ABSTRACT

KITTLE AUTRY, MEAGAN ALEXANDRA. Genre Change Online: Open Access and the Scientific Research Article Genre. (Under the direction of Dr. Carolyn R. Miller).

Historically, the scientific research article (SRA) has been a relatively stable genre, and one that has been well studied from a rhetorical perspective (Bazerman, 1988; Berkenkotter & Huckin, 1995; Gross et al., 2002). The recent rise of open access has brought along with it significant changes in research article publishing, but what does that mean for the writing of the key academic genre of the SRA? This dissertation seeks to understand what may be happening to the scientific research article in light of open access, and how that may influence our understanding of genres and genre change, particularly in cases involving digital media. To address this exigence, this dissertation undertakes a genre analysis of scientific research articles published in two successful open access biology journals, *PLOS Biology* and *BMC Biology*. Each case study features an analysis of sampled articles from the journal, the broader genre "ecosystem" to establish potential influence of open access on the SRA, and authors who have published in it.

Based on the case studies reported in this dissertation, I argue that the scholarly research articles analyzed here are not evidence of complete genre change, but that the more accurate term for what is happening with the SRA in light of open access is adaptation of the genre. By doing this, I will reframe the discussions that are taking place about open access being "revolutionary" and the internet "revolutionizing communication," moving the focus away from technology and back to that with which rhetoricians are primarily concerned: context. While technology is certainly an *aspect* of the context, the Internet, in this case, is just an environment—it is not a determiner of the genre or the actions of the authors and editors. The context that becomes critical here is the ideology of science and how that comes

into play with the ideology of open access. Science is a powerful and influential way of understanding the world, and my discussion of this study's implications focuses on how we see this power and influence on the profession's key genre, the scientific research article. This project concludes with a discussion of the study's limitations and directions for future research.

Genre Change Online: Open Access and the Scientific Research Article Genre

by
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DEDICATION

To my mom and dad—

who saw my potential and pushed me to do whatever I dreamed of doing

BIOGRAPHY

Meagan Kittle Autry is a rhetorical scholar whose research interests include rhetoric of science and technology, genre theory, digital media, open access, and higher education administration. Her work has appeared in the journals *Environmental Communication*, *Communication Monographs*, *First Monday*, and *Enculturation*, as well as a couple of edited collections. Her postsecondary education began at Catawba College for her Bachelor of Arts (Honors) in English with a minor in French Literature and Sociology. She then enrolled at North Carolina State University for her Master of Arts in English and subsequently for her Ph.D. in Communication, Rhetoric, and Digital Media. She now serves as the first-ever Director of Thesis and Dissertation Support Services in the Graduate School at N.C. State, an administrative position that combines her research interests in professional and scientific writing and higher education. Her work focuses on creating life-long scholarly writers, increasing thesis and dissertation completion rates, and decreasing the time it takes graduate students to earn their degrees. She designs and leads workshops on research writing and the doctoral degree process; directs dissertation institutes; coaches individual students in their writing; and partners with appropriate groups across campus to help with graduate student success.

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CHAPTER 1: INTRODUCTION TO THE OPEN ACCESS MOVEMENT AND SCIENTIFIC RESEARCH ARTICLES

Professionally our methods of transmitting and reviewing the results of research are generations old and by now are totally inadequate for their purposes … But there are signs of a change as new and powerful instrumentalities come into use … The world has arrived at an age of cheap complex devices of great reliability; and something is bound to come of it. (Bush, 1945, "As We May Think")

What does it mean for information to be "closed," behind a pay wall that few members of the general public can view and only institutions of higher education with large enough library budgets can have access to? What are the problems with taxpayer funded research being locked from public view? What does it mean for information to be truly open? With over 190,000 articles published in nearly 4,800 different open access journals in 2009 alone, and an average yearly growth rate of 30% for the number of articles published open access (Laakso, Willing, Bukvova, Nyman, & Bjork, 2011), there is little doubt that open access will play a key role in the future of academic research.[1] But why is the process of publishing and accessing information changing? Are we seeing change for the sake of change, or does the move toward open access to research represent shifting values among the larger academic community? And what is happening to our key academic genre, the scientific research article, among all this change?

Not only have new affordances of technologies such as word processors, the Internet, and email changed the way in which scholarly manuscripts are prepared, submitted, peer reviewed, and produced (Gross, Harmon, & Reidy, 2002), these technologies have allowed

[1] By contrast, the estimated number of total journal articles published in 2009 is 1.5 million, which includes both conventionally published articles and open access articles (Jinha, 2010).

for alternative possibilities to the traditional closed access publishing model, the most common of which would be the open access model. In contrast with the closed access model, which has been around nearly as long as the journal article itself, the idea of open access is not yet well understood within academic communities. The Internet and World Wide Web, with seemingly endless possibilities for information dissemination, have scholars thinking anew about the process of publishing and disseminating scholarly work, the levels of access that people can and cannot have with closed access publishing, issues of cost, and how scholars can best take advantage of the affordances of digital media and the Internet. Associated with the changing abilities to produce, disseminate, and rework ideas are shifting ideas about copyright and how the rights of authors can or should change with the use of digitally-networked and other technologies. But before I can break down these issues and examine open access in academia more critically, I must uncover the kairotic moment to which the open access movement is responding as well as changing ideas about access to information, copyright, and intellectual property in light of digital media.

The kairos of open access

The very first open access journals (initially established as "digital only journals") were conceived of in the late 1980s and launched in 1990, among them the *Bryn Mawr Classical Review*, *Postmodern Culture*, and *The Public-Access Computer Systems Review*. The following year, in 1991, scientists at Cornell launched arXiv, an open access archive for pre-print and published versions of papers in the fields of physics, mathematics, computer

sciences, and more. arXiv has been warmly welcomed by those academic communities and boasts a constantly increasing rate of submissions to the archive, now totaling over 7,000 papers a month and nearly 780,000 papers total since its inception over 20 years ago (arXiv, 2012). Early numbers for open access journals and article publication have been difficult to track, particularly in the case of journals that started up but were not successful, ceasing operation, and that did not plan any long-term solutions for archiving and providing access to the information that they did publish. Sometimes journals started, as in the case of the popular humanities journal *Enculturation,* stuttered for a while, only to resume and thrive from that point forward. Crawford (2002) estimates the number of open access journals in existence in 1995 was 86; at the time of his study in 2001, however, he could only find clear evidence that 49 of those titles still published on a somewhat regular basis, giving a 57% mortality rate. With additional journals founded since 1995, however, the total number of open access journals in existence in 2001 was of course higher than that. Based on his study, Crawford coined the term "arc of enthusiasm" for online publishing, which he says describes the initial interest in a journal which leads to a successful first few years publishing, with interest stagnating after that, leading to the journal become defunct or publishing at much less regular intervals after five or so years. Other studies of open access journals have found a similar "mortality rate" to that of Crawford (Wells, 1999; Hedlund, Gustafsson, & Bjork, 2004).

In 2003, *Nature, Science,* and *The Scientist* all declared the concept of open access as among the top stories in science for the year, prompted primarily by the launch of *PLOS*

Biology by the Public Library of Science (more commonly known as PLOS; Willinsky, 2006). *PLOS Biology* began to compete with *Nature* and *Science* for top-quality articles produced by biologists, but along the way, it altered the landscape of scientific publishing (and as some would argue, for the better). The basis of their model, discussed in more depth below, is that the people who fund the research should be paying for it to be published and not by those who want to read it. PLOS soon released more open access journal titles (*PLOS ONE*, *PLOS Medicine*, and *PLOS Genetics*, to name a few) and has become a major force in scientific publishing in the years since the release of its first publication. After PLOS's launch, open access has grown significantly over the last decade. Laakso et al. (2011) report an average yearly increase of OA journals around 18% and an average yearly increase in OA journal articles around 30%. This stands in contrast to the average yearly increase of non-OA journal articles, which holds steady at 3.5%. The Directory of Open Access Journals, the premiere database which tracks open access journals, now lists nearly 10,000 OA journals,[2] linked through their site. Thus, while not all open access journals survive past their first issue, a significant number of them survive and sometimes even thrive as venues for research in academia.

In conjunction with the development of alternative outlets for scholarly research, broader social, cultural, and technological changes have created an atmosphere ready for open access. Economically, we are seeing increasing resistance against major corporations that dominate markets and earn astronomical profits every year, such as Exxon Mobil's 2012 second quarter profit of $16 billion, the highest quarterly profit ever recorded by a U.S.

[2] As of September 9, 2013.

Corporation (Hargreaves, 2012). This opens up a space for discussion about the ethics of such profits and the impact on society. Within academia, those producing knowledge—faculty, researchers, post-doctoral scholars—see the publishers that they provide this knowledge to, for free or for a very low price, making extremely high profits every year. For example, in 2011, Elsevier reported $1.1 billion in profits, for a profit margin of approximately 36% (Elsevier, 2011). However, despite that the content is being provided to publishers for little to no cost at all, journal subscription prices are higher than ever, having increased at rates far above inflation or even tuition increases. The Association of Research Libraries (2011) finds that journal subscription price increases, over the last 30 years, have outpaced inflation by more than 250%. The average yearly cost for a university library's subscription to a single chemistry journal is $4,427, and in physics, $3,649 (Bosch & Henderson, 2012). Further contributing to the rising journal prices is the practice of "journal bundling," which occurs when publishers force bundling of popular journals with less popular but equally expensive ones in order to ensure their products get purchased and their profit margins remain acceptable to their shareholders.

These practices by journal publishers are occurring simultaneously with unprecedented cuts to higher education, with library budgets cut such that they are cutting back on the journals to which they subscribe, effectively cutting many researchers out of the pool for reading the research that they produce or need to be reading in order to produce more. Many university libraries, even those at what we consider wealthier institutions in the United States, can no longer afford these subscription prices with their reduced budgets and

are as a result significantly cutting back on their journal holdings. Harvard University shocked the academic world in April 2012 when the Faculty Advisory Council released a memorandum announcing their library could no longer afford the ever-increasing journal subscription prices: “We write to communicate an untenable situation facing the Harvard Library. Many large journal publishers have made the scholarly communication environment fiscally unsustainable and academically restrictive. This situation is exacerbated by efforts of certain publishers … to acquire, bundle, and increase the pricing on journals” (Harvard Faculty Advisory Council, 2012). Part of their solution to this budget problem is to encourage faculty to deposit post-prints of their journal articles in repositories (also known as green OA, which is defined in the following section) or to publish in OA journals, along with overall encouraging greater use and acceptance of OA in academia.

It appears that 2012 was the true tipping point for the movement not only within the academic community, but also as open access gains credence in communities beyond these research institutions. Now, many U.S. colleges and universities have pledged support for open access and even adopted open access publishing policies, including Columbia University, Cornell University, Harvard University, North Carolina State University, University of California—San Francisco, and the University of Maryland, to name just a few. The policies range from universities encouraging faculty to publish in open access journals, to faculty resolutions asking administrators to adopt such policies, or, in the case of Harvard, deciding not to renew particular closed access journals because of their exorbitant subscription costs in favor of supporting open access initiatives at the institution instead. This

momentum carries over from 2011's "Academic Spring," the term used to describe the rising movement against commercial publishers who some feel are exploiting the hard work of academics for their own monetary gain. Researchers, librarians, and other academics argue that ownership of research findings and ideas needs to move out of the hands of corporate publishers and back into the possession of those who are doing the research. They cite the increasingly unaffordable journal subscription rates that publishers demand as a disservice to citizens around the world who deserve to benefit from the research academics do, particularly (but not solely) because this work is often publicly funded. The "Academic Spring" movement is in part prompted by the mass signing of a petition by nearly fourteen thousand academic researchers[3] saying that they would cease publishing in, reviewing for, or otherwise providing editorial work for journals published by Elsevier in protest of the company's support for SOPA/PIPA (see description of these bills below) and the Research Works Act in the United States, as well as other grievances about the company globally, including its role in organizing exhibitions for global arms trade. This protest of Elsevier and the growing movement against the company that followed has highlighted several important factors that contribute to the open access movement. Mathematician Timothy Gowers from the University of Cambridge, the scholar who started the "Cost of Knowledge" petition against Elsevier, maintains a blog documenting his academic work. Gowers is not alone, as many of the other mathematicians and other academics in a wide range of disciplines who signed his petition do the same, pointing to a decreasing need for corporate publishers to be the main (or only) site for disseminating work.

[3] As of June 20, 2013. Source: http://thecostofknowledge.com.

Proponents of open access recognize the power that the government has to potentially require open access publication of publicly funded research, so in May 2012, Cameron Neylon, PLOS Director of Advocacy, and others started a petition to ask the White House to do just that. The petition argues,

> Requiring the published results of taxpayer-funded research to be posted on the Internet in human and machine readable form would provide access to patients and caregivers, students and their teachers, researchers, entrepreneurs, and other taxpayers who paid for the research. Expanding access would speed the research process and increase the return on our investment in scientific research. ("Require free access," 2012)

The petition garnered the signatures of over 30,000 U.S. persons who support an initiative for all publicly-funded research to be published online and freely available. Unfortunately, the petition did not receive an official response from the White House, which requires 100,000 signatures in 30 days to earn a response.

The concern with disseminating academic research is closely connected to the idea of accessing it as well. The United States' government has taken interest in issues of regulating the Internet, specifically with accessing and disseminating of information more broadly. U.S. Representative Lamar Smith introduced a bill in late 2011 called the "Stop Online Piracy Act" (SOPA) that proposed expanding the jurisdiction of American law enforcement to include online pirating of copyrighted intellectual property. A similar bill called the "Protect IP Act" (PIPA) was introduced in the U.S. Senate. Proponents of the bills cited the loss of

profits that companies encountered when their copyrighted material was pirated or counterfeited, while opponents of the bills claimed that the losses to innovation, violation of free speech, and potential for law enforcement to block internet addresses wholesale for any kind of violation would strongly outweigh any potential gains for those few companies whose interest PIPA aims to protect. On January 18, 2012, Wikipedia and several thousand other websites protested SOPA/PIPA by blacking out their site content to users, demonstrating in effect what the web could possibly look like should the bill be enacted into law. Two days later, under extreme pressure from tech giants like Google as well as the general public, over 7 million of whom had signed petitions against it (Google, 2012), the House Judiciary Committee postponed SOPA indefinitely. Thus, layered in with the complex discussion of who has the right to share the research that academics produce is the notion of providing access to materials that academics may use in their research. Attempts at bills such as these might hinder the OA movement, as even materials that are published openly could be restricted if they include content that is copyrighted (despite the fair use clause, designed to allow materials published for educational purposes to do just that).

As a result of the impact these bills could have on the open access community and its movement, many U.S.-based researchers signed Tim Gowers' "Cost of Knowledge" petition against Elsevier in response to the publisher's support of the Research Works Act. Currently in the U.S., the National Institutes of Health (NIH) requires that research funded by its agency, as public funds, be published in the open access PubMed Central repository no more than twelve months after initial publication. These mandates are common worldwide,

including most major government funding in the United Kingdom and Germany. The Research Works Act was introduced to prohibit such mandates from U.S. funding agencies and was initially supported by Elsevier, though through pressure from the petition and other sources, Elsevier withdrew its support of the bill. The Representatives who introduced the bill at the end of 2011, Darren Issa and Carolyn Maloney, later stated they would no longer strive to see the bill enacted (Howard, 2012).

Overall, the key idea of open access is that the scholarly publishing system is broken. This is attributed to many factors, which I have outlined above, focusing particularly on how corporations make a profit from the research that public universities and the government pay for, but also emphasizing how important it is that research be widely available in the future for those who may want to use it in research, teaching, or other academic purposes. On a larger scale, the ideology of "open" and its related movements—open source, open science, free culture, and so on—is that, in the famous words of Stewart Brand, "information wants to be free." In part, the Internet is what leads to information wanting to be free, as it is an effective way to make this happen, and so do other digital media that have recently been developed. A related movement, the free culture movement, for example, focuses on creative works and making them available to distribute, modify, and build from in unlimited ways. Open access offers a tightly-focused version of the open/free movement by championing openness specifically for academic works.

Open access: A definition and models in scholarly publishing

From the previous section, it is clear that open access is an important issue for academic researchers. But what exactly does it mean? Open access refers to content that can be freely accessed by readers, viewers, or users at the point of viewing, opening, or downloading the text. In other words, the content is free for anyone with internet access to read. To make this happen, content producers often license their work through the Creative Commons (CC). Established by Lawrence Lessig, noted scholar of intellectual property and copyright law, in 2002, Creative Commons is a type of copyright license that allows creators to maintain their copyright of their material while at the same time waiving other elements of the traditional "All Rights Reserved" copyright restrictions, thereby permitting others to access, download, reuse, and/or remix the material for their own purposes. Says Lessig (2004), the aim of CC licensing "is to build a layer of *reasonable* copyright on top of the extremes that now reign" (p. 282). Six different Creative Commons licenses are available, ranging from the least restrictive "Attribution CC-BY" license, which allows others to distribute, remix, build on, and even distribute commercially someone's work as long as attribution is given to the original creator, to the most restrictive "Attribution-NonCommercial-No Derivatives" license, which allows downloading and sharing of an author's work but no reuse of the material. The range of options in between allow content producers to state explicitly whether derivative works are allowed, whether these derivatives must also be licensed under Creative Commons, or whether commercial reuse of the material is permitted. Creative Commons is not the only type of license that can be used to provide

materials as open access, but it is certainly one of the most widely used and well known (Suber, 2012).

The Public Library of Science is one of the major open access publishers that use Creative Commons licensing for the material published in its journals and on its websites (including blog posts and forum discussions). Beyond licensing, though, there is a range of open access publishing models that journals can undertake. As a non-profit organization and advocacy group, PLOS follows an author-pay publishing structure, with varying fee structures for each individual publication. Many research groups in the sciences now incorporate open access publishing costs into their grant requests, and PLOS sets aside some funds to support authors who are unable to pay its publication fees, which range from $1,350 to $2,900. Articles are then freely available at each journal's individual site. Other open access journals offer commenting on articles for members of the journal's online community, while others have introduced openly posting manuscript drafts for online peer review before publishing the final product.

The open access publishing landscape is also often commonly divided into two main kinds of open access: "green OA" and "gold OA." Gold OA, as the name implies, is the highest standard to which academics aspire for their research; it refers to research published originally in an open access journal that makes the content available freely to all users. Green OA, on the other hand, refers to research that is often initially published in a closed access journal but is also made available by the author(s) through an institutional repository, using their authorial rights to make freely available to anyone a pre- or post-print version of their

work. [4] arXiv is an example of an institutional repository; most institutions of higher education host their own repositories through their libraries. Nearly any journal article can be available through green OA (repositories) as most publishers have agreements that allow pre- or post-print versions of the articles to be openly hosted in a repository. It is this identification of "green OA" that can make it difficult to calculate the total number of articles published via open access in any given year, especially to make a point of comparison with conventionally-published articles. Having articles that are published first in a closed-access journal and then posted to a repository can lead to confusion and double-counting publication numbers. The most dedicated open access proponents, however, see these two categories as false distinctions for open access, as promoting green OA promotes the practice of continuing to publish in closed-access journals. Critics of this distinction see the ultimate goal as making all publicly funded research openly available and want to avoid creating different categories of potentially acceptable OA practices in favor of simply advocating all research be openly published.

Dissertation focus: Genre theory and open access

From this brief historical and conceptual tour through issues of open access, one thing is clear: change in the publishing of academic journal articles is afoot. In the context of the

[4] To clarify some definitions: Pre-print refers to a version of an article before peer review; post-print refers to a peer-reviewed version of a journal article before it has been typeset and formatted by publisher. Articles published as "green OA" are by definition then simultaneously published closed access (the publisher's version) and open access (the version on the researcher's site/institutional repository). This adds a complicated layer to studying the influence of open access. The focus of this study will be solely on "gold OA," or articles that are published open access by the publisher immediately.

academic journal article, this should give us pause. Historically, the academic journal article is a relatively stable genre. Its development has been thoroughly chronicled (Bazerman, 1988; Berkenkotter & Huckin, 1995; Gross et al., 2002), demonstrating some change over time but remarkable stability as an important genre for the evaluation of the contributions that scholars make to their field (Schryer, 1993), and subsequently, for tenure and promotion. The developments seen through (though not completely limited to) the open access movement are significant in the way that they represent some of the biggest changes to journal publishing in a long time, reconceptualizing major issues in scholarship. A turn to open access represents a fundamental shift in the ways in which scholars view their own work and the work of others, the ways that people can access research, and the ways that other institutions are involved in the process. Much has been said already about the rise of open access as a preferable method for publishing and disseminating research, as evidenced by the many bloggers who have taken up and documented the cause (Mike Taylor, David Parry, and Richard Poynder, to just name a few well-known ones), but no one has yet closely examined the potential changes that the genre of the journal article is undergoing, particularly with respect to open access.

In light of the ubiquity of journal websites and online publication of journal articles, however, it is increasingly difficult to view the scholarly research article as a single genre that stands alone. Instead, a stronger analytical approach takes into consideration the genre ecosystem of the academic journal: the editorial policies, other forms of publication produced by the journal, access policies, audience, reach of the publication, peer review procedures,

commenting capabilities, tenure and promotion, citation practices, blogs promoting the research, and more. Each journal ecosystem has its own unique elements, but they each have the same core: the scholarly research article. In other words, we have one relatively stable genre surrounded by a more varied and highly susceptible to change system surrounding it. While the "ecosystem" of a journal has been around as long as the journal itself, what we are seeing now with the development of the ecosystem online is a rich yet understudied system that is undergoing a lot of change that rhetorical genre theory must better be able to account for. In this section as well as the next (and more fully in chapter two of this dissertation), I outline the elements of an analytical framework that considers the academic journal article historically as a relatively stable genre, develops the concept of the journal ecosystem, and uses rhetorical genre theory to account for the potential change that we are seeing take place with open access journal ecosystems and the journal article genre online.

The academic journal article: A historically rich yet stable genre

Research in scholarly publication has a rich history; indeed, the study of academic scholarship by academia has been well documented throughout the twentieth and twenty-first centuries. Why the scholarly research article? As Gross et al. (2002) argue, these texts "have become the canonical form for the communication of original scientific results" (p. 4). This genre has received quite a lot of attention over the years, notably in an attempt to chronicle its development into the influential genre that it is today. This literature is rich and diverse, covering disciplines from rhetoric of science, sociology of science, history of science,

philosophy of science, and information science; a full treatment cannot be addressed here. However, we can acknowledge contributions to some important discussions about the research article that demonstrate where research into this topic stands today. The history of this genre, as told by the scholars who have studied it, is one of a relatively stable genre once its identity as a scholarly genre was developed and its contribution to academia was clear.

The primary focus for rhetorical scholars studying the original research article has been in scientific research articles (SRAs) (Bazerman, 1998; Myers, 1990; Berkenkotter & Huckin, 1995; Gross et al., 2002). As one of the most important studies in the history of the scholarly journal article, Bazerman traces the history of the SRA from the emergence of the experimental report to its development as recognizable genre. He argues that the genre developed as the preferable way to present empirical knowledge, and the genre shaped the disciplines that used the SRA as the genre developed as well. His extensive research into the first English language scientific journal, *The Philosophical Transactions of the Royal Society*, reveals that the first articles published by the journal primarily reported accomplishments, observations, travel logs, and theoretical pieces. However, as the genre developed, experiments became a frame for solving problems, and later became supporting evidence for hypotheses and conclusions about the natural world. Bazerman argues that language realizes the work of science, and that the texts of science became inherently stable as the concepts of experiments and hypotheses gained traction in science.

Also studying *The Philosophical Transactions* as a way to chart the development of the SRA as a genre were Gross et al. (2002). The strength of their work is the impressive

historical range that they address and the sample size that accompanies a study encompassing over 300 years of scientific journal publishing. They not only study *The Philosophical Transactions*, but also nearly one hundred other journals published in two additional languages (French and German). Their analyses of articles span four centuries, allowing them to offer the following conclusion about the stability of the original research article: "In the 20th century, we find the scientific article growing considerably more uniform across national boundaries and scientific disciplines" (p. 230). Contributing to this conclusion of stability are an increasingly objective style, stylistic and presentational preferences for efficiency in communication, arguments that are confirmed through theory, and an increasing prominence of visual elements integrated into the argument.

While these and other scholars have studied the SRA holistically, other studies have focused on more precise components of the genre to better understand certain individual elements. Swales (1990, and later revisiting in 2004) analyzes research articles from a linguistic perspective. His research is best known for developing the theory for the now-standard model for original research article introductions, the "Create a Research Space" (CARS) model that is now frequently taught to graduate students as they learn the practices of academic research communities: 1) establishing a territory; 2) establishing a niche; and 3) occupying the niche. Less well-known, but equally important for research on the genre, is his discussion of the other components of the journal article, particularly the Discussion section, where his 2004 book builds on previous research, including Berkenkotter and Huckin (1995; see below). Though his main field is linguistics, rhetorical genre scholars have found Swales'

work on the journal article useful for their own work, especially in understanding how the research article introduction establishes the exigence and value context for the work to the discourse community into which the author is writing and also for understanding which rhetorical moves must be made before other rhetorical claims can be asserted.

Berkenkotter and Huckin (1995) examine the idea of "news value" in SRAs, connecting the concept with shifting reading habits of those in the scholarly community, analyzing several specific elements of the scientific research article to do so: the title, headings, structure of the introduction and discussion, and visual elements such as graphs, charts, and images. They argue that changing reading habits of scientists result in changing genre conventions for articles, emphasizing how genres can act as a window into the values and norms of the community enacting them. They also build on Swales' (1990) model for journal article introductions by identifying a mirror image of the CARS model for introductions in the discussion section of articles: they begin by occupying the niche, reestablish the niche based on the results, and then move to establish additional territory that could be occupied by this work. However, both Swales and Berkenkotter and Huckin acknowledge this part of the genre is more nebulous and less frequently true to form than introductions, which follow the CARS formula in a much truer fashion.

Gross et al.'s (2002) work falls into both the category of studying the articles holistically to track change over time as well as examining particular components of the scientific research article to characterize it within a particular century. To analyze sets of articles within specific time periods (the 17th, 18th, 19th, and 20th centuries) separately, they

chose three broad categories: style, presentation, and argument. Methodologically, they partitioned each of these categories into operationalizable variables, such as the frequency of passive voice phrases for style, or the arrangement of differently named sections for presentation.

Another trend in research into the scholarly research article is the influence of technology on the publication process. Computer-based technologies led to new roles for communicators, particularly in scientific publishing. As scientists adopted computers to conduct their daily communicative and research activities throughout the late twentieth century, she argues, their roles in the publishing process began to shift and blurred from the traditional roles in print publishing. Most significantly, say Crawford, Hurd, and Weller (1996), the Internet has transformed scientific communication and publishing, resulting in changing roles and responsibilities for those involved. Mackenzie Owen (2007) focuses on one element of publishing that Crawford talks about, the SRA, from an historical perspective. He analyzes specific features of articles as well as tracks changes to technology (and specifically the medium of delivery) for SRAs to conclude, “In evolutionary terms, scientific communication has adapted itself by a process of *encapsulation*: through digitization of the journal as a container, the scientific article is able to remain relatively stable even within a digital environment” (p. 218; emphasis in original). Casper (2009) also highlights changes in scientific publishing in light of the Internet, but emphasizes where Mackenzie Owen’s work falls short: the SRA does not exist in a vacuum, but is instead a genre that is dependent on other texts and genres that surround it. Casper focuses on how online communication

technologies affect genres of scholarly research within science, comparing peer review models for the esteemed subscription journal *Science* with the newly established online only and open access *PLOS ONE*. He takes an actor-network theory approach along with genre criticism to examine the interactions afforded by online media and how that changes the genre system of published scientific research. Casper's project specifically explores the mechanisms for post-publication review afforded by the online media of *Science* and *PLOS ONE*, examining online comments and use of forums and other community tools to determine where in the scientific article genre ecosystem these new mechanisms for article feedback fall.

Finally, in light of the growing popularity of open access journals, researchers of scholarly publication (generally in the field of library/information sciences) have also turned their attention to open access and the change it is bringing to scholarly publishing, though our understanding of this changing in publishing practices is not yet well understood. Research on open access publishing has mainly been conducted by those in library/information sciences, and thus far has focused on two main areas: 1) measuring the growth of OA publishing; and 2) understanding the influence of open access on how researchers both obtain and use OA published work. I have reviewed above some of the key findings for the former area of research and will simply reiterate here the difficulty that researchers have in tracking the increase in OA publishing due to the various ways in which something can be considered open—either being published via gold OA, or becoming open after a certain embargo period, or being placed in an open repository—thus making this a difficult area to fully understand.

Here, I will focus on research on how scholars use open access so that we might understand the influence such publications have on the future of study, across any of the fields that participate in OA publishing. Several studies find that open access articles are more frequently accessed and/or downloaded than closed-access articles (Brody, Harnad, & Carr, 2006; Davis, 2010; Gargouri et al., 2010). However, studies have been conflicted in their findings as to whether open access articles are cited more frequently than closed-access ones, and if they are, to what extent OA articles have an advantage over non-OA articles. While Davis finds that OA articles are cited no more than closed access ones, the current consensus seems to be that publishing via open access yields a greater citation impact. Harnad and Brody (2004) find that in the field of physics, articles made available OA were more highly cited than articles in the same journals that were not. Eysenbach (2006), in the most thorough work to date, reports that articles immediately available via open access were twice as likely to be cited within the first four to ten months, and nearly three times as likely after ten months, of being published than articles published in subscription access journals. Gargouri et al. (2010) find that articles available via open access "are cited significantly more than non-OA articles," and that this citation impact is even stronger for the most highly cited articles in a field. Such studies have led to the description of the "open access advantage": because they are more easily searched online and accessed, OA articles have a download advantage, along with a "competitive advantage." OA articles compete with non-OA articles for citations, and as the former are more readily available, they can be used and/or cited more frequently than non-OA articles. Overall, most research into OA focuses on quantitative

measures of influence on publishing; other than impact factors and increased article numbers and citations, very little is known qualitatively about how open access has (or has not) changed the landscape of publishing and by extension, the writing of scientific research articles.

From this brief overview of select issues in scholarly publishing, a couple of gaps in the literature, closely related, are apparent: 1) Many studies of the scholarly journal article neglect to consider the other genres that surround and influence it, such as the review article, the editor's introduction, or the special issue; and 2) The influence of open access on this historically stable genre is not yet well understood from a writing and rhetorical perspective. The dissemination of scientific research articles has also been understudied in the field of rhetorical genre studies, though rhetorical delivery is seeing resurgence, rightfully so, in rhetorical studies (e.g. McCorkle, 2012). As with these previous works, the majority of research on the SRA focuses on those published through a paid-access (also sometimes referred to as subscription, closed access, or toll access) model. The sole work in rhetorical genre studies that examines an open access journal is Casper's dissertation (a small part of which is forthcoming as a chapter in an edited collection on science and the Internet), which moves in the direction of helping us better understand the influence of technology and open access on the research article; that is, he has made important first steps in understanding the changes that are occurring within the larger genre ecosystem. His work is limited to a study of one open access journal in a specific subdiscipline of genetics and genomics, and focusing primarily on the feedback mechanisms each journal supplied; as an early work on the topic,

his research simply could not take into account the wider range of issues that should be considered with open access journal articles, including the affordances and constraints of the technologies used by the journal, the structure of the journal articles, authorship practices, editorial practices, and more. Overall, though, his approach to viewing publishing journal articles as an ecosystem is a useful concept for my own study. In the section that follows, I will begin to establish the theoretical underpinnings for understanding genre change online, including the idea of examining the genre ecosystem of the academic journal in conjunction with the genre of the journal article.

Theory for examining genre change online

Genre theory is becoming once again relevant, now for the purposes studying rhetorical texts in light of digital media. Giltrow and Stein's (2009) edited collection features chapters that demonstrate this resurgence of interest in genre, and particularly in the case of this collection, genres online. Miller (2011) argues that an explosion of texts and information in the past has prompted a response with interest in genre as ways to understand and think through texts, and hence, a return to thinking about genre. The concept of genre is fairly well understood, but the question of how genres change over time, and particularly now how they change online, proves a more difficult question to answer. This dissertation seeks to better understand how and when genres change online and the key factors contributing to genre change through an examination of a historically well-researched genre: the academic journal article. A study of open access journal articles can explore the concepts of genre change

online not only because the antecedent genre is so well understood, but also because there are many potential elements of change in the context surrounding SRAs.

To examine issues of genre change, this study builds on several key elements of rhetorical genre theory. First, I work from the perspective of genre as social action (Miller, 1984): I see genre as the recurring, typified action itself, not as a tool for accomplishing action. Second, I work from the perspective of genre as texts in context, so genre analysis necessarily includes both textual analyses of the articles and a discussion of the context surrounding the articles, including the overall workings of the journal and the perspectives of the authors and editors of the journal. Finally, it is important to see these born-digital open access articles as a part of a larger grouping of genres that all work together online, so I work from a particular framework to examine these all together and not just the singular genre of the original research article itself. In what follows, I establish the theoretical framing for my project; the full methodological description for studying genre change online is a full chapter on its own, the second chapter of this dissertation.

In her seminal article, Miller (1984) describes genre as “typified rhetorical action” (p. 151), and with this work, she shifted the focus of rhetorical genre studies from taxonomic approaches to text to examining texts in context. Rhetorical genre theory examines texts in context, form and content, and product and process (Devitt, 1990). Genre is a unifying theme for studying language and action: “It enables us to relate the grand themes that characterize a culture, a community, a period, to the forms of and in its texts” (Lemke, 1994, qtd. in Swales, 2004, p. 241). The strength of genre analysis, as many rhetorical genre theorists implement it,

is that it includes both text-focused examination as well as study at the larger socio-cultural level. Devitt (2004) says it is imperative to recognize genres as inherently social, as they require multiplicity to achieve action, be used, and/or be recognized: multiple people, multiple actions. Genres cannot exist independent of people—writers and audience—who take action through genre. It is this emphasis on context and not merely form and content that makes genre theory an important critical lens through which we view the texts. As rhetorical structures, genres "normalize activities and practices, enabling community members to participate in these activities and practices in fairly predictable, familiar ways in order to get things done" while at the same time being dynamic due to the changing conditions of communities, technology, and other frameworks that affect genre enactment by discourse communities (Bawarshi & Reiff, 2010, p.79).

