

# Open Access: the beast that no-one could – or should – control?

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## Introduction

“The main thing, it seems to me, is to remember that technology manufactures not gadgets, but social change,” declared science historian and broadcaster, James Burke, in a lecture given in 1985 (Burke, 2005). This was several years before the rise to global dominance of the personal computer and the internet, but history’s knack of repeating itself means that the words are no less true of the digital revolution of the last two decades. The recasting of information into electronic forms that can be replicated and transmitted instantly across the globe has changed our relationship with it in myriad ways. This poses stiff commercial challenges in some industries – music, film and newspapers, for example – but at the same time has given rise to whole new businesses such as search, social networking and online retailing. It has also created opportunities for public access to public information, which is changing the provision of some government services and opening up new avenues for democratic dialogue.

The effects have been no less profound within academia, even if they have been slower to work through the system. Our relationship with research papers and data is changing because it is easier and cheaper than ever before to put these scientific outputs into the public domain. In the era of printed journals, the thought of doing so had never arisen because of the barriers to distribution. Now that these have largely disappeared, the obvious question, in some minds at least, is: why not?

However, this simple question does not have a simple answer. There remains considerable debate about how much open access should be allowed to perturb the mores of scholarship and research, or to breach the walls of the academy. At the core of discussions on open access, at least in policy formulations, is the idea that the public, as taxpayers, should have access to the research that they fund. Academic perspectives on open access, by way of contrast, tend to be more focused on the internal operations of scientific research, although there are signs that the issue is at least stimulating discussion within the academy on how access to research findings should be made more public.

The growth of open access has coincided with shifting ideas of public involvement in science, from the deficit model associated with public understanding of science initiatives to the more balanced notion of public engagement (Stilgoe et al., 2014). It is tricky therefore to dissect out the precise effects of open access on developing modes of public engagement with science, but that shall be the aim of this chapter. To set the scene, I will begin with a brief description of the open access movement and recent policy initiatives before discussing their impact on the attitudes of scientists towards the broader open science agenda and public engagement. I will then consider the effects of open access (and allied moves) on the authority and independence of science – concepts that are perturbed by the increasingly blurred boundary between the academy and the public. Lastly, I will focus attention on the various publics that are actively seeking to engage with science and scientists, mainly through advocacy groups or the growing ranks of citizen scientists; here, while the impact of open access appears relatively modest, it has the capacity to spring surprises that point to future growth.

While it lurks in the background, only occasionally pushing to the front, open access is nevertheless a topic that provides useful focus to some of the broader issues raised by the interaction of public and academic domains. It sharpens the questions of what exactly the public wants or needs in terms of access to scientific research, and of what the academy is prepared to yield in return for continued public support. Although open access has the capacity to change the dynamics of engagement between the public and the

academy, realization of this potential requires examination of the balance of power between them, and perhaps a clarification of the notions of academic freedom and responsibility. The journey of the last twenty years suggests that no-one is in overall control of these processes. This is perhaps inevitable, and may even be desirable, in a democratic society that aspires to be more open.

## What is open access and how has it been implemented as a policy?

Open access is very much an academic initiative, largely conceived as a tool for researchers. Its origins lie broadly within the messy confluence of digital technology and open licensing for software (Eve, 2014, Suber, 2012), but a defining moment appears to be Stevan Harnad’s ‘Subversive proposal’ of 1994 (Harnad, 1994). This advocated the free electronic dissemination of research results but was conceived as “applicable only to ESOTERIC [...] scientific and scholarly publication”; it aimed to further learned enquiry by “fellow esoteric scientists and scholars the world over.” The 2002 statement from the Budapest Open Access Initiative (Chan et al., 2010), defined open access to the research literature as:

*“its free availability on the public internet, permitting any users to read, download, copy, distribute, print, search, or link to the full texts of these articles, crawl them for indexing, pass them as data to software, or use them for any other lawful purpose, without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself”*

This encapsulates a broader notion of the intended audience, listing “scientists, scholars, teachers, students, and other curious minds”, but falls short of explicit mention of the public.

