The Four Pillars of Scholarly Publishing: The Future and a Foundation

Jarrett E. K. Byrnes[1], Edward B. Baskerville[2], Bruce Caron[3], Cameron Neylon[4], Carol Tenopir[5], Mark Schildhauer[6], Amber Budden[6], Lonnie Aarssen[7], Christopher Lortie[8]

1 - Department of Biology, University of Massachusetts Boston, Boston, MA 02139

2 - Department of Ecology and Evolutionary Biology, University of Michigan, Ann Arbor, MI 48109

3 - New Media Research Institute, Santa Barbara, CA 93101

4 - PLOS, Carlyle House, Cambridge, UK

5 - School of Information Sciences, University of Tennessee Knoxville, Knoxville, TN 37996

6 - National Center for Ecological Analysis and Synthesis, Santa Barbara, CA 93101

7 - Department of Biology, Queen's College, Kingston, ON, Canada

8 - Department of Biology, York University, Toronto, ON, Canada

This is a work in progress. Please feel free to comment at http://goo.gl/xGqil

Abstract

With the rise of the Internet, scholarly publishing has embraced electronic distribution. But the tools afforded by the Internet and other advancing technologies have profound implications for scholarly communication beyond just distribution. We argue that, to best serve science, the process of scholarly communication must embrace these advances and evolve. Here we consider the current state of the process in ecology and evolutionary biology and propose directions for change. We identify four pillars for the future of scientific communication: (1) an ecosystem of scholarly products; (2) immediate and open access; (3) open peer review; and (4) full recognition for participating in the process. These four pillars will guide the development of better tools and practices for discovering and sharing scientific knowledge in a modern networked world. Things were far different when the existing system arose in the 1600s, and though it has served its purpose admirably and well, it is time to move forward.

PeerJ PrePrints | https://peerj.com/preprints/11 | v1 received: 25 Apr 2013, published: 25 Apr 2013, doi: 10.7287/peerj.preprints.11

Many forms of Government have been tried and will be tried in this world of sin and woe. No one pretends that democracy is perfect or all-wise. Indeed, it has been said that democracy is the worst form of government except all those other forms that have been tried from time to time. ~*Winston Churchill*

Introduction

We live in an age of rapid communication open to an ever-growing pool of information and ideas, yet our current system of communicating the results of scholarly activities dates back to the 1660s and still reflects many of the restrictions of that time. It limits access to those outside the ivory tower, keeps the review process behind the closed doors of anonymity, and operates at a speed often slower than the scholarship itself. Is this a model for 21st-century publishing? Or do the general principles that have become apparent with the growth of the information age provide a template for a better, more efficient, form of scholarly communication? Can we improve our science by changing the foundations of scientific discourse? With the rapid rise of scholarly discourse online (Fox 2012), the time is right to examine how we can improve the system. Here, we present a framework that provides the foundation for these considerations.

The debate on open-access publishing reflects the ongoing changes in how scientists interface with content and how their expectations for access have shifted, and moreover points the way towards more significant changes to the system. Many scientists have already recognized that open access produces better science, because it guarantees that researchers have the access to the literature they need; this access is crucial for their everyday work (Tenopir 2012). In fact, recently the predominant discussions about open access have moved past whether science needs open access or not and right on to the details of how it will be funded and how existing journals and societies will adapt to the change. As we concede that access must be open for the sake of good science, we naturally should ask what other aspects of the publishing process should also be opened up.

PeerJ PrePrints | https://peerj.com/preprints/11 | v1 received: 25 Apr 2013, published: 25 Apr 2013, doi: 10.7287/peerj.preprints.11

Here, we propose four pillars for a more open future of scholarly publishing: (1) a widening of our definition of scholarly products; (2) immediate open access to these products at the start of their assessment and refinement; (3) open public review for scholarly products; and (4) an improved ability to assess scholarly products and the overall contributions of scholars. These pillars do not stand alone, but meet at a common foundation: the need to link products together to better enable discovery of relevant information. Embracing these core principles, we believe, will enhance both the speed and quality of the scientific enterprise.

An Ecosystem of Scholarly Products

Scholarly publishing in EEB is largely limited to a single species of product, the narrative paper. This monoculture of scholarly production is curious, particularly given that an entire subfield of ecology is devoted to the demonstration that diversity can lead to higher levels of function in the world's ecosystems (Loreau et al. 2001). The narrative paper artifact is a product of print publication, and is increasingly seen as only one vehicle for science knowledge and practice to emerge in a digital world. In its recent white paper, the Force11 association has envisioned two aspects of new science artifacts: artifacts that capture the "relationships between knowledge, claims, and data," and artifacts that promote the reproducibility of science workflows (Bourne et al. 2012). It is time for EEB to move beyond the devaluation of a alternative types of scholarly product and embrace the larger ecosystem of scholarly products.

