to a more exploratory purpose.

We also observed a meeting that addressed social, ethical and governance concerns around cutting edge and proposed genetic editing technologies. The observation helped illuminate current thinking in the U.S. around possibilities for science governance that go beyond risk-based analysis. The diverse panelists provided a multitude of important perspectives, including science, law, and religion. Twenty-eight speakers addressed these issues through presentations and panel dialogue.

3.1.3 National workshop

The U.S. national workshop was hosted at Arizona State University's Tempe campus on Monday 27 February 2017. It brought together 26 stakeholders from the U.S. federal government, the private sector, civil society, and academia.[2]

3.2 The organizational studies

3.2.1 Document studies

The organizational analysis of BDI was based, in part, on the analysis of the organization's large website (https://biodesign.asu.edu/), 10 public relations documents/brochures, one employee demographics data spreadsheet, and employee satisfaction surveys conducted by the organization.

3.2.2 Interviews for Reviews

The organizational analysis draws extensively from the analysis of 18 semi-structured interviews, used to understand the variety of practices, attitudes, and experiences of the Biodesign Institute. The interviewees were chosen to represent key leadership positions at the executive level, as well as a sample of research center directors. These directors were chosen based on existing rapport with the research team and a willingness to participate in the study. Each of the directors was asked to provide the names of potential participants within their centers. All interviewees were asked to provide the names of other potential participants to create a snowball sample. Additionally, key participants with expertise on specific RRI elements were targeted through website analysis and snowball sampling, in order to understand practices around these elements in particular.

3.2.3 Focus groups

Focus groups were conducted on 24 January and 2 February 2018. Each focus group included 10-15 participants from BDI and from elsewhere at ASU where the particular issues discussed also have currency, e.g., the library system for data and ethics and the Center for Gender and Equity in Science and Technology for gender and diversity and data and ethics. The focus groups considered case studies of proposed good practice to inform possibilities for improving practice around gender, ethics and data within BDI.

[2] For more information about the national workshop, download the full report here: https://www.rri-practice.eu/knowledge-repository/national-workshop-reports/.

3.2.4 Outlook process

The formation of the outlook took place following the conclusion of the focus groups. A pair of reports on the focus group was delivered to the organization's leadership, and a final meeting on ways forward was convened between executive leadership and the research team. At this meeting, a set of actions in response to the focus groups and research findings was agreed upon, the research team produced a summary document, or "outlook" of these proposed actions, and delivered it back to the organization's leadership. The organization's leadership has taken ownership of the proposed actions, and plans to administer them internally going forward, with assistance on monitoring progress from the research team.

Subsequent to the conclusion of the outlook report, the central administration of the university authorized project PI Guston to submit a proposal for a university-wide initiative in responsible innovation. The experience of RRI Practice and working with the Biodesign Institute will provide a preliminary framework for the aspects of the initiative that are internal to other research performing entities within ASU.

4. The context for RRI: the national science policy system

4.1 General country information

The U.S. is the third most populous country in the world, with an estimated population, as of May 2018, of 327.5 million.[3] According to the most recent census data, the majority of the population self-identifies as white (76.9%), 13.3% Black or African American, 5.7% as Asian, 1.5% as native, and 2.6% identify as more than one category.

Eighty-seven percent of the U.S. population has graduated from high school or higher, and 30.3% hold a bachelor's degree or higher.[4] The 2016 median household income is $55,322, with 12.7% of the population categorized as in poverty.[5] Assessments of the population in terms of such broad averages, though, gloss over the high levels of inequality present in the US in income, health, mortality and education across class, gender and race. The US has a Gini Index of 41.5,[6] reflecting a relatively high level of inequality compared to that of this project's partner countries. These inequalities are amplified across racial lines. For instance, the median wealth level of black households is 13 times lower than that of white households, and infant mortality among black women is twice that of white women across levels of education.[7] Observed trends in these disparities is that they are becoming more extreme, not less so over time.

The U.S. leads the world in gross domestic expenditures on R&D, spending $457 Billion in 2013.[8] This rate of expenditure is about 2.8 percent of GDP, lagging just behind German R&D expenditures by GDP and far exceeded by Korea, Japan and Isreal. The US produced 25% of the world's top 10% of most-cited publications

---

[3] United States Census Bureau. Available: https://www.census.gov/popclock/. Accessed: May 7, 2018.

[4] United States Census Bureau. Available: https://www.census.gov/quickfacts/fact/table/US/PST045216. Accessed: May 7, 2018.

[5] United States Census Bureau. Available: https://www.census.gov/quickfacts/fact/table/US/PST045216. Accessed: May 7, 2018.

[6] World Bank. "Gini Index"

[7] Brookings. **Time for justice: Tackling race inequalities in health and housing. October 19, 2016. Available:** https://www.brookings.edu/research/time-for-justice-tackling-race-inequalities-in-health-and-housing/#_edn8. Accessed: May 10, 2018.

[8] National Science Foundation. Science and Engineering Indicators 2016. Available: https://www.nsf.gov/statistics/2016/nsb20161/#/report/overview/science-and-technology-in-the-world-economy. Accessed: May 7, 2018.

in 2016, down from 38% in 2005.[9] One-third of all degrees awarded in the US in 2012 were science and engineering fields.[10] Women in the US make 12-16% less than men in comparable positions, and between 2012 and 2015 only 10% of patents listed women inventors.[11]

4.2 Legal and other binding normative frameworks

The 13th Amendment of the US Constitution abolished slavery in 1865.

The 14th Amendment of the US Constitution in 1868 defines citizens of the US inclusively and requires due process and protection under the law for all citizens (among other things).

The 1964 Civil rights act outlawed discrimination based on race, color, religion, or national origin in hotels, motels, restaurants, theaters, and all other public accommodations engaged in interstate commerce, desegregated schools and universities, and prohibited discrimination in employment and protected voting rights (among a host of other actions less relevant to this report).[12] Implementation of the law has been uneven and repeatedly challenged, necessitating many subsequent efforts, including an executive order (Order 11375) by President Lyndon Johnson in 1967 explicitly banning sex-based discrimination in hiring and employment. The Americans with Disabilities Act (1990) extended similar civil protections to Americans with disabilities. Other updates to the law responded to court decisions limiting the applicability of the civil rights act, notably to allow victims of gender-based pay discrimination to seek remediation under the civil rights act.

Title IX of the education amendments of 1972 is a statute stating, "No person in the United States shall, on the basis of sex, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any education program or activity receiving federal financial assistance."[13] The law has played a central role in issues around inclusion and discrimination in public universities, and thus in the research community. As such, interpretation of Title IX and its legacy are discussed in greater detail in the section on gender and diversity below.

The 1990 Clery Act and its 2013 update, the Campus Sexual Violence Elimination (SaVE) Act, requires federally funded institutions (include those receiving federal student aid) to be transparent about the occurrence of particular crimes on campus, including sexual violence, maintain a public crime log including information on dating violence, domestic violence, sexual assault, and stalking incidents."[14] Institutions must publish these statistics annually, issue timely warnings, and have an emergency response system in place. Finally, they must protect the confidentiality of victims.[15]

On 4 April 2011, the U.S. Department of Education issued a "Dear Colleague Letter" regarding Title IX, with the aim of easing burdens on complainants in sexual assault cases. The letter offered an interpretation of Title

---

[9] OECD. Highlight's from the OECD Science, Technology, and Industry Scoreboard 2017. Available: http://www.oecd.org/unitedstates/sti-scoreboard-2017-united-states.pdf Accessed: April 7, 2017.

[10] National Science Foundation. Science and Engineering Indicators 2016. Available: https://www.nsf.gov/statistics/2016/nsb20161/#/report/overview/science-and-technology-in-the-world-economy. Accessed: May 7, 2018.

[11] OECD. Highlight's from the OECD Science, Technology, and Industry Scoreboard 2017. Available: http://www.oecd.org/unitedstates/sti-scoreboard-2017-united-states.pdf Accessed: April 7, 2017.

[12] Equal Employment Opportunity Commission. Available: https://www.eeoc.gov/eeoc/history/35th/thelaw/civil_rights_act.html. Accessed: May 15, 2018

[13] U.S. Department of Education. "Title IX and Sex Discrimination." Available: https://www2.ed.gov/about/offices/list/ocr/docs/tix_dis.html. Accessed March 26th, 2018.

[14] Rape, Abuse and Incest National Network. "Campus SaVE Act." Available: https://www.rainn.org/articles/campus-save-act. Accessed: May 15, 2018.

[15] Cornell Law School Legal Information Institute. "20 U.S. Code § 1092 - Institutional and financial assistance information for students." Available: https://www.law.cornell.edu/uscode/text/20/1092. Accessed: May 15, 2018.

IX declaring that public universities should use a preponderance of evidence[16] as the standard of proof in sexual assault cases involving student-on-student assault, rather than stricter burdens of evidence, and that universities are required to allow accusers to appeal not-guilty verdicts. The letter required that adjudications should happen within 60 days, and it discouraged cross-examination of accusers.[17]

After the 2016 presidential election, the administration of President Donald Trump has effectively reversed the Dear Colleague letter. In September 2017, the Department of Education's Office of Civil Rights issued a "Q&A on Campus Sexual Misconduct" that outlines an approach shifting focus to the defense of the rights of the accused. The document rescinds the Obama-era directive to use the "preponderance of evidence" standard, offering institutions the option of using the higher standard, "clear and convincing evidence." The guidance also nullifies the requirement to adjudicate within 60 days and offers the option of resolution through mediation.[18] The Q&A was published as an interim measure in advance of an intended rulemaking procedure, which has not yet been initiated as of the writing of this report.

The Obama administration's Department of Education issued another Dear Colleague Letter in 2016, addressing the protection of transgender students under Title IX. The letter highlights that schools must "treat a student's gender identity as the student's sex for purposes of Title IX and its implementing regulations."[19] This guidance was rescinded by the Trump administration's own Dear Colleague letter in 2017.[20]

Other relevant Dear Colleague Letters released under President Obama's Department of Education include one offering guidance on "Gender Equity in Career and Technical Education,"[21] one offering "Guidance on Obligations of Schools to Designate a Title IX Coordinator,"[22] and others with less direct relevance to this report but detailing rules for the protection of civil rights in various areas of education.[23] This series of guidance documents sought to clarify and ensure protections for women and other minority groups across the U.S. educational system.

President Obama signed an Executive Order in July 2014 titled "Fair Pay and Safe Workplaces,"[24] which seeks to ensure compliance of federal contractors with labor laws, notably by establishing pay transparency reporting rules and banning forced arbitration[25] clauses for sexual harassment in employment contracts. The executive order was issued after the Government Accountability Office published a report documenting a

---

[16] Preponderance of Evidence is a standard in civil law in which a small difference in the weight of evidence may be dispositive, as opposed to the clear and convincing standard in administrative law or the beyond a reasonable doubt standard in criminal law in the US, both of which require higher levels of evidence to convict.
[17] U.S. Department of Education. April, 2011. "Dear Colleague Letter." Available: https://www2.ed.gov/print/about/offices/list/ocr/letters/colleague-201104.html Accessed: May 16, 2018.
[18] U.S. Department of Education Office for Civil Rights. September, 2017. "Q&A on Campus Sexual Misconduct." Available: https://www2.ed.gov/about/offices/list/ocr/docs/qa-title-ix-201709.pdf. Accessed: May 16, 2018.
[19] U.S. Department of Education. "Dear Colleague Letter on Transgender Students." May 13, 2016. Available: https://www2.ed.gov/about/offices/list/ocr/letters/colleague-201605-title-ix-transgender.pdf. Accessed: June 4, 2017.
[20] U.S. Department of Education. "Dear Colleague Letter." February 22, 2017. Available: https://www2.ed.gov/about/offices/list/ocr/letters/colleague-201702-title-ix.pdf. Accessed: June 4, 2018.
[21] U.S. Department of Education. "Dear Colleague Letter on Gender Equity in Career and Technical Education" June 15, 2016. Available: https://www2.ed.gov/about/offices/list/ocr/letters/colleague-201606-title-ix-gender-equity-cte.pdf. Accessed: June 5, 2018.
[22] U.S. Department of Education. "Dear Colleague Letter on Title IX Coordinators." April 24, 2015. Available: https://www2.ed.gov/about/offices/list/ocr/letters/colleague-201504-title-ix-coordinators.pdf. Accessed: June 5, 2018.
[23] U.S. Department of Education. "Sex Discrimination." Available: https://www2.ed.gov/about/offices/list/ocr/frontpage/faq/rr/policyguidance/sex.html. Accessed: June 5, 2018.
[24] The White House. "Executive Order—Fair Pay and Safe Workplaces." July 31, 2014. Available: https://obamawhitehouse.archives.gov/the-press-office/2014/07/31/executive-order-fair-pay-and-safe-workplaces. Accessed May 31, 2018.
[25] Forced arbitration clauses remove the right of the complainant to be heard in court, allowing for private modes of resolution.

significant level of federal contracts being awarded to companies in flagrant violation of U.S. labor laws.[26] On 27 March 2018 President Trump repealed this executive order.[27]

The 1980 Patent and Trademark Act Amendments of 1980, known as the Bayh-Dole Act,[28] created uniform patent policy across federal funding agencies. The legislation entitles universities and other publicly funded entities to retain intellectual property rights over inventions created as a result of federally funded research. Under the act, universities are required to have a capacity to handle intellectual property, and must allow individual researchers to pursue patents if the university chooses not to. Universities may create exclusive licenses, but must allow for government use. The legislation includes other caveats relating to obligations to favor small businesses in licensing, royalty sharing directives, and instructions on the use of excess royalties for research and education.[29]

The National Science Foundation Grant Guidelines require a discussion of "broader impacts" in research grant applications. The requirement has potential effects on gender equality and diversity, science education and public engagement.[30]

NSF also has data sharing guidelines that are part of these instructions, which are discussed more explicitly below, in the section on open access.

A 2013 directive from the U.S. Office of Science and Technology Policy (OSTP) requires "each Federal agency with over $100 million in annual conduct of research and development expenditures to develop a plan to support increased public access to the results of research funded by the Federal Government."[31] Thus, key research funding organizations, including the National Science Foundation (NSF), the National Institutes of Health (NIH), the Department of Defense (DOD), the Department of Energy (DOE), and others[32] developed and implemented public access and data sharing requirements for grantees, and they have set up repositories to house research for public access. The OSTP directive, enacted under President Obama, is no longer on the White House website, but the public access requirements of these funding agencies have not been rescinded; thus it is still de facto policy as of the publication of this report.

The 2017 Executive Order 13783, "Promoting Energy Independence and Economic Growth," states, "it is also the policy of the United States that necessary and appropriate environmental regulations comply with the law, are of greater benefit than cost, when permissible, achieve environmental improvements for the American

---

[26] U.S. Government Accountability Office. "Federal Contracting: Assessments and Citations of Federal Labor Law Violations by Selected Federal Contractors." September 2010. Available: https://www.gao.gov/assets/310/309785.pdf. Accessed: May 31, 2018.
[27] The White House. "Presidential Executive Order on the Revocation of Federal Contracting Executive Orders." March 27, 2017. Available: https://www.whitehouse.gov/presidential-actions/presidential-executive-order-revocation-federal-contracting-executive-orders/. Accessed: May 31, 2018.
[28] National Institutes of Health. "Bayh-Dole Regulations." Available: https://grants.nih.gov/grants/bayh-dole.htm. Accessed: May 18, 2018.
[29] University of Pittsburgh Innovation Institute. "Bayh-Dole Act at a Glance." Available: http://www.innovation.pitt.edu/resource/bayh-dole-act-at-a-glance/. Accessed: May 18, 2018.
[30] National Science Foundation. "Proposal Preparation Instructions. Chapter II" Available: https://www.nsf.gov/pubs/policydocs/pappguide/nsf13001/gpg_2.jsp#IIC2d. Accessed: May 18, 2018.
[31] Holdren, John P. "Memorandum for the Heads of Executive Departments and Agencies." Office of Science and Technology Policy. Available: https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/ostp_public_access_memo_2013.pdf. Accessed: May 18, 2018.
[32] Full list of agencies with public access plans available here: https://cendi.gov/projects/Public_Access_Plans_US_Fed_Agencies.html.

people, and are developed through transparent processes that employ the best available peer-reviewed science and economics" (emphasis added).[33]

The 2017 Executive Order 13777, "Enforcing the Regulatory Reform Agenda," tasks federal agencies with reducing regulation. The order outlines a host of parameters for what kinds of regulations should be identified and eliminated, including "in particular those regulations that rely in whole or in part on data, information, or methods that are not publicly available or that are insufficiently transparent to meet the standard for reproducibility."[34]

Referring to the executive orders outlines above, the EPA proposed a new rule on 30 April 2018 entitled "Strengthening Transparency in Regulatory Science,"opening a public comment period ending on 30 May 2018. The rule, if adopted, would require that the data from scientific studies that are pivotal to EPA regulations be "publicly available in a manner sufficient for independent validation."[35]

The 1974 National Research Act requires that all federally funded research involving human research subjects be reviewed by an Institutional Review Board (IRB). The Act also established the first bioethics commission, "President's Commission for the Study of Ethical Problems in Medicine and Biomedical and Behavioral Research," and tasked it with creating ethical guidelines for human subjects research.[36] The outcome of this effort was the 1978 Belmont Report, establishing 3 key ethical principles: respect for persons, beneficence, and justice. The act also issued Title 45, Part 46 of the Federal Code of Regulations: Protection of Human Subjects. Parts of this set of regulations became known as the Common Rule, when it was codified and standardized across agencies (with the exception of the FDA, which follows a modified version of the rule) in 1991.[37]

The 2017 update to the Common Rule offers some significant updates, most interestingly, changing the definition of human subjects (and thus the purview of protections) to explicitly include identifiable biospecimens,[38] but not non-identified biospecimens.[39]

The America COMPETES Act[40] was signed into law in August 2007 under President George W. Bush and reauthorized in 2010 under President Obama. It lays out a wide range of efforts to increase the level of STEM education, offering grant opportunities and creating new programs across government agencies. The Act

---

[33] Executive Office of the President. March 28, 2017. "Promoting Energy Independence and Economic Growth: Executive order 13783." *The Federal Register*. Available: https://www.federalregister.gov/documents/2017/03/31/2017-06576/promoting-energy-independence-and-economic-growth. Accessed: May 18, 2018.

[34] Executive Office of the President. March 1, 2017. "Enforcing the Regulatory Reform Agenda: Executive order 13777." *The Federal Register*. Available: https://www.federalregister.gov/documents/2017/03/01/2017-04107/enforcing-the-regulatory-reform-agenda. Accessed: May 18, 2018.

[35] Environmental Protection Agency. April 30, 2018. "Strengthening Transparency in Regulatory Science." *The Federal Register*. Available: https://www.federalregister.gov/documents/2018/04/30/2018-09078/strengthening-transparency-in-regulatory-science.

[36] "Public Law 93-348." *The Federal Register.* Available: https://history.nih.gov/research/downloads/PL93-348.pdf. Accessed May 18, 2018.

[37] Breault, J. L. (2006). Protecting Human Research Subjects: The Past Defines the Future. *The Ochsner Journal*, *6*(1), 15–20.

[38] An identifiable biospecimin is one that can be connected as belonging to a particular identifiable donor

[39] Council on Government Relations. February 1, 2017. "Common Rule Overview." Available: https://www.cogr.edu/sites/default/files/Summary%20of%20Changes%20to%20the%20Common%20Rule_COGR.pdf. Accessed: May 18, 2018.

[40] America Competes Act. PL 69. 110th Cong. Aug 9 2007. Available: https://www.congress.gov/110/plaws/publ69/PLAW-110publ69.pdf. Accessed: June 7, 2018.

targets NSF for increased funding and requires institutions funded by NSF to provide training on the responsible conduct of research to students and post-docs.

The American Innovation and Competitiveness Act is legislation with a wide set of directives regarding basic research, STEM education, as well as innovation and technology transfer. Highlights include a section allowing federal science agencies to use crowdsourcing and collaborative citizen science to advance their missions and instructing the NSF to award grants to increase minority participation in STEM fields.[41]

4.3 Political and cultural values and discussions related to STI

U.S. political values have evolved out of Enlightenment thinking, providing a similar basis as that of fundamental European values.[42] The U.S. Constitution, which guides federal policies, and thus S&T policy, points to justice and liberty as particular guiding values, while articulating a more specific set of fundamental rights and freedoms. These include the free exercise of religion, freedom of speech, of the press, of assembly, as well as many other individual rights. These rights are based in an underlying principle of individualism, which is widely cited as a key marker of U.S. political and cultural values. While there is no explicit right to research articulated in the U.S. Constitution, the collection of rights to speech, press and assembly and other rights recognized by courts, as well as a tradition of academic freedom, lend a sense of strong legal protection for scientific research.

The Belmont Report, which continues to define ethical principles and guidelines for human subjects research in the U.S., similarly relies on three basic ethical principles, which it understands as "generally accepted in our cultural tradition"[43]—Respect for Persons, Beneficence, and Justice.

In articulating the analytic framework of "civic epistemology," which she defines as a tool for "understanding how knowledge is culturally constituted as a basis for collective action,"[44] Sheila Jasanoff identifies US political culture as contentious, in contrast to that of Europe, which she labels communitarian. Jasanoff notes that this contentious civic epistemology is characterized by a reliance on a diversity of interested parties in creating knowledge and making truth claims, and a strong reliance on lawsuits, court rulings, transparency, and quantification in stabilizing the credibility of truth claims and their representatives.[45]

U.S. innovation policy and planning documents demonstrate a strong belief in markets as the best mechanisms to guide innovation and the distribution of its benefits. Evidence can be seen in the Bayh Dole Act, which creates incentives for the commercialization of publicly funded research (see previous section for a longer description of the Act). Further, strategy documents for attaining good technological futures such as the 2012 Bioeconomy Blueprint point to the twinned potential for markets and technological innovation to "allow Americans to live longer, healthier lives, reduce our dependence on oil, address key environmental challenges, transform manufacturing processes, and increase the productivity and scope of the agricultural sector while growing new jobs and industries."[46] The blueprint's recommendations focus on education more targeted to industrial needs, funding for research and development, removing "regulatory barriers" to innovation, and

---

[41] American Innovation and Competitiveness Act. S 3084. 114th Cong. Jan 6 2017. Available: https://www.congress.gov/bill/114th-congress/senate-bill/3084. Accessed: June 10, 2018.
[42] Schroeder D., Rerimassie V. (2015) Science and Technology Governance and European Values. In: Ladikas M., Chaturvedi S., Zhao Y., Stemerding D. (eds) Science and Technology Governance and Ethics. Springer, Cham.
[43] U.S. Department of Health, Education, and Welfare. (1979) The Belmont Report. Available: https://www.hhs.gov/ohrp/sites/default/files/the-belmont-report-508c_FINAL.pdf.
[44] Jasanoff, S. (2007). *Designs on nature: science and democracy in Europe and the United States* (5. print., 1. pbk. print). Princeton, NJ: Princeton Univ. Press, 255.
[45] Ibid. 260.
[46] White House. (2012). National Bioeconomy Blueprint. Available: https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/national_bioeconomy_blueprint_april_2012.pdf. Accessed: June 30, 2018.

moving technologies from lab to market. In short, the document sees potential and seeks ways to stimulate markets to reach that potential.

The U.S. has also evolved a political culture that relies on scientific and quantitative evidence to legitimize rules and regulations.[47] The U.S. State Department, for example, works around the world to institute what the agency understands to be "science-based" policies in other nations that align with U.S. policy.[48]

Current trends counter some of the established elements of U.S. political culture discussed above. For instance, recent actions by the Trump administration seek to interfere with market-led changes in energy technologies by intervening to support coal-based energy and other favored technologies, departing from more traditional logics of market-led innovation.[49] Additionally, the administration has actively pared down State Department personnel, reducing resources for global outreach around science-based policy.[50] Another trend away from previously established political culture is President Trump's choice not to appoint a director to the Office of Science Technology Policy, a position that also typically serves as science advisor to the President.

5. Aspects of responsibility in national science policy

5.1 The conceptualizations of responsibility in national science policy

Responsibility in U.S. national science policy is primarily understood in terms of responsible conduct of research. Responsible conduct of research (RCR) can be understood as what the National Academies refer to as the quality and integrity of research. As the National Academy of Medicine defined these terms in 1989, "Quality in this sense refers to the rigor with which experiments are designed and carried out, statistical analyses performed, and results accurately recorded and reported, with credit given where it is due. Integrity in research means that the reported results are honest and accurate and are in keeping with generally accepted research practices."[51]

Concerns around RCR arose around a set of high profile cases of scientific misconduct in the late 1970s and early 1980s, spurring actions by U.S. Congress, efforts within the scientific enterprise, and analysis by the National Academies to assess the prevalence and causes of misconduct and to make recommendations about how to address it. This issue remains one of serious concern in the U.S., with the most recent National Academies report on the topic published in 2017.[52] The concerns that RCR seeks to address—scientific misconduct and the falsification of results – are part of a broader set of issues around scientific reproducibility that join open access and open data with questions of incentives and practices regarding quality of lab specimens, lab practices and research funding, all in the service of producing more reliable and actionable scientific research. These concerns were popularized in part by the publication of Richard Harris's Rigor Mortis: How Sloppy Science Creates Worthless Cures, Crushes Hope and Wastes Billions.[53] Harris diagnoses a number of problems within the scientific enterprise, suggesting that updated standards of lab practice need to be

[47] Porter, T. M. (1996). *Trust in numbers: The pursuit of objectivity in science and public life*. Princeton University Press.
[48] United States Secretary of State. (2007, November 27). FY 2008 BIOTECHNOLOGY OUTREACH STRATEGY AND DEPARTMENT RESOURCES. WikiLeaks Public Library of US Diplomacy. Available: https://wikileaks.org/plusd/cables/07STATE160639_a.htm. Accessed: June 30, 2018.
[49] Kormann, C. (2017). "There's a Dangerous Bubble in the Fossil Fuel Economy, and the Trump Administration is Making it Worse." *The New Yorker*.
[50] Finnegan, C. "Alarmed by cuts and lack of leadership, 200 US diplomats call on Congress to defend diplomacy." *ABC News*. Available: https://abcnews.go.com/Politics/alarmed-cuts-lack-leadership-200-us-diplomats-call/story?id=54094907. Accessed: June 30, 2018.
[51] National Academy of Medicine (1989). *The Responsible Conduct of Research in the Health Sciences.* National Academy Press. Available: https://www.nap.edu/read/1388/chapter/1. Accessed: June 25, 2018.
[52] National Academies of Sciences, Engineering and Medicine (2017). *Fostering Integrity in Research*. National Academy Press. Available: http://nap.edu/21896. Accessed: June 25, 2018.
[53] Harris, R. (2017). Rigor Mortis: *How Sloppy Science Creates Worthless Cures, Crushes Hope, and Wastes Billions.*

disseminated and enforced and that ways of assessing the quality and employability of researchers should be changed drastically. From the perspective of the researchers he interviews, highlighting impact factors and incentivizing the pure volume of publications over-populates the field with hastily completed or manipulated research. The 2017 American Innovation and Competitiveness Act (signed into law by President Obama very near the end of his presidency) shares these concerns, directing NSF to "enter into an agreement with the National Research Council to: (1) assess research and data reproducibility and replicability issues in interdisciplinary research, and (2) make recommendations for improving rigor and transparency in scientific research."[54] These issues are thus a matter of ongoing investigation at the national level.

In this use of the term, the "responsibility" in RCR is clearly much more narrowly construed than that of RRI, but engages some of the same elements, such as research ethics, open science, and transparency. One attempt to broaden attention to RRI-like concerns was the creation of the Center for Engineering Ethics and Society (CEES) within the National Academy of Engineering (NAE) in 2007. Following the recommendation of a committee chaired by Norm Augustine (on which subcontract PI Guston served), NAE chartered CEES to address the social responsibilities of engineering in the context of accelerating social and environmental change. Its major activities have included managing the Online Ethics Center, which provides educational institutions, engineers, scientists, and students with materials to aid in meeting federal requirements for RCR; hosting workshops and other engagement exercizes that bring diverse perspectices to the consideration of social and ethical issues associated with engineering; and producing reports and other materials to support ethics training, deliberation, and education.[55]

The NIH-funded Ethical, Legal and Social Implications (ELSI) program has also been an important element of how responsible research is understood in the U.S. The ELSI program was established in 1990 to provide science-society research alongside and integrated with the Human Genome Project; it was supported by congressional mandate to receive at least 5% of the HGP budget.[56] ELSI is described in an NIH review as "a reflection of a commitment to a more socially responsible way of doing science, which agencies funding work in other biomedical and scientific disciplines have begun to emulate."[57] It is a well-known funding program, and a model that is often cited as one way of producing research that brings social concerns together with cutting edge science.