Even so, the statement did identify open access as an “unprecedented public good” a concept used by economists to identify commodities that are non-excludable and non-rivalrous – in other words, available to all and undiminished by use (Stephan, 2012) – and a label that draws the notion of public value into the discussion. The public dimension has certainly featured in the formulation of governmental open access policies, which have tended to enshrine the rights of the public as taxpayers. David Willetts, the former UK minister for universities and science, and a strong driver of open access, trailed his thinking in a speech to the Publishers’ Association in May 2012: “As taxpayers put their money towards intellectual enquiry, they cannot be barred from then accessing it.” (Willetts, 2012) He did not elaborate on what the taxpayers might do with this access, despite the fact that his interest in the issue was first stirred by his own difficulties in getting hold of research papers while writing *The Pinch*, his book on the intergenerational social contract. In a similar vein, the 2013 White House memorandum on open access stated simply that “citizens deserve easy access to the results of scientific research their tax dollars have paid for.” (Holdren, 2013) The European Union’s guidelines on open access for its Horizon 2020 research program lists the same goal but also envisions open access as a way to “involve citizens and society” through “improved transparency of the scientific process.” (EU, 2014) Again, however, the details of how citizens might be involved are left as an exercise for the citizens. Perhaps that is because making publicly-funded research accessible is just one component of a broader open data policy landscape that is shaped by a diverse set of motivations. Return on investment remains a central preoccupation for governments – the release of public research and data is clearly seen as a way to stimulate innovation in new products, services and markets. But there is also, in the UK at least, a desire to improve public services, and a developing recognition of the link between transparency and democratic accountability – both for government and for the

governance of scientific research (Boulton et al., 2012). The emergent concept of Responsible Research and Innovation (RRI), which places value on public input into efforts to anticipate the risks associated with novel avenues of research, such as nanotechnology or systems biology, seems likely to be co-opted as a further justification but appears too recent to have figured in open access policy formulation (Stilgoe et al., 2013).

### **How has open access impacted attitudes among scientists?**

Reaction to open access among academics has been decidedly mixed. Some have embraced it enthusiastically. Others, though sympathetic in principle, have been hostile to various aspects of implementation; still others have objected to the less restrictive forms of Creative Commons (CC) licensing as a gross infringement of authors' rights (Allington, 2014, Mandler, 2014) (see below). There has been a vociferous internal debate between various open access advocates, publishers, learned societies, universities, funders and representatives of different scholarly disciplines (Eve, 2014).

This debate has been ignored by the vast majority of scientists. While they seem sensitive to the resonance of open access with the amateur ethos of sharing that still survives within the research community, scientists are busy people with many more pressing preoccupations, and generally only turn to the issue once a manuscript has been accepted for publication and the question of compliance with funder policies rises to the fore.

The lack of engagement among research scientists has not been helped by the convoluted history of open access policy development. In the UK the implementation of a new policy by Research Councils UK (RCUK) in 2012-13 stuttered at first. The original strong preference for gold open access was subsequently refined to make it clear that green open access routes were acceptable alternatives (RCUK, 2014). The terms gold and green open access have yet to sink deep roots in academic or public minds and require some clarification. Gold open access entails making the published paper immediately available via the journal, which in many cases requires payment of an article processing charge (APC) – with obvious cost implications that were not well received, particularly at a time when public funding for research was under severe pressure; green open access generally means that the authors' peer-reviewed manuscript (not yet formatted or copy-edited by the journal) is made available through an institutional repository. The green route is free to the author – its costs hidden within repository investment and the traditional subscription model of publishing. Green open access is often subject to publisher embargoes – delays of months or years before the manuscript is made available.

The subsequent announcement that the Higher Education Funding Council for England (HEFCE) will require all publications to be open access to qualify as submissions to future Research Excellence Framework (REF) exercises was agnostic on whether open access should be achieved by the gold or green routes. Although this was a bold move (Eve et al., 2014), the dislocation with the thrust of the RCUK policy added to researcher confusion, which has been exacerbated by opposition from research-intensive universities and publishers that extracted temporary modifications of the policy from HEFCE. The recent review of UK open access policy by Adam Tickell has recommended harmonization of RCUK and HEFCE policies in order to simplify the requirements imposed on researchers (Tickell, 2016). Good policy requires effective implementation. But, although one of the ultimate aims of open access is the public interest, it is possible to detect in these machinations, at least in the short term, a greater preoccupation with the interests of researchers.