By understanding genre as typified rhetorical action that is inherently social, I can identify a few potential drivers of genre change: the needs of genre users, technology change, and major social or cultural shifts. It is important to note that these drivers of change do not exist separately; indeed, they often work in tandem to drive the shifts we see in texts. The first, change driven by the needs of genre users, is emphatically plural: one person does not a genre make. Genres are inherently social, and as such, change accordingly. Inherent in this issue as a driving factor for genre change is the idea that no single person's life is perfectly stable; change is inherent in being human: we grow, we age, we become educated, we change jobs, we become responsible for other living, breathing things. Our needs change, so our needs for communication change, too. And because genres develop in

groups/communities/collectives, and function to achieve the goals of these collectives of people, they change according to the needs of those who use them to accomplish social action. As people have new social action that they need to achieve, and as old exigences fade away, users need the texts they write to shift accordingly. These needs may or may not be driven in part through the rise of new technologies, the phasing out of old technology, changing cultural values, specific local needs, or for many more possible reasons. Early rhetorical genre theorists explored the idea of the changing needs of users, including Yates (1989), who examined the emergence of the business memo as a genre. Business managers had newly adopted the idea of systematic management (in and of itself a cultural change at companies), which created a need for a new type of internal communication in businesses. Thus, the memo was born: it eliminated the need to use letterhead internally, worked with the new filing system, and cut down on time for communicating in the workplace. Of course, these new business needs are coupled with the development of certain technologies in the workplace as well. The memo also developed in part because businesses now had typewriters that facilitated faster writing and increased legibility. The creation of vertical filing systems (a technological advancement) also made the smaller memo size a perfect fit.

Related to the needs of genre users is our understanding that genres—and various genre assemblages, like genre sets, systems, and ecosystems—represent community ownership and the epistemologies of the communities that use them. Building on Miller's work, as well as that of Swales (1990) and others, Berkenkotter and Huckin (1995) describe how study of genre provides insight into the community ownership of genres. In particular,

they describe how “genres of academic writing function to instantiate the norms, values, epistemologies, and ideological assumptions of academic cultures” (p. 22). Berkenkotter and Huckin work from the perspective of genre as situated cognition, taking a socio-cognitive approach to understanding genres within academic contexts. Their work builds on the understanding that “genres dynamically embody a community’s ways of knowing, being, and acting” (Bawarshi & Reiff, 2010, p.78). Related to genres’ representation of values within a community is the way in which genres can be regulated and regularized (Schryer & Spoel, 2005). Genres can be regulated by the community, as resources that refer to the specific knowledge or skills needed for the professionals within it. They can also be regularized, or less formally managed practices that derive from situational use and lacking the codification of regulated resources. According to Schryer and Spoel, genres as both regulated and/or regularized resources “index professional beliefs and attitudes” in ways that are important to those developing their identity within a community, particularly for those in professional fields (p. 250). When the values of a community change, or the needs of professionals within that community change, then the genres change accordingly.

A second important driver of genre change is technology. While it could be argued that this element belongs within the third category “major social or cultural shifts” (and indeed the two categories are not mutually exclusive), what previous research in rhetorical genre theory shows is that technology or media, as our major means of communication and source of instability within culture, belong in a category for consideration on its own. Many genre theorists make arguments for technology as a driver of genre change. For example,

email emerged because we had networked computers that made communication must faster and/or convenient than phone or letter. Yates, Orlikowski, and Okamura (1999) begin to theorize about this influence, arguing, “because our use of a communication medium necessarily involves the enactment of genres, technology-use mediation—through its influence on the use of a medium—would also influence the enactment of genres within it” (p. 85). Yates et al. found that in a lot of cases, users of a new technology (such as a new electronic team room used in an organizational communication setting) often imported genres from analog settings that they were familiar with, but as their use of the technology continued, the genres began to shift in accordance with the affordances and constraints of the technology they were using, something that Miller and Shepherd (2009) also highlight as a driver of genre emergence in their discussion of the blog.

Finally, major social or cultural shifts can drive genre change—or resist it. Berkenkotter and Huckin (1995), Bazerman (1988), Devitt (2004), and others all make an argument for the importance for genre research to incorporate socio-cultural examination into analysis of textual features of the genre for this very reason. “Socio-cultural examination” means studying not just the genres themselves by how they are manifested textually, but also how users see genres, whether they are authoring genres, the intended audience, or both. Devitt (2004) impresses the importance of this kind of work to understand genre “because ideologies, values, assumptions, and epistemologies are rarely explicit” (p. 53). The connection here is that large shifts in cultural practices and values also have an effect on the practices and values of the humans in that culture, and so their communicative needs or

habits will also change to reflect this. For example, in the case of open access, there are several social and cultural influences working together as a part of this rapidly-growing movement, as articulated in the above timeline toward the explosion of the open access movement: resistance against record corporate profits, unsustainable journal subscription prices, unprecedented cuts to higher education, and shifts in the definition of scholarship in light of new/digital media. These issues all work together across the disciplines to make open access a timely response to what seems like an increasingly dire situation for academic researchers, and many are adapting their publication practices accordingly.

While I have delineated these drivers of change separately, this is really a false separation: in reality, genre change rarely, if ever, stems from a single source. The key is that genre change happens because of all or many of these influences together. Blogging platforms created a discursive space for people to engage with blogging; dissatisfaction with the mainstream media gave some individuals the motivation to create an alternative; and culturally, a society of voyeurs who were watching reality TV and reading juicy memoirs (among other things, of course) created a readership for just such blogs. Miller and Shepherd (2009) argued successfully that all of these things must be considered together for us to really understand genre change, and their work serves as a model for rhetorically exploring genre change. The justification for this is that we recognize at some level how genre and culture can be understood together, and how genres can reflect the norms, values, ideology, and epistemology of the communities that use them. Bazerman's (1988) work analyzing the development of the scientific article not only examines how the context shapes the genre, but

also how the genre shapes the context. Along with a textual analysis, Bazerman charts how the emergence of the first scientific journal and the development of articles and other genres of the journal shaped science as a social enterprise. He argues that the genre of the scientific article played a key role in the development of the social structures of science, including the role of the journal editor, the role of the scientist as a reporter of his/her work, and the role of readers of these journals. Part of my argument for looking specifically at open access journal articles is that this momentum toward open access in academia is at the same time a function of a global and cultural shift resulting from our increased usage of digital technology and the Internet. Many people see not only how easy it is to share information freely in the world, but also the possibility of how much richer our culture can be for doing so, and how we can bring access, knowledge, and information to those who have historically been without or lacking adequate access. As a result, we share much of our information openly online, publish blogs of our work, and most crucially as academics, publish our scholarly research in open journals or deposit pre- or post-prints in repositories.

Most importantly for this research, if genres are social, and change according to needs of users, technology, or cultural shifts, they must also necessarily change because of other genres. Rhetorical genre theorists recognize that a single genre does not exist independently of other genres; indeed, any given genre is influenced by those that came before it (antecedent genres) and the other genres that exist in the institutional, organizational, or social setting in which it is situated. These are generally known as genre assemblages, or various ways that genres can be grouped according to their use. Devitt (1991) and later

(2004) talks about genre sets as "more loosely defined sets of genres associated through the activities and functions of a collective but defining only a limited range of actions" (2004, p. 57). This concept recognizes that discourse communities have a broad range of genres that they use, but that there are often particular genres that work together and are consistently used together to achieve specific purposes within the community. Her definition and is inherently rhetorical, based in the actions that the genres work to achieve and what they communicate about the community that uses them. Building on the idea of a community having genre sets, Orlikowski and Yates (1994) theorize that the various sets of genres that a community enacts constitutes their genre repertoire, saying that "A community's genre repertoire indicates its established communicative practices" (p. 546). Yates, Orlikowski, and Rennecker (1997) build on this previous work in defining the genre system, which they say is "an interrelated sequence of genres enacted by members of a particular community" (p. 51), which also have the potential to overlap when necessary. A genre set is similar to a repertoire in that the genres within a set are used to accomplish goal of a person or an organization. A system can be larger than a set because it consists not only of a particular set of genres that a person or community uses to accomplish a goal, but it also includes related genres even though they may not all accomplish the goals of the same person or community. For example, a letter of recommendation is a part of a graduate student's genre system, but it would not be a part of any of her genre sets. Spinuzzi (2003) adds another genre assemblage to our discussion of genre with his theorizing about genre ecologies. He frames genre ecologies as synthesizing genre theory, activity theory, and distributed cognition, arguing that

genres are “mediating artifacts [that] qualitatively change the entire activity in which works engage” (p. 38). Spinuzzi’s conception of genre ecologies is designed to describe how genres overlap as well as to serve as the way in which a community thinks through its activities as opposed to seeing genres, as he says, merely as performing or communicating the activities of a group. His focus on overlap comes from a misinterpretation of Orlikowski and Yates, whom he claims do not account for that particular interaction of genres in their discussion of repertoire. The key difference between the way that Spinuzzi frames ecology and other genre assemblages is that he says ecologies assume that genres *mediate* action instead of *communicate* it. In this way, genres are viewed as tools rather than texts that can accomplish any action or successful communication. This approach, I would argue, moves away from a rhetorical genre approach, which is the more useful approach for looking at texts as being able to achieve social action through the ways in which they are enacted by communities.

While various genre assemblages are appropriate analytical frameworks for particular genres and communicative circumstances, none of the assemblage frameworks briefly described here quite fits the purpose at hand of examining the genres surrounding the SRA and the changes that are taking place with scholarly publishing. Recently though, scholars have explored a fifth option for thinking through genre assemblages, genre ecosystems, though the scholarship on this terminology has not quite come together yet into a cohesive framework. Bawarshi (2001) describes genres as “rhetorical ecosystems” because they “help reproduce sociorhetorical environments by providing communicants with the rhetorical conventions for enacting them” (p. 73). That is, genres shape and reproduce our

environments; they are ecosystems because they are home to our "rhetorical habits as well as social habitats" (p. 73). This approach to seeing genre as an ecosystem focuses on how all the elements of one's life shapes one's writing. This approach to genres uses the terminology that I am thinking about, though it seems as if Bawarshi's discussion ecosystem is less composed of multiple genres (as the scientific research article ecosystem is) and more composed of social elements that influence the use of a genre.

More recently Casper (2009) argued for using the term ecosystem to examine the various genres that comprise scientific publishing. He reasons that Spinuzzi's description of ecologies touches on an important component of studying genres—the idea of environment—but is decidedly less rhetorical than genre theorists are looking for, hence the need for a different yet related concept for genre assemblages, which he proposes: ecosystem. While closely related to the term ecology, his use of ecosystem is designated as a more rhetorical approach than Spinuzzi's term ecology. In theorizing about genre ecosystems, Casper studies the new mechanisms for providing feedback on journal articles published online, arguing that these new mechanisms change the journals' environment and thus the reading practices of users as well as the perspective they bring to the online texts. The interconnected relationships of these elements—the central genre of the SRA, new genres of feedback, along with the affordances of the technologies being used—lead Casper to conclude that the perspective of an ecosystem most accurately describes the phenomenon at work in the online scientific journals of *Science* and *PLOS ONE*. He says the concept of ecosystem combines the concepts of genre systems and genre ecologies, maintaining the

symbiotic, interconnected nature of “genre ecologies” but leaving behind the problematic principles of activity theory in favor of seeing genres within an ecosystem as more dynamic and decentralized. He argues that ecosystem is a particularly useful concept for studying genres online, saying, “All texts exist in a fluctuating pool of other texts, but there is a greater diversity of relationships between online texts than between print texts” (p. 137).

I argue that Casper’s discussion of online scientific journals as genre ecosystems is an appropriate and useful framework for examining these texts, this concept of genre ecosystem can be expanded to other genre ecosystems beyond science (though the latter is a discussion for another dissertation entirely). However, his theorizing of genre ecosystems has yet to be taken up in genre theory and is in need of further development to be useful for genre scholars. While he incorporates a consideration of environment (or context, as Devitt says), a thorough discussion of the influence of environment, relationships between particular factors, and specifically that of technology on the environment are not fully discussed in his work. I see, however, that the ecosystem concept allows for a close examination of the key text, the SRA, in open access as well as other texts connected to the genre and influential elements surrounding the key text. This stems from our understanding of genres as texts in context. The ecosystem includes many of the ideas already mentioned here—the political economy of academic publishing, the history of the SRA as a genre, the fields of study in which they are situated—as well as other elements that will be examined in the actual case studies (and the justification for these other elements is explained in Chapter 2). Therefore, this dissertation will explore the concept of genre ecosystem as a way to productively examine genre change

for the way that the ecosystem metaphor encompasses the important elements of genre change that I have previously outlined.

SRA Genre Ecosystem and Scientific Ideology

An important concept that surrounds the ecosystem that has yet to be explained is the ideology of science, as the review of the literature above shows that culture (of which ideology is an important part) plays a key role in genre change and thus deserves to be specifically addressed here.[5] First, science has specific standards for what constitutes knowledge, which Kuhn (1962) describes as "the assent of the relevant scientific community" (p. 94). With scientific research articles, this assent is given through peer review, and when published, others in the community provide assent by citing work and building upon it in future research. Second, the culture of science has been historically understood to be conservative (Mackenzie Owen, 2007), in addition to the strict gatekeeping functions that help to ensure high quality in scientific endeavors (Merton, 1942). To that end, Merton argues that science has a particular ethos that is expressed through four key norms of science: universalism, communalism,[6] disinterestedness, and organized skepticism. Universalism, according to Merton, means that any scientist can contribute to the building of scientific knowledge, regardless of any personal or social characteristics. Communalism means that findings do not belong to the scientist(s) who made them, but to the scientific community as a whole and belong to the public domain. Disinterestedness as a norm explains

[5] There are many elements to the culture of science, and due to the nature of this project, it is impossible to cover all of it here. As such, I will focus on a few key scholars of science whose work I will connect to the study of the SRA.

[6] Merton's original term was communism, but communalism has become the more commonly used term to refer to this norm

that scientists do not publish for the purposes of personal gain, or for prestige, but for the greater scientific purpose of extending knowledge. Merton's final norm, organized skepticism, means that new scientific claims are subject to critique and close scrutiny by the scientific community prior to being accepted by said community. While not intended to encompass all elements of the social system of science (for example, there is no mention of technical norms), and while these terms have not gone without some critique (eg. Macfarlane & Cheng, 2008), they have proven be a useful way to talk about the culture of science.

Gross (1985) helps to unpack the connection between science, ideology, and the SRA genre. SRAs, he says, are typifications that are designed to construct the reality of science, and for many, the reality of science—the way it is primarily conducted—is through induction, where a conclusion becomes probable based on strong evidence that is given. Ideologically, induction has a significant influence on science. Gross explains how the order of a scientific research article may "distort" the actual processes scientists follow in their work (p. 16), but because data and observation are seen as the primary basis for conclusions, the IMRAD order is followed and demonstrates how nature is "speaking." The introduction demonstrates how the experiment at hand continues the work or research program of previous scholars, the methods section relays details on the process so that other scientists could judge for themselves the merit of the work, the results section presents how nature is speaking in a clear manner, and the discussion section ends the paper with statements that were sufficiently founded based on the presentation that just occurred. Thus, in the SRA, we can see the communal belief in the objectivity of scientific investigation.

Beyond reflecting Baconion induction, the sections of the SRA also reflect Merton's norms in critical ways, thereby further reinforcing the culture of science with each replication of an IMRAD article. When introductions situate the current work within that of others in the research community, they also reflect the value of communalism, using the results that are communal to further knowledge within science. This also reflects disinterestedness, where they acknowledge that their work is not of their own sole discovery, but that at its heart, the work is based in the community and benefits science. When writing detailed methods sections, scientists also demonstrate the value of organized skepticism, whereby presenting a thorough description gives readers the ability to closely scrutinize the work that has been done and determine the validity of results based on having a thorough description of the process. Organized skepticism is also reflected in the above discussion of induction, objectivity, and science. Scientists seem themselves as skeptics when approaching research problems, and they come to conclusions based on a preponderance of evidence that leads them to that point. This influence of induction also introduces the norm of universalism: if one skeptical scientist can be persuaded based on the facts from a study, then it is assumed that any reasonable person would also be persuaded by them and draw a similar conclusion.

The entire process of publishing an article also reinforces these norms, as the act of making work public touches on the communalism of the work while also subjecting it to organized skepticism through the peer review process. And of course, the fact that many peer reviews are blind or double-blind demonstrates the norm of universalism, for the work is judged on the merits of the methods, data, and conclusions and not based on the person or

persons submitting the work. All in all, these norms and other elements of the scientific ideology persist and are an integral part of the enterprise of science. By extension, then, they are also influential for the key genre of science, the scientific research article. By considering the ideology of science as a key cultural component for the genre, I will also explore in this dissertation the influence the ideology of science has on the broader ecosystem I am considering in this analysis of OA SRAs.

Overview of chapters

With the theoretical foundation for this work established, chapter two of the dissertation describes the research approach taken and the measures used to complete this study of open access research articles in the sciences. In this chapter, I review our current understanding of the scientific research article genre from the literature. I then describe the specific methods for my project, including the justification of field and open access journal choices, as well as the three parts of my genre analysis: 1) textual analysis of sample articles; 2) analysis of the genre's broader genre ecosystem; and 3) questionnaires for the authors and editors of the journals studied. I conclude with a discussion of how these three parts inform a study of genre change.

Chapters three and four describe the results from my two case studies, *PLOS Biology* and *BMC Biology*, respectively. The chapters describe, in order, the three parts of my analysis: sample texts in the genre, the genre ecosystem, and genre user questionnaires. Each

case study chapter concludes with a discussion of the results and puts them into conversation with previous literature on the specific features of SRAs and scientific journals.

The fifth and final chapter synthesizes the results from the two case studies and discusses the implications of this work for the field of rhetorical genre studies. I explain why these cases are not evidence of genre change, returning to key ideas of genre as social action and the role of a genre's ecosystem as key indicators of genre change (or not). In doing this, I reframe the discussions that are taking place about open access being "revolutionary" and the internet as "revolutionizing communication," moving the focus away from technology and back to what rhetoricians are primarily concerned with: context. In this study, a key element of the context is the ideology of science, and in the final chapter, I explore what the culture of science means for the SRA genre. I conclude with a brief discussion of the study's limitations and directions for future research.

CHAPTER 2: GENRE ANALYSIS METHODS FOR OPEN ACCESS SCIENTIFIC RESEARCH ARTICLES

The goal of this dissertation is to better understand how genres change online through a case study of the key features of and sample texts from a genre that historically been well-studied: the scientific research article (SRA). Because genres are inherently social, and no genre exists in isolation from other genres, this study also examines the SRA genre ecosystem, a framework that allows for an understanding of the SRA genre and its ecosystem as interconnected and interdependent. Changes in the ecosystem may lead to changes in the focal genre, and vice versa. To investigate today's SRA and its genre ecosystem, along with possible drivers of change, I undertake a qualitative study of open access original research articles in the sciences, specifically biology. My two main research questions are:

- What influence does open access have on the SRA genre? How can this influence be characterized?
- How can the influence of open access on the SRA help us to better understand genre change online?

The main approach to answering these questions is through genre analysis. Such an approach incorporates research that is social, situational, cultural, and of course, rhetorical. The data for genre analysis in this case includes sample texts of the genre as well as an examination of the rhetorical situation, audience, purpose, and related genres. Thus, data analysis for this

dissertation is divided into two parts: 1) genre analysis of the open access scientific research article and 2) critical description of the OA SRA genre ecosystem.

This chapter explains in detail the methodological approach taken for this study, including justification of sample cases, development of measures for analysis, and steps taken to complete the research. The answers to research question one are explored in chapters three and four as I report on the findings from my analysis of *PLOS Biology* and *BMC Biology*. The dissertation concludes by synthesizing the discussion of research question one from the two case study chapters and by answering the second research question in the fifth chapter.

Open access biology journal case studies

To examine genre change online, this dissertation presents two case studies examining the emerging practices of open access (OA) publishing of scholarly articles on the Internet. My study focuses on the field with the richest history of research, the scientific research article (SRA), specifically in biology. In keeping with the rich history of genre research on scientific texts, I use two highly representative case studies to examine what is possible for texts in the SRA genre. While this research approach lacks the power to broadly generalize to other scientific texts or to predict the future of the genre, the benefit of offering rich detail and a close reading offers insights not available with other methods, such as statistical analyses on a large number of texts. This has been, and continues to be, a strength of genre studies. While the study of journals now also includes bibliometric studies, particularly

favored in the social sciences (including information science), the rich descriptive detail provided by the qualitative case study gives context that cannot be seen with citation analysis and other bibliometric computations. The well-documented limitations to bibliometric analysis (Waltman, Costas, & van Eck, 2012) mean there is a need for the qualitative work undertaken here to understand the context surrounding the numbers.

For this dissertation, the field of biology serves as a strong case study for examining open access journal publications for three reasons. First, because of the field's significant move toward open access over the last decade, open access journals are more plentiful. As of the beginning of 2013, the Directory of Open Access Journals (DOAJ) has nearly 300 biology journals indexed from around the world (DOAJ, 2013). Second, there is a good base of research on writing in biology (Myers, 1990; Berkenkotter & Huckin, 1995), facilitating comparisons grounded in previous research. Finally, in recent years, biology has become an important cluster of disciplines in the sciences, with emerging disciplines such as computational biology and conservation biology and its focus on understanding life and living organisms.

I sample from two relatively prominent OA journals from the field. The first journal I examine is *PLOS Biology*, which was launched in October 2003 and is the flagship journal of the Public Library of Science (PLOS). PLOS has since followed with six other open access journals and has become one of the premier OA publishers in the sciences. Two years after *PLOS Biology* began, it earned an impact factor of 13.9, making it the highest ranked journal in the field of general biology, where it has remained since (PLOS, 2005). The second

journal I examine is *BMC Biology*, one of the flagship journals of BioMed Central, which offers more than 220 open access journals in science, technology, and medical disciplines. *BMC Biology* is a highly ranked journal published by BioMed Central, and its 2012 impact factor of 6.53 (up from 5.75 in 2011) is one of the highest for all BMC journals.

Methods Part One: Analysis of the OA SRA

The first step of my study examines the quintessential academic genre, the original scientific research article. Here, my sampling is purposive; to understand open access SRAs and to draw comparisons to non-OA articles that had been previously studied, I need to examine examples of articles that have been well-received upon publication. For this study, I am sampling the five most viewed original research articles published by each journal, for a total of ten articles for my genre analysis. The determination of the five most viewed articles was made based on the most up-to-date metrics available for each journal on the date of data collection. In some cases, the most viewed articles are also some of the most highly cited from the journal. The choice to study the most viewed articles in the journal is motivated by an imperative for the open access movement: OA explicitly strives to increase access to and visibility of scientific research for both researchers and a more general audience. Because of this imperative to reach beyond expert communities, my method attempts to account for public engagement with these articles. Measuring citations only offers an insight into how the article is received within the scientific community. Conversely, looking at page views provides a metric that accounts for both a scientific and a non-scientific audience thus

acknowledging the affordances of open access journals. Additionally, drawing on exemplars for analysis follows a long tradition of work in the rhetoric of science, where scholars like Charles Bazerman (1988) and Alan Gross and his colleagues (2002) examine selective cases in their study of scientific articles.[7] My textual analysis of these fifteen sample SRAs draws on the approaches of these scholars as well as the works of Myers (1990), Schryer (1994), Berkenkotter and Huckin (1995), and Mackenzie Owen (2007) to identify key features of the genre, using features for analysis developed previously by these researchers to discover possible points of change and/or stasis between the closed-access articles they studied and the open access articles examined here.

Descriptive features for article analysis

A main goal of this dissertation is to discover the kind of influence, if any, open access is having on the publication of original research in the sciences. To determine the influence of open access on this genre, I draw on the rich history of genre research on the SRA, using similar measures for a comparative analysis between closed access and open access articles so that potential changes or influences could be identified. Before describing previously used descriptive features for analysis and my adaptations of these measures to fit my study, I first offer a description of the traditional scientific research article as we most

[7] The methods of Bazerman and the theoretical conclusions of Gross et al. have not gone without criticism (Harris, 2009); however, these works are still valuable precedents for studies of the scientific research article genre, as their results offer an important point of comparison for the data that I am collecting here.

recently understand it as a starting point for my genre analysis of the open access scientific research article.

In his now-classic study, Bazerman's (1988) readings of *The Philosophical Transactions* and *Physical Review* paved the way for other genre analyses of the SRA in its most current form. His methods and insights shaped future studies in several fields, including rhetoric of science and genre studies. Because of their thoroughness and focus on articles published all the way up until 1995, Gross et al. (2002) provide a particularly enlightening picture of the SRA as it stood at the end of the twentieth century. From their study of randomly selected articles from the most cited scientific research journals of the century (from fields such as physics, biology, biochemistry, as well as general science journals such as *Science* and *Nature*), they conclude that articles from 1900 on became more highly specialized as well as standardized, due in part to the significant increase in scholarly publishing. Journals began to issue style guides, and in many ways, they say, writing and presentation style converged. This century also saw the rise of what Halliday (1998) calls "scientific English," or objective style, and Gross et al. note its rise not only in English-speaking countries, but also in countries whose primary language was different, and where their researchers desired a broader audience for the country's scientific work. In a further discussion of style, Gross et al. note that one of the most significant changes to scientific articles is their cognitive complexity, saying, "As science has grown more theoretically and methodologically complex, its grammar has adapted by adding substantially to the complexity in its noun phrases and by deployment of specialized literary devices . . . aimed at

compactly conveying technical messages to small groups of highly trained readers in a specialized field" (p. 167). The increasing complexity of noun phrases and use of quantitative and mathematical expressions in the SRA, write Gross et al., contributes to the increased cognitive complexity of the genre, in addition to the content being highly professionalized and specialized. Furthermore, in describing the presentation of articles, Gross et al. (2002) offer the following synopsis of modern SRAs: They feature titles with specific claims (often results) and complete or nearly complete clauses; develop abstracts that immediately follow the title and author name(s); feature an introduction with standard moves (Swales "Create a Research Space" model, 1990); feature three-step conclusions that are similarly formalized; contain an ever-increasing number of citations to previous literature; frequently incorporate acknowledgement sections; use a sophisticated "finding system" (p. 181) that incorporates headings, subheadings, and table and figure numbers; increasingly rely on visualizations; and tend to have the canonical IMRAD logic. Berkenkotter and Huckin (1995) had similar findings in their research, including more informative titles with "syntactic fullness" (p. 32); inclusion of main findings in the introduction; informative subheadings; de-emphasized methodology sections, either through shorter sections, smaller font, or relocation to the end of the article; and overall increasing similarity to news reports.

Finally, in understanding genre rhetorically as social action (Miller, 1984), it is necessary to review the social actions of the scientific research article as we understand them at present. Science is, at its heart, a practice of consensus, and the key genre for science reflects this. Bazerman (1988) describes the SRA in physics as having a key function to

"produce statements to be validated by that community as knowledge" (p. 182). His research demonstrates how the genre has changed over time as the enterprise of science changed, with research articles being increasingly problem-driven, theoretically based, and methodologically precise. In the late twentieth century, he and other scholars (Berkenkotter & Huckin, 1995; Gross et al., 2002) find that the SRA reflects the epistemological norms of the community in which it is situated.

Overall, from previous research, we are offered a picture of a highly stylized genre with specific expectations for the presentation of methods, data, and results that come strictly from the data, and a genre that fulfills a specific role for the discourse community in which it is situated. Or, put another way, this is a genre that is highly dependent on previous iterations of the genre as a standard for future instances of it, standards that an entire global community of researchers recognize, write into, and expect from each other. For the purposes of this dissertation, I build on Gross et al.'s conclusions about the state of the SRA genre at the close of the twentieth century, adapting methods where necessary to account for technological and other potential changes that have occurred during the eighteen years since they conducted their study. I supplement the picture that Gross et al. paint with Myers (1990), who looks specifically at article writing in biological fields. Myers' study of two biologists working on grant proposals and journal articles shows how "writing *produces* biology" (p. xii; emphasis in original) and how the community into which the biologists must write necessarily shapes the outcome of both individual texts and the genres that make up the field of biology. Specifically, I borrow from Myers his discussion of how claims in the field are negotiated

during the process of publishing an article; my study here of open access articles will show how this negotiation now moves beyond the pre-publication of the text to post-publication as well. To examine the SRA in its open access form, I analyze the following elements of the genre:

Article title

Though it is a relatively simple measure, an SRA's title is not to be overlooked in a genre analysis of these texts. For my analysis, I continue in the tradition of other examinations of the SRA, particularly that of Berkenkotter and Huckin (1995). They analyzed the titles of 350 original scientific research articles from biology, biochemistry, and physics from 1944 through 1989, concluding that over time, the article title became "more informative" (p. 33). Their conclusion of "more informative" articles stems from several key features that they identified. One, titles moved from being strictly topical to nearly forming (or in some cases, completely forming) a complete sentence. Titles became longer, and as a result, gave more information to their readers. Berkenkotter and Huckin also identified "semantic richness" in the titles (p. 33), referring to how over time, titles shifted from giving a general topic of the article to announcing the results of the investigation being reported. Given that previous research has shown gradual change in the title over time, this is an important category to continue to examine to see if any further shifting is taking place in light of publishing in open access formats as compared with what we already know from the studies cited above.

For this study, titles of articles are determined by looking at the top of every original research article's page, which is often made to stand out on the article's webpage by being displayed in a much larger type size and often type font than the rest of the article. Titles are cross-referenced with the corresponding issue's Table of Contents to ensure proper identification of and accuracy of the title. Titles are analyzed for both length and for syntactic fullness and semantic richness, following Berkenkotter and Huckin's (1995) analysis of titles that found an increasing number of titles formed complete sentences and/or directly communicated results from the study being reported. In their study, and as I adopt here, syntactic fullness is determined by the presence of both a subject and a predicate. To investigate semantic richness, titles are analyzed for whether or not the final results of the research study are foregrounded in the title, thereby loading the title with rich detail about the research in question.

Article length

Bazerman (1988), in his analysis of *Physical Review*, found that the average length of articles in the journal varied over time. At the turn of the twentieth century, articles averaged 7,200 words, but within a decade dropped to around 4,500-5,000 before slowly climbing over the course of the century. In the final years of his calculations, the 1980s, articles averaged approximately 10,000 words (or their equivalents, such as numbers or acronyms). Mackenzie Owen (2007), in his analysis of online journals, found that while there are no immediate economic or technical limitations for the publication of online articles, journal editors still "express concern about the capability and willingness of readers to absorb large quantities of

information, especially when reading from the screen" (p. 164). For this study, I calculate the average length of articles in words or their equivalents (where applicable) and compare these with numbers found in previous studies. I also note language used on behalf of the journal to justify any policies in place in terms of a length requirement or suggestion.

Overall structure

The overall structure of an SRA is an important element of understanding the genre conventions of research articles. Gross et al. (2002) dedicate one third of their data collection to this feature, which they called "Presentation." For ease of analysis, I break down their Presentation category into three more easily distinguishable ones: overall structure, visuals, and navigational tools (the latter two features are described below). For overall structure, I rely on identification of the use of IMRAD logic for formatting for research articles (Introduction, Methods, Results, and Discussion), as this has become the standardized structure for SRAs from the twentieth century forward (Gross et al., 2002; Sollaci & Pereira, 2004). I look for all four of these key sections, other expected sections of an original research paper such as an Abstract and References, as well as less frequently seen sections such as Author Summary, Acknowledgements, and Author Contributions. Sections are identified by heading titles and are cross-referenced with navigational tools (see below) in journals where this was applicable (all articles in the sample included headings, which were required by the journals). Frequency of sections is calculated for all sampled articles. Uniquely titled sections

and those that were not used are also noted, and the implications of such usage (or non-usage) are discussed.

Use of images, graphs, and other visuals

Bazerman (1988) tracked the rise of visual aids in the SRA as well as their gradual shift toward being more rhetorical, moving away from raw data to refined reporting and representation of results in visual form. He notes how they not only served to report results of experiments, but also served to demonstrate the care taken in the process of research by illustrating newly designed apparatuses or steps taken during the procedure, starting as early as 1706. These "visual aids," as Berkenkotter and Huckin (1995) call them, can take many forms, and for the purposes of this study, I note all types as both Bazerman and Berkenkotter and Huckin identified them in their research. Such visual aids included raw data tables, graphs, line drawings, schematic diagrams, and photographs. However, I must also accommodate other visual aids as made possible by the affordances of the web and the individual journal's publishing preferences. These include image sliders (narrow content boxes that allow a user to scroll through thumbnail versions of figures and graphs in the article), short videos, PowerPoint slides, and more.

Use of visuals in scientific writing may be an area that is the most understudied in terms of known article features (Fahnestock, 2012), though other scholars are working toward a better understanding of their use (Gross, 2009; Gigante, 2012; Gruber & Dickerson, 2012). For this study, visuals are tracked to examine their use in an open access format, for

example, such as when they are ultimately linked back to open science notebooks or other open sources.

Article layout and use of navigational tools

Navigational tools is a category that has thrived and expanded with web technologies and the publishing of articles online. Initially, this category—layout—was limited to use of section headings and subheadings, as noted by Berkenkotter and Huckin (1995) and Gross et al. (2002) in their research. However, there is a much broader range of possibility for navigational features when an article is published online (Gross et al.). Mackenzie Owen (2007) argues that navigation is inherent in the structure of not only the article, but also the entire journal, and can take forms that are both natively digital as well as print-based. He gives the example of hyperlinks as natively digital, but article endnotes as a print-based navigational tool that has been adopted in the digital realm in terms of "forward referencing" within an article itself (p. 155). For the purposes of this study, I examine both print-based and digital-native navigation. I note the use of section headings as well as subheadings, but also added other features of articles that contributed to the navigational aid of readers: hyperlinks embedded in articles, including anchor links to other sections of the article as well as links out to other articles (generally as a part of a citation; see below for my analysis of citations as a part of intertextuality), and the portability of the articles to mobile devices, which are globally the fastest-rising category of device for accessing the Internet, and are predicted to continue to be for several more years (Cisco, 2012).

Intertextuality

I also look at intertextuality as a component of the scientific research article, as theorized by Berkenkotter & Huckin (1995). They describe and evaluate intertextuality in SRAs as the way in which authors construct original arguments in textual representations of the research activity that takes place in their labs.[8] Originality, in terms of their arguments, comes from both the comparison to and building on to the works of others who have come before. As such, the key element to intertextuality is the situating of an author's argument among those that have come before in the field. Berkenkotter & Huckin examine primarily the functions of citation in SRAs in their study, because, they argue, "Citation establishes the intertextual linkages that diachronically connect scientists' laboratory activity to significant activity in the field, and thus serves to establish a narrative context for the study to be reported" (p. 47). Intertextuality is a critical component to the rhetorical aspect of science (Myers, 1990), and necessarily shows how the local knowledge of the lab interfaces with the broader knowledge framework within scientific fields.