5.2 The notion of 'RRI' in national science policy discussions

RRI does not exist on any appreciable level in U.S. national science policy discourse. RRI exists as a concept among a relatively limited number of academic social science researchers and the scientists and other related stakeholders that they engage, especially at Arizona State University, but in the national policy space RRI is not currently a term that is used or understood as meaningful beyond its face value.

5.3 Ethics in the national science system

A. Description of the practice and its development and an assessment of how well it currently works:

[54] American Innovation and Competitiveness Act. S 3084. 114th Cong. Jan 6 2017. Available: https://www.congress.gov/bill/114th-congress/senate-bill/3084. Accessed: June 10, 2018.

[55] National Academy of Engineering. "Center for Engineering Ethics and Society (CEES)." https://www.nae.edu/Activities/Projects/CEES.aspx. Accessed: August 19, 2018.

[56] McEwen, J. E., Boyer, J. T., Sun, K. Y., Rothenberg, K. H., Lockhart, N. C., & Guyer, M. S. (2014). The Ethical, Legal, and Social Implications Program of the National Human Genome Research Institute: Reflections on an Ongoing Experiment. *Annual Review of Genomics and Human Genetics*, *15*(1), 481–505.

[57] McEwen, J. E., Boyer, J. T., Sun, K. Y., Rothenberg, K. H., Lockhart, N. C., & Guyer, M. S. (2014). The Ethical, Legal, and Social Implications Program of the National Human Genome Research Institute: Reflections on an Ongoing Experiment. *Annual Review of Genomics and Human Genetics*, *15*(1), 481–505.

The U.S. has a well-established and systemically embedded system of Institutional Review Boards (IRBs) for human and animal subjects research at research institutions that seek federal funding. This system arose out of a series of high-profile revelations of inhumane research and was mandated by law in the National Research Act of 1974. The Tuskegee Syphilis study, one of the most infamous instances of unethical research practice, animated discussion and passage of the 1974 act. The study was conducted over many years by the U.S. Public Health Service and the Tuskegee Institute to observe the effects of syphilis on a group of impoverished, rural black men. The men were told they were receiving treatment for "bad blood," but they were intentionally never treated, even after penicillin became a known treatment for the disease. During the study spouses and children were infected with the disease, and the entire study population was left unaware that they had the disease, and that they were not in fact being treated. The aim of the study was to observe the course of the disease across time and until death.[58] Ultimately, since objections brought up within the Public Health Service did not result in the end of the study, the details of the study were leaked to the press, causing widespread public outrage. The Tuskegee Syphilis study was by no means the only research conducted during the early and mid-20th century that is now understood to be unethical, but it is a key historical element of U.S. research ethics policy and discourse. It serves an appreciable framing function in how ethics is conceptualized and taught in the U.S.

The National Research Act created a commission to establish ethical principles and guidelines for human subjects research, which produced the Belmont Report.[59] The Belmont Report is a key document on which ethical research practice in the U.S. is based. As outlined above, the report established 3 key ethical principles: respect for persons, beneficence and justice. The act also issued Title 45, Part 46 of the Federal Code of Regulations: Protection of Human Subjects. Parts of this set of regulations became known as the Common Rule, when it was codified and standardized across agencies (with the exception of the FDA, which follows a modified version of the rule) in 1991.[60] Since this time the common rule has been updated, most recently in 2017.

The 2017 update of the Common Rule was closely watched for its treatment of human specimens, which has been a contentious issue and the subject of a number of key court decisions over the past several decades, most notably Moore v. Regents of the University of California (1976), which determined that biospecimens removed from patients' bodies are not their personal property, nor are such patients due a share of any profits earned as a result of research and technological development based on those specimens.[61] Interest in the issue of human specimens and medical ethics was broadened greatly with the publication of Rebecca Skloot's 2010 book, The Immortal Life of Henrietta Lacks,[62] which was subsequently turned into an HBO original movie. The 2017 update of the Common Rule creates some significant changes, most interestingly, updating the definition of human subjects (and thus the purview of protections) to explicitly include identifiable biospecimens, but not non-identified biospecimens.[63]

Within this historical context, U.S. research ethics practice at the lab and research level is very legalistic, with a focus on producing ethical research through following the letter of the law, rather than on more deliberative or reflective processes of ethical practice. Additionally, a diversity of funding bodies and the corresponding

---

[58] Centers for Disease Control and Prevention. "The Tuskegee Timeline." Available: https://www.cdc.gov/tuskegee/timeline.htm. Accessed: June 27, 2018.

[59] "Public Law 93-348." *The Federal Register.* Available: https://history.nih.gov/research/downloads/PL93-348.pdf. Accessed May 18, 2018.

[60] Breault, J. L. (2006). Protecting Human Research Subjects: The Past Defines the Future. *The Ochsner Journal*, *6*(1), 15–20.

[61] Moore v. Regents of University of California. Justia US Law (U.S. 1990). Available: https://law.justia.com/cases/california/supreme-court/3d/51/120.html.

[62] Skloot, R., & Turpin, B. (2010). The Immortal Life of Henrietta Lacks.

[63] Council on Government Relations. February 1, 2017. "Common Rule Overview." Available: https://www.cogr.edu/sites/default/files/Summary%20of%20Changes%20to%20the%20Common%20Rule_COGR.pdf. Accessed: May 18, 2018.

variation in how social and ethical issues are treated by funders, contributes to an uneven engagement with research ethics across research programs, institutions, and disciplines. Existing overarching regulation and oversight for research ethics has emerged from high-profile crises, such as the revelation of the Tuskegee syphilis study. Accordingly, periodic crisis continues to drive efforts to restructure and reform the U.S. research system today.

Since the passage of the National Research Act, bioethics committees have played a central role in the national science policy space, advising presidents on ethical issues in the life sciences. President Obama's Presidential Commission for the Study of Bioethics was established by executive order in 2009 and served through 2017. The commission produced a series of reports and accompanying pedagogical materials to support is commitment to bioethics education.[64] Chaired by political theorist Amy Gutman, the commission relied on deliberative democracy as a central tool "to develop recommendations about actions that the federal government should take to maximize the benefit, minimize the risk and identify appropriate ethical boundaries."[65] The commission's report on synthetic biology imagined a framework akin to RRI, calling for "prudent vigilance."[66] According to the commission, this approach calls for "ongoing evaluation of risks along with benefits. The iterative nature of this review . . . recognizes that future developments demand that decisions be revisited and amended as warranted by additional information about risks and potential benefits." [67] Such an approach clearly seeks to integrate the anticipatory and reflexive elements espoused by RRI into proposed best practice for the governance of biological innovation. Additionally, the commission's report on neuroethics highlights the importance of integrating the natural and social sciences in pursuit of socially advantageous outcomes in neuroscience research.[68] As such, bioethics bodies have played a significant role in articulating and advancing RRI values in the US research landscape. Bioethics bodies are appointed at the discretion of each presidential administration, and President Trump has yet to appoint any bioethics advisory body.

Modes of conducting ethical and responsible research are also very much shaped by the ongoing NIH ELSI program (discussed above in section 5.1). ELSI has been emulated by other agencies and in cross-agency programs, including by the Department of Energy for its part in HGP and in NSF for the "responsible development" of nanotechnology within the National Nanotechnology Initiative.[69]

Additionally, U.S. ethical research discourse and policy is currently quite focused around questions related to Responsible Conduct of Research (RCR), especially reproducibility of biomedical research. This concept is introduced in section 5.1. RCR is an issue of concern going back to the late 1980s, which has evolved and remains a central concern for Congress, funding bodies, and scientists today. In 2007, the America Competes Act mandated of the National Science Foundation: "The Director shall require that each institution that applies for financial assistance from the Foundation for science and engineering research or education describe in its grant proposal a plan to provide appropriate training and oversight in the responsible and ethical conduct of research to undergraduate students, graduate students, and postdoctoral researchers participating in the

[64] The Hastings Center (2017). About the Presidential Commission for the Study of Bioethical Issues. Available: https://doi.org/10.1002/hast.726. Accessed: June 27, 2018.

[65] Stein, R. (2010). Q&A with Amy Gutmann of Presidential Commission for Study of Bioethical Issues. The Washington Post. Available: http://www.washingtonpost.com/wp-dyn/content/article/2010/06/08/AR2010060805317.html. Accessed: June 27, 2018.

[66] Presidential Commission for the Study of Bioethical Issues. (2010). *New directions: The ethics of synthetic biology and emerging technologies*. Available: https://bioethicsarchive.georgetown.edu/pcsbi/sites/default/files/PCSBI-Synthetic-Biology-Report-12.16.10_0.pdf. Accessed: August 19, 2018.

[67] For an analysis of this approach see: Wiek, A., Guston, D., Frow, E., & Calvert, J. (2012). Sustainability and anticipatory governance in synthetic biology. *International Journal of Social Ecology and Sustainable Development*, *3*(2), 25-38.

[68] Presidential Commission for the Study of Bioethical Issues. (2014). *Gray matters: Integrative approaches for neuroscience, ethics, and society.* Available: https://bioethicsarchive.georgetown.edu/pcsbi/sites/default/files/GrayMatter_V2_508.pdf. Accessed: August 19, 2018.

[69] Guston, D. H. (2014). Understanding 'anticipatory governance'. *Social studies of science*, *44*(2), 218-242.

proposed research project."[70] This discourse tends to narrow the conception of relevant ethical issues to lab practice and ensuring the validity of published scientific findings, over the broader ethical concerns addressed by ELSI research and bioethics bodies.

B. Main barriers (structural, cultural or related to interchange dynamics)

A current political/social barrier to the continued progress to increased ethical deliberation, debate around research and innovation in the U.S. is the lack of interest in science, and in expert advice in general, on behalf of the current presidential administration.

A structural barrier within the scientific enterprise to expanding ethical practice is the level of professional pressure and time constraints that seems to be increasing over time. The need to publish extensively, win grants, mentor graduate students, etc. leaves little time for ethical reflection.

A further barrier is the market and financial incentives that come from private sector research funding, and can lead to the pursuit of research that may not align with public values and goals. Alongside this is a lack of government oversight and an active push to remove regulations that may serve to correct these trends.

Accordingly, the diversity and pluralism of funders, which many view as a systemic strength, can impede the creation of ethical norms and practices across research programs and disciplines. In this environment, it can take high-profile crises to forge coordinated responses that create norms and standards across funding agencies.

C. Main drivers (structural, cultural or related to interchange dynamics)

The main driver of research ethics in the U.S. is the solid legal foundation, and the historical lessons around bad ethical practice that continue to inform ethics education and procedures. These counter the void produced by the current lack of political engagement in this area.

Popularization of issues in research ethics in texts such as Skloot's book on Henrietta Lacks, and Harris' book on the crisis of reproducibility in science also drive attention to the ethics issues such books highlight, and spur action toward improving structural and cultural factors that influence research outcomes and science policy. These books contribute to the creation of a sense of crisis that has proven effective in driving change in U.S. science ethics governance.

D. Best practices[71]

This research does not give us the resources to credibly analyze the nature of existing practices such that they are identifiable as "best practices." The practices discussed in this report are those that aspire to the goals associated with RRI, and which have the potential to be identified as best practice through further analysis.[72]

Important practices in the U.S., the motivations of which align with the ethics key of RRI, include:

---

[70] America Competes Act. PL 69. 110th Cong. Aug 9 2007. Available: https://www.congress.gov/110/plaws/publ69/PLAW-110publ69.pdf. Accessed: June 7, 2018.

[71] See section 5.3 D for a discussion of the challenges associated with efforts to identify best practices in this research context.

[72] D. H. Guston. 2001. "Toward a 'Best Practice' of Constructing 'Serviceable Truths'." Pp. 97-118 in W. Dunn, M. Hisschemoller, J. R. Ravetz and R. Hoppe, eds., *Knowledge, Power, and Participation in Environmental Policy and Risk Assessment*. New Brunwick, NJ: Transaction Press

1. National legislation that requires ethics-influenced oversight of research practices such as human and animal subjects research and the creation of institutional review boards;
2. The funding by agencies such as NSF, NIH and DOE of ethical, legal and social implications research alongside large research funding agendas such as the Human Genome Initiative and the National Nanotechnology Initiative; and
3. The chartering of national bioethics commissions (with special attention to their role in deliberative democracy).

None of these practices is without fault, and it is easy to unearth a plethora of critiques of these institutions and their modes of ethical reasoning and practice. Whether they are truly best practices is certainly open to debate, as each has its historical basis within the U.S. and particularities that would play out very differently if transferred to another national or cultural setting.

5.4 Societal engagement strategies in research

A. Description of the practice and its development and an assessment of how well it currently works:

Societal Engagement in Research and Innovation is more emerging and less fully institutionalized in the US than many of the other RRI keys. Proposals for societal engagement with science arose in the early 1980s, driven by activist movements around scientific issues.[73] Attempts to institutionalize societal engagement and transparency in the U.S. research system, though, came significantly later than these early scholarly discussions.

Societal engagement falls under the "broader impacts" requirement in National Science Foundation (NSF) grant requirements. These requirements are relatively non-specific in their prescriptions, and in this context engagement is one of several possible ways to make research meaningful rather than a specific requirement for funding. According to the NSF grant proposals and award policies and procedures guide, "The Broader Impacts criterion encompasses the potential to benefit society and contribute to the achievement of specific, desired societal outcomes."[74] Details on what such benefits to society may entail and how broader impacts should be understood include are offered, but remain quite general:

> Broader impacts may be accomplished through the research itself, through the activities that are directly related to specific research projects, or through activities that are supported by, but are complementary to the project. NSF values the advancement of scientific knowledge and activities that contribute to the achievement of societally relevant outcomes. Such outcomes include, but are not limited to: full participation of women, persons with disabilities, and underrepresented minorities in science, technology, engineering, and mathematics (STEM); improved STEM education and educator development at any level; increased public scientific literacy and public engagement with science and technology; improved well-being of individuals in society; development of a diverse, globally competitive STEM workforce; increased partnerships between academia, industry, and others; improved national security; increased economic competitiveness of the US; and enhanced infrastructure for research and education.[75]

This definition suggests a general interest in societal engagement broadly defined, but it neither requires nor specifically encourages researchers to engage in two-way communication with publics.

The Obama administration encouraged a kind of societal engagement through an emphasis on "open innovation," a term that "characterize[s] efforts to access the skills and contributions of citizens and other

[73] Petersen, J. C. (Ed.). (1984). *Citizen participation in science policy*. Univ of Massachusetts Press.
[74] National Science Foundation. "Proposal & Award Policies & Procedures Guide" Available: https://www.nsf.gov/pubs/policydocs/pappguide/nsf15001/aag_6.jsp#VID4. Accessed: May 18, 2018.
[75] Ibid.

external stakeholders."[76] This effort was not primarily focused on changing scientific practices, but rather it was part of a broader effort to make government more transparent. In a 2009 Memorandum for the Heads of Executive Departments and Agencies, Obama outlines the intention to make government participatory and collaborative, among other things. He argues, "Public engagement enhances the Government's effectiveness and improves the quality of its decisions. Knowledge is widely dispersed in society, and public officials benefit from having access to that dispersed knowledge." [77] The focus on technology and innovation as part of governing and integral to rendering government more transparent, as well as the directive to federal science funding agencies to play a key role in the implementation of these efforts, means open government work in the U.S. has created some of the most direct and explicit efforts toward making research and innovation more socially engaged.

The Office of Management and Budget, in response to the 2009 memo discussed above, published a directive to federal agencies instructing them, in open government plans that the memo required every agency to put together, to "explain in detail how your agency will improve participation, including steps your agency will take to revise its current practices to increase opportunities for public participation in and feedback on the agency's core mission activities."[78] Additionally, the memo "directs agencies to describe how they would use innovative feedback mechanisms, technology platforms, and such methods as prize competitions to increase opportunities for public participation and collaboration with those outside the agency and in other levels of government."[79] Since science funding agencies such as NSF and NIH have been required to create plans and take actions on this basis, open government efforts have driven much activity in societal engagement with science.

Some of the content of these memos and directives were also made more concrete in their inclusion in science and technology legislation during Obama's presidency. For example, the America Competes Act of 2011 "provides, among other things, government-wide authority for executive branch agencies to use public prize competitions to advance their missions."[80] Additionally, the 2017 American Innovation and Competitiveness Act declares, "Federal science agencies may use crowdsourcing and voluntary, collaborative citizen science to advance their missions."[81]

Arising from these directives and legislative efforts, an extensive portfolio of prize competitions has been conducted by federal agencies.[82] The General Services Administration (GSA) created a website to host these activities, challenge.gov, which hosts hundreds of challenges the public can compete in, with thousands of

---

[76] United States Government Accountability Office. *Open Innovation: Practices to Engage Citizens and Effectively Implement Federal Initiatives.* October 2016. Available: https://www.gao.gov/assets/690/680425.pdf. Accessed: June 8, 2018.

[77] The White House. "Presidential Documents: Transparency and Open Government." Federal Register 74 (15). January 26, 2009. Available: https://www.gpo.gov/fdsys/pkg/FR-2009-01-26/pdf/E9-1777.pdf. Accessed: June 10, 2018.

[78] Office of Management and Budget. "Open Government Directive." December 8, 2009. Available: https://www.treasury.gov/open/Documents/m10-06.pdf. Accessed: June 10, 2018.

[79] United States Government Accountability Office. *Open Innovation: Practices to Engage Citizens and Effectively Implement Federal Initiatives.* October 2016. Available: https://www.gao.gov/assets/690/680425.pdf. Accessed: June 8, 2018.

[80] United States Government Accountability Office. *Open Innovation: Practices to Engage Citizens and Effectively Implement Federal Initiatives.* October 2016, p 2. Available: https://www.gao.gov/assets/690/680425.pdf. Accessed: June 8, 2018.

[81] American Innovation and Competitiveness Act. S 3084. 114th Cong. Jan 6 2017. Available: https://www.congress.gov/bill/114th-congress/senate-bill/3084. Accessed: June 10, 2018.

[82] United States Government Accountability Office. *Open Innovation: Practices to Engage Citizens and Effectively Implement Federal Initiatives.* October 2016. Available: https://www.gao.gov/assets/690/680425.pdf. Accessed: June 8, 2018.

dollars in prize money offered for tasks ranging from working with face recognition algorithms to innovating to prevent childhood obesity.[83]

In 2015, the Office of Science and Technology Policy Issued a memo to the heads of executive departments and agencies, on citizen science and crowdsourcing. The memo defines citizen science as “the public participates voluntarily in the scientific process, addressing real-world problems in ways that may include formulating research questions, conducting scientific experiments, collecting and analyzing data, interpreting results, making new discoveries, developing technologies and applications, and solving complex problems.”[84] The memo outlines principles for agencies to apply, and directs them to employ a coordinator for citizen science and crowdsourcing, and to catalogue their citizen science and croudsourcing projects on a website, created by GSA. The website created to collect and communicate these projects is Citizenscience.gov. At the time of this writing, the website lists 424 projects across 26 agencies.[85] Much of this engagement is structured around sourcing expertise from the public rather than discovering public values and priorities. In this sense, societal needs, and thus the goals and parameters of projects are already outlined, while citizens are encouraged to provide technical expertise to achieve them. Other formats for engagement, such as open dialogue initiatives, tend to be more focused on collecting information and understand different perspectives, values and priorities.[86] One example of such an effort is NASA’s work with Expert and Citizen Assessment of Science and Technology (ECAST), which is a group of institutions facilitating public engagement around science and technology. The organization helped NASA engage publics and explore views on how to protect the earth from asteroids, in order to prioritise technology investment and future agency missions. “These in-person and online forums, known collectively as the Asteroid Initiative Citizen Forums, took place in November 2014 and February 2015. The forums were used to obtain information on participant preferences, priorities, and values.”[87] This and other such programs seek citizen input on very specific and pre-framed issues of public concern, with input ranging from values and priorities to possible soultions to address more technical questions.

The Department of Health and Human Services (HHS), of which NIH is part, points primarily to its use of cash prize challenges as its open innovation and public engagement strategy.[88] While NSF also highlights its use of prizes and challenges to engage the public with innovation, the agency has been active in funding projects that go further in encouraging public engagement more broadly around values and priorities in research and innovation.

A significant aspect of public engagement with science in the U.S. is accomplished through science museums and science centers. One example is a $40 million award under the National Nanotechnology Initiative for the Nanotechnology Informal Science Education Network, which joined together several hundred museums and

---

[83] Challenge.gov. “Newest Challenges.” Available: https://www.challenge.gov/list/. Accessed: June 10, 2018.

[84] Office of Science and Technology Policy. “Memorandum to the Heads of Executive Departments and Agencies: Addressing Societal and Scientific Challenges through Citizen Science and Crowdsourcing.” September 30, 2015. Available: https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/holdren_citizen_science_memo_092915_0.pdf. Accessed: June 10, 2018.

[85] Federal Crowdsourcing and Citizen Science Catalog. Available: https://ccsinventory.wilsoncenter.org/. Accessed June 11, 2018.

[86] United States Government Accountability Office. *Open Innovation: Practices to Engage Citizens and Effectively Implement Federal Initiatives.* October 2016. P. 11. Available: https://www.gao.gov/assets/690/680425.pdf. Accessed: June 8, 2018.

[87] United States Government Accountability Office. *Open Innovation: Practices to Engage Citizens and Effectively Implement Federal Initiatives.* October 2016. P. 11. Available: https://www.gao.gov/assets/690/680425.pdf. Accessed: June 8, 2018.

[88] United States Departmet of Health and Human Services. *Open Government Plan Version 4.0*. September 2016. Available: https://www.hhs.gov/sites/default/files/hhs-open-gov-plan-v4-2016.pdf. Accessed: June 11, 2018.

science centers to develop, share, and exhibit materials about nanotechnology.[89] While much of this kind of activity does not achieve the aspiration of two-way communication, some of it does – as researchers are sometimes active participants in programs developed by museums for general publics. In the U.S. such informal settings in which the public participants are not confined to the role of students are arguably appropriately conceived of as engagement activities. The Federal funding available for such activities, however, and particularly that through NSF, is invariably labeled "education" or "learning" so as not to trigger potential political scrutiny of the funding of particular museums or exhibitions.

A wide range of other public engagement activities go on in the U.S. research and innovation space, not all of which are funded by government funding bodies. Philanthropies are funding public engagement activities around technological advance as well. One such project, conducted by researchers at Arizona State University and the Expert and Citizen Assessment of Science and Technology (ECAST) network, is funded by the Alfred P. Sloan Foundation. The research engages the public around solar geoengineering, with the goals of "understand whether and how reasoned deliberation among citizens can usefully inform geoengineering research governance," and understanding "how this public input influences the way scientists, funders, and other stakeholders approach geoengineering research."[90]

The national workshop conducted for this research project[91] included a sample of other organizations' work on making space for public engagement in research and innovation. The Union of Concerned Scientists (UCS), for instance, advocates for scientist-community collaborations in an effort to empower communities that tend to be "shut out of important policy discussions in part because they lack access to scientific information or the ability to evaluate and interpret technical findings."[92] The organization encourages scientists to engage in such partnerships, providing materials and best practices for these efforts. The collaborations UCS looks to establish include two-way communication, joint framing of problems and mutual benefit. One case-study the UCS guide cites is exemplary of yet another mode of societal engagement, one that allows problems to be framed outside of the scientific community.

The American Association for the Advancement of Science hosts a program for "On-Call Scientists," which "connects scientists, engineers, and health professionals interested in volunteering their skills and knowledge with human rights organizations that are in need of technical expertise."[93] In this case, human rights organizations frame problems they need solved, and they are able to leverage necessary expertise in order to address their core missions more effectively.

Another perspective on community engagement came from Massachusetts Institute of Technology researcher Kevin Esvelt, who seeks to engage communities early on in biotechnology research that his group conducts. This research group maintains that "community-guided technology development provides sufficient time for thoughtful and broadly inclusive deliberations, informed by ongoing empirical studies, to decide whether or not the technology should be deployed. By disclosing the details of our research projects, we acknowledge that communities may decide against the risk of deployment and agree to abide by community decisions."[94] Both of these organizations pursue public engagement in science and technology, not in response to federal

---

[89] National Informal Stem Education Network. http://www.nisenet.org/. Accessed: August 19, 2018.

[90] Consortium for Science, Policy & Outcomes. "Exploring Democratic Governance of Solar Geoengineering Research." Available: https://cspo.org/research/governance-of-geoengineering-research/. Accessed: June 11, 2018.

[91] Responsible Research and Innovation in Practice. "National Workshop Reports." Available: https://www.rri-practice.eu/knowledge-repository/national-workshop-reports/. Accessed: June 11, 2018.

[92] Union of Concerned Scientists. *Science-Community Partnerships: A Scientist's Guide to Successful Collaboration.* 2016, p. 2. Available: https://www.ucsusa.org/sites/default/files/attach/2016/04/ucs-scientist-community-partnerships-2016.pdf. Accessed: June 8, 2018.

[93] AAAS. "On-Call Scientists." Available: https://oncallscientists.aaas.org/en. Accessed: June 11, 2018.

[94] Sculpting Evolution. "Current Research Involving Gene Drive Systems." Available: http://www.sculptingevolution.org/genedrives/current. Accessed: June 11, 2018.

funding guidelines, but because they view public engagement as producing unique value in research and communities.

This review barely scratches the surface of the multitude of public engagement activities being carried out by science and innovation groups across the United States. The only generalization that can sum up this area is that it is characterized by multiplicity and diversity.

B. Main barriers

While public engagement in research and innovation in the U.S. has been guided by a vision of open innovation from the Federal government, and a multitude of visions exists for value and best practice in public engagement from a diverse array of other organizations, most research conducting organizations simply do not embed public engagement principles in the research practice or use public engagement techniques to inform their research agendas.

One barrier to a robust public engagement practice – as defined by this research project in terms of open, inclusive deliberation, co-creation and knowledge co-production – is a desire in much of scientific culture to maintain autonomy over research agendas. Further, there is a tendency, exemplified by how the U.S. federal government conducts societal engagement, to hold scientists out as the best knowers of what should be debated, and how issues should be framed in advance of any public deliberation.[95]

As things stand, societal engagement is a broad category, with interpretations ranging from the creation of efforts to inform the public about research, to inviting them to solve technical problems, or soliciting input on planned changes in science policy. Correspondingly, the NSF grant review procedures include a broader impact assessment, but it remains vague. NSF does not offer a well–articulated statement of two-way communication with publics, nor does the agency require societal engagement per-se, as there are a multitude of ways to fulfil the broader impacts requirement. As such, societal engagement is open to definition by those conducting it, and remains essentially voluntary and "extra" in research conducting organizations across the U.S.

Another barrier is availability of time and funding to conduct public engagement that is integrated in research projects. Grant applications are infamously long and arduous, and principal investigators exist in an environment in which they are already spread thin and strapped for time. In such a context, there is little incentive to engage in activities that are perceived as a distraction from the main activities of science. A 2015 survey conducted among scientists by the Union of Concerned Scientists found that time constraints were the most significant barrier for "scientists and technical experts to engage more with local community groups or policy makers."[96]

The availability of time and resources extends beyond the scientific enterprise and into the publics that are to be targeted for engagement. In the words of one of the national workshop participants, "One of the assumptions is . . . that there are people out there eager to become engaged. That that's easy to do, when in fact, most of the time, we have a hard time getting our colleagues to pay attention to some of these questions, never mind the world outside. You say, 'Well, everybody should care about this,' but in fact, everybody's pretty busy. They're caring about a whole lot of other things."[97]

---

[95] Hurlbut, J. B. (2010). *Experiments in democracy: The science, politics and ethics of human embryo research in the United States, 1978–2007*. Harvard University.

[96] Union of Concerned Scientists. *Science-Community Partnerships: A Scientist's Guide to Successful Collaboration.* 2016, p. 12. Available: https://www.ucsusa.org/sites/default/files/attach/2016/04/ucs-scientist-community-partnerships-2016.pdf. Accessed: June 8, 2018.
[97] National Workshop. Arizona State University. February 27, 2017.