Some advocates see open access primarily as a service to science, its purpose being to accelerate and enrich the processes of research by freeing access to the primary literature. Indeed, scientists (Breckler, 2006) and humanities scholars (Osborne, 2013) have frequently been skeptical of the public appetite for open access because they would not be able to understand research papers, a view sometimes deployed in defence of the status quo (Anderson, 2015) and one that is repeated and extended by publishers, who have even sometimes argued that unfettered public access to research could even be harmful (Suber, 2012).

There is little doubt that the sophistication of the research literature, coupled with its formal, jargon-laden style, are barriers to understanding by the proverbial man or woman in the street. But such elitist views underestimate the sophistication of some members of the public, as we shall see below, and represent a risky stance in a democratic society.

Concerns have also been expressed in some quarters that open access policies, are an infringement of academic freedom. However, such arguments tend to expand the definition of academic freedom beyond its broadly agreed provisions to protect the right of scholars to investigate and publish on topics of their choosing without fear of sanction from university employers or governments. Kyle Grayson, for example, has asserted that it should also include the right "to place your research where you believe it will have the biggest impact on the audience that you are trying to reach" (Grayson, 2013), while Rick Anderson argues it also entails "the right to have some say as to how, where, whether, and by whom one's work is published" (Anderson, 2015). In particular, Anderson argues that these freedoms are lost through the imposition of CC-BY licences, which allow free re-use by third parties (provided that acknowledgment and reference back to the original are made), and that open access policies requiring such licences amounts to "coercion". The coercion of academics features in journalist Richard Poynder's lengthy critique of HEFCE's new policy of only admitting open access papers in future REF assessments (Poynder, 2015). He argues that the exclusionary and divisive nature of the REF, which assesses only a minority of university researchers and teachers, and is widely viewed as punishingly bureaucratic, makes it a strange bedfellow for the sharing and egalitarian impulses of the open access movement. Poynder's view is that open access advocates "made a fundamental error when they sought to co-opt government to their cause".

There are certainly some legitimate issues to be tackled here (Kingsley, 2016). The freedoms given to users of CC-BY licensed open access content to create derivative works remain a particular fixation among some humanities scholars (Mandler, 2014), fearful of remixing that obscures attribution or the author's original intent. However, Eve and Kingsley have argued that such concerns are over-stated and reflect an under-estimation of the protections afforded by CC licences and the ethical norms of the academy (Eve, 2015, Kingsley and Kennan, 2015). Nevertheless, it is undeniable that open access rubs up against academic freedom, as acknowledged by Curt Rice in making the case that open access can actually bolster the privileges accorded to scholars (Rice, 2013). Academic freedom remains a contested concept that should be considered negotiable as the place of scholarship within society continues to evolve. The concerns expressed by critics have mostly reflected the internal preoccupations of the academy, but alongside academic freedoms and rights, it is also appropriate to consider the questions of responsibilities. A counter-view to Poynder is that linkage of open access to the REF can be seen as entirely appropriate since both are forms of public accountability. Whether funders should have a say in how the research that they support should be published is also a legitimate question, especially if the aim is to broaden the readership so that it might stir as many minds as possible, be integrated into their thoughts, and give rise to new syntheses and insights. What more could – or should – a scholar hope for? But it is a question that has been addressed rather cautiously, not least because researchers and their institutions remain in the thrall of journal impact factors for career advancement and research assessment.

### **Has open access changed attitudes of scientists to public engagement?**

Arguably, open access may serve as a useful first point of contact for many scientists with the broader, public-facing open science movement. But how effectively does it expose scientists to their public duty, for many a concept defined only by the aspirational 'plans for public engagement' sections found in grant application forms?

We should note first that the UK government's Public Attitudes to Science survey (Castell et al., 2014) has revealed a popular demand for scientists to be more involved in discussions about their research. Anecdotally, there is increasing acknowledgement by scientists of the need to interact with various public constituencies, though also wariness of how to go about this.

For example, should such interactions happen in academic or public forums, including social media? There is also fear of exposure to the demands of advocacy groups that refuse to play by academic rules of engagement (see below).

