**Science Policy Research Report**

# New Directions for Impact – Broader Impacts 2.0

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**Executive summary**

This research report offers an environmental scan of recent US and international developments surrounding efforts to promote the broader societal impacts of scientific research. It seeks to provide the scientific community and policy makers with a better understanding of the current state of research into broader impacts, to outline trends, and to point toward fruitful new directions for research. The report concludes that *the central question surrounding broader impacts today is how best to combine the traditional focus on the supply side (scientists disseminating facts to the public) with greater attention to the demand side (the public's receptivity to science)* in order to enhance communication and benefit society.

Policy Recommendations

1. *Conduct research on both the 'supply side' and 'demand side'*. The question of broader impacts has broken loose from its origin in the STEM and policy communities to become fundamentally inter- and transdisciplinary in nature. Future research on broader impacts must account for both 1) the original, intra-scientific debate surrounding broader impacts (issues of autonomy and accountability, resistance versus acceptance, peer review and metrics) and 2) the ongoing changes in the overall cultural receptivity of science. Therefore, **Congress should increase funding for NSF's Directorate for Social, Behavioral, and Economic Sciences**.

2. *Require the assessment of potential 'grimpacts'*. It is unrealistic, and increasingly politically naïve, to present accounts of scientific and technological impact as always 'win-win'. Therefore, **the requirement for imagining possible broader impacts should be modified to include an account of the possible negative impacts (or 'grimpacts') of technoscientific advance**.

3. *Acknowledge the 'ecosystem' of broader impacts*. Disciplinary standards and university promotion and tenure criteria usually reward scholarly impact at the expense of broader impacts activities. Therefore, **funding agencies should create venues for ongoing dialogue with higher education policy groups, professional societies, and others to realign the higher education reward system with the realities of Broader Impacts 2.0**.

Potential Impacts of Suggested Policy Changes

1. The new cultural environment for receptivity to science highlights the need for expanded broader impacts research in areas such as history, anthropology, media studies, psychology, political science, philosophy, and science, technology, and society studies. **Increased funding for social, behavioral, and economic sciences, especially with a focus on understanding the demand side for scientific and technical knowledge, will help us learn how best to maximize the value to taxpayers of tax dollars spent on research**.

2. **A genuine effort to account for the potential negative impacts of research on society is likely to increase the level of trust society has that the research it funds will actually benefit society**. Ignoring potential grimpacts, however, will continue to feed a post-truth narrative.

3. Aligning university promotion and tenure guidelines with funding agency policies to promote broader impacts activities is a tall order. However, **doing so will radically increase the chances that researchers will take broader impacts activities as seriously as they do scholarly impact**.

> The aide said that guys like me were "in what we call the reality-based community," which he defined as people who "believe that solutions emerge from your judicious study of discernible reality." I nodded and murmured something about enlightenment principles and empiricism. He cut me off. "That's not the way the world really works anymore. We're an empire now, and when we act, we create our own reality. And while you're studying that reality—judiciously, as you will—we'll act again, creating other new realities, which you can study too, and that's how things will sort out. We're history's actors … and you, all of you, will be left to just study what we do."
>
> – Suskind 2004

## 1. Introduction

Public science agencies today expect excellence in advancing science, coupled with a clear description of accompanying societal benefits. This report outlines current trends for increasing the impacts of scientific research, such as the focus on responsible research and innovation, Altmetrics, and the Open Science movement, as well as the wider effects of trends in social media and the development of an increasingly relativistic culture upon broader impact activities.

Public science has always been tied to societal needs. But until the mid-1990s, parties to the social contract between science and society – the scientific community, the policy community, and government itself, as representative of the people's interest – assumed the passive dissemination of scientific knowledge into society. This view, the 'linear model', was endorsed by leading post-war thinkers such as Vannevar Bush and Michael Polanyi (2000). 'Broader impacts' were seen as the natural result of the power of scientific research, as discoveries made their way out to society.