Finally, another barrier may be the indifference of the current administration to these issues, which may ultimately slow the momentum created by initiative at the highest levels in engaging publics with issues around science and technology in the previous administration. As has been widely noted, President Trump has long eschewed expert advice, only naming a science advisor and appointing a Director to the Office of Science and Technology Policy in August 2018, an unprecendented delay in modern U.S. presidential history.[98]

C. Main drivers

One of the most significant drivers of increased societal engagement with science and technology has been the repeated directives and policy focus of the Obama Administration on public engagement in government and innovation. Although the current administration does not exert influence of this kind, the impacts of Obama's engagement in this area are ongoing, and many of the programs and policies that promoted progress in this area continue to produce results.

Further, since no innovation system is truly "national" in a very globalized scientific environment, the broader growing international interest in public engagement as an integral part of science and technology engages US scientists with these ideals, even in the face of flagging leadership at the executive level.

Another driver of societal engagement is the existence and growth of university research programs that target social engagement with science and technology as a central object of study and key site of intervention. Arizona State University's School for the Future of Innovation is just one example of this kind of program, which is constantly engaged in a host of activities drawing society and scientists into dialogue and engaging publics with issues of direct relevance to social values, well-being and technoscience, from geoengineering to self-driving cars.

D. Best practices [99]

Important practices in the U.S., the motivations of which align with the societal engagement key of RRI, include:

1. Public engagement and research sponsored by research funding and performing agencies on particular research agendas or technologies;
2. Sponsored ELSI and/or broader impacts activities that include societal engagement;
3. Public panels and hearings with stakeholders and publics, convened as open discussions of key areas (e.g., governance) of emerging technologies; and
4. New approaches to open government and open science that include or are supportive of societal engagement.

5.5 Gender equality and diversity strategies in the science system

A. Description of the practice and its development and an assessment of how well it currently works

Current discourse and policies around gender in the U.S. center strongly on workplace harassment and sexual assault. On a cultural level this can be observed by the relevance and visibility of what has been termed "the #metoo movement." News coverage of gender equality has been focused on a series of high profile cases in

[98] Guarino, B. (2018) "Trump desperately needs a science adviser, experts say. He just doubled the record for time without one." The Washington Post. Available: https://www.washingtonpost.com/news/speaking-of-science/wp/2018/07/27/trump-just-doubled-the-record-for-time-without-a-science-and-technology-adviser/?utm_term=.44513416dd41. Accessed: August 3, 2018.

[99] See section 5.3 D for a discussion of the challenges associated with efforts to identify best practices in this research context.

which sexual harassment and sexual violence have been publicly reported and, in some cases, litigated. In many of these cases, high profile men have lost their positions as political leaders, entertainers, news reporters, etc.[100] This cultural movement has received national and global attention, and the kinds of accounts that have driven it have been echoed in scientific spaces as well.[101] Surveys examining the prevalence of sexual harassment in STEM have found rates ranging from 20-50 percent of female students who have been sexually harassed by faculty or staff in their programs.[102]

The issue of sexual harassment and assault in science and education goes back further than the current political moment. Civil rights and gender equality have been guiding political issues in the U.S. for the entire history of the country. Additionally, the struggle for rights and equality for marginalized groups, especially blacks, has a long a fraught history with the struggle for women's rights. The presumed and stated affinity of the goals of groups fighting for gender equality and racial equality have been repeatedly undermined by a series of betrayals on both sides, but the goals of gender equality, racial equality, justice for marginalized groups, and the struggle for LGBTQ rights are broadly understood as aligned and inseparable as part of a progressive agenda in the U.S.

The main framework in the U.S. for handling issues of discrimination is the Civil Rights Act, of which Title IX of the Education Amendments of 1972 is of particular interest for the scientific enterprise, since it targets discrimination on the basis of sex in federally funded education programs, thus greatly impacting a significant proportion of research-conducting organizations in the US.

The Obama Administration's Department of Education issued several "Dear Colleague Letters." These documents provide guidance to educational institutions on a range of issues with direct relevance for gender equality in education and science, including maternity and paternity leave, and modes of addressing sexual assault. Two of the most controversial letters were reversed by the Trump administration soon after he took power. One detailed protections for transgender students, asserting that they must be treated in accordance with their own gender identity, and one detailed requirements for the adjudication of sexual assault claims on campus, which specified a lower threshold of evidence to establish wrongdoing than was widely observed at the time in such cases.

The pay gap between men and women has been an issue of political significance for some time as well in American politics. A widely cited statistic estimates that women make around 80% of what men make in the same positions, doing the same work.[103] A series of laws and executive orders have sought to address issues of pay inequality in different ways over time, including an executive order by President Barack Obama in 2014 titled "Fair Pay and Safe Workplaces." This directive increased transparency and sought to ensure federal contractors were complying with fair pay and civil rights laws before they were awarded further federal contracts. These regulations were preceded by a Government Accountability Office report revealing the

[100] Carrig, David. "Not just Hollywood: Men facing sexual misconduct claims since Harvey Weinstein." *USA Today*. October 31, 2017. Available: https://www.usatoday.com/story/money/business/2017/10/31/harvey-weinstein-sexual-harassment/808277001/. Accessed May 10, 2018.

[101] Neill, Ushma S. "When Scientists Say 'Me Too.'" Scientific American. October 18, 2017. Available: https://blogs.scientificamerican.com/voices/when-scientists-say-me-too/. Accessed: May 10, 2018.

[102] National Academies of Sciences Engineering and Medicine (2018*) Sexual Harassment of Women Climate, Culture, and Consequences in Academic Sciences, Engineering, and Medicine*. National Academies Press. Available: http://nap.edu/24994. Accessed: June 19, 2018.

[103] Economic Policy Institute. "Gender Wage Gap." Available: https://www.epi.org/data/#?subject=wagegap-mf. Accessed: June 11, 2018.

widespread non-compliance of federal contractors with these employee protections.[104] President Trump also revoked this executive order in early 2017.[105]

A significant effort to encourage the participation of women and underrepresented groups in science has been ongoing on the part of funding agencies and other private and non-governmental organizations. The participation of women and minorities in STEM has attracted increasing attention as progress has been slow even in the face of repeated articulations of the value and desire for increased representation of these groups.

NSF, in its guidelines for meeting its broader impacts requirements, encourages researchers to include mechanisms to "Broaden participation of under-represented groups; e.g., by establishing collaborations with students & faculty from institutions & organizations serving women, minorities, & other groups under-represented in STEM."[106] Accordingly, the organization seeks to include a diverse pool of reviewers in order to facilitate an increase of diversity in its funded projects and researchers: "NSF is constantly striving to increase both the size and diversity (gender, disabilities, ethnic, geographic, race, institutional, etc.) of the pool of reviewers to ensure that the merit review process benefits from broad input provided by individuals with a wide range of perspectives."[107] Existing science and technology policies in the U.S. back these efforts and others on the part of funding agencies. For example, the American Innovation and Competitiveness Act instructs NSF to award grants to increase minority participation in STEM fields.[108]

One program NSF administers to this end is the ADVANCE Program, which acknowledges the role of implicit bias and structural factors that affect the success of women in science. "The goals of the ADVANCE program are (1) to develop systemic approaches to increase the representation and advancement of women in academic STEM careers; (2) to develop innovative and sustainable ways to promote gender equity that involve both men and women in the STEM academic workforce; and (3) to contribute to the research knowledge base on gender equity and the intersection of gender and other identities in STEM academic careers."[109] The program funds programs designed to target structural and cultural factors in science technology and engineering organizations that differentially affect women.

Similarly, NIH funds work under a program entitled "Building Infrastructure Leading to Diversity" (BUILD), which is "designed to learn how to attract students from diverse backgrounds into the biomedical research workforce and encourage them to become future contributors to the NIH-funded research enterprise."[110] These grants are specifically designed to research ways of increasing diversity of students pursuing biomedical research.

---

[104] U.S. Government Accountability Office (2010). "Federal Contracting: Assessments and Citations of Federal Labor Law Violations by Selected Federal Contractors." Available: https://www.gao.gov/assets/310/309785.pdf. Accessed: May 31, 2018.

[105] The White House. "Presidential Executive Order on the Revocation of Federal Contracting Executive Orders." Available: https://www.whitehouse.gov/presidential-actions/presidential-executive-order-revocation-federal-contracting-executive-orders/. Accessed: June 20, 2018.

[106] National Science Foundation. Broader Impacts Review Criterion. Available: https://www.nsf.gov/pubs/2007/nsf07046/nsf07046.jsp. Accessed: June 20, 2018.

[107] National Science Foundation. *Open Government Plan 4.0*. September 2016, p. 13. Available: https://www.nsf.gov/pubs/2016/nsf16131/nsf16131.pdf. Accessed: June 10, 2018.

[108] American Innovation and Competitiveness Act. S 3084. 114th Cong. Jan 6 2017. Available: https://www.congress.gov/bill/114th-congress/senate-bill/3084. Accessed: June 10, 2018.

[109] National Science Foundation. ADVANCE: Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers." Available: https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5383. Accessed: May 30, 2018.

[110] "Building Infrastructure Leading to Diversity" Diversity Program Consortium. Available: https://diversityprogramconsortium.org/pages/build. Accessed: June 25, 2018.

Beyond the public research conducting and funding enterprise, private science and technology organizations such as Intel, for example, are also making efforts to create a more diverse and inclusive corporate workforce. Intel's website notes,

> Diversity and inclusion are among the most important forces driving the company's evolution and reinvention. In 2015, Intel committed $300M to support a goal of reaching full workforce representation of women and underrepresented minorities in our U.S. workforce by 2020. Our focus is to invest in education pathways programs, university partnerships, diverse entrepreneurs, anti-online harassment initiatives, and spending with diverse suppliers.[111]

While diversity has been a stated goal of government and private entities for over a decade, achieving these goals has not been as easy as changing recruitment and public relations policies. A report by an interagency policy group acknowledges the elusive nature of achieving diversity in STEM, identifying bias as a systemic barrier that must be addressed to make progress in this area.[112]

A recent report by the National Academies of Sciences, Engineering and Medicine reaffirms the elusive nature of progress in this area, identifying sexual harassment as a key inhibitor of increased participation of women in science, medicine and engineering. The report notes, "While policies against sexual harassment are widely in place and have been for many years, nonetheless, sexual harassment continues to exist and has not significantly decreased. While adherence to legal requirements is necessary, it is not sufficient to drive the change needed to address sexual harassment."[113] The report notes that the mode of addressing sexual harassment at many institutions is implementing a purely legalistic approach, focusing resources on attempting to avoid legal culpability rather than on genuine culture change, for example, providing an environment in which sexual harassment is not tolerated.

Racial inequality and bias in science are also enduring issues in the U.S. The history of slavery of African Americans and genocide of Native Americans in the U.S. continues to permeate U.S. society, visible in the documented racial disparities in treatment and wellbeing from employment and remuneration[114] to health outcomes[115] and police brutality toward particular minority groups.[116] These have recently become renewed political, social and scientific issues in the U.S. Despite efforts to promote diversity in STEM education and the STEM workforce, the participation of these groups in research and innovation remains disproportionately low. According to the National Academies of Sciences, Engineering and Medicine,

> In 2007, underrepresented minorities comprised 38.8 percent of K-12 public enrollment, 33.2 percent of the U.S college age population, 26.2 percent of undergraduate enrollment, and 17.7 percent of those

---

[111] Intel. "Diversity and Inclusion Policy." Available: https://www.intel.com/content/www/us/en/policy/policy-diversity-inclusion.html. Accessed: June 20, 2018.

[112] Interagency Policy Group on Increasing Diversity in the STEM Workforce by Reducing the Impact of Bias (2016). *Reducing the Impact of Bias in the STEM Workforce: Strengthening Excellence and Innovation*. Available: https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/ostp-opm_bias_mitigation_report_20161129_final.pdf. Accessed: June 20, 2018.

[113] National Academies of Sciences Engineering and Medicine (2018*) Sexual Harassment of Women Climate, Culture, and Consequences in Academic Sciences, Engineering, and Medicine*. National Academies Press. Available: http://nap.edu/24994. Accessed: June 19, 2018.

[114] Economic Policy Institute. "Black-White Wage gap." Available: https://www.epi.org/data/#?subject=wagegap-bw. Accessed: June 25, 2018.

[115] Villarosa, Linda (2018). "Why America's Black Mothers and Babies Are in a Life-or-Death Crisis." *The New York Times Magazine*. Available: https://www.nytimes.com/2018/04/11/magazine/black-mothers-babies-death-maternal-mortality.html. Accessed: June 25, 2018.

[116] Nodjimbadem, Katie (2017). "The Long Painful History of Police Brutality in the U.S." Available: https://www.smithsonianmag.com/smithsonian-institution/long-painful-history-police-brutality-in-the-us-180964098/. Accessed: June 25, 2018.

earning science and engineering bachelor's degrees. In graduate school, underrepresented minorities comprise 17.7 percent of overall enrollment but are awarded just 14.6 percent of S&E master's degrees and a miniscule 5.4 percent of S&E doctorates.[117]

Further, NIH-supported research shows that bias against women and underrepresented minorities is exhibited across the scientific enterprise. For instance, one study demonstrated that "Black applicants are less likely to receive independent research grants compared to white applicants."[118]

Issues of race and gender are deeply intertwined and have significant crossover and mutually reinforcing effects. As such, scholarship investigating these issues largely positions gender and diversity issues in terms of intersectionality, an approach adopted by NSF in its discussion of the ADVANCE funding opportunities: "All ADVANCE proposals are expected to recognize that gender does not exist in isolation from other characteristics, such as race/ethnicity, disability status, sexual orientation, foreign-born and foreign-trained status, faculty appointment type, etc., and should offer strategies to promote gender equity for all faculty."[119] As such, it is problematic to address only gender or only race in efforts to create a more inclusive scientific enterprise, and the history of particular groups and the broader social context in which scientific research exists must be considered in assertions of what diversity means in a particular context.

While progress in this area remains slow, research on how to promote diversity, an increasing acknowledgement of the intertwined issues of sexism and racism in U.S. society, and a willingness to address such issues seriously, suggests that change is actually occurring. There is a wide recognition of the lack of diversity in science, and a growing articulation and dissemination of research that argues that groups are more productive when they are diverse, and that "science benefits from diversity."[120] The interagency working group report on the influence of bias on the STEM workforce notes, "the lack of human diversity in many S&T fields will likely constrain America's role as a preeminent leader in the global economy."[121] At the same time, U.S. political culture is seeing significant backlash toward efforts to make U.S. institutions and culture more inclusive. This backlash is featured most prominently in the campaign rhetoric of President Trump, and in his

---

[117] National Academies of Sciences Engineering and Medicine (2011) Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads. Available: http://nap.edu/12984. Accessed: June 11, 2018.

[118] Interagency Policy Group on Increasing Diversity in the STEM Workforce by Reducing the Impact of Bias (2016). *Reducing the Impact of Bias in the STEM Workforce: Strengthening Excellence and Innovation*, p. 35. Available: https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/ostp-opm_bias_mitigation_report_20161129_final.pdf. Accessed: June 20, 2018.

[119] National Science Foundation. ADVANCE: Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers." Available: https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5383. Accessed: May 30, 2018.

[120] Science Benefits from Diversity (2018). *Nature*. Available: https://www.nature.com/articles/d41586-018-05326-3/. Accessed: June 25, 2018.

[121] Interagency Policy Group on Increasing Diversity in the STEM Workforce by Reducing the Impact of Bias (2016). *Reducing the Impact of Bias in the STEM Workforce: Strengthening Excellence and Innovation*. Available: https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/ostp-opm_bias_mitigation_report_20161129_final.pdf. Accessed: June 20, 2018.

successive actions to reverse protections of women and minority groups,[122] to discredit and halt protests of police violence against African Americans,[123] and to normalize white supremacist violence.[124]

One approach to address the lack of diversity in scientific research is that of Arizona State University's Mathematical and Theoretical Biology Institute (MTBI). MTBI is a summer research opportunity directed toward preparing underreprented minorities at the undergraduate level for graduate level biology and math research. The program is unique in that it encourages students to formulate their own research questions, providing instruction on methods and techniques, allowing them to address their own research interests in an intensive 8-week program.[125] For this work, founding director Carlow Castill Chavez has received multiple awards and recognitions, including a Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring.[126]

Another instance of an initiative directed toward increasing diversity in science, this time at the level of research programs, is Arizona State University's Southwest Borderlands Initiative. The Initiative appoints faculty with research focusing on the US-Mexico border, with the explicit goals of improving the university's instructional capacities regarding its local surroundings, as well as recruiting and retaining a diverse faculty whose diversity reflects that of the community served by the university.[127] The program models an approach in which research agendas can simultaneously be designed to promote diversity and address local concerns, without falling back on quotas and other modes of diversity promotion that have become legally problematic in the U.S. context.

B. Main barriers (structural, cultural or related to interchange dynamics)

Despite progress in this area, many cultural barriers to gender equality and diversity in research and innovation exist in the U.S. One key barrier, discussed at more length above, is the backlash against cultural and legal efforts toward increasing diversity and inclusion. This resistance has had concrete effects of reversing laws and rules that support increased diversity in science.

Another cultural factor that remains a significant barrier to progress is unconscious bias. Recognition of this impediment to progress, though, is thought to be a first step toward reducing its effects. The interagency policy group notes, "Evidence shows that it is very difficult to change implicit or unconscious biases, but it is possible to change behaviors that are shaped by biases." The report notes that people tend to want to be fair, and if made aware of their biases, they can work to counteract them. "Over the last decade, nationwide efforts

---

[122] E.g. The White House. "Presidential Executive Order on the Revocation of Federal Contracting Executive Orders." Available: https://www.whitehouse.gov/presidential-actions/presidential-executive-order-revocation-federal-contracting-executive-orders/. Accessed: June 20, 2018; U.S. Department of Education Office for Civil Rights. "Dear Colleague Letter on Transgender Students." May 13, 2016. Available: https://www2.ed.gov/about/offices/list/ocr/letters/colleague-201605-title-ix-transgender.pdf. Accessed: June 4, 2017.

[123] Edelman, Adam (2018). "Trump says NFL players who kneel during the national anthem 'maybe shouldn't be in the country.'" *NBC News*. Available: https://www.nbcnews.com/politics/donald-trump/trump-says-nfl-players-who-kneel-during-national-anthem-maybe-n876996. Accessed: June 25, 2018.

[124] "Full Text: Trump's comments on white supremacists, 'alt-left' in Charlottesville." *Politico*. Available: https://www.politico.com/story/2017/08/15/full-text-trump-comments-white-supremacists-alt-left-transcript-241662. Accessed: June 25, 2018.

[125] Mathematical and Theoretical Biology Institute. www.mtbi.asu.edu. Accessed: August 19, 2018.

[126] Arizona State University School of Life Sciences. "Carlos Castilo-Chavez." www.sols.asu.edu/carlos-castillo-chavez. Accessed: August 19, 2018.

[127] Arizona State University Office of the University Provost. "Southwest Borderlands Initiative." https://provost.asu.edu/initiatives/southwest-borderlands. Accessed: August 19, 2018.

to enhance diversity have been predicated on the hypothesis that implicit biases are ubiquitous and unlikely to change, but training and awareness can and has reduced the impact of these biases."[128]

The National Academies identify additional structural and cultural elements of the research and innovation system that impede progress on sexual harassment, and thus are barriers to gender equality and diversity:

> Four aspects of the science, engineering, and medicine academic workplace tend to silence targets of harassment as well as limit career opportunities for both targets and bystanders: (1) the dependence on advisors and mentors for career advancement; (2) the system of meritocracy that does not account for the declines in productivity and morale as a result of sexual harassment; (3) the "macho" culture in some fields; and (4) the informal communications network, through which rumors and accusations are spread within and across specialized programs and fields.[129]

Another significant barrier is U.S. legal structure and precedents, which make it very difficult for institutions to explicitly seek to hire researchers from underrepresented groups. Affirmative action policies have been widely challenged across the U.S., and struck down in many cases. Thus, seeking to hire someone of a particular identity could get a research organization in legal trouble. One such recent case was brought against Harvard for its affirmative action strategies, which the suit claims limit the number of Asian-Americans admitted each year. The case is just one in a series of challenges to affirmative action policies in college admissions. Such legal challenges seek to eliminate race as a consideration in higher education admissions policies, and even though many have been unsuccessful, serve to discourage institutions from implementing or expanding explicit affirmative action admissions policies. Arizona State University representatives, for example, are quick to point out that the university does not use quotas in admissions or hiring decisions, as such a practice is illegal. This context puts U.S. institutions looking to diversify faculty and student populations in a delicate position, as laws surrounding such practices are under active contention, with unclear delineation between legal and illegal affirmative action practices.

C. Main drivers (structural, cultural or related to interchange dynamics)

The national movement to speak out against sexual harassment is driving reckoning with how women are treated in U.S. research and innovation spaces. Universities and the private sector have seen the effects of this movement, energizing efforts to change culture and enforce protections for women.

While listed as a barrier to certain goals around diversity and gender equality, a significant structural driver to increased equality is also the existing infrastructure of laws, rules and funding mechanisms that promote progress in this area. For instance, NSF guidelines reward grant proposals that "Broaden participation of under-represented groups, for example, by establishing collaborations with students and faculty from institutions and organizations serving women, minorities, and other groups under-represented in the mathematical sciences."[130] Despite the efforts of the Trump administration to rescind Obama-era policies, especially those protecting women and minorities, the long history and rich and complex collection of laws and initiatives in this area provides a certain level of durability and institutional inertia of which it is difficult to quickly reverse the course.

---

[128] Interagency Policy Group on Increasing Diversity in the STEM Workforce by Reducing the Impact of Bias (2016). *Reducing the Impact of Bias in the STEM Workforce: Strengthening Excellence and Innovation*. Available: https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/ostp-opm_bias_mitigation_report_20161129_final.pdf. Accessed: June 20, 2018.

[129] National Academies of Sciences Engineering and Medicine (2018*) Sexual Harassment of Women Climate, Culture, and Consequences in Academic Sciences, Engineering, and Medicine*. National Academies Press, p. 3. Available: http://nap.edu/24994. Accessed: June 19, 2018.

[130] National Science Foundation. "Broader Impacts Review Criterion." Available: https://www.nsf.gov/pubs/2007/nsf07046/nsf07046.jsp Accessed: May 17, 2018.

D. Best practices[131]

Important practices in the U.S., the motivations of which align with the gender equality and diversity key of RRI, include:

1. Federal legislation promoting non-discrimination in all aspects of Federal involvement with other public institutions and other institutions receiving Federal funds, including educational and research institutions;
2. Focusing on the transformation of culture in research and educational institutions, emphasizing transparency and accountability, creating more diffuse systems of hierarchy and power, supporting research directly addressing sexual harassment, and broadening the culpability for harassment and culture to the entire academic community (among others);
3. Approaching issues of race, gender and other identity factors as deeply enmeshed and mutually reinforcing issues (the lens of intersectionality); and
4. Reconceptualizing hiring practices, research problem framing, and standards (e.g., "excellence") with an eye toward attracting a more diverse pool of applicants from which to choose.

5.6 Open access and open science strategies in the national science system

A. Description of the practice and its development and an assessment of how well it currently works

Open Access practices and policies in the U.S. national science system were formalized and energized by a 2013 directive from the U.S. Office of Science and Technology Policy (OSTP) requiring "each Federal agency with over $100 million in annual conduct of research and development expenditures to develop a plan to support increased public access to the results of research funded by the Federal Government."[132]

This policy led the federal funding organizations that have a broad impact on practices at U.S. research conducting organizations such as the National Science Foundation (NSF), the National Institutes of Health (NIH), Department of Defense (DOD), Department of Energy (DOE), and others[133] to implement public access and data sharing requirements for grantees and establish open access repositories. The policy was enacted under former President Obama, and the language was removed from the White House website as part of the transition to the Trump Administration, which has made an effort to roll back many of the previous administration's policies. Nevertheless, as things stand the funding agencies have maintained their open access requirements and repositories, leaving the system established by the 2013 directive effectively in place.

While all of these funding agencies have different public access policies, they have broad similarities. For example, the NSF's policy

> requires that either the version of record or the final accepted manuscript in peer-reviewed scholarly journals and papers in juried conference proceedings or transactions (also known as "juried conference papers") be deposited in a public access compliant repository designated by NSF; be available for download, reading and analysis free of charge no later than 12 months after initial publication; possess

[131] See section 5.3 D for a discussion of the challenges associated with efforts to identify best practices in this research context.
[132] Holdren, John P. "Memorandum for the Heads of Executive Departments and Agencies." Office of Science and Technology Policy. Available: https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/ostp_public_access_memo_2013.pdf. Accessed: May 18, 2018.
[133] Full list of agencies with public access plans available here: https://cendi.gov/projects/Public_Access_Plans_US_Fed_Agencies.html.

> a minimum set of machine-readable metadata elements in a metadata record to be made available free of charge upon initial publication; be managed to ensure long-term preservation; and be reported in annual and final reports during the period of the award with a persistent identifier that provides links to the full text of the publication as well as other metadata elements.[134]

The NIH has a similar policy, stemming not from the 2013 directive, but from a 2008 congressional appropriations bill, which mandated the NIH require research funded by the organization to be made available on the PubMed repository no later than 12 months after the original publication date.[135] According to NIH, use of PubMed is increasing rapidly, indicating that the open access policy has been successful in making the results of federally funded scientific research available. According to the NIH, "On a typical weekday, more than 1 million unduplicated users retrieve over 1.65 million articles. The number of articles retrieved has doubled in the past three years, from 17 million retrievals per month in 2009 to 35 million in 2012."[136]

The Gates Foundation[137] and other non-governmental organizations have followed suit, instituting comparable or more stringent public access policies for the research they fund.

The implementation of public access policies by prominent funding agencies has also spurred an increase by higher education institutions in publishing their own open access policies. Massachusetts Institute of Technology (MIT) was an early adopter, having approved a university-wide open access policy in 2009, but OA policies are now widespread across U.S. institutions of higher education.

Beyond open access to scientific publications, corollary questions and procedures around open data are part of public access plans and ongoing site of concern and disagreement within U.S. scientific and political spaces. While creating open access to scientific publications has been a relatively straightforward and in many ways successful, creating mechanisms and justification for open access to data raises more ethical questions, and can be rather more complex, not only in logistics but also in science policy and regulatory spaces.

Upon taking office in 2009, President Obama issued a memo to heads of federal agencies outlining a set of values that the agencies would need to take immediate action to implement and plan around. The memo focused on making the government transparent, participatory and collaborative. While the focus here is on open government, the directive and subsequent government actions in this area gave impetus to releasing government data and creating rules and infrastructure for making scientific data more accessible as well.

In response to this directive, the Office of Management and Budget issued the Open Government Directive, which outlined concrete actions agencies should take "to implement the principles of transparency, participation, and collaboration set forth in the President's Memorandum." Among various actions directed toward making government business more accountable, the directive instructs, "Within 45 days, each agency shall identify and publish online in an open format at least three high-value data sets (see attachment section 3.a.i) and register those data sets via Data.gov. These must be data sets not previously available online or in a downloadable format."[138]

---

[134] National Science Foundation. Public Access: Frequently Asked Questions." Available: https://www.nsf.gov/pubs/2016/nsf16009/nsf16009.jsp#q22. Accessed: June 5, 2018.

[135] Consolidated Appropriation Act, 2008, PL 161, 110th Cong. (2008). Available: https://www.gpo.gov/fdsys/pkg/PLAW-110publ161/html/PLAW-110publ161.htm. Accessed: June 5, 2018.

[136] National Institutes of Health. "Plan for Increasing Access to Scientific Publications and Digital Scientific Data from NIH Funded Scientific Research." February 2015. Available: https://grants.nih.gov/grants/NIH-Public-Access-Plan.pdf. Accessed: June 5, 2018.

[137] Bill & Melinda Gates Foundation. "Bill and Melinda Gates Foundation Open Access Policy." Available: https://www.gatesfoundation.org/how-we-work/general-information/open-access-policy. Accessed: June 6, 2018.

[138] Office of Management and Budget. "Open Government Directive." December 8, 2009. Available: https://www.treasury.gov/open/Documents/m10-06.pdf. Accessed: June 10, 2018.

Both NIH and NSF address open data as part of their 2015 public access plans, and the agencies have had data sharing requirements for over 25 years. The 2013 directive has brought renewed energy and focus to data sharing discussions in the U.S., and a shift of focus of such policies from the norm of requiring researchers to provide data to colleagues when it is requested, toward a more proactive system of data management planning and required repository use.