Analyzing intertextuality for this dissertation also serves to highlight the new possibilities that scientists have to connect with other research when publishing their articles with open access platforms. For the purposes of this dissertation, the citation practices of

[8] Intertextuality can also refer to the incorporation of a variety of other texts within a single text, such as an image, and is in this way closely linked to multimodality, particularly in the field of composition. For the purposes of this project, I am working with the definition of intertextuality previously used in the field of rhetoric of science to study scientific research articles.

authors are examined to see how intertextuality is manifest in open access SRAs. While Berkenkotter and Huckin (1995) studied the development of a scholarly research article from the first draft, through revisions, and to the final published paper in their chapter, "You Are What You Cite: Novelty and Intertextuality in a Biologist's Experimental Article," such an in-depth examination is not possible for this study. Here, citations, including their linking practices (which connect to the category of navigational tools) are analyzed for number of references and their general rhetorical function within each section of the article, including such purposes as establishing previous research, refutation, evidence, or corroborating authority. Counting the number of references per article is a method borrowed from Bazerman (1988) in his reporting of physics articles in the twentieth century, where he saw a decline in the number of references at the beginning of the century but then a rapid increase from the 1960s forward. The rhetorical examination draws from Berkenkotter and Huckin's argument for citations as "instantiat[ing] a rationalist view of the cumulative nature of scientific discovery" (p.59). That is, a primary purpose of citation is to demonstrate how this original work comes out of and builds onto the work that has come before in an effort to show where the novelty (and by extension, value) of the new work lies. Furthermore, while SRAs still maintain traditional citation styles appropriate for the journal and/or discipline, the affordances of their medium bring into play additional elements of intertextuality. Linking within citations may lead out to another scholarly article, a journal's website, the researcher's website or open notebook, or another place online; each of these were identified and rhetorical function noted.

File format(s)

Finally, it is important to acknowledge the multiple possibilities for digital file formatting in the sample journals. File formats are a new component for the analysis of research articles, as previous studies conducted by Bazerman (1988) or Berkenkotter and Huckin (1995) looked at publications only in their printed and bound journal form. In this study, article formatting is different across both journals, and each journal offers different file formatting possibilities beyond the default presentation on the screen. Possibilities included XHTML versions of the article incorporating very different styles through the use of stylesheets or downloadable PDF files that readers and researchers can save. McKenzie Owen (2007) writes that the choice of PDF is common in biology, particularly when also used with HTML formats, but that the continued use of PDF as a distribution format is "interesting" because it is a primarily printed document format (p. 143).

Part One methods summary

Overall, the analysis of these components of the scholarly research article genre in light of open access academic publishing paints a picture of the ways in which publishers are rethinking article publication. As the individual case studies in chapters three and four will illustrate, these components of articles differ across journals but offer a snapshot of the current state of open access scientific research articles. By offering such a snapshot, the results of this synchronic study add another point in the historical timeline of studying SRAs that began with the first SRA ever published (Bazerman, 1988) and continued throughout the

intervening years since (Bazerman, 1988; Berkenkotter & Huckin, 1995; Gross et al., 2002). From the comparison of these components, I draw conclusions about the elements of the genre that are adapting in light of open access publishing practices, a full discussion of which concludes this dissertation (chapter five).

Methods Part Two: Description of the SRA genre ecosystem

In conjunction with my textual analysis of sample SRAs, I also examine the broader genre ecosystem of the articles, which are composed of various other genres and technological applications, depending on the journal. It is also necessary to look outward from the main genre of the SRA to the broader community of practice in order to understand the recurring rhetorical situations, related genres, and the multiple genre functions, socially, situationally, and ideologically. To understand these elements and thus the changes to the scientific research article, I am focusing on what we might call the "genre ecosystem" of the SRA. Recall from chapter one that the concept of genre ecosystem within rhetorical scholarship is as-of-yet undertheorized, so the work conducted here is contributing through an examination of a specific ecosystem online. The concept of an ecosystem in biology is that of a community of organisms that interact with each other and with the physical environment surrounding them. These interactions within the ecosystem facilitate sustainability for the organisms involved, and they imply a certain dynamic equilibrium that balances competing resources and needs for those participating. In genre theory, we think of a genre ecosystem in parallel ways: the ecosystem is the community of genres that interact

with each other and with the variety of contexts in which they are used. Ecosystems necessarily include many genres, and the ecosystem for the scientific research article is no exception. The SRA genre ecosystem includes genre sets (Devitt, 2004), such as initial article submission, reviewer feedback, an author's revised resubmission, and the final version of an article. That set accomplishes the goal of the author and journal editorial board to publish new research findings; following Devitt, the set in this case helps accomplish a limited range of goals for the community and does not attempt to represent the entire range—repertoire—of genres and purposes to which these genres may be put. The SRA ecosystem also includes a variety of other genres in the repertoires (Orlikowski & Yates, 1994) of the editor (rejection letter, request for reviews, call for a special issue), authors (original research article, letter to the editor, review article, etc.), and others who interact with the genre, such as copy editors, publication assistants, and readers. In the case of repertoires, they include the various genres that users may enact at any given time, but which do not all necessarily need to be used to accomplish any given function of the community. Swales' (2004) concept of genre chain has a chronological connotation that is applicable to the process of publishing an SRA. He calls chains "successions of genres," where there is a specific order to the enactment of the genres. In the case of the SRA, the chain may include (in rough order) rough draft, research article (initial submission) with a letter to the editor, peer review, revised research article with a letter to the editor, acceptance letter, and the final, published version of the SRA. The key to genre chains is that there is a specific function that the order achieves; in the case of the SRA, the submission, peer review, revision, and resubmission order works to meet the

standards for the publication of scientific research by ensuring the rigor of the work and general acceptance of the methods and findings within the specific research community of the journal.

All in all, an ecosystem is a potentially wide-ranging assemblage of genres, incorporating formal communications alongside informal communications. And in the case of the scholarly research article genre, a thorough description of the ecosystem also includes consideration of the medium and the variety of tools that journals incorporate into research articles, the publicity practices they follow, and the audiences they reach. I conducted a preliminary search of the possible genres within the SRA ecosystem for my sampled journals by browsing each's website. While a journal's website does not include an exhaustive list of all of the genres within the SRA ecosystem, it does serve as a primary source for a majority of the SRA genre users and as such is a valuable source for this line of research. Beginning on the homepage, I look for explicit discussion of, links to, or other notification of genres enacted. I also browsed journal archives and read the instructions for authors and reviewers to account for a wide range of possibilities. I found that between the two journals in this study, the variety of genres incorporated into the SRA ecosystem is wide-ranging. The genres were mostly "official," being sanctioned communications or implementation of tools by the journal itself, though the lines blur somewhat with the study of the journal's social media presence and the way that research is promoted over such channels. Because of this, I divide here my ecosystem analysis into various components as presented by the journals: homepages, publishers, social media tools, and so on. Often these components incorporated

several genres and not just a single genre. Because there is no "official" list of genres enacted by a journal and the writers in its community, it would be problematic to analyze the ecosystem strictly by genre, as any list would necessarily not be comprehensive as genres are never completely stable (Schryer, 1994). Thus, I here organize my examination of the SRA ecosystem by the major components in the ecosystem and the genres that may be enacted within those components. I examine the following components for the sample journals:

Publisher

Genres communicate information about a discourse community's norms and ideologies (Berkenkotter & Huckin, 1995), so an important consideration for the SRA genre ecosystem is the publisher that is backing the dissemination of scholarly research. In working with an open access publishing model, each of the publishers of my two sampled journals is professing adherence to the ideology of the open access movement. For this component, I study the makeup of the publishing group, which ranges from being advocacy groups to one of the world's most renowned organization of scientists. To complement this understanding of who is behind the publishing, I also examine the ways in which these publishers publicly communicated their open access beliefs and practices, such as through statements on their companies' websites, to draw conclusions about the ideology of publishing open access research articles that the publishers were putting forward.

Journal homepage

Unless a potential reader has a direct link to an article, it is necessary to navigate the journal's homepage in order to find the specific publication that is being sought. To understand the relationship between the journals' main "faces" to the online world and the articles that they publish, I study the journals' homepages to see how articles are emphasized, linked to, and otherwise made central on the homepage of their websites. The possibilities include, but are not limited to, highlighted boxes with the most recent publications, a section for the most highly commented or most recently commented on articles, or a box highlighting different special collections for people interested in a particular topic.

Other publication genres

I also look briefly at the other genres that each journal published to discern their relationship to the SRAs that were published. These genres are identified using cues from the journal and/or publisher; if the website lists these texts as other genres that they published (sometimes called article types), I include them here for analysis. Often, these genres incorporate the same sharing features and had article metrics calculated in the same way as the SRAs, indicating on the part of the journals that they see their mission in publishing work related to biology that a variety of genres are useful and valuable to the research community as well as the more general public.

Publication practices and policies

To understand the scholarly situation into which these authors were writing and the influence of the publishing process on the SRA genre, I look at the journals' publishing policies, including their aims and scope, stated editorial policies, and other pertinent publishing information, such as time from submission to publication. I consider here the process for publishing in these journals and how certain stages of the publishing process may be adapted (or may not be) in moving to an OA model as well as the metagenres (Giltrow, 2002) provided by the journals, discussions of the expectations for formatting, citation style, and other instructions for authors. These features painted a picture of one particular genre system within the broader SRA ecosystem, incorporating authors, editors, and reviewers and the genres they all use to influence the final version of the SRA. Because publication practices have been studied before (especially in biology, by Myers, 1990), my focus here is drawing comparisons from practices and policies highlighted in previous research to the practices and policies of these journals, looking specifically to see open access seems to influence the scholarly research article ecosystem.

Content copyright licensing

In 2007, Mackenzie Owen argued, "The approach to copyright [in online journals] does not seem to be very much different from that in print journals" (p. 161). He found that in the majority of cases in his sample, authors had to transfer copyright to the publisher, while the remaining could keep their copyright, with certain restrictions such as allowing the

publishers first rights to reproduction. For the sample articles that I examine, I note the copyright licensing for each. The type of license selected by the journal and/or the authors necessarily influences what can and cannot be done with the published work (for a full explanation, see Lessig, 2004). Copyright information is generally found within or connected to the journal's discussion of its open access policy. Both of the journals utilize the Creative Commons licensing for their copyright agreements, though one of the publishers has adopted the entire CC-Attribution license as their own and given it a new name in lieu of using the CC-proper license (a full discussion of this takes place in chapter four). This component is a critical factor for differentiating the publication of journal articles just online and the publication of articles in open access.

Promotional practices

Journals recognize that in an age of many journals and outlets for scientific research, it is not enough to just publish the best research that is out there. For a journal to be successful—to earn a reputation for publishing strong research, attract attention, and garner continued support in the research community in the way of future manuscript submissions and readership—it must also have a plan for promoting the work that gets published openly. PLOS is known for its smart promotional plan for all of its journals, which includes an expansive PLOS Blog network and Twitter presence. For this component of the SRA ecosystem, I examine each journal's promotional practices, often listed under their "Information for Authors" or "About Us" section of the website.

Article metrics

Article metrics have become an important part of the online journal publishing scene. However, there is no single standardized way for online journals to calculate statistics, likely because of the complications that arise from determining whether an article was simply accessed (and if so, on purpose), in what format, or if it were even fully read. The kinds of statistics reported by the two journals shed light into the functions of their publishing that they see as important and often serve as an argument for the prominence of the journal or the strides made in online, open access publishing. Indeed, metrics have become an important consideration for authors in their choice of where to publish, for in the shifting publishing landscape, some measurement of the impact of their scholarship is still necessary for their career and also helps them make an informed decision about the venue for their research. For this ecosystem component, I note the types of statistics the journal made available and the justifications that are offered for collecting that information.

Commenting features

As Casper (2009 and in press, 2013) identifies, many journals that publish online (and often only online) have adopted commenting features that allow readers to comment on articles and other genres published by the journal. However, previous research (McKenzie Owen, 2007) notes that thus far, online journals have been less than successful at engaging readers in meaningful commentary online. This study will update this observation. The commenting features for the two journals studied in this dissertation range from informal to

more formalized. Like many online journals, the journals here allow commenting directly on the article's page by logging in as a registered user and offering comments. For this article ecosystem component, I describe how the journals enact commenting systems as well as look at their actual usage by journal readers.

Sharing features

Finally, journals use a combination of tools to encourage a wider audience for the research that they publish, a component that I've called "sharing features," which include social media tools, email to links, social bookmarking tools, reference management tools, RSS feeds, and email alerts. These features are found on the pages for individual articles as well as on the journal's homepage. The purpose of examining these tools is to identify the type of reach they encourage and to approximate their use within the community. The latter is possible because many of the social media buttons include counts of how many times the article had been posted or shared, such as with tracking article sharing on Twitter using the journal's embedded "Tweet this" function, which keeps a count of the use of that tool. Tools used by the journals studied here are all quite similar, and the sharing mechanisms they have in place could easily be found on a newspaper's website or other online information outlet: it essentially seems to be standard practice in the age of "Web 2.0." This component, while certainly not exclusive to open access journals, demonstrates a benefit of open access, when a Tweet about an article or placing it in one's Mendeley library means that anyone else can also see, access, and use the information as it is shared or saved.

Part Two methods summary

What is clear from these features is that an article that is born digital—only ever posted online and not formulated for print distribution—has a lot of features that distinguish it quite clearly from its print antecedents. Furthermore, the affordances of OA additionally distinguish the articles studied here from their closed-access counterparts. Certainly, all OA articles are online, but it is important to remember that not all online articles are OA. Indeed, most journals now, whether closed or open access, have some kind of online presence. Many of the closed access online versions of journals incorporate elements similar to the open access ones studied here. For example, *Environmental Communication*, a Taylor and Francis journal, includes social media sharing buttons where users can share just the abstract (if they do not have full access) or the full article (though those without access would not be able to view it; they would simply be routed to the abstract). The journal also tracks article metrics for the most read (counted as article views) and most cited. It is not surprising that for *Environmental Communication*, the most viewed articles are the ones where authors paid for permanent open access for readers. The most viewed article, "Why it Matters How We Frame the Environment," (Lakoff, 2010), has 2,600 views in a little less than three years of being published. The most viewed closed access article in the journal has a mere 462 views in two years of being published.

While closed access and open access online articles have some similar features, I argue that adding the layer of open access to an online publishing model results in significant distinctions from closed access online articles. Most significantly, the access to, uses of,

reuses of, uptake of, remix of, and redistribution of these articles is limitless, and as a result, the SRA genre itself as well as the other genres and features in the SRA ecosystem reflect this. Open access incorporates further elements for consideration, such as the ethos of the authors and publishers as well as the potential reach of the research, given its free and open availability (if one has Internet access, of course). With open access and the use of digital media technologies for publication and dissemination of research, there are new modes of relationality in the ecosystem of science publishing, and this dissertation highlights these emerging relationships and genres. While Mackenzie Owen's study of open access journals up until 2004 found that "they have in no way transformed the research article by incorporating specific digital properties" (p. 169), much has changed in the last decade since his study. This dissertation shows the ways in which open access scientific research article publishers are now (and still are not) implementing elements with digital affordances into their publishing practices and the influence these elements have on the scientific research article.

In order to get a full sense of the genre ecosystem of the scientific research article, my dissertation research methods also include a broader socio-cultural examination beyond my study of the components listed above. Bazerman (1988), Berkenkotter and Huckin (1995), Devitt (2004), and others all make an argument for the importance for genre research—and particularly in their cases, where they were studying genre change—of incorporating socio-cultural examination into analysis of textual features of the genre. Genres are inherently social, and people take action through genres. This means studying not just the texts

themselves, but also how users see genres, whether they are authoring genres, the intended audience, or a bit of both. Devitt (2004) emphasizes the importance of this kind of work to understand genre, saying:

> Because ideologies, values, assumptions, and epistemologies are rarely explicit, however, those participating in the group with the genres being examined are the most reliable interpreters of the discourse's cultural as well as situational meaning. It is difficult for those who have not acted through the genres to recognize the full meaning and significance of textual features. Just as users of the genre are the most reliable definers of a genre, they are also the most reliable interpreters of that genre. (p. 53)

To that end, I developed questionnaires for authors of these publications to understand their view of the open access scientific research article and their motivations, if any, for publishing in an open access journal (see Appendix A). Questionnaires were sent to the corresponding author for each of the fifty most-viewed scientific research articles for both journals (response rates for the journals are reported in their respective chapters). I also developed questionnaires for the editors of each journal for insight into how they see the genre of the journal article in light of OA and how they see OA influencing the overall ecosystem of the journal itself (see Appendix B). Questionnaires were sent to the email addresses listed for editorial correspondence for each journal (see chapters three and four for a full reporting on questionnaire distribution and response rate). While Devitt says that describing the practice of genre use necessarily means that the actual genre users should be the people to identify

and name them, my purpose here extends beyond that to ask genre users to identify possible points of change to the genre that they are aware of through enculturation into their discipline and to reflect on whether or not that constitutes a change in the genre or a change of some other kind. Finally, I will supplement my understanding of the turn to open access in the sciences with research into how the research community makes arguments about OA publishing/practices. Sources for such an understanding include blog posts about open access, statements from professional organizations or universities, and other public discussions of the field's stance on OA and the future of scientific publishing.

Answering research questions

The first part of my study, examining the features of the open access SRA, allows me to make a comparison to results from previous studies in rhetoric of science of the SRA and consider evidence for the potential genre change that is taking place. For example, changing practices in the titling of SRAs in open access journals speaks to a particular influence of open access ideology (this will be explained more fully in the results chapters). Furthermore, the second part of my research method then allowed me to identify influential factors that might be propelling this genre change by looking at the genre ecosystem in which these SRAs are situated. The surveys address the role of the authors and editors in the ecosystem and demonstrate the motives for the communities of discourse at hand. Put together, these elements shed light on the direction in which science and the dissemination of scientific knowledge is moving in the twenty-first century.

CHAPTER 3: *PLOS BIOLOGY* SCIENTIFIC RESEARCH ARTICLES AND THE ARTICLE GENRE ECOSYSTEM

Introduction to *PLOS Biology*

This chapter details the first case study of this dissertation, an examination of *PLOS Biology* and the scientific research articles (SRAs) published by the journal. *PLOS Biology*, the flagship journal of the Public Library of Science (PLOS), was launched online in October 2003. This publication is a general biology journal, welcoming submissions from the broad range of subdisciplines in the field, including microbiology, cell biology, genetics, computational biology, and more. The journal also accepts "works at the interface of other disciplines, such as chemistry, medicine, and mathematics" that are significant, original, and relevant to any or all areas of biology ("About *PLOS Biology*," PLOS, n.d.). It additionally publishes genres beyond the scientific research article, including opinion essays, news features, book reviews, and more. The language on the PLOS website, such as the mission statement, makes clear that the organization envisions the global, internet-using public as the broad audience for this journal, but the website's design is tailored to still meet the needs of researchers in the biological sciences, implying perhaps a primary focus on this demographic. The journal includes in its target audience "the international scientific community as well as educators, policy makers, patient advocacy groups, and interested members of the public around the world" ("About *PLOS Biology*"). It particularly emphasizes how the audience of scientific researchers is highly globalized. One way that PLOS acknowledges this globalized

audience and authorship for its journals, and the differing needs of researchers around the globe, is through its Global Participation Initiative, which offers publication charges at varying rates depending on an author's home country and/or research location, acknowledging that researchers in certain parts of the globe have fewer resources to work with than others. Additionally, because it does not charge subscription fees, the research published in this journal is theoretically available to any scientists and other readers in any country around the globe (who have internet access, of course) and not just those employed in countries with post-secondary institutions wealthy enough to afford journal subscriptions.

In the ten years since the journal's debut (October 2003-December 2012), *PLOS Biology* has published 1,596 research articles. It has in a short period of time earned a strong reputation in the scientific community, which is backed by a strong ISI impact factor of 12.69 for 2012. This makes it the highest ranked journal in the "Biology" category (Thomson Reuters, 2012). While the journal does not make public its acceptance rate (or any data that would allow its calculation), its "Guidelines for Authors" page indicates that "rejection rates are quite high." PLOS, through its flagship journal of *PLOS Biology*, has built its brand around the concept of publishing articles that are both central to the field and that push the boundaries of publishing, technology-wise, in academia. The new ideas for the scientific research article that PLOS has put forth with *PLOS Biology* and its other journals, PLOS's overall publishing model, and the implications for the SRA genre and its genre ecosystem are discussed in this chapter, based on the results of the methods described in the previous chapter. Part One examines elements of the scientific research article genre, with an

explanation of the journal's policies and/or practices when applicable prior to an analysis of the five articles sampled from the journal. In Part Two of the chapter, I explain the elements of the SRA's genre ecosystem as implemented by PLOS, and Part Three details the results from the surveys of authors and editors along with more detailed information about the PLOS community's perspective on open access. This chapter concludes with a summary of results and implications for the SRA genre and genre ecosystem based on the case study of this particular journal and its governing organization.

Part One: Analysis of five sample articles

In this section, I describe the results of my analysis of five sample articles from *PLOS Biology* (see Table 1). First, I provide a brief rhetorical description of these sample articles, which are the five most-viewed SRAs of all time in the journal and represent a range of subdisciplines of biology. The most-viewed article with 139,144 views (and counting)[9] is "The Diploid Genome Sequence of an Individual Human" by Levy et al. (2007). This article reports the results of the first ever attempt to assemble an entire diploid human genomic DNA sequence, that of J. Craig Venter, who is the founder of his own genome research institute and a leader in U.S. genome research. The project was an enormous undertaking, with the analysis of over 20 billion base pairs of Venter's DNA, and required the work of thirty-two collaborators, all of whom are listed as authors on the article. The Author Contribution section indicates they all participated in data analysis, seventeen contributed to

[9] All data reported here and elsewhere in the chapter are as of the date of data collection, January 17, 2013.

the conception of the study and design of the methods, and sixteen of them wrote the manuscript. Venter himself is listed as last author on the article, as is customary for the sponsor of the lab conducting the work. The study concludes that human genetic variation shown in Venter's DNA is between five and seven times greater than anyone else had previously concluded through less rigorous genome analysis. The authors hope their methodology for sequencing "can serve as a model for the emerging field of en masse personalized genomics," and judging by the high number of views and citations of the article, it has been well-received by the field.

Table 1 - General statistics for the sample articles from *PLOS Biology*

Title	# of views	Title word length	Article word length	# of authors	Days from submission to publication	# of citations (by others)
The Diploid Genome Sequence of an Individual Human (Levy et al., 2007)	139,144	8	24,546	32	118	362
Ultrasonic Songs of Male Mice (Holy & Guo, 2005)	101,626	5	8,913	2	262	84
Mapping the Structural Core of Human Cerebral Cortex (Hagmann et al., 2008)	99,363	8	10,765	7	209	307
How Many Species are there on Earth and in the Ocean? (Mora et al., 2011)	96,985	11	5,855	5	251	73
Human MicroRNA Targets (John et al., 2004)	89,659	3	17,957	6	134	1,054

The second most-viewed article, with 101,626 views is “Ultrasonic Songs of Male Mice” by Holy and Guo (2005). The authors are researchers at the Washington University (St. Louis) School of Medicine, where Holy runs a lab and Guo was a graduate student at the time of publication. The authors sought to expand our understanding of the biology of song through a study of the songs of male mice, which are typically inaudible to a human ear. They recorded male ultrasonic sounds to discover that the mice communicated syllables in conjunction with pitch changes, evidence that they do communicate in a form of “song” that can be rich and diverse just like those of songbirds.

The third most-viewed article, “Mapping the Structural Core of Human Cerebral Cortex” by Hagman et al., (2008), with 99,363 views, mapped the network structure of nerve fibers within the cerebral cortex using functional brain imaging technology, including diffusion spectrum imaging (DSI) for the first time of a human cerebral cortex. This map identified a matrix of locations in the cerebral cortex that are highly connected, what the authors call the “structural core” of the human brain. When they used a functional MRI to record the brain activity of study participants, they discovered a correlation between the connections the DSI discovered and the brain signals the MRI measured. They posit that this central core may act as a central system to coordinate processes in both hemispheres of the brain. This is an important step toward a complete mapping of brain activity, and the authors indicate a next step would be to incorporate subcortical brain areas into future study.

The fourth most-viewed article, “How Many Species Are There on Earth and in the Ocean?” by Mora et al., (2011), has 96,985 views and addresses the gap in biology of having

such a poor understanding about how many species there are alive today on the planet. The authors argue that such an understanding is crucial to maintaining a sustainable ecosystem and providing adequate support for our planet's species. Thus, they set out to come up with a more accurate method for estimating the total number of species. They review the currently known methods for estimating species before explaining their own approach. They take an example of well-known taxonomic groups, where we have a good understanding of class, order, family, genus, etc., and demonstrate consistent patterns in estimating the number of species assigned to those. Assuming these patterns remain consistent for other lesser-known taxonomic groups, they estimate the total number of species for other groups, and ultimately, the planet: 8.7 million species, with an error allowance of plus or minus 1.3 million.

Finally, the fifth most-viewed article is "Human MicroRNA Targets" by John et al., (2004), with 89,869 page views. This article is the most cited in the journal, with 1,054—nearly three times more than the next most cited. Three of the authors are affiliated with the Memorial Sloan-Kettering Cancer Center in New York City, which sponsored the study. The goal of the study was to better understand exactly which genes microRNAs regulate, as we know that they do regulate genes, but not the full extent of it. The authors developed an algorithm to determine just that, testing on humans, rats, and mice to identify genes that are potential targets for microRNA regulation. Their algorithm identified 2,273 genes in the sample populations that might possibly be regulated by microRNA, also finding that one molecule of microRNA can regulate multiple genes at a time and that often the genes regulated by the same microRNA are functionally related. This research provides some of the

information needed for other biologists to understand the actual process of microRNA regulation.

These five sample articles demonstrate a variety of topics within the field of biology as well as methodological practices. Next, I detail the results of my analysis of these five sample articles for the variety of genre features described in the previous methods chapter.

Article title

PLOS Biology article titles were examined for length as well as grammatical and cognitive complexity. The journal offers specific guidelines for authors writing titles; it limits the number of characters permitted in the title to 150 (including spaces), and most notably, asks that titles "be comprehensible to readers outside your field" and "avoid specialist abbreviations" when possible (*PLOS Biology* Guidelines for Authors, PLOS). As a result, many of *PLOS Biology*'s article titles are quite short with few words, such as Levy et al.'s (2007) "The Diploid Genome Sequence of an Individual Human," or the even shorter "Human MicroRNA Targets" by John et al. (2007). Presumably, the limitation of more specialized terminology and encouraged use of more common terms instead helps articles to appear in global search engine results, thus aiding with the goal of having a global, non-expert audience for the research in addition to the scientific community. The average title length from the sampled articles was seven words (see Table 1 for full reporting of sample article title lengths). For the top 50 most-viewed articles in the journal, the average title length was ten words. These titles, in terms of length as well as content, are quite different

from what Berkenkotter and Huckin (1995) and Gross et al. (2002) describe as the then-standard for scientific research article titles. Berkenkotter and Huckin found at the time that "titles have become more informative" over the course of the 20th century, with titles often being complete or nearly complete sentences that are conceptually rich in content—such as announcing study results—becoming increasingly common (p. 33). In contrast, the titles in *PLOS Biology* read more like early-mid 20th century titles: they do not form complete sentences, nor do they contain any results from the study. They resemble an example that Berkenkotter and Huckin cite as an example of mid-20th century brevity, "On the Specificity of DNA Polymerase" (p. 33). Of the five sample articles from *PLOS Biology,* four of them contain only a subject but no predicate, such as Holy and Guo's (2005) brief, "Ultrasonic Songs of Male Mice." The one article with a title that forms a complete sentence (Mora et al., 2011) was the longest one in the sample and posed a question, "How many species are there on Earth and in the ocean?" that a reader would presume the article attempts to answer. Phrased in this way, it is possible that this clause contributed to the many hits that the article has received, as it could be a common question posed by many a searcher on Internet. In the top 50 most-viewed articles, which have a slightly longer average title length, only six have titles that form a complete sentence. None of the five titles in the sample announce study findings, a very different percentage than the more than two-thirds of titles that announced findings in Berkenkotter and Huckin's study. Only five in the top fifty announce study findings, and these are five of the same that are also complete sentences (the sixth that forms a complete sentence is the one in the sample five, Mora et al., 2011, and though it does not

announce study findings, it comes close). In sum, both the grammatical and cognitive complexity of titles in *PLOS Biology* are significantly less than those of titles from preceding studies, likely a result of the journal's explicit policy about length and stated target audience, which leads to shorter, more general article titles.

Article length

PLOS Biology encourages the submission of research articles of a wide range in length, including "both substantial full-length bodies of work and shorter manuscripts that report novel findings that might be based on a more limited range of experiments" so long as they are of "outstanding scientific significance" ("*PLOS Biology* Guidelines for Authors"). Here, the journal seems to combine two genres that have previously been recognized as separate, the scientific research article and the research letter (sometimes just called letter or note; Penrose & Katz, 2010). Accordingly, the five sampled articles from the journal range in length. The most viewed article in the journal (Levy et al., 2007) is quite long, with 24,546 words; however, the second most-viewed article (Holy & Guo, 2005) was significantly shorter, with only 8,913 words (see Table 3-1 for article lengths of all five sample articles). Because a sample size of five is not large enough to determine significance and draw conclusions from the average, the average length of the twenty most-viewed articles was calculated. From a sample size of twenty, the average article length was 12,007 words, with a wide range of lengths, from as short as 2,505 words, to as long as 27,452 words. Bazerman (1988) reported an average length of 10,000 words for articles in the *Physical Review* by the 1980s, so the average length in the top twenty *PLOS Biology* is only slightly longer than this

average from the late twentieth century (unfortunately, he did not also report on the range of article lengths). Overall, the wide range in length was a bit surprising, but not unreasonable given that the journal does not specify an average length and publishes on a wide range of topics in the field of biology.

Overall structure

For this feature, sample articles were analyzed for structure and congruity with the canonical IMRAD logic for SRAs in the biological sciences. In the guidelines for authors, PLOS indicates that a manuscript's structure will generally include these main sections: Title, authors, affiliations, abstract, introduction, results, discussion, materials and methods, references, acknowledgements, and figure legends. With these guidelines, it is clear that there is one significant aberration from the canonical IMRAD model for *PLOS Biology* articles: the materials and method section, instead of being the second main content section, is placed after both the results and discussion (but still before end content such as supporting information, references, and other sections). In essence, the structural logic for *PLOS Biology* articles becomes I-R-D-M, and indeed, all of the sample articles followed this order of main sections. This change in structure foregrounds the findings of the research articles. It reflects what Berkenkotter and Huckin (1995) as well as Gross et al. (2002) found to be a shift toward thinking about "news value" for researchers: the most important information for them to read is featured earlier in the article, with less crucial information provided afterward should they want or need to read it. For scientists with a lot of literature to review and a

limited time to read it, this structure provides efficiency in reading and allows them to read in a top-down, inverted pyramid format, with the less critical methods information provided after the key details of the study's findings. Berkenkotter and Huckin noted the debut of this rearrangement with their initial study, reporting that methodology sections overall were de-emphasized between the mid-twentieth and late twentieth century, either by being relocated toward the end of an article or by being printed in a smaller type size than other sections of the article.

When users read an article in the journal, a large title and accompanying authors names are the first thing to see on the page. Abstracts are the first major text fields displayed on the page, allowing readers to quickly scan for an article's relevance to their own work or the purpose at hand. Some, but not all, articles then feature an "Author's Summary," a section that begins with a paragraph of additional information from the authors about the study, generally written less formally than the abstract. Three of the five sample articles featured a brief one-paragraph authors' summary. This section also includes authors' names and affiliations, as well as other important information such as any financial disclosures and reports of competing interest. This information is incorporated regardless of whether there is a paragraph description from the authors, and it continues the now-standard practice in both print and online of ensuring author standing in a professional community and accounting for any potential bias or influence in the research. In the author summary, the journal also lists the dates that the work was received, accepted, and published, another gesture toward professionalization that helps to establish priority in case of disputes over attribution of

discoveries. This is another common standard from print publishing, practiced by many publishers. In the case of *PLOS Biology*, this move also demonstrates the journal's dedication to publishing scientific research in a timely matter when it is still relevant. The average time to publication in the sample texts was 195 days, or approximately six and a half months (see Table 1 for time to publication statistics for all five sample articles). All of these details provided with the articles continue in what Gross et al. (2002) identify as the increasing professionalization of science. By this description, the authors refer to the standardization of presentation that they saw in their historical study of SRAs and increase in codification by journals of the standards by which they publish, including article structure, length, citation style, and more, as well as bylines with author affiliations, which serve as an assurance that the authors are members of the professional research community. Gross et al. also call the front matter of SRAs "setting the intellectual context" (p. 172), where the above-mentioned features like the abstract, author affiliations, and potential conflicts of interest situate the work that follows in a particular research community.

The main content sections of the journal's articles represent those included in the standard IMRAD article logic, but with an adapted order of presentation. This logic, however, is not stated as mandatory for publication, though the journal justifies publishing articles with this structure, saying, "Uniformity in format will facilitate the experience of readers and users of the journal" ("*PLOS Biology* Guidelines for Authors"). The website indicates the general information to be provided in the I-R-D-M sections: the introduction "should put the focus of the manuscript into a broader context"; the results "should provide

details of all the experiments that are required to support the conclusions of the paper"; the discussion "should spell out the major conclusions and interpretations of the work including some explanation of the significance"; and the materials and methods "should provide enough detail for the reproduction of the findings" ("*PLOS Biology* Guidelines for Authors"). Within each section, articles may also incorporate subheadings specific to the topic of the article. For example, Holy and Guo's (2005) Results section breaks down the results by the elements that were studied, with subheadings such as "Features of Syllables: Pitch Changes," "Pitch Jumps and Mechanisms of Sound Production," and "Temporal Sequencing of Syllables." All in all, the journal's guidelines for these major sections align with the Council of Science Editors' summary of the IMRAD format (CSE, 2006).

With these guidelines, PLOS gestures toward the importance of previous genre knowledge as a way to help readers, especially its new target audience of non-experts, understand the information contained within the same genre. This genre knowledge comes from what Berkenkotter and Huckin (1995) call the genre's form and content as well as the situatedness of the genre. They argue "genre knowledge embraces both form and content, including a sense of what content is appropriate to a particular purpose in a particular situation at a particular point in time" (p. 13). Thus, it would be reasonable for PLOS to encourage this standard structure, so all of its readership might know what information to expect in which sections of the article, aiding in comprehension and uptake of the information. The scientific community expects this logic for different reasons than the global, non-expert audience. As Gross et al. (2002) note, in addition to these sections communicating

important information about the rigor and validity of the research, they are also incorporated because of what they call “the general social pressure to conform” to the standardized structure of the article. Gross et al. acknowledge this standardization is as much about rigor and validity as it is about communicative efficiency for busy scientific readers. But for each group, this semi-standardization serves an important purpose. Additionally, through the situatedness of the structure—and its recurrence throughout the journal—non-expert readers might be enculturated into the discourse community. The concept of situatedness comes from Berkenkotter and Huckin (1995), a term they use to describe how our understanding of genres is firmly embedded in the activities that we do when using the wide variety of genres in our repertoires. Here, the logic of a scientific research article is something that derives from the practices of science and the reading habits and needs of a scientific audience. Titles and abstracts come first to provide readers with a brief introduction to the work, allowing them to decide if it is worth continuing (for whatever reasons they may have). As Berkenkotter and Huckin found in their study of scientists’ reading patterns, scientists tended to read the Results next, looking in particular at the visuals provided (figures, graphs, etc.) to look for important data. The visuals not only present a lot of information in a small space, but they are easy to locate in the text. Then, if the information was worth pursuing for readers, they would read the Introduction and Discussion, often ignoring the Methods entirely (except in situations where they were not confident in the methods used). The clear section headings allow readers to make choices about what to read and in what order through clear signaling of content sections. Furthermore, the logic of IMRAD offers a clear narrative for the work

being reported on. As Berkenkotter and Huckin reported on from a different study on the development of a scientist's research article, while the exact chronology of the research may not fit neatly into the IMRAD section order, this logic provides important context that situates the work reported on with that which has come before. Thus, IMRAD has become the standard method for reporting research results and has become accepted by the community as a model for reporting on research. For scientists, then, this structure is highly situated: even if they have never had explicit instruction on the writing of a scientific research article, they are aware of an article's logic and standard sections through their reading and use of previous research. Non-experts or non-scientists reading these articles would not have the same genre knowledge if they are not a part of a scientific community, and thus would have to acquire knowledge of the genre through other means. Here, PLOS has specified that consistency and use of specific headings will help those members of its readership acquire some of the genre knowledge necessary to begin to make use of the research published in its articles.

