

Justifying Public Funding for Science

Public funding for science is increasingly coming under attack. This paper asks what normative force these charges possess, and what arguments are available to counter them. I examine two justifications of state support for science: Vannevar Bush's vision of the universal material benefits from scientists pursuing basic research and John Rawls's liberal justification of science funding as a voluntary public good. I argue that both accounts neglect the important political impact of scientific research and its status as the source of knowledge for the modern state. I then trace the implications of the political role of science for the appropriate forms of democratic input into funding decisions.

‘Was duck penis study an appropriate use of taxpayer money?’ ran a Fox News headline from 2013. The associated article attacked a government-funded animal behavior study on duck genitalia conducted at Yale University as a wasteful use of federal money. Two years earlier, another scientific study had been held up for ridicule: ‘Your tax dollars at work: shrimp on treadmills’ (Fox News 2011). Although the immediate target of the attack was different, the main goal was the same: to criticize the National Science Foundation for wasting hundreds of thousands of taxpayer dollars in support of scientific projects that were supposed to seem obviously trivial to a layperson. To make the point more vivid, the earlier story included a rather fascinating video from the study, featuring – what else? – a shrimp exercising on a miniature treadmill, while a scientist took notes on its performance.

Mocking randomly selected examples of ‘silly’ science has become a standard rhetorical tool for US Republicans who want to complain about the federal government’s wastefulness (Greenfieldboyce 2011). In a new line of attack, the Trump administration proposed major cuts to all federal programs supporting climate change research on the grounds that it clashed with the energy needs and economic vitality of the country (Rice and King 2017; Waldman 2017). This time, scientists were charged with actively harming American economic interests. Since both the level and distribution of public funding for basic scientific research is increasingly coming under attack, it is important to consider what normative force, if any, these charges may

possess, and what arguments are available to counter them. This requires being clear about the justifications offered for supporting science with public funds and what these justifications imply about the degree and kind of political intervention appropriate in decisions about the distribution of funds. Justification becomes necessary when the value of an activity can no longer be taken as self-evident. In the second half of the twentieth century, research in the natural sciences consistently enjoyed high levels of public support and financial investment from the state. This meant that while political theorists dedicated a lot of attention to defending funding for the arts, the humanities and environmental preservation in the face of low or declining public support (Collini 2012; Munoz- Dardé 2013; Nussbaum 2016), the grounds for funding science received little philosophical scrutiny. This paper seeks to fill this gap.

The paper proceeds by examining two different justifications offered in support of funding science. I show why they are inadequate, and then I sketch a third line of justification that accounts for the neglected political implications of science funding. The first section focuses on Vannevar Bush's influential arguments from the 1940s, which laid the foundations for an ambitious program of publicly funded science in the US. Bush argued that universal public benefits would follow from basic scientific research and that these benefits would be best realized if scientists were given a high degree of autonomy to pursue their curiosity. The second section contrasts Bush's argument with the liberal justification provided by John Rawls. Rawls did not play a key role in shaping the national funding regime for science, but he provided one of the most influential normative accounts for how a liberal democratic state should treat the provision of public goods. His account implicitly rejected elitist approaches such as Bush's by arguing that state support for science (and art) must be based on the benefit principle, which would ensure that each person paid only for the benefits that they wanted. Despite their differences, both of these accounts failed to pay attention to the

important political implications of scientific research: its role in determining political problems and their possible solutions, and its status as the authoritative source of knowledge for the modern state. In the third section, I will argue that the close connection between scientific inquiry and truth, and the special link between science and policy in the modern state provide additional grounds for justifying the public funding of science beyond those that apply to the public provision of roads, bridges, infrastructure, or even of art. I will end by discussing which kinds of political input into funding decisions would be appropriate once we recognize the political consequences of funding science.

I. Vannevar Bush and a Vision of the Common Good

At the end of World War II, President Roosevelt asked the engineer and science administrator Vannevar Bush to develop a new vision for how the government might support scientific research in the postwar period.¹ The report that Bush produced in response, called *Science: The Endless Frontier*, became the most influential document setting out the role that science could play in a large modern democracy (Kleinman 1995). Bush's argument had two key features. The first was the justification of public support for science almost entirely on the basis of expected material benefits.

Advances in science when put to practical use mean more jobs, higher wages, shorter hours, more abundant crops, more leisure for recreation, for study, for learning how to live without the deadening drudgery which has been the burden of the common man for ages past. Advances in science will also bring higher standards of living, will lead to the prevention or cure of diseases, will promote

¹ For more background on the debates around science in this period see Kevles 1995 [1978]; Kleinman 1995; Mann 2000; Savage 1999.

conservation of our limited national resources, and will assure means of defense against aggression. (Bush 1960[1945], 10)

This was a clever strategy for addressing the dilemma facing science at the end of the war. The American public appreciated the role that scientists had played in winning the war, but lacked a non-military vision that could justify continuing to spend large amounts of public funds on abstract scientific research. At the same time, cutting edge science had become increasingly dependent on the continuation of large amounts of public funding, as military investment in science during the war had changed the nature and scope of scientific research. Bush's challenge was to come up with a persuasive narrative for what science could do to improve the lives of ordinary citizens in order to ensure continued public investment in basic research.

The second key tenet of the report was the necessity of granting scientists a high degree of autonomy from political processes and giving them control over the distribution of public funds.² Bush claimed that the public would benefit most from science if scientists were left free to pursue abstract research into areas that interested them: 'Scientific progress on a broad front results from the free play of intellects, working on subjects of their own choice, in the manner dictated by their curiosity for exploration of the unknown' (1960[1945], 12).

These two features, which defined the structure of science policy for the next several decades, gave science funding an unusual status among public goods. Although spending on science was justified on the basis of its expected public benefits, the public would have little say in how these benefits would come about. This special status faced a justificatory challenge: its plausibility depended on establishing the link between the

² See Douglas 2009; Kitcher 2001 for recent arguments in favor of this ideal.

public good and scientists pursuing their curiosity, but it was not obvious what could supply this link.

Any account that claims that some means will be effective in furthering public welfare must either presuppose knowledge of what constitutes it or include a procedure for how it should be determined. Bush's report developed a very clear and concrete vision of what would constitute the public good for America in the postwar years: full employment, production of goods and services to raise the standard of living, cheaper and better products to give the country an advantage in international trade, technological developments to increase agricultural productivity and medical advances to cure disease. In short, a materialist conception of progress that emphasized benefits from rapid economic growth and increased productivity. While this was certainly a vision of *common* good, in the sense that it claimed the universal desirability of this bundle of material goods, it pushed forward an elite-driven vision instead of allowing a democratic one.