The FY1998 creation of a separate Broader Impacts Criterion at NSF marked a decisive shift in these assumptions: making science relevant to societal needs was now thought to require conscious efforts. These efforts took a variety of forms, but they generally assumed both a passive and a static model of public understanding. Scientists knew things the public did not, and so scientists devised ways to increase the supply of scientific information to the public. This, the 'deficit model' of public understanding, came under increasing criticism in the early 2000s. Scrutiny focused on the ways that personal and local knowledge offered a valuable adjunct to scientific knowledge, as it was recognized that local communities are also often in possession of relevant insights.

But this criticism of the deficit model no longer captures the current challenges for scientific attempts to communicate with the public. The public has grown more restive toward the scientific community, as scientifically established facts are increasingly portrayed as political in nature. This shift reflects two new elements in the relation between science and society. First, 40 years of social constructivist critique have filtered out into wider society, contesting the traditional objectivist model of the nature of science. Second, the last 10 years have seen massive changes in the media landscape, opening new opportunities for both influencing (or more balefully, manipulating) public opinion.

Combined, these two factors have changed the landscape for broader impacts. Consensus views of the scientific establishment have been traditionally presented as a narrative disseminated to the public. But now these narratives are contested by counter-narratives organized by a variety of actors, who use the tools of social media to distribute divergent storylines. These actors enlist the public through powerful mediating devices (e.g., Google, Facebook, Twitter) in order to contest consensus accounts of the scientific community in ways that are often invisible to scrutiny. Then, in an ironic reversal, both the scientific consensus and journalistic attempts at refereeing the resulting debates are often dismissed as "fake news." Generating controversy in this way both casts doubt on the consensus scientific account by

implying that the issue is more contested than it actually is, and more generally encourages the belief that all knowledge is biased.

This is the situation that the scientific community finds itself in today in attempting to enhance its broader impacts. Our research into the current state of broader impacts suggests that questions of post-truth are not a passing fad, but instead represent a major challenge to the scientific community. The science and policy communities must reckon with new social, media, and political realities that call for new approaches for the achievement of broader impacts. The central question surrounding broader impacts today is how best to combine the traditional focus on the supply side (scientists disseminating facts to the public) with greater attention to the demand side (the public's receptivity to science) in order to enhance communication and benefit society.

## 2. Background

Concerns with the broader impacts of science gained focus in the early 1990s (for instance, the Ethical, Legal, and Societal Implications [ELSI] Program within the Human Genome Project), and were established as an explicit element of *ex ante* research evaluation with the introduction of the two Merit Review Criteria – intellectual merit and broader impacts – at the National Science Foundation in FY1998 (Holbrook 2012). Since this time there has been an ongoing evolution of thinking about the nature of broader impacts, both in the US and abroad, where the term has increasingly shifted to the notion of Responsible Research and Innovation (RRI).

Three periods in the development of thinking about broader impacts can be identified – with the understanding that the attitudes characteristic of earlier periods have not vanished, but continue even as each new development has been added to the mix:

> **1. 1945-1990:** During the Cold War the question of broader impacts was rarely treated as a distinct problem. Policy makers and researchers assumed that broader impact was a mostly automatic process. Researchers were granted a large degree of autonomy, with accountability addressed in a disciplinary manner, through the mechanism of peer review. If the science passed disciplinary muster, it had fulfilled demands of accountability. Broader dissemination was viewed to be a largely unproblematic process – or at the least, not an issue for scientists.
>
> **2. 1990-2007:** The end of the emergency footing of the Cold War encouraged a more critical attitude toward the societal benefits of science. Policy makers now saw the question of societal accountability as an issue distinct from theoretical rigor. Researchers often resisted such demands for increasing accountability, on the grounds that they interfered with the autonomy of scientific research. Nevertheless, the period witnessed the gradual development of more sophisticated attention to questions of broader impacts.
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> **3. 2007-present:** This period has seen growing pressure upon funding agencies to demonstrate accountability, as evidenced by the America COMPETES Acts of 2007 and 2011, the 2013 revision of merit review criteria at the NSF, and the European Commission's focus on 'the three Os' (Open Innovation, Open Science, and Open to the World). This period has also seen the development of new approaches to peer review, such as incorporating research 'users' into the peer review process, and the growing use of metrics for assessing broader impacts, including altmetrics (Priem et al., 2010).