Overall, the change in structure and logic also is consistent with the ethos of PLOS's open access, global audience mission. One part of its audience, scientific researchers, would be interested in or could one day use the materials and methods section, but non-experts would not find that section as useful or relevant for their purposes, and as such, moving this section until after the results are reported and discussed helps the journal accommodate the two different audiences at once. Those who want or need to read that information could

continue with it, but those who do not could end their reading before getting to that section while still getting the main content of the article.

Use of images, graphs, and other visuals

Visuals play a key role in the communication of empirical research data and findings in scientific research articles. The sample articles were studied for their use of visuals, including the number of visuals as well as rhetorical purpose. Most of the articles published in *PLOS Biology* contain some form of images, graphs, or other visuals to support the article and aid comprehension of the findings. *PLOS Biology* follows standard scientific publishing practices in its use of the general term "figure" to cover the range of possibilities for visuals, including graphs, photographs, schematic diagrams, designed graphics, and realistic drawings, but also permits tables and the submission of video for article visuals. The journal has very particular guidelines for the incorporation of figures and tables into the articles it publishes, as do most, if not all, print and online journals. PLOS mandates titles, which can be no more than 15 words long, for all figures and tables, along with an optional figure legend. Figures can fall into one of two categories: 1) those embedded within the article or 2) those appended as supporting information. The journal additionally provides criteria for file size, quality, format, color mode, background coloring, white space, font type and size, figure dimensions, and more. Accompanying the criteria is a section dedicated entirely to providing instructions for creating the specific file types that are required. These instructions help to make publishing in the journal more accessible for authors who are unfamiliar with photo or

graphics editing software, though the sheer length and complexity of the “Guidelines for Figure and Table Preparation” page may be a deterrent to the most seasoned researcher or even someone with reasonable graphics software skills.

The number of visuals incorporated into the five articles in my sample ranges from one to thirteen tables, three to fifteen figures, and an overall number of five to 28 visuals (see Table 2 for a full breakdown of the visuals in the sample articles). Four of the five have a total number of visuals ranging between five and nine, with the outlier having 28 total visuals. The articles also contain an average of eight additional visuals appended at the end of the article in a section titled, “Supporting Information,” which comes right before the References section. Not surprisingly, the longer articles have the most accompanying visuals. Levy et al.’s (2007) “The Diploid Genome Sequence of an Individual Human,” includes 28 visuals, comprising fifteen figures and thirteen tables, with an additional twelve items of supporting information (three figures, eight tables, and one poster). The visuals in the sample articles follow Gross et al.’s (2002) identification of four main types of visuals: graphs, tables, schematic diagrams, and photographs/realistic drawings. Embedded within the article and restricted by the text frame size, the visuals are not immediately as intelligible as a reader would need them to be; to be able to read the axis labels, for example, a reader must click on the visual to bring up a pop-up window with a larger view of the figure or graph. This window displays all of the visuals in the article and is scrollable; a reader can easily browse all of the visuals at this more comfortable viewing size within the pop-up window. The visuals from the sample articles are also available in a range of formats: figures or tables can

be downloaded as a single Microsoft PowerPoint slide, or in image formats .png or .tiff. Most of the visuals are available in color, a significant change and improvement to the comprehension of complex tables and figures over earlier printed versions of the scholarly research article.

Table 2 - Visuals in *PLOS Biology* sample articles

Article	# of figures	# of tables	Total # of visuals in article	# of supporting information visuals
The Diploid Genome Sequence of an Individual Human (Levy et al., 2005)	15	13	28	12
Ultrasonic Songs of Male Mice (Holy & Guo, 2005)	8	1	9	5
Mapping the Structural Core of Human Cerebral Cortex (Hagmann et al., 2008)	8	1	9	6
How Many Species are there on Earth and in the Ocean? (Mora et al., 2011)	3	2	5	4
Human MicroRNA Targets (John et al., 2004)	4	3	7	14

Gross et al.'s (2002) comprehensive analysis of SRAs and the visuals featured in them in the twentieth century led to the conclusion that "it is the interaction of visual and verbal texts, an interaction enabled and facilitated by devices of style and presentation, that constitutes the heart of scientific argumentative practices at the end of the 20th century" (p.213). Visuals contribute to the argument of the article by accomplishing several potential functions, such as to "highlight theoretically vital features, arrange streams of data so that they can be categorized and taken in at a glance, help communicate how an experimental apparatus works, and illustrate complex relationships not easily communicable in regular prose" (p. 200). Indeed, visuals work together with the words scientists write to accomplish the persuasive goals of the text. As Latour (1990) has said about the critical role of visuals, it is a way for a scientist to say to readers, "If you don't believe what I've written, see for yourself" (p.36). But, that purpose for visuals has now expanded to not only complement the writing, but serve as a critical component of the article itself.

The sample articles from *PLOS Biology* are strong examples of this critical interaction between the verbal and the visual. In Mora et al.'s (2008) article estimating the number of species on the planet, which argues for not only their final results but also their new methodology for deriving their numbers, they incorporate several figures to justify the validity of their calculation methods. These figures are charts that demonstrate the patterning in species prediction across class, order, family, and so on, patterning on which they base their calculations. The argument for their methodological choice is strengthened with the use of these figures through the thorough illustration of their reasoning while at the same time

succinctly displaying a significant amount of data in the charts. It should be noted, though, that the two specific figures that demonstrate their methods are found in the Introduction section of the paper. The authors do not wait until after the Results and Discussion to first mention these where they might more likely be expected to be reported in the Materials and Methods section. The placement foreshadows the methods as one of the contributions the article makes to the literature and additionally foregrounds justification for the methods for the scientific audience, who may likely have questions about their methods prior to reading the results and discussion. Mora et al. essentially adapted the I-R-D-M logic of *PLOS Biology* articles to present their work in a manner so that the scientific community could more readily accept their work as a valid contribution to the field. They also use a table to assemble several streams of data from dozens of previous studies on cataloguing the number of species on the planet; this simplified table allows the reader to see in one place all of the research conducted previously. This table is also placed in their Results section, despite speaking more to their methodological choices, where it serves as a point of comparison to their own calculations about the number of species on the planet, demonstrating a difference between previous calculations and those the authors obtained using their new methods.

Holy and Guo's (2005) use of visuals also advances their argument for the capability of mice to "sing" as we understand songbirds to. They incorporate a figure with the frequency of mouse vocalizations over time to demonstrate the variation in frequency of the songs, a vital component of their argument for considering the vocalizations of mice as full-fledged songs. While they could simply tell the story of how the male mice would sing, they use the

measures of frequencies in the graph to show exactly what happened. Following this figure are several more specific visualizations of the songs, including the correlation between pitch change and syllables, another vital theorization of their argument. What is also interesting to note here is that in addition to visuals being important for this article, Holy and Guo introduce other modes that work together with both the verbal and visual to make the argument: they include four recordings of the songs from their study. *PLOS Biology* allows for and can accommodate multimodal forms of supporting information, and the inclusion of sounds in this particular case lets readers hear a lower frequency range of what the scientists heard in their study and allows them to showcase their findings that mice do actually "sing" in a way that we have typically assigned to songbirds, but had not previously associated with mice.

Overall, the articles in my sample also support Gross et al.'s (2002) conclusion that "very few statements regarding new facts or explanations are made in the absence of visual evidence" (p. 201). The visuals in *PLOS Biology* articles serve this same important purpose. Indeed, the visuals are a critical component of the argument in these articles, and in the absence of these, the arguments would stand quite differently.

Article layout and use of navigational tools

For its 10th anniversary, PLOS launched a redesign of all of its journals and websites, including *PLOS Biology*. (For more detailed discussion of the web design, see the section "Journal Homepage," below). Included in the redesign was a reconsideration of article

layout. PLOS reports that this redesign was user-driven: the group wanted to create a research product with a layout that was more useful for researchers, designed around the way that "researchers find and use content" (PLOS Homepage, 2013). Searching practices of its global, more generalized audience are not mentioned. The redesign includes the following components of all PLOS's journals' articles:

- Figures: Figures are displayed more prominently than in the original design, including an image slider at the very top of the article underneath the title, author affiliations, and information viewer (see Figure 1). Figures are also displayed more prominently throughout the articles and in search results on the journal's site.
- Navigation: Navigation has been improved with clear article sections persistently showing on the sidebar and a floating title bar that follows the reader down the page once she scrolls past the article's abstract.
- Information viewer: Immediately underneath the title and author affiliations is an "information viewer," essentially a set of five tabs with five different information viewing options for the article: The article itself, detailed information about the authors, article metrics, comments on the article, and related content found within the journal. Clicking on one of the tabs takes you to the respective page's information, and users must navigate back to the article, for example, by using the same tabs again.
- Minimal design: Articles are presented in a clear and minimalist manner, with a white background and a lot of whitespace on the page.

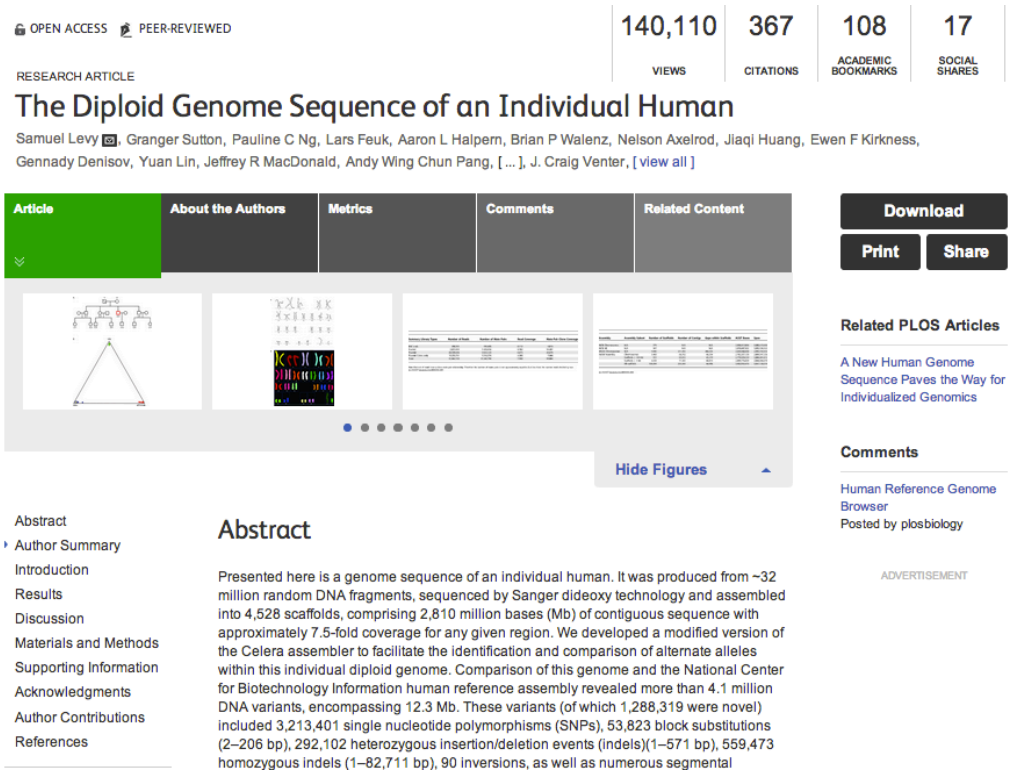

Figure 1 - A *PLOS Biology* sample article showing redesign with information viewer (green and gray tabs), figure slider (white squares featuring the figures), and persistent sidebar on the left with the names of individual article sections.

The well-considered use of navigational tools and user-driven website redesign continue in the history of the SRA as a genre with "an elaborate finding system of headings, graphic legends, numbered citations, numbered equations… [which] allows scientist-readers to navigate more easily among the diverse components of the article" (Gross et al., 2002, p. 186).

The sample articles in this study exemplify Gross et al.'s description of SRAs as having "an elaborate finding system." In the print SRAs they studied, they identified several elements to this "finding system": headings and subheadings; numbered equations, figures, and tables and their accompanying captions; numbered citations in the text that correspond

with entries in a References section. According to Gross et al., the headings were the most important navigational tool for the print articles they studied. In the case of the articles in *PLOS Biology*, the information viewer is the first navigation a reader encounters on an article's webpage and gives readers several options to find exactly what they are looking for quickly and easily. The default view is the article text, but a reader can easily obtain additional information about the authors, or more detailed metrics such as the number of PDF downloads, with a single click. The second navigational tool is a left hand sidebar that lists all of the sections in the article; now, instead of the reader running her eyes down the page to look for headings, she can simply click on the heading title she is most interested in reading, and the anchor link will take her to the corresponding place on the webpage for the article without having to scroll through the article text. This sidebar persists as a reader browses the article, so the options follow down the page to ensure easy navigability. The choice to keep a persistent sidebar with the section headings demonstrates that like print journals, these titles as a form of navigational logic are important for readers.

Intertextuality

The analysis here of intertextuality in *PLOS Biology* draws from the work of Bazerman (1988) and Berkenkotter and Huckin (1995) and their examination of citations as a way to discern intertextual linking between scientific practice and broader activity of their field. The authors of the sample articles construct their own original arguments through the incorporation of other textual representations, primarily through citation. Not surprisingly,

the longer articles have more citations of other research; the longest article (Levy et al., 2007) has 106 references, while the shortest (Holy & Guo, 2005) has 70 fewer, with only 36 (see Table 3 for complete comparison of word length and number of references in the sample articles). All of the sample articles incorporate more citations than the average that Bazerman (1988) found in the *Physical Review*, which he reports as approximately 25 references per article.[10]

We see with *PLOS Biology* just as Berkenkotter and Huckin (1995) saw in their own research how citation conventions and the writing of the SRA demonstrate the long-held belief that science is a knowledge-building enterprise (Lakatos, 1970). Each of the sample articles incorporates citations in the Introduction section to situate the work in the prior literature, demonstrating where in the field the knowledge-building that they are doing takes place, which literature they are drawing from, and which gaps in the field they are working to fill in. This is done, for example, with a general statement of knowledge for the field, accompanied by a series of numbered references: "A major feature of cortical functional connectivity is the default network [12-18]" (Hagmann et al., 2008). Here, the works that are cited are not engaged with, but simply incorporated as a numbered reference noting that this has been found before and is a statement upon which they will build. This is consistent with findings by Berkenkotter and Huckin's study of a biologist's introduction.

[10] It is possible that the difference could be partially accounted for here due to the difference in disciplines. But, as there are no studies on the history of the number of citations specifically in the biological sciences, this is the best number available for comparison.

Table 3 - Comparison of article word length and total number of references in articles

Article	Article Word Length	Total # of References
The Diploid Genome Sequence of an Individual Human (Levy et al., 2005)	24,546	106
Ultrasonic Songs of Male Mice (Holy & Guo, 2005)	8,913	36
Mapping the Structural Core of Human Cerebral Cortex (Hagmann et al., 2008)	10,765	54
How Many Species are there on Earth and in the Ocean? (Mora et al., 2011)	5,855	38
Human MicroRNA Targets (John et al., 2004)	17,957	127

The Results sections, due to the inverted nature of this section with the Methods, also have adjusted citation practices to accommodate this adaptation of structure. In the sample articles, Results sections often incorporate citations for the methodological work that the researchers are drawing from, and these come immediately before the authors explain particular results derived from those methods. For example, in Mora et al.'s (2011) article on calculating the number of species on the planet, they incorporate seven intertextual references in their Results section to justify the choices they made in calculating taxa, citations that work to argue for the soundness of their methodological choices because they are based in previously accepted research. Other citations in Results sections indicate

corroboration of previous research (Hagmann et al., 2008), or where results align with similar work done on other species (Holy & Guo, 2005). Discussion sections also include citations for the purpose of corroborating previous research (Hagmann et al., 2008) or to indicate where results of study may be taken further to estimate how long it would take and how much money it would cost to do a full classification of all of the species on the planet (Mora et al., 2011). Materials and Methods sections incorporate citations to demonstrate the research from which the methods were derived and additionally where source data were obtained (John et al., 2004).

All of the citations within the body of the SRAs are hyperlinked; the citation numbers are hypertext anchor links that when clicked take the reader to the corresponding entry number in the References section of the article. The full citation in the References section incorporates a hyperlink in the Digital Object Identifier (DOI). There are a few different possible destinations for the links within the full citations. When the citation is for another PLOS article, the DOI is a link directly to that article in the PLOS journal; this is possible, of course, because the articles are open access online. When the citation is for a closed access journal available online, the DOI links directly to the article on the journal's website; however, full-text access is restricted, and typically only the full citation and abstract is available to non-subscribers. Additionally, at the end of the full citation in the References section for any closed access article from other journals, there is another line that reads, "Find this article online." When clicked, it leads a user to another page on the *PLOS Biology* site with the title of the article and links to several databases a reader could use to find the

article online, including CrossRef, PubMed, and Google Scholar. In this way, PLOS attempts to help users find whatever research they may need, even if it is research behind a paywall. This affordance for citation practices is relatively new, only possible with the introduction of online research articles. While it is possible to have this type of linking to other research articles from closed access articles to other closed access articles (and indeed, some of the citations from *PLOS Biology* articles are to closed access articles), this affordance is maximized when linking from one open access article to another, where the article linked to is immediately available in full text: something not possible with a print copy of a journal. Finally, the journal takes advantage of the medium by also including hyperlinks within the text linking out to relevant sources for readers. For example, in Mora et al.'s (2011) methods section, they include the full web address to each of the databases that they used in parentheses immediately before the endnote citation number.

Overall, the use of citations in *PLOS Biology* is an element of the SRA that exemplifies Berkenkotter and Huckin's (1995) classic statement, "Genre conventions signal a discourse community's norms, epistemology, ideology, and social ontology" (p. 4). While the articles in this journal may have somewhat inverted the logic of the canonical IMRAD format to foreground results and discussion for the broad audience of readers, as well as for fellow scientists, the authors of these articles have adapted their writing in ways that still present the information in a manner that would be acceptable to the scientific community based on the norms and values for reporting research. That is, they have woven into their Results sections citations that justify the methodological choices they made, as they have not yet had an

opportunity to fully present their materials and methods at the point when they are reporting on their results. This incorporation of methods citations is a rhetorically savvy choice by authors, who anticipate potential counterarguments about validity by placing methods citations in multiple sections of the article.

File format(s)

For initial submissions, PLOS accepts articles as .doc, .docx, .rtf, or .pdf format, but mandates that only text files (.rtf or .doc) are permissible for the production process of accepted articles. The final versions of the published articles in this sample are available online in three formats: HTML, PDF, and XML. Articles are can be accessed directly from the monthly issues in which they are aggregated. They are available primarily in an HTML format that incorporates hyperlinks, anchor links, and graphs and other images, so when a user accesses an article from its issue or through the journal's search engine, this is the default view. Users who wish to save any article for future use can download the article as a PDF or in its original XML file format. The average number of PDF downloads for the five sampled articles is 14,330, with approximately 15.5% of HTML article views leading to PDF downloads. Articles additionally feature the option for researchers to download the article's citation in either RIS or BibText format for automatic import into a reference manager of their choice. These options provide flexibility to researchers and other readers and accommodate nearly every possible viewing need or usage for the published research.

Part One summary

Overall, this analysis of SRA features demonstrates that the sample articles from *PLOS Biology* fit within the genre that we understand as the scientific research article, with a few adaptations for audience as well as the ideology of the publisher. One significant difference from the print antecedents is the guidelines for article title length and content. PLOS has specific guidelines for titles which make them more accessible to the global (potential) audience of the journal and which makes them more likely to appear in Google searches due to the fact that they contain less, if any, scientific jargon and instead are composed of more common or otherwise less technical terms. These adaptations also fit given the affordances of the digital media used to produce and disseminate the work. The navigation is a great example of this; the prominence of visuals in the image slider and anchor-linked headings allow scientists to quickly find information they are seeking but additionally put emphasis on what might be most appealing and digestible to a non-expert, the graphical representation of the data. Another point of note is the inverted logic of the articles in this journal, and the ways in which authors then compensate for their understanding of—and as well what they think of their audience's understanding of—the traditional IMRAD logic of scientific research articles. While *PLOS Biology* deemphasizes the methods section in favor of "news value" items in the article, the authors compensate for knowing their audience's expectations of methodological soundness and validity by working that information into the Results section via citations. Thus, while the journal has likely set this set of criteria for the article

format with its multiple audiences in mind, the authors are clearly writing their articles with their fellow scientists in mind.

Part Two: Description of *PLOS Biology* SRA genre ecosystem

Publisher

The Public Library of Science is a non-profit publisher that also identifies itself as an advocacy group, with a mission "to accelerate progress in science and medicine by leading a transformation in research communication" by making the published literature a public resource ("About," PLOS, January 2013). Its main objectives are to "provide ways to overcome unnecessary barriers to immediate availability, access, and use of research" as well as to "pursue a publishing strategy that optimizes the openness, quality, and integrity of the publication" ("About"). With these statements, it immediately sets itself apart from the many for-profit companies that publish scholarly research, while at the same time assuring readers that it is equally dedicated, if not more so, to the progress of science by improving the process of disseminating scientific research globally. In this statement, we see early foreshadowing to a key element of the PLOS mechanism, the *reach* of the research.

There are several ways that PLOS works toward its mission of improving scientific publishing and increasing access to scientific research globally while simultaneously developing a successful and sustainable model for open access publishing. In 2011, the gross revenue for the organization was $24.7 million, which came from publishing a record number of articles across all of its journals ("Progress Update 2011-2012," PLOS, 2012).

Publishing costs increased to $14 million that year, but were low enough for PLOS to be able to give $2.5 million in waiver funding to authors, covering all or part of the publication fee for those who needed assistance, such as authors from lower income countries ("Progress Update 2011-2012"). Furthermore, to accommodate this sizable increase in publishing volume, PLOS has developed its own open source journal publishing platform, Ambra. Maintaining an in-house platform has also led to better access for users worldwide, as PLOS claims that the average load time for a research article fell from 4 seconds to 0.8 seconds ("Progress Update 2011-2012"). Ambra is an innovative platform that facilitates data collection of article-level metrics (ALMs), another feature unique to PLOS publications (detailed below). The remainder of Part Two examines how PLOS publishes its flagship journal, *PLOS Biology*, and the general ecosystem in which its SRAs are situated.

Publication practices and policies

In launching *PLOS Biology*, PLOS simultaneously introduced new ideas for publishing practices in the sciences. New articles are published weekly, with official issues launching monthly and aggregating research published during those weeks. In this model, authors pay a standard publication fee based on their country of research. For researchers who are from what it calls "upper and middle income countries," the publication fee is $2,900. Researchers from "lower income countries" are either charged a flat fee of $500 or can have their fee waived entirely. PLOS also offers a fee waiver for authors who are unable to pay the processing fee, which may occur for a variety of reasons. While these fees may surprise

some, charging article fees for publication in the sciences is not at all a new practice. In the 1970s, for example, the average article publication fee to authors in the United States publishing in the life sciences was $167 (King et al., 1981). In 2013, many closed access scientific journals still charge publication fees to authors, often in the form of individual page charges.

The *PLOS Biology* editorial staff encourages presubmission inquiries about the suitability of a research article for the journal. Suitability, as defined by the author guidelines describing the presubmission inquiry process, is based on the strength of the research in the disciplines of life sciences, but with "a particular emphasis on those areas for which unrestricted access is especially important to the research community or to the general public" ("*PLOS Biology* Guidelines for Authors," PLOS). The presubmission inquiry is intended to identify the articles that best fit the journal's goals of opening scientific research to the world and that have the potential to make a significant impact on the research community and/or the global, more general audience of the journal.

The review and publication processes for *PLOS Biology* are still relatively similar to other scientific research journals (it is PLOS's largest journal, *PLOS ONE* that is experimenting with the traditional review process). Once an article has been submitted to *PLOS Biology*, it is assigned to one of the journal's professional editors to determine whether the subject is appropriate for the journal and to enable the author to work with an Academic Editor (generally a member of the Editorial Board) to judge the validity of the claims based on the research conducted and results found. These steps constitute the standards for an

article to be sent out for review; if an article meets those basic criteria, it is then typically sent to two or more expert reviewers who judge the work on its scientific and technical merits, providing feedback for the journal editors and article authors. The professional editors consider the reviews and often consult the Academic Editor in making a decision on a manuscript; PLOS lists four possibilities for the decision: accept as submitted, accept with revisions, revise and resubmit, or reject. The website indicates that the editorial staff makes every effort to have a decision made on an article that is sent for review within approximately a month's time, and that once an article is accepted, it appears online within about six weeks. With ten editors, another dozen production staff, and a full-time Editorial Board along with the Academic Editors, *PLOS Biology* certainly has an efficient publication process.

In addition to the publisher's role to initially disseminate research, it is also charged with ensuring that the research is available for scholars and the public in the years to come. Preservation is a key issue for open access publishers as well as for all types of published scholarship in the digital age. The United Nations Educational, Scientific, and Cultural Organization (2012) released a report and policy recommendations about the pursuit of OA, noting the importance of preservation and that not all OA practices emphasize long-term preservation in a sustainable way. It is not enough for OA journals to make research openly and freely available, but they must also pursue preservation so that the research is accessible for many years to come.

Content copyright licensing

The standard copyright license used by *PLOS Biology* is the Creative Commons Attribution License (CC-BY), which allows authors to retain their copyright but gives users the permission to read, download, reuse, distribute, or otherwise work with the material in the articles so long as the original authors are given credit for their work. Authors may choose a different Creative Commons license if they wish to do so. PLOS Editor Cameron Neylon explains one of the reasons for adopting this particular CC license as standard: "The whole point of the web is that it exists on a massive scale and the potential value of a network rises as the square of its size. . . . We need to move from controlling access and permissions to assuring people that they have access and permission with systems that don't require our intervention" (Neylon, 2012). Any figures or tables published in articles are also published under a CC license, and, as such, authors are asked not to submit previously copyrighted visuals unless they have already obtained permission to use them. All of the articles in the sample considered here use the default CC-BY license, and the copyright information is prominently displayed in the "Author Summary" section of the article, right above the introduction. These authors all consented to the most open license that the journal recommends using, sending a message that they see opening their research in such a way as a strong move professionally and not as a risk to their work.

Journal homepage

The journal's homepage has a pleasing clean and modern design, with plenty of soft gray and white space surrounding the two main areas of focus on the page: a left-side content box highlighting the most recently published articles and a right-side context box featuring the cover image of the current month's issue (see Figure 2 for an example). The left content box has a tabbed menu that makes prominent three elements of the site; the default display is a list of the most recently published articles in the journal, but users can also click two other tabs to see the "most viewed" articles from the last month or "featured discussions," which are links to articles that have recently solicited comments from registered users. The title bar of the homepage features the tag line, "Publishing science, accelerating research." The clean design is continued in the menu, with three simple options: Browse, For Authors, and About Us. Hovering the cursor over those labels gives a reader several options in each category, including information for publishing with the journal, a link to the archives, and more about the journal's editorial board, policies, and history. These three options give three clear paths to the journal's wide potential audience and are predictable links that persist throughout the site. Right beside these three paths is a search box. Since half of users will generally browse menu lists initially to find information and the other half will use a search mechanism to find what they are looking for (Lynch & Horton, 2009), this design adeptly provides for the information-seeking needs of an audience of scientific researchers.

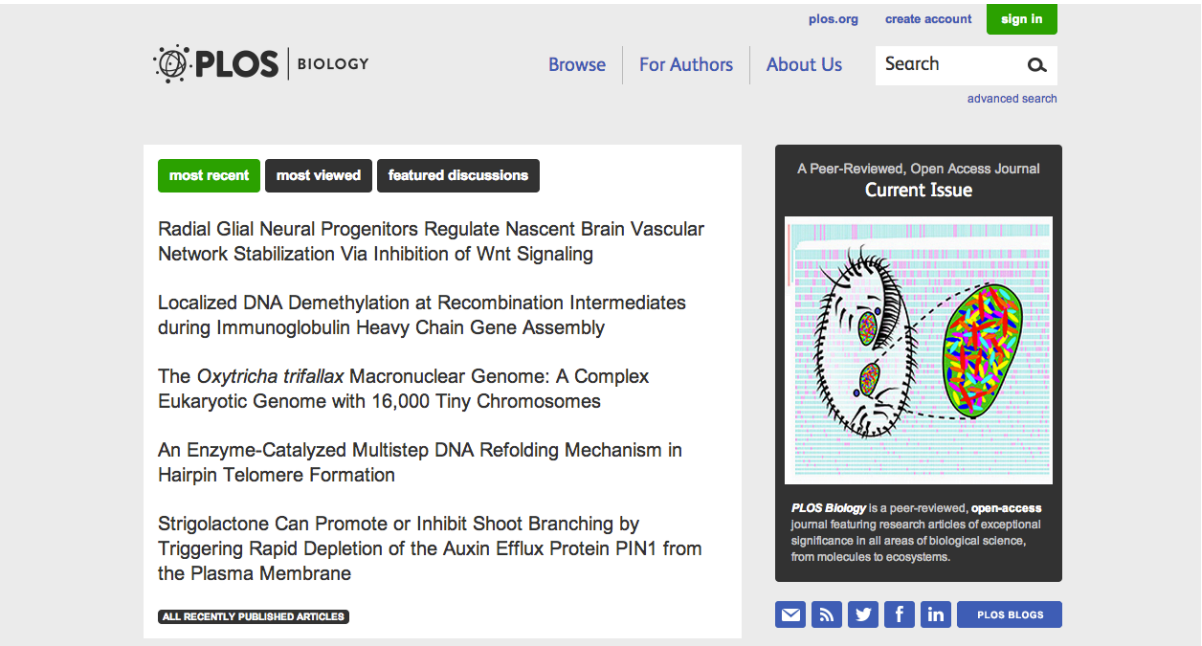

Figure 2 - The *PLOS Biology* homepage, with the default "Most Recent" articles table selected. The right side of the page features the "cover" image of the most current issue of the journal.

Further down the page, a different content box highlights "Weekly Editor's Picks" (see Figure 3), which are often recently-published articles that the journal's editors view as potentially significant to the field and for which it has commissioned accompanying synopses (see an explanation of the synopsis genre in the "Other publication genres" section below) or new community pages, articles in which organizations can describe their efforts to discover new research findings and/or disseminate scientific knowledge. Beside the editor's picks content box are several smaller content sections: social media tool links, a box that stands out in a deep gray reading, "Publish with PLOS," an area listing recent posts on the PLOS Blogs, and a final space highlighting sciences news "From the Web."

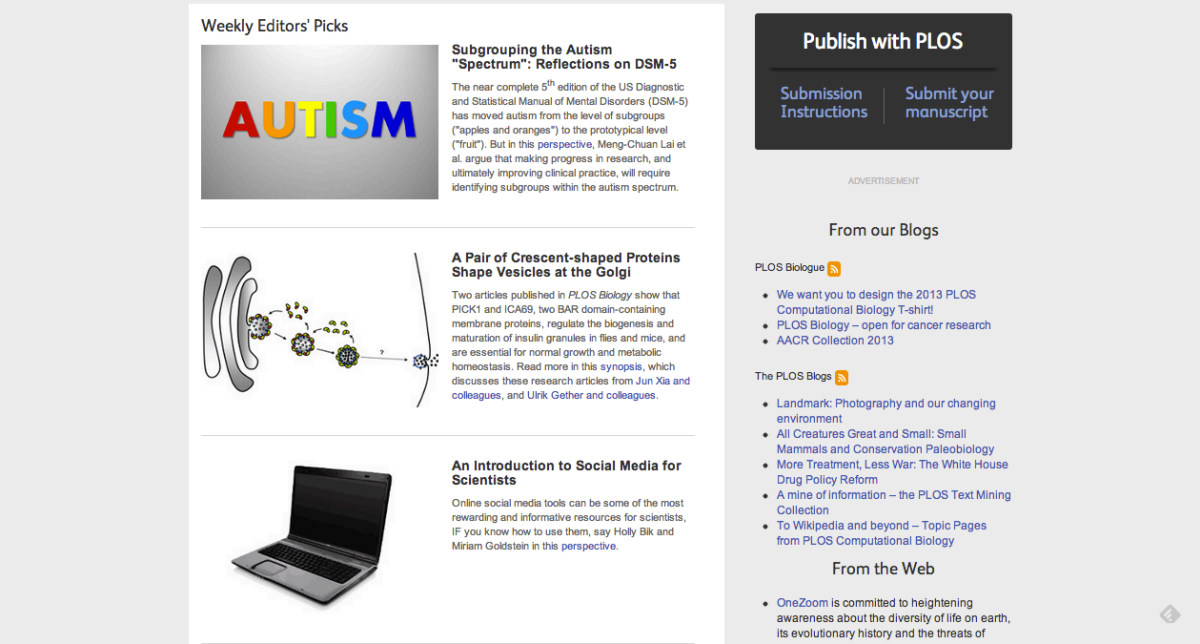

Figure 3 - Further down *PLOS Biology*'s homepage appears the feature, "Weekly Editor's Picks," highlighting what the journal's editorial team sees as significant articles the journal has recently published.

Overall, the homepage serves as the journal's hub that has clear points of entry for both sections of the target audience: researchers can choose to see the newest published work or the latest issue, can search for specific content, or can access information about publishing in the journal; and the non-expert audience can browse research, easily find most accessible articles detailing latest research, or connect to PLOS's other informational sites of interest, such as its blogs or social media streams. The "most recent" articles content box most clearly targets those within the community of biology, with the titles that include taxonomy names and other scientific terminology, and the "Weekly Editor's Picks" directly below it most clearly targets the non-expert audience, with less jargon-filled titles such as "Transforming a Stem into a Bush" and "Tantalizing Glimpses into a Fragmented Genome." In doing so, the

journal's website incorporates a combination of a temporal theme and an audience theme to its information architecture (Wurman, 1989). The first theme fits with the value in science of sharing information in a timely manner with the research community for the advancement of knowledge and as well to make a priority claim on the research uncovered, while the second helps the journal in its open access mission to make research readily available to a global public and gives the public several different ways to interact with the works PLOS publishes.