It is significant that Bush rested his argument on a particular conception of public welfare, rather than admitting the inherently political and contested nature of its determination. In doing so, he was trying to avoid two alternative lines of argument: the first was the democratic line that the public interest should be determined through the appropriate political procedures and should be responsive to the wishes and values of the public, whatever they might be. This would have paved the way for more political input into the direction of scientific research as well as the total level of funding, so it is clear why Bush wanted to avoid it. The second alternative was to maintain that scientists should be given the authority to determine what would be in the public interest because of their superior wisdom and knowledge. This would have been an explicitly anti-democratic line, but it would also have been philosophically more coherent than Bush's position because it provided a straightforward justification for

giving full autonomy to scientists. Instead, Bush put himself in the position of having to defend the bold and untested empirical claim that abstract scientific research would be the best way to maximize the public benefits he had described.

Since no system of public funding for basic research of a comparable scale had ever been tried before, it was impossible to provide empirical evidence to support this claim. And Bush did not provide a direct explanation from scientific research to specific outcomes. Instead, his main point was that whatever people might want from science, basic research would be the way to get it (Kitcher 2001). Scientists would distribute funds among projects with an eye to solving important puzzles, contributing to scientific progress, stimulating further research or opening up new possibilities for future inquiry. Public benefits would follow if scientists simply pursued the most significant advances and produced the most important breakthroughs. The argument mimicked the classical economists' argument for the free pursuit of private profit: Just as the economists claimed that society as a whole benefited from the pursuit of profit by individual businessmen, so too would society as a whole benefit from individual scientists' free pursuit of their curiosity.

The high level of trust in science and scientists after the war meant that this argument did not meet much resistance. But public acceptance does not amount to normative merit; it is important to examine what could justify it. There may not have been empirical evidence, but there were influential philosophical arguments about scientific progress that had clear implications for the distribution of funds. Bush's claim that the greatest scientific progress would be made if scientists were free to pursue their interests followed a theory of scientific progress developed by the scientist-turned-philosopher Michael Polanyi.

In a series of papers in the 1940s, Polanyi traced scientific progress to the activities of a community of scientists sharing methods and standards, left free from

political interference (Polanyi 1941a; Polanyi 1941b; Polanyi 1945a; Polanyi 1945b).³ He developed the argument through an analogy between scientists and actors in a free market economy.

[The] self-co-ordination of independent initiatives leads to a joint result which is unpremeditated by any of those who bring it about. Their co-ordination is guided as by 'an invisible hand' towards the joint discovery of a hidden system of things. Since its end-result is unknown, this kind of co-operation can only advance stepwise, and the total performance will be the best possible if each consecutive step is decided upon by the person most competent to do so.

(Polanyi 1962, 55)

There were two key epistemic points supporting this argument. The first was the indeterminacy of scientific research. Polanyi maintained that it was impossible to predict where the most significant scientific advances would come from. Any attempt by a funding committee to direct the course of science toward a specific purpose would fail because of this limitation. Note the striking similarity between this argument and Hayek's argument against central planning on the basis of informational limitations (Hayek 1945). Just as Hayek argued that the insurmountable information problem facing central planners showed the futility of government interventions with the economy, Polanyi argued that the indeterminacy of science meant that government interference with funding decisions would be pointless. His alternative was to leave it all to experts: 'So long as each allocation follows the guidance of scientific opinion, by giving preference to the most promising scientists and subjects, the distribution of grants will automatically yield the maximum advantage for the advancement of science as a whole' (Polanyi 1962, 60).

³ More developed versions of this views can be found in later works such as Polanyi 1951; Polanyi 1962.

The second point that held up the argument was a cumulative view of scientific progress. Polanyi subscribed to the traditional view of science moving incrementally toward a complete picture of the truth. He compared the scientific enterprise to a giant jigsaw puzzle, with each scientist carefully watching the moves of others in order to make the new moves that became possible as a result of earlier ones (Polanyi 1962). This account assumed a fundamental unity in science, such that all research fits together to form a coherent whole, which corresponds to the truth about the physical laws of the universe. The selection of research questions is thus not really an open choice: The scientist's problems are given by earlier work in the area and the gaps in existing knowledge. The significance of a research agenda comes from the role of the particular finding in filling out the missing pieces in the puzzle and contributing to its completion.⁴ Science benefits society simply by making rapid progress in completing the puzzle.

The indeterminacy argument is hard to dispute, but does not support autonomy for scientists on its own. It simply shows the difficulty of directing the research enterprise toward predictable outcomes. Indeterminacy could just as easily lend support to a distribution scheme that allocates funds equally among all projects, or one that determines allocation randomly. Polanyi's argument for scientific autonomy depends on his second claim that scientific progress is a linear and cumulative movement toward a unified picture of truth. This view implies that at any given moment, there are only a few possibilities for new discovery, which are determined by the most recent discoveries in a particular area. The next move in the puzzle is fairly definite, and only scientists who have been closely following the work of other scientists can know what it is. Central planners who want to direct research toward the solution of pressing social

⁴ See Dupré 2004; Kitcher 2001 for more on this philosophical position and its weaknesses.

problems will simply not be able to tell which areas are likely to yield discoveries. This justifies giving autonomy to scientists over decisions about the allocation of funds.

However, this picture of linear and cumulative scientific progress was radically challenged by Thomas Kuhn in *The Structure of Scientific Revolutions* (1962). Kuhn affirmed Polanyi's description of everyday scientific research as an esoteric puzzle-solving activity, but rejected the claim that each problem solved was one small step toward a full picture of truth. He argued instead that the ordinary activities of scientists, which he called normal science, should be understood as advancing a particular paradigm – a set of shared methods, standards and accumulated knowledge. The puzzles selected by scientists are significant only relative to the paradigm, rather than corresponding to an external standard of truth. The most significant and radical discoveries take place during periods where the paradigm becomes unable to solve important puzzles and breaks down. It is then replaced by a new paradigm in a dramatic event Kuhn called a scientific revolution. Normal science is still essential to significant discoveries, but only because it prepares the conditions that make a revolution possible. The revolution itself is unintended and strongly resisted by practitioners of the old paradigm, who want to defend their own methods and findings.

An important consequence of Kuhn's challenge was to undermine the intrinsic significance of the everyday puzzles of scientists and thus also Polanyi's claim that scientists know best which problems are likely to produce significant discoveries. Kuhn nonetheless agreed with Polanyi that scientists must be left to pursue their puzzles – not because they knew where the next major breakthrough would come from, but because only a scientist working within a paradigm could detect the anomalies that would eventually lead to a revolution. Paradoxically, the necessary condition for radical and creative novelty turned out to be a scientific community that was rigidly controlled, esoteric and elitist.