This third stage, however, now appears to mark the transition to a new state of affairs, as intra-scientific efforts at increasing broader impacts are being overtaken by larger cultural forces. The most salient of

these forces are the undermining of consensus scientific conclusions, and the growth of criticisms of mainstream media as 'fake news'. These two phenomena are both cause and effect of the fragmented social media landscape. These changes are common across Western culture, but are particularly prominent within the United States (US) and United Kingdom (UK), and can be seen as the result of neopopulist reactions to societal dislocations resulting from continued technoscientific innovation.

These new conditions suggest the need to reexamine our thinking about broader impacts. Hitherto, conversation about improving broader impacts has focused on the 'supply side' of the science-society relation: how can we influence science and engineering communities so that they are more responsive to public needs and perspectives? But public needs and perspectives have been viewed as being both passive and static in nature. While different audiences (policy makers, museums, school groups, the public in general) were recognized, little attention was paid to the possibility that both the assumptions and the views of these groups could shift over time, and thus necessitate continual innovations in how to make the connection between science and society. Nor was thought given to the fact that the views of one or another segment of the public could be consciously managed by either state or non-state actors. But under the influence of new social media and the fragmentation of any common core of accepted facts, the 'demand side' of broader impacts is changing in precisely these ways (Higgins 2016, National Academies 2016, Anonymous 2017, Holbrook 2017).

**The central conclusion of this research report is that the rise of a new social environment for the reception of scientific research calls for the reframing of our thinking about broader impacts.** New cultural assumptions and a new media environment are challenging the epistemic supremacy of science as uniquely reliable knowledge. This situation highlights the need for research into finding new means for integrating scientific insights with a wide range of audiences.

The rest of this report has two goals. In section 3, it reviews the latest elements of what can be called the intra-scientific debate surrounding broader impacts, in terms of its major themes – autonomy versus accountability, resistance versus acceptance, peer review and metrics, and mechanisms for encouraging broader impacts. These issues are of continuing importance. The report, however, puts its greatest weight on section 4, which argues that particular focus needs to be paid to ongoing changes in the general cultural receptivity of science.

## 3. Broader Impacts: The State of the Art

This section outlines the state of the art concerning broader impacts. It begins with an account of the underlying philosophical issues surrounding the introduction of broader impacts criteria as part of research funding decision making. It then outlines the major approaches that have been used to assess and encourage broader impacts activities (peer review, quantitative metrics, and programmatic efforts).

### *3.1 The history, philosophy, and politics of impact*

The US National Science Foundation was conceived as an agency that would support basic research in service to society. Vannevar Bush (1945) saw the link between basic research and societal benefits is that the former is necessary for the latter. As Bush put the point, without basic research, the wheels of societal progress will grind to a halt. Bush does not suggest that basic research is sufficient to meet societal needs. Yet during the post-war and Cold War period, the automatic sufficiency of basic research to benefit society was often assumed by science policy makers (Pielke and Byerly 1998). Although particular issues sometimes dominated the scene – for instance, during the Space Race or the War on Cancer – questions of science policy were essentially reduced to questions of funding for more research, and in general to how much more funding was needed. The underlying assumption of this approach is that more funding for scientific research will lead to greater societal benefits.

The late 1970s saw a shift toward more neoliberal, market-based meachanisms in both the US and Europe. Despite their differences, US presidential administrations from Carter to Obama were in basic agreement with British Prime Minister Margaret Thatcher and most of the leaders of Western Europe that 'there is no alternative' to liberal democracy organized around free market capitalism. Under neoliberalism, the government sets policies to minimize the state, maximize the global market, and provide 'market' incentives for individuals citizens to perform in the way that the government would like. As Foucault (2008) suggests:

> Government must not form a counterpoint or a screen, as it were, between society and economic processes…. Basically, it has to intervene on society so that competitive mechanisms can play a regulatory role at every moment and every point in society and by intervening in this way its objective will become possible, that is to say, a general regulation of society by the market. (145)

What Foucault calls 'neoliberal governmentality' means government installing competitive regulatory mechanisms to leverage the freedom individuals have to respond to the power exerted on them by those mechanisms.