Even when the encounter with open access raises questions of public interest, penetration of the academic mindset has been limited, in part because of the complexity of issues at stake. These include questions of the reliability of open access research literature (raised by concerns about vanity publishing in author-pays models of publishing), and the questionable peer review quality of so-called predatory journals, both of which potentially undermine public trust in research. It is difficult to quantify these concerns, which are mitigated by the desire of serious scholars to protect their reputation. In any case, as Kingsley has argued (Kingsley and Kennan, 2015), to a significant extent they pre-date the rise of open access and encompass deeper systemic problems with traditional peer review processes of scholarly publishing (Smith, 2006). Related concerns have emerged more recently over the reproducibility of scientific findings – either through error or fraud (Casadevall and Fang, 2012). Open access is not touted as a ready solution to such ills though the fact that it maximizes the readership of the research literature clearly enhances the capacity for post-publication detection of errors or fraud.

The question of the cost of open access is one that has also exercised academics but more because of the perceived incursions into research budgets, particularly by the gold-favoring RCUK policy, or the demands placed on authors not in receipt of research grants. The broader question of the total cost of scholarly publishing has received less attention, in part because academics live largely in ignorance of the cost of journal subscriptions, which are normally managed on their behalf by university librarians. Although the global direction of travel is away from subscription models towards a totally open access world, the details of the transition remain obscure – and mired in enduring arguments between various stakeholders. Economic modelling suggests that a fully open access publishing system could deliver savings by creating a market where there is genuine competition for publishing services (Swan and Houghton, 2012), but these have yet to be realized. There is no easy escape the dysfunctional features of the market in journal subscriptions, in which journals cannot be regarded as competing products by their purchasers and market forces are distorted not only by academic ignorance of costs but also by their preoccupation with journal prestige (Schieber, 2013). As a result, relatively little thought has been given by researchers to the argument that they should be seeking value for money in acquiring access to the research literature. Arguably researchers should be sensitive to the issue of cost, especially when there is pressure on public funding, to avoid signaling insular attitudes. However, the complexity and lack of predictability of the pace and extent of transition to a functioning open access market are significant impediments in this debate.

For some scientists the argument for open access is a moral one. Mike Taylor's insistence that paywalls are immoral and that the scientist's job "to bring new knowledge into the world" requires them to make it freely accessible is a challenge to long-standing norms of the academy (Taylor, 2013). However, there is a growing sense that the ground is shifting in response to public need. Recent initiatives by funders and publishers to provide free access to research on Ebola virus and Zika virus in response to serious public health crises have thrown a spotlight on the slow and restrictive practices that have come to dominate publishing (Curry, 2016). In announcing the moves to speed the release of Zika virus research the statement of the consortium of funders and publishers led by the Wellcome Trust spoke of an "imperative". It was not described as a moral imperative but did seem to resemble one. The logical corollary to these initiatives is to ask why they should not be extended to other infectious diseases – HIV, Tuberculosis and malaria infections have caused more harm than Ebola or Zika viruses – or even to other research areas where there is a strong public interest, such as antimicrobial resistance, climate change, or secure supplies of energy, water and food? Here the idea of open access has prised open a narrow gateway that has the potential to be transformative. It has yet to become a mainstream conduit into the public domain but the norms of the academy and its duty to the public interest are evidently still being negotiated.

The pressures towards greater openness seem increasingly irresistible and may benefit further as the latest generation of

scientists – which has grown up with the internet – takes its seat in the academy. Among them are some notable idealists. Neuroscientist Erin McKiernan, for example, sees access to information as a human right and has pledged to work as openly as possible (McKiernan, 2015). The Open Access Button was created by two medical students, David Carroll and Joe McArthur, as a web-browser tool to help readers who encountered publisher paywalls to access free versions of the research papers (Carroll and McArthur, 2013). Sci-Hub, a freely accessible repository of over 48 million research papers created by software developer and neurotechnology researcher Alexandra Elbakyan, is a more radical and controversial reaction to journal paywalls. Though the repository is clearly in breach of copyright law – at the time of writing Sci-Hub is the subject of a legal complaint initiated by Elsevier – Elbakyan has defended it by citing the provision in the UN declaration on human rights that asserts the right of everyone "to share in scientific advancement and its benefits" (Taylor, 2016). The moral complexities here, which have somber echoes of the case brought against open access activist Aaron Swartz after he had downloaded several millions documents from JSTOR, are beyond the scope of this chapter. However, the work of these activists highlights the youthful perspective that the present state of scholarly publishing is an increasingly ill fit with the digital world. It represents a significant component of ethical and technical arguments about scholarly publishing that cannot ultimately be settled in court.