Fortunately, we have already begun to recognize that there is more than one scholarly product that is of value to advancing science. Publication of data has become increasingly commonplace, with whole journals devoted to data papers (e.g., Dataset Papers in Ecology[1], Ecological Archives[2]) and the establishment of best practices (Chavan and Penev 2011). Outside of scholarly journals, blogs have become fertile ground for the presentation of short observations (e.g., http://wfsu.org/blog-coastal-health/) or rich media products that allow users to interact with

[1] http://www.hindawi.com/dpis/ecology/
[2] http://esapubs.org/archive/

PeerJ PrePrints | https://peerj.com/preprints/11 | v1 received: 25 Apr 2013, published: 25 Apr 2013, doi: 10.7287/peerj.preprints.11

and visualize data in ways not possible in traditional journal articles. Other services have evolved to allow scientists to collect software and workflows (e.g., GitHub[3], RPubs[4]).

All of these pieces of scientific work are products of the scholarly production. They are generally viewed as second class, however, and often not afforded formal recognition in the annals of scholarly discourse. Given the fragmented landscape where these pieces of work are able to live, there is no centralized way to archive the observations, rich media displays, or software that can ensure that they will remain part of the development of science in more than an ad hoc way. Essentially, we are denying the future of science these advances, as their long-term future is uncertain. We are cutting off a mode of scholarly production, and limiting the floor of information to scientists in the future - and by future, we may mean as little as a year, as blogs or startups blink in and out of existence. If the purpose of scholarly communication is to advance the forward progress of science by ensuring the flow of current results to future scholars, this must change. Beyond just creating new recognized venues for this work, a line on a scholars CV listing a data product, software package, or other scholarly resource needs to be valued equally to a narrative product in hiring and tenure decision making.

Immediate Access

Once a researcher or research team deems the fruits of their scientific labor ready for the limelight, it's time for them to begin the cycle of peer review. The critique of scientific work by one's peers is the cornerstone of scientific publishing (Goodman et al. 1994), and it is absolutely essential in order to have scientific work become part of the permanent record of human progress. Without a review process, there would be no way to confidently make an initial assessment of the validity of a single piece of work. That said, the review process takes time. Sometimes weeks. Sometimes months. Sometimes, with rejection, resubmission, re-review, etc. as scientists climb through a series of journals until their paper finds a home, years (Ioannidis 1998). Is science being served by the long delay between when a researcher has results ready for the public to

[3] http://github.com
[4] http://rpubs.com

PeerJ PrePrints | https://peerj.com/preprints/11 | v1 received: 25 Apr 2013, published: 25 Apr 2013, doi: 10.7287/peerj.preprints.11

scrutinize, and when the scientific community actually gets to view them? What are the consequences of this time lag for the progress of science?

The conservative answer is that immediate access to new pieces of scholarly publication before going through a peer review process will seriously harm science. If this were true, then math, physics, and astronomy should have imploded in the 1990s. By the late 1980s, high-energy physicists were frequently exchanging manuscripts prior to peer review via email lists. This process became centralized and formalized at the LANL Preprint Archive, which became the arXiv, in the 1990s. (Ginsparg 2008). Rather than immediate access being an impediment to scientific progress or diluting the field with crackpots, it has advanced the speed of science in the disciplines that use it (Davis and Fromerth 2007, Gentil-Beccot et al. 2010), and provided a valuable forum for new results and ideas to be discussed widely, beyond just a pool of two to three reviewers.

It should be noted that although the arXiv facilitated the widespread adoption of a preprint culture in physics, mathematics, and computer science, that preprint culture existed in particle physics *before* the creation of the arXiv (Ginsparg 2008). In EEB, we have no preexisting preprint culture to start with; instead, we must copy the physicists. Although people frequently circulate pre-publication versions of manuscripts to close colleagues, the understanding is that these early versions are not for widespread consumption, and certainly not for dissemination on a public email list or website for the whole field to see. Thus EEB must undergo a fundamental cultural change in order for the dissemination of preprints to become standard practice.