For example, the Interagency Working group on Digital Data published its report in 2009 titled Harnessing the Power of Digital Data for Science and Society, in which it emphasized the importance of preservation of digital scientific data in the name of national and global interests. The report envisions "a digital scientific data universe in which data creation, collection, documentation, analysis, preservation, and dissemination can be appropriately, reliably, and readily managed."[139] This vision is premised on the idea that having data readily available allows their use beyond that imagined by the original producers of the data. "The power of a data set can be amplified by ingenuity through applications unimagined by the authors and distant from the original field. Re-use and re-purposing of digital scientific data have dramatic benefits."[140]

The 2013 Office of Science and Technology Policy Memo on Public Access also included key directives on data sharing, outlining a requirement to maximize public data access while protecting privacy, recognizing Intellectual Property interests and balancing the goal of preservation with cost and administrative burden.[141]

NIH Public Access Plan includes data sharing provisions, stating that "To the extent feasible and consistent with applicable law and policy; agency mission; resource constraints; U.S. national, homeland, and economic security digitally formatted scientific data resulting from unclassified research supported wholly or in part by Federal funding should be stored and publicly accessible to search, retrieve, and analyze."[142] The plan goes on to emphasize that the policy protects the integrity of science, that privacy protections should not be undermined by data sharing, IP will continue to be protected, costs should be considered and not all data need to be shared, and data management should be an integral part of the research planning process.

Like NIH, NSF requires researchers to submit data management plans as part of grant proposals: "Investigators are expected to share with other researchers, at no more than incremental cost and within a reasonable time, the primary data, samples, physical collections and other supporting materials created or gathered in the course of work under NSF grants. Grantees are expected to encourage and facilitate such sharing." Further, these guidelines require researchers to balance their interest in creating intellectual property with their responsibility to share the products of their research as widely as possible: "NSF normally allows grantees to retain principal legal rights to intellectual property developed under NSF grants to provide incentives for development and dissemination of inventions, software and publications that can enhance their usefulness, accessibility and upkeep. Such incentives do not, however, reduce the responsibility that investigators and organizations have as members of the scientific and engineering community, to make results, data and collections available to other researchers."[143]

---

139 Interagency Working Group on Digital Data. "Harnessing the Power of Digital Data for Science and Society." January 2009, p. 1. Available: https://www.nitrd.gov/pubs/Report_on_Digital_Data_2009.pdf. Accessed: June 7, 2018.
140 Ibid, p. 4.
141 Executive Office of the President Office of Science and Technology Policy. "Memorandum for the Heads of Executive Departments and Agencies." February 22, 2013. Available: https://www.eff.org/sites/default/files/ostp-public-access-memo.pdf. Accessed: June 7, 2018.
142 National Institutes of Health. "National Institutes of Health Plan for Increasing Access to Scientific Publications and Digital Scientific Data from NIH Funded Scientific Research." February 2015. p23. Available: https://grants.nih.gov/grants/NIH-Public-Access-Plan.pdf. Accessed: June 7, 2018.
143 National Science Foundation. "Proposal Preparation Instructions. Chapter VI" Available: https://www.nsf.gov/pubs/policydocs/pappguide/nsf15001/aag_6.jsp#VID4. Accessed: May 18, 2018.

While these requirements encourage sharing, archiving and the creation of data management plans, relevant data sharing infrastructure and concrete rules for what data must be shared, in what formats, and where it should be deposited is still lacking, falling well short of reaching the 2009 interagency working group's vision of "a comprehensive framework of transparent, evolvable, extensible policies and management and organizational structures that provide reliable, effective access to the full spectrum of public digital scientific data."[144] Guidelines rest heavily on the content of data sharing plans and the judgment of researchers, allowing for "exceptions for proprietary or otherwise restricted data, including but not limited to personally identifiable information, business confidential information, security, among other concerns."[145]

While the lack of clear rules and streamlined archiving infrastructure for data and sample sharing in most fields leave these data sharing programs with plenty of room for growth, the exceptions, which are broad in their current form, are important in that a significant amount of scientific data is restricted from release by ethical principles overseen by Institutional Review Board guidance that protects research subjects. Further, the potential for scientific data to be deanonymized and/or weaponized against those who have provided it in good faith is no small issue. This challenge has been recently made abundantly clear in controversies over the role of Cambridge Analytica in democratic elections, and ongoing concerns about how Facebook has acted as a collector and steward of consumer data. The ways that data can be used by any number of private or government actors that are deemed inappropriate abound, and potential misuse must be taken into account in efforts to create more transparent research practices and to make data more easily available for public interest and reuse.

Despite widespread fears after the 2016 presidential election that the Trump Administration would remove government data sets that are publicly available, that has largely not been the case. What the administration has done, though, is take down a series of informative websites, and appreciably revise others, largely to erase information about, and any mention of, climate change.[146] The Trump administration has also been actively using open data and open science concepts and language to promote policies that seem to be at odds with the aims and values held by the open access community, playing on some of the vulnerabilities that the principle that science is superior and verifiable only if the data on which it is based is publicly available for inspection and review. Executive orders that are part of President Trump's "deregulation" agenda[147] have targeted regulatory science as a prime site for enforcing scientific transparency and for eliminating regulations that are based on science for which data is not publicly available.[148] [149]

EPA proposed a new rule on 30 April 2018, titled Strengthening Transparency in Regulatory Science," and opening a public comment period ending on 30 May 2018 (what many have pointed to as an irregularly brief

---

[144] Interagency Working Group on Digital Data. "Harnessing the Power of Digital Data for Science and Society." January 2009, p. 2. Available: https://www.nitrd.gov/pubs/Report_on_Digital_Data_2009.pdf. Accessed: June 7, 2018.

[145] National Science Foundation. "NSF's Public Access Plan: Today's Data, Tomorrow's Discoveries: Increasing Access to the Results of Research Funded by the National Science Foundation." March 18, 2015. Available: https://www.nsf.gov/pubs/2015/nsf15052/nsf15052.pdf. Accessed: June 7, 2018.

[146] Sunlight Foundation (2018). "In its first year, the Trump Administration has reduced public information online." Available: https://sunlightfoundation.com/2018/01/04/in-its-first-year-the-trump-administration-has-reduced-public-information-online/. Accessed: June 27, 2018.

[147] White House. "President Donald J. Trump is Delivering on Deregulation." December 14, 2017. Available: https://www.whitehouse.gov/briefings-statements/president-donald-j-trump-delivering-deregulation/. Accessed: June 8, 2018.

[148] Executive Office of the President. March 28, 2017. "Promoting Energy Independence and Economic Growth: Executive order 13783." *The Federal Register*. Available: https://www.federalregister.gov/documents/2017/03/31/2017-06576/promoting-energy-independence-and-economic-growth. Accessed: May 18, 2018.

[149] Executive Office of the President. March 1, 2017. "Enforcing the Regulatory Reform Agenda: Executive order 13777." *The Federal Register*. Available: https://www.federalregister.gov/documents/2017/03/01/2017-04107/enforcing-the-regulatory-reform-agenda. Accessed: May 18, 2018.

comment period for such a significant change in policy). The rule, if adopted, would require that the data from scientific studies that are "pivotal" to EPA regulations be "publicly available in a manner sufficient for independent validation."[150] While this policy relies on the general, ostensible premise of "open science," it is controversial and tends to be opposed by those who do or might otherwise embrace open science principles, for example, the Sierra Club, which has launched a campaign against the proposed rule, and provides a submission form with stock language to facilitate the submission of public comments in opposition.[151] Arguments against the rule cite studies that rely on confidential data such as patient health records, which would be inadmissible under such a rule, a perspective reflected by many of the public comments on the rule.[152] Further, the use of the term "pivotal" introduces questions of which scientific studies will be deemed pivotal and thus held to the standard of transparency, while others, likely those based on industries' proprietary science, will be given a pass as far as open data requirements.[153] Additionally, the rule opens to contest an array of existing regulations based on studies for which data may not be available. This use may serve as a key example in which the principles of open science can be subverted to achieve negative outcomes.

There is currently no clear indication of how the current administration will interact with open science policies and practices beyond those discussed above. A bill entitled Fair Access to Science and Technology Research Act (FASTR) has been repeatedly introduced (in 2013, 2015 and 2017), which would reinforce as congressional law the Obama Administration's 2013 Executive Order requiring funding agencies with budgets over $100 million to enforce particular standards of access for the research they fund.[154] The bill also addresses embargo times on publicly funded research publications and data, as well as data reuse terms. The Trump administration has not expressed support or disdain for the law, although the Office of Management and Budget hosted a round table on open data as a driver of economic growth in July 2017.[155]

While the Obama administration had a relatively active agenda on open access and open data, the engagement of the current administration with these efforts is ambiguous. That said, the lack of leadership at the executive level has not perceptibly slowed efforts toward making science more transparent and available at other political and scientific sites within the US. Open access and open data projects continue to proliferate at institutional, national and global scale.

Open science initiatives are being undertaken independently, on premises beyond regulatory compliance. Kevin Esvelt, Director of MIT's Sculpting Evolution group, argues that the current model of secretive science hinders scientific progress and makes the lives of researchers more difficult.[156] Esvelt argues, "Opening science from the earliest stages will enhance safety and reliability by encouraging collective scrutiny of safeguards and research plans. It will accelerate scientific progress by enabling coordination among researchers. And it can

---

[150] Environmental Protection Agency. April 30, 2018. "Strengthening Transparency in Regulatory Science." *The Federal Register*. Available: https://www.federalregister.gov/documents/2018/04/30/2018-09078/strengthening-transparency-in-regulatory-science.

[151] Add Up. "Stop Scott Pruitt from Censoring Science!" Available: https://www.addup.org/campaigns/stop-scott-pruitt-from-polluting-science. Accessed: May 18, 2018.

[152] Regulations.gov. Public comments for proposed rule "Strengthening Transparency in Regulatory Science." Docket ID: EPA-HQ-OA-2018-0259. Available: https://www.regulations.gov/docketBrowser?rpp=50&so=DESC&sb=postedDate&po=0&dct=PS&D=EPA-HQ-OA-2018-0259. Accessed: May 18, 2018.

[153] Bergeson & Campbell PC. "Regulatory Developments: EPA Releases Strengthening Transparency in Regulatory Science Proposed Rule." April 30, 2018. Available: http://www.lawbc.com/regulatory-developments/entry/epa-releases-strengthening-transparency-in-regulatory-science-proposed-rule. Accessed: June 8, 2018.

[154] SPARC. "FAQ for the Fair Access to Science and Technology Research Act (FASTR)." Available: https://sparcopen.org/our-work/fastr/faq/. Accessed: June 8, 2018.

[155] Data.gov. "Roundtable on Open Data for Economic Growth." July 11, 2017. Available: https://www.data.gov/meta/roundtable-open-data-economic-growth. Accessed: June 8, 2018.

[156] Sculpting Evolution. "Why Open Science?" Available: http://www.sculptingevolution.org/blog/whyopenscience. Accessed: June 8, 2018.

improve public confidence and the likelihood of balanced assessment by actively inviting and addressing concerns early in development." Esvelt's team follows through on this ideal by openly posting its research proposals online, before the work gets done.[157] Such efforts to open the research process are in dialogue with broader trends in the US toward interdisciplinarity, where innovation in scientific practice is visible and supported by a growing number of stakeholders with an interest creating a more sophisticated and functional research environment. Esvelt's group hopes to set a precedent for a more open and engaged way of conducting research.

Bio-Bricks, a U.S. non-profit, work on another, less commonly-addressed aspects of open science, creating mechanisms for increased access to material inputs for science. The organization is part of a group working on alternative material transfer agreements that offer more flexibility in terms of access, attribution, reuse, redistribution and non-discrimination.[158]

Other initiatives, such as the Joint Roadmap for Open Science Tools (JROST) bring together a diverse group of interested organizations in an effort to "bring together technology organizations and researchers who are actively involved in the design and production of open scholarly infrastructure. Our objectives will be to explore shared goals and outcomes, develop cross-platform user stories, and identify obvious areas of mutual collaboration."[159] These represent a nascent effort to map what would be necessary to create the infrastructure and mechanisms to create a robust open science environment.

B. Main barriers

Creating broad open access to publications is relatively successful endeavor in the U.S. Some barriers to broader open access are in many ways cultural, in that scientists in some institutions and fields do not place emphasis on the importance of publishing their work openly. While existing open access policies and practices are growing continuously in the wake of policies and increased emphasis in this area by funding bodies, patenting and intellectual property concerns will probably continue to block realization of open access in some areas. Additionally, embargoes of 12 months remain the standard on most deposited publications published in non-open access journals, and are unlikely to remain in place, with many advocates defending the work and value of publishers, and the need for them to monetize the work that they do.[160]
Barriers to creating a more robust open science environment are multiple, centered not only on logistical and funding issues (structural), but also very real ethical concerns that need to be addressed in such efforts.

According to the David Marques, Senior Vice President of Research Data Services at Elsevier, barriers to increased data sharing include "lack of mechanisms for assigning credit, lack of distribution control, fear that others obtain key insights the scientists themselves have they overlooked, lack of standardized nomenclatures."[161] In this assessment barriers are logistical and cultural, but not insurmountable.

The current administration's de-emphasis of this work has clear potential to act as a barrier, in that legislation and resources for creating the systems and requirements for open science are no longer actively advancing

---

157 Sculpting Evolution. "Sharing Research Plans." Available: http://www.sculptingevolution.org/proposals. Accessed: June 8, 2018.

158 Biobricks Foundation. "Open Materials Transfer Agreement." Available: https://biobricks.org/openmta/. Accessed: June 8, 2018.

159 Joint Roadmap for Open Science Tools. May 11, 2018. Available: http://jrost.org/2018/05/11/jrost-launched.html. Accessed: June 8, 2018.

160 Available: https://scholarlykitchen.sspnet.org/2016/02/01/guest-post-kent-anderson-updated-96-things-publishers-do-2016-edition/. Accessed: June 8, 2018.

161 Marques, David. Written statement submitted to National Research Council meeting to elicit stakeholder input on public access to data. Available: http://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_083132.pdf. Accessed: June 6, 2018.

this agenda. Additionally, the ways in which open data has been politically leveraged in support of a deregulatory agenda, and to discount an existing body of scientific knowledge, has the potential to act as a barrier to broadening support and participation within the scientific community.

A further cultural barrier identified by actors engaged in this space is that review of data management plans in research grants depends on the wherewithal for grant reviewers to assess them and to promote good practices that go beyond checking off that they have been provided. Additionally, some researchers do not see the value of sharing data and doubt the existence of demand for their data by other researchers. Thus they may not be committed to creating and carrying through data management plans.[162]

The availability and funding for servers for storage and management of data is also a potential barrier to the creation of a robust open science environment. As Jared Lyle of the Interuniversity Consortium for Political and Social Research notes, "providing access to and preserving scientific data can be expensive….We advocate longterm (sic) funding for specialized, longlived (sic), and sustainable repositories that can mediate between the needs of scientific disciplines and data preservation requirements."[163]

C. Main drivers

A significant cultural driver of open science is the repeatedly reaffirmed notion that it is essential for science to remain open, even in the face of security risks faced by the release of gain of function research results or DNA sequences of deadly viruses. Scientific bodies in the U.S., facing the reality of possible security threats and issues of international conflict over scientific practice, turn to this culturally embedded conviction of the necessity for open science despite the risks it can pose.[164]

Structural drivers in this area include existing requirements and momentum that continues to drive the creation of mechanisms and consortiums interested in creating a robust open science environment. Additionally, global interest in open science, which draws the U.S. into networks beyond U.S. borders are an additional structural driver for continued development of open science in the U.S.

In many ways, the programs and processes launched by the Obama administration continue, despite the change in leadership. Efforts to clarify and improve open data requirements and mechanisms are ongoing, and are not as yet an overly polarized political issue (unlike other areas of interest for this report, such as gender equality). This orientation toward continued progress is a potentially significant driver of open access and open science in the U.S. It is demonstrated in statements such as that made in the NSF's public access plan, indicating that the plan is not a conclusion but rather part of a continued effort to this end.[165] Further, as things stand, the NSF and NIH have not seen significant reductions in their funding under the new administration, allowing the development of policy and practice around open data to continue as a priority in these funding agencies.

---

[162] Wallas, Jillian. Written statement submitted to National Research Council meeting to elicit stakeholder input on public access to data. Available: http://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_083132.pdf. Accessed: June 6, 2018.

[163] Lyle, Jared. Written statement submitted to National Research Council meeting to elicit stakeholder input on public access to data. Available: http://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_083132.pdf. Accessed: June 6, 2018.

[164] The National Academies of Sciences Engineering and Medicine. "Seeking Security: Pathogens, Open Access, and Genome Databases." 2004. Available: http://nap.edu/11087. Accessed: June 4, 2018.

[165] National Science Foundation. "NSF'S Public Access Plan: Today's Data, Tomorrow's Discoveries: Increasing Access to the Results of Research Funded by the National Science Foundation." March 18, 2015. Available: https://www.nsf.gov/pubs/2015/nsf15052/nsf15052.pdf. Accessed: June 7, 2018.

D. Best practices[166]

Important practices in the U.S., the motivations of which align with the open access key of RRI, include:

1. The creation of data management plans as part of research proposals. While data sharing infrastructure and practices remain piecemeal, the practice of writing data management plans in the research planning process is broadly understood as productive in improving research, data management and preservation, and intentional practices around data by researchers. This practice is increasingly implemented across the (publicly funded) U.S. research and innovation system.
2. Accessibility requirements imposed by research funding agencies, e.g., NIH.
3. Presenting research proposals for review before the research gets done (e.g., the work done by the research group at Massachusetts Institute of Technology). While this work is nascent and not broadly adopted, it has potential to increase transparency, early public engagement with, and interdisciplinary oversight of research.
4. Use of Open Material Transfer Agreements (MTAs). This is an initiative of global scale, spearheaded in the non-governmental sector, and apart from national standards and practices in the U.S. government. Creating the legal infrastructure for more accessible, searchable and attributable material transfer is an oft overlooked but important element of open science practices (Biobricks Foundation).

5.6 Science education as integrated in research[167]

A. Description of the practice and its development and an assessment of how well it currently works

The U.S. federal government and funding agencies vast amount of legislation designed to advance STEM education across the educational system, and the national academies have produced a series of reports detailing the state of the U.S. STEM education landscape, with recommendations on how to improve it. This work, however, tends not to be focused on the integration of science education and research, so much as improving STEM education through teacher training and provision of standards and tools for classroom use.

For instance, America COMPETES is broad legislation aimed at a range of science and technology issues, including authorizing a host of funds to support grants seeking to improve teacher training, research on higher education, and efforts of states to improve the alignment of secondary school graduation requirements with the demands of 21st century postsecondary endeavors."[168]

Additionally, the STEM Education Act of 2015 not only redefines STEM education to include education in computer science across government agencies, but it also directs NSF to continue to award grants supporting "research and development of innovative out-of-school STEM learning and emerging STEM learning environments in order to improve STEM learning outcomes and engagement in STEM."[169]

A recent increased interest on the integration of research and K-12 education is reflected in the American Innovation and Competitiveness Act, which authorizes funding "to foster on-going partnerships between

[166] See section 5.3 D for a discussion of the challenges associated with efforts to identify best practices in this research context.

[167] See http://ec.europa.eu/research/swafs/pdf/pub_science_education/KI-NA-26-893-EN-N.pdf for an explanation of what is meant with this key.

[168] America Competes Act. PL 69. 110th Cong. Aug 9 2007. Available: https://www.congress.gov/110/plaws/publ69/PLAW-110publ69.pdf. Accessed: June 7, 2018.

[169] Stem Education Act of 2015. PL 59. 114th Cong. Oct 7, 2015. Available: https://www.congress.gov/114/plaws/publ59/PLAW-114publ59.pdf. Accessed: June 27, 2018.

institutions involved in informal STEM learning, institutions of higher education, and education research centers."[170] Nonetheless, the vast majority of legislative and research efforts do not specifically target embedding science education in research. Rather, they create a panoply of funding and program opportunities that may occasionally achieve some level of engagement of researchers with public or K-12 education.

NSF's Broader Impacts criterion for grant applications also includes the opportunity to demonstrate broader impacts through research dissemination and public science education, although broader impacts targets have become less specific over the years and more recently, "the targets for broader impacts are purposefully not prescribed, but left open to innovation from the field."[171]

NSF also funds research with special programs for educators. These funding calls are various, but are broad enough that they can fund research projects that engage scientists in public science education. For instance, one opportunity listed on the agency's site under special programs for K-12 Educators is "Innovative Technology Experiences for Students and Teachers (ITEST):

> ITEST is a research and development program that supports projects to promote PreK-12 student interests and capacities to participate in the STEM and information and communications technology (ICT) workforce of the future. The ITEST program supports research on the design, development, implementation, and selective spread of innovative strategies for engaging students in technology-rich experiences that: (1) increase student awareness of STEM occupations; (2) motivate students to pursue appropriate education pathways to STEM occupations; or (3) develop disciplinary-based knowledge and practices, or promote critical thinking, reasoning skills, or communication skills needed for entering STEM workforce sectors.[172]

Such funding opportunities, and others like it, facilitate unique research and engagement projects that often integrate science education in research.

One NSF-funded project around science education, the NSF Graduate STEM Fellows in K-12 Education Program, has engaged more than 10,000 graduate students, 1,000 Primary Investigators, and 12,000 K-12 teachers, partnering "science, technology, engineering, and mathematics (STEM) graduate students (Fellows) with K–12 teachers on a sustained basis" from 1999-2012.[173] A guide based on the experience of the fellows, teachers and researchers offers key insights into lessons learned and engagement methods and strategies derived from the program, and the project has been held up as a model to be followed by other funding and research organizations. The guide describes the project as aiming

> to develop scientists who are effective communicators, K–12 Teachers who have a rich content knowledge in STEM, and K–12 students who are scientifically literate. One of the main ways that these goals are met is by integrating GK–12 Fellows' research into the classroom. Fellows enter the classroom as resident science "experts" who offer their research skills, knowledge, and know-how by collaborating with GK–12 Teachers and interacting with students.[174]

---

[170] American Innovation and Competitiveness Act. S 3084. 114th Cong. Jan 6 2017. Available: https://www.congress.gov/bill/114th-congress/senate-bill/3084. Accessed: June 10, 2018.

[171] National Science Foundation (2014). *Perspectives on Broader Impacts*. Available: https://www.nsf.gov/od/oia/publications/Broader_Impacts.pdf. Accessed: June 28, 2018.

[172] National Science Foundation. "Innovative Experiences for Students and Teachers (ITEST)." Available: https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5467&org=NSF. Accessed: June 28, 2018.

[173] American Association for the Advancement of Science. (2013). *The Power of Partnerships: A Guide from the NSF Graduate Stem Fellows in K–12 Education* (GK–12) Program. AAAS, p. 1.

[174] American Association for the Advancement of Science. (2013). *The Power of Partnerships: A Guide from the NSF Graduate Stem Fellows in K–12 Education (GK–12) Program*. AAAS, p. 49.

The project has been cited as a leading example of "embedding scientists in communities and creating lasting partnerships."[175]

One of the largest and most far reaching recent engagements of scientific researchers with K-12 science education has been the design of new common core standards, which U.S. states are not obligated to adopt, but which have by and large been adopted across the country. The new common core standards are the result of a years-long effort to conceptualize and articulate standards for science education with the goal of instilling an appreciation of the power and beauty of science, develop student abilities to discuss science-related issues in an informed manner, and to carefully consume available scientific information related to their lives. Further, the standards aim to help students gain the capacities to "continue to learn about science outside school; and have the skills to enter careers of their choice, including (but not limited to) careers in science, engineering, and technology."[176]

This effort engaged many different scientists across the country, including the participation of the American Association for the Advancement of Science (AAAS), the National Academy of Sciences, the National Academy of Engineering, as well as Achieve Inc., the American Teachers Association, and the Carnegie Corporation of New York. Countless U.S. scientists contributed to design the new common core standards, which are offered and modified by state educational standards across the U.S. Recent actions by U.S. Education Secretary Betsy DeVos appear to be a reversal in the emphasis on the importance of STEM education in K-12 classrooms, as well as a move to provide materials for scientific instruction from conservative think tanks rather than facilitating sharing of practices and approaches shared by scientific researchers.[177]

While there is no centralized mandate that requires scientists to embed science education in research, voluntary initiatives on the part of research conducting organizations and individual scientists to engage with the public and help teach science in K-12 classrooms abound. These initiatives are as diverse as they are numerous, and difficult to get an overview of their scope and nature. A 2015 Pew research poll of AAAS scientists reports, "Virtually all scientists engage with citizens. Mid-career and older scientists are especially likely to speak to reporters. Younger scientists are more likely to use social media. And blogging is something that equally spans the generations under age 65." Since much of what this project views as science education gets characterized as public engagement, it may be helpful for the reader to review the above section 5.4 of this document titled "Societal Engagement Strategies in Research."

Additionally, public understanding of science is a topic that is generally of great interest within the scientific community in the U.S. (as well as elsewhere), as public research funding broadly depends on the continued recognition of scientific research by the public and its representatives. Much discussion and theorizing goes into assessing and analyzing "public understanding of science." In this context scientists are broadly encouraged and energized to participate in public engagement activities the goal of which tends to be informing the public about science and ongoing research, while broadening public support for science.[178]

B. Main barriers (structural, cultural or related to interchange dynamics)

---

[175] Komoroske, L. M., Hameed, S. O., Szoboszlai, A. I., Newsom, A. J., & Williams, S. L. (2015). A Scientist's Guide to Achieving Broader Impacts through K–12 STEM Collaboration. *BioScience*, *65*(3), 313-322.

[176] National Academies of Sciences Engineering and Medicine (2012). *A Framework for K-12 Science Education*. National Academies Press, p. 1. Available: https://www.nap.edu/catalog/13165/a-framework-for-k-12-science-education-practices-crosscutting-concepts. Accessed: June 11, 2018.

[177] Strauss, V. (2017). "Science teachers: DeVos's Education Department is misinterpreting federal law." *The Washington Post*. Available: https://www.washingtonpost.com/news/answer-sheet/wp/2017/07/02/science-teachers-devoss-education-department-is-misinterpreting-federal-law/?noredirect=on&utm_term=.910b59bce257. Accessed: July 3, 2018.

[178] National Science Foundation (2014). *Perspectives on Broader Impacts*. Available: https://www.nsf.gov/od/oia/publications/Broader_Impacts.pdf. Accessed: June 28, 2018.

One barrier to increased integration of science education in scientific research is a widespread sense that engagement with publics and science education efforts are extra, and that they take away from valuable resources and time for research. According to one participant of the national workshop conducted as part of this research, parts of the scientific community tends to continue to see science education as unrelated to their work.

A lack of institutional support and structural career incentives for scientists to engage in public education activities is also a persistent structural barrier.

C. Main drivers (structural, cultural or related to interchange dynamics)

According to reports from the National Workshop, grant reviewers have become more strongly evaluative in their treatment of broader impacts sections of grant applications, rendering the necessity to produce broader impacts a more relevant requirement for researchers to secure funding.

The current political atmosphere in the United States seems to reject policy relevant expertise and the value of scientific research. As such, there may be extra incentives for scientists to try to engage publics and contribute to science education. Anecdotal evidence based on a series of conversations with young scientists supports this conjecture, as well as the well-attended Marches for Science that drew huge crowds across the U.S. shortly after the inauguration of President Trump.[179] There is a sense of crisis, to which one answer that has been offered is better science communication and education. A March for Science three-day summit in in July 2018 was billed as "a network-wide meeting for emerging and established leaders across fields to share knowledge, build community, and develop their skills as science advocates, educators, and organizers."[180] Such examples suggest that the imperative to engage and educate publics around science is increasing in the U.S. science community.

D. Best practices[181]

Important practices in the U.S., the motivations of which align with the science education key of RRI, include:

1. Support for the creation of deep ongoing connections between STEM graduate students and K-12 classrooms.
2. Implementation of science funding programs with a broad definition of broader impacts, inviting a truly diverse collection of science education initiatives across research labs and institutions.
3. Leveraging a broad range of scientific research expertise to produce a set of science education standards for K-12 classrooms.