The Government Performance and Results Act (GPRA) of 1993, which required US federal agencies to provide evidence of the results of the federal tax dollars invested in their activities, is an example of neoliberal governmentality. The idea behind GPRA was that government could be made more efficient by focusing agencies on the returns on taxpayer investments. At the NSF, one of the responses to GPRA was the FY1998 revision of the Merit Review Process to include both intellectual merit and broader impacts (Holbrook 2005, 2012). The idea that the results of investments in scientific research should be demonstrated not only in terms of publications or patents, but also in terms of benefits to society was a way of intervening on the scientific community to allow scientists and engineers to compete among themselves to be able to demonstrate their value to society. Similar moves – captured under the rubric of the 'Impact Agenda' – were also made in the UK and across Europe.

Intra-scientific thinking on broader impacts has focused on the two mechanisms of peer review and quantitative metrics (§3.2 and §3.3).

*3.2 Broader impacts and peer review*

The debate surrounding broader impacts can be characterized as revolving around the issues of academic freedom, the autonomy of science from society, and the obligation of scientists receiving public funds to demonstrate accountability. Since FY1998, proposers and reviewers have been tasked with explicitly articulating and assessing whether and how the proposed basic research would benefit society (Frodeman and Holbrook 2011; Rothenberg 2010 has a different reading, arguing that broader impacts have been a focus since the founding of the NSF). Other science and technology funding agencies around the world – especially in Europe – adopted their own approaches to incorporating considerations of societal benefit into the proposal and review process (Holbrook 2010, Holbrook and Frodeman 2011, Frodeman and Briggle 2012, Holbrook and Hrotic 2013). By the second decade of the 21st Century, the idea that research should be judged in terms of both its scholarly and societal impact had become the norm, at least among science policy makers (Hill 2016). Some, of course, wanted to find even better ways to make sure scientists remained accountable to the public, suggesting 'extra layers' of accountability or the inclusion of non-scientists on peer review panels (Smith 2016, Mervis 2017). However, neoliberal governmentality through impact requirements elicited significant pushback from the scientific community (APS News 2007, Braben et al. 2009, Lok 2010, Bhattacharya 2012). Although less prominent, there were also some academic champions of impact (Holbrook 2017).

Over the last 15 to 20 years, across Europe and in both the US and the UK, peer review criteria were revisited, clarified, or otherwise modified to ensure that accountability demands were satisfied. Researchers themselves gradually began to move past their initial resistance to broader impacts requirements, and funding agencies began to focus on how to enable researchers better to address the broader impacts of their work. In 2009, the Research Councils UK (RCUK) undertook a review of their approach toward increasing the broader societal impact of scientific research. In contrast to most other public science agencies (including the NSF at the time), RCUK placed emphasis on the element of *process* ('pathways to impact') as compared to *product* or outcome. Researchers were encouraged to imagine each of the steps along the path to societal impact rather than focusing only on the end state or result.

Pathways to Impact encouraged researchers to:

- identify and actively engage relevant users of research and stakeholders at appropriate stages;
- articulate a clear understanding of the context and needs of users and consider ways for the proposed research to meet these needs or impact upon understandings of these needs;
- outline the planning and management of associated activities including timing, personnel, skills, budget, deliverables and feasibility;
- include evidence of any existing engagement with relevant end users. (RCUK 2011)

The NSF's governing branch, the National Science Board, published the results of its own "Review and Revisions" of NSF's Merit Review Process in December, 2011 (NSB/MR-11-22). The review reaffirmed that peer review was the appropriate mechanism for reviewing NSF proposals, including their broader impacts. The revisions included a new emphasis on proposer and reviewer attention to *how* broader impacts were to be achieved (i.e., to *process*). In addition, the National Science Board suggested that NSF should look to assess the broader impacts of its funded research *in the aggregate*, rather than limiting its assessments to the level of the individual proposal.