We view immediate access as a fundamental cornerstone of the future of scholarly publishing. This extends beyond preprints of papers before they are submitted to a formal journal, but immediate open quality assured data, as is already done by the Long Term Ecological Research network (Karasti and Baker 2008) and open and shareable code, as is mandated by some journals already (ESA Author Instructions 2013). Once a research product is deemed ready for the world

PeerJ PrePrints | https://peerj.com/preprints/11 | v1 received: 25 Apr 2013, published: 25 Apr 2013, doi: 10.7287/peerj.preprints.11

by a lab, in order to speed science and improve the quality of the work itself, it must be immediately accessible to the scientific public for reading, discussion, and judgement. Keeping it behind the closed doors of one or more editorial processes serves little purpose other than to slow down the dissemination of knowledge. Indeed, as the best way to evaluate a piece of work is to have the most knowledgeable scientists *read* and then evaluate that work, we do not serve science by potentially restricting their access to only a limited pool of reviewers. Open, immediately accessible manuscripts can be read, assessed, and critiqued by a larger audience of interested scientists, thus improving both the reach and the quality of scientific discourse.

Open Review

The hallmark of our scholarly publishing system is the acceptance of new work into the corpus of science only after the work has been reviewed and approved, often after substantial revision, by anonymous peer reviewers in a closed-door process. The current process of reviewing a paper is a triumph of the intellectual endeavor of science. Reviewers attempt to dispassionately rake a new piece of scientific information over the coals of rigor. They put a large amount of time, effort, and thought into ensuring the highest quality information reaches the general scientific audience. And yet, once this process is complete, the intellectual discourse of review is discarded into the dustbin of the editorial process. Moreover, we acknowledge that review is a human process. Inaccuracies, grudges, bias, and more can all creep into the review process, often without intentional malice (see Lee et al 2012 for review). This information is likewise consigned to the dustbin. Furthermore, anonymity itself may not be a best practice. While anonymity may free a reviewer to be critical, it may also free a reviewer to engage in behavior that furthers a personal agenda—conscious or not—rather than the agenda of science. This, open review (Kriegeskorte 2012) provides a way to bring fresh air into the process, reducing bias and improving review utility.

We cling to the need to closed peer review, often citing the simple and seemingly obvious assumption that reviewers are more willing to be openly critical of a work if they will not suffer any retaliation from the authors. Once a piece of work is accepted, all of those reviews vanish,

PeerJ PrePrints | https://peerj.com/preprints/11 | v1 received: 25 Apr 2013, published: 25 Apr 2013, doi: 10.7287/peerj.preprints.11

only to be seen again inside of offices of the journal's publisher. Are these two pieces of our current review system beneficial for science?

Anonymous review assumes that anonymity will allow for better commentary and more stringent critiques that will ultimately improve the quality of a published article. This is not always the case, however. Anonymity allows for a wide variety of abuses within the peer review process, including suppression of work similar to a reviewer's own, nepotism influencing article acceptance, and sexism affecting article acceptance, among others. None of these help science. Furthermore, opening up the identities has been shown to either have no impact on the quality of review (van Rooyen et al. 1998) or actually benefit the final finished product (Walsh et al. 2000) particularly when authors and reviewers can interact (Leek et al. 2011). From the perspective of science, there is little to be lost and much to be gained by abandoning anonymity in the peer review process.

Furthermore, why is review closed? Why are useful pieces of thoughtful commentary discarded, so that readers cannot see what their colleagues think of new work. Largely, this is to protect anonymity, which we have discussed above. If reviewer identities are open to authors, why should their identities and contributions not be open to the readership? Some journals, such as PLOS One[5], F1000 Research[6], and PeerJ[7] offer the co-publication of reviews already. They create a rich starting point for further conversation about the import of new work, and are created by readers who have, by their participation in the review process, thought long and hard about a wide variety of issues contained in the work.

The change in the publication process to open up review is small: final comments are posted alongside a published piece of work. The benefit to future scientists of seeing these comments is immense, and, as above, the costs are likely small. Moreover, having reviews published

[5] http://www.plosone.org/
[6] http://f1000research.com/
[7] https://peerj.com/

PeerJ PrePrints | https://peerj.com/preprints/11 | v1 received: 25 Apr 2013, published: 25 Apr 2013, doi: 10.7287/peerj.preprints.11

alongside scholarly products creates a culture of conversation. This change in culture may well facilitate further comments, responses, and counter responses. A wide variety of online tools have evolved to facilitate this type of conversation, and we see them already taking flight on Twitter and in the world of blogs (e.g., the #arseniclife example, see Zimmer 2011). If the publications themselves took the lead in changing our culture towards one of more open conversation, a better process of scientific dialogue would result.

Full Reputation and Recognition

When we review and edit manuscripts, we are making an intellectual contribution to the development of science. We are giving rich thoughts and commentaries to an author, and helping to shape the development of the field of science. Because reviews are never seen outside of the authors of a paper and editors of a journal, this contribution goes largely unrecognized beyond a brief line in the synergistic activities portion of our curriculum vita. Even in an open system, however, when our colleagues, with a little legwork, could see how much we have reviewed, we still do not have any sense of whether we are making a meaningful contribution to the scholarly discourse.