Other publication genres

Each monthly issue of *PLOS Biology* is divided into two main sections: the magazine section and the original research article section. Unlike the original research articles, most of the magazine section articles are submitted and published by invitation, generally by professional science writers. These, however, are still peer reviewed prior to publication. The magazine portion can feature a wide range of possible genres: "Essays," "Challenges Series," "Unsolved Mysteries," "Perspectives," "Public Engagement," "Primers," "Synopses," "Editorials," "Book Reviews/Science in the Media," "Community Pages," "Cool Tools Series," "Education Series," "Historical and Philosophical Perspectives," and "Obituaries" ("*PLOS Biology* Guidelines for Authors," PLOS). In the ten years since *PLOS Biology* began, the journal has published 1,467 magazine section pieces. The appearance of these genres varies each month and is identified in each issue with individualized headings. PLOS asks that these magazine genres be written in a way that is "inclusive and accessible" to "a readership that extends beyond the traditional research community and that includes

scientific educators, students, physicians, patients, and the interested public" ("*PLOS Biology* Guidelines for Authors," PLOS). This practice implies a new attention by scientific publishers to "parascientific genres" (Kelly & Miller, forthcoming), or genres alongside science. Similar practices in *Nature* and *Science* are a predecessor to this effort by *PLOS Biology* and other PLOS journals.

The part-magazine, part-research journal model for *PLOS Biology*, then, provides content that reaches a broad audience with a wide range of published material. Indeed, this model is meeting with much success, as some of the most-viewed published pieces in *PLOS Biology* are some of the magazine genres, such as the Unsolved Mystery, "What Controls Variation in Human Skin Color," with over 120,000 views, and the Feature, "Genetically Modified Corn: Environmental Benefits and Risks," which has over 104,000 views. That means these two non-SRAs are the second and third-most viewed pieces published in the journal, respectively. These statistics speak to the reach of some of these more "accessible" articles, which are accessible not only because of their free availability to the public, but also because they are written in a way that is tailored to a general audience which includes non-experts. This combination of both a technologically accessible as well as conceptually accessible publication no doubt contributes to the high number of views and subsequent shares, bookmarks, and citations that these articles receive (more on those digital affordances below).

One of the key roles for these additional genres is to support the genre of the original research article. For example, the journal publishes "Synopses," which are commissioned

essays written by professional science writers that summarize one specific new research article published in that same issue. PLOS states that the goals of these essays, which are written for a general, non-expert audience, are to offer "insight into the significance of the published work" ("*PLOS Biology* Guidelines for Authors, PLOS). For example, a January 2013 synopsis summarized findings from an article (Cantlon & Li, 2013) that used innovative research methods, for which the researchers studied neural activity of children as they viewed educational videos from *Sesame Street* with functional magnetic resonance imaging (fMRI) (Weaver, 2013). The seven-paragraph, 544-word essay highlighted the means researchers used to come up with their findings, which were able to predict the performance of children on math tests based on their neural maturity and how closely their neutral patterns mapped onto those of adults while the children watched the real-world situated educational program of *Sesame Street*. The synopsis makes both the findings and the significance of the research methods more accessible to a wider audience through its concise methods description and discussion of the research results. In the first three weeks of being published, the synopsis has garnered over 3,800 views.

Article and other metrics

PLOS, as a publisher, takes a different approach to impact factor and other research metrics than other academic publishers do. While it has been assigned an ISI impact factor of 12.69 for 2012, making it the highest ranked journal in the "Biology" category (Thomson Reuters, 2012), PLOS does not tout this statistic on its website. Instead, PLOS uses its own

method of measuring the success of articles it publishes through the collection of individual article metrics to determine the "impact" of a single piece of scholarship. Argues PLOS, "we believe that research articles should primarily be judged on their individual merits, rather than on the basis of the journal in which they were published" (PLOS, "Article-Level Metrics Information"). Additionally, research demonstrates that measures such as impact factor and even just citation number can be problematic as a measure of "success" or "impact." For example, Falagas and Alexiou (2008) cite common practices of editors who attempt to "game" the impact factor system for greater prestige for their journal, and Whilhite and Fong (2012) describe practices of coercive citation in the academy. Thus, these measures do not come without a caveat, and have indeed been emphasized by many scholars.

PLOS's article-level metrics (ALMs) are made of five different components, and as a part of the journal's 10th anniversary redesign, metrics received their own designated tab in the top-level menu on each article's page (see Figure 4). First on the page are lists of citation counts, as calculated by several third party services such as Web of Science and PubMed Central. The number of citations that an article has is also displayed prominently in the upper right hand corner of the screen when viewing an SRA, no matter which tab is activated. Under the metrics tab, the number of citations from the upper right hand corner is broken down by citation source, such as the number coming from Scopus, CrossRef, PubMed Central, or ISI Web of Science. Second, PLOS tracks article usage, which includes HTML views of the full article, the number of PDF downloads, and views of the original XML back-end information for the article (which is what generates the HTML and PDF formats). PLOS

employs both the standard robot exclusion list[11] as well as its own more stringent exclusion list in order to maximize the validity of these usage statistics and minimize the impact of robot activity on article statistics (though it acknowledges that no system for doing so is perfect). The number of article views (HTML, PDF, and XML combined) is displayed prominently in the upper right hand corner of each article alongside the citation count. Under the metrics tab, article usage is displayed in a table that breaks down views and downloads by the source (on the PLOS website or through PubMed Central). It also calculates the percentage of article views that led to PDF downloads and tracks the usage statistics across the number of months the article has been out.

[11] Robots are programs that travel to millions of webpages to retrieve them and the documents on those pages, often for indexing purposes. These robots would register as a "hit" on a webpage. A group of like-minded technical people maintain a list of robot programs, as there is no official organization for such programs, and publish it online for others to use. People can use the list to register their site with robots (to ensure indexing in search programs, for example) or, in the case of PLOS, can use the list to eliminate from the article access metrics hits from robot programs. For more information, see *The Web Robots Pages* where the list is maintained at http://www.robotstxt.org.

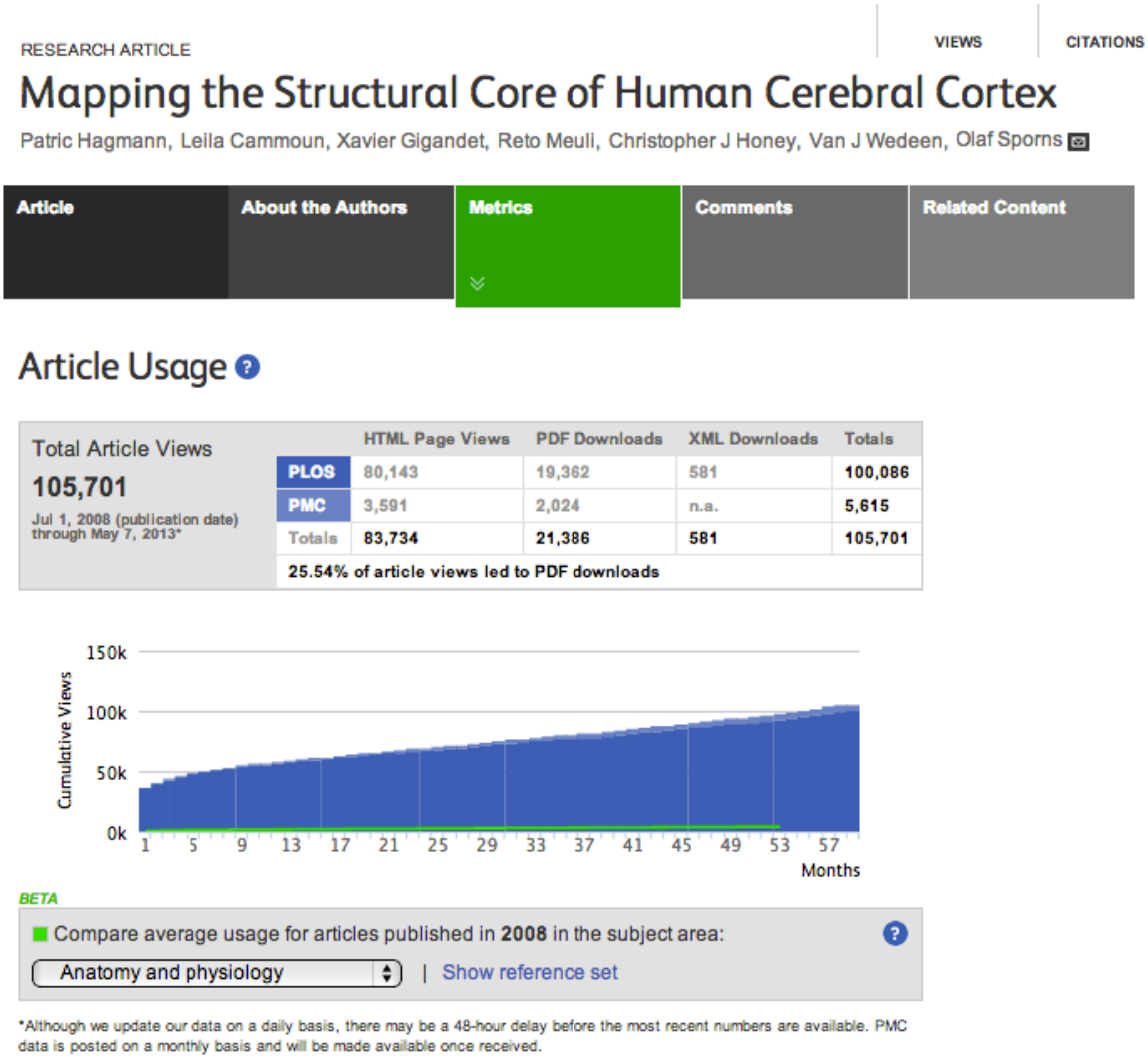

Figure 4 - An example of the article-level metrics (ALMs) available through the "Metrics" tab for a *PLOS Biology* article.

Third, PLOS tracks media and blog coverage of an article, acknowledging with this article metric the importance of research uptake in addition to the more traditional counting of article citations, especially when considering the potential readership outside of the scientific research community. PLOS uses third party blog aggregators to track research

dissemination along with standard “trackback” functionality, providing a trackback URL for each article it publishes to encourage outside bloggers to use the function. Blog uptake and media coverage are featured in the “Metrics” tab, where known coverage is listed under the appropriate source (e.g. the number of blog entries about an article found in “Research Blogging”). PLOS acknowledges that coverage of blog uptake is not yet comprehensive, as it relies primarily on others to do the linking for them, but it is continuing to work on this element to improve its reliability (PLOS, “Article-Level Metrics Information,” n.d.). Fourth, PLOS employs social media and reference management tools in its articles (discussed in more detail in the “Sharing features” below), and displays counts of these usage statistics with each article published under the “Metrics” tab, such as how many times an article has been tweeted, shared on Facebook, or sent to a user’s CiteULike account (see Figure 5). Fifth and finally, it also considers what it calls “PLOS reader evaluation” in the ALM. More simply, these are the comments that registered PLOS journal readers leave on articles and a “star” rating that those readers can put on an article within the PLOS platform itself.

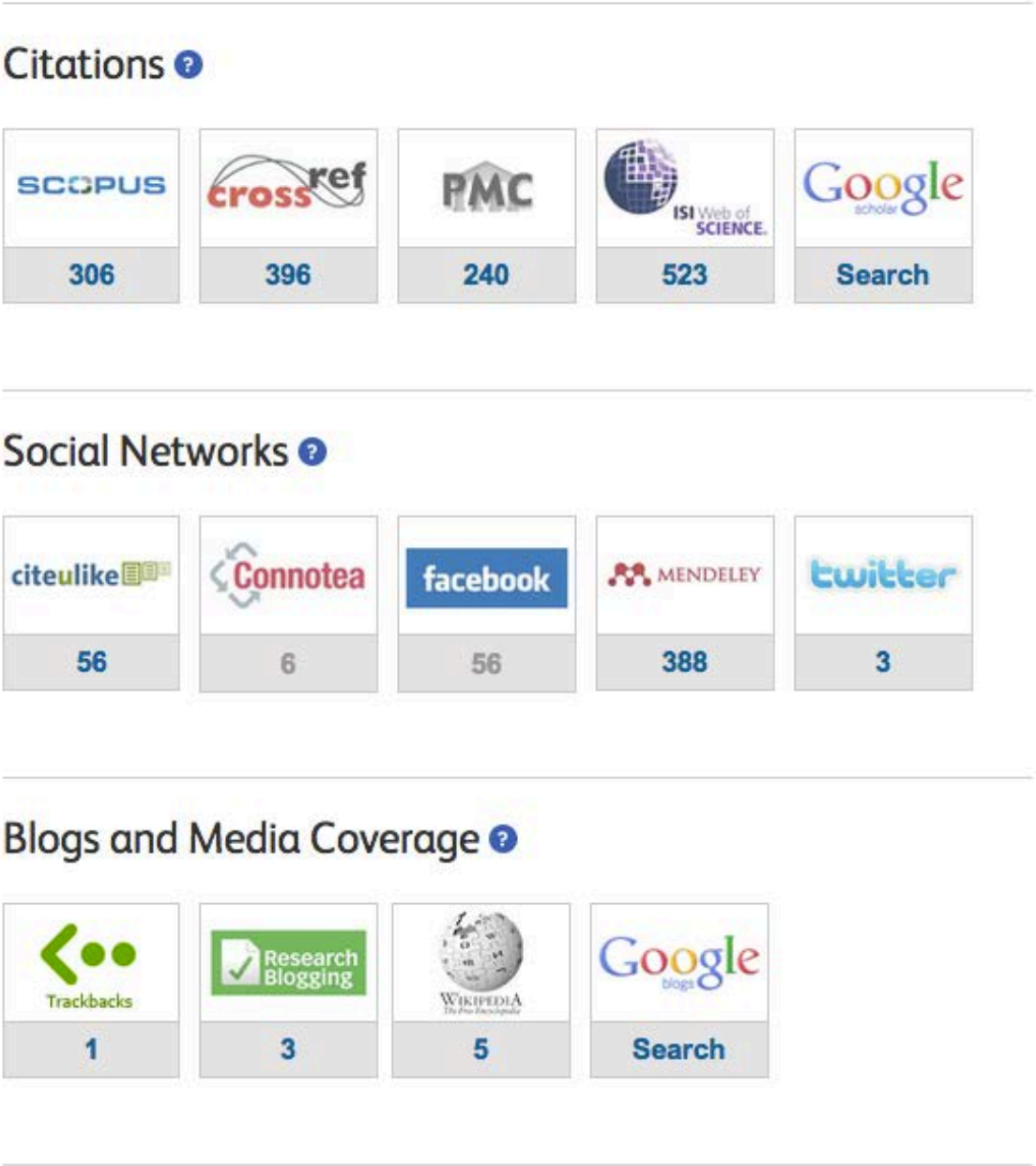

Figure 5 - Just below the article usage metrics on the same "Metrics" tab are the citation, social media, and blog/media coverage metric reporting on a *PLOS Biology* article.

In a step that aligns with its open access mission, PLOS recently opened the application programming interface (API) for its ALMs to allow users to explore new possibilities with the data that PLOS is collecting about article use and reuse in its journals. Users can search for articles from a particular journal, from a particular time period, and more to take advantage of the rich data set that the newly-designed platform allows them to collect. This data was instrumental in the data collection for this dissertation as well, facilitating the search for the most-viewed research articles in the journal for the selection of sample articles as well as for the questionnaire portion of data collection (see Part 3 of this chapter).

Promotional practices

PLOS says that its goal is not only to measure the reach of the articles it publishes through the use of article-level metrics, but also to extend the publication's reach through a variety of promotional practices and sharing features (the latter of which are discussed in the following section). The journal is indexed in the following databases: PubMed, MEDLINE, PubMed Central, Scopus, Google Scholar, Chemical Abstracts Service, RefAware, EMBASE, PschyInfo, and Web of Science. A major site of promotion for all PLOS journals is the PLOS Blog Network, through which PLOS regularly highlights work published in its journals along with other interesting issues in science. New articles are featured in a "Weekly Roundup" blog post of the journals, creating additional exposure. PLOS also touts regular coverage of its journals in major world publications and news outlets such as *The New York Times* and the BBC. For example, in early January 2013, *PLOS Biology* published the above-

mentioned ground breaking research about the connection between real-life educational television shows and predicting intellectual development of children through brain scans (Cantlon & Li, 2012). The journal had also commissioned the accompanying synopsis, which made details of the research more comprehensible to a wider audience of non-experts, and the research was subsequently picked up by *Time Magazine*, CNN Blogs, and *The Huffington Post* (Ghosh, 2013). These practices are similar to those used by *Nature* and other scientific research publishers to promote the work in their journals. For example, *Nature* staff members write brief summaries of notable SRAs published in their journal. And, like with PLOS, articles published by the Nature Publishing Group are indexed in several of the largest, most prominent indexing services, including the British Library, CrossRef, EBSCO, Google Scholar, PubMed, and Scopus. All in all, article promotion is an important element of publishing SRAs. It is one of the benefits that a publisher provides to authors for their work: these publishers generally have access to indexing, press releases, and other promotional practices that are simply not feasible for today's scientists either on their own, or if they are self-published.

Sharing features

PLOS Biology and other PLOS journals incorporate sharing mechanisms into both the articles themselves as well as the journals' websites, particularly on the homepage. Within the articles themselves (both original research and magazine articles), beside the information tabs are three buttons: Download, Print, and Share. Hovering over the Share button gives a

user the following options to distribute the article: Reddit, Google+, StumbleUpon, Facebook, Connotea, CiteULike, Mendeley, Twitter, and Email. Several of these sites are social media sites, where sharing the article would mean that a link would be provided for any of the user's connections to click and view on it, while others such as CiteULike and Mendeley incorporate a reference management component, where the article is stored for future research use. The metrics tab includes a "Social Networks" section where the number of times that particular article is shared using one of those sharing options is tracked. For example, in the most-viewed diploid genome article, the metrics tab indicates that it has been shared on Facebook 14 times and on Twitter 3, while it has been sent to the reference management program CiteULike nearly 70 times (see Table 4 for full reporting on sharing metrics from sample articles). For these metrics, the journal uses the category "blogging" to represent aggregate number of blog mentions, Nature.com blog networks, and "pingbacks" (when blogs are linked to within other blogs) to the article.

Table 4 - The social media and bookmarking sites where *PLOS Biology* sample articles have been shared

Title	Citeulike	Connotea	Facebook	Mendeley	Twitter	Blogging	Wikipedia
The Diploid Genome Sequence of an Individual Human (Levy et al., 2005)	70	28	14	14	3	2	13
Ultrasonic Songs of Male Mice (Holy & Guo, 2005)	2	0	1	95	14	1	6
Mapping the Structural Core of Human Cerebral Cortex (Hagmann et al., 2008)	56	6	56	351	3	1	5
How Many Species are there on Earth and in the Ocean? (Mora et al., 2011)	27	0	652	36	19	4	18
Human MicroRNA Targets (John et al., 2004)	26	4	0	283	1	0	0

These sharing features provide another level of connectedness and openness for the articles that *PLOS Biology* publishes. If a recurrent social action of scientific research articles is to share research with the scholarly community, then these sharing features add another layer of complexity to how the dissemination of the research is executed. These sharing functions also contribute to the visibility of these articles on the web. Sites such as CiteULike, Twitter, and Mendeley are publicly searchable, so entries created by clicking on the "Share" button via *PLOS Biology* would appear in relevant or related searches that users do on the web. PLOS argues that such practices are important for twenty-first century scientific publishing, as "appropriate use of the social network data types will aid the

discovery of related papers as well as reveal that article's readership reach" ("Article-Level Metrics Information," n.d.). Here PLOS makes the appeal that not only does linking one of its own articles aid in scholarly research, but it also can assist in the research process by encouraging the use of public, searchable databases of related citations such as Mendeley. This also creates a traceable source of public use, if it is the case that private citizens use the social media tools when reading an article in the journal.

Commenting features

All PLOS journal websites follow the same policy and practices for commenting. Any registered user may log in to the site to comment on an article once it has been published. Any person is eligible to register with the site, but must agree to giving his or her full first and last name, along with a geographic location and email address. Full names and general location accompany publicly posted comments. PLOS allows for general comments about the article as well as corrections, which users identify as such by checking the appropriate box when they are writing in the comment box. Comments posted appear right away; corrections posted initially appear as comments until PLOS staff approve the text to appear as a correction to the article. Users may reply to each other's comments in a threaded manner.

PLOS also outlines what it considers appropriate language and content for comments and corrections, mandating that "all contributions must conform to the norms of civilized scientific discussion" ("Guidelines for Comments and Corrections," PLOS). Such a requirement for the "norms of civilized scientific discussion" presumes some level of genre

knowledge on the part of registered users and potentially of membership in the broad discourse community of professional science; such a presumption may either work to exclude non-expert users from the commenting portion of the journal, or, perhaps more hopefully, to encourage users to observe other examples of the commenting genre to learn the decorum of "civilized scientific discussion." PLOS editorial staff monitor the conversations to ensure these meet the website's guidelines for commenting.

There is not much precedent to the study of commenting on online journal articles, likely due to the fact that it is both a newer phenomenon and not generally a feature that is heavily utilized (Priem, 2011). A study by Casper (2013, forthcoming) of *PLOS ONE* comments characterizes them as "somewhat shorter and less-formal versions of the e-letters and letters to the editor in *Science*" (p. 11); in his case study, fewer than one third of the articles from his sample had one comment or more. Only three of my *PLOS Biology* sample articles had any comments, and for one, the most viewed article of all time, the one comment was by the lead author, who used the comment space to provide information for readers about where they could find the web application developed as a part of the study. The two other articles have three (Hagmann et al., 2008) and nine (Mora et al., 2011) comments each. The comments on Mora et al.'s cerebral cortex article each represent three different purposes for commenting: 1) The commenter poses several questions about the research, including validity of methods and the implications of the findings; 2) The commenter praises the work done as important and illuminating to his own work; and 3) The commenter posts a link to his blog, on which he has written a long response to this and other related works that were

recently published. The comments on the species article also include two of those purposes, posing questions about the research and linking to a personal blog post with extended commentary on the work, along with two additional purposes: First, critiquing and correcting the work; and second, linking to news coverage of the article. This article has several comments that critique and correct, and often these comments have multiple purposes, such as questioning the methods or validity of the claims at the same time. Some of the comments are quite long as compared to other comments on articles, such as one that critiques the fungi estimates in which the commenter sketches out his own estimate, citing previous research by other biologists, in a total of 466 words. All in all, the commenting space, while underused, when used seems to serve a purpose of allowing readers to question the work that was done, offer critique and correction of the work, commend the work, or disseminate it. This suggests the possibility for interaction and, most importantly, dialogue about the work that was done. However, none of the authors of the works ever weighed in on any questions, critiques, or corrections of their work, suggesting that this tool is indeed underutilized by the community.

Part Two summary

Overall, the ecosystem of *PLOS Biology* reflects the ideology of the publisher, PLOS, and its status an advocacy group as well. It undertakes several initiatives to open scholarship and science to the world, and some of the features analyzed here reflect this mission. The social media sharing features, for example, allow authors and readers to disseminate the research across their social networks to increase the potential audience—or at the very least,

the visibility—of the work across scientific and global communities. The commenting system works to open science to the scientific community by allowing engagement with the work and the authors without the limitations of location. In essence, the ecosystem of *PLOS Biology* is centrally concerned with the reach of the research in ways that are significantly different than what was possible with print journal publication.

Part Three: Perspective of users participating in the genre

To complement my own analysis of *PLOS Biology*'s SRAs and SRA genre ecosystem, I sent questionnaires to authors who had published in the journal and editors of the journal to get their view of the genre (see Appendix A for author questionnaire). I sent questionnaires to the corresponding author for the fifty most-viewed articles of all time published by the journal, using the email address listed in the article by the journal. Eight of the emails to authors were returned due to the email address no longer being valid, a challenge to connecting with authors particularly who published in the early years of the journal. Many of the authors are no longer with the institution that they were with at the time of publication back in 2004, for example. When possible, I tried to find alternative email addresses for authors. A total of nine authors responded to the questionnaire, for a 21% completion rate from the 42 questionnaires that were successfully delivered. The authors who responded to the survey represent a range of topical focuses under the large umbrella of biology, including genomics, ecology, cognitive neuroscience, nuclear biology, microbiology, and health policy, and come from across the United States, Canada, and Europe. I sent questionnaires to six

editors of the journal; the editors cited being simply too busy to take the time to answer the questions that I had asked (see Appendix B for editor questionnaire). Participant response is always a challenge to this type of data collection (Mehta & Sivadas, 1995), and technical issues such as out of date email address listings add to the limitation of questionnaire data collection with my online research methods. The results from these questionnaire responses are described in this section.

The first part of the questionnaire (questions 2-5) focused on the reasons why authors chose to publish their work in *PLOS Biology,* and by extension, open access. Eight of the nine respondents cited that one reason they chose to publish in this journal is because they are an open access advocate (see Table 5 for full list of possible answers and the number of responses for each). Authors could choose as many answers as were applicable and add their own if the possibility was not covered in the list. The second most common answer, with five respondents checking this option, was the journal's reputation; one respondent in particular said that the journal was getting a lot of press at the time of submitting their article. The third most popular response, with four selections, was that the journal was the right fit for their research. Both of the second and third most popular answers here fit with the motivation of many researchers historically when publishing their work; a journal's reputation and the right fit for the work are primary considerations when publishing a manuscript for many authors (including the biologists studied by Myers, 1990). When asked in question #4 what the single most important factor in submitting their work to *PLOS Biology* was, the respondents were essentially evenly split between their stance as an open access advocate and the journal's

strong reputation in their field (four for the former; five for the latter). In explaining their responses to the above-mentioned question, respondents reported that they desire to publish more articles online in open access but cite "conservative" universities and fields in general, by which they mean their institution's tenure and promotion committees, which are concerned with the "H-index"[12] of the faculty researchers, or their own graduate students who are acutely aware of publishing the high impact journals to get good jobs, or the journals in their particular area of specialty, which are still primarily closed access and an important source for scholars in the field. One of the respondents specifically commented that they view open access as "a good thing, and can't wait until universities start valuing all the broader impacts of our research," indicating a view that the research is valuable beyond only the place in which it is published—but it is a value that is not truly realized when only looking at journal impact factors or H-index scores.

[12] "H-index" (short for Hirsch index) is a measure designed by J.E. Hirsch (2005) to determine through a mathematical formula the scientific research output of a scholar and the "impact" this research has on the scientific community. It is based on a scholar's number of scientific research articles and most-cited scientific research articles.

Table 5 – *PLOS Biology* author question #4 and responses

What factors contributed to your decision to publish your article in *PLOS Biology*? Select all that apply.	
Answer	**Number of responses (out of 9 total respondents)**
I am an open access advocate.	8
Some or all of my coauthors wanted to publish in this journal.	2
Some or all of my coauthors wanted to publish in open access.	2
My funding agency for this research mandates open access publishing.	0
The journal's reputation.	5
I am or one of my authors is a member of the organization that publishes this journal.	0
The focus of the journal was the right fit for the research.	4
I have published in this journal before.	0
Some or all of my coauthors have published in this journal before.	0
Other	1

A second portion of the questionnaire (items 5-8) asked the authors specifically about the new type of metrics that PLOS tracks on its journals. Seven of the nine respondents were aware of the article-level metrics available for their work; six reported having looked at them at some point, but only four had actually used them for a particular purpose, reporting that

they used the statistics for applying for funding opportunities, for some form of self-promotion, or for tracking interest in the particular topic (see Table 6 for full list of possible answers and number of responses for ALMs). From the questionnaire responses, it seems that authors are generally aware of the metrics, glad that they are there, but somewhat unsure of exactly what do with the wealth of data made available to them.

Table 6 – *PLOS Biology* author question #8 and responses

If you have viewed your article usage statistics, have you ever use the statistics for…	
Answer	**Number of responses (out of 9 respondents total)**
Tenure or promotion case?	1
Funding applications?	2
Self-promotion (job application, biographical statement, etc.)?	1
Promotion of related research/work?	1
Tracking reader interest in the topic of the article?	1
Other	1
I have never used the statistics other than to see what they are	3

The final section of the questionnaire (questions 9-17) asked respondents to report their views about what is different about *PLOS Biology* and the articles published in the journal compared with its print-based and closed access counterparts. Unsurprisingly, to these respondents the resounding difference between both print-based articles and *PLOS Biology* articles and closed access online articles and *PLOS Biology* articles is their global availability to both the scientific community and to private citizens. Seven out of the nine respondents said this was the most significant difference between closed-access online articles and open-access online articles. This focus on accessibility for all echoes one of the main goals of the current open access movement and demonstrates that the respondents recognize that goal as

being at least somewhat achieved by *PLOS Biology*. Only one respondent brought up the environmental benefits of online-only publications, citing them as "significant" in their response.

One significant difference between *PLOS Biology* and other closed-access online journals is the cost to authors for publishing. Interestingly, only one respondent brought this up as a difference between print-based or closed-access online and open access, but the same respondent brought it up multiple times during the questionnaire. Many open access journals in the sciences, though not all, incorporate a publishing fee for authors (such as the one that *PLOS Biology* charges). These costs are not insignificant and must be sourced somehow; while many authors can draw this from their research grant funding, it cannot be assumed that all researchers would have access to that kind of money to publish their work. The respondent commented specifically that they "publish in the best journal that [they] can afford to publish in," an important reminder of this very fact. On the other hand, another respondent wrote that her research team will "pay for [the optional fee to make the work] open access if we publish in a closed access journal," so cost is not a prohibitive factor for all scholars at all times. Here, the respondent refers to a newer practice of traditional publishers like Elsevier and Sage providing an option for authors to purchase open access rights for their work even when the publish in closed access journals. For example, for a fee of $3,250, an author can make her Taylor and Francis *Environmental Communication* article available in open access instead of through subscription only, which is the traditional model of the journal.

The final question to the authors was whether they believed that publishing in open access has had any influence on how they write their research articles. Four respondents indicated that it made no difference to them whatsoever. One indicated that they made sure to incorporate more figures, especially in color, since the digital format of the journal incorporates such an affordance, but acknowledged that this accommodation came more out of the affordance of the digital format than the accessibility of the article. Two others answered that they explicitly make an effort to write differently for their different potential audiences. One respondent claimed that they "try to write articles to make them more understandable to a non-specialist audience," one of only two times that the mention of accommodation came up in the questionnaires. Another said, "It is easy enough to write for a broad audience, it just takes attention to detail to accomplish it."

Overall, the few responses that I did receive indicated that authors see the reach of their work as being a new and critical component to publishing in *PLOS Biology* or other open access journals. This is an important factor in their publishing decision, and responses generally indicate that these researchers understand the merits of their work being open to a broader audience of potential readers. However, response is fairly mixed regarding how authors actually write the articles they publish. For some, it makes no difference, while others are cognizant of the different needs of their different audiences. The responses of *PLOS Biology* authors show that they are acutely aware of the new audiences that their research can reach now through open access and that they generally support this endeavor for a variety of reasons, as reported above.

Conclusion: From Public Library of Science, a new approach to publishing scientific research articles

With respect to content, articles in *PLOS Biology* still resemble the traditional (print-based, closed access) scientific research article. PLOS does encourage an adaptation of the article's logic with the relocation of the methods section, but this is not a significant aberration from practice. Instead, it follows in what other scholars (Berkenkotter & Huckin, 1995) have previously found about the adaptation of article logic as a trend that continues today, perhaps with more frequency and in higher-profile journals like *PLOS Biology*. But, what PLOS has done is adapted the publication process, access, interface, and post-publication model for scholarly research articles dramatically. To that end, these articles still closely resemble the conclusion that Gross et al. (2002) drew about the development of the SRA as "an objective, efficient conveyor of cognitive complexity" (p. 215). This finding also supports Mackenzie Owen's (2007) claim that the medium of distribution is not having a revolutionary impact on the publication of SRAs in the way that many people predicted. We might also attribute part of this similarity to deliberate choice on the part of PLOS. Some of their publishing practices and policies are quite different, so might they be making a conscious choice for consistency with other high quality journals for another reason? If the main genre's structure and logic change in addition to these other elements, including publication practices, access levels, and post-publication possibilities, it might be too much change too quickly for the scientific community to support the journal's endeavors. Thus, to mitigate potential resistance to these changes, PLOS takes many steps and puts significant

effort into ensuring that authors meet very specific standards for publication. This is not to say that these are by definition high standards or low standards, but instead that PLOS has its own set of expectations about what an open access research journal should look like and executes this as a part of its mission.

This approach to publishing scholarly research articles has specific implications for the genre's ecosystem, a couple of which I will outline here, and others which I will discuss in the final chapter. The most significant issue identified in this chapter's analysis is the focus on the reach of the research. With the introduction of new elements to the scholarly research article ecosystem, PLOS has had to develop a strategy for managing and promoting these features. Article-level metrics are a feature unique to PLOS publications. As yet, no other publishers track statistics on the article-level in the way that PLOS does, particularly in eschewing any measurement of "impact" on the journal level. In its efforts to track article-level statistics, PLOS promotes a new model for determining the importance of research to the field. In lieu of having one editor and two reviewers who have the responsibility of determining the acceptance of work on the merits of its potential importance to the field, PLOS is shifting the responsibility to the community of biology at large. PLOS argues that "articles in all journals should be assessed on their own merits rather than on the basis of the journal in which they were published"; thus it established its broad range of metrics ("About *PLOS Biology*," PLOS). These metrics demonstrate the emphasis PLOS places on the reach of research. The metrics account for views, downloads, and citations—relatively traditional measures—as well as newer tools, such as social bookmarks or shares on social media

websites. That is, they track the reach of an article across several web platforms (though obviously not all, a limitation to the data they do collect). PLOS also encourages researchers to use the metrics for their own benefit. It encourages authors to incorporate the ALMs for an article on their CV, to provide the data to their department in reviews, download an ALM widget that can be incorporated in a Wordpress-based personal website, and even download a custom "postcard" of article level metrics for their article to share with any audience they choose ("Researchers," PLOS Article-Level Metrics, n.d.). PLOS also promotes ALMs as a tool for university departments to use in making tenure, promotion, and hiring choices "for a granular, comprehensive view of a researcher's past and current work" to ensure a school can "make solid staffing decision" ("Institution," PLOS Article-Level Metrics, n.d.). No research has yet been done to determine whether any institutions have taken up this suggestion and incorporated any of the PLOS ALMs into staffing decisions.