The problem with this position was that it took for granted the continued emergence of alternative views capable of challenging a paradigm and precipitating a revolution, but did not explain why this should be true. In fact, Kuhn's own view implies that the scientific community is structured precisely to extinguish this possibility: Kuhn claimed that scientists working in a paradigm would do everything in their power to resist threats to their paradigm. It is therefore curious that he did not consider the possibility that they might succeed only too well and end up extinguishing radical innovation. The risk that normal science might stifle innovation is even more serious under a system of scientific research that depends heavily on the availability of funding. If scientists working in paradigm have a high degree of autonomy over the distribution of funds, then the easiest way to defend a paradigm is by funding projects that develop the paradigm and not funding those that challenge it radically.

One of the most original contributions of Kuhn's *Structure* was to shift attention away from the lone individual following the scientific method and onto the dynamics of a community of scientists working with shared and unquestioned standards, norms and assumptions. Yet Kuhn's famous examples of scientific revolutions were all drawn from periods that preceded the emergence of a highly professionalized community of scientists with shared and strongly enforced norms. Innovators such as Copernicus, Newton, Lavoisier, and Einstein, who overturned established scientific consensus, emerged in scientific contexts without a professional community with institutional tools for resisting new ideas. This mismatch between his examples and his conclusions makes it difficult to share Kuhn's belief that a closed community of specialists entrusted with complete control over funding decisions will continue to produce radical ideas that undermine their own shared assumptions and findings. The argument for giving complete autonomy to scientists over funding decisions runs into difficulty when we consider the possibility that the process might

develop in ways that would prevent rather than encourage the free pursuit of ideas and the emergence of significant discoveries. If, as Kuhn's theory implies, a highly autonomous scientific community can use control over funding to resist new ideas that might threaten existing paradigms, outside intervention may be necessary to ensure the continued possibility of radical challenges. I will return to this idea in the third section.

II. Rawls's Liberal Justification

So far, I have examined the philosophical underpinnings of Bush's argument for expansive state support for basic scientific research and a high degree of autonomy for scientists over the distribution of funds. Bush made his case on the basis of a specific and rather materialistic conception of progress and flourishing for postwar America. In this section, I will question the justifiability of relying on such a particular vision of the good to support public funding for science in a liberal democracy. After all, scientific research is not equally valuable to all citizens, and not all who value it do so for the instrumental reasons that Bush offered. Since dedicating large amounts of funds to science will detract from other goods and services that the state could be providing, we must consider whether and when it is acceptable for a liberal state to fund an activity on the basis of a specific vision of the good. A promising way to address this question is by juxtaposing Bush's arguments for science funding with liberal arguments for public funding that implicitly reject his approach. To this end, this section will examine John Rawls's arguments for funding science in a liberal society. The passages where Rawls mentioned science are few and invariably paired with public funding for the arts, but they are well worth examining as they provide a striking contrast to Bush's approach. While Bush appealed to a specific conception of the good, at the heart of Rawls' argument was the idea that justification for public provision of certain kinds of goods should avoid appealing to any particular conception of what constitutes a public benefit.

In *A Theory of Justice*, Rawls divided expenditures by the state into two categories: those required by justice and those that are not (Rawls 1971, 62). The former is governed by his two principles of justice and apply to the background institutions in a society, including legal definitions of property rights and a scheme of taxation (1971, 29). These are expenditures necessary for the sustenance of a just basic structure in which all resulting distributions of income and wealth would also be just. These expenditures are not subject to a popular vote. What justifies their imposition on all citizens is the fact that they are a necessary cost of living in a just, mutually advantageous cooperative venture.⁵ What is of interest here is Rawls' second category of public goods: those not required by justice.

Rawls pointed out that the requirements of justice might not cover all public expenditures that citizens might wish to make. 'If a sufficiently large number of them find the marginal benefits of public goods greater than that of goods available through the market, it is appropriate that ways should be found for government to provide them' (Rawls 1971, 282). Since justice does not require the provision of these additional public goods, the principle regulating their provision would be solely that of benefit; individuals would be taxed in proportion to the benefits they receive. Interestingly, the only specific class of public goods he mentioned as an illustration for this category was funding for the arts and sciences (Rawls 1971, 331).

Rawls gave more precise form to this requirement by appealing to Wicksell's unanimity principle. In an 1896 article, Knut Wicksell had argued that if a public good is an efficient use of social resources, there must be a distribution of tax burdens that would gain unanimous approval (Wicksell 1958). Decision-makers should consider

⁵ This contentious claim gave rise to the famous debate between Rawls and Nozick on whether the benefits derived from a cooperative enterprise could ground an obligation to share its burdens. Nozick 1974.

proposals for public goods together with alternative schemes for the distribution of tax burdens. Only those tax schemes that gained unanimous approval should be provided. Under such a scheme, those who would derive no benefit from the good would not be forced to pay, and the distribution of burdens across individuals would track the value of the good for each person. Rawls adopted this principle and proposed the creation of a separate branch of government – the exchange branch – to deal with the application of this principle to particular decisions (Rawls 1971, 283).

Wicksell's unanimity principle is strange as a theory of public goods (Miller 2004, 131-3; Tuck 2008, 191-2). For one thing, it ignores the possibility of strategic behavior or bargaining by individuals to secure better deals for themselves. Under this system, individuals have an incentive to misrepresent their preferences in order to secure a lower tax rate for goods that they would like to have provided. Since everyone has this incentive, the unanimity principle will result in the under provision of public goods. This is a version of the classic free rider problem. But even if we bracket the possibility of strategic behavior, the rule still allows for an extremely narrow scope for state provision of non-justice goods. Specifically, it only allows the provision of goods that represent a Pareto improvement. Under this rule, the state could not make anyone subsidize goods she would not benefit from or pay more for a good than its value to her. Only those taxation packages under which no one would be a net loser would pass the unanimity requirement. The principle applies a narrow understanding of economic efficiency to the realm of public provision.