5.7 Incorporation of AIRR dimensions into science policy discussions

5.8.1. Diversity and inclusion

Diversity is a term that is widely used in the U.S. to discuss demographic factors of those engaged in research and decision-making. Inclusion is used similarly, but more often to indicate the flexibility and responsiveness of organizations to the positionality and perspectives of the diverse populations they seek to include. Thus, inclusion is seen as a best practice in strategies to diversify science and science-policy spaces. The context,

[179] March for Science. "By the Numbers." Available: https://www.marchforscience.com/by-the-numbers. Accessed: June 28, 2018.
[180] March for Science. "Signs." Available: https://www.marchforscience.com/summit-about. Accessed: June 28, 2018.
[181] See section 5.3 D for a discussion of the challenges associated with efforts to identify best practices in this research context.

current practices, barriers and drivers for these aspects of diversity and inclusion can be referenced in the above section on Gender and Diversity.

To the extent that this research understands inclusion in terms of including publics in research planning and assessment strategies, these dimensions are discussed in terms of open innovation in the U.S., and the available data on these elements can be found in the above section on Societal Engagement.

5.8.2. Anticipation and reflexivity

A. Description of the practice and its development and an assessment of how well it currently works

Anticipation and reflexivity are difficult to assess, as such activities are often informal, undocumented, and vary across personnel and agency, researcher and research conducting institution. Because anticipation and reflexivity are not areas of policy focus or rule-making, much of what goes on in these areas is opaque.

To the extent that these activities have been institutionalized, the U.S. congressional Office of Technology Assessment (OTA), active from 1972-1995, was one key site at which such modes of analysis were routinely carried out in the U.S. science-policy space. The role of OTA was to produce "competent, unbiased information concerning the physical, biological, economic, social and political effects" of technology.[182] In the service of this goal, OTA's mandate included identifying probable impacts of technologies, considering alternative options and technological methods, and identifying areas where more research was needed. These functions rendered OTA's reports a significant site of anticipation around science and technology, while it existed.

Bioethics commissions are also a key site at which anticipation and reflexivity have been undertaken in the U.S., and where engagement with these bodies facilitates anticipatory thinking on the part of scientists themselves. Since bioethics bodies depend on researchers to articulate possible future technological possibilities upon which to base ethical deliberations, the engagement of these bodies, when they are active, with the public and scientists facilitates anticipation and reflexivity across society. Additionally, the last presidential bioethics commission explicitly prescribed anticipation on the part of researchers and practitioners working on genome sequencing.[183] As reported above, there is not currently a bioethics commission, nor any indication of the prospect of one being convened by the current presidential administration.

Ethical, Legal, and Social Implications (ELSI) research (discussed in more detail in the above section titled "Ethics in the National Science System") funded by the NIH as part of the Human Genome Project, is also a site at which anticipation and reflexivity around biological research are richly engaged. For example, the latest funding opportunity description for ELSI research includes a request for "[s]tudies on the anticipated and actual psycho-social and behavioral impact of genetic and genomic information on affected individuals, their families, and populations."[184] While not all ELSI research is explicitly anticipatory or reflexive, the research funding agenda provides a fertile space for these kinds of approaches and modes of analysis.

---

182 Pl 92–484, Oct. 13, 1972, 86 Stat. 797.

183 Presidential Commission for the Study of Bioethical Issues. (2013). *ANTICIPATE and COMMUNICATE Ethical Management of Incidental and Secondary Findings in the Clinical, Research, and Direct-to-Consumer Contexts.* Available: https://bioethicsarchive.georgetown.edu/pcsbi/sites/default/files/FINALAnticipateCommunicate_PCSBI_0.pdf. Accessed: June 28, 2018.

184 Department of Health and Human Services. "Ethical, Legal, and Social Implications (ELSI) of Genomics Research Project Grant Program." Available: https://grants.nih.gov/grants/guide/pa-files/PA-17-444.html. Accessed: June 29, 2018.

Public engagement activities that aim to consult the public on questions around science policy also tend to implement anticipatory techniques. For more information on such activities in the U.S. research and innovation space please see the section above titled "Societal engagement strategies in research."

Finally, one area in which the public is already engaged in anticipatory engagement around technologies, but which is unresponsive to these engagements, is in public input for the regulation of new technologies. Government agencies such as EPA and FDA frequently solicit public comments on regulatory decisions, but then reject as irrelevant the vast majority of the comments that the public makes, because they are insufficiently responsive to the narrow concerns of the parameters of environmental assessments and risk-based decision-making. The submission of comments on pending regulatory decisions is often the sole opportunity for people to engage on issues concerning the technologies that will shape their world and their lives. Existing processes are largely deaf to comments addressing alternative technological modes of solving social issues, economic concerns, and other non-risk oriented concerns. The lack of an outlet to address the full range of concerns around emerging technologies and scientific governance represent a lost opportunity for anticipatory and reflexive public engagement around technological possibilities.

B. Main barriers

One barrier to anticipation and reflexivity is an abiding cultural and political commitment in the U.S. to "deregulation" and "free markets." The shared understanding that the market is the best regulatory and distributive device is in direct opposition to conceptualizations of technological governance that take an anticipatory and reflexive approach to think about desirable futures and ways of attaining them.

Correspondingly, the narrow focus on risk in the U.S. regulatory system actively deflects broader public engagement with anticipation and reflexivity.

Further, the rather pronounced divide in U.S. political experiences and attitudes undermines the credibility of modes of governance and engagement that posit the possibility of reasoned deliberation around desirable futures.

C. Main drivers

Drivers of these techniques appear to be the implementation of programs explicitly geared to broader social goals such as ethical reflection and public engagement, which tends to engage with anticipation and reflection as key modalities. Examples, as discussed in more detail above, bioethics commissions, the ELSI research funding program, and the multiple and various public engagement activities around particular technologies.

D. Best practices[185]

Important practices in the U.S., the motivations of which are anticipatory and reflexive, include:

1. Research funding for science and society research in conjunction with larger research funding programs (such as ELSI).
2. Establishing technology assessment offices to provide science advice to governing bodies.
3. Funding societal engagement exercises around particular technologies and research programs.

[185] See section 5.3 D for a discussion of the challenges associated with efforts to identify best practices in this research context.

5.8.3 Openness and transparency

Openness and transparency in science are central issues is the U.S. research and innovation space, especially at the level of government data sharing. Openness and transparency were issues dealt with at length by the Obama administration. These practices as well as barriers and drivers are discussed in full above, in the section titled "Open access and open science strategies in the national science system."

5.8.4 Responsiveness and adaptation

A. Description of the practice and its development and an assessment of how well it currently works

Responsiveness and adaptation in the U.S. is organized primarily around economic and market mechanisms. Such activities, like anticipation and reflexivity, are often wrapped into strategies adopted by organizations, either explicitly of informally. In the case of the U.S., these are not values with explicit plans and modes of enactment. Rather, a reliance on markets to guide economies and technological development underlies strategies to promote responsiveness and adaptation.

The Patent and Trademark Act Amendments of 1980, known as the Bayh-Dole Act[186], forms the basis of how U.S. Congress has sought to construct an S&T system that is nimble and responsive. As described above, the legislation entitles universities and other publicly funded entities to retain intellectual property rights over inventions created as a result of federally funded research. Under the act, research conducting organizations have an obligation to patent and attempt to commercialize such inventions. Such efforts to mandate and incentivize the conversion of publicly funded research into marketable technological products and services demonstrate the commitment of Congress to market formation and market guidance of technological advance.

B. Main barriers (structural, cultural or related to interchange dynamics)

One barrier generally to responsiveness and reflexivity in the U.S. S&T system broadly is the concentration of economic and political power in the hands of corporate and private entities whose goal is to maintain particular sociotechnical configurations around key areas of S&T innovation, such as energy systems. In the case of energy transformation, explicit and intentional actions are being taken at the highest political level to prevent particular forms of responsiveness and adaptation, including the supression and deletion of information about climate change and the restriction of the ability of U.S. agencies such as EPA and NIH to communicate with the public or congressional representatives.[187]

Additionally, at the level of research conducting organizations, there is a systemic and hierarchical structure that allows institutions and organizations to deflect accountability for policies that many argue are inherently corrosive to the production of reliable science in the public interest. Thus, many agree that the drive to "publish or perish" is detrimental to the quality of scientific research, but even those in leadership positions decry their lack of power to change these structural elements of the research and innovation system. As such, there are strong systemic forces within the scientific enterprise that inhibit responsiveness and adaptation.

C. Main drivers

---

[186] National Institutes of Health. "Bayh-Dole Regulations." Available: https://grants.nih.gov/grants/bayh-dole.htm. Accessed: May 18, 2018.

[187] Sunlight Foundation. "Reports of Federal Government Agencies Directed Not to Communicate with the American Public." Available: https://sunlightfoundation.com/list-of-federal-government-agencies-told-not-to-communicate-with-the-public/. Accessed: June 29, 2018.

While it is difficult to define drivers of responsiveness, it is likely that the diverse and distributed nature of the S&T system, with a diversity of programs, institutional mandates, goals, etc. promotes a level of agility and responsiveness that a more streamlined system may sometimes hinder. Clearly, the opposite could be argued as well.

D. Best practices[188]

None.

5.8 The integrated or fragmented nature of different responsibility related aspects

Because RRI is neither a term of art used nor a set of agendas pursued in the U.S., there are not policies or analyses that use these terms in any coherent manner. Science and technology legislation addresses many of these areas as part of a broad set of directives. Legislation addressing "K-12 STEM teaching and learning" addresses issues regarding "race, gender, income, and disability status of program participants," and discusses ethics mentoring as part of NSF broader impacts review. It outlines requirements for RCR training for young researchers, and makes stipulations about the "open exchange of data and results" by Federal civilian agencies with one another, policymakers and the public. In this way expansive legislation manages to touch on many of the key areas of RRI (although not explicitly on AIRR dimensions), without using the exact terminology, and without presuming them to be part of a coherent whole. These concerns are addressed in separate sections of the legislation, and are ultimately dealt with as distinct areas of action, not part of a larger programmatic logic.

Additionally, during the Obama administration, open government, public access, and open innovation were terms used to discuss elements of government policy and practice that broadly map onto the RRI elements open access/open science and societal engagement, as well as transparency. Government documents and reports treat these topics as deeply intertwined.

For example, the Union of Concerned Scientists introduces the mission of its guide to science-community partnerships in this way: "People who can freely access and consider scientific information are better equipped to engage in the decisionmaking (sic) processes that support a stronger democracy. When community members and scientists collaborate, they bring together unique strengths and types of knowledge that can help address our most pressing challenges, inform decision making at the local level, and develop solutions that benefit all people."[189]

Further, the line is often blurred between science education and societal engagement as defined RRI elements. Thus, documents discussing one often tends to discuss the other as well, even if ostensibly addressing either education or engagement alone. An additional layer of crossover is that documents specifically addressing STEM education almost always discuss STEM in terms of diversity, defined in terms of gender, race, and disability.

Interestingly, ethics is a term that often enters into explicit discussions of science education but is conspicuously absent in discussions of public engagement and open science (largely termed open government, public access or open data, and open innovation). While all of these areas seem to be fundamentally based on ethical principles, and certain projects like open government and open access are implicitly presented as

---

[188] See section 5.3 D for a discussion of the challenges associated with efforts to identify best practices in this research context.

[189] Union of Concerned Scientists. *Science-Community Partnerships: A Scientist's Guide to Successful Collaboration.* 2016, p. 2. Available: https://www.ucsusa.org/sites/default/files/attach/2016/04/ucs-scientist-community-partnerships-2016.pdf. Accessed: June 8, 2018.

deeply ethical and just projects, there is little or no mention of ethics by name in such plans and statements. Similarly, in documents that address gender and diversity in science as their primary topic, ethics is not generally a part of such discussions either.

AIRR dimensions are not directly addressed as goals or issues. Although transparency is discussed to some degree in open government materials, and inclusion in some discussions around gender and diversity, the more intellectually abstract elements such as reflexivity, responsiveness and adaptation almost never appear. "Anticipate" and "anticipated" (but rarely anticipation) may appear incidentally, but not as a central goal or strategic behavior.

Based on this analysis, one can say that many RRI keys and related concepts are central concerns in U.S. science policy discussions. They often make appearances together in the same analyses, but they are largely treated as separate issues and areas of action and intervention. Some keys arise frequently as relevant concepts in discussions of others. For instance, gender and diversity are especially cross cutting issues that arise in discussion of the other keys. RRI elements may not always map directly onto the ways in which U.S. policy addresses similar issues, such as the orientation to open government driving significant work on societal engagement and open data in complicated ways. Despite this remarkable level of crossover and cross-pollination, these elements are not recognized in the U.S. as part of a coherent and interrelated science-policy agenda.

6. Organizational reviews and outlooks: Research conducting organization

6.1 Mapping of the organization

The Biodesign Institute was launched at Arizona State University in 2003 with the intention of furthering the University's research mission. The Institute is understood to embody "the guiding principles of the New American University, as defined by Arizona State University President Michael Crow, specifically, to conduct use-inspired research, fuse intellectual disciplines and value entrepreneurship."[190] The Institute has the mission to "address today's critical global challenges in healthcare, sustainability and security by developing solutions inspired from natural systems, translating solutions into commercially viable products and clinical practices."[191]

The Biodesign Institute employs about 480 people, and has 16 research centers. The organization has about $50M in annual research expenditure, and is actively scaling up, building new research space, hiring, and creating new centers, with the goal of reaching $100M in annual research expenditure by 2020.[192]

The Institute is led by an Executive Director, who is also the director of one of the Institute's research centers. The six-person leadership team additionally includes a Chief Operating Officer, Deputy Director, Chief Scientific Operations Officer, a Senior Director, and a Marketing and Communications Director. This leadership team is responsible for vision, budgeting, compliance monitoring, internal and external communications, setting organizational policies, coordinating events, and other duties associated with management of any large organization. The leadership team does not, though, explicitly set research priorities or direct research trajectories within the 16 individual centers. Center directors run their own centers, made up of numerous labs, with research faculty, administrators, lab techs, post-docs and graduate students working under them.

---

[190] Arizona State University, The Biodesign Institute. "About." Available: https://biodesign.asu.edu/about. Accessed March 21, 2018.

[191] Arizona State University, The Biodesign Institute. Mission. Available: https://biodesign.asu.edu/about/mission. Accessed March 21, 2018.

[192] Arizona State University, The Biodesign Institute. "Future." Available: https://biodesign.asu.edu/about/institute/future. Accessed March 21, 2018.

Decisions about research agendas then, are by and large made at the center director and research faculty level. Leadership sees decision-making as rather diffuse and non-hierarchical. In the words of one member of the leadership team, "we're just constantly looking at where in the organization is the right place for X-type decision to get made, or Y-service to be provided. I would say we're pretty flat, but I know that's like, nobody wants to answer, we're really hierarchical. We're hierarchical when you need to be."[193] An example given in this context is how the Institute's space is allocated, which is understood to be a decision for leadership, versus questions of how to support education or responsibly conduct research, which are understood by leadership to be questions that should be answered democratically and at other levels of the organization. The 16 centers have significant discretional control over their operations, goals, funding sources, research priorities etc., contributing to the rather siloed structure of the organization. There is not, according to those that we interviewed, much communication or collaboration across centers. As such, those lower in the organizational hierarchy, such as post-docs and lab techs, do not see themselves so much as part of a larger organization, than as part of the individual labs in which they work. Upon being hired, employees are briefly oriented to working at the Institute, but this is more an overview of the structure of the organization, overview of leadership roles and personalities, and tour of the website and building than, an exercise in enculturation of any substance. Accordingly, there are not clear shared values, or a sense of organizational culture, etc. that spans the Institute. In fact, the research values of center directors and faculty are demonstrably at odds with one another in various instances.

The organization's leadership, beyond its Executive Director, is accountable to ASU's President, Michael Crow, and to the Executive Vice President of ASU Knowledge Enterprise (OKED), Sethuraman Panchanathan. This oversight is conducted primarily through quarterly management committee meetings. Above University leadership, the University and by association, the Biodesign Institute, is answerable to the Arizona Board of Regents. The Biodesign Institute does also have an internal advisory board, comprised of a variety of ASU affiliates, but the role of this board is not yet clearly defined, and in the words of one of its members, it's purpose "is to help Biodesign think about how it relates to the rest of the ASU community." As such the role of the board is lightly advisory, and it does not serve an oversight function.

Research at the Institute is broadly targeted at producing biomedicine and health outcomes, sustainability, and security, but is quite diverse in the application of these goals, and funding sources. The Institute houses research from sustainability education to genetic evolution, personalized medicine, infectious disease, human waste data analysis, cancer vaccination research, and much more. The Institute is subject to competition for grant funding alongside other researchers nationwide, with a high level of dependence on the ability of researchers to secure outside funding to sustain research activities.

The Biodesign Institute sees itself as nimble and innovative. It prides itself in being a place where researchers are given a wide latitude to follow their curiosity, and where things are possible that may not be elsewhere. One member of the leadership team explained, "We have, 'expect the unexpected,' as one of our taglines, 'the official home of the why not,' is another tagline, and, 'a new kind of research center at the New American University,' is another one."[194] The organization is also in the middle of a considerable planned expansion, which not only targets an expanded budget, but includes the construction of two additional buildings (one of which is already underway), adding on to the two existing buildings that currently house its activities. One member of the leadership team described their aspirations for the Institute this way, "I think the goal is to make this a very large Institute with a broad research agenda. A lot of us do health related research. . . . There are people here who are doing environmental research, energy research, sustainability research, even security research. I think we should grow in all of those areas."[195]

[193] Interview A: leadership team
[194] Interview C: Leadership Team
[195] Interview B: Leadership Team

6.2 Aspects of responsibility in organizational policy and practice

6.2.1 The conceptualizations of responsibility in the organization

Most within the Biodesign Institute are not familiar with RRI as a defined concept. When asked to discuss what it means to them, and what it might productively signify more broadly, interviewees offered definitions with significant variability. Frequently, interviewees framed their understandings in terms of responsible conduct of research (RCR), as in this response from a member of the leadership team, "There is a concept called the responsible conduct of research, RCR is the abbreviation for it. I think it's NSF, right? I think it's the—you know. We've spent time thinking through how do we support that at the institution level. Really, what we've always settled back on is that's gotta be, to some extent, a relationship between principal investigators and the people that work in their labs, because of the fact that they're so—it's discipline specific."[196] Here it is evident that in the eyes of leadership, communication around responsibility is understood in terms of research ethics, which is communicated predominantly via online training and informal interactions at the lab-level.

When invited to think beyond the rather narrow definition of RCR, responses ranged from "I'm responsible for advancing the human species" to defining responsibility as "an awareness of possible negative consequences—the point about research is it wouldn't be research if you knew what you were doing." While there were a lot of thoughtful responses, there is no understanding of responsibility that unites the organization, nor is there a guiding force of institutional culture to encourage responsible research practice beyond RCR training.

The few researchers who had some familiarity with RRI as a concept, through previous contact with ASU's social science researchers in the School for the Future of Innovation in Society, saw engagement with RRI in a positive light. One interviewee reflected on his change of perspective that came with contact with scholars of RRI: it helped him realize that if "one took a systematic approach to thinking about research while it was happening, you could actually affect the outcomes in the world beyond the research laboratory." Others pointed to the University's design aspirations as a general guidance for how the Biodesign Institute's responsibility might be framed, but those not on the leadership team cited a lack of operationalization and follow-through in areas that should be central to actualizing the aspirations. ASU's eight design aspirations are "leverage our place, enable student success, transform society, fuse intellectual disciplines, value entrepreneurship, be socially embedded, conduct use-inspired research, and engage globally."[197] One member of the leadership team pointed to these when articulating future goals for the Institute: "Those [design aspirations] frame everything we do. We will continue with that. We're growing. We're gonna grow by at least a third, if not more than half, 50 percent more. That means—and they're bringing engineers into this new building, so that they'll be with the idea being that we can get discoveries into practical use quicker, because engineers are the ones who can actually develop the diagnostic and the tools that come from the discoveries, so that's part of the vision, is stronger impact, more cures, more diagnostics."[198] Thus, these aspirations represent an important element of what the Institute's leadership sees as its responsibility, and they can provide a framework for understanding the possibilities and limits to RRI in this particular context. Beyond these parallels drawn with the design aspirations, while sustainability is central to the Institute's mission, and research excellence is important for assessment and hiring, those who we interviewed did not see RRI as significantly overlapping another key term, nor did they argue that its concerns are already addressed by another action concept.

---

[196] Interview A: Leadership Team

[197] Arizona State University. "Design Aspirations." Available: https://newamericanuniversity.asu.edu/about/design-aspirations. Accessed: March 26th, 2018.

[198] Interview C: Leadership Team

In general, when presented with the EC RRI keys, researchers found them useful for thinking about RRI, if somewhat limited in certain ways. Some interviewees thought safety or sustainability should be added, and most thought gender equality was far too narrow, preferring diversity, or inclusion in its place. These ideas will be addressed at greater length below, in the more focused discussion on the gender equality key. All of this is not to say that the RRI keys go entirely unaddressed at the Biodesign Institute, rather they are treated as separate issues, and handled in a diverse set of institutionally and historically contingent ways. There was little appreciation for the aim of uniting them under one concept, and as such, researchers and leadership were much more comfortable discussing these issues individually.

The important potential role of Biodesign Institute leadership in creating a more coherent culture of responsibility was highlighted by those with the longest tenure at the Institute. For these interviewees, leadership could drive ethical debate, collaboration across centers, and anticipatory work. When asked if there were any turning points in the history of the Institute in how issues of responsibility had been dealt with, the nearly universal response was to point to changes in leadership that had taken place in the past. Most pointed to an influential and charismatic previous institute director, who had particular vision and personal qualities that allowed him to do what no one since has achieved as far as vision and collaboration. In contrast, those further down the chain of command in the organization, such as lab techs and doctoral students, saw the Institute's leadership as much less significant. They had very little sense of the organization as providing a vision or cultural leadership at all. Instead, they viewed themselves as part of a particular lab, for which the individual leadership was very important. As such, those doing the actual lab work, and who are being trained to be future leaders in scientific research at Biodesign do not have a clear sense of being part of a unique and innovative organization. Rather their identities, ethics, and understandings of the place of research within local communities and internationally is largely defined by their direct supervisors.

6.2.2 Ethics in the organization

A. Description of the practice and its development and an assessment of how well it currently works

The Biodesign Institute follows ASU policy for ethics trainings and approvals. The predominant mechanism for fostering ethical scientific practice is the nation-wide policy of Institutional Review Board oversight, in which research projects involving human subjects, including human specimens, must be assessed by ethics review personnel before data collection can begin. At Arizona State University, this oversight mechanism is carried out by the office of Research Integrity and Assurance, which works with researchers to review research proposals, consent material, and data storage and sharing plans, to ensure proper procedures are followed, and that research plans adhere to basic tenets of ethical research practice. Institutional Review Boards must include one community member in addition to researchers at ASU and officers in the Office of Research Integrity & Assurance.[199]

ASU also has an Institutional Training Plan for the Responsible Conduct of Research, published in 2010, in direct response to updated requirements of the National Science Foundation's updated "Proposal & Award Policies and Procedures Guide (PAPPG) requiring that beginning January 4, 2010, institutions must certify, at the time of proposal submission, the institution has a plan to provide appropriate training and oversight in the responsible and ethical conduct of research to undergraduate students, graduate students, and postdoctoral researchers who participate in NSF-funded projects."[200] As part of this policy, student researchers and post-

---

[199] Arizona State University. "Human Subjects Institutional Review Board." Available: https://provost.asu.edu/committees/human-subjects-institutional-review-board. Accessed: March 26th, 2018.

[200] Arizona State University's Institutional Training Plan for the Responsible Conduct of Research. Available: https://researchintegrity.asu.edu/sites/default/files/archive/ASU%20RCR%20Institutional%20Plan%207-13.pdf. Accessed: March 22, 2018.

doctoral researchers are required to participate in online trainings on responsible conduct of research (RCR). In addition to online trainings, ASU's Knowledge Enterprise Development Office cites seminars and colloquia and continuing education by principle investigators as part of RCR training, but these are not mandated or audited elements of the training, and it is unclear how prevalent any further education in RCR beyond the online training is within the Institute or the University.[201] One interviewee who works in a lab, in response to inquiry about ethics training available at the Institute that go beyond the online trainings, "Yes, and of course you have the lab trainings and stuff like that. I personally never got too much into the after-hours things that they put out. That's my own fault. They definitely do provide an opportunity for that to occur. . . . It's not part of work. At 5:00 p.m., don't necessarily want to hang around here for another two hours. I'd sooner have a beer on my couch next to the fiancée"[202]

Interview questions on ethics, like similar prompts around responsibility, generated a diverse set of responses by researchers across the Institute, with varying levels of interest in these issues, and thoughts about where key issues lay. Many senior researchers had well developed ideas about ethical practice and the goals of their research, and recounted explicitly articulating them to their lab techs, although none that we spoke with had clear, formalized procedures or materials for doing so. One lab tech, when asked if his supervisor communicated about broader social topics and ethics explained, "Yeah, you just jump into the— Like, I just jumped into the research, and I just kind of figured out how he operated, what his philosophy on things was, along the way. And I kind of read some of his interviews and seen— You know, in his live meeting, he kind of talks, but once you're in a bubble, a school of thought, you kind of just start to pick things up."[203] Here, goals of research and ethics are implicit, and thought to be picked up through working in the lab, rather than explicit conversations.

Interviewees affirmed the importance of ethics for the scientific process, but there is a sense that ASU's Institutional Review Board (IRB) procedures adequately handle ethical issues, and thus ethics are sufficiently embedded in existing research practices. When particular training and requirements were mentioned by interviewees, they were noted to be requirements of funding bodies, such as those discussed above by NSF, but also the National Institutes of Health, "One of the areas where we have training—but it's as a result of my NIH funding and it's not, to my knowledge—although, I may be saying something wrong here—a required ASU training, it is required with NIH grant—is ethical research practices in health science research….Open access record keeping, responsible use of potentially hazardous materials, ethical guidelines for research, and so on, all of those things are built into NIH funding these days. Both when you review proposals and when you write them, there is a component in the NIH funding."[204] Thus researchers in the Institute are subject to different ethics obligations depending on their funding sources, and view funders as the primary driver of this kind of activity.

While ethical conduct and principles are widely viewed as important in the Institute, and individual researchers clearly have well thought out ideas about ethics, there is a lack of coherence and communication across the organization on these issues. For some, this results in research ethics being rather narrowly construed as falsification of data.

Researchers at the Biodesign Institute are described by one interviewee as understanding ASU to be the "wild west of science, [and] that they could do things here that they weren't permitted to do anyplace else." Accordingly, a tagline used for communicating the culture of the Institute is "the official home of the 'why not?'" This implies an intentional eschewing of popular norms and limits to scientific research. Of course, the

---

[201] ASU Knowledge Enterprise Development. "Responsible Conduct in Research." Available: https://researchintegrity.asu.edu/rcr. Accessed: March 22, 2018.
[202] Interview L. Lab workers.
[203] Interview K. Lab workers.
[204] Interview G. Senior Researchers.

"wild west" was not a terribly ethical place by today's standards, but that reality does not come through as part of the institutional culture of pushing boundaries and transforming the world. Published promotional materials express a similar cultural value, declaring, "this is a no holds barred culture, where curiosity and creativity are on overdrive."[205]

At the Institutional level, and unevenly across the labs and centers, ethics can function more as a box to check, and a legal obligation to ensure compliance, than a strong element of organizational culture, deliberation, or shared values. While senior researchers don't feel that they have the incentives, time or resources for addressing the dearth of ethics discourse in the Institute, leadership has treated ethics, up until this point, as an area that should and can be dealt with at the level of each individual lab in the Institute.

B. Main barriers (structural, cultural or related to interchange dynamics)

Interviewees cited resource allocation as a key reason for the relatively little time and focus expended toward ethical reflection and communication on their work. Essentially, there is no time to reflect on ethics, no incentive to do so, and ethical boxes are checked by completing IRB requirements, so why double efforts? Such processes render ethical reflection an activity that is being taken care of by someone else, somewhere else. One interviewee explained it this way: "We are right now in a situation where ethics responsibility is an afterthought, a luxury of those who have the means to get along and think about it."[206]

Another barrier identified was the lack of shared ethical frameworks. When asked about barriers and drivers in this area, a senior researcher notes:

> I think there's huge challenges because we can all agree on making progress. When we ask what type of progress do we wanna make, and how do we wanna apply what we call progress and new technologies? I think the opinions are gonna differ. Particularly in a setting right now where the whole country is very polarized already and just by political party. I mean we're still the same species, have the same needs, so it should be fairly simple to identify a common setup, you know.[207]

Similarly, in the focus group on ethics and data, one participant argued, "I think [we need] both the trainings, so that it's developing an institution or professions that have a common understanding, [but also] I think there's a lot of work on where that common ground should land. I don't think there's—we've talked about the dual-use research quite a bit. There aren't good, easy answers."[208] These and other comments highlight the lack of shared values and agreement across the institution, and the lack of existing resources for addressing these differences, and training junior researchers in this area. For the senior researchers, ethical issues are important, but the space (time, resources and incentives) to discuss and address these issues is lacking.