PLOS's approach to publishing, tracking statistics, and maximizing the reach of research seems to speak to the broadest ecosystem possible for scientific research. We can compare this with the publishing model of a longtime prestigious journal in the sciences, *Nature*, which requires a subscription for access to its SRAs, while so-called "popular" content—that written for a broader audience than scholarly researchers—is available freely on its website. Essentially, while some content is available openly to anyone who may want to access it, the key content of the journal—its very reason for publishing—can only be accessed by paying readers, effectively eliminating from its audience non-scientists and scientific professionals alike without an institutional subscription or enough disposable

income to purchase one. *Nature* also tracks article metrics, a link to which is available in the front matter of each *Nature* article. This data collection is quite extensive and in many ways is similar to the metrics collected by PLOS. *Nature* reports data on citations from Web of Science, Scopus, and other databases, total page views, news or blog mentions, Tweets about the article and geographical location, as well as what it calls, "Online attention," which encompasses several Altmetrics[13] such as Tweets, Facebook mentions, and social reference sites like Mendeley and CiteULike (for a full page view of these metrics, see Appendix C). Authors can also access article download statistics for their publications by logging into their author account on the website, but this information is not similarly available to readers. Overall, from the examples of *PLOS Biology* and *Nature*, it seems that metrics are becoming increasingly important for journals. These metrics become an important measure not only for the journals themselves as a rich source of data about the work that they do, but they can also serve a purpose for the authors of the individual articles, who can potentially use these metrics for career purposes, including future publishing decisions and even significant career milestones such as applying for tenure or promotion. Also notably for this study is that while *Nature* collects some data similar to what PLOS collects about its articles, there's a significant difference in the framing of *Nature*'s statistics: they categorize the statistics as

[13] According to the Altmetric website, the service is "a system that tracks the attention that scholarly articles and datasets receive online," and does so by retrieving data from social media sites (such as Twitter and Facebook), from "traditional media" in many languages, and online reference programs such as Mendeley and CiteUlike. This data is aggregated into an overall "score" derived from an algorithm for the online attention. The score is placed in a colorful circle, with strands of the circle each representing different sources. For example, an article with many Tweets would have a more predominantly blue circle, as that is one of the main colors of Twitter's site. For more information, see www.altmetric.com.

"attention"—which due to their subscription policy, is primarily academic—while the advocacy group PLOS focuses on the ideas of availability and access to the work that it publishes.

Most significantly for the SRA as a genre, through PLOS's efforts at open access to scholarly research, as seen here in the case study of its flagship journal *PLOS Biology*, the social action of the scientific research article genre incorporates a broader audience of experts and non-experts alike who might take up this research, use it, and learn from it. Historically, the SRA genre has reported advances in science to a community of primarily fellow scientists. When an article is published, a researcher reading an article would have known that this was the first time these results were reported, and that this research responded to a specific idea that had not yet been fully explored (or reported on satisfactorily). These elements remain for the SRA as published by *PLOS Biology*, but the open access publishing and advocacy of the journal adds another layer to the audience and potential social action of the genre: use, and usefulness, for a broader audience than expert scientists.

No longer is this a genre that is limited to a select audience of initiated experts with institutional privileges, such as those with university libraries purchasing journal subscriptions. The SRA is instead becoming a genre that is written, published, and disseminated with a broader audience in mind. (Whether there is much broader public uptake, it is hard to say for sure, as PLOS does not track IP addresses, and it would be highly difficult to know the identity of the person at the IP address, even if it did collect that data.)

PLOS specifically states that a main goal for the work that they do is to make science a public resource, one that people they call "nonscientists" can understand and also put to use. In other words, for PLOS, the scientific research article and the other genres it publishes serve an important purpose to not only report original research to an expert community, but also as a resource for a wider community of those interested in science or who may have a need for the information beyond the academic research community.

Because of this additional social action, some in the research community are concerned that this shift in audience means that the research is somehow less valid or less significant because it is published with some considerations for the non-expert, global community (Suber, 2012). This case study of *PLOS Biology*, however, should help to allay these fears. More importantly, some authors of articles in this journal acknowledge that the way in which they write these articles, in addition to now the way in which journals publish the articles, must adapt given the new social action of the genre. Here, the authors are possibly at odds with their tenure and promotion committees, who may question whether publication in a certain venue may really mean that it is peer reviewed, or their Dean, who may not understand that while it is available to the general public, it is still sound scholarly research. At the very least, the authors who responded to the questionnaires for this study know that this journal publishes sound research and they choose to publish here based on the strong reputation that PLOS has earned for itself. However, in an historically conservative community (Mackenzie Owen, 2007), there is at least some lag between those who understand and accept open access publications (as reported by journal authors) and those

who do not yet grasp that these are sound research publications that now have a broader reach, and potentially greater influence, because of how the articles are published.

CHAPTER FOUR: *BMC BIOLOGY* SCHOLARLY RESEARCH ARTICLES AND THE ARTICLE GENRE ECOSYSTEM

Introduction to *BMC Biology*

This chapter reports on the second case study of the dissertation, which analyzes in detail the original research articles and genre ecosystem of *BMC Biology*. *BMC Biology* is the flagship journal of BioMed Central (BMC), a major open access publisher in science, technology, engineering, and mathematics (STEM) fields. The journal specializes in peer-reviewed research and methodology articles related to any aspect of biology while also publishing reviews, opinion articles, and other genres (described in Part Two below). While it does not explicitly state the audience it envisions for the journal, the website makes occasional references to articles being available to "a wide, global audience" (BMC, "About *BMC Biology*," 2013). Like *PLOS Biology*, *BMC Biology* has recently celebrated its tenth anniversary of publishing. This includes the first seven years of the journal, and the last three after it subsumed a sister publication, *The Journal of Biology*, which is also open access, and then published together under the title of *BMC Biology* thereafter. With this fusion, *BMC Biology* adopted some of *The Journal of Biology*'s policies (Robertson, 2013. The journal publishes articles as they are accepted and aggregates them into monthly issues, publishing twelve issues in each journal volume. In ten years, the journal has published over 720 articles of all genres (see Part Two for a description of those that it publishes). It also periodically publishes special collections on specific topics of interest to the biology community, such as December 2012's "cell geometry" collection. Most recently, it published a ten year

anniversary special issue titled, “From origins to open questions,” for which the editors invited authors of some of the most highly accessed articles to revisit their original works, providing an update on the research. The editorial board also authored various editorials and question and answer articles about their ten years of publishing, with a particular focus on how the journal’s peer review process has evolved.

Being of similar age to the other case study, but having several distinct differences, including the type of publisher, *BMC Biology* serves as an interesting point of comparison for understanding the SRA genre in open access. Like the previous chapter, Part One here examines the scientific research article genre as enacted by *BMC Biology* through a study of five sample articles and the journal’s policies and practices. Part Two of the chapter examines the SRA genre ecosystem in *BMC Biology* and Part Three reports the results of my author and editor questionnaires about their views of open access and publishing with this journal. This chapter concludes with a synthesis of the case study and the implications for the SRA genre as enacted by this journal and BioMed Central. A full discussion of the two cases will be brought together in the final chapter, which will examine the implications of these cases for the SRA genre, the genre ecosystem, and what these results mean for understanding genre change.

Part One: Analysis of five sample articles

In Part One of this chapter, I describe the results of my analysis of the five most-viewed articles in *BMC Biology*. To begin, I provide a short rhetorical description of these sample

articles. First, the most-viewed article from the journal with 64,256 views,[14] "The First Metazoa Living in Permanently Anoxic Conditions" by Danovaro et al. (2010) reports on the finding of the first multicellular organisms living without oxygen on the planet, which were discovered deep in the L'Atalante basin in the Mediterranean Sea. The authors extracted sediment from the basin and isolated the different organisms found living within it. This is a remarkable finding, as researchers previously thought that only single-celled organisms could live in such an extreme environment, one with permanently anoxic conditions (without oxygen). The researchers identify three new species of Loricifera, a kind of marine metazoan. They found that these organisms have evolved to cope with the extreme conditions of their environment, including mitochondrial adaptations. These findings show how little we still know about the deepest parts of the oceans on the planet and particularly about the evolutionary mechanisms that have allowed such organisms to thrive for so long. As the most-viewed article, it has 64,256 views, over 25,000 fewer than the fifth-most viewed article in *PLOS Biology*, and nearly 75,000 fewer than that journal's most viewed (see Table 7 for full reporting of sample article information, including number of accesses).

[14] All data reported here and elsewhere in the chapter are as of the date of data collection, January 17, 2013.

Table 7 - General data for sample *BMC Biology* articles

Title	# of views	Title word length	Article word length	# of authors	Days from submission to publication	# of Citations (by others)
The First Metazoa Living in Permanently Anoxic Conditions (Danovaro et al., 2010)	64,256	8	6,963	6	85	51
Extensive Population Genetic Structure in the Giraffe (Brown et al., 2007)	29,776	7	8,360	10	79	48
Pair of Lice Lost or Parasites Regained: The Evolutionary History of Anthropoid Primate Lice (Reed et al., 2007)	28,212	14	6,322	4	171	47
Scribble Mutants Promote aPKC and JNK-Dependent Epithelial Neoplasia Independently of Crumbs (Leong et al., 2009)	26,828	11	11,471	5	132	16
Evidence that a West-East Admixed Population Lived in the Tarim Basin As Early as the Early Bronze Age (Li et al., 2010)	23,050	17	6,523	13	145	21

The second most-viewed article for this study, with 29,776 views, is “Extensive Population Genetic Structure in the Giraffe” by Brown et al. (2007), which describes a study of DNA analysis of giraffes for the purposes of better understanding evolutionary diversification of mammals. The researchers identified six different groups of giraffes based on their coat patterning (called pelage) that are recognized as subspecies and analyzed the DNA of 266 giraffes from all six different pelage groups. They also analyzed the location of 381 giraffes to complement their analysis. Their results show genetic subdivision among the

six subspecies that is confirmed by their geographical locations (essentially, genetic isolation) and that interbreeding among giraffes is therefore quite limited. They conclude that because of this lack of interbreeding, it is possible that there may be different species of giraffe rather than a single one with subspecies.

The third most-viewed article is by Reed et al. (2007), titled "Pair of Lice Lost or Parasites Regained: The Evolutionary History of Anthropoid Primate Lice," and has 28,212 views all-time. Lead author David Reed is based at the University of Florida, where his lab studies mammals and their evolutionary history. This article reports their attempt to understand mammalian evolutionary history based on studying the evolution of the parasites that they host, focusing on lice. Humans can have two types of lice, head and pubic, and by studying the evolution and genetic drift of both of these, the authors gained some insight into the origins of sexually transmitted diseases in humans. They found that human head lice have an evolutionary track similar to the head lice of chimpanzees, and that human pubic lice have an evolutionary path similar to that of the head lice of gorillas, revealing a discontinuity in the evolutionary development of human lice. The authors conclude that humans obtained pubic lice from gorillas, which has significant implications for science's understanding of the history of sexually transmitted diseases.

The fourth most-viewed article, "*scribble* Mutants Promote aPKC and JNK-Dependent Epithelial Neoplasia Independently of Crumbs," by Leong et al., (2009), with 26,828 views, reports research that has implications for cancer biology. The *scribble* gene regulates cell polarity in drosophila (small flies) and essentially acts as a tumor suppressant for the insect.

The researchers set out to understand how the regulation and suppression take place, so they analyzed the *scribble* cells in the eyes and brain of the flies. Their results showed that this suppression occurs because of the inhibition of certain kinase protein pathways (aPKC and JNK). The authors conclude that we may be able to abstract this idea to how humans could potentially suppress cancer genes.

Finally, the fifth-most viewed article analyzed in this study is "Evidence that West-East Admixed Population Lived in the Tarim Basin as Early as the Early Bronze Age" by Li et al. (2010). To date, the article has 23,050 views. The authors report findings from DNA analysis of remains excavated from the Tarim Basin, an important migratory location in far Western China and a passage point between the West and East Asia. They specifically analyzed remains of twenty Xiaohe people, remains which are to date the oldest found in the Tarim Basin. Their analysis revealed these people had the dominant haplogroup (groups of alleles on a chromosome) C of East Eurasians (typical for Siberian populations or East Asians) as well as haplotype H of Western Europeans. While research had previously shown these people to be of mixed descent, the authors argue their results demonstrate coexistence at least a century earlier than previously thought, perhaps back to the early Bronze Age.

These five most-viewed original research articles, as in the previous case study, represent a variety of subdisciplines of biology, including evolutionary biology, cell biology,

genetics, and zoology.[15] I now turn to explaining in detail the results of my analysis of key genre features of these sample articles.

Article title

As with the previous case study, *BMC Biology* article titles were examined for length as well as grammatical and cognitive complexity. This journal itself does not provide any specific instructions about writing titles, but if authors navigate the BioMed Central publisher page, in the "For Authors," section offers writing "tips" for researchers who want to publish in its journals, including one page specifically on writing titles and abstracts. The publisher justifies this focus by saying, "The title and abstract are the most visible parts of your article" (BioMed Central, "Writing titles and abstracts," 2013). This resource emphasizes that often researchers read no more than these two elements of the article, and "it is thus important to catch the reader's attention by making the title and abstract as concise, accurate, and readable as possible." The page also mentions that many people search for articles using online search engines, so "it is therefore important to include in the title and/or abstract the words that potential readers of the article are likely to use during a search." The resource never mentions who specifically constitutes "potential readers," especially in light of the potentially wide audience for the articles that it publishes since the work is open access. Specific advice about writing titles includes the direction to be as "accurate, informative, and complete as possible" so that the article can be found by those who would want to read it. The publisher encourages

[15] All of the sample articles come from *BMC Biology* proper and not from the sister *Journal of Biology*.

the use of full scientific names, the avoidance of short forms, and generally being "as descriptive as possible."

These directives for specificity are reflected in the titles of the five sample articles in my study, though it would be impossible to know if all of the authors published in the journal had read and taken into consideration these instructions when submitting their manuscript. If authors did not see these instructions, it may be the case that they are using their previous genre knowledge when composing this key part of their work. In the five articles, title lengths ranged from seven words (Brown et al., 2007) to eighteen (Li et al., 2010), with an average of almost twelve words per title. From a larger sample of the top fifty most viewed articles in *BMC Biology*, the average title length was a little more than thirteen words, slightly longer than the *PLOS Biology* fifty-text sample, whose titles averaged ten words each.

In terms of grammatical complexity, only one of the five sample article titles constituted a complete sentence. However, despite the other four sample article titles not being complete sentences, these titles still provided a richer description nonetheless than the *PLOS Biology* ones, because those are limited in the number of characters that could be included within them. This richer description comes in the form of a more specific topic, such as "The First Metazoa Living in Permanently Anoxic Conditions" (Danovaro et al., 2010) or "Evidence that West-East Admixed Population Lived in the Tarim Basin as Early as the Early Bronze Age" (Li et al., 2010). The latter is an example of the more informative title that Berkenkotter and Huckin (1995) write about, though like the former, it does not form a

complete sentence. Only one of the five titles featured a complete sentence with both a subject and predicate, "*scribble* Mutants Promote aPKC and JNK-Dependent Epithelial Neoplasia Independently of Crumbs" (Leong et al., 2009), which is the same number as the *PLOS Biology* samples. This title also features highly discipline-specific language, which greatly contrasts with the examples from the previous chapter, but again, reflects the directive from the publisher regarding writing titles with specific terms for publications. From the larger sample of the fifty most-viewed articles, eighteen (36%) formed complete sentences, and 25 (50%) announced study findings. This former number fits the pattern Berkenkotter and Huckin found of increasing percentages of titles having complete sentences, and the latter is generally consistent with their findings that at least a majority of titles at the end of the twentieth century announce results of the study in the title itself.

Generally, these titles are more similar than the titles in *PLOS Biology* to those that Berkenkotter and Huckin (1995) saw as trending toward at the end of the twentieth century. *BMC Biology* titles more frequently incorporate more syntactic richness in the form of full sentences, and more foregrounding of the key parts of an original research article: the results. One notable exception to the highly informative, foregrounding bottom-line information from my sample is a title that features a humorous play on words: "Pair of Lice Lost or Parasites Regained: The Evolutionary History of Anthropoid Primate Lice" (Reed et al., 2007). While such humor is not typical in scientific research articles, these allusions point toward a thoughtfulness put into the article's title on the part of the authors, and perhaps that has contributed to the article being one of the most highly viewed articles in the entire

journal. Overall, however, the most significant difference between the two cases is that the titles in *BMC Biology* are more likely to announce findings and have a greater "news value" than the articles in *PLOS Biology*.

Article length

BMC Biology does not provide any guidelines for article length, merely structural guidelines (described below) that would result in articles having to be at least a certain length to cover all of the material required for the journal. Neither does the publisher, BioMed Central, provide a length requirement for their publications, saying, "There is no absolute constraint on the length of articles published in a BioMed Central journal. However, please remember that for the benefit of peer-reviewers and readers articles should be as concise as possible" (BMC, "Author FAQ," 2013). Here, the publisher makes an appeal on behalf of the community to indicate the value of conciseness in part to aid in efficiency for readers wanting to cover new literature, as well as for busy peer reviewers who have many other tasks to complete in addition to their voluntary manuscript reviewing. As with *PLOS Biology*, there is also no explicit mention of another historically common genre, the research letter; with its appeal for concision, *BMC Biology* is perhaps indirectly combining the two genres into the one larger category of "research articles."

The appeal to consideration for the research community the journal makes seems to be reflected in the length of the articles that the journal publishes. The average length of the five sample articles is 7,928 words. The range of article lengths was much smaller than for *PLOS*

Biology; for *BMC Biology*, lengths ranged from 6,300 to 11,400, with three of the articles in the 6,300-6,900 word range. The average length of a larger sample of the top twenty most viewed articles in the journal is 8,184, with only four of the top twenty being over 10,000 words long. This average falls below Bazerman's (1988) finding that SRAs averaged 10,000 words in length, but is significantly higher than Penrose and Katz's (2010) reporting of research letter lengths, which vary by journal and are generally less than 2,000 words. This finding also supports Berkenkotter and Huckin's discussion of the trend toward greater "news value" in scientific research articles, for which they argue scientists increasingly search for and read SRAs in a highly selective manner. Shorter SRAs would facilitate easier reading, and in terms of finding the "news value," of an article in *BMC Biology*, a reader would likely have the results foregrounded in the title as well as would simply get to the results faster in an article of shorter length.

Overall structure

As in the previous chapter, sample articles from *BMC Biology* are examined for structure and the presence of the canonical IMRAD logic for scholarly research articles. There are some notable adaptations to the journal's choice for article logic. First, *BMC Biology* has opted to use the section title "Background" in place of the more traditional label "Introduction" for the first main section of text in an article. This title conveys an expectation about the type of information that is expected within it: to explain the reasoning behind the research and what it seeks to accomplish. Second, the journal provides specific guidelines for

the overall order of manuscript text sections, stating that they should include the following sections in this specific order: “Title page, Abstract, Keywords, Background, Results and discussion, Conclusions, Methods, List of abbreviations used (if any), Competing interests, Authors’ contributions, Authors’ information, Acknowledgements, Endnotes, References, Illustrations and figures (if any), Tables and captions, and Preparing additional files” (*BMC Biology*, “Instructions for authors,” 2013). These guidelines demonstrate that this journal also diverges from the canonical IMRAD logic and has adapted the structure to I-R-D-C-M to suit the needs of its audience by placing the methods section after the results, discussion, and conclusion, but still before the end matter of the article. As in *PLOS Biology*, this new logic foregrounds the research findings, an important adaptation for busy scholars in a culture where there are so many publications to read and not enough time for them to read everything that gets published. Placing results, discussion, and the conclusion ahead of the methods allows readers to get to the key elements earlier, but still incorporates the methods for those who need the information and take the time and find out.

BioMed Central provides an additional resource for authors of any of its journals when they are preparing manuscripts for publication. In the “For authors” section of its website, the publisher features an article, “Tips for preparing your manuscript” by a prominent science and medical writer, Tim Albert. Albert’s tips encompass all points of the writing process, from before scientists begin writing, while they are writing, and the final stage of preparing a manuscript. In this article, Albert identifies the main sections of the article—in the IMRAD format, not *BMC Biology*’s adapted logic. He further prescribes the lengths of each of these

sections: introduction should be two paragraphs, methods six, results six, and discussion seven. None of the articles in my sample followed these suggested section lengths. The highlight of Albert's article is the main message: no matter what the topic, the main message of an article should be absolutely clear. He communicates his own clear main message by emphasizing that an author should determine what the main message is before beginning to write, where clear statements of the main message fit in the various sections of the article, and that that is the first thing an author should read for when finishing a first draft.

The five articles in my sample varied in logic used to present their research. This is not surprising, given the mixed instructions provided by the journal and publisher to authors. Four of the articles (Danovaro et al., 2011; Leong et al., 2009; Brown et al., 2007; Reed et al., 2007) used the adapted *BMC Biology* suggested I-R-D-C-M format, while one of the articles (Li et al., 2010) wrote in the more traditional IMRAD logic suggested by Tim Albert. Within this adapted logic, some of the articles used the joint heading "Results and Discussion," while others maintained these as distinct sections. Conclusions were generally the shortest main content section, with the Methods following it. In the same larger sample of the 20 most-viewed research articles, eighteen used the adapted I-R-D-C-M logic, and just two used the traditional IMRAD logic. Interestingly, the two exceptions were both articles that were written by only Chinese authors at Chinese research institutions, and none of the adapted format articles were. I do not have an explanation why Chinese authors used the more traditional IMRAD logic, though it seems that this did not have an effect on their ability to publish their research in the journal.

Use of images, graphs, and other visuals

All BioMed Central journals can incorporate visuals into the research articles, and the publisher provides a few brief instructions for authors who wish to include them in their manuscripts. BMC accepts visuals in EPS (for diagrams), PDF (for diagrams), and TIFF (for photographs) formats. It additionally provides the guideline that visuals should be clear and legible at a scale of 600 pixels wide, the default viewing size for a visual when a reader clicks on one of them within an article. Genre theorists call these kinds of instructions meta-genres: they are "situated language about situated language," guidelines that offer explicit directions for activities in a discourse community and put one genre (the subject of the instructions) in context with other related genres (Giltrow, 2002, p.190). As its own genre, instructions are also a part of the broader genre ecosystem that I am studying here.

Like many journals, *BMC Biology* divides the visuals incorporated into their articles into categories. They have three: figures, tables, and "additional files." Figures and tables are visible within the text of an article at a smaller scale, though to view the visual at a better, easier to read scale, a reader must click on the linked visual label (ie. "Figure 1), and it will appear in a pop-window on the screen. The visuals are also accompanied by descriptive captions to provide context. Links to "Additional files" are also embedded within an article with descriptive (and sometimes quite long) captions. These additional files can be incorporated right above or below a table or figure (see Figure 6 for an example of how visuals are displayed in *BMC Biology* articles). For additional files, however, the visual is not displayed within the text of the article and is only viewable when a reader clicks to download

the file. These are available in several file formats, and are not always strictly visuals—they can also be survey instruments, data sets, or other forms of information of value to the article. Most commonly, the file format for this category is as a Microsoft Word document, a format that could potentially include an image, a table, or many other types of information that would be suitable for inclusion as an additional file. All three categories (figures, tables, and additional files) are set off from the main sections of article text in by a light gray background and have linear borders on the top and bottom of the captions.

Additional file 2. The effect of Rose Bengal on living and dead specimens. (a and b) Light microscopy (LM) images of living deep-sea nematodes collected from oxygenated sediments adjacent to the anoxic basin and stained with Rose Bengal; (c) LM image of dead deep-sea nematode stained with Rose Bengal; (d) LM image of living deep-sea copepods collected from oxygenated sediments adjacent to the anoxic basin and stained with Rose Bengal; (e) LM image of deep-sea copepod exuviae stained with Rose Bengal.
Format: PDF Size: 603KB Download file
This file can be viewed with: Adobe Acrobat Reader

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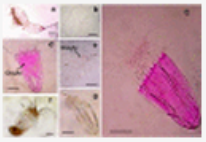

Figure 1. Metazoans retrieved from the deep hypersaline anoxic L'Atalante basin. **(a)** Light microscopy (LM) image of a Copepod exuvium (stained with Rose Bengal); **(b)** LM image of dead nematode (stained with Rose Bengal); **(c)** LM image of the undescribed species of *Spinoloricus* (Loricifera; stained with Rose Bengal); **(d)** LM image of the undescribed species of *Spinoloricus* stained with Rose Bengal showing the presence of an oocyte; **(e)** LM image of the undescribed species of *Rugiloricus* (Loricifera, stained with Rose Bengal) with an oocyte; **(f)** LM image of the undescribed species of *Pliciloricus* (Loricifera, non stained with Rose Bengal); **(g)** LM image of moulting exuvium of the undescribed species of *Spinoloricus*. Note the strong staining of the internal structures in the stained loriciferans (c and d) vs. the pale colouration of the copepod and nematode (a, b). The loriciferan illustrated in Figure 1e was repeatedly washed to highlight the presence of the internal oocyte. Scale bars, 50 μm.

The permanent reducing conditions of anoxic sediments can preserve dead organisms and their protein for a long time, so that microscopic analyses do not provide proof of the viability of an organism. However, the abundance of these loriciferans was the highest reported so far world-wide per unit of surface sediment investigated (range: 75 to 701 individuals m^{-2}). This finding is *per se*

Figure 6 - A screenshot of how visuals (represented by Figure 1) and additional files (represented by Additional file 2) are displayed in a *BMC Biology* article.

The sample articles from the journal all included visuals in their texts, ranging from five to eight visuals each, including three to eight figures and zero to three tables. Four of the five included additional files, ranging from two to 22. Visuals were incorporated into all sections of the sample SRAs, though not every article included a visual in every section. As in *PLOS Biology*, the visuals in the sample articles fit in Gross et al.'s (2002) four main types

of scientific visuals: graphs, tables, schematic diagrams, and photographs/realistic drawings. And, we again see how the visuals work with the written text to accomplish the persuasive goals of the article. For example, Danovaro et al. (2010) include a visual that is a series of photographs of the metazoa they retrieved from the L'Atalante basin to prove that they found these metazoa alive under anoxic conditions (shown in Figure 6 above). They incorporate both specimens they found living and those they found dead, using the color from a protein-binding stain to prove that some of the species were indeed alive when discovered, as the dead specimen did not take very much of the color from the stain and remained relatively clear, whereas the live specimen turned a bright pink that is readily apparent in the figure. Their discovery is ground-breaking for the field, and as such, this figure works with their written explanation of results to together make a strong argument for the validity of their findings.

Article layout and use of navigational tools

The default view for an SRA in *BMC Biology* is an HTML version of the article (see Figure 7 for a screenshot of the default article view). At top of an article page is the same six tab menu that is displayed on every page, with options to navigate to the main portions of the site: "Home," "Articles," "Authors," "Reviewers," "About this journal," and "My *BMC Biology*." The background of the page is a very light gray color, offering a slight contrast to the content boxes featured on the page, which are white. The article itself occupies the central portion of the page in a white content block. At the top, there are several labels for the

articles, including article type (ie. research article, question and answer; see section below for full description of genre published by the journal), article availability ("Open access"), and if applicable, a red label identifying the article as "Highly accessed." The title is displayed in blue font larger than the article text size, making it prominent on the page. Individual sections of the article, such as Results, are also labeled in the same larger blue font. The left portion of the page features a smaller white navigation box with the main article content sections. Like the section menu in *PLOS Biology*, it persists as a reader navigates down the page. A reader can also navigate directly to a particular section by clicking on the section name in that menu. The right side menu, in contrast with the simple section menu, contains many options for viewing additional information. At the top is the title of the journal and the volume number, both hyperlinked to their respective destinations. Next, readers have "Viewing options" for the different file formats and additional files included in the article, or can navigate to "Associated material," such as the article's PubMed record or reader comments, or to "Related literature," through a variety of hyperlinked searched options that include Google Scholar and PubMed. *BMC Biology* also includes in the menu links to "Tools" it makes available, such as the possibility to download the article's references, email the article to a colleague, or post a comment. The final option on the right side menu is to share the article across a variety of social media channels, including Facebook, Twitter, and Google+.

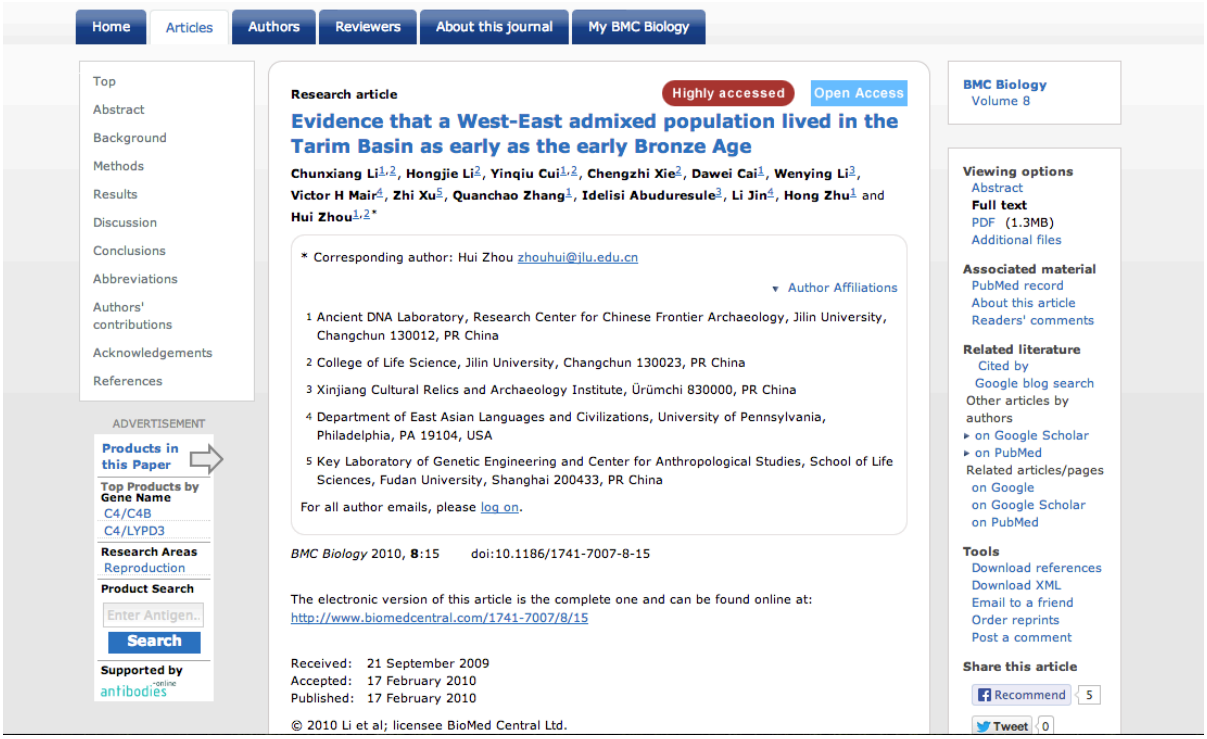

Figure 7 - The default view of a sample article in *BMC Biology*.

The finding system for *BMC Biology* articles is located on both the left-hand and right-hand sides of the page. The persistent sidebar, also a feature in *PLOS Biology*, is a convenient way for readers to navigate a lengthy article without having to scroll the page in search of the exact place needed. This is a logical choice for navigation in this medium; in HTML, there are no logical breaks in reading the way that there are with pages, or page numbers to guide the reader to the right section, so this navigation bar facilitates ease of finding content no matter where a reader is on the webpage. The right-side menu, however, is less user-friendly, particularly for less experienced users. The smaller font size de-emphasizes the content, making the eye look right over it in favor of the moving sidebar on the left and the prominent text in the middle of the page. This menu, though, provides a lot of

important content for the reader, such as additional data files critical to the research, or a link to comment on the article. The lengthy list of options on this menu also gives the page a cluttered look, particularly when contrasted with the cleaner design of the *PLOS Biology* article pages. Overall, there are many links, and many possibilities for finding additional content or information related to the article, but there is no reporting on the usage of this additional information by the journal, so it is hard to say if what kind of engagement users have with all of the possibilities provided by *BMC Biology*.

Intertextuality

Like the articles sampled in the previous chapter, articles in *BMC Biology* also develop their own arguments in part through the incorporation of previous works in the field. While the articles in *BMC Biology* are generally shorter than those in *PLOS Biology*, these articles incorporate just as many references to other works in the body text (see Table 8 for a comparison of article word lengths and total number of references). In the same way that the range of article lengths from the sampled articles was smaller with *BMC Biology* than with *PLOS Biology*, so the range of the number of references from the sampled articles smaller. Though the range is smaller with *BMC Biology*, again all of the sample articles incorporate more references than the average of 25 references per article that Bazerman (1988) reported in the mid to late twentieth century.

Table 8- A comparison of article word length and the total number of references of articles in *BMC Biology*

Article	Article Word Length	Total # of References
The First Metazoa Living in Permanently Anoxic Conditions (Danovaro et al., 2010)	6,963	38
Extensive Population Genetic Structure in the Giraffe (Brown et al., 2007)	8,360	73
Pair of Lice Lost or Parasites Regained: The Evolutionary History of Anthropoid Primate Lice (Reed et al., 2007)	6,322	43
Scribble Mutants Promote aPKC and JNK-Dependent Epithelial Neoplasia Independently of Crumbs (Leong et al., 2009)	11,471	45
Evidence that a West-East Admixed Population Lived in the Tarim Basin As Early as the Early Bronze Age (Li et al., 2010)	6,523	46

Articles in *BMC Biology* also demonstrate how science is a knowledge-building enterprise (Lakatos, 1970) by weaving citations throughout the article to argue for what is previously known in the field, what has yet to be known, and where the published work contributes to the vast literature of the field. Background sections incorporate citations to previous work done in the field related to the topic at hand and identify where work has yet to be done. For example, in Brown et al.'s (2007) article on the differing pelage patterns in African giraffes, citations in the Background section set up what is currently known about

genetic differences in giraffes, speciation, and the effect those have on giraffe pelage. The authors use the seventeen citations in this section to establish that while there are several schemes explaining the pelage, there is no single, comprehensive scheme that accounts for speciation in an accurate way. Thus, they situate their study as being more comprehensive and aiming to identify more clearly pelage differences and the relationship these differences have to habitat and speciation of African giraffes.

Results and Discussion sections—sometimes separate, sometimes combined, and again in this journal typically inverted and appearing before the Methods sections—primarily contain citations in order to acknowledge where study results correspond with discoveries reported in previous research or where what the authors discovered can be partially explained by introducing results from other studies. For example, Danovaro et al. (2010), in reporting on their discovery of metazoa living in anoxic conditions, incorporate citations to two previous studies reporting the discovery of lociferans in sediment to explain the novelty of what they discovered. Their citations refer to studies which found these specimens to be relatively rare in the Mediterranean, thus demonstrating their discovery of these plentiful specimens to be "surprising." The Conclusion sections contained the fewest citations, including two (Danovaro et al.; Li et al., 2010) with none at all. Citations in this section for the other three articles linked to related ideas for future research and also, as in the case of Danovaro et al., connected to where other scholars emphasized the importance of research on particular issues in order to better understand the species.

Finally, Methods sections, placed after the Conclusion, most commonly incorporated citations to indicate where methodological and material choices stemmed from previous research that had been done. For example, Reed et al. (2007) cited the studies from which they had derived their louse specimen extraction methods (including one self-citation, as the primary author Reed is regarded as one of the foremost experts in the field).