Articles have citation counts, download statistics, and other alternative metrics (Priem et al. 2010). Reviews are transitory pieces of thought that we have no systematic way of judging. Furthermore, scientists who make incredible contributions to the literature by the strength and thoroughness of their reviews go completely unrecognized, lumped with those who would send a two sentence summary judgement with little detail beyond, "This looks fine."

The reputation and recognition of not just the quantity of reviews, but also the quality of reviews is an essential pillar of any future scholarly review system. This reputation serves not only to aid editors and authors in finding the most useful reviewers, but also serves to help scientists better quantify how well they are contributing to the scholarly discourse around them.

PeerJ PrePrints | https://peerj.com/preprints/11 | v1 received: 25 Apr 2013, published: 25 Apr 2013, doi: 10.7287/peerj.preprints.11

This is a problem that has been solved in many less formal platforms. The past twenty years have witnessed a lively development of tools to assess commentary on internet discussion boards (e.g., http://reddit.com) and professional and academic question and answer sites (e.g., http://mathoverflow.com, http://stackoverflow.com). Once discussion is in the open, the community is able to give feedback on its usefulness, generating a rich quantitative reputation. A system where not only is the amount of reviewing done by individuals, but the quality, judged both by the author and community - as well will foster a far more rich and meaningful scholarly ecosystem. Perhaps the greatest benefit is to reviewers themselves. It will enable us to see when where and how our reviews are the most helpful. We will able to collectively become better reviewers, and improve the quality of the process that births new work in the peer reviewed world.

Networked Discovery of New Work via Better Review Tools

Each of the steps listed above would be a significant and positive benefit to the scholarly publishing system. They serve a greater purpose, however, when considered as a whole. They can facilitate the discovery of new literature, speeding the development of science.

A common problem in the literature is that one can miss new work that is highly relevant to them either due to its placement, unknown authors, or being in a discipline that appears irrelevant to an author. Often, connections to new work are made by a colleague sending another a reprint. In this way, we already have a slow informal reputation mediated information distribution system. If reviews and commentary on papers are open, we can begin to use this information to create networks of reading habits that can inform what new literature we should be discovering. This kind of networked discovery has been a boon for corporations such as Amazon, Netflix, and others.

The first step towards better networked discovery is open access. Despite living in an information deluge (Bell et al. 2009), the transformation of this data into useful information is

PeerJ PrePrints | https://peerj.com/preprints/11 | v1 received: 25 Apr 2013, published: 25 Apr 2013, doi: 10.7287/peerj.preprints.11

often hidden behind paywalls and embargo policies. Thus, the first element to enhance discovery is the immediate open access to the panopoly of scholarly products that can be available - but with sufficient curation so that information can be filtered and sifted with ease. With the growth of open access journals, we are already moving towards this world.

Furthermore, by incorporating reputation and recognition systems, scientists can tune the discovery process. Readers can tune their discovery process to examine what their most highly regarded peers in their discipline are reading. They can find pieces being read or recommended by those whose commentaries and thoughts they themselves have highly rated. They can see what those with whom they strongly disagree find fascinating in the new literature, a progressive way of keeping one's intellectual horizons open to new thoughts and ideas. There are a huge number of ways this information can be harnessed to facilitate the discovery of new work that can change the intellectual development of a reader's science.

Effective search engines made the modern Web possible. As the Web has evolved, the use of machine-learning algorithms to find interesting needles in gigantic haystacks has been vital for commercial services such as Amazon and Netflix. Expert human curation—the current purview of journals—will always remain vitally important for evaluating and reflecting on research. But automatic software tools, guided by data, text, human curation, and online social networks, will enable scientists to far more easily stumble upon research in the first place. Search engines have already had a huge impact on how we find research, but machine-assisted discovery of new and interesting research from across the academic corpus is just beginning to have an impact (e.g. see current attempts at Research Gate, F1000[8] and Google Scholar). We look forward to further improvements in how discovery algorithms, human-computer interaction, and online social networks enhance the ability of scientists to make connections.