Rawls justified his adoption of this principle on the grounds that it would prevent the state from imposing unwanted burdens on people by appealing to perfectionist justifications that they did not share (Rawls 1971, 325). While expenditures required by justice are justified on the basis that everyone benefits from a just system, this logic cannot be applied to discretionary goods, which are justified by appeal to

particular conceptions of the good. ‘The principles of justice do not permit subsidizing universities and institutes, or opera and the theater on the grounds that these institutions are intrinsically valuable and those who engage in them are to be supported even at some expense to others who do not receive compensating benefits’ (Rawls 1971, 332). This, he argued, would be equivalent to forcing people to subsidize the private expenses of others.⁶

In *Justice as Impartiality*, Brian Barry rejected the view that a market-mimicking procedure must be the solution for disagreement over public goods and argued instead that the decision should be settled through a democratic process (Barry 1995, 143-151). On Barry’s procedural account, decisions about public goods must be treated the same way as any other political decision, where people with different and incompatible preferences must reach an agreement about what to do. Appeals to specific conceptions of the good would be allowed as arguments in deliberation, and the final decision would be made through a fair decision procedure, such as majority rule, agreed upon in advance.

Replacing unanimity with a majoritarian decision rule means that some people would be forced to subsidize goods that they did not want and would not benefit from. What justifies imposing tax burdens on the minority in these cases is not the intrinsic value of the good, but the fact that its provision is agreed upon through a fair decision procedure, which gives no special advantage to any conception of the good. This, in

⁶ This became a fundamental tenet of liberal conceptions of state funding. In the 1990s, when U.S. conservatives were attacking government funding for the National Endowment of the Arts, there was a lively debate among liberal theorists on whether public support for the arts could be justified on a liberal conception of the state, assuming that support for “high” art went against the preferences of the majority. Most theorists concluded that it was very difficult to do so. On this very interesting debate, see Brighouse 1995; Carroll 1987; Dworkin 1985, 225; Feinberg 1994.

turn, is justified on the basis of the overall desirability of a system that allows individuals to cross-subsidize public goods for others: I subsidize your football stadium in return for your subsidizing my opera house. As long as each citizen has a reasonable chance of finding herself in the majority some portion of the time, everyone has reason to prefer this system since it will supply more of the goods that each person desires.⁷

Rawls endorsed a similar position in *Political Liberalism* and *Justice as Fairness: A Restatement* (Rawls 1996, 214; Rawls 2001, 151-2). While he maintained the earlier distinction between goods that concern ‘constitutional essentials and the requirements of justice’ and those that do not, he argued in these later works that the provision of non-justice goods could be decided by a democratic vote, rather than through unanimity. With the requirements of justice already in place, citizens could try to persuade each other of their preferences over public goods with arguments drawn from their comprehensive doctrines. Rawls was reluctant to put many goods in the non-justice category, but science and art remained paradigm cases: ‘Fundamental justice must be achieved first. After that, a democratic electorate may devote large resources to grand projects in art and science if it so chooses’ (Rawls 2001, 152).

Rawls did not elaborate on the particular arguments that individuals could make in favor of funding science. As long as these arguments do not derive from claims about justice, their content is irrelevant to the structure of justification. Bush’s appeal to the necessity of basic scientific research for economic development, full employment and progress would be equally acceptable as appeals to the intrinsic value of knowledge and understanding. His justification did not discriminate between the content of

⁷ This is obviously an imperfect system. There might well be a problem with persistent minorities, who never get any of their desired goods. Miller points out that in an earlier work, Barry suggested that a majoritarian decision rule would be chosen only in societies where people could expect to find themselves in the majority at least half the time. Barry 1991; Miller 2004.

particular conceptions of the good or particular accounts of benefit. This framework could accommodate a vision such as Bush's if most individuals were convinced of the desirability of such a vision of public welfare and of the role of abstract science in achieving it. But this view must compete on the political terrain with rival views such as those that defend a more targeted and applied science or those that claim that the state need not support science at all.

This line of argument will naturally have trouble providing the normative grounds for continued provision in cases where most individuals do not want the benefits and do not take the activity to be intrinsically valuable. This difficulty has plagued liberals trying to defend state support for the arts against conservatives attacking it on the grounds that it wastes money and encourages high-brow or offensive art.⁸ How might the liberal argue against the charge that certain scientific studies are wasteful? One possible response is to point out the overall advantages of a system of basic research that involves funding many esoteric and seemingly trivial projects. Since we cannot know in advance which projects will yield the most innovative discoveries, it is reasonable to diversify funding. Even if most projects turn out to be dead ends, the system can be justified by the significant advances made in some areas. Instead of scrutinizing each project on the basis of whether it contributes to the desired public benefits, this approach argues that we should judge the system.

The second defense shows how particular studies are in fact indirect means to achieving the desired public benefits. A requirement that grant applications outline expected public benefits encourages scientists to justify their work in terms of imagined downstream benefits even where these may not be obvious. The scientists who conducted the duck genitalia and shrimp treadmill studies followed these two strategies

⁸ See n. 6 above, especially Dworkin 1985.

to defend their work against attacks. The author of the duck study emphasized the importance of funding basic research (Brennan 2013), while the author of the shrimp study emphasized the links between the health of marine organisms and the safety of the seafood that humans consume (Scholnick 2014). While the first defense appeals to the value of the overall practice of funding basic research, the second is a direct defense of particular projects.⁹

However, both of these arguments will have limited reach. The appeal to the benefits of the overall system may shield individual projects from demands for justification, but the system as a whole must still be justified, and opponents may well reject its value. Moreover, appealing to the system cannot always remove individual projects from scrutiny, either. If an area of research is particularly expensive and particularly removed from the benefits that citizens want, citizens or their representatives can rightly object that this goes beyond what they believe is justified by appeal to the overall system of funding basic research and that special justification must be provided because of the heavy tax burden. In the end, appeals to the benefits may prove unpersuasive to critics, and the government may decide to withdraw funding from a specific project, as in the highly publicized case of the Superconducting Supercollider project in the 1990s (Kevles 1995 [1978]).

I have called this a limitation, but it counts as such only from the perspective of someone trying to defend science funding against attacks. This limitation need not be a bad thing from a democratic perspective; it might simply point to the right place to draw the line between scientific autonomy and political interference in the undertaking of costly scientific projects with taxpayer money. In any case, my goal here is not to settle the question of which scientific projects are worth their cost, but to sketch the

⁹ See Rawls 1955 for a discussion of the distinction between justifying a practice and justifying a particular action falling under it, and the significance of the distinction for utilitarianism.

form that normative arguments for and against funding might take within a framework of private conceptions of the good. Ultimately, an institution justified on the basis of its benefits to citizens must be supported by evidence of the benefits or their likelihood, whether benefit is interpreted on a case-to-case basis or at a systemic level. If we endorse the liberal view that people should not be forced to pay for benefits they do not want, then the question of whether public funds should be spent on science will depend on the ability of defenders to persuade opponents of the value of funding it.