In the UK, the government not only introduced 'Pathways to Impact' as a criterion for grant proposals to the RCUK, but also for the first time in 2014 added an impact element to the judgment of the second aspect of the dual funding system, the Research Excellence Framework (REF). UK universities undergo periodic national evaluations of research quality, which help the Higher Education Funding Council of England (HEFCE) distribute funding to universities (rather than to researchers, as through the competitive grants system). The REF defines impact as "an effect on, change or benefit to the economy, society, culture, public policy or services, health, the environment or quality of life, beyond academia" (HEFCE 2017). Every university department puts together a narrative describing its impacts, and these narratives are reviewed by disciplinary peers.

This emphasis on peer review as the appropriate means to assess broader impacts also led to the rise of broader impacts experts of various sorts. One type is researchers in science policy, who study the use of societal impacts criteria as part of research assessment (for instance, the authors of this report or those cited in Bornmann 2013). Another type of broader impacts expert works in the fields of education and public outreach, taking on responsibility for assessing and addressing broader impacts, sometimes working with, and sometimes working for researchers. The NSF-funded National Alliance for Broader Impacts (NABI), for example, was created in order "to create a community of practice that fosters the development of sustainable and scalable institutional capacity and engagement in broader impacts activity" (NABI 2018). In Canada, the term of art is "Knowledge Mobilization," which often relies on "knowledge brokers" to connect the producers and users of research. The National Institutes of Health

(NIH) sponsored the creation of the Science of Team Science (SciTS) and the notion of 'translational medicine', which are related approaches.

*3.3 Developing quantitative metrics for broader impacts*

Quantitative metrics have also been developed to vie with peer review as the best means of assessing broader impacts. October 2010 saw the publication of "Altmetrics: A Manifesto," which promised to measure impact in ways that moved beyond citation counts (Priem et al. 2010). Incorporating traces left on the web, altmetrics capture various types of communication (e.g., Facebook, Twitter), mentions (e.g., blogs), downloads (e.g., Mendeley), and non-traditional citations (e.g., Wikipedia). Today, altmetrics take many forms, from the numbers-informed narrative of Impactstory.org to the single article-level number generated by Altmetric.com. Indeed, altmetrics today are so diverse that the National Information Standards Organization (NISO) has organized an attempt to standardize them. Even without established standards for what counts as an altmetric, researchers are exploring whether altmetrics can account for just the sort of broader impacts on society traditional scholarly impact metrics miss (Holbrook et al. 2013, Philosophy Impact 2016).

In 2014, HEFCE organized an Independent Review of the Role of Metrics in Research Assessment and Management, under the leadership of James Wilsdon. The review issued its report, *The Metric Tide*, in 2015. The review found widespread support for peer review, accompanied by general skepticism toward metrics, and concluded that metrics could not simply replace peer review in the REF (Wilsdon et al. 2015). Most recently, under the rubric of Open Science, the European Commission has instituted a series of expert and working groups to examine altmetrics and their potential to assess the broader impacts of research (EC 2016).

*3.4 Programatic approaches to broader impacts*

In the early 2000s, funding agencies began to develop programmatic approaches to addressing broader impacts. One approach is to develop programs that examine the pathways from research to broader impacts. NSF's Science of Science and Innovation Policy (SciSIP) Program – which began grant competitions in 2007 – is a salient example. One of the original goals of the SciSIP program was to generate a discipline known as 'the Science of Science and Innovation Policy'. This new discipline would develop a cadre of researchers who would create a sustainable body of knowledge about how research becomes useful to policy makers. Such Science and Innovation Policy Scientists could come to the aid of policy makers who sought advice on matters of, say, policy formation (*ex ante* evaluation) or policy impact and effectiveness (*ex post* evaluation). The initial impetus for founding SciSIP was not simply to produce knowledge of value to a select group of academics, but rather actually to have an impact on science and innovation policy. The Workshop on Government Decision-Making to Allocate Scientific Resources, of which this report is a part, is precisely the sort of activity SciSIP was designed to support.