C. Main drivers (structural, cultural or related to interchange dynamics)

The most significant driver for potential improvement of the organization's ethics practice is the new interest that the Institute's leadership has shown in this area, and the proliferation of thoughtful ideas on how to go about doing so within the organization. While existing institutional culture and norms do not foster ethical reflection across the Institute, there is an expressed interest in changing the status quo.

---

[205] Biodesign Campiagn 2020 brochure
[206] Interview F. Senior Researchers.
[207] Interview F. Senior Researchers.
[208] Focus group on ethics and data. January 24th, 2018.

Additionally, requirements of funding bodies have driven a significant amount of existing ethical engagement of researchers, thus funding requirements remain a significant driver in this area, and as such, have the potential to drive progress in this area.

D. Best practices[209]

Important practices at BDI, the motivations of which align with the ethics key of RRI, include:

1. Embedding ethicists in labs.
2. Engaging in partnerships with social science researchers to expand ethical reflection and debate.

E. Current indicators

The organization does not use indicators to measure ethical practice.

F. All points of improvement

The Institute has been very successful at sourcing talent from all over the world, contributing in key ways to the University's design aspirations of global engagement. Accordingly, since BDI is filled with researchers of so many different cultures and backgrounds, it is especially important to discuss and articulate institutional values and practices clearly, including the articulation of what some U.S. based researchers often view as universally accepted, and deeply embedded scientific values. Interviews elicited a multitude of examples in which it was made clear that basic understandings of how science is conducted and communicated are not shared across researchers, students and staff. Interviewees often found such differences surprising, revealing assumptions about scientific values and practices that would benefit the entire community to make explicit points of conversation and communication at the institutional level. This requires the acknowledgement that ethics and cultures of responsibility are not inherent to the material practices of science. They vary across cultures and backgrounds, and they must be articulated, communicated, and continuously examined to uphold the highest standards of scientific practice.

Given the time and resource limitations of research faculty then, one way of addressing this which leadership noted may be included in the practices of one of the new centers at the Institute, is to embed an ethicist directly in the laboratory. Encouraging these kinds of interdisciplinary partnerships across the University not only supports ethical research, but also responds to and supports the University's design aspiration of fusing intellectual disciplines.

Others suggested the allocation of a certain portion of grant funds to a committee housed at the Institute that undertakes ethical deliberation and whose responsibility it is to remain abreast of research and conversations that are taking place around research and innovation ethics nationally and globally, with periodic seminars and report-backs to communicate this with leadership and other researchers at the organization.

Another suggestion is to find material ways for the Institute to appreciate and incentivize ethical engagement of researchers. This is premised on the understanding that promotions do not occur through demonstrating good ethics. Not only incentivizing but routinizing ethical reflection in all parts of research was noted as a desirable goal, although suggestions for how to create such widespread cultural change were less forthcoming.

The lack of an existing coherent ethical discourse at the organizational level has been recognized by the Institute's leadership, in some part through this research projects' intervention, leading to the organization of

[209] See section 5.3 D for a discussion of the challenges associated with efforts to identify best practices in this research context.

a focus group at the Institute around the topic of ethics and data. This focus group brought together 13 people from inside of the Biodesign Institute and across the University with active interest in issues around ethics and data. The aim was to map out the relevant landscape of the issue, and generate ideas for how Biodesign can lead in this key area for creating a more responsible research enterprise at ASU, in the US, and across the globe. Since the chosen topic of the focus group was ethics and data, interventions that were suggested are largely targeted at ethical data stewardship, rather than ethics more generally, but they do offer some potential for development of institutional discourse and practice around ethics. Some of the suggestions most relevant to ethics are outlined here.

The focus group recommended producing an ethical statement about the use of ASU's data repositories not harming basic human rights. There is the potential for misuse of the accessibility of data, and ASU does not currently have a statement of this kind. There is no signature mechanism inside of the repository. IP licenses have mechanisms of this kind, which can be done in the way that creation of recombinant DNA and use of stem-cells is managed.

Active conversations among faculty and students on the topic of data ethics should be facilitated. There are observable and problematic contrasts in how ethical research and data is conceptualized, even among faculty. Conversations need to work on these problems, form best practices, and raise awareness. This is a complex terrain, and it is important to identify ways that the Institute can support researchers and students alike in navigating it. A common ground needs to be established as far as language and transparency, but there is work that needs to be done first on where that common ground should land.

More questions of ethical practice are addressed later in this document as part of the section on open access, as ethics and data sharing were discussed in conjunction during the focus group, and these comments are more relevant to questions of open science.

G. Agreed points of improvement, with action plans and indicators for success

Results from the focus group were delivered to the leadership and discussed in a review meeting. Leadership saw value in many of the suggestions from the focus group. The proposed actions were many and varied, and they warranted, in the eyes of the leadership team, the formation of a task force dedicated to the twinned topics of data and ethics. During the meeting, an appropriate leader for that task force was identified, and a plan for creating a charter for the task force was agreed on, with the task force leader primarily in charge of collaborating on that charter with the leadership team. Some elements of a possible charter were mentioned. These were to create an institutional statement on data sharing and ethics, to seek to embed data and ethics issues within existing organizational practices and routines, and to create modes of recognition for excellence in ethics and data stewardship.

Indicators for success for the agreed upon points of improvement include (these will overlap somewhat with those listed in the open access and open science chapter, as these efforts are one and the same for the Institute):

- The formation of a task force on ethics and data stewardship
- The completion of a charter for this task force
- The creation of modes of recognition for ethics and data stewardship.

H. Resulting matrix

See Annex 2.

6.2.3 Societal engagement strategies in organization

A. Description of the practice and its development and an assessment of how well it currently works

Conceptualizations of public engagement at the Biodesign Institute seem to overlap with those around science education to a large degree. Those who we interviewed frequently cited many of the activities discussed under this heading as part of science education efforts, and vice versa. This raises the key question of how the difference between these activities might be understood, and how that could contribute to building best practices in these areas at the Biodesign Institute.

When discussing public engagement, nearly everyone that we spoke with cited the Institute's participation in two university-wide events, The Night of the Open Door, and Homecoming, as key public engagement events at the Institute. These are important events during which ASU invites the community onto its campus and into labs, museums and learning spaces. These outreach events often bring 2,000-3,000 visitors into the Biodesign Institute alone. These events include hands-on activities geared to educate the public about research going on at the Institute and engage citizens of all ages on scientific topics.

Biodesign also promotes public engagement through its marketing and communications work. The Institute maintains an extensive and informative website, with a range of video and text content conveying information about the scientific work being done at the Institute, its personnel, mission, monthly news updates, etc. The Institute has a range of active social media accounts including Facebook, Twitter, Pinterest, Instagram, LinkedIn and Vimeo. Finally, public outreach materials also include a wealth of print media ranging from posters and brochures to book-length publications detailing the Institute's mission, history and news, as well as current projects that its researchers are engaged with.

Beyond these centrally coordinated public outreach activities, the Institute's various centers engage in community outreach in different ways and to varying degrees. Similar to science education, these efforts are largely the work of researchers and staff who are dedicated to public engagement for their own reasons and leverage it in pursuit of their own ends and values. These two levels of public engagement appear largely disconnected from one another. There is no clear centralized incentive for public engagement activities as part of the daily work of the centers from the Institute's leadership or the University. Interviewees that saw public engagement as important and valuable said that they conducted these activities on their own initiative, with little perceived institutional support. In fact, public engagement activities were in some instances viewed as a drain on resources with no material return in terms of monetary support, prestige, job security, etc. Material incentives and resources were cited as crucial elements for increasing public engagement activities across the organization.

Public engagement does increasingly hold some value in grant applications, which may increase interest, but it is not clearly defined, and tends to be highly peripheral to research activities. In the past, researchers at the School for the Future of Innovation in Society have partnered with particular labs to run public engagement activities around particular issues and research agendas. While these activities were viewed positively by the researchers involved, they have tended to be seen as interesting and fun add-ons, but not indispensable to the conduct of responsible research. Ongoing funding and institutional support for such collaborations is not currently a priority.

In some instances, grant funding has been allocated to employing public engagement professionals within particular labs, which offers a more advanced level of public engagement activities than may be possible in centers without dedicated personnel. What public engagement looks like in these cases, though, depends heavily on the views and experience of those particular professionals, as there is little guidance from within the Institute on why public engagement may be desirable, what best practices look like, and what kinds of outcomes are desired. One of the centers currently employs an outreach specialist, with the explicit function of conducting public outreach for two of the center's labs. This person is able to do more targeted public outreach for the labs, and engage with smaller groups of people, facilitating more in-depth conversations than the larger events such as Night of the Open Door, discussed above. The role of this person is "to create installations, exhibitions, experiences, anything that's going to illustrate the primary research. It's an outreach capacity."[210] Even this work, though, tends more toward science education of a kind, than public engagement, if public engagement is to be understood as representing two-way communication between researchers and society. For instance, when asked about best practices for public engagement the interviewee remarked, "How do you take some of this really problematic deep science and figure out ways to communicate it to somebody with an eighth-grade background, for example, whose mother is dying of cancer or something? This stuff really matters.[211]

The value of outreach is fundamentally educational in this interviewee's understanding, to communicate what scientists are doing to publics, who are understood to be uninformed and detached from research, to their detriment. Even in this setting, in which creative ways to engage with publics were being actively sought, the framing persists of finding new ways of communicating out to the less educated in order to change the reception of research, rather than communicate more symmetrically about values around research and community priorities.

B. Main barriers (structural, cultural or related to interchange dynamics)

The main barrier to more advanced levels of public engagement within the organization is the lack of interest in two-way communication in public engagement on most levels. Conceptualizations of public engagement that are closer to RRI best practices are present in U.S. discourse, such as that of the American Association for the Advancement of Science (AAAS). AAAS Center for Public Engagement with Science and Technology defines public engagement with science as "intentional, meaningful interactions that provide opportunities for mutual learning between scientists and members of the public. Mutual learning refers not just to the acquisition of knowledge, but also to increased familiarity with a breadth of perspectives, frames, and worldviews." At the institutional level, the Biodesign Institute approaches public engagement in a manner more oriented toward science education, in that it is directed toward developing community understanding of science, not soliciting input and mutual learning. If we understand best practices to necessarily involve two-way communication, the Institute does not actively promote such activities.

One reason for this reticence seems to be a deficit model of public understanding of science that many at the Institute espouse, in which communities are understood to be in need of betterment, and are not imagined to have anything to contribute to science. Another possible barrier to the kind of idealized public engagement conceptualized as part of RRI and by AAAS is a concern that if scientific practice is more transparent and open to public input, this will lead to increased problems and impediments to research. As the public engagement practitioner commented when asked about this, "PETA [People for the Ethical Treatment of Animals] is a very big issue."[212] Two-way public engagement may help to address these kinds of trepadition on the part of researchers as well as publics, especially through engagement methods that are structured around performance and dialogue rather than more direct confrontation around particular controversial technologies.

C. Main drivers (structural, cultural or related to interchange dynamics)

The main potential driver of progress in public engagement toward a more two-way model of public engagement is the University's institutional culture promoting interdisciplinarity, and thus potential partnership with social scientists in the future, as well as the design aspiration of social embeddedness. Since ASU aspires to social embeddedness and the production of use-inspired research, the creation and

---

[210] Interview I. Other Institute Functions.
[211] Ibid.
[212] Interview I. Other Institute Functions.

implementation of best practices in public engagement have the potential to be leveraged in the service of these aspirations. Although the organization does not currently show significant interest in developing social engagement toward the two-way symmetrical model, the broader institutional context and openness to change hold open the possibility for future development of such practices.

D. Best practices[213]

Important practices at BDI, the motivations of which align with the societal engagement key of RRI, include:

1. Hiring lab personnel dedicated to public engagement.
2. Hosting large events in the research space, allowing the public to visit laboratories and engage with scientists.

E. Current indicators (if any)

Public engagement and related science education efforts tend to be measured in terms of number of individuals reached, for instance headcount of those who attend events and estimated reach of email blasts, visits to website, etc.

F. All points of improvement

The focus on two-way communication and learning is a key difference between science education and best practices in public engagement. RRI similarly offers a framework for thinking about public engagement that focuses not only on the transfer of information from scientists to the public, but to the ways that the public can help shape research trajectories, give feedback, communicate values, and offer insight on research that scientists may not be well positioned to generate themselves. Our investigation reveals little orientation of existing public engagement work at BDI to this kind of symmetrical, two-way communication, which is the main improvement in this area suggested by the researchers.

In order to achieve the aim of two-way communication and benefit, public engagement must be directly connected to research going on inside of the labs, involve those who drive research agendas, and find ways to directly engage research with community needs and concerns. Ideas in this area generated by those outside of leadership positions in the organization included supporting these efforts with material resources and making public engagement a more regular, available and programmatic part of research. One interviewee explains in this regard,

> I think also one of the issues is really it needs programmatizing. Rather than these one-off things that are proof of concept or whatever, I think they're really great and everything. I think people should really have a program where there's certain—you do one thing a month or whatever. People grow to expect it. You build on what you've done before. None of that stuff is happening. There's very few places to actually see work here, like work that is actually tied to research. There's no spaces for that. There's no programs for that. I think it's a real issue.[214]

G. Agreed points of improvement, with action plans and indicators for success

The Institute's leadership feels that efforts it is engaging in this area are sufficient, and developing in a manner sufficiently in-line with its needs and values, such that it chose not to engage with researchers on this topic.

[213] See section 5.3 D for a discussion of the challenges associated with efforts to identify best practices in this research context.
[214] Ibid.

H. Resulting matrix

See Annex 2.

6.2.4 Gender equality and diversity strategies in the organization

A. Description of the practice and its development and an assessment of how well it currently Works

The Biodesign Institute employs 480 people, 43% of whom are women, representing a 2% increase since 2008. The bulk of women are in non-managerial roles, and the 2% increase is largely in post-docs and graduate research assistants, as well as some faculty.

The Institute is quite diverse, internationally speaking, as 50% are of international origin. This does not account for class diversity or define diversity in terms of inclusion of underrepresented groups such as African Americans and Native Americans, which are represented on a very minimal level in the Institute. Imbalances concerning types of role and seniority also persist across the organization.

The executive team is 50% women, which is also a strength in terms of representation. But, with only 3 women directors of 16 centers, and a research faculty with fewer than half as many women as men, basic representation discrepancies exist in the research enterprise.

Initially, interviews revealed that top actors across the Institute viewed gender equality as adequately addressed by existing policies, despite the evident dearth of women in scientific leadership roles. A few key people acknowledge that there is an issue, but there has not been not a broader conversation or awareness about gender equality that sparks action, debate or acknowledgement that there may be room for improvement at the Institute.

Explicit policies do not exist within the Institute to promote gender equality. Rather, the Institute refers to U.S. law, Title IX, and to the work of the University's Office of Equity and Inclusion, which handles Title IX violations and the University's affirmative action policy. Title IX is the 1972 statute stating, "No person in the United States shall, on the basis of sex, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any education program or activity receiving federal financial assistance."[215] Accordingly, Arizona State University prohibits all forms of sex discrimination under Academic Affairs Manual policy 401.[216] ASU's Office of Equity and Inclusion is responsible for Title IX compliance, and offers a host of resources, including trainings and information sessions that can be conducted at an academic unit's request. All University faculty, staff, and student workers are required to take a 90-minute online training module on workplace behavior, and a 15-minute online training module on Title IX and the Duty to Report rule that went into effect in 2014. Under this rule all ASU employees are required to report allegations of unwanted sexual conduct to university officials, such as the Dean of Students or Office of Equity and Inclusion. Additionally, the University promotes events such as Sexual Assault Awareness Month in April, which includes events from a dedicated day on which people are encouraged to wear denim, to attend open mic events, workshops, yoga

---

[215] U.S. Department of Education. "Title IX and Sex Discrimination." Available: https://www2.ed.gov/about/offices/list/ocr/docs/tix_dis.html. Accessed March 26th, 2018.
[216] Arizona State University. "Academic Affairs Manual." Available: https://www.asu.edu/aad/manuals/acd/acd401.html. Accessed: March 26th, 2018.

sessions, and other activities designed to address cultural issues and raise awareness of this pervasive cultural problem.[217]

A representative interviewed from the University's Office of Equity and Inclusion (OEI) suggested that the main barrier to achieving gender equality is a lack of widespread proper understanding of ASU's Title IX policies. Additionally, the interviewee de-emphasized cultural issues that are resistant to the message of its trainings. This procedural approach, which is instituted as best practices by the University and referred to when questions of gender equality are raised with Biodesign leadership can only achieve so much in terms of creating an inclusive culture, and does not address the subtler cultural factors around gender and diversity at the Institute, or the dearth of women and other underrepresented groups in scientific leadership roles.

One interviewee offered an illuminating account of subtler cultural tendencies that continue to pervade U.S. culture, scientific practice and, consequently, the Biodesign Institute. The interviewee recounted a meeting where institutional research compliance personnel were present with US-based and international PIs and students. The interviewee noted that the dynamic was such that it was clear that there was a gender-based imbalance of power. The men were in charge and the women were only considered important when called upon by research compliance personnel. Such behavior reflects a pervasive cultural issue more than an incident of misconduct as defined by Title IX, and thus is likely to go unaddressed by existing efforts at the university level to promote gender equality.

Existing efforts to implement inclusive hiring processes and in other decision-making forums include the insistence that hiring committees and other panels include women and other underrepresented groups. Although these existing efforts to make search committees more diverse are a good start, this can lead to women, and especially women of color, getting sourced to do an inordinate amount of this kind of labor (committee work, panels and other situations in which they are called on to represent women), given their underrepresentation within the organization in the first place. Similarly, women of color often have to undertake a higher mentorship burden, taking on additional emotional labor, because students are more diverse than the faculty. This puts an additional burden on women and women of color, which can ultimately be detrimental to achieving desired career goals for these researchers. This labor tends not to be recognized or valued as highly as publishing and grant writing, activities that may have less time devoted to them as a consequence of higher service and mentorship burdens.[218]

It is not clear that the OEI trainings can translate into an inclusive culture without further institutional action by BDI to make these issues directly relevant to practices at the Institute. University leadership at the highest level was cited across interviews as very supportive of efforts to promote gender equality and create a truly inclusive environment. Such an institutional commitment to gender equality provides an institutional context in which BDI can act as a leader, actively working against ingrained cultural attitudes that inhibit gender equality and inclusion defined more broadly.

Most interviewees seemed puzzled that gender alone is targeted by the keys, rather than diversity, inclusion, intersectionality, or another term to acknowledge that gender is not the only demographic factor that should be considered in efforts to render research and innovation more responsible. One participant in the focus group on gender and diversity explains this point:

> It's a little complex, because [intersectionality is] oftentimes phrased as being just about identity, that, "Oh, I am an Asian woman. I am a black man. I am an Indian man." It's about more than that. It's about the social context in which you're in. . . . in the United States, we have a much more multicultural system

---

[217] Arizona State University. "Movement for Violence Prevention Events." Available: https://eoss.asu.edu/movement-for-violence-prevention/events. Accessed: March 26th, 2018.
[218] Focus group input. February 2nd, 2018.

> because we have so many different cultures. Recognizing what is the context, what are the constraints, and what are the power relations in that society that give meaning to these identities that actually help you to understand what these mean.[219]

B. Main barriers

Laws against quotas and court decisions against most versions of affirmative action are structural/legal barriers to making the Institute more diverse.

Those researchers at the Biodesign Institute who did express a concern about gender equality there cited it as a systemic "chicken-or-the-egg" issue, in that there are fewer qualified female scientists available, especially at the higher level, and a system dominated by men tends to reproduce itself. When excellence is framed in particular ways by a particular demographic that currently holds the authority to define excellence, it can create a cycle that is virtuous for some and vicious for others.

C. Main drivers

Despite the recent decay in some of the further reaching aspects of affirmative action and executive oversight of diversity, there are still very strong legal protections against discrimination that continue to influence practice.

Broader social norms and action are also important drivers, as is demographic change itself, among college and university students. Creating inclusive institutions to match increasingly diverse cohorts coming into higher education and research is a significant challenge, but one that is broadly identified and accepted.

This need, in turn, has meant a significant commitment by leadership at the organizational and university level to addressing these issues.

D. Best practices[220]

Important practices at BDI, the motivations of which align with the gender equality and diversity key of RRI, include:

1. Policies and resources dedicated to preventing and addressing sexual assault.
2. Dedicated personnel (at the University level) for addressing complaints and training faculty, staff, and students.
3. Implementing "duty to report" rules that require faculty and staff to report any allegations of unwanted sexual contact to relevant university authorities.

E. Current indicators (if any)

Demographic numbers of the Institute's employees, including gender and ethnicity. The center focuses primarily on nationality as the indicator of diversity.

F. All points of improvement

The following suggestions for points of improvement were advanced during the focus group discussion on gender and diversity in research, which took place 2 February 2018:

---

[219] Ibid.

[220] See section 5.3 D for a discussion of the challenges associated with efforts to identify best practices in this research context.

The language of diversity and inclusion needs to be consciously differentiated. Diversity is about getting the numbers up. The student body is diverse because it represents Arizona, but there is a difference between diversity and inclusion. You can be very diverse while not being inclusive. Diversity is representation, inclusion is having input from all of these perspectives, which changes practice and culture. It is important to pursue inclusion as the standard for how institutions evolve and adapt as they become more diverse, rather than viewing diversity as a value in itself. Accordingly, power dynamics and intersectional identitities should be taken into account in measures of diversity and inclusiveness. For example, high numbers of international employees do not necessarily render an organization sufficiently diverse if underrepresented groups that are part of the community served by the organization are not represented.

One of the ways that the university should be able to consider questions about inclusion is not only in building inclusive social structures, but also in being inclusive in the construction and design of knowledge and technologies. An important concept that is logically prior to the design aspirations and the charter of ASU is that different people bring different content to the work that they do.

The Biodesign Institute can expand the kinds of questions asked around gender to be more inclusive. Such an expansion can be a win-win situation, helping those who identify as gender non-binary feel welcomed into the organization, while raising awareness in the rest of the population about these differences. It can be better to ask, "do you identify outside of the gender binary" as a way of getting relevant information. Framing this issue in a way that is constructive and inclusive. Thus, alternately, offering a choice of "non-binary" or "other______" in addition to male and female on forms can be an effective way to be more inclusive. That non-binary students have safety concerns means that such inclusive language may be the minimum that needs to be done.

It would be helpful for BDI to have a center or a person who works directly on these issues. Since it is a flagship of the university, it would be wonderful if Biodesign led the charge and demonstrated good practices for the university to follow. There is, though, the question of whether one employee could possibly handle this task, as a multi-pronged approach will be necessary.

The Office of Equity and Inclusion can be brought in to do trainings. OEI offer a variety of trainings, including "bystander training." They will answer questions about how to handle issues of equity and inclusion even beyond areas like Title IX in which the university and BDI as part of it have legal obligations.

Women of color are invited to do a significant amount of mentoring, and important committee work, which is ultimately not reasonably valued in hiring and promotion decisions. Because of well-meaning efforts to improve gender equality, women get overburdened to do work that is not incentivized, valued or rewarded. It would be helpful to create mechanisms in which women are able to get buyout or other recognition for their additional burden of mentorship and committee work.

One potential opportunity is paying or otherwise creating incentives for women and minorities to be part of a task force to address these issues. Part of such an effort would be finding ways to relieve people in order to participate meaningfully. The efforts of a task force include opportunities for publication as well, although these may not be seen as valuable in recruitment and advancement. Such efforts would have to go hand in hand with efforts to redefine excellence for hiring and promotion. Promoting organizational systemic change in these ways is key.

The way that centers are created inside of BDI could also be changed to promote inclusion and diversity. The Institute should consider designing a center instead around a particular knowledge area, one which would bring in diverse leadership and address topics of research as defined by the priorities of underrepresented communities.

While BDI has little to with buiding curriculum, change can also be made there. Diversity and inclusion issues can be handled by teachers in the classroom in interesting ways, and the particular disciplines that work on these issues that should be leading the intellectual charge. An approach that looks more like an appreciation of the scholarship in these areas might would work well. Research seminars presenting work on implicit biases, scholarship on gender in the laboratory setting, and other inclusion-based research about science and technology could serve to share awareness and create a more inclusive environment. A second opportunity is to work with the arts to communicate across borders. Partnerships with the theater and dance school as well as other campus groups could be promoted to create awareness and culture change.

It is also helpful to have a variety of ways of posing and answering questions. For example, there are opportunities to write questions on cards and pass them forward in the Institute's town halls. How such questions are received has a lot to do with whether they are asked in the first place. There are numerous instances in which questions have been publicly laughed at when received in the town hall. Such responses don't create an inclusive environment, and they are chilling to those who feel less confident in participating in group events.

On an individual level, Biodesign community members can be encouraged to learn, and become more inclusive, by living in and allowing the multicultural world into their daily lives. Following people of color on social media, for example, can help explose them to diverse points of view that they might normally not see. Similarly, scholarship of people of color and women should prominently feature on syllabi, not as a one week focus, or at the end of the semester.

Opportunites should be created for smaller conversations around these issues that would allow people to speak about their particular experience without feeling judged, and allowing for different communication styles. A forum to share best practices could be helpful, and an anonymous online suggestion box for possible changes geared at inclusivity could be a complementary resource.

G. Agreed points of improvement, with action plans and indicators for success

Results from the focus group were delivered to the leadership and discussed in a review meeting. Reservations were expressed by the leadership team about the idea of explicitly targeting hires of people with particular race and gender identities, as this is a legally problematic idea. Thus, the decision was made to target cultural elements of the organization.

A task force to address these issues and find other points of improvement will be created. Some of the areas that the task force will work on were decided in the meeting, while other areas require more exploration before appropriate actions can be determined.

The Institute currently features a series of speakers on a variety of topics. It was indicated that the inclusion of speakers who conduct research on gender, race and other diversity issues in science are a primary avenue the organization would pursue for making change in this area.

Working with the University's Title IX office, the organization will offer trainings on implicit bias and other key topics for cultural change.

Additionally, looking across the Institute's other procedures and activities, an assessment will be undertaken examining where the Institute's values on gender equality and diversity could be better communicated within existing activities.

Indicators for success for the agreed upon points of improvement include:

- The formation of a task force on gender equality and diversity;
- Inclusion of at least one talk per year relating to race, gender and/or diversity in science in the existing speaker series;
- Having at least 10% of the Institute's members attend bias and other diversity trainings made available in partnership with the Title IX office.
- perception indicators (to be measured annually through questionnaires), for instance: awareness of the impact of stereotypes and unconscious bias on diversity in science; barriers for inclusion; understanding of the diversity dimension in research, etc.;
- % of black, Latino and native people compared to AZ demographic data.
- % of men/women that are principal investigators on a project (annual evaluation);
- % of men/women that are first (corresponding) authors on research papers/publications (annual evaluation).
- % of research projects including gender/diversity analysis or considering gender/diversity dimensions.

I. Resulting matrix

See Annex 2.

6.2.5 Open access and open science strategies in the organization

A. Description of the practice and its development and an assessment of how well it currently works

As of 3 May 2017 Arizona State University has an open access policy, but it remains an open question the extent to which the repository created as part of that policy will be used. ASU's open access policy is hybrid: optional for most researchers, mandatory for grants from funders that have a public access policy. Funders with a public access policy include NIH, NSF, EPA, and others. It is mandatory to have a policy for "each Federal agency with over $100 million in annual conduct of research and development expenditures." At its core, the repository provides a way for the university to ensure that grant funding requirements are met. The university library is positioned to play a role in facilitating compliance and working with researchers to fulfill the requirements and aspirations of the open access policy. The library also has information on available discounts on open access publishing options. Additionally, the Research and Creative Activities Committee is available help find funding to make research at ASU open access.