### **How does open access affect the authority and independence of science?**

Scientists commonly see themselves as part of a self-governing community of experts and science as a responsible, self-correcting process of knowledge generation. For this reason they defend institutions such as peer review, which provides scientific control over what gets published. In the UK, this perspective shores up the Haldane Principle, the right of scientists (within certain strategic constraints set by government and the research councils) to determine which research projects should be funded. However, this view of self-governance is coming under external challenge, from government transparency, impact and RRI agendas, from related shifts in the responsibilities owed to public engagement, from some of the public trust issues mentioned briefly above in relation to the reliability of the research literature, and from special-interest campaign groups (*e.g.* on animal research, climate change, and genetic modification).

While the boundary between academic science and the rest of the world has never been impermeable, it has been used to demarcate the sphere of authority of scientists within which they assert a degree of independence. The growth of open science and social media in particular make this boundary more porous and, while open access does not appear to have had particular effects, this interface is worth examining as a potential locus for future action.

For the most part the relationship between scientists and social media remains guarded. Some have embraced the openness provided by new democratizing channels of communication, but many continue to sneer at blogs, even those written by scientists. Although there have been cases where meaningful scientific critique has appeared in blogs, the view is still prevalent that these are not appropriate channels for discussions between scientists. For example, following the publication by a team of Nasa researchers in *Science* of a claimed discovery of bacteria that could incorporate arsenic into their DNA, the space agency refused to engage with the critique published on the blog of microbiologist Rosie Redfield because it did not feel it to be "appropriate to debate the science using the media and bloggers" (Jha and Kingsland, 2010).

However, there is a growing sense that Nasa's view is behind the curve. The web-site PubPeer.com has used the tools of social media to create a platform for open discussion of the research literature. It has emerged as a prominent venue for the identification of errors in research papers and, on occasion, instances of scientific fraud. A controversial feature of the platform is that commenters may remain anonymous (or 'unregistered') (Blatt, 2015) – their credentials unknown – but the scientists behind the site assert that the quality of comments from registered and unregistered users is indistinguishable (PubPeer, 2015).

The organic – some might say unregulated – growth of PubMed is a testament to the enabling power of the internet and is again diagnostic of unmet need in the present publishing system. However, although the identity of many of its users is unknown, their comments and criticisms still largely reflect the internal debates of researchers about quality control in the published literature. Different challenges arise when the research being discussed touches on matters of public interest or concern. Although there is recognition that transparency is the key to developing and maintaining public trust (Boulton et al., 2012, Stilgoe et al., 2013), and that scientists have a duty to respond intelligently when confronted by questions about their research, the upsurge in such confrontations engendered by social media can pose severe difficulties. As Lewandowsky and Bishop have recently pointed out, “openness can be exploited by opponents who are keen to stall inconvenient research” because campaigners may not be “committed to informed debate” (Lewandowsky and Bishop, 2016). These may be difficult debates for the scientific community but they are important and inevitable in a democratic society – and need to be conducted with some care. Helpfully, Lewandowsky and Bishop have concocted an (albeit controversial) tool-kit to help scientists navigate around some of the more dubious tactics that some campaigners may deploy.

Open access has not yet assumed a prominent role in these interactions. They seem likely to be more frequent in an open access world but should, hopefully, also be better informed. Moreover, a general disposition towards openness is a core part of building trust through transparency. Experiments in open access journals with open peer review (e.g. F1000Research, Atmospheric Chemistry and Physics) further increases the transparency of the scientific enterprise, as well as helping to mitigate some of the worst effects of anonymous peer review.

### **What is the impact of open access on the capacity of different publics to engage with science?**

As noted above, open access was not primarily conceived as a service to the general public or as a driver of public engagement. Policy statements may have nodded in this direction by mentioning the rights of taxpayers to access the work they have funded, but there is a degree of blindness here because of course not all citizens are taxpayers.

Nevertheless, there is a broad array of public audiences for the research literature that includes politicians and civil servants, policy researchers, media, non-governmental organizations, large and small businesses, independent scholars, patient advocacy groups, and citizen scientists. The impact of open access on these groups has not been investigated systematically and is hard to quantify. It seems likely to be relatively minor given that only a minority of research articles is reckoned to be open access; current estimates are that around 20-30% of the research literature is freely available through journals or repositories, though the growth trend is clearly upward (Laakso and Björk, 2012, RIN, 2015).