III. A Political Argument for Funding for Science

The Rawlsian argument puts science squarely in the category of opera, museums, zoos and lacrosse fields: goods that are justified by privately held conceptions of the good. There might be very good reasons to value them, but large costs should not be forced on people who do not want the benefit. But does science properly belong in this category? There are clear parallels between the attacks against art and against science on the basis of triviality and wasting money, and the defenses against these attacks appear to leave science and art in a similar position. But science has been the target of another line of attack mentioned earlier: that certain lines of scientific research are harmful to individual or national interests. Recent attacks on climate change funding, for instance, have pursued this line. This charge stems from the unique claim of science and scientists to providing truths about the world. Scientific findings hold the power to change the beliefs that are reasonable to hold and the public policies that are reasonable to pursue. This creates significant political stakes around the outcomes of certain areas of research.

Appeals to private benefits or private value cannot account for these political implications. The problem is not that the private benefits framework gives the ‘wrong’ answer; it might well turn out that there are in fact no persuasive normative arguments

for continued public funding when a majority does not wish to spend its money on research that it regards as harmful or biased. The problem is rather that conceptualizing funding for science as a matter of benefits for individuals misses the irreversible collective impact of scientific findings. The close connection between scientific inquiry and truth, and the special link between science and policy in the modern state create additional reasons for the public funding of science that go beyond those that apply to the public provision of roads, bridges, infrastructure, and even of art. Recognizing the political consequences of scientific research is crucial not only for a more robust defense of continued public funding, but also for an appreciation of what role, if any, political interventions might properly play in decisions about the allocation of the public funds set aside for science.

Before I develop this argument, two clarifications are in order: First, I take it to be a sociological fact that science occupies the role of an authoritative source of truth in secular modern states. Even those who reject specific scientific claims do so on the grounds that they are wrong or unscientific, instead of denying the claim of science to providing authoritative and useful knowledge. I recognize that this need not be the case. The political status of science does not simply follow from its claim to revealing the truth (or the truth of this claim), but rather from the fact that this is widely accepted. Astrology also claims to reveal the truth, but has no policy influence (I hope!), and it is conceivable that scientists might be allowed to pursue their research in a theocratic society without being regarded as a reliable source of truth for policy purposes.

Secondly, I accept the liberal view that the state shouldn't impose costs on people for public goods that are justified by appeal to privately held conceptions of the good that are neither shared nor determined through democratic procedures. This rules out a justification of public funding for science that focuses on its essential role for a certain vision of human flourishing and excellence – one that might appeal to the

importance of the pursuit of truth for the proper development of human capacities or for the possibility of leading deeper and more complex lives. Instead, I will make the case from a set of fundamental political interests that are shared by all who participate in a democratic society. The argument remains within a liberal framework, but provides a fuller account of how the role of funding for science should be theorized within it. In particular, I challenge Rawls's categorization of science funding as a discretionary good whose justification appeals purely to private benefits or private value.¹⁰

With that, I want to turn to the question of how the connection between science, truth and politics affects arguments for public funding. I will focus on three distinctly political roles for science: as a means for effective policies, as a resource for the democratic empowerment of citizens and as an agenda-setter for political debates.

Most modern states depend on scientific expertise. Scientific knowledge enables policymakers to find effective means for realizing democratically determined ends. In areas ranging from human health to environmental protection, technological risk to foreign policy, science is instrumental to the making of good policies. It is a core assumption of modern states that claims to truth in policy contexts must be scientific. Since politicians and government officials cannot produce the knowledge they need, they depend on the existence of a scientific community capable of producing and sharing it. This establishes an intimate relationship between the activities of scientists at

¹⁰ One way to situate my argument within a Rawlsian framework would be to say that science should fall within the domain of public reason – of fundamental questions about constitutional essentials and basic justice – rather than of discretionary goods. The difficulty with this is that the political role of science is not about justice per se, but rather about the requirements of a well-functioning democratic process. Perhaps Rawls's bipartite classification scheme of justice and non-justice goods is too restrictive for this purpose. Introducing a third category of goods that can be justified by appeal to political values more broadly might be a useful amendment.

research institutions and the fundamental political interest in bringing about good outcomes and attaining collectively determined ends.¹¹ John Dewey recognized this relationship when he noted that ‘genuine public policy cannot be generated unless it be informed by knowledge, and this knowledge does not exist except when there is systematic, thorough and well-equipped search and record’ (Dewey 1927, 178).

This reason for funding science is instrumental; it stems from a shared public interest in good outcomes. Most political issues cannot be addressed only by appealing to values or conceptions of the good. On questions such as whether human activities contribute to climate change, whether smoking causes cancer or whether vaccines cause autism, citizens and their representatives depend on scientists to provide the facts – and the facts matter crucially. There is nothing specifically democratic about this role that science plays in politics; a totalitarian regime could likewise justify large amounts of public investment in scientific research on the grounds that it would improve outcomes.

Democracies have a further political interest in funding scientific research, which is not shared with non-democracies. This is the role that scientific inquiry can play in providing citizens with a source of knowledge independent from the state, which citizens can use to hold government officials accountable. At the very least, democratic accountability requires a sphere of free public discourse. However, on complex technical issues, common sense knowledge is unlikely to be enough to give citizens a meaningful ability to check the activities of government officials since decisions are often justified by appeals to expert knowledge. Citizens must also have access to

¹¹ It is more common for research in the social sciences to be linked to the achievement of desired policy outcomes, although I bracket this issue in this paper. Desmond King shows how the social science funding regime in Britain was built on the assumption of the identity of publicly funded research with political ends (King 1997). By contrast, the US National Science Foundation tended to favor social science research that looked more like basic science (Larsen 1992).

expertise to be able to understand and challenge policymakers. Scientific inquiry can fulfil this need and support a specifically democratic form of competence and empowerment for citizens. Publicly available scientific knowledge can also allow citizens to revise their opinions, form more informed preferences and reconsider their ends. These are related to good outcomes, but they possess greater normative weight because of their relationship to the essential condition of democratic legitimacy that citizens have a meaningful opportunity to hold policymakers accountable.