ASU's open access policy does not address data sharing, but faculty and staff recognize it as important for improving responsible practice in research. Open science benefits include internal goals like increased reproducibility, and data management plans required by NSF, for example, should involve data sharing plans as well. Publications are often only interpretations of the data and thus do not actually provide the data.

ASU's Office of Knowledge Enterprise Development Research (OKED) focuses on ensuring that research use and data sharing matches the spirit of what has been signed off on as part of the informed consent process. OKED is thus developing a module to use the Open Science Framework (OSF) and Institutional Review Boards (IRB) across the institution. In these efforts, choosing the granular part that actually needs to be shared is key to making data open. The library plays the role of consultation service and is available to act as a partner to help plan projects in advance to facilitate appropriate data sharing. The library also provides assistance in helping researchers make sure data is organized and publishable, facilitatating replication.

Those we spoke with at the Biodesign Institute on the topic of open access emphasized its importance for science and society. Public funds pay for scientific exploration, and thus it should produce publicly available knowledge. This area generated a fair amount of excitement among interviewees, but incentives to publish in open access journals are non-existent within BDI, and as a general rule it is structurally disincentivized, as the more prestigious journals are not open access. Open access publishing that does go on is largely driven by requirements by research sponsors and the resulting University-wide policy.

B. Main barriers

As with the broader national context, conflicting logics exist at the Institute, such as the drive to pursue intellectual property versus the value of openness and transparency. Additionally, a lack of strong guidance and discussion around dual-use research may render discourage data sharing by default among well intentioned researchers with an eye to avoiding security risks.

There exists a lack of structural incentives for open access and open science, including a lack of even modest resources to purchase open access in traditional journals, that may impede progress toward optimal levels of sharing and access.

A similarly structural issue that researchers experience, is a lack of time and resources to devote to making their research transparent and available. Enabling access in a coherent and usable manner takes conscious effort, education, and institutional resources, which could certainly be fortified.

C. Main drivers

While some structural issues exist, as detailed above, these are not insurmountable. The interest expressed by leadership in addressing these issues, as well as openness and even enthusiasm among some researchers for the goals of open access, indicates the potential for work and resources to be allocated in this domain.

Additionally, as funding agencies develop infrastructure, incentives and requirements for open access and data sharing, organizational practice is likely to advance as well. This is demonstrated by interview responses in which researchers primarily pointed to requirements of funding agencies as explanation for their current practices in this area.

D. Best practices[221]

Important practices at BDI, the motivations of which align with the open access key of RRI, include:

1. The University has an open access database for publications available to all researchers.

E. Current indicators

Biodesign Institute does not track open access publishing, and does not have indicators in this area. Once the database is fully implemented, a potential indicator could be share of publications represented in the database.

F. All points of improvement

Fusing intellectual disciplines requires dialogue across projects on what researchers are doing before research is published, and in many cases even before research is conducted. Similarly, social embeddedness and global engagement would be greatly facilitated by breaking down barriers to social engagement, citizen science, and access by scholars in less resource-endowed institutions, by making research plans, methods and results freely available and open to public input. Leaders in this area can work toward creating a transparent research

[221] See section 5.3 D for a discussion of the challenges associated with efforts to identify best practices in this research context.

culture, in which those lacking monetary resources and elite access can gain knowledge, contribute to its creation, and offer perspectives and on-the-ground information that the scientific enterprise currently does not successfully access or leverage. Such openness provides benefits not only for society but for scientific progress itself.

The Biodesign Institute could lead in this area by creating incentives for open access publishing, participation in open data publishing practices, specimen treatment transparency, and other open science practices. One way to support such policies, beyond articulating open access as an institutional value, would be to value publication in open access journals more highly than those behind a paywall in the incentives structures, and to encourage researchers to offer their work to repositories above and beyond grant requirements. Further, Biodesign could become an active partner in ongoing projects elsewhere in the university to innovate and create mechanisms for open science, and it could reward innovation in open science initiatives at the center and lab level.

Leadership should engage the research community and critically examine the question: "What are our values about what we are willing to reward?" As part of this self-reflection, the devaluation of research that is the result of collaboration (through incentives around single author publications) should be dispensed with, given ASU's design aspiration to fuse intellectual disciplines. Productivity measures greatly influence researchers' behavior, and changing these metrics is key to producing more open science. Today you cannot get tenure without a particular number of papers published in prestigious journals, and publications in open access journals are not as highly valued as in key journals such as in Science. While equal value to all publication outlets is not the goal, creating mechanisms that convey the value of broadening access would be valuable. Publishing one, best, very rigorous and well considered paper is a good goal, but getting the number of publications up is more highly incentivized. There are many aspects of research that are counter-productive but still incentivized. There is already an active conversation among the research community for some such changes, and thus there is a good opportunity for BDI to lead. It is recommended that the proposed task force analyze the opportunities to take such criticism into account and propose an innovative and visible system of valuation that addresses these issues.

Discussions and training are needed to help researchers make decisions around data sharing and open access. These must produce a cohesive statement of how the organization handles data, and as such Biodesign and ASU should have data ethics statements. Accordingly, a statement on data practices such as a teaching philosophy could be helpful as a hiring technique.

Just because access to research may be 'open' does not mean that the research is legible. There is a key relationship between science communication and open access/open data. If the aim is to get more eyes on science, it is key to design complementary science communication to make open data and open access publications more publicly digestible. One recommended change to support this goal is to change how online scientific bios are structured. Rather than a list of citations on researcher biography pages, a lay summary and a link to the open access version of the article could be provided. Similarly, when data sets are made publicly available, they should be accompanies by lay summaries.

Simply communicating the results of research after the fact may be insufficient in some cases. Some research, on which public action might ultimately be based, should have public engagement plans built into it. This suggests that publics should be engaged before data presumed to help them is generated. To facilitate this kind of early engagement, it may be useful to define a faculty role whose purpose is to marry the generation and extension of knowledge (similar to extension agents at agricultural and mechanical universities in the U.S.).

Collaborations with the library and other units should be institutionalized, as they are another way to ease the resource burden and facilitate the participation of researchers in open access and open data initiatives.

G. Agreed points of improvement, with action plans and indicators for success

Results from the focus group were delivered to the leadership and discussed in a review meeting. Leadership saw value in many of the suggestions from the focus group. The proposed actions were many and varied, and they warranted, in the eyes of the leadership team, the formation of a task force dedicated to the coupled topics of data and ethics. In the meeting an appropriate leader for that task force was identified, and a plan for creating a charter for the task force was agreed on, with the task force leader primarily in charge of collaborating on that charter with the leadership team. Elements of a possible charter were mentioned, including creating an institutional statement on data sharing and ethics, embedding data and ethics issues within existing organizational practices and routines, and recognizing excellence in ethics and data stewardship.

Indicators for success on the agreed upon points of improvement include (these will overlap somewhat with those listed in the open access and open science chapter, as these efforts are one and the same for the Institute):

- The formation of a task force on ethics and data stewardship;
- The completion of a charter for this task force;
- The publication of an institutional statement on ethics and data stewardship;
- The creation of modes of recognition for ethics and data stewardship;
- An increase in number of researchers in the Institute using data repositories and open access publishing (requires a baseline measure and post-implementation measure, both of which need to be created)

H. Resulting matrix

See Annex 2.

6.2.6 Science education as integrated in research

A. Description of the practice and its development and an assessment of how well it currently works

Science education activities are currently unevenly distributed across BDI, with no clear central organization or bank of knowledge. Initial interviews suggest that efforts toward educating the public on science issues are largely concentrated within the Pathfinder Center. This center spearheads the Sustainability Science Education Project, which offers professional development courses to K-12 teachers centering on sustainability issues. Science education appears to be concentrated on particular issues (such as sustainability), in centers that take an interest in the activity. As a result, efforts are not well-integrated across BDI, and many centers engage minimally or not at all in science education beyond the education efforts inherent to the work of hiring and training Ph.D. students and post-docs (which we understand to be outside of the scope of the RRI-Practice project's definition of science education). The lack of centralized leadership of these efforts may inhibit cross-center learning on science education, creating a chaotic approach to science education directed at communities outside of the University.

Many researchers at the Biodesign Institute do take part in university-wide science education endeavors, like the "Ask A Biologist" website, which presents an interactive platform for members of the public to engage with researchers at ASU on particular questions of interest around biology. The site is positioned as a "biology learning resource tool for students, teachers, parents, and life-long learners,"[222] and it offers materials specifically targeted at k-12 teachers and students. The site sees a lot of traffic, claiming 30,000 visitors each day. The site allows members of the public to pose questions that then get answered personally by researchers at ASU.

Interviews reveal ongoing efforts to expand science education efforts by BDI leadership. Interviewees mentioned a plan to equip a science tour bus that would travel to K-12 schools, offering hands-on science education. Such efforts reflect an institutional commitment to science education beyond the University, and they could be integrated into a more concretely articulated set of goals and ongoing commitment of resources for science education by the Institute. Discussion on how best to conduct science education in a more coherent and Institute-wide manner is currently ongoing, providing a prime opportunity to think about how ideas and knowledge at all levels of BDI can be leveraged to create a set of science education policies and programs that engage directly with work being done in the labs, and which successfully embody ASU's Design Aspirations.

When discussing science education at the Institute, some interviewees brought up concerns that new efforts to conduct science education through the communications department may not succeed in either leveraging lab-level expertise and or reflecting the values of the centers. Specifically, some were concerned that this approach would lead to an orientation toward fund-raising and marketing, rather than a deep engagement with proven techniques for producing successful learning.

B. Main barriers (structural, cultural or related to interchange dynamics)

The organization's leadership sees its efforts as sufficient in this area, and yet the values and priorities for science education that exist throughout the institution are not made central by science education efforts at the leadership level. Additionally, the Institute does not make clear use of research on effective science education to inform its efforts.

While expertise and capabilities for effective science education are distributed through the university, institutional resources do not sufficiently support distributed efforts. Instead, these resources are expended at the top.

Finally, there is a lack of collaboration across research projects and centers surrounding science education practices and experiences, preventing efficient institutional learning.

C. Main drivers

The dedication of an entire research center to science education activities has the potential to drive the creation and adoption of best practices in education, if other impediments are removed.

D. Best practices[223]

Important practices at BDI, the motivations of which align with the science education key of RRI, include:

1. Research is conducted on the effectiveness of science education practices, and the science education efforts of one center are revised and redesigned in response to instructor feedback.
2. The online platform "ask a biologist," which creates open lines of communication between researchers and publics.

[222] Ask A Biologist. Available: https://askabiologist.asu.edu/.
[223] See section 5.3 D for a discussion of the challenges associated with efforts to identify best practices in this research context.

3. Using a mobile-lab that travels around to schools, giving demonstrations to students.

E. Current indicators

Science education and public engagement tend to be measured in terms of numbers of individuals reached with no real ability to measure the intensivity of the interaction.

F. All points of improvement

While efforts toward creating coherent science education activities benefit from direct engagement across centers and projects, scientific leadership for tracking and guiding science education appears desirable. This is not solely because communication and learning across projects can help reduce repeat mistakes and unnecessary duplication of efforts. Reaching out haphazardly to the communities within which ASU operates has the potential to create misunderstanding and engagement fatigue within these communities. One interviewee gave an account that illustrates these issues. The interviewee reached out to a school in the area to gauge interest in sharing resources for science education with their classroom teachers. The person who answered the phone gave an unenthusiastic reply, explaining that they would not work with ASU anymore, since they had repeatedly been subject to affiliates of the university ending projects abruptly and not offering resources of lasting value. Pathfinder Center is tackling this problem and is looking to cross all OKED entities focused on sustainability and STEM outreach for teachers and their students. Science education efforts coordinated through BDI should similarly seek to foster engagement across centers, while providing leadership and resources to facilitate a consistent and committed relationship with the communities it serves.

ASU aspires to transform society, and science education that reaches communities beyond the population of ASU students certainly contributes to meeting this goal. Social transformation can have uneven results, so a keen eye to how scientists are reaching out to communities and engaging in science education is particularly important for positive social transformation. The development of programs that facilitate open communication and cross-center learning, while drawing on situated knowledge within the organization is key to achieving success in science education in this context.

Many researchers at the Institute are concerned with meeting the needs of underserved populations, and making their innovations accessible to all, rather than the small elite who can typically afford cutting edge technologies. Researchers across the Institute cited issues of equity in distribution of technological benefits across populations as a driving force in their research. This ethic of leveraging technological innovation in the service of addressing social inequality may well suggest a path for science education efforts that might similarly seek to counter prevailing inequities in science education that exist at the community and global levels.

G. Agreed points of improvement, with action plans and indicators for success

The Institute's leadership team expressed a sense that they had sufficient plans under way in this area, and was not interested in engaging with the RRI project on these issues.

H. Resulting matrix

See Annex 2.

6.2.7 Incorporation of AIRR dimensions into policies

A. Description of the practice and its development and an assessment of how well it currently works

In contrast to the keys, the AIRR dimensions do not have clear implementation within the organization, nor was their mention met with much enthusiasm or comprehension, overall. While a few engagements with researchers in ASU's School for the Future of Innovation and Society (SFIS) have introduced researchers to tools such as embedded social scientists in labs, foresight activities, and public engagement initiatives, these activities have been isolated and not instituted into regular practice at the level of any labs, centers, or more broadly at BDI. Elements such as anticipation and reflection are generally viewed within the organization as the purview of social scientists, rather than the responsibility of researchers themselves or the larger Institute. For example, one senior researcher suggested, "Why don't you do something productive, and try and be anticipatory? Go engage early with us. Tell us okay, we see this might be a problem; that might be a problem."[224]

Biodesign researchers do in some ways exhibit an attention to innovation outcomes, evidenced by an oft-cited dedication to producing beneficial technologies that will be widely available and inexpensive. Additionally, the Institute's mission to focus on health, sustainability, and security clearly emphasizes outcome-based research, which necessitates a certain level of anticipation in research design, if these outcomes are to be achieved. Nonetheless, many in the organization struggled to see how the AIRR dimensions apply to research at Biodesign, or how they are different from the keys.

When asked about these dimensions of AIRR, most interviewees seemed at a bit of a loss, viewing these dimensions as a rather abstract set of ideals, in contrast to the keys which seemed more concrete and approachable. As such, some chose not to engage with prompts around these dimensions, while others tried to draw parallels with something more familiar to the organization's values, such as innovation. For example, one respondent argued, "Yeah, and adaptation, being able to evolve. That's sort of the definition of innovation, right? Innovation is that you can change."[225]

At the leadership level, AIRR dimensions seemed to interviewees to be elements of ethical research practice that get handled at the level of Institutional Review Boards: "Initially, it sounds like it's different, but in fact, it really isn't that different because those are the kinds of things that you do get considered by the IRB when you applied to get your research."[226] In terms of organizational operation, another leadership team member found the AIRR dimensions to be so obviously part of the culture they in fact did not bear discussion:

> I think it's funny, 'cause I think those characterize things that people who were not us would discuss. I think 'cause we're already that way—I mean, we're incredibly adaptive, we change all the time. We work together in new—we're so far ahead of so many other institutions in terms of the way that we work. I think that's people talk about that when they aspire to be like us, as opposed to this is just the way that we are. Very dynamic. Things change all the time.[227]

Elaborating, they emphasized the impression that each practice of the organization is constantly up for reassessment and change. If something has been done in the past, that is not sufficient reason to do it in the same way in the future. The interviewee regarded this as evidence of engagement with AIRR principles, and thus found them essentially redundant.

B. Main barriers (structural, cultural or related to interchange dynamics)

Ingrained ideas about what science is drive a resistance to AIRR keys. In interviews BDI researchers preferred the keys over AIRR dimensions. One member of the leadership team expressed this familiar view of science,

---

[224] Interview E. Senior Researchers.
[225] Interview M. Other Institute Functions.
[226] Interview B. Leadership Team.
[227] Interview A. Leadership Team.

"If you look, historically, it's hard to stop the research juggernaut. The desire to learn new things is compelling. It's hard to put the genie back in the bottle. Even if we were to try to restrict that kind of discovery here in the states or in this institution, it will get it done elsewhere."[228]

Similarly ingrained views on the culture of science, and the inherent responsibility of scientists that exist in the organization (and more broadly in US innovation culture) emerged in an interview with another member of the team: "one of my first inclinations was to use, as a priority message, the idea that the scientists here had a strong commitment to social responsibility. When I use that, when I tested that with my leadership group, they came back with the pushback that, "Well, all scientists are that way."[229]

C. Main drivers

One driver of possible improvement in engagement with the AIRR dimensions is availability of social science researchers in SFIS for partnerships, and the institutional commitment to interdisciplinarity. Those interviewees who had existing conceptualizations of RRI, shaped by collaboration with STS scholars, reflected favorably on their experiences collaborating with researchers in SFIS. Workshops, public engagement, and scenario development activities were cited as providing expertise, resources and perspectives that are not readily available at the Institute. One interviewee described views on such collaboration:

> For me, it's a great pleasure being [at ASU] because it's very forward-looking, and there's few places in the world that do things so aggressively, rather than just talking about stuff, but actually doing it. That it's great to work with these folks and also integrate. I've worked with folks from [SFIS] to conduct workshops and invite stakeholders from the police or citizens, and the mayor's office and politicians, [etc.], to hear how they feel about what it is that we're doing, and what . . . they're interested in, and what . . . they're scared about, and how they envision the future.[230]

The AIRR dimensions cross and complement the keys and have the potential to promote action, planning and reflection based on an awareness of the multitude of research and innovation outcomes that are possible, when they are framed as tools for approaching more concrete issues. Thus, a shared driver of all four AIRR dimensions within the Institute, is the willingness of the leadership to consider social science interventions around data, ethics, gender and inclusion. Interventions that have been proposed around these more concrete areas of concern include activities and seminars that promote questioning and reflection, embedding social scientists in laboratories, fostering conversation among faculty, students and publics around data sharing, compositing institutional data ethics statements, and other such activities, in which anticipation and reflexivity have the potential to play a significant role. Thus, commitments around the keys may drive increased engagement with AIRR dimensions.

D. Best practices[231]

Important practices at BDI, the motivations of which align with the AIRR dimensions of RRI, include:

1. Engaging with Institutional Review Boards to enhance for anticipation and reflexivity.
2. Collaboration with social scientists and humanists elsewhere in the university.

E. Current indicators (if any)

---

[228] Interview B: Leadership Team
[229] Interview C. Leadership Team.
[230] Interview F. Senior Researchers.
[231] See section 5.3 D for a discussion of the challenges associated with efforts to identify best practices in this research context.

None.

F. All points of improvement

The Biodesign Institute is well populated with great ideas and initiatives of the kind RRI is interested in promoting--moves to engage stakeholders, new ways to do science education and deliberate on key ethical questions raised by their work. What seems to be lacking is the awareness, support and engagement across the Institute with what others are doing in these areas, and how particular labs and centers may be innovating in practices and approaches to research that could benefit the Institute through wider uptake. Interviews revealed a lack of connection among centers and a lack of learning relationships across projects. They also revealed the lack of a coherent institutional identity across actors and pay grades, all of which belies the aspirational framing that BDI's marketing materials offer. The 2020 Biodesign brochure portrays the Institute like this: "Imagine hundreds of scientists working together. Biologists, physicists, chemists, engineers, mathematicians—asking questions, learning from one another, and crossing all boundaries to discover new ways to help people everywhere thrive."[232] This is a wonderful vision, but one which, as things stand, is not fulfilled in practice at the Biodesign Institute. For this ideal to come to fruition, increased communication across the dimensions described here are necessary.

Fostering a more deeply held institutional culture that highlights responsibility in research and innovation could contribute to the realization of ASU's design aspirations and leadership of the Institute in the broader University context and across the world. Engendering dialog about institutional values can in itself foster a more thoughtful and responsible community.

G. Agreed points of improvement, with action plans and indicators for success

The leadership team did not express interest in pursuing change on these dimensions of RRI.

H. Resulting matrix

See Annex 2.

6.2.8 Other concepts used to characterize responsibility in the organization

Sustainability is a strong element of responsibility, and several senior researchers framed their work in terms of its contribution to sustainability. Sustainability also appears in the core mission of the organization. Some research at the Institute is in fact geared toward producing more sustainable futures, such as the sustainability education research, and the work done in the Environmental Health and Engineering Center. Nonetheless, sustainability is not a shared value across all centers, as one senior researcher referred to it as "warmed over Malthus,"[233] arguing that sustainability is in fact the antithesis of responsibility.

Similarly, equity in research outcomes is a value held by many of the researchers as part of how they understand their responsibility.

Lab safety was also a concern mentioned by a couple of the participants, as something that should be understood as part of responsible research.

Intersectionality or inclusion could also be added to the keys, perhaps augmenting or broadening the key of gender equity.

---

[232] The Biodesign Institute. "Biodesign 2020" (brochure).
[233] Interview E. Senior Researchers.

6.3. Reflection on Review findings, Outlooks developed and ways forward

6.3.1 The integrated or fragmented nature of different responsibility related dimensions

The Institute does not operate within the RRI framework. Thus, these all seemed like relevant issues for science, but they are not treated in any kind of unified manner by the Institute. In fact, when the research team brought up the idea of a focus group around these topics, the Institute's leadership viewed the array of issues as too broad to have a coherent conversation about in one focus group. As a result, two separate focus groups were proposed and hosted. One focus group addressed data stewardship and ethics, while the other addressed gender and diversity. This separation of topics is just one indicator of the distinct nature of many of the RRI elements, as conceptualized and enacted within BDI.

As the design of the focus groups also reflects, though, some of the RRI elements are more naturally part of one conversation than others. It seemed reasonable to host a focus group on Data and ethics together, which allowed for a more or less coherent discussion of ethical issues surrounding data stewardship, and to some degree scientific practice more broadly. Data stewardship appears to be viewed as an area where more work around ethics needs to be done, while other areas of ethics are viewed within the organization as sufficiently handled by the Institutional Review Board process. Additionally, the data ethics discussion in the focus group naturally included discussions of how to communicate about open access articles and open data sets with publics, recognizing that availability of information and data was not sufficient to make it truly accessible to a broad audience. This direction of the conversation recognized that a certain level of public engagement or science education was also an integral part of actions around data and ethics. Nonetheless, at the level of institutional action, implementation of these various goals tends to be sorted out by topic rather than integrated into one action plan or coordinated across activities.

6.3.2 Common barriers or drivers

One clear common barrier is resource flows and money. In the words of one researcher, when asked if there were any barriers they could identify to the implementation of RRI, "Money. The way money flows in science is not necessarily very well aligned with [the RRI elements]. . . . It's a very difficult problem to solve. Until you solve the way money moves and flows into the system, you're not going to completely solve those other problems."[234] This critique is pervasive, and not particularly novel, but continues as a noted structural barrier to the kinds of change targeted by RRI.

A cited common driver of progress for all RRI aspects ASU's institutional culture. For instance, ASU's broad array of available trainings, and interventions that help researchers think about the larger context in which they are working. One senior researcher noted, "Over the years, I think helps to change the attitude that I started out in life with, which is, I'm a smart physicist, get out of my way. I know all about physics. Don't talk to me about these other annoying things. That's all I'm interested in is physics."[235] This experience of a changing perspective over time in response to the larger institutional culture demonstrates the effectiveness of existing value commitments on the part of ASU leadership, but also indicates a potential for creating intentional shifts in the outlook of researchers over time, that may align with the aims of RRI.

6.3.3 Final reflections and plan for follow-up

As discussed above, the organization was interested in engaging with the research team on gender and diversity as well as data stewardship and ethics. The final outlook was drafted based on a final meeting with

[234] Interview H. Senior Researchers.
[235] Interview G. Senior Researchers.

the organization's leadership and delivered back to the liaison for review on July 26th, 2018, receipt of which was confirmed by the liaison. Going forward, the research team is available for consultation and assistance with articulation of the charter of the planned task force, and other support functions, as well as progress monitoring around the success indicators.

7. Discussion of findings

Given the fragmented yet entangled nature of the work on RRI elements in the U.S., it is difficult to make any decisive statements about the general RRI landscape and prospects. One observation that is valid across the RRI elements is that each of these areas was of much greater interest and the space of a significantly greater amount of action during the previous presidential administration. Under President Obama, legislation on science policy moved research and initiatives forward in these areas in significant ways, while the Trump administration has seen inattention to some areas, such as ethics, open access, and societal engagement, and reversals of key policies in others, such as gender and diversity, open data, and science education. Nonetheless, many initiatives initiated by the Obama Administration persist under the Trump administration, since they are already in motion, and have not been actively reversed. An example of this are the various citizen science initiatives and competitions that play a key role in the U.S. government' strategies around societal engagement with science and innovation. So, while it is unlikely that the U.S. government will embrace the RRI framework at any point in the near future, the individual elements of interest for RRI are in a general state of directionless uncertainty.

In this context, it is interesting to examine a case study of a research conducting organization within such an ambiguous and uncertain national context. Overall, the organization does not appear to be changing course in response to the ambiguity and reversals seen at the national level. By and large, scientists and leadership at the research conducting organization saw the areas defined by the RRI keys (ethics, science education, open science, societal engagement, and gender equality and diversity) as important areas for attention and resources, and their approach seemed quite well aligned with the national context as produced before and during the Obama administration. There was not any indication that the new leadership and its actions in any way undermined the need for forward progress around inclusion, transparency, or engagement in general.

Some notable elements of the national context are reflected in the organizational context, which warrant some review and analysis. As mentioned above, a strong engagement with elements of all the keys was observed in the research institute, but with a separate but intertwined nature of how key areas are conceptualized and addressed, with a configuration largely mirroring that of the national context.

For instance, leadership at the Institute expressed an interest in ethics, with the questions of reproducibility and prevention of misconduct as the basis for this interest, supported by a sense that a national conversation on these issues made them an important focus for the Institute going forward. These concerns, then, become naturally tied with data sharing and other open science issues, as transparency is seen as a key mode of dealing with misconduct and the crisis of reproducibility. In this way, the concerns and action motivations of the Institute mirror the national context. Again, similarly to the national context, there is strong support for open access publishing when possible at the Institute, and repositories for the purpose are available, but there is less of a clear-cut and effective framework and set of infrastructures for sharing data, with work on how to train researchers in data management and organization ongoing, and data sharing infrastructure and mechanisms for sharing still multiple and in flux.

At both the level of the research conducting organization and the level of national discourse around science education and public engagement, there is a lack of conceptual division between these activities, or the sense that they are in pursuit of different goals. As such, much of what is considered science education within the RRI framework is dealt with as an issue of public engagement, while some activities that RRI-practice would see as societal engagement are understood as science education efforts. At the national and institutional level, the distinctions made by the RRI framework are quite different from the lines drawn between science education and societal engagement in the U.S.

Accordingly, regarding gender equality and diversity, the national and organizational contexts are well-aligned, without taking into account recent shifts in the priorities and directions of the Executive branch. Issues around gender equality (broadly) and diversity are more prominent and important than ever, despite efforts by President Trump and his Department of Education to reverse the actions of the Obama Administration in this area, and reverse cultural momentum. At the same time, the set of legal and cultural realities that structure these issues in the U.S. render it difficult to gain traction for change at any level. Studies of efforts to diversify the STEM fields and address sexual harassment acknowledge that despite loud claims that change is desirable, very little progress to that end has been made. At the organizational level as well, there is a wide acknowledgement that gender equality and particular kinds of diversity are lacking, and a desire to address it. Despite this broad recognition, tractable ways forward are more difficult to identify. Barriers to progress in this area are the legal impediments to direct affirmative action and hiring to fill quotas, as well as subtler modes of behavior and cultural elements that lead to high attrition rates of women and underrepresented minorities in STEM education and professions. Another more ambiguous element in this ecosystem is the increase of reporting and publicity around sexual harassment. On one hand, these actions are outing corrosive behavior and making it clear that many behaviors previously viewed as benign are unacceptable and inhibitory to diverse and innovative workplaces. On the other hand, such trends may also be inhibiting discussion and progress toward cultural change in some contexs, due to fears about job loss, legal culpability, and workplace controversy.

Similarly, many of those interviewed at the institutional level saw issues with resource availability, time to spend on activities that seem valuable but are not institutionally supported. There were plenty of those who observed that research incentives are often contrary to the interests of producing scientific progress, but these issues appear intractable at any scale. Those analyzing this at the systemic level see it as an issue of management and hiring, while those at the level of organizational management view the issue as a broad systemic reality, in which the hands of senior researchers and institutional leadership are tied.