That said, there is a range of citizens' groups who for various reasons want not just increased access to read the research literature, but also to be able to make their own contributions to it. These include advocacy groups, particularly around healthcare and environmental issues (e.g. pollution, biodiversity), as well as the citizen science movement.

Such groups predate the internet (and open access) – the British Society for Social Responsibility in Science and Science for the People, for example, nucleated in the 1960s and 1970s around concerns about weapons research and environmental pollution – but they have been greatly stimulated by the organizational power of the web and the general increase in access to information that it affords.

A 2007 report, “e-Patients: how they can help us heal healthcare” provides an insightful analysis of the rise of patient advocacy (Ferguson, 2007). The report defines e-Patients as “citizens with health concerns who use the Internet as a health resource” and concludes that health professionals have both underestimated the ability of patients to access and provide useful online resources, and over-estimated the hazards of imperfect online information. The threat of a phenomenon that was initially seen as a challenge to paternalistic medical practice is dissolving amid recognition that informed patients are themselves valuable

partners in managing healthcare. In the UK the NHS Expert Patients Programme seeks to augment and harness this resource.

The particular benefits of open access in this space appear patchy and uneven, perhaps due to its relative novelty and the still limited extent of research that is published in this form. But there are initiatives to overcome this. PatientPower, for example, campaigns for greater access, as well as providing other sources of information. PatientInform is an initiative run jointly by publishers, medical societies and health professionals to enable access to the research literature to member organisations, though not directly to members of the public. The demand for access is very widespread – in 2006 80% of internet users were reported to have searched online for information on at least one of 16 different medical conditions (though the particular demand for access to the primary research literature will only be a fraction of this). This type of search activity is most prevalent among younger people who have grown up with the internet, and seems likely only to increase as they reach middle and old age, despite continued skepticism from some publisher advocates.

Just as interesting is the increasing involvement of patient groups in medical research and publishing, which has led to innovations that are likely to increase awareness of the potential of open access. A striking recent example springs from work on the rare genetic disorder, N-Glycanase 1 deficiency (known as NLGY1). The condition was initially identified after Cristina and Matt Might linked up with genetics researchers in the search for the underlying cause of their young son's problematic physical and mental developmental. Genome sequencing identified previously unknown mutations in the N-Glycanase 1 gene and triggered the search for other patients. Thus far the case follows a pattern of parental advocacy that is familiar from Hollywood movies such as *Extraordinary Measures* or *Lorenzo's Oil*, but the interesting twist here – which is an important signal of the dynamism of patient-researcher interactions – is that the push to develop a treatment for NLGY1 has kick-started a citizen-science project (Mark2Cure) to text mine the research literature. In its first publication (made available as an open access preprint on the bioRxiv), the project has shown that groups of citizens can identify and link keywords within the biomedical literature as accurately as a researcher with PhD-level training (Tsueng et al., 2016).

The Mark2Cure study does not have any citizen scientists as authors, but this is being normalized as an appropriate role. The open access British Medical Journal “welcomes studies that were led or coauthored by patients”, while the interdisciplinary, health and social care journal Research Involvement and Engagement (also open access) has a patient advocate, Richard Stephens, as a co-editor-in-chief. Beyond patient groups, citizen scientist authors can readily be found in the literature on environmental pollution (Davis and Murphy, 2015, Padró-Martínez et al., 2015).

Similar developments – and challenges to traditional authority – are detectable across the whole spectrum of citizen science, even in those areas where interest is driven by curiosity rather than personal need. Citizen scientist projects vary enormously in scope, format and level of engagement (Silvertown, 2009); some ‘extreme’ citizen scientist projects have even found ways to involve participants who can neither read nor write (Grove, 2011). Shirk has ranked five degrees of citizen involvement as contractual, contributory, collaborative, co-created and collegial (Shirk et al., 2012). In contractual projects, communities effectively hire researchers to do a piece of work, while at the other end of the spectrum collegial projects represent institutionally acknowledged research contributions made independently by citizen scientists. The three intermediate classes, which have self-explanatory titles, are the predominant forms.

Attitudes to and experiences of open access vary within the citizen science movement. Anecdotally, project organizers from the ranks of academia have reported sporadic demands for research papers that are often satisfied on an ad hoc basis by distributing electronic versions accessed through university library subscriptions. Nevertheless, there is sensitivity to the issue. Robyn Baily at Cornell University, who leads the ornithological Nestwatch project told me in an email that she was pleased to have been able to publish a paper co-authored with citizen scientist Gerald Clark in the open access journal PeerJ (Bailey and Clark, 2014), recognizing the need to share the results with all participants in the project. But she also acknowledged the pressure on academics to publish in

high-impact journals, which can dramatically increase costs if immediate access is desired.