File format(s)

BMC Biology accepts several different file types for initial submission of manuscripts, including Microsoft Word documents, Rich text format (RTF) documents, PDFs, LaTeX files, and DeVice Independent format. Figures and images are accepted in the following formats: PDF (which the journal indicates is the preferred format for diagrams), single pages of Word documents, PowerPoint slides, or EPS, PNG, TIFF, JPEG, or BMP files. The default view for published articles is online in an HTML format, and each article has its own dedicated URL. BMC also makes available a PDF file of the article. Additional files, when applicable are available for download in various formats, include image files and sound files. Four of my five sample articles included additional files. Each is available to download as a separate file. The journal encourages authors to provide additional information in the form of datasets, tables, or other files, a gesture that makes sense in light of the journal being published open access. The additional files are even labeled with a small banner titled, “Open Data,” indicating that these files are also published with the same copyright license as the article itself (for more on *BMC Biology* copyright licenses, see below).

Part One summary

From the above description, it is clear that the open access sample articles from *BMC Biology* are consistent with our understanding of the SRA genre. While the interface has changed, and includes many more options for interacting with the information within and surrounding the article, the purposes and content of the research articles remains quite similar to print antecedents, along with other elements of the genre. Articles contain the expected IMRAD logic, though the section order is adapted. Authors continue to use visuals woven into their argument to enhance what they are reporting. Professional affiliations are still featured to demonstrate membership in the discourse community. However, some other adaptations have arisen that are worth noting, not just for the fact that they have happened, but because they can be attributed to adaptations for the benefit of the audience (in this case, scientists) and not simply because the technology allows for it. For example, despite the affordance of the medium allowing for practically unlimited space for article text, *BMC Biology* articles tend to be shorter than the print articles Bazerman (1988) examined. So, instead of taking up what is made possible by the technology, this shorter article length suggests an accommodation of the scientific audience, who has access to an ever-increasing amount of information and has less time to read all of the literature available in the field. Other elements of the article could be filed under an accommodation of the audience rather than primarily using all of the affordances of the technology, such as moving the Materials and Methods section to the end of the article, or the inclusion of additional files in articles. The Materials and Methods sections could be included anywhere within the body of the

article thanks to the ease of moving text in a digital format, but they are strategically placed at the end of the article, where information deemed less critical is made available for those who may want or need it, but for those who just want to learn about the most critical contribution of the article to the literature—the findings—they are placed in a position where a reader could stop reading before that section. Likewise, additional files are available for those who may need or who may want to see them, but for those who are not interested, they are not included in full view within the article.

Part Two: Description of the *BMC Biology* SRA genre ecosystem

Publisher

BioMed Central is a major figure in open access scientific research publishing, with 243 journals in its repertoire as of January, 2013. It is a commercial publisher, like Elsevier or Taylor and Francis, though it only publishes articles open access. BMC is a London-based component of Springer, a global publishing company that has over 1,750 STEM journals and 88,000 eBooks, including special collections and reference books in its portfolio. Out of the various traditional, for-profit academic publishers, Springer is noted as the one making the greatest effort in the realm of open access publishing (Wickham, 2012).

BioMed Central also incorporates an advocacy component into its practice, which is primarily realized through its website in the form of merchandise that can be purchased and whose profits go toward the publisher to continue its work. The advocacy that it does also includes primarily print-based media: users can download posters, leaflets, or wallpaper for

their computer desktops that have various open access slogans and/or imagery in support of the open movement. Indeed, BMC encourages users to "download one or more of the posters, print them out, and display them prominently around your lab" (BMC, "Advocacy," 2013). This primarily print-based advocacy seems a bit out of place given it is an online-only journal publisher, though a user could distribute these files electronically as well.

Publication practices and policies

Like many open access journals in the sciences, *BMC Biology* incorporates an article-processing charge into its publication process. The standard fee is $2,410 (US), though it offers fee waivers for authors from low-income countries. Countries qualified in this category are not listed on the journal's website. *BMC Biology* will also waive the processing charge if authors' institutions are member of BioMed Central. BMC says the goal of having institutions purchase memberships is to decrease the hardship on individual researchers across various departments by allowing the institution to cover the cost by supporting the open access publisher (BMC, "About Membership," 2013). Such a move would also help institutions ensure that their publicly-funded researchers comply with any open access policies the funding institutions might have.

BMC Biology's submission and review practices are fairly standard for a scientific research journal. It operates an online submission system that requires one of an article's authors to submit the manuscript along with a cover letter that clearly states the justification for the article's publication along with any potential issues, such as competing interests.

Authors may also suggest peer reviewers who would be appropriate for completing that element of the publication process. Articles submitted to *BMC Biology* are first reviewed by in-house editors, which include staff at the publisher and an Editorial Board of scientists. These editors make an assessment of the "suitability in principle" of a submission before it is either sent out for peer review or rejected and returned to the author(s) (BMC, "About BMC Biology," n.d.). When a manuscript makes it to the review process, it is generally reviewed by at least two experts.

BMC Biology provides extensive guidelines for its reviewers on its website with a page dedicated to the responsibilities and expectations for those doing peer review. First, the journal asks reviewers for "detailed, constructive comments" and when possible for citations "to substantiate their comments" (BMC, "Guide for *BMC Biology* Reviewers," n.d.). After this information in the introductory paragraphs, the journal provides a listing of eleven "Points to Consider" in the review. These include basic questions about the research question, its originality and usefulness to the field; the appropriateness of the data and the interpretations offered; the suitability of research methods and their level of description in the manuscript; the strengths and weakness of the writing, figures, and tables; and any potential ethical issues or competing interests that should be noted. Reviewers are also reminded that the journal has high expectations for the reviews to be completed in a timely manner as well as confidentially, as set out in the standards for responsible conduct of research (Steneck, 2006).

After an article is reviewed, and if it is accepted with revisions, *BMC Biology* offers a less common option for authors, an option that displayed in a prominent manner on its website: authors may opt out of re-review. *BMC Biology* provides, "to minimize frustration and delay to authors, and help maximize the efficiency of peer review," the ability to let authors decide whether or not their article will again be sent out to referees before a final decision is made on the manuscript. To be eligible, authors must have completed revisions based on prior reviewer feedback. However, these articles are not simply published; they are subject to a thorough review by a journal editor, who will assess how and how well the authors addressed reviewer feedback, and finally are still sent to one reviewer who will offer a decision for the manuscript based on the judgment whether "the data are adequate to support the conclusions" (BMC, "About *BMC Biology*," n.d.).

Articles, when accepted, are published immediately (the same day) on the website and labeled as a "provisional PDF." Professionally copyedited and formatted versions of the article in both PDF and HTML formats are published shortly thereafter at the same link location as the provisional version was initially posted (which is at that time taken down). All in all, BMC highlights its publication process as timely, and by extension courteous, for authors.

Content copyright licensing

BMC Biology uses the copyright and license agreement exercised by its publisher BioMed Central. While it has named the license after the publisher, titling it the "BioMed

Central Open Access license agreement," it is in in spirit identical to the Creative Commons Attribution License (BMC, "BioMed Central Copyright and License Agreement," 2013). Thus, anyone is able to freely copy, distribute, display, make derivatives of, or use commercially the work that is published in the journal under the condition that the original authors are given credit for their work. The articles indicate that copyright belongs to the author(s) and that BMC has been licensed to publish it in this journal. All authors of the work must agree to this license for an article to be published. It is significant that such a large open access publisher would use the Creative Commons licensing spirit, thus increasing the profile of such copyright agreements. At the same, though, adopting the language in creating its own licensing agreement gives the publisher a level of control over enforcing the license. This is much less commonly done by journals, and would take a significant amount of time and effort on the part of the journal to enforce. The journal does not provide any information on its website about this matter, however.

Journal homepage

The *BMC Biology* homepage features a lot of information for prospective readers or authors, reviewers, and members. The most valuable real estate portion of the page, the upper left quadrant, features several key elements: the journal's logo, emblazoned with "10th anniversary" and an orange box that says "Impact Factor 5.75"; six menu tabs that take users to the different section within the site, brief paragraphs about the journal, and a Flash-based image slider that rotates different messages and images every eight seconds (see Figure 8 for

a screenshot of the homepage). The options in the menu at the top of the page are: "Home" (the default), "Articles," "Authors," "Reviewers," "About this journal," and "My *BMC Biology*." This area serves as a general introduction to the journal, offering options for the various audiences who may be navigating to the site for a variety of purposes. The top right-hand corner has three menu tab options: "BioMed Central" (the default), "Journals," and "Gateways," other options available through the publisher that users can explore for related content or scholarship.

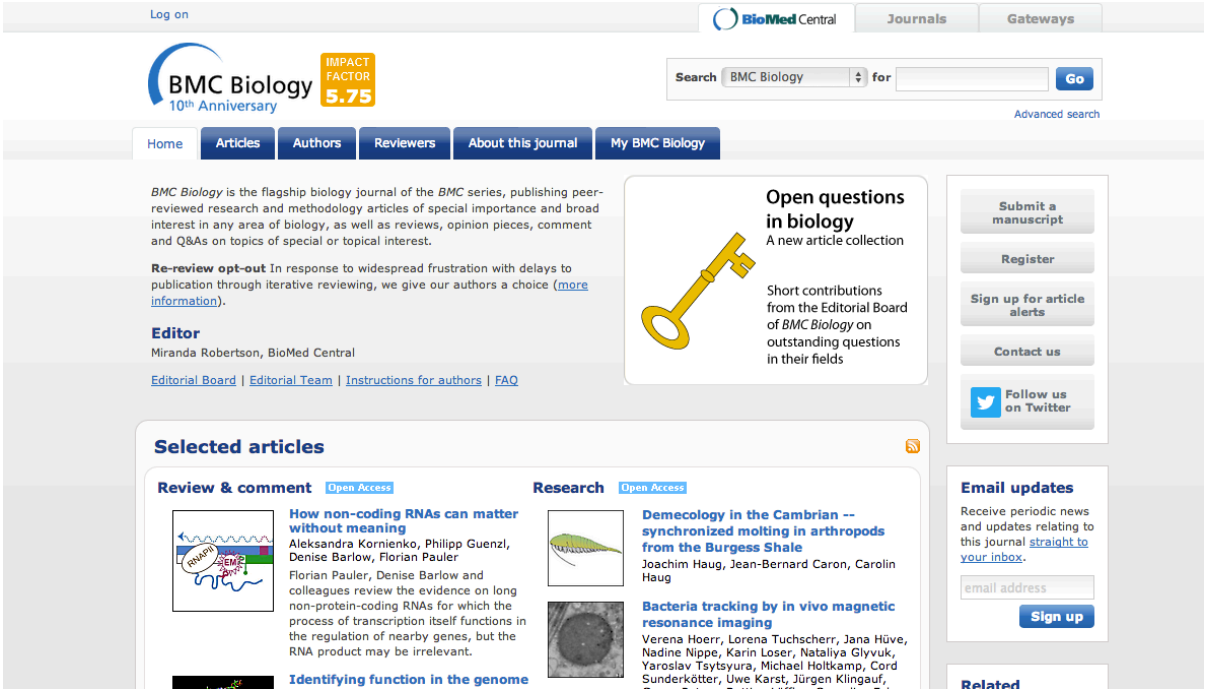

Figure 8 - A screenshot of the homepage of *BMC Biology*.

Below the introductory information, the majority of the homepage space features links with teaser images from the respective articles that link to them under the heading, "Selected

articles." One column features review articles and commentaries, and a second highlights recently accepted and published original research articles. Beside each column's label is a bright blue box announcing "Open Access," reinforcing the journal's practices for its audience. Following a link to one of the listed articles, a reader would find the provisional abstract and PDF of the article, as per the journal's practice of publishing that version immediately upon acceptance with the final copy-edited, formatted version posted shortly thereafter. Underneath this content box is another box featuring "Latest articles from *BMC Biology*," which a reader would interpret to be the most recently published articles in descending order from the most recently accepted with its provisional text posted. This box links to all of the publication genres within the journal (described below). Other content boxes alongside and beneath this one include "Topical Q&As," links to the journal's "Question and answer" series of publications; "Article collections," links to aggregated special topics series; "Latest articles from *BMC Medicine*," the other flagship journal of the BMC series of journals; a feed with links to the journal's blog; a feed featuring recent Twitter posts; and finally, a brief statement about the journal's predecessor, the *Journal of Biology*, which was assimilated into *BMC Biology* back in 2010. This final content box might strike the reader as being out of place and belonging more appropriately in the "About" section of the journal, for it could be easily overlooked in a location such as the final content box and brief paragraph on the homepage.

The far right-hand portion of the page features several smaller menus. The first one offers choices for different interactions one could have with the journal: "Submit a

manuscript," "Register" (for an account), "Sign up for article alerts," "Contact us," and "Follow us on Twitter." Immediately below, but separate from it, is a box that allows a user to submit his or her email address to receive news and alerts from the journal via email. The last two content boxes on the right-hand side are 1) links to items that are "Related," other BMC journals or gateways available through the publisher; and 2) a list of databases that index *BMC Biology*.

All in all, the homepage incorporates the major points of entry for the journal, based on the main interactions people would have with it. Scientists looking to read the most recent publications can find those prominently displayed on the homepage. Reviewers looking for directions can easily find those under the "Reviewers" tab. Public audiences may have a few points of entry, either with articles or perhaps with the latest blog entries. The "teaser" images mentioned above, being drawn directly from the articles, can be highly technical drawings, though some are brightly-colored photographs, indicating perhaps somewhat of an attempt to interpellate a broader audience. The menu tabs for these interactions are clear and prominent on the page. The layout, however, with the multitude of content boxes of different sizes and shapes, gives a cluttered appearance. There is no clear focal point on the page for the eye to rest. The information layout seems at times arbitrary; having information about the journal's re-review opt-out policy in bold and in the most prominent location on the homepage makes the journal seem disorganized or at best, as if it believes that such as policy is a significant reason why *BMC Biology* should stand out from other journals in the field and thus make it a good choice for authors.

Other publication genres

Each monthly issue of *BMC Biology* includes a variety of published genres. In addition to research articles, the journal also accepts editorials, commentary, opinion pieces, methodology articles, review articles, corrections, correspondence, question and answer pieces, software, and comments. The first six of these genres fit with the typified recurrences in other scholarly journals. The "Question and answer" series includes articles that are solicited works which discuss a current issue in biological research in an accessible way that interested non-experts could understand and appreciate. BMC describes these as "easily digestible and often lively guide[s] to topics of current interest or fundamental importance" (BMC, "Question and Answer," 2012). Software pieces are articles written in the traditional IMRAD format that discuss the development of a new kind of software designed to help address research problems in the field. These articles are a formal way of announcing to the scientific research community that the tool is available for broad use. The final of these publication genres, comments, are different from the typical commentary: these are pieces in topical series run by the journal that are solicited to address a specific pressing issue in the area of research related to the series. They are short, quickly published pieces (sometimes accepted within two days of submission) that bring to the fore a problem that future research could address.

These other genres are also quite popular for the journal: of the top ten most-viewed published pieces of all time in the journal, six of them are genres other than the original

research article.[16] These include a couple of review articles, a methodology article, and several question and answer pieces. Nearly all of the question and answer pieces in the journal are labeled with a bright red "Highly accessed" button. BMC describes this designation as for "articles that have been especially highly accessed, relative to their age," though it is not explicitly stated how many views an article must have to receive this designation, and the designation is permanent once an article has received it (BMC, "Most viewed articles on BioMed Central," 2013). The most-viewed "Question and answer" article, "What is the Golgi apparatus, and why are we asking?" has 27,617 views, just one view less than the most-accessed review article, "Molecular dynamics simulations and drug discovery." As with many of the additional genres published in *PLOS Biology*, it is likely that the combination of being technologically accessible and conceptually accessible (Kelly & Kittle Autry, 2013) results in the high number of views.

Article and other metrics

BioMed Central uses traditional impact factor measurements for its journals as one way of indicating their uptake in and importance to the fields that the journals address. Approximately half of its journals—those that have been in production for at least three years—are indexed by Thomson Reuters (ISI), which provides citation tracking and impact factors for journals. BMC uses these impact factors to promote its journals and to identify some of them as "high impact," including *BMC Biology*. *BMC Biology* has an impact factor of 6.53

[16] Usage/access statistics are all as of the date of data collection, January 7, 2013, unless otherwise noted.

for 2012, up three quarters of a point from the 2011 factor of 5.75. By touting the impact factors for its journals, BMC appeals to scientists by using metrics that they would be familiar with based on their experience with other journals in the field, including those with a much longer history than *BMC Biology*. BMC also has its journals indexed with an alternative journal citation metric system, SCImago Journal Rank. This research service is a free alternative to the paid Thomson Reuters system, and provides a ranking for journals using information from Scopus. Scopus is a database run by Elsevier, and is the largest in the world with its collection of abstracts and citation. SCImago Journal Rank offers a numerical rank for the more than 17,000 journals that it tracks. As of the latest year available (2010), *BMC Biology* ranks 256th in the ranking system of the 17,000 plus journals.

BMC also tracks individual article metrics, though on a much smaller scale than PLOS does for its publications. BMC makes it easy for a user to track the most viewed article in its journals, providing links to lists of the most viewed in the last 30 days, last year, and of all time. It also provides metrics for each of those time periods. For example, the fourth most viewed article of all time in the journal by Leong et al. (2009) is also the most viewed article for the month of January 2013 (at the time of data collection, the most recent month available for the journal's "last month" category for usage statistics), with over 11,000 views during the time period of January 7th-February 8th, 2013.[17] This article was also the most viewed in the last year, with nearly 37,000 views within that time period. Unlike in *PLOS Biology*,

[17] This article became the most-viewed article of all time in the journal in April, 2013, and as of June 21, 2013, has 91,143 views. While the viewing of journal articles tends to taper off over time, this article clearly became newly relevant to the journal's readership in 2013.

though, this detail is not prominently displayed on the article itself. To find that information, a reader has to click on the "About this article" option in the right-hand menu bar (see Figure 9 for a screencapture of this information). The journal lists the following data on article views: the last 30 days, the last 365 days, and all time. Also available when clicking on this option is the article's Altmetric score with the Altmetric logo (recall from the previous chapter that *Nature* uses the Altmetric system for its own articles). The small Altmetric logo demonstrates an individual article's score just above the data of article views. Overall, the data provided here are on a much smaller scale than that provided by either *PLOS Biology* or *Nature*, though there are similarities to the most basic kind of data collected, in all-time views and Altmetric scores, respectively.

Figure 9 - An example of *BMC Biology*'s use of article metrics, which includes number of views for the article and the use of Altmetric scoring.

Promotional practices

On its "About" page, the journal touts several reasons for authors to publish with *BMC Biology*, one of which includes how the journal handles promotion of material it publishes. For those who sign up for content alerts (using the sign up option on the homepage, described above), new article notifications are regularly emailed to them. Articles may also be featured elsewhere on the BMC network of sites, which includes its other journals and the publisher's overall homepage. The journal is also indexed by 22 different indexing services, including the following major indexes in the sciences: CAS, Embase, MEDLINE, PubMed and PubMed Central, Science Citation Index, Scopus, and Google Scholar. Additionally,

BMC regularly publishes press releases about its newly-published material, and articles in *BMC Biology* may be featured in these.

While it is not mentioned in the promotional practices section of their website, the journal also regularly tweets about recently published material, incorporating a link to the article in the posts. The account additionally tweets monthly "round-ups" of the articles it publishes. Overall, the journal incorporates standard practices for article promotion—many publishers offer email alerts for journal contents—with one new social media-driven promotional practice.

Sharing features

On each article's webpage, *BMC Biology* features three sharing options along the right-hand side menu: Facebook, Twitter, and Google+, all as buttons featuring the site's logo. Incorporated into these buttons are counts for each item. For example, the most-viewed article in the journal, "The first metazoa living in permanently anoxic conditions," has been shared (or as the Facebook button calls it, "Recommend[ed]") 183 times. A fourth button called "More options" displays additional sharing possibilities when a reader hovers over it, including the reference management sites CiteULike, Mendeley, and Connotea, as well as the now-defunct social bookmarking site Del.icio.us and a "Share via email" option. Overall, the sharing offerings through *BMC Biology* are essentially standard on the web, and the journal does make it possible for its readers who engage in the use of social media sites to disseminate articles across those channels.

Commenting features

BioMed Central applies the same user commenting policy across its journals. Only registered users may comment on articles; a user may register with any BMC journal, and this registration is applicable across any of the journals for commenting purposes (and other user benefits as well). BMC welcomes users comments on any of the pieces that it publishes. Article commenting is moderated by the publisher; comments do not appear until they are approved by a staff member. The publisher's commenting policy includes a list of reasons for which a comment may be denied, thus establishing decorum for user comments. Reasons for denial includes comments that "appear to be indecent, offensive, or contain negative content of a personal, racial, ethnic, sexual orientation, or religious character" (BMC, "Comments policy," 2013). Also outlined are guidelines for appropriateness to the topic at hand; comments will not be posted if they "are irrelevant to the article, are trivial, appear to be advertising, [or] are a repetition of comments posted elsewhere on BioMed Central" (BMC, "Comments policy," 2013). Finally, BMC's policy includes a mandatory declaration of competing interests to the article on which a user is commenting. These include possible financial competing interests, or competing interests of another nature, such as political, academic, commercial, or religious.

Despite encouragement for users to comment, in practice, this does not seem to happen much. Only one of the articles in the sample, the most viewed of all time, had user comments. The first comment is a question from a user affiliated with a Hungarian medical

school, and the second is a response by the first and corresponding author from the article. The exchange ends after the response is given.

Part Two summary

Overall, the ecosystem of the SRA in this case study is highly dependent on the publisher, BioMed Central. BMC is responsible for many open access journals—254—and as such probably has a somewhat standardized approach to its journals to make such an endeavor feasible. In the case study here with *BMC Biology*, BMC seems to take a "safe" approach to incorporating various elements into the articles. Statistics are available, but at a very general level, articles can be shared on social media, but just through the most popular social media sites, and commenting is facilitated, but has strict guidelines and is closely monitored. The engagement with the commenting system reflects this: there are no comments by non-scientist users, and there are very few comments by the scientists themselves, who traditionally have not been able to engage with published research in this way. Overall, this appears to be an ecosystem that is closely controlled by the publisher and intended primarily for a scientific audience and much less so, if at all, for a general audience with an interest in the research.

Part Three: Perspective of users participating in the genre

The final component of my analysis of SRAs in *BMC Biology* includes gathering information from key users of the genre, authors who have published in it and the editors of

the journal. I sent a questionnaire to the corresponding author for the fifty most-viewed articles of all time in the journal using the email address for correspondence listed in the article (see Appendix A for author questionnaire). Thirteen of the messages were returned indicating the email address no longer exists; I was able to locate the correct address for three of the thirteen for a total of ten undelivered questionnaire requests. A total of ten authors responded to the survey for a 25% response rate for the questionnaires successfully delivered, just slightly higher than the response rate of the *PLOS Biology* authors. The authors represent an impressive array of concentrations in biology, including phylogenetics, evolutionary biology, microbiology, molecular genetics, medical entomology, and biomechanics. These authors are also spread out around the globe, working in four different countries: Sweden, England, Thailand, and the United States. I also attempted to send questionnaires to the editors of the journal but again met difficulty in getting responses (see Appendix B for editor questionnaire). Editor emails for *BMC Biology* are not published online; instead, a general mailbox address is provided. In this email, I requested permission to contact the five editors of the journal with my questionnaire. The staff member monitoring the general mailbox contacted the editors with my request. Just one editor indicated he would help me with my research, and he did fill out responses to my questionnaire.

The first part of the questionnaire (items 2-5) asked authors about why they chose to publish their work in *BMC Biology* and at the same time, in open access. These responses were quite similar to the responses of authors published in *PLOS Biology*. Eight of the ten authors selected the reason “I am an open access advocate” as one reason they chose to

publish in the journal (see Table 9 for full list of possible answers to question #4 and the number of responses for each). The second most common answer (just as with *PLOS Biology* authors), with seven respondents choosing this option, was again the journal's reputation. Five authors also indicated that the journal was the right fit for their research, and four authors both chose that some or all of the coauthors wanted to publish in this journal as well as in open access. The responses authors wrote in when selecting "Other" as an option were also illuminating. Two authors indicated visibility as a factor, with one author writing, "I and my co-authors wanted the increased exposure that we perceived to come along with publishing in an open-access journal." Two authors wrote in that time to publication was fairly fast and thus an important reason for their choice to publish in *BMC Biology*. When answering the question about the key reason why they chose to publish with BMC, the answers were much more mixed. The most popular choice, with four authors selecting this one, was the journal's reputation. No other answer received more than two selections; two authors once again wrote in under "Other" the speed of publication and two authors selected the option of the journal being the right fit for their research.

Table 9 - Author question #4 and responses

What factors contributed to your decision to publish your article in *BMC Biology*? Select all that apply.	
Answer	**Number of responses (out of 10 total respondents)**
I am an open access advocate.	8
Some or all of my coauthors wanted to publish in this journal.	4
Some or all of my coauthors wanted to publish in open access.	4
My funding agency for this research mandates open access publishing.	0
The journal's reputation.	7
I am or one of my authors is a member of the organization that publishes this journal.	0
The focus of the journal was the right fit for the research.	5
I have published in this journal before.	0
Some or all of my coauthors have published in this journal before.	0
Other	4

When asked about the differences between open access online articles and other publishing models in question #10, the authors had several different responses. Notably, two authors indicated they saw no difference at all between print journals and the online articles published by *BMC Biology*. My question was phrased generally so as not to point authors in

a particular direction, but I might hypothesize here that these two authors are speaking more to the research *content* than to the other features of the journal, for example, which based on Parts One and Two of this chapter demonstrate noticeable differences. Among authors who noted differences, four authors mentioned access as a significant difference, two mentioned speed of publication, and two mentioned visibility. These are all important factors for research scientists, whose careers depend on not just the ability to publish their work but also to have it seen by others in the scientific research community and for it to be viewed as quality research. One respondent keyed in on the affordances of the medium and the possibilities for what an article might look like, saying, "Page limit [is] not as great with online journals; fewer restrictions on figures, tables, [and] photos." When asked what the main difference is between closed access online journals and open access online journals, nine of the ten respondents indicated that access/audience was most significant. "Access," "accessibility," and "wider audience" were commonly used to describe this difference. Notably, one respondent said specifically that there was greater access to the information by the scientific community. Another said, "It's really nice to know that anyone around the world can view the articles online for free." These are the only two instances where respondents specified who they were talking about in their recognition that more people would be able to access their work. Only one respondent included copyright in his[18] answer to this question, indicating that ownership of work might be less of an issue for scholars publishing in this journal.

[18] I use "his" here and "he" elsewhere because all of the authors who responded to my author and editor questionnaires for this journal were men.

However, while authors recognize that journals like *BMC Biology* bring a new level of visibility to their work and identify themselves as open access advocates, their publishing practices as described in this questionnaire still include many closed access journals. All of the authors indicated they still publish in closed access journals, with seven of them indicating that they publish in closed access for at least half of the work they publish, if not more (see Table 4-4 for a full reporting on the authors' descriptions of their publishing practices). The author who indicated "Other" provided more detail, explaining, "I publish where appropriate to get to [the] relevant audience in a timely manner." Overall, there is still a big gap between the recognition that authors have for the importance of open access and the visibility it brings their research and their ability to do so in a way that is satisfactory for them career-wise. The *PLOS Biology* authors had similar responses, indicating that this might be a general issue for open access publishing and not just for authors in a particular journal.

Table 10 - Author question #11 and responses

Which of the following statements best describes your personal publishing practices for original scholarship?	
Answer	**Number of responses (out of 10 respondents total)**
I only publish in open access scholarly journals.	0
I primarily publish in open access journals, but occasionally publish in closed access journals.	2
I publish approximately the same number of articles in open access journals as closed access journals.	4
I primarily publish in closed access journals, but occasionally publish in open access journals.	2
I primarily publish in closed access journals, but make pre- or post-prints available in a repository or on my own personal website.	1
Other	1

Finally, the *BMC Biology* authors had a pretty clear stance on whether or not publishing in open access has any influence on the way that they write up their research for publication: emphatically no, with eight of the ten authors saying this in response to question #17, which asked, “Has publishing in open access had any impact on the way in which you write your original research articles?” The authors generally interpreted this question as referring to quality, with a respondent expanding, “We write the paper the best we can.” Another author indicated that while he did not see a change in the writing yet, he thinks that there will be because open access has led to an increase in the number of journals publishing. He correlates an increase in journals with more opportunities for authors to publish, which to him “means that most any type of work can be published somewhere if it is of good quality.”

Essentially, he argues that it is not the style or structure of writing that is changing for scientists, but instead, it is increasing their ability to be prolific. Whether or not this is a legitimate claim about open access journals is another question, but at least for now, that is how this respondent feels about open access publications. Only one indicated he saw a clear change, saying that because open access journals tend to not have length limits for articles, then it allows authors to have "less terse text."

Overall, authors focused on issues of access as a significant element to the publishing that *BMC Biology* does. Like the authors of *PLOS Biology*, they recognize the reach that their articles now have to a global audience and additionally understand the importance of that reach. While the publishing method is much different for these articles, though, the authors seem relatively certain that this does not have an impact on the actual content of the articles, indicating that they still compose their articles in a similar manner no matter what the venue (dependent on individual journal guidelines, of course). What they emphasize here is that the quality of their work does not change, regardless of how openly it is published. They make no mention of accommodating a wide global audience or adaptations based on the affordances of the technologies used to publish their articles.

As mentioned above, only one editor responded to my questionnaire, which by no means represents enough data to identify trends in open access editorial practices. However, it is still interesting to hear the responses of the one editor who was kind enough to share his thoughts, as it sheds light into the daily practices and thoughts of those working for an open access journal. While the authors who published in this journal did not tend to see the articles

they wrote as doing anything different, the editor's responses indicate that the journal's editorial policies are leaning toward articles that "are generally accessible, and can serve as learning material for those outside of a field." He does not clarify what he means by accessible, or for whom the work is accessible, but the use of "a" field gestures toward a cross-disciplinary understanding more than the understanding of a general public audience. The editor also gestures toward another kind of change by saying that a significant difference between their open access journal and print journals is "the ability to be more open about data and methods by including supplementary information that wouldn't fit in a print journal." This is made possible in part because of the affordances of the technology, in part because it makes publishing that much information affordable for the journal without a cost of printing information by the page. However, he recognizes that another affordance of the technology, decreasing time to publication, introduces issues of quality that are an important concern for the scientific community to address if they are going to continue to seek out "'high quality' high rejection-rate [sic] journals under an open access model."

Overall, the authors and the editor who responded to the questionnaire show a strong understanding of and support for the increased accessibility provided by the open access publishing model of *BMC Biology*. Both groups also have a keen awareness of time to publication, while the editor's comments reflect the tension of speed and quality would not be uncommon for a journal editor. The responses are mixed as to whether there is any significant "change" to the scientific research article as it is executed by this journal. What is clear is that asking about whether they see "change" evokes different definitions of the term,

and that the authors in particular see “change” as potentially negative for the quality of the work that they are producing, and as such, they do not acknowledge any change is occurring.

Conclusion: BioMed Central’s safe approach to publishing open access scientific research articles

All in all, this analysis shows that the work published in *BMC Biology* also still resembles in many ways the traditional scientific research article, with some adaptations taking advantage of the digital format or that are consistent with what previous research has found for the genre at the end of the twentieth century. For example, the journal has deemphasized the methods by altering their placement in the final published version, which is a logical extension of Berkenkotter and Huckin’s (1995) finding that through the end of the twentieth century, methods sections were becoming gradually more deemphasized. Remaining the same are key features: Titles follow scientific convention, the articles are highly intertextual, authors use visuals along with written text to present their arguments, and the works are peer reviewed. Despite the affordance of the medium allowing for virtually unlimited length, articles are generally shorter than print versions, also accommodating a busy audience and reflecting the “news value” trend in SRAs that Berkenkotter and Huckin reported on. Additionally, key users of the genre—authors—do not see any significant change in the genre. Beyond specific features of the articles and on the journal’s website, audience considerations have not seen significant changes either. While PLOS has made some editorial decisions to adapt to the potentially wider audience, such as mandating shorter

titles with fewer technical terms, BMC's journal articles are still best suited to the scientific community and do not make any additional concessions for a non-expert audience who may want to take them up. Instead, they have other genres to serve that purpose, such as the question and answer.

As with *PLOS Biology*, it seems that what is happening here with the SRA genre are not broad changes across the board that are on the "cutting edge." Instead, the findings in this case study, like the previous, are consistent with Mackenzie Owen's (2007) argument that the internet is not having a revolutionary effect on the scientific research article. While being published openly on the internet changes the potential reach of the work, and there are some adaptations because of the affordances of the medium, nothing here points to a paradigm shift in scientific research article writing and publishing. Similarly, Gross et al. (2005) suggested that their own findings were also not of any revolution in science, but instead what they called evolution. They argue this latter term does not necessarily imply that any change that has occurred over time is for the betterment of science, instead, just that there has been change—without any judgments about the quality of the change to the genre.

Furthermore, while the research is open, there is still a heavy hand of the publisher on all of the work published in *BMC Biology*, and indeed, the publisher is a for-profit entity with a reputation to maintain with the scientific community in order for it to continue to publish work. There are fewer, if any, unique features to this journal when compared with *PLOS Biology* and the efforts of PLOS. The journal, and the publisher, have a reputation to maintain, and just as researchers choose to publish in *BMC Biology* because of the speed of

publication and openness, they could just as easily decide against submitting their research to this journal if they felt that the work being done by the publisher strayed too far from what they considered to be good publication practices. And this fits with our understanding of science: it is consensus based, and a journal lacking consensus from the research community about its publication practices would not fit into a model of “science” as we understand it (Kuhn, 1962). Thus, more so than PLOS, BioMed Central’s publishing choices, and by extension enactment of the scientific research article genre, remain true to the publishing practices and SRA genre that we have been long familiar with and that rhetoric of science and genre scholars have thoroughly studied.

CHAPTER 5: SCIENCE, OPEN ACCESS, AND THE SCIENTIFIC RESEARCH ARTICLE

This fifth and final chapter synthesizes the results from the case studies presented in chapters three and four and discusses the implications of this work for the fields of rhetorical genre studies and rhetoric of science. It will do so specifically by addressing the two main research questions introduced in chapter two:

1. What influence does open access have on the SRA genre? How can this influence be characterized?
2. How can the influence of open access on the SRA help us to better understand genre change online?

To answer these questions, I summarize key takeaway points from the case studies undertaken in chapters three and four. Next, I will articulate why these case studies are evidence of genre adaptation, connecting the discussion back to my theorizing in the first chapter about genre ecosystems. Overall, this chapter will argue that the scientific research articles studied in this dissertation are not evidence of complete genre change, but that the more accurate term for what is happening with the SRA in light of open access is adaptation of the genre. There are slight changes to features in the articles and new affordances introduced by the technologies being used, but these are incremental adaptations that have not resulted in complete genre change. By doing this, I will reframe the discussions that are taking place about open access being “revolutionary” and the Internet “revolutionizing

communication," moving the focus away from technology and back to that with which rhetoricians are primarily concerned: context. While technology is certainly an *aspect* of the context, the Internet, in this case, is primarily an environment—it is not a determiner of the genre or the actions of the authors and editors. The context that becomes critical here is the ideology of science and how that comes into play with the ideology of open access. Science is a powerful and influential way of understanding the world, and my discussion of this study's implications focuses on how we see this power and influence on the scientific research article. This chapter concludes with a discussion of the study's limitations and directions for future research.