The European Commission's Horizon 2020 has highlighted the notion of 'Responsible Research and Innovation' (RRI) both as a programmatic objective ('Science with and for Society') and as a 'cross-cutting issue' that unites all other Horizon 2020 objectives. Under the leadership of Carlos Moedas, Commissioner for Research, Science and Innovation, the European Commission has recently begun to address what have become known as 'the three Os' – Open Innovation, Open Science, and Openness to the World (Moedas 2015). The three Os do not represent specific funding programs themselves, but rather serve as goals for the direction of current programs and the organization of the Framework Programme (FP9) to follow Horizon 2020. In general, the three Os represent a continuation of neoliberal science policies: a focus on bringing scientific insights to the market more rapidly (Open Innovation); increasing the efficiency of research, as well as its capacity to serve as a socio-economic driver (Open Science); and using science as diplomacy to open the world to Europe and vice versa (Open to the World) (EC 2016).

The European Commission is also currently focused on several important efforts to establish infrastructure for open science: 1) the European Commission Open Science Cloud, 2) the European Commission Open Research Publishing Platform, 2) and the European Commission Open Science Monitor. In general, the Open Science Cloud can be conceived as a digital infrastructure – a one-stop shop – for data management and data sharing. The Open Research Publishing Platform will provide open access publishing for articles produced as the result of European Commission funding. Publishing on the Open Research Publishing Platform will be free and open only to those who receive Commission funding. The Open Science Monitor both provides information on various open knowledge practices and serves as a way of documenting existing practices. It stops short, however, of developing indicators to incentivize open knowledge practices.

*3.5 Broader Impacts: the state of the art*

Beginning with the September 2011 special issue of *Research Evaluation* on "The The state of the Art in Assessing Research Impact" (Donovan 2011), a consensus has emerged that the state of the art concerning broader impacts assessment is to use peer review of narratives that incorporate quantitative metrics and engagement with potential users of the research in supporting roles. Joining this consensus is *The Metric Tide* (Wilsdon et al. 2015) and the report of the European Commission Expert Group on Altmetrics (Wilsdon et al. 2017). The European Commission's Open Science Policy Platform also formed a Working Group on Altmetrics (now Working Group on Next Generation Metrics) that consists of various stakeholders charged with responding to the Expert Group; the Working Group also concurred with the consensus (AWG 2017). In addition to using indicators to measure they call "Open Science behaviours themselves," the Working Group suggests the development of a new sort of next-generation metrics:

> (2) *indicators that provide insight into the quality, value and potential impact of the research outputs in a way that incentivises open science behaviour*. The context of this second type of indicators is broader. It should focus on the *development and application of a set of new and innovative indicators, both quantitative and qualitative, that measure quality, value and potential impact* of a researcher, project or organisation's outputs – while retaining and improving existing indicators that do so already. (AWG 2017, authors' italics)

The point of the distinction between these two types of metrics seems to be to move beyond simply measuring existing behaviors toward using a new generation of metrics to 'incentivize' or steer researchers or organizations toward adopting Open Science behaviors. That assessment instruments (whether quantitative or qualitative) can have such a 'steering effect' is well-documented in the literature (e.g., Rip 1998). What is interesting about the Working Group's recommendation is that it is explicit about the desire to steer researchers and research performing organizations toward Open Science. Whereas previous broader impacts policies were often presented as incremental changes (or even as no real change at all, according to Rothenberg 2010), the Working Group goes so far as to insist that universities should change their reward systems to encourage Open Science.

The European Commission's procedures with regard to 'the three Os' are themselves examples of Open Science behaviors on an organization level. That the Commission employs both Expert Groups and Working (i.e., stakeholder) Groups that respond to each other in successive iterations is a way of engaging the potential users of the research in policy formation. The point is for the stakeholders and the experts to have real input into policy making. Indeed, a new Expert Group has recently been formed to address the idea of this new sort of next-generation metrics recommended by the Working Group.