The two arguments provided so far focus on the role of scientific knowledge in the making and judging of political decisions. However, scientific inquiry also plays an important role in determining which issues will arrive at the decision stage in the first place. Scientists' decisions about which questions to pursue determines which issues will acquire political salience, and the way scientists choose to frame a question shapes how the public and politicians will think about it. On issues such as healthcare, aging, climate change and environmental quality, scientific findings have set the political agenda and defined the terms of public debate (Sarewitz 2010). For instance, scientists studying climate change early on prioritized understanding the causal mechanisms and predicting the consequences, with the assumption that solutions would follow more readily from an understanding of the underlying physical processes (Sarewitz 2010). Funding for research on the possibilities for adaptation and technological innovation therefore lagged behind funding for research into the study of the physical science for many years. This, in turn, limited the options available for tackling the problem, even while placing the fact of climate change and its impacts irreversibly on the political agenda.

As E.E. Schattschneider famously put it, 'The definition of alternatives is the supreme instrument of power' (Schattschneider 1960, 68). Those who make the funding decisions can intentionally or unintentionally rule out certain courses of action. This makes funding decisions for science the locus of an important political power. Science

can enhance democratic rule if the knowledge that becomes available supports democratic priorities and increases a society's ability to shape its future through favored courses of action. But it can also constrain democratic possibilities if new knowledge thwarts collectively determined goals and aspirations or creates unforeseen and potentially unwanted needs and problems. Whether the relationship between science and democracy will be a productive one therefore depends not only on the quality and reliability of the knowledge but also on decisions about which knowledge is pursued.

We are now in a position to consider what these three arguments for the political role of scientific research imply for funding decisions. It will be interesting to contrast the implications of this view with Bush's recommendation for giving a high degree of autonomy to scientists to attain the greatest material benefits for the public.

First, the political impact of scientific knowledge, and especially its role in bringing about certain outcomes, may place some areas of science funding in the category of goods whose public provision is required by justice. For instance, if there is a duty of justice to help those who are harmed by the natural disasters caused by climate change, funding climate research may be necessary for the ability of the state to fulfil this duty. Similarly, if the state has a duty to provide healthcare for those with certain rare diseases, this might require funding research into the discovery of cures. The argument follows something like a transitivity principle for duty: if you have a duty to do x, you also have the duty to do those things that are a means to x.¹² In practice, it will often be highly unclear that a particular area of research will yield the right kind of information to fulfill a duty of justice. It will be uncertain whether funded projects will succeed, whether they will succeed in time, whether the findings will turn out to help the cause of justice rather than create new and unimagined injustices and so on. But in

¹² As Robert Goodin puts it, 'You ought to do things that are means towards the principal thing for the same reason you ought to do that principal thing' (Goodin 2012).

cases where certain avenues of research can plausibly be tied to research necessary to realize duties of justice, there will also be a duty to publicly support these areas of inquiry.

Secondly, the political role of science has implications for how decisions about the distribution of funds should be made. If the political benefits of science are at least part of the justification for public support of science, then institutions that make funding decisions should be designed with an eye to realizing the desired political benefits. Which decision structures will best realize these goals is ultimately an empirical question, but in the absence of the right sort of data and the difficulty of testing alternative institutional structures, we need to rely on theoretical principles to guide the process of institutional design. The agenda-setting power of science and its effect on the possibilities for democratic rule suggests that priority-setting decisions should involve some democratic input. How funds should be distributed between biomedical research and environmental studies, space exploration and oceanography are decisions that must be made by appealing to the values and preferences of citizens. These are analogous to fundamentally political questions about how to distribute funds between education and healthcare, national defense and environmental quality. Since science is supported by public funds for the purpose of public benefit, however that is to be defined, the priorities of the scientific research agenda should be set with democratic input. Expert opinion on the likelihood of making significant progress in these scientific areas will be relevant to the decision, of course, but in the end, the ordering of priorities must be made democratically. Indeed, the current practice in the United States is to shape priorities for science funding on the basis of national political priorities.

Since the beginning of the twenty-first century, there has been a significant increase in the share of scientific research funded by corporations, philanthropists and private foundations (Broad 2014; Greenberg 2007). While this might speed up the

progress of science and increase its public benefits, it also raises the worry that the interests, needs and priorities of corporations and private individuals will shape the scientific agenda. This may mean that private organizations can circumvent political processes by enacting their vision of a good society through their private funding decisions, rather than by seeking majority support. The increase in privately funded science therefore also has implications for the distribution of public funding. The distributive impact of scientific projects becomes particularly salient when more science becomes privately funded. If scientific issues that benefit certain groups or industries are supported disproportionately through private funds, then it might be necessary to counterbalance the effects of private science through more directed public funding.

It is common to draw the line for political input into science funding at the general level of priority setting, leaving the distribution of funds within each area to scientists. This is inadequate because it leaves the determination of how a particular issue will be considered in the public sphere and the alternatives that will be available to decision-makers entirely to scientists. Formal decision-making power may still lie in political processes, but it is constrained by funding decisions made far earlier by scientists. The distribution of funds within an area has different political implications than priority setting at a more general level. While priority setting determines which problems will gain more traction, the distribution of funds within an area determines the range of possible answers to a particular problem. At the decision stage, laypeople can either accept one of the available scientific options, or they can reject them all, but they cannot produce new science. This is the limitation of studying the relationship between science and politics by focusing only at the decision stage. The success of democratic deliberation about how to act depends on the availability of a range of competing alternative views that citizens and representatives can examine and challenge.

Citizens will not have a meaningful opportunity for choice unless they are presented with a range of alternatives on the same question.

The agenda-setting role of science points to the need for more democratic input into funding decisions. The next question is what the other two arguments – from the interest in better outcomes and the interest in empowering citizens to hold their government accountable – imply about the desirability of political intervention into funding. One plausible answer is that both provide *prima facie* reasons for insulating funding decisions from outside interference. The argument goes as follows: The success of the relationship between scientific inquiry and competent policy-making depends on the scientific community's ability to set internal standards of quality. The distribution of funding among competing research proposals is one of the main ways in which the scientific community discriminates good ideas from bad ones. The overall success of this gatekeeping mechanism in providing reliable knowledge justifies the reliance of policymakers on the findings of scientists. As long as it is accepted that scientists are more likely to possess the methods that will lead to truth, democracies have an interest in protecting scientific funding from outside attempts to guide its direction. Political interference with funding decisions can be problematic because it can impede the production of high quality, reliable information. The short time horizon of politics can make politicians give up support for particular areas of research prematurely, before research efforts can reach fruition. Worse, political interference may be directly motivated by a desire to prevent good policies by blocking the emergence of truth. This also effectively prevents citizens from acquiring the information that they need to criticize government officials. When a government decides to withdraw funds from research on a pressing political issue such as climate change, it is reasonable to suspect that the interference is motivated by a desire to suppress politically inconvenient truths and thereby prevent sensible policymaking on the issue.