These factors are recognized by other citizen science projects and, although there is widespread understanding of the need to ensure that the published results of citizen scientists are made available to participants as part of an important positive-feedback loop, open access publication appears to be a relatively unusual avenue for doing so. Newsletters and blog posts serve as alternative means of communication that have the advantage of being more digestible, (though for many rare diseases, there are few secondary resources and affected communities have no choice but to look at the primary literature). The Zooniverse, a diverse collection of projects appears unusual in having a clear policy requiring results to be published in open access venues. In contrast FoldIt, a popular and successful game-based project to predict the three-dimensional structures of protein molecules does not, though their published papers – which sometimes include gamers as co-authors – are made available as PDFs through the project website.

Citizen science is a dynamic and innovative area. Demand for access to the wider research literature seems likely to increase, as the more engaged participants seek to better understand their projects. Given the increasing sophistication of the contributions made by citizen scientists, it also seems appropriate to ensure that papers arising from their projects are made available to the whole community by open access. As a case in point, a recent open access paper from the EteRNA project – an online game designed to search for improved methods for predicting the fold of RNA sequences – has three gamers, Jeff Anderson-Lee, Eli Fisker and Mathew Zada, as co-authors (Anderson-Lee et al., 2016). This arose because the Rhiju Das, the project leader at Stanford University, noticed that Anderson-Lee and Fisker (joint first authors on the paper alongside two of the academics on the project) had independently compiled extensive documentation on their approach to the RNA folding problem and he encouraged them to write it up. EteRNA has an informal open access policy that is about to be written into the End User License Agreement. “It just seems like the right thing to do,” Das told me in an email.

The positive feedback effects of open access on citizen science are important, not just for recognizing citizen scientists’ contributions and enhancing their knowledge and skills, but also as a way of making professional scientists more aware of the high-level capabilities of their citizen counterparts. The wider impacts of citizen science are difficult to assess, but it is an activity that could further increase the porosity of the walls of academia in ways that could have other societal benefits, for example, enhancing citizen participation in discussions around RRI.

### Concluding Remarks

In theory, the potential contribution of open access towards making science public is self-evident. In practice, it is harder to discern. The snapshot presented in this chapter is piecemeal – and quite possibly partial – because the forces at play have yet to reach any kind of equilibrium.

Though the pace of change may not be fast enough for its most enthusiastic supporters, the rise of open access through the advocacy of academics and the policy initiatives of governments and funding agencies is indisputable. Awareness of the challenge of open access to traditional modes of scholarly publishing is widespread within academy, which appears sympathetic in principle, even if the various requirements of policy implementation are not universally welcomed. Signs that it may help to make scientists more outward-facing are emergent but hard to separate from more general moves to opening up the academy.

On the side of the public – or publics – levels of awareness and use are more limited. In certain quarters open access is seen as very important, but it is also just one form of research information that is available to citizens via the internet. That said, it is important to recognize that the intermediaries to information, such as journalists, bloggers or advocacy groups, stand to benefit from increased open access.

The idea of open access as a ‘journey’ has become something of a cliché, at least in the UK, but it retains a kernel of truth. Although the direction of travel is upwards from a relatively low baseline, the trajectory remains prone to deviation. Few would have predicted the present destination at the outset of the 1990s.

Just as the diffuse boundaries between disciplines are reckoned to define a territory of creative interaction, the public-academy boundary that accompanies open access (even if it was not there at conception) appears to be fertile territory. And not just for technical innovation and challenges to custom and practice within the academy – there are signs too, among academics, new publishers and citizen scientists, that it can bring new life.

As the primary producer and consumer of the research literature, the academy remains in overall control. But there are pressures from above and below for open access as part of the open science agenda that offer the benefit of greater integration and mutual understanding between scientists and society. There are risks here, particularly in contentious areas of research which can attract attention from combative campaigners, but few people seriously contend that these can be mitigated by restriction of access to the research literature. Public dialogue is an essential feature of democratic societies and can only be served by measures to increase the knowledge-base of that conversation.

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