## 4. Broader Impacts: The New State of Affairs

> "Truth and veracity weren't his top priority," said Ben Shapiro, a writer for the [*Breitbart*] site who quit in 2016 over frustrations with Bannon. "Narrative truth was his priority rather than factual truth." Bannon basically agreed.
>
> – Green 2017

### *4.1 Areas of Additional Research*

These developments have improved both the supply side of science for society and our means of assessing impact. At the same time, science today finds itself in an increasingly discomforting societal position—its conclusions ignored, its veracity under fire, and its insights lacking the broader impact that they deserve. In sum, the receptivity to scientific information and perspectives seems to be lessening rather than increasing.

This point about the public's receptivity to science parallels a similar debate now receiving attention within the field of journalism. The multiplicity of media sources for news, and claims of media bias, have put unprecedented strains on journalism today (Fallows 2016). The same is true for science. Science today needs to think the 'demand' side of broader impacts: for even if we are able to improve the veracity of science, making it more robust and reliable, and our means of communicating its insights, this does not address the question of cultural receptivity. As Higgins (2016) and others have noted, there is growing sense that we live in a "post-truth" society where science simply has no purchase on public debate. If we have entered a new media environment, a universe of Twitter and irreconcilable truths, what are the consequences for science seeking to have broader societal impacts?

The receptivity of society to scientific information is being decisively shaped by an unprecedented political-media environment. Of course, the media has always 'mediated', i.e., shaped as well as communicated the news; since McLuhan (1964), we have understood that 'the medium is the message'—the medium of communication shapes the nature of the message itself. But this process had been viewed as primarily a characteristic of the intrinsic qualities of the particular medium (print, TV, movies, etc.; Postman 1985). Today, however, we have witnessed unprecedented changes to the media landscape.

McLuhan is also famous for speaking of the development of a 'global village'. From some perspectives, this has been borne out: economically, effects ricochet around the planet, a Greek debt crisis affecting Wall Street, and vice versa. We are also witnessing the collapse of all societal elements into one massive sphere: politics and entertainment have become one common phenomenon, with ratings for cable news programs reaching new highs at the same time that polls show less confidence in the news media than ever. But the situation is deeply paradoxical: we have also witnessed the fragmentation of the media in terms of the loss of a master narrative of what constitutes truth.

In 1979 Lyotard offered a "report on knowledge" – *The Postmodern Condition* – that anticipates our situation today. According to Lyotard, the postmodern condition characterized a society that had lost faith in the veracity of its grand legitimating narratives. In its place, Lyotard described the possibility of competing and irreconcilable narratives working on local, rather than global, levels. Lyotard's point has gained practical relevance: our culture's metanarrative of science providing society a uniquely objective type of truth has largely been lost. Lyotard's vocabulary of dueling 'genres of discourse' – of scientific and the narrative genres – helps us to get a handle on recent events. When the scientific genre dominates and holds every other approach to the standards of scientific rigor, the result is positivism. When the narrative genre dominates and rejects science altogether, requiring only that 'facts' fit a certain narrative, the result is what is today's 'post-truth'.

The more self-conscious advocates of the latter point of view call their perspective the Dark Enlightenment (e.g., Moldbug 2009). The point of the Dark Enlightenment is to provoke a situation that the philosopher Robert Fogelin (2005 [1985]) called "deep disagreement" – a situation in which rational arguments cannot be used to resolve disputes. Thus even as scientific standards of research have been rising, societal trust in the veracity of science has been in decline (Herzberg 2016). This situation is not limited only to science, of course; expertise in general is being questioned, as populist movements have grown in strength worldwide. But the scientific community faces its own special difficulties, represented by the new administration, led by a president the Union of Concerned Scientists has deemed "hostile to science" (Carter et al. 2017), and which has proposed budget cuts for the NSF of $776 million, an 11 percent reduction (Achenbach and Sun 2017).

*4.2 Future Directions: Broader Impacts 2.0*

As a result, in the pursuit of broader impacts the scientific community today needs not only to focus on the 'supply side' of scientific information, i.e., the robustness of scientific results. Now it must also understand the shifting aspects and varying receptivity of the 'demand side' for scientific information, the ways in which the receptivity of society for scientific information is changing. In particular, the rise of a new media landscape calls for a careful consideration of a neglected aspect of the pathways to impact: the influence of narrative-based media that places its own distinctive framing on information (scientific or otherwise) before that information enters the public realm.