These arguments support a *prima facie* case for scientific autonomy over the distribution of public funds. The case is only *prima facie* because the use of funding as a gatekeeping mechanism for quality also provides a reason against scientific autonomy over the distribution of funds. Recall the earlier discussion of Kuhn's claim that scientists left to pursue their own puzzles without interference would prepare the necessary conditions for the most radical discoveries, even as they actively resisted new ideas that challenge the assumptions of their paradigm. I pointed out that under a system where most scientific research depends on large amounts of funding, those who control funding decisions might succeed only too well in rejecting radical new ideas that would lead to the most significant discoveries. If scientists working within a paradigm also have control over the distribution of funds, then the easiest way to ensure the continued success of the paradigm is by funding projects that extend the paradigm and not funding those that challenge it.¹³

The role that funding has come to play in scientific research means that the possibility of dissent in science depends not only on the absence of constraints on free inquiry, but also on an active strategy of funding that supports dissenting views and distributes funds among a wide variety of approaches. To leave the decision entirely to scientists' assessment of what counts as good quality in light of existing standards can prevent the funding of new ideas that can potentially challenge those very standards and expose the errors of widely accepted scientific views. Polanyi compared scientists to actors in a market economy, whose uncoordinated pursuit of truth would bring about the best results for all. To extend his analogy, giving scientific agencies full control over the distribution of funds could lead to the emergence of monopolies in knowledge production, led by the assumptions and priorities of those who sit on funding

¹³ For evidence that this is happening, see Nicholson and Ioannidis 2012.

committees. It is therefore necessary to establish funding institutions that can fulfill the function of antitrust law for science and ensure fair competition among scientific ideas.

The political impact of scientific research creates a democratic stake in the existence of diverse viewpoints within the scientific community, capable of challenging the reigning paradigms. This might be realized through institutional innovations such as earmarking funds for unconventional approaches and less established scientists, ensuring diversity of scientific viewpoints on funding committees, reserving seats for non-experts and experts from different scientific disciplines, supporting long-term research in more speculative and risky ideas, and distributing some portion of funds through a lottery among a number of projects that meet a certain threshold of quality.¹⁴ It should not be surprising that these kinds of changes would be good for science as well as for democracy; the point is that the political justification for publicly funding research places some of the responsibility for setting up and overseeing such institutions on policymakers and citizens, rather than giving full autonomy to the scientific community over the use of public funds. This is not an argument for leaving particular funding decisions to citizens or bureaucrats, but for democratic responsibility and oversight for the creation and maintenance of a system of funding that encourages competition, diversity, and dissent within the scientific community.

Conclusion

In order to respond to attacks against the level and distribution of public funds for science, we first need to understand how science funding has been justified and then consider whether we find these justifications to be satisfactory. Different arguments for supporting science with public funds suggest different answers for the acceptability of reducing funding or interfering politically with how it is distributed. To answer these

¹⁴ For more on funding science through a lottery, see Avin (in press).

questions, I first examined Bush's arguments for setting up a vast federally funded scientific enterprise after the war on the grounds that it would boost economic progress and productivity. I then turned to Rawls's more modest liberal argument for funding science as a voluntary good, which could be provided by the state if individuals found the benefits desirable on their private conceptions of the good. The problem with both of these views, I argued, is that they neglected the political consequences of funding science. Neither can help us understand what is truly at stake in something like the view that if climate change research appears to harm American economic interests, there should simply be less funding for it.

To account for the political stakes in funding science, I sketched an alternative justification for funding science, rooted in the shared democratic interests of citizens: in bringing about good policy outcomes, setting the political agenda, and acquiring the knowledge and competence to hold policymakers accountable on technical issues. These three interests pull in different directions on the desirability of political input into funding decisions. The agenda-setting power of science points to the necessity of more democratic input, both in setting priorities and in diversifying approaches within issue areas, especially under a regime with more privately funded science. The need for reliable knowledge for policymaking and accountability points in the direction of giving autonomy to scientists, but must be balanced against the worry that a closed expert community might develop patterns of funding that stifle dissent and innovation, which in turn would limit the opportunities for contestation in the public sphere.

The question of how to set up funding institutions that encourage dissent and facilitate the emergence of truth is usually thought to be a concern for scientists and philosophers of science. One of my goals here was to show that this problem is also a democratic one, and the responsibility for resolving it must be shared between policymakers and scientists. This is not only because scientific research is pursued with

public funds and invariably justified by appeal to public benefits, but also because the direction of new scientific research, the reliability of scientific findings and the possibility of dissent within the scientific community have direct impact on democratic deliberation and decision-making. In the end, I hope to have made clear that public funding for science is a deeply political issue, from the justification of the decision to support science with public funds to the making of specific decisions about how to distribute funds – and rightly so.

References

- Avin, S** (*in press*) Centralized funding and epistemic exploration. *The British Journal for the Philosophy of Science*. doi:10.1093/bjps/axx059.
- Barry, B** (1991) Is democracy special? In his *Democracy and Power: Essays in Political Theory Part 1*. Oxford, UK: Clarendon Press, pp. 24-60.
- Barry, B** (1995) *Justice as Impartiality: A Treatise on Social Justice, Vol 2*. Oxford, UK: Oxford University Press.
- Brennan, P** (2013). Why I study duck genitalia. Available from http://www.slate.com/articles/health_and_science/science/2013/04/duck_penis_controversy_nsf_is_right_to_fund_basic_research_that_conservatives.html (accessed 14 August 2018).
- Brighouse, H** (1995) Neutrality, publicity, and state funding of the arts. *Philosophy & Public Affairs* **24** (1):35-63.
- Broad, W** (2014) Billionaires with big ideas are privatizing science. *The New York Times*, 15 March. Available from http://www.nytimes.com/2014/03/16/science/billionaires-with-big-ideas-are-privatizing-american-science.html?_r=0 (accessed 14 August 2018).
- Bush, V** (1960[1945]) *Science: The Endless Frontier*. Washington, D.C.: National Science Foundation.
- Carroll, N** (1987) Can government funding of the arts be justified theoretically? *Journal of Aesthetic Education* **21** (1):21-35.
- Collini, S** (2012) *What Are Universities For?* London: Penguin Books.
- Dewey, J** (1927) *The Public and Its Problems*. Chicago, IL: The Swallow Press.
- Douglas, H** (2009) *Science, Policy and the Value-Free Ideal*. Pittsburgh, PA: The University of Pittsburgh Press.
- Dupré, J** (2004) Science and values and values in science. *Inquiry*, **47**, 505-14.
- Dworkin, R** (1985) *A Matter of Principle*. Cambridge, MA: Harvard University Press.
- Feinberg, J** (1994) Not with my tax money: the problem of justifying government subsidies for the arts. *Public Affairs Quarterly* **8** (2):101-123.
- Fox News** (2011) Your tax dollars at work: shrimp on treadmills, 26 May. Available from <http://video.foxnews.com/v/960953334001/?#sp=show-clips> (accessed 14 August 2018).
- Fox News** (2013) Was duck penis study an appropriate use of taxpayer money? 25 March. Available from <http://www.foxnews.com/opinion/2013/03/25/was-duck-penis-study-appropriate-use-taxpayer-money.html> (accessed 14 August 2018).