8. Conclusions

8.1 Policy recommendations to national policy makers

Recommended actions that can be taken at the U.S. national level to forward responsible research and innovation include:

Look across the broad landscape of funded programs for science education and public engagement to find best practices and forward methodological research for best practices in this area. Such a diversity of programs and opportunities are funded, but not enough lessons learned and ways forward are drawn out of these experiences and streamlined to advance knowledge and practice in science education and public engagement. Science education and public engagement programs that fulfill the parallel goals of instilling scientists in training with much needed science education and public engagement competencies are fundamental to progress, and enriching science-education and increasing the visibility and embeddedness of scientists within the broader community.

The U.S. should make public engagement more of a clear priority with goals and an articulation of what the goals and objectives of particular interventions are. Programs should be assessed, and successful programs exampled and funded as part of long-term policy. This should explicitly facilitate public engagement around science and technology policy that is premised on multi-directional communication, and open definition of the terms of debate. Such an approach would ideally create a space for public deliberation around technological advance that goes beyond risk analysis, leveraging anticipatory methods.

Refund the Office of Technology Assessment. This government function is central to the ability of lawmakers to make informed decisions around scientific issues.

8.2 Policy recommendations to European policy makers

This research has found the U.S. context to be the outcome of particular historical, cultural and policy configurations that are not broadly shared across nations, and thus what works or exists in the U.S. does not easily transfer across national boundaries. Thus, recommendations to European policy makers are necessarily circumscribed. Recommendations include:

- Increase international-scale collaborations around RRI-dimensions
- Avoid fractious national political debates among allies and member states by targeting international outreach at levels below the national or executive level
- Address issues of identity and diversity through an intersectional lens, do not just focus on gender.
- Integrate AIRR dimensions as modes of enacting keys

8.3 Recommendations to research conducting and funding organizations

Our general recommendations for research conducting organizations begin with the suggestion that interested organizations fund or commission an RRI assessment of their own organizations, and consider forming task forces to address each area of interest in a way tailored to meet the organization's needs. The process of analysis and interrogation helps to articulate a baseline understanding of the existing situation, issues of concern, potential areas of improvement, and areas of shared interest among the organization's members that may not otherwise be visible. Other more specific recommendations below may not map well onto research conducting organizations in different social and legal contexts and with different priorities than the organization where these recommendations were formulated. Nonetheless, below are some suggestions for research conducting organizations:

- Clearly articulate institutional values and priorities, and host forums for development and continued discussion of these values. RRI dimensions can be introduced through research talks and other artistic and cultural engagements which introduce areas of interest and establish shared values, rather than creating the threat of reprisal for undesirable behaviors.
- Consider feasibility and desirability of changes to how researchers' priorities are structured. This may require an explicit redefinition of "excellence" parameters used in hiring strategies.
- Offer trainings for researchers on public communication and outreach philosophies and techniques.
- Hire scientifically literate staff to facilitate science education and public outreach programs that facilitate direct open lines of communication between researchers and key publics, especially K-12 students and teachers.
- Create institutional statements on data stewardship, and integrate researcher engagement with such questions into hiring strategies and conceptualizations of excellence.
- Partner with social science researchers and research institutes, cross-share findings and objectives to find areas of potential partnership, collaboration and mutual support.

8.4 Best practices[236] scalable to European or national level

A range of good practices are offered throughout the document. Those that may be relevant at the national or supranational level include:

- Address structural aspects of scientific training and practice that provide a fertile ground for sexual harassment and other forms of discrimination. The National Academies propose modes of addressing sexual harassment for advancing gender equality and diversity in research and innovation, focusing on transforming culture over legal compliance, emphasizing transparency and accountability, creating more diffuse systems of hierarchy and power, supporting research directly addressing sexual harassment, and broadening the culpability for harassment and culture to the entire academic community (among others).[237]
- Acknowledge issues of race, gender and other identity factors as deeply enmeshed and mutually reinforcing issues in RRI keys. An intersectional approach to equality and inclusion is recommended in place of the more narrowly gender-focused key.
- Institute a set of (ideally scalable cross-nationally) practices for sharing research plans for broad interdisciplinary review before the research gets done, as part of open science. While this work is nascent and not broadly adopted, it has potential to increase transparency, early public engagement with, and interdisciplinary oversight of research. See the work of MIT's Sculpting Evolution research group for more details on the justification, objectives, and experience of this initiative.[238]
- Promote Open Material Transfer Agreements (MTAs) as part of open science. Creating the legal infrastructure for more accessible, searchable and attributable material transfer is an oft-overlooked but important element of open science practices. See the work done in this area by the Biobricks foundation.[239]

---

[236] See section 5.3 D for a discussion of the challenges associated with efforts to identify best practices in this research context.

[237] National Academies of Sciences Engineering and Medicine (2018*) Sexual Harassment of Women Climate, Culture, and Consequences in Academic Sciences, Engineering, and Medicine*. National Academies Press. Available: http://nap.edu/24994. Accessed: June 19, 2018.

[238] Sculpting Evolution. Sharing Research Plans. Available: http://www.sculptingevolution.org/proposals. Accessed: July 2, 2018.

[239] Biobricks Foundation. "Open Materials Transfer Agreement." Available: https://biobricks.org/openmta/. Accessed: June 8, 2018.

- Funding programs to connect STEM graduate students with K-12 classrooms.
- Provide policies and resources dedicated to preventing and addressing sexual assault, such as dedicated personnel (at the University level) for addressing complaints and training faculty, staff, and students; Duty to Report rules that require faculty and staff to report any allegations of unwanted sexual contact to relevant university authorities; legal protections for transgender people; and use of a third category in fillable forms allowing people to identify outside of the male-female binary.
- Fund researchers dedicated to studying science education techniques and producing materials that are responsive to those research finding.
- Facilitate global networks and forums for governance of potentially transformative emerging technologies that are inclusive and transparent, inviting multiple viewpoints.[240]

[240] Jasanoff, S. and Hurlbut, J.B. (2018). "A global observatory for gene editing." *Nature*. Available: https://www.nature.com/articles/d41586-018-03270-w. Accessed: July 3, 2018.

9. Annex 1: Reviewed documents

American Association for the Advancement of Science. (2013). The Power of Partnerships: A Guide from the NSF Graduate Stem Fellows in K–12 Education (GK–12) Program. AAAS.

Committee on Homeland and National Security of the National Science and Technology Council. (2016). 21st Century Science, Technology, and Innovation Strategy for America's National Security. Available: https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/NSTC/national_security_s_and_t_strategy.pdf. Accessed: June 11, 2018.

Council on Government Relations. (2017). "Summary of Changes to the Common Rule." Available: https://www.cogr.edu/sites/default/files/Summary%20of%20Changes%20to%20the%20Common%20Rule_COGR.pdf. Accessed: June 7, 2018.

Department of Education Office for Civil Rights. (2017). "Q&A on Campus Sexual Misconduct." Available: https://www2.ed.gov/about/offices/list/ocr/docs/qa-title-ix-201709.pdf. Accessed: May 16, 2018.

Department of Education Office for Civil Rights. (2011). "Dear Colleague Letter." Available: https://www2.ed.gov/print/about/offices/list/ocr/letters/colleague-201104.html Accessed: May 16, 2018.

Department of Education Office for Civil Rights. (2016). "Dear Colleague Letter on Transgender Students." Available: https://www2.ed.gov/about/offices/list/ocr/letters/colleague-201605-title-ix-transgender.pdf. Accessed: June 4, 2017.

Department of Education Office for Civil Rights. (2016). "Dear Colleague Letter on Gender Equity in Career and Technical Education." Available: https://www2.ed.gov/about/offices/list/ocr/letters/colleague-201606-title-ix-gender-equity-cte.pdf. Accessed: June 5, 2018.

Department of Education Office for Civil Rights. (2017). "Dear Colleague Letter." Available: https://www2.ed.gov/about/offices/list/ocr/letters/colleague-201702-title-ix.pdf. Accessed: June 4, 2018.

Department of Education. (2015). "Dear Colleague Letter on Title IX Coordinators." Available: https://www2.ed.gov/about/offices/list/ocr/letters/colleague-201504-title-ix-coordinators.pdf. Accessed: June 5, 2018.

Department of Health and Human Services. (2016). Open Government Plan Version 4.0. Available: https://www.hhs.gov/sites/default/files/hhs-open-gov-plan-v4-2016.pdf. Accessed: June 11, 2018.

Department of State. (2012). Digital Government: Building a 21st Century Platform to Better Serve the American People. Available: https://obamawhitehouse.archives.gov/sites/default/files/omb/egov/digital-government/digital-government.html. Accessed: June 8, 2018.

Department of State. (2013). The Open Government Partnership Second Open Government National Action Plan for the United States of America. Available: https://obamawhitehouse.archives.gov/sites/default/files/docs/us_national_action_plan_6p.pdf. Accessed: June 8, 2018.

Environmental Protection Agency. (2018). “Strengthening Transparency in Regulatory Science.” The Federal Register. Available: https://www.federalregister.gov/documents/2018/04/30/2018-09078/strengthening-transparency-in-regulatory-science.

Executive Office of the President. (2017). “Enforcing the Regulatory Reform Agenda: Executive order 13777.” The Federal Register. Available: https://www.federalregister.gov/documents/2017/03/01/2017-04107/enforcing-the-regulatory-reform-agenda. Accessed: May 18, 2018.

Executive Office of the President. (2017). “Promoting Energy Independence and Economic Growth: Executive order 13783.” The Federal Register. Available: https://www.federalregister.gov/documents/2017/03/31/2017-06576/promoting-energy-independence-and-economic-growth. Accessed: May 18, 2018.

Executive Office of the President Office of Science and Technology Policy. (2013). “Memorandum for the Heads of Executive Departments and Agencies.” Available: https://www.eff.org/sites/default/files/ostp-public-access-memo.pdf. Accessed: June 7, 2018.

Government Accountability Office. (2004). GENDER ISSUES Women’s Participation in the Sciences Has Increased, but Agencies Need to Do More to Ensure Compliance with Title IX. Available: https://www.gao.gov/new.items/d04639.pdf. Accessed: June 28, 2018.

Government Accountability Office. (2010). Federal Contracting: Assessments and Citations of Federal Labor Law Violations by Selected Federal Contractors. Available: https://www.gao.gov/assets/310/309785.pdf. Accessed: May 31, 2018.

Government Accountability Office. (2016). Open Innovation: Practices to Engage Citizens and Effectively Implement Federal Initiatives. Available: https://www.gao.gov/assets/690/680425.pdf. Accessed: June 8, 2018.

Interagency Working Group on Digital Data. (2009). Harnessing the Power of Digital Data for Science and Society. Available: https://www.nitrd.gov/pubs/Report_on_Digital_Data_2009.pdf. Accessed: June 7, 2018.

Interagency Working Group on Open Data Sharing Policy of the Subcommittee on International Issues of the Committee on Science of the National Science and Technology Council. (2016). “Principles for Promoting Access to federal Government-Supported Scientific Data and Research Findings Through International Scientific Cooperation.” Available: https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/NSTC/iwgodsp_principles_0.pdf. Accessed: June 8, 2018.

McEwen, J. E., Boyer, J. T., Sun, K. Y., Rothenberg, K. H., Lockhart, N. C., & Guyer, M. S. (2014). The Ethical, Legal, and Social Implications Program of the National Human Genome Research Institute: Reflections on an Ongoing Experiment. Annual Review of Genomics and Human Genetics, 15(1), 481–505.

National Academies of Sciences, Engineering and Medicine. (2004). Seeking Security: Pathogens, Open Access, and Genome Databases. National Academy Press. Available: http://nap.edu/11087. Accessed: June 4, 2018.

National Academies of Sciences Engineering and Medicine. (2010). Gender Differences at Critical Transitions in the Careers of Science, Engineering, and Mathematics Faculty. National Academies Press. Available: http://nap.edu/12062. Accessed: June 19, 2018.

National Academies of Sciences Engineering and Medicine. (2011). Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads. National Academies Press. Available: http://nap.edu/12984. Accessed: June 11, 2018.

National Academies of Sciences, Engineering and Medicine. (2014). Emerging and Readily Available Technologies and National Security. National Academies Press. Available: http://nap.edu/18512. Accessed: May 23, 2018.

National Academies of Sciences, Engineering and Medicine. (2017). Fostering Integrity in Research. National Academy Press. Available: http://nap.edu/21896. Accessed: June 25, 2018.

National Academies of Sciences Engineering and Medicine. (2018). Sexual Harassment of Women Climate, Culture, and Consequences in Academic Sciences, Engineering, and Medicine. National Academies Press. Available: http://nap.edu/24994. Accessed: June 19, 2018.

National Academies of Sciences Engineering and Medicine. (2018). Graduate Stem Education for the 21st Century. National Academies Press. Available: http://nap.edu/25038. Accessed: June 27, 2018.

National Academies of Sciences Engineering and Medicine. (2012). A Framework for K-12 Science Education. National Academies Press. Available: https://www.nap.edu/catalog/13165/a-framework-for-k-12-science-education-practices-crosscutting-concepts. Accessed: June 11, 2018.

National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research. (1979). The Belmont Report. Available: https://www.hhs.gov/ohrp/sites/default/files/the-belmont-report-508c_FINAL.pdf. Accessed: May 23, 2018.

National Institutes of Health. (2015). Plan for Increasing Access to Scientific Publications and Digital Scientific Data from NIH Funded Scientific Research. Available: https://grants.nih.gov/grants/NIH-Public-Access-Plan.pdf. Accessed: June 5, 2018.

National Science Foundation. (2014). Perspectives on Broader Impacts. Available: https://www.nsf.gov/od/oia/publications/Broader_Impacts.pdf. Accessed: June 10, 2018.

National Science Foundation. (2015). NSF's Public Access Plan: Today's Data, Tomorrow's Discoveries: Increasing Access to the Results of Research Funded by the National Science Foundation. Available: https://www.nsf.gov/pubs/2015/nsf15052/nsf15052.pdf. Accessed: June 7, 2018.

National Science Foundation. (2015). Revisiting the STEM Workforce: A Companion to Science and Engineering Indicators 2014. Available: https://www.nsf.gov/pubs/2015/nsb201510/nsb201510.pdf. Accessed: June 11, 2018.

National Science Foundation. (2016). Open Government Plan 4.0. Available: https://www.nsf.gov/pubs/2016/nsf16131/nsf16131.pdf. Accessed: June 10, 2018.

Office of Management and Budget. (2009). "Open Government Directive." Available: https://www.treasury.gov/open/Documents/m10-06.pdf. Accessed: June 10, 2018.

Office of Science and Technology Policy. (2015). "Memorandum to the Heads of Executive Departments and Agencies: Addressing Societal and Scientific Challenges through Citizen Science and Crowdsourcing." Available:

https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/holdren_citizen_science_memo_092915_0.pdf. Accessed: June 10, 2018.

Office of Science and Technology Policy Committee on Science. (2016). “Charter of the Interagency Working Group on Open Science Committee on Science National Science and Technology Council.” Available: https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/NSTC/cos-iwgos-charter-1016-signed.pdf. Accessed: June 8, 2018.

Presidential Commission for the Study of Bioethical Issues. (2013). ANTICIPATE and COMMUNICATE Ethical Management of Incidental and Secondary Findings in the Clinical, Research, and Direct-to-Consumer Contexts. Available: https://bioethicsarchive.georgetown.edu/pcsbi/sites/default/files/FINALAnticipateCommunicate_PCSBI_0.pdf. Accessed: June 28, 2018.

Report of the Interagency Working Group on Digital Data to the Committee on Science of the National Science and Technology Council January. (2009). Harnessing the Power of Digital Data for Science and Society. Available: https://www.nitrd.gov/pubs/Report_on_Digital_Data_2009.pdf. Accessed: June 11, 2018.

“Science Benefits from Diversity.” (2018). Nature. Available: https://www.nature.com/articles/d41586-018-05326-3. Accessed: June 7, 2018.

Union of Concerned Scientists. (2016). Science-Community Partnerships: A Scientist’s Guide to Successful Collaboration. Available: https://www.ucsusa.org/sites/default/files/attach/2016/04/ucs-scientist-community-partnerships-2016.pdf. Accessed: June 8, 2018.

White House. (2009). “Presidential Documents: Transparency and Open Government.” Federal Register 74 (15). Available: https://www.gpo.gov/fdsys/pkg/FR-2009-01-26/pdf/E9-1777.pdf. Accessed: June 10, 2018.

White House. (2012). National Bioeconomy Blueprint. Available: https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/national_bioeconomy_blueprint_april_2012.pdf. Accessed: June 30, 2018.

White House. (2014). U.S. Open Data Action Plan. Available: https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/us_open_data_action_plan.pdf. Accessed: June 10, 2018.

White House. (2014). “Executive Order—Fair Pay and Safe Workplaces.” Available: https://obamawhitehouse.archives.gov/the-press-office/2014/07/31/executive-order-fair-pay-and-safe-workplaces. Accessed May 31, 2018.

10. Annex 2: Matrices

Table 1: Analysis of the open access key

	Structural issues	Cultural issues	Interchange related
Current organizational practices	University policy on OA; Library offers support serviced for open access and open data.	Widely shared positive view of OA in the organization.	Federal research granting agencies require open access on the part of funded researchers.
Potential drivers for the open access-key	Increasing institutional attention to the issue and organizational support for OA and data sharing.	Shared understanding that OA and data sharing are increasingly important for research practice and funding success; support on the part of leadership for	Requirements of funding agencies for data sharing and OA.

		initiatives around data management.	
Potential barriers to the open access-key	Prestige and career incentives still tied to journal impact factor and not OA; conflicting logics between open science and intellectual property/commercial incentives; time and resources for focusing on OA and data sharing remain limited.		Prestige in broader national science system remains correlated with journal impact factor above OA considerations. OA is not yet a broader systemic norm.
Most important potential organizational actions	Create a task force on Data stewardship and ethics; Incentivise and reward OA and data sharing; Create of a mechanism to track rates of open access publication within the organization; Create an institutional statement on data stewardship	Raise awareness of open access and data management ethics through seminars and other events; communicate institutional values around open science.	Partner with the library for open access and data sharing support.
Indicators for success	Formation of a task force on data stewardship and ethics; Completion of a charter for this task force; Publication of an institutional statement on ethics and data stewardship; Creation of institutional mechanisms of recognition for ethics and data stewardship; Creation of a mechanism to track rates of open access publication within the organization; An increase in institutional rates of use of data repositories and open access publishing.	Increased awareness across research staff indicated by answers to questions in survey.	Institutionalized partnerships with other units in the university and/or the community
Potential indicator for improved performance	• 10 % increase in reported awareness of OA policies & data sharing practices in organizational surveys by 2020. • 10% increase in OA publishing within the institute.		

Table 2: Analysis of the gender/diversity-key

	Structural issues	Cultural issues	Interchange related
Aspects of organizations	A stark gender imbalance exists among research faculty, with over twice as many male research faculty than female; The organization is diverse in terms of international representation, but less so in terms of underrepresented populations such as blacks, Latinos and native people; Strong sexual harassment policies are in place; The Office for Equity and Inclusion on campus provides enforcement.	Recognition that gender imbalance is an issue, but little real awareness of how it can be addressed.	Gender and diversity are the subject of a long history of legislation at the level of the U.S. federal government; Gender equality is an issue of active public concern in the US, as a result of the Metoo movement, and regressive political positions of the current presidential administration.
Potential drivers for the gender/diversity-key	Established structures for addressing claims of sexual harassment; Duty to report claims of sexual harassment.	Increasing articulation and recognition of imbalances; commitment of leadership to making space for addressing issues associated with gender equality and diversity.	National legal protections against discrimination; Broader social movements at the national level for various aspects of gender equality and protection from sexual harassment;
Potential barriers to the gender/diversity-key	Current resource allocation to these issues is low; No dedicated personnel within the Institute for addressing these issues.	Self-reproducing culture; little understanding of how the issue might be addressed; low enthusiasm for most modes of intervention.	Strong national legal impediments to quota-based hiring; orientation of the university toward legal coverage over accountability and cultural development.
Most important potential organizational actions	Appoint a task force to coordinate and drive action in this area. Assess and take action on other ways in which gender equality and diversity can be embedded in existing organizational activities.	Work with the University's Title IX office to provide trainings on implicit bias and other relevant topics.	Seek insights from other departments and researchers who engage with these issues for possible areas of intervention; invite speakers from outside of the organization who conduct research on gender and diversity issues for Institute-wide seminars.
Indicators for success	Formation of a task force on gender equality and diversity; Completion of a charter for this task force.	Increased awareness of implicit bias and existing issues of inequality.	Increased interaction on gender and diversity issues with other departments; inclusion of these topics in research seminar series.
Potential indicator for improved performance	Existing indicators ▪ % of women employed ▪ number of different countries of origin represented by faculty and staff Potential new indicators: ▪ perception indicators (to be measured annually through questionnaires), for instance: awareness of the impact of stereotypes and unconscious bias on diversity in science; barriers for inclusion; understanding of the diversity dimension in research, etc.; ▪ % of black, Latino and native people compared to AZ demographic data. ▪ % of men/women that are principal investigators on a project (annual evaluation); ▪ % of men/women that are first (corresponding) authors on research papers/publications (annual evaluation). ▪ % of research projects including gender/diversity analysis or considering gender/diversity dimensions (annual evaluation, out of total n. of projects).		

Table 3: Analysis of the Ethics key

	Structural issues	Cultural issues	Interchange related
Aspects of organizations	Engages university institutional review board oversight RCR training for graduate students and post-doctoral researchers Limited time and resources available for ethics	Uneven engagement across labs with ethical deliberation. Ethical deliberation viewed as a luxury for which there is insufficient time to engage Reliance on IRB procedures to address ethical issues	The organization is embedded within the university, which provides clear formalized, legalistic ethics procedures and trainings. National funding-based requirements for RCR training and review board oversight drive ethics practice
Potential drivers for the ethics-key	New interest that the Institute's leadership has shown in this area.	While existing institutional culture and norms do not foster ethical reflection across the Institute, there is an expressed interest in changing the status quo.	Requirements by funding bodies may potentially evolve, and new requirements drive change. National conversations around reproducibility and ethical conduct create sense of crisis and may drive change within the organization as well.
Potential barriers to the ethics-key	Little time to reflect on ethics, no incentive to do so. Lack of existing resources for addressing differences in ethical frameworks, and training junior researchers in this area.	Lack of shared ethical frameworks and understandings.	Ethical boxes are checked by completing IRB requirements at the university level, thus little perceived need to create mechanisms at the organizational level.
Most important potential organizational actions	Formation of a task force on data stewardship and ethics; Completion of a charter for this task force; Publication of an institutional statement on ethics and data stewardship; Creation of institutional mechanisms of recognition for ethics and data stewardship; Speakers are invited	Increase awareness across research staff.	Form partnerships to support ethical engagement outside of the Institute—with other units in the university, and potentially beyond.
Indicators for success	The existence of a task force on ethics and data stewardship The completion of a charter for this task force The creation of modes of recognition for ethics and data stewardship.	Survey responses indicating increased awareness and engagement with ethical issues	Institutionalized partnerships with other units in the university and/or the broader community
Potential indicator for improved performance	• Perception indicators (to be measured annually through questionnaires), for instance: levels of perceived ethical engagement of institutional leadership; sense of institutional support for ethical deliberation; reported contact with project interventions such as seminars and ethicists; and knowledge of available resources. • Instances of reported problematic or unethical research practice.		

Table 4: Analysis of the Societal Engagement key

	Structural issues	Cultural issues	Interchange related
Aspects of organizations	Large-scale “open-house” events hosted at the organization Distributed practices at the center, lab, or researcher level. Diverse, and not well accounted for, monitored and sourced as potentially scalable practices	Shared understanding of the aims and strategies of public engagement largely framed as a one-way communication	The university has a stated dedication to community embeddedness and interdisciplinarity
Potential drivers for the Societal Engagement key	The diversity of practices at the individual lab and researcher level has the ongoing potential to introduce new practices and ways of engaging publics into institutional practice	The organization understands itself to be nimble and innovative. Such openness to change holds open the possibility for future development of more two-way communication in societal engagement.	The university’s institutional culture promotes interdisciplinarity and social embeddedness. Increasing partnerships with other units across the university. Requirements and incentives for public engagement activities by funding organizations.
Potential barriers to the Societal Engagement key	Lack of commitment to two-way communication with publics	Prevalent understandings of the role of the community in science and the role of scientists in the community Concern that if scientific practice is more transparent and open to public input, this will lead to increased problems and impediments to research	Political climate that positions citizens as pro- and anti-science
Most important potential organizational actions	Seek researchers interested in engaging in two-way communication in public engagement with labs	Expand understanding of relationship between researchers and the community	Seek out and expand partnerships with units and organizations across the university and community
Indicators for success	Existing indicator: public engagement and related science education efforts are measured in terms of numbers reached.	N/A	N/A
Potential indicator for improved performance	N/A – The organization’s leadership was not interest in engaging with the project in this particular area at the current time. As such, no points of improvement were agreed upon in this area, and thus no indicators for success generated.		

Table 5: Analysis of the Science Education key

	Structural issues	Cultural issues	Interchange related
Aspects of organizations	Science education activities are currently unevenly distributed across the Institute, with no clear central organization or bank of knowledge Lack of coordination and cross-learning among diverse science education activities Science education appears to be concentrated on particular issues (such as sustainability), in centers that take an interest in the activity	Sense that science education (beyond core commitments such as educating lab personnel and graduate students) is extra, and potentially takes time away from scientific research	Many researchers take part in producing content for the "Ask A Biologist" website, a university-wide interactive platform for members of the public to engage with researchers at ASU on particular questions of interest
Potential drivers for the Science Education key	Ongoing efforts to expand science education efforts at the level of BDI leadership The dedication of an entire research center to science education activities	Shared appreciation of the value in educating the community that ASU serves Shared ethic of promoting equity in distribution of technological benefits across populations may suggest a path for science education efforts to counter prevailing inequities at the community level and beyond	Interest at the university level in innovating and coordinating science education efforts
Potential barriers to the Science Education key	Disjuncture between leadership and others in the organization concerning values and goals of science education efforts Lack of dedicated resources to promoting science education across the organization, rather resources are expended in a top-down manner Lack of collaboration in this area across centers	Marketing and fundraising orientation of centralized efforts at science education Lack of engagement with education research for many existing science education initiatives	
Most important potential organizational actions	Foster engagement on science education activities across centers, while providing leadership and resources to facilitate a consistent and committed relationship with the communities it serves	Facilitate dialogue around best practices for science education across the Institute	
Indicators for success	N/A	N/A	N/A
Potential indicator for improved performance	N/A – The organization's leadership was not interest in engaging with the project in this particular area at the current time. As such, no points of improvement were agreed upon in this area, and thus no indicators for success generated.		

Table 6: Analysis of the AIRR Dimensions

	Structural issues	Cultural issues	Interchange related
Aspects of organizations	Elements associated with the AIRR dimensions are not clearly pursued or programmatized the Institute's mission to improve health, sustainability, and security suggests a somewhat anticipatory orientation BDI aims to be nimble and responsive to past experiences, few routinized procedures	Elements such as anticipation and reflection widely viewed as the purview of social scientists Generalized lack of understanding of the role of these dimensions, and how they might be operationalized	Position of the Institute within the university, associated cultural commitments of the university toward interdisciplinarity, social embeddedness, and global engagement
Potential drivers for the AIRR Dimensions	Willingness of the leadership to consider social science interventions around data, ethics, gender and inclusion, potentially leading to engagement involving AIRR dimensions Engagement with Institutional Review Boards, and other tools of ethical consideration can be conceptualized as avenues to enhance institutional capacity for anticipation and reflexivity.		Partnerships with other units in the university, such as SFIS, may enable the development of capacities associated with the AIRR dimensions
Potential barriers to the AIRR Dimensions	Problematic juxtaposition and overlap of the keys with the AIRR dimensions produces a preference for keys	Ingrained ideas about the nature of scientific inquiry, and scientific autonomy	Lack of clear articulation of relationship between AIRR dimensions and the keys among RRI-advocates
Most important potential organizational actions	Hosting activities and seminars that promote questioning and reflection	Fostering conversation among faculty, students and publics around data sharing, institutional data ethics statements, and other such activities, in which anticipation and reflexivity have the potential to play a significant role	Embedding social scientists in laboratories
Indicators for success	N/A	N/A	N/A
Potential indicator for improved performance	N/A – The organization's leadership was not interest in engaging with the project in this particular area at the current time. As such, no points of improvement were agreed upon in this area, and thus no indicators for success generated.		