The contract between science and society as outlined by Vannevar Bush, the architect of US science policy after World War II, did an admirable job of simultaneously asserting the relevance and neutrality of science. But this framing was always unstable. As we've discovered, most strikingly in the cases of climate science or research on gender, the more relevant the results and the more portentous the implications, the more inevitable that there will be push back from one or another element of society. Ambiguities inevitably arise in the interpretation of complex phenomena that are a poor fit for a binary political culture. The current situation of science in culture can even be seen as the ironic result of its success—perhaps it was inevitable that anything this powerful would become enmeshed in ethical, political, economic, and religious debates.

Science as it is practiced now finds itself maladapted to a changing social landscape. It not only must demonstrate its economic and policy relevance, and be attentive to a wide range of ethical and cultural effects; it also needs a better grasp of how its attempts to provide objective, unbiased information and perspectives will be received in a heterogeneous media environment. NSF's Broader Impacts Criterion—and similar requirements across the landscape of science—face a new status quo: whether through talk radio or WebMD, science is now grist for everyone's mills. Scientists may pine for the good old days of autonomy, but they are left with trying to adjust to changed cultural circumstances.

The April, 2017 March for Science was one recent attempt to respond to the changed place of science in culture. The confusion at this new state of affairs was expressed by a woman carrying a sign that read, "I can't believe I have to protest for reality." It is crucial to give the scientific community a better understanding of the anomalous social space that science now finds itself within, and a richer set of conceptual tools for responding to it. We think of this new space for scientists as Broader Impacts 2.0: scientists need to cultivate the ability to understand the pathways by which scientific work can be taken up into ongoing ethical, economic, or cultural debates. Of course, predicting these pathways is impossible; but scientists can get better at anticipating the pathways by which impact—or the lack of impact—occur.

*4.3 Recommendations*

We conclude this report with a set of recommendations that comprises an ecosystem approach to broader impacts, where greater success requires an integrated response on the part of the STEM and HASS academic communities, policy makers, funding agency officials, professional societies, and media sources.

**#1** – The question of broader impacts has broken loose from its origin in the STEM and policy communities to become fundamentally inter- and transdisciplinary in nature. **Therefore, future research on broader impacts must account for both 1) the original, intra-scientific debate surrounding broader impacts (issues of autonomy and accountability, resistance versus acceptance, peer review and metrics) and 2) the ongoing changes in the overall cultural receptivity of science.** This second, cultural element highlights the need for expanded broader impacts research in areas such as history, anthropology, media studies, psychology, political science, and philosophy.

**#2** – It is unrealistic, and increasingly politically naïve, to present accounts of scientific and technological impact as always of a 'win-win' nature. Therefore, **the requirement for imagining possible broader impacts should be modified to include an account of the possible negative impacts (or 'grimpacts') of technoscientific advance.** Such accounts are likely to increase the believability of scientific accounts across society (cf. National Research Council and National Academy of Engineering 2014).

**#3** – Funding agencies have taken the lead in supporting research that benefits society; but such agencies are only one part of the research ecosystem. Disciplinary standards and university promotion and tenure criteria are often at odds with agency policies, rewarding scholarly impact at the expense of broader impacts activities. Therefore, **funding agencies should create venues for ongoing dialogue with higher education policy groups (such as the Association of American Universities and the Association of Public and Land-grant Universities) and professional societies (such as the American Association for the Advancement of Science) to realign the higher education reward system with the realities of Broader Impacts 2.0.** This dialogue should involve stakeholders from across the scientific community, broadly construed, and should include members of both STEM and HASS, as well as a range of other elements of society.

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**Appendix 1: Key Publications**

Anonymous, 'How the World Was Trolled: Once considered a boon to democracy, social media have started to look like its nemesis'. *The Economist*, November 4, 2017.

Bornmann, Lutz, 2013. "What is societal impact of research and how can it be assessed? A literature survey." *Journal of the Association for Information Science and Technology*, 64 (2): 217-233.

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