Conclusions

[8] http://blog.f1000.com/2013/04/08/follow-and-filter-your-interests/

PeerJ PrePrints | https://peerj.com/preprints/11 | v1 received: 25 Apr 2013, published: 25 Apr 2013, doi: 10.7287/peerj.preprints.11

The above four pillars—a widening of our definition of scholarly products, immediate open access to some versions of these products, an open public review for scholarly products, a greater ability to recognize both the quantity and quality of contributions by scholars to the communication process—all build into a system that leads to better information discovery and faster more intellectually vibrant science. The principles we discuss here are not new or foreign to science, but naturally extend from current publishing system. Although they will require substantial changes to some of our current scientific publishing practices, we are already seeing the growth of experiments in scholarly communication such as PLOS One, PeerJ, F1000 Research, and more. The scientific community as a whole appears quite interested in determining how best to change our practices of scholarly communication to lead to the highest quality and quickest flow of ideas. We hope that the principles we have laid out above can create a robust discussion and further experimentation by the scientific and publishing community working together. These discussions will raise many deep questions. To note grapple with them would be a disservice to science.

Acknowledgements

This paper is a product from the NSF funded National Center for Ecological Analysis and Synthesis working group 12651 "The future of publishing in ecology, evolutionary biology, and environmental science."

References

Bell, G., T. Hey, and A. Szalay. 2009. Computer science. Beyond the data deluge. *Science* 323:1297–1298.

Bourne, P. E., T. Clark, R. Dale, A. de Waard, I. Herman, E. H. Hovy, and D. Shotton. 2012. Improving future research communication and e-scholarship: a summary of findings| Force 11. Macquarie University ResearchOnline.

Chavan, V., and L. Penev. 2011. The data paper: a mechanism to incentivize data publishing in biodiversity science. *BMC Bioinformatics* 12:S2.

PeerJ PrePrints | https://peerj.com/preprints/11 | v1 received: 25 Apr 2013, published: 25 Apr 2013, doi: 10.7287/peerj.preprints.11

Davis, P. M., and M. J. Fromerth. 2007. Does the arXiv lead to higher citations and reduced publisher downloads for mathematics articles? *Scientometrics* 71:203–215.

Fox, J. 2012. Can blogging change how ecologists share ideas? In economics, it already has. *Ideas in Ecology and Evolution* 5:74–77.

Gentil-Beccot, A., S. Mele, and T. C. Brooks. 2010. Citing and reading behaviours in high-energy physics. *Scientometrics* 84:345–355.

Ginsparg, P. 2009. The global village pioneers. *Learned Publishing* 22:95–100.

Ioannidis, J.A.. 1998. Effect of the statistical significance of results on the time to completion and publication of randomized efficacy trials. *JAMA: The Journal of the American Medical Association* 279:281–286.

Karasti, H., and K. S. Baker. 2008. Digital Data Practices and the Long Term Ecological Research Program Growing Global. *International Journal of Digital Curation* 3:42–58.

Kriegeskorte, N. 2012. Open evaluation: a vision for entirely transparent post-publication peer review and rating for science. *Frontiers in computational neuroscience* 6:79.

Lee, C. J., C. R. Sugimoto, G. Zhang, and B. Cronin. 2012. Bias in peer review. *Journal of the American Society for Information Science and Technology* 64:2–17.

Leek, J. T., M. A. Taub, and F. J. Pineda. 2011. Cooperation between Referees and Authors Increases Peer Review Accuracy. *PLoS One* 6:e26895.

Loreau, M., S. Naeem, P. Inchausti, J. Bengtsson, J. P. Grime, A. Hector, D. U. Hooper, M. A. Huston, D. Raffaelli, B. Schmid, D. Tilman, and D. A. Wardle. 2001. Biodiversity and ecosystem functioning: current knowledge and future challenges. *Science* 294:804–808.

Priem, J., D. Taraborelli, P. Groth, and C. Neylon. 2010, October 26. altmetrics: a manifesto – altmetrics.org. http://altmetrics.org/manifesto/.

Tenopir, C. 2012. The value of scholarly reading in the life sciences. Ideas in Ecology and Evolution 5:63–73.

Van Rooyen, S. 1998. Effect of Blinding and Unmasking on the Quality of Peer Review: A Randomized Trial. *JAMA: The Journal of the American Medical Association* 280:234–237.

PeerJ PrePrints | https://peerj.com/preprints/11 | v1 received: 25 Apr 2013, published: 25 Apr 2013, doi: 10.7287/peerj.preprints.11

Walsh, E., M. Rooney, L. Appleby, and G. Wilkinson. 2000. Open peer review: a randomised controlled trial. *The British Journal of Psychiatry* 176:47–51.

Zimmer, C. 2011, May 27. The Discovery of Arsenic-Based Twitter. http://www.slate.com/articles/health_and_science/science/2011/05/the_discovery_of_arsenicbased_twitter.single.html.

PeerJ PrePrints | https://peerj.com/preprints/11 | v1 received: 25 Apr 2013, published: 25 Apr 2013, doi: 10.7287/peerj.preprints.11