- Goodin, R** (2012) Excused by the unwillingness of others? *Analysis*, **72** (1):18-24.
- Greenberg, D** (2007) *Science for Sale*. Chicago: University of Chicago Press.
- Greenfieldboyce, N** (2011) 'Shrimp on a treadmill': the politics of 'silly' studies. Available from <https://www.npr.org/2011/08/23/139852035/shrimp-on-a-treadmill-the-politics-of-silly-studies> (accessed 14 August 2018).
- Hayek, FA** (1945) The use of knowledge in society. *The American Economic Review* **35** (4): 519-30.
- Kevles, DJ** (1995 [1978]) *The Physicists: The History of a Scientific Community in Modern America*. Cambridge, MA: Harvard University Press.
- King, D** (1997) Creating a funding regime for social research in Britain: the Heyworth Committee on Social Studies and the founding of the Social Science Research Council. *Minerva* **35**, 1-26.
- Kitcher, P** (2001) *Science, Truth and Democracy*. Oxford, UK: Oxford University Press.
- Kleinman, DL** (1995) *Politics on the Endless Frontier: Postwar Research Policy in the United States*. Durham, NC: Duke University Press.
- Kuhn, TS** (1962) *The Structure of Scientific Revolutions*. Chicago, IL: University of Chicago Press.
- Larsen, ON** (1992) *Milestones and Millstones: Social Science at the National Science Foundation, 1945-1991*. New Brunswick, NJ: Transaction Publishers.
- Mann, AK** (2000) *For Better or For Worse: The Marriage of Science and Government in the United States*. New York, NY: Columbia University Press.
- McKelway, D** (2013) What to cut: as Congress treats crises with new programs, government grows. *Fox News*, 25 March. Available from <http://www.foxnews.com/politics/2013/03/25/what-to-cut-as-congress-treats-crises-with-new-programs-government-grows.html> (accessed 14 August 2018).
- Miller, D** (2004) Justice, democracy and public goods. In Keith Dowding, Robert Goodin and Carole Pateman (eds), *Justice and Democracy: Essays for Brian Barry*. Cambridge, UK: Cambridge University Press, pp. 127-49.
- Munoz-Dardé, V** (2013) In the face of austerity: the puzzle of museums and universities. *Journal of Political Philosophy* **21** (2):221-42.
- Nicholson JM and Ioannidis JP** (2012) Research grants: conform and be funded. *Nature* **492** (7427):34.
- Nozick, R** (1974) *Anarchy, State and Utopia*. New York, NY: Harper and Row.

- Nussbaum, M** (2016) *Not for Profit: Why Democracy Needs the Humanities*. Princeton, NJ: Public Square.
- Patten, A** (2012) Liberal neutrality: a reinterpretation and defense. *Journal of Political Philosophy* **20** (3): 249-272.
- Polanyi, M** (1941a) The growth of thought in society. *Economica* **8** (32):428-56.
- Polanyi, M** (1941b) Cultural significance of science. *Nature* **147** (3717):119.
- Polanyi, M** (1945a) The autonomy of science. *The Scientific Monthly* **60** (2):141-50.
- Polanyi, M** (1945b) The planning of science. *The Political Quarterly* **16** (4): 316-28.
- Polanyi, M** (1951) *The Logic of Liberty: Reflections and Rejoinders*. Chicago, IL: University of Chicago Press.
- Polanyi, M** (1962) The republic of science: its political and economic theory. *Minerva* **1** (1):54-73.
- Rawls, J** (1955) Two concepts of rules. *The Philosophical Review* **64** (1):3-32.
- Rawls, J** (1971) *A Theory of Justice*. Cambridge, MA: Belknap Press of Harvard University Press.
- Rawls, J** (1996) *Political Liberalism*. New York, NY: Columbia University Press.
- Rawls, J** (2001) *Justice as Fairness: A Restatement*. Cambridge, MA: Harvard University Press.
- Rice D and King L** (2017) Trump's budget proposal 'savages' climate research, scientists say. *USA Today*, 23 May. Available from <https://www.usatoday.com/story/news/nation/2017/05/23/trumps-budget-proposal-savages-climate-research-scientists-say/102062556/> (accessed 14 August 2018).
- Sarewitz, D** (2010) Normal science and limits on knowledge: what we seek to know, what we choose not to know, what we don't bother knowing. *Social Research* **77** (3):997-1010.
- Savage, JD** (1999) *Funding Science in America: Congress, Universities, and the Politics of the Academic Pork Barrel*. Cambridge, UK: Cambridge University Press.
- Schattschneider, EE** (1960) *The Semi-Sovereign People: A Realist's View of Democracy in America*. New York, NY: Holt, Rinehart and Winston.
- Scholnick, D** (2014) How a \$47 shrimp treadmill became a \$3-million political plaything. Available from <https://www.chronicle.com/blogs/conversation/2014/11/13/how-a-47-shrimp-treadmill-became-a-3-million-political-plaything> (accessed 14 August 2018).

Starnes, T (2013) Austerity! Feds spend \$400,000 to study duck genitals. Available from <http://humanevents.com/2013/03/20/austerity-feds-spend-400000-to-study-duck-genitals>, accessed 30 January 2018.

Tuck, R (2008) *Free Riding*. Cambridge, MA: Harvard University Press.

Vaidyanathan, G (2015) Republicans attempt to use mockery to cut sound science. Available from <https://www.scientificamerican.com/article/republicans-attempt-to-use-mockery-to-cut-sound-science> (accessed 14 August 2018).

Waldman, S (2017) Trump administration seeks big budget cuts for climate research. Available from <https://www.scientificamerican.com/article/trump-administration-seeks-big-budget-cuts-for-climate-research> (accessed 14 August 2018).

Wicksell, K (1958) A new principle of just taxation. In Musgrave R and Peacock A (eds), *Classics in the Theory of Public Finance*. London: Palgrave Macmillan, pp 72-118.