Open access and the scholarly research article

The goal of this study has been to extend our understanding of the scientific research article genre in light of open access and how in turn this knowledge may inform our understanding of genre change more broadly. Chapter one introduced a framework for understanding genre change online, a framework that informed the methods developed in chapter two. The case studies of scientific research articles in *PLOS Biology* and *BMC Biology* in chapters three and four offer examples of two successful open access journals in the field of biology. While we cannot generalize to all scientific research articles or even to all SRAs in biology from these two examples, these cases do offer useful insights into the possible influence of open access and the potential for genre change or variance that we are seeing in scientific research publishing.

As scientific research journals, *PLOS Biology* and *BMC Biology* are quite similar in many respects: they publish original research in the general field of biology, inviting work from a range of subfields; they publish the articles in the journals open access; they have editorial boards for peer review of SRAs; they publish other genres in addition to the scientific research articles, including a summary genre that offers the results of key SRAs for a non-expert readership; they publish only online; their online presence encourages interaction on the part of readers, including through the use of social media tools, user accounts, and commenting features; they track user statistics closely and use these statistics to justify their work and to market the journals. Closed access, "traditional" journals share many of these same features (save for the open access elements), though this depends on the individual journal being examined. Journals increasingly have an online presence that includes some use of social media, online user accounts, and/or comments in addition to a website for the journal, and they also track varying kinds of usage data for that site, even if they only keep that information internal. At the individual article level of this study, we see that the articles published in these two journals are similar in a few key respects: they employ the traditional IMRAD logic in an adapted order; the articles include an elaborate finding system of headings and hypertextual links; arguments are made through a combination of verbal and visual texts; there is a heavy use of citation to create highly intertextual arguments; and articles feature other information that reflects the professionalism of science, such as author affiliation or potential conflicts of interest. These features are generally consistent with "traditional," closed-access journals, with the two different possibilities for

article logic, IMRAD and IRD(C)M, likely being the most highly variable component across journals.

Most significantly from the results of the case studies, we see that the SRAs in both journals have features that accommodate their main audience, the busy research scientist of the 21st century. Articles include abstracts that summarize the work and important findings, are easily navigable to the point in the article most pertinent to the scientific reader, include additional information outside the main text of the article for those most interested in it, and have adapted the IMRAD logic to a new IRD(C)M one that is more efficient for readers who are more focused on results and less on the methods. These features align with the findings of Berkenkotter and Huckin (1995) who wrote about the emerging trend of "news value" for SRAs and the shifting of article writing toward the accommodation of reading practices more analogous with newspaper reading than journal article reading, partly due to the fact that there is always more literature than any scientist can read. Methods information, for instance, can often be common knowledge, write Berkenkotter and Huckin, and what a scientist is really looking for in an article is the most "newsworthy" point: the main findings. Thus, it is not surprising to find that articles in *PLOS Biology* and *BMC Biology* continue this trend previously identified in the literature to accommodate their key audience, and when combined with Berkenkotter and Huckin's report of print journals, it is clear that this tailoring is not necessarily specific to open access articles or to the medium of delivery.

The similarities listed above among the journals and articles studied here are also features that aid our understanding of the scientific research article as a genre. While the

articles may now be published entirely in a relatively new medium (considering the history of the genre), given the features described above, the scientific research article still closely resembles the genre that has been so closely studied by rhetoric of science and/or genre scholars. Genres are fitting to their rhetorical situation; if a genre no longer seems to fit, then it will change (Miller, 1984). In the case of the scientific research article published in open access, the genre continues to fit the situation: here, the scientific research community *and* various publics have a need for the research and the discoveries made in a timely manner, and that is what is happening with the SRA genre published in open access. In terms of the specific needs and interests of these various publics, they can certainly differ: for example, citizen scientists would be interested in different information than policy makers at the level of state government. At this point, more research is needed on the various audiences for open access scientific research articles, their use, and other information (which I discuss further in the final section of this chapter).

We might say that we are seeing some incremental change with the genre as enacted here by *PLOS Biology* and *BMC Biology*, such as the continued adaptation of the IMRAD logic, which Berkenkotter and Huckin (1995) first identified as an emerging adaptation in their own study. This adapted logic is important for the genre, but it has been gradually happening over a couple of decades, now, and at this point fits well with the multiple audiences of open access SRAs. Articles also incorporate more additional information, making more data and results reporting open to the readership of these articles than previously has been available. We also see that the research letter genre, initially a distinct

genre with a long history (such as Watson & Crick's "A Structure for Deoxyribose Nucleic Acid") and that has been well studied in the rhetoric of science, is fading from use. This genre is missing from the publishing repertoire of both PLOS and BMC; instead, the SRA genre seems to encompass it, with both publishers saying that they invite articles of all lengths, and *PLOS Biology* specifically stating, "We will consider manuscripts of any length; we encourage the submission of both substantial full-length bodies of work and shorter manuscripts that report novel findings that might be based on a more limited range of experiments" (PLOS, "*PLOS Biology* Guidelines for Authors," n.d.). In this single sentence, PLOS essentially combines two genres, both with their own rich histories, into one genre. In practice, however, none of the SRAs from my sample of twenty in each journal had lengths that would fall into the traditional letter length of under 3,000 words; all had at least 4,000.

With incremental changes like these, I argue that the conclusions to this study are not as simple as "it is still the exact same genre" or "it is entirely different." What is more accurate is that we are seeing some adaptations to the tried and true features of the genre. One of the key adaptations, changes to the IMRAD format, has been observed previously and is continuing today. In what follows, I articulate how open access does influence some important elements of the scientific research article, offering instead a more complex picture than simply saying the SRA is still entirely the same genre that Gross et al. (2002) and Mackenzie Owen (2007) described several years ago. While the main textual portions of articles still report on scientific research, offering new insights to the field reported in a highly stylized way, the new philosophical approach of open access to the availability of this

research is an important development along the historical timeline that Bazerman (1988), Myers (1990), Berkenkotter and Huckin, Gross et al., and Mackenzie Owen have to this point identified.

The open access journals studied here, as well as many others browsed for the purposes of this research, emphasize highly their dedication to the broader dissemination and wider reach of scientific research. *PLOS Biology*'s journal description, for example, specifically mentions this: "*PLOS Biology* is an open-access, peer-reviewed general biology journal published by PLOS, a nonprofit organization of scientists and physicians *committed to making the world's scientific and medical literature a public resource*" (PLOS, "About *PLOS Biology*," n.d., emphasis mine). In contrast, the mission of *Nature* is divided into two separate goals; the first mentions the goal of serving the world's scientists, the second to "ensure that they results of science are rapidly disseminated to the public throughout the world" (Nature, "About Nature," n.d.). So, while global availability of scientific research is also a goal of *Nature*, it is subordinated to the idea of rapid dissemination within the statement, and made a secondary goal after first serving the scientific community. The open access goal of making scientific research globally available to anyone who may be interested in it means that SRAs published in open access journals necessarily have a different kind of audience than articles published in closed-access journals (either online or in print). However, a larger audience does not a new genre make. Just because more people may potentially see it or read it does not mean that there is a new recurrent social action. We may see additional genres in the SRA ecosystem, such as the Synopses published by PLOS, the

blog network PLOS runs, or social media posts adapting the information reported in the articles, but the results of this study show that the main exigence of the SRA published in open access is not changing for the authors who are writing them. They still write to report the results of their research for the scientific community.

Additionally, the potential for reach is not the same thing as the actual uptake of the research. As Freadman (1994) says, “Knowing a genre is also knowing how to take it up” (p. 63). We still do not yet have a good picture of how the different audiences for the research published open access are actually accessing, reading, and using it. It is one thing if the whole world in principle has access to the research, but it is another thing entirely if a great variety of readers, including scientists, non-scientists, and those with a variety of kinds of expertise are actively seeking out the work published and using it for whatever their purpose may be—a dermatologist looking for the latest treatment of a skin disease, or a parent looking for information about lice given a recent outbreak at a child’s school. Citations historically have been an indicator of uptake by the scientific community, but for a global audience of both scientists and non-scientists, including the “general public” or policy makers, uptake is more difficult to document. The metrics tracked by many journals, include the two studied here, provide some information about how many times an article has been navigated to, but these statistics do not provide an accurate number of people who have used—or even actually intended to view—the research within that article. Furthermore, they do not provide any information about who these readers are, an important consideration I will explore. While citations can continue to be a measure of uptake in the scientific community,

there is not yet any good measure of uptake for the global audience of non-scientists who may need and use the work being published.

Issues of audience for the open access scientific research article are indeed complex. Genres can be understood and even partially defined by understanding the background knowledge readers of a genre are assumed to have (Berkenkotter & Huckin, 1995). But when the *potential* audience of a genre is every literate person with an internet connection, what does that mean for defining and understanding the genre? Furthermore, if genres belong to a group to achieve social action for that discourse community (Devitt, 2004), where does a broader global audience, with at least some non-experts, fit into our understanding of the scientific research article as a genre? Historically, the SRA has had a primary audience of scientists, and more specifically, those in the field in which the journal they are published in specializes. As Bazerman (1988) writes, the importance of audience for SRAs is that those reading a journal in the field "share an acceptance of much knowledge, evidence gathering techniques, and criteria of judgment" (p. 46). This can be said of the scientific audience for *PLOS Biology* and *BMC Biology*, but it cannot also be said for the broader audience of non-scientists. The journals studied here, I would argue, recognize this difference in background knowledge and accommodate (Fahnestock, 1986) their audiences accordingly through the publication of summary genres, such as *PLOS Biology*'s "synopses" of interesting articles that it publishes. PLOS additionally requires that titles for articles published in its journals be relatively short and jargon free, but beyond this mandated accommodation, the articles sampled for this dissertation do not exhibit any specific accommodation of a broader, non-

expert audience. Neither do the responses from the authors who responded to the questionnaire indicate that they deliberately write articles to accommodate a broader audience. Indeed, several respondents specifically stated that publishing in open access does not change a thing about how they write SRAs.

What emerges from this study is a complex issue of audience for genres like the SRA that are both regulated and regularized by a discourse community, are highly stylized, and are critical for the careers of those writing them. Because of the stakes for publishing SRAs—a primary way that university-based scientists obtain tenure and promotion and for those in other research-based employment to demonstrate productivity—those who write them are highly invested in the continuation of the genre as well as the reputation of the genre. On the other hand, authors recognize that their work does not "belong" to only a select community of readers: because they often use public funds to generate this knowledge, many believe the research published through the use of these funds should be available to the public funding it. (This is not the entire argument for open access, of course, but it is one of the most critical.) Despite recognizing that the "general public" should be considered a part of their audience, however, the authors who responded to the questionnaires seem to have a hard time reconciling the differing audiences within their writing. Overall, the issue of audience is not one that can be quickly resolved, and additional research is needed to better understand if and how audiences beyond the scientific research community, such as policy makers or medical practitioners, are engaging with the SRA genre in open access.

Genre as social action

In chapter two, I described the recurrent social action of the scientific research article as advancing statements for the larger scientific community to authorize within that community as knowledge (Bazerman, 1988). I return to it now in the conclusion of this dissertation to bring together the results of the case studies and the issue of genre change. The research reported here shows that despite changes in the main medium of distribution, increased availability of the work, adaptation of article logic to better accommodate the needs of the various audiences, and incorporation of additional media in the scholarly publishing process (such as sound files or social media buttons), the recurrent social action of the SRA has not changed. While we have what are arguably improvements to publishing scientific research and improvements to the technologies that we use to access the research being published, we are not seeing a complete change to the SRA genre, but rather what I have called adaptation, or notable incremental changes that still maintain the key social action of the genre. Authors are still composing articles to forward an argument from their research to be accepted within the community as knowledge.

These results are consistent with those of Mackenzie Owen (2007), who concluded from his study of emerging "e-journals" that the scientific research article "remained relatively unchanged in the age of digitization" (p. 225). His study examined emerging online-only subscription-based journals, looking at some of the same features analyzed here, including article file format, commenting features, multimedia, navigation, and editorial policies. Many of the journals he reviewed incorporated features similar to those analyzed in

this dissertation, and indeed the results were similar in some cases. For example, he concludes that while "in theory e-journals offer the possibility of a more active involvement of the reader [through commenting] . . . in practice we found relatively few examples… where interaction actually takes place" (p. 147). So, while over a decade has passed since Mackenzie Owen's research, the results of this study are similar in nature: change is not, in fact, upon us. The technology may be more advanced—Internet speeds may be faster, screen resolution may be better, file sharing may be easier— and the availability of the research may be increased, but the enactment of the genre remains the same. All in all, there is no doubt that the fundamental action of the scientific research article is still the same when published in open access: it reports original research for the scientific community.

Furthermore, the SRA genre still forwards these arguments for new knowledge in its highly stylized way. Scholars have previously shown how scientific language is stylized, such as Halloran and Bradford's (1984) discussion of metaphors in scientific writing, or Fahnestock's (2002) in depth study of several rhetorical figures in science. Style is an important feature of scientific writing, including the SRA. Gross et al. (2002) write that the ongoing consistency of the highly stylized nature of the SRA happens in part through a combination of social pressure to conform to these guidelines and to be accepted within the field, with peer review and editorial processes performing a crucial gatekeeper function. This means there is a lot of resistance from the scientific community to any potential changes to the genre. This is where we see the idea of genres that can be both regulated resources—the knowledge and skills that the discourse community readily recognizes and requires for

communication—and regularized resources—those that are not formally codified like regulated resources, but instead stem from practice within the community (Schryer & Spoel, 2005). The SRA genre is regulated in the way that it has codified expectations that are presented through the publisher and editors of a given journal. The editors and peer reviewers serve to see through many of these regulations, such as including a title, writing in the standard of the IMRAD (or IRDCM) logic, presenting evidence for claims, and citing previous research. As Schryer and Spoel found in the medical community they studied, the scientific research community has several meta-genres that help with the regulation of the SRA, such as instructions for authors and publisher's policies. If someone writing into the genre fails to adhere to expectations, his or her article can be rejected by the community—literally, in the case of the research article. The SRA genre is also regularized, however, in less explicit ways that emerge from practice and centuries of publishing research. An example of this is the high use of visuals; the journals in this study do not require the inclusion of visuals, but yet every article included multiple visuals. This phenomenon has arisen out of scientific practice, where a lot of data can be conveyed through carefully designed tables, figures, or diagrams, and then the body text of the article can focus on the key parts of each visual that convey the "narrative" of the results. A picture can in fact be worth a thousand words, and becomes an important method for communicating both a lot of information as well as the most critical information into a condensed space.

This combination of being regulated and regularized lead to the SRA genre also being highly stylized, and indeed, the open access SRA studied in this dissertation is also still

highly stylized. Articles are relatively uniform; they include generally impersonal writing; they feature arguments made through verbal and visual texts; and they have specific presentation features that aid in navigation and comprehension of materials. Not much has changed with respect to the stylizing since Gross et al. (2002) reported similar findings in their study. We can partially attribute this, perhaps, to our understanding of the standards for scientific knowledge: "assent of the relevant scientific community" (Kuhn, 1962, p. 94). Too much change, too quickly for the scientific community means that researchers may not fully support the changes to stylizing in addition to the changes to licensing, distribution, and other OA features described here.

The history of this genre and its social action are well documented in genre studies and the rhetoric of science, as established throughout this dissertation. But a significant gap in the research has been to consider the distribution model, a gap that becomes more apparent now with open access and the variety of accessibility models for published scientific research articles. Up until now, genre analysis of the SRA has only looked at print journals distributed through subscription, often offered as a part of membership in a researcher's disciplinary society. Thus, since this was the same across journals and sample texts, there was perhaps no reason to consider what the model of distribution demonstrated about the genre. But this is no longer the case, with the method of distribution for scientific research more complex than ever. Some journals publish both print and online versions; some do this with "online first" articles; very few, if any at all, publish only in print; increasing numbers publish only online, with these including both closed access and open access journals; and some closed-access

(whether only online or both online and in print) allow authors to purchase open access licensing for their articles. Indeed, the landscape of online publishing is complex. Rhetorical scholarship has begun to think of delivery anew (e.g. Brooke, 2009; McCorkle, 2012) in light of all of the digital technologies we now have for communicating. This type of exploration for genres in particular seems important given the ubiquity of the technologies and the great changes being attributed to them colloquially. But what do digital technologies as a medium of delivery really mean for a genre? Delivery, rhetorically, does not just mean the method of distribution (Brooke). Instead, it also has implications for our understanding of culture through the way that technologies are represented and the roles that they come to play in our culture (McCorkle). This is the kind of research that is newly relevant for genre studies and that will be important to take up in the near future.

This study supports these more complex views of delivery and medium by arguing that the technology has not, in fact, changed the SRA in some "revolutionary" way. Instead, what is happening is a more complex relationship between how the technologies afford certain elements of the culture of science to come through in ways that other media had not previously done. For example, sharing the results of one's work with other scientists has always been a key component of the culture of science. Sharing of course takes place through publication, but an important element of sharing goes beyond the act of publication. Scientists would share their work with their "invisible college" of colleagues (Crane, 1972) by photocopying and mailing or distributing the work at conferences. Now, sharing of articles (and other written forms of work) takes place over email, through posts on

Academia.edu or Twitter, and through other digitally-networked technologies. The purpose, however, remains the same—it is simply facilitated through newer forms of media. With these new and significantly different communication possibilities, we must view the concept of delivery as not only the medium used, but as a more complex picture of expanding networks and reaching new audiences.

In addition to the lack of research on distribution, previous research on the SRA genre also has not generally included an examination of the influence that publishers have on the genre and its enactment, but they also play an important role in seeing through the social action of the genre for the scientific community. As distribution models for journals become more complex, we must not overlook what the publishers are doing, for they play an important role in the ecosystem of the genre. In the case studies here of open access journals, we see the potential for the publisher to influence the genre. PLOS is at its heart an advocacy group, working to make the world's research accessible to all who may be interested. BMC, on the other hand, is a for-profit publisher, but is also engaged with the advocacy to a certain degree and at the very least aware of and responding to the open access movement through their offerings of open access journals. Knowing that genres are sites of ideological and social action (Schryer, 1994), we must not overlook the role of these organizations in the publishing of SRAs. The open access movement is an ideological movement about the availability, use, re-use, and distribution of scientific (and other) texts. Both of these publishers assist in forwarding the ideology of open access and to help make it more accepted in the scientific and scholarly communities in which their journals are situated.

However, what we do not see from these publishers is any dramatic changes to the SRA genre when enacted in open access. The publishers work hard to maintain the high standards for publishing scientific knowledge that are driven by the scientific community itself, such as through the peer review process. These standards come out of the practice of the scientific community, a community that is highly self-selective and yet whose members depend on the recognition of published articles for career success. These rigorous standards incorporate consensus on a smaller scale, through peer review, to test what may be acceptable on a larger scale for the community—all things that are key for the building of scientific knowledge. Thus, it is difficult for a publisher to introduce significant change to the publishing process (as evidenced by the current resistance to post-production peer review in lieu of the current pre-production peer review model) because the current standards are rooted in the values and practices of the scientific community. It is not surprising that the articles published in the journals studied here still look very much like the SRAs of other closed-access journals that are published online. What, then, is happening? It seems as though the ideology of open access is competing against a highly influential, highly established ideology: science. This idea will be explored in the following final section of the dissertation.

Understanding genre change

After reviewing the main findings of this study and answering my first research question on open access and the scientific research article genre, I now turn to the second: how do the results of this study help us understand the concept of genre change online, more

broadly? First, I offer a brief review of the genre change discussion from chapter one. I identified three key drivers of genre change: the needs of genre users, technology change, and major social or cultural shifts. I argued that these influences work together to produce genre change, and that genre change rarely, if ever, stems from a single source. Because of this, my genre analysis combined textual analysis of genre examples as well as a study of the broader genre ecosystem and queries to actual genre users. The ecosystem metaphor introduced in chapter one—and that is all that it is, a metaphor, and it has its limitations—helps us to think through the context of a genre and the factors that I have identified as possibly working toward genre change. Thinking about genres as inhabiting an "ecosystem" allows us to think about genres in their bigger picture, not just defining a genre in terms of just content, an audience, or the author. The ecosystem concept instead allows us to look at the interactions among all of the constituent parts of the genre that affect one another, recognizing in this case that the scientific research article genre functions within a system of other genres, such as peer review, letters to the editor, article summaries, and so on, as well as functions within the technological affordances and constraints of the media used and the people engaged with the work. It also incorporates ideas from the greater community in which the genre is situated. In this particular case, the concept of ecosystem leads us from the key genre and the genre system in which it is situated to the broader community of sciences and its ideology, which I explore below.

I began this study with the hypothesis that genre change is indeed what is happening to the scholarly research article. That was not a far-reaching hypothesis to make: it is difficult to

find a news report in 2013 that does not talk about the internet, social media, or smart phones as having a "revolutionary impact" on communication to "change the way we communicate forever." The hyperboles abound. There have even been statements that say with new technology must come rapid change to the communication and dissemination of science (Kantardjieff & Ng, 2012). For dissemination, we can say this change is at least partially true: we now Tweet journal articles when they are published or "pin" them, saving them to read for later. But claims about revolutionary genre change thus far have shown to be more overgeneralization than fact. Genre change does not just stem from new or significantly more powerful technologies, as we can see here with the case of open access SRAs. Mackenzie Owen (2007) concludes that while new technology, particularly the internet, has influenced the "*distribution channel* of scientific information" it has changed "relatively little for the genre of the article itself," as scientists still seek out articles from the journals themselves (p. 224, emphasis in original). Scientists still turn to journals for articles because of this change-resistant culture of science, where journals serve an important role of gatekeeper in the mission to build scientific knowledge. My own study here supports the position of Mackenzie Owen that despite rapid changes in the technology available for preparing, publishing, and disseminating scientific research articles, the SRA genre itself has not undergone significant genre change, for the primary social action of the genre is consistent with the genre historically. Scientists still write their articles seeking validation and uptake from the rest of the community to see their work as knowledge for the field. Thus, there is

not a major cultural shift (one of my three elements of genre change) in science surrounding the genre.

The genre ecosystem was a fruitful component of my analysis here, and while supporting my claim for a lack of clear genre change for the SRA, the ecosystem does show interesting adaptations and considerations for the SRA genre and for scientific publishing in general moving forward. Much of this stems from the increased use of digital tools by journals, editors, and authors themselves. Importantly, OA SRAs and other written genres in these OA journals have multiple intended audiences and increase the potential visibility of the scientific research being conducted. While historically prevalent genres, such as the research letter, are fading from use, other written genres emerge, responding to new exigencies prompted by a wider, more global audience with varying levels of scientific expertise. The synopsis in *PLOS Biology* is a good example of this, where editors make choices about potentially critical research findings and hire professional science writers to adapt the information for a more general audience. These synopses then help to bridge the gap between the scientific research community and its lesser viewed journals to a broader community of publics and highly viewed media and journalism sites, including *The New York Times* and *Huffington Post*. Furthermore, the inclusion of newer social media tools and other sharing capabilities into the ecosystem represent a change in the sharing and networking that scientists could do with their research. One could argue that sharing an article on Twitter is a digital version of photocopying a print of an article for a colleague, with a larger potential for sharing the work online as the world's millions of Twitter users

could have access to the Tweet and article link. Thus, it is clear that the way we share SRAs through the genre's ecosystem is more powerful than previous sharing capabilities (when defining powerful as the ability to reach more people and in a relatively short amount of time), adding a significant number of people to the potential audience for the work. Notably, this audience is also more diverse: as mentioned earlier, people now "listening in" to scientists on Twitter include a range of science writers and journalists, citizen scientists, and interested laypeople, among others.

However, while the ecosystem has clearly changed from early scientific print journals, this study shows that despite drastic changes in the distribution method and accessibility of scientific research articles, what I have seen through this study is that the genre of the SRA does not necessarily change in the midst of it. I am, of course, only looking at a small slice of time in the history of the SRA, so it is important to acknowledge that significant change may occur once the OA SRA is published for a couple more decades. Ultimately, my conclusions about genre change and variation for this quintessential academic genre center around the ideas of the culture of science, the ideology of open access, and the complexity of genre change. The introductory chapter acknowledged the importance of culture on genre, and specifically in the case here of the SRA and the highly influential culture of science as previously described by philosophers of science Kuhn (1962) and Merton (1942). From the results of this study, and my conclusions about the lack of "revolutionary" genre change, we see how the institutional values of science shape the genre of the scientific research article (e.g. Myers, 1990). Merton's four norms of science, universalism, communalism,

disinterestedness, and organized skepticism, are also highly relevant to the discussion of genre change here. In the late twentieth and early twenty-first centuries, the notion of communalism in science has been challenged by those arguing that increased competition for resources (such as grants) and the influence of for-profit industries such as drug manufacturing demonstrate that science is "particularized" and does not often meet the communalism ideal (Macfarlane & Cheng, 2008). With the communalism of science being challenged, we might say that while it is an ideal of science, it might not always be practiced. But, if you believe Merton, it is still that: an ideal of science. Communication is implicit in this norm, as knowledge cannot truly be communal if it is not effectively communicated to the members of the community.

Open access (and other elements of the open movement, like open labs and notebooks) revisits this notion and may help science return to this norm that Merton wrote about so long ago. Recalling the discussion in chapter one, open access is about the ideology of "open": making the world's knowledge available to everyone with an internet connection, including scientists who might work in countries with fewer resources, and allow them to use and re-use freely to continue building upon that knowledge. Furthermore, the open access movement has had much of its initial success and uptake in the sciences: it is readily acknowledged that the sciences have taken up open access on a larger scale more quickly than the social sciences or humanities. The sciences were also the first disciplines to go online (Hafner & Lyon, 1992). These two actions are not by accident; the ideas behind these two phenomena are built into the norms of the scientific community, specifically that of

communalism. Sharing research with the world through open access, and sharing research quickly with their "invisible colleges" (Crane, 1972) and other scientists by using an Internet connection are exactly the notions of communalism that Merton exalted science for.

Thus, we have a profession that inherently values being open, but we see that other characteristics of the community also make it resistant to radical changes to scientists' communicative habits. If open access is compatible with science, how is it that I have previously described them as competing when it comes to genre change and the scientific research article? To borrow from Garvey (1979), communication *is* the essence of science. It is not only how scientists share their work, but more critically, it also how they evaluate one another's work, launch successful careers, receive recognition, and maintain status within the scientific community. In the case of the SRA, writing articles is a way to construct knowledge claims for the community (MacDonald, 1994). Any changes to this genre constitute a significant change to the way that science is practiced—not something that happens easily. Bazerman's (1988) work shows that the development of this genre and along with it, the practices of science, happened over the course of three centuries.

Merton's other norms are influential for the SRA as well. OA has been subject to scrutiny for its enforcement of peer review (eg. Bohannan, 2013), with some journals in other fields trying to experiment with the tried and true method of peer review in order to develop alternative models that help to disseminate research results more quickly. This often called "open peer review," where work is published in a preliminary form and any members of the journal can post comments—offering peer review—of the article in an open, online format.

The work is then revised and officially published by the journal. However, this model has not been very successful, with few journals taking it up. The journals in this study subscribe to the traditional model of peer review, as do many of the most highly regarded open access journals in the sciences. In this way, the norm of organized skepticism is apparent: while experimenting with a new distribution model, the two journals studied here have stayed very close to the accepted format of peer review to maintain the principle of "detached scrutiny of beliefs" (Merton, 1942, p. 126). Peer review is an important genre convention that has not changed with open access—and perhaps more importantly, it is the peer review process that partially helps to maintain continuity with other genre conventions. Peer reviewers have expectations for the genre that they carry over from non-OA SRAs. Authors must often make revisions as recommended by the peer reviewers, thus perpetuating the expectations for the genre that carry over from non-OA sources. Peer review is a key source of continuity for the culture of science and particularly for its influence on the SRA publishing process.

Overall, from the results of the study, we can perhaps conclude that what is happening here with open access SRAs is the result of new technologies making it possible to enact scientific norms in a new way, but it is not fundamentally changing the social action of this highly important genre for the community. For example, the authors who responded to the questionnaire inherently understood the value and importance of sharing their research with the broadest possible audience, which includes those outside of the scientific community. For the first time, they have a relatively feasible publishing system for doing so, thanks to open access journals and publishers. However, because communication through this genre is at the

heart of scientific activity, the primary social action being accomplished through the genre remains, for any significant changes to this has important implications for the larger scientific community. Science itself is a powerful ideology, open access is also a burgeoning and influential ideology, and the ideas contained within each make understanding any potential change for the quintessential genre of science quite complex. While open access has seen much momentum in the last several years, the culture of science thus far has been more influential on its key genre, resisting claims of "revolutionary" change and ensuring recognizability of the SRA as we know it.

Study limitations and avenues for future research

As the first rhetorical genre study of open access, this research has several limitations. The first is a limitation that several studies of the SRA have faced: the reach of this research covers only one area of science, biology. Because journals tend to specialize in a particular field, a case study of only a few journals is necessarily limited by the fields covered by those journals. Additionally, this study was limited to journals publishing in the English language. While English often called the international language of science (Garfield, 1979), there are of course still journals that publish in other languages and in open access. Therefore, it would be useful for future studies to consider a broader range of disciplines and languages, building on the model of analysis developed here.

Furthermore, even within the study of open access SRAs in the field of biology, there are elements that were not feasible to include in a study of this size. The two journals

selected are successful examples, but there is a broad range of open access journals in the field that may have their own approach and requirements for publishing. Additionally, "ecosystem" is a large concept, and inevitably, there are elements of the SRA ecosystem that could not be included in this study, including gathering information from other key figures in the publishing process, such as peer reviewers who agree to serve the journals studied and the readers (both scientific and non-scientific) of these articles. This information would provide insight into more of the process, including how these key players in science view the exigence of the SRA in open access.

There are many avenues for future research on this topic. While my own research focused on online-only, open access SRAs, building on previous research of closed-access, print-based SRAs, there is a major gap in the timeline of the SRA that needs to be filled: a study of closed-access, online SRAs. Mackenzie Owen (2007) covered some of this research, though not from a rhetorical genre perspective, and he focused on emerging online-only journals. The majority of journals being published are still closed-access online journals, many of which made the transition from print only to online (perhaps still sending print copies to subscribers). What happened to the research article in journals when they transitioned from print, with limited affordances, to online, with many more? Did authors change their approach to writing, with the possibility for unlimited additional visuals, or even simply color versions? This is an important gap to fill in on the timeline of the history of the SRA.

Finally, as open access becomes more accepted within the broader scholarly research community, it will be important to revisit the question of genre change in academic research genres. Research articles look different across the disciplines (see *Kairos* in the field of rhetoric and composition, for example), and thus the influence of open access on the genre may differ across research specializations. Additionally, if it is increasingly acceptable to see the research published by scientists and other scholars as information that should be readily open to and available for general/non-specialist, interested publics (in addition to the scholarly communities it is already available to), the question then arises whether technological access to the research is enough, or if we need to now take up issues of writing and conceptual accessibility. In their current form, many SRAs are not necessarily accessible to those outside of a particular scientific field, and certainly not for many non-scientists who may be interested in the work. Making scientific knowledge open is a major goal of the open access movement, but the movement fails to acknowledge the fact that scientific knowledge is *writing*, writing that can be made more open to more people through revisioning what scientific writing looks like in scientific journals. Some journals have begun to take this up, as the PLOS publications have, through "primer" or "synopsis" genres that are paired with articles deemed to be significant. But what about the remaining research? This is an issue that Ashley R. Kelly and I (2013) have started to take up and will continue to pursue in the future, as we feel strongly that having an Internet connection does not actually make scholarly research "open" to all those who may be interested in or benefit from it. To us, the true meaning of "open" goes beyond the technological to the conceptual, and this exploration and

advocacy fits well into rhetorical genre scholarship. All in all, the question of open access and any potential influence on our reporting of academic research—especially given the possibilities for making knowledge available on a global scale—make future research on genres and open access one that is important for the academy *and* public audiences.

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APPENDICES

Appendix A: Questionnaire for Authors

1. Name:

2. Field of research:

3. Country where you are primarily located:

4. What factors contributed to your decision to publish your article in [*PLOS Biology or BMC Biology*]? Select all that apply.
    1. I am an open access advocate
    2. Some or all of my coauthors wanted to publish in this journal
    3. Some or all of my coauthors wanted to publish in open access
    4. My funding agency for this research mandates open access publishing
    5. The journal's reputation
    6. I or one of my coauthors is a member of the organization that publishes this journal
    7. The focus of the journal was the right fit for my research
    8. I have published in this journal before
    9. Some or all of my coauthors have published in this journal before
    10. Other: _____ [Please specify.]

5. Of the options you selected above, which do you feel was the most important factor contributing to your decision to publish your article in [*PLOS Biology or BMC Biology*]?
    1. I am an open access advocate
    2. Some or all of my coauthors wanted to publish in this journal
    3. Some or all of my coauthors wanted to publish in open access
    4. My funding agency for this research mandates open access publishing
    5. The journal's reputation
    6. I or one of my coauthors is a member of the organization that publishes this journal
    7. The focus of the journal was the right fit for my research
    8. I have published in this journal before
    9. Some or all of my coauthors have published in this journal before
    10. Other: _____ [Please specify.]

6. Are you aware of the article usage statistics available for your published article in [*PLOS Biology or BMC Biology*]?
    1. Yes
    2. No

7. If you answered yes to the previous question, have you ever looked at your article usage statistics?
    1. Yes

2. No

8. If you answered yes to the previous question, have you ever used the statistics for the following (check all that apply):
    1. Tenure or promotion case
    2. Funding applications
    3. Self-promotion (job application; biographical statement, etc.)
    4. Promotion of related work
    5. Tracking reader interest in the topic of the article
    6. Other: _____ [Please specify]
    7. I've never used the statistics other than to see what they are

9. In your opinion, what are the most significant differences (if any) between print-based research articles (ie. those you may have received in the mail in a paper-bound journal issue) and the online-only articles published in [*PLOS Biology or BMC Biology*]?

10. In your opinion, what are the most significant differences (if any) between closed-access online research articles and the open access articles published in [*PLOS Biology or BMC Biology*]?

11. Which of the following statements best describes your personal publishing practices for original scholarly research?
    1. I only publish in open access scholarly journals
    2. I primarily publish in open access journals, but occasionally publish in closed access journals
    3. I publish approximately the same number of articles in open access journals as closed access journals
    4. I primarily publish in closed access journals, but occasionally publish in open access journals
    5. I primarily publish in closed access journals, but make pre- or post-prints available on a repository or my own personal website
    6. Other: _____ [Please specify]

12. Please explain your answer to question 11.

13. Which of the following best describes how you make decisions about publishing in closed access or open access?
    1. I publish only in open access and choose the journal that best fits my research accordingly
    2. I choose the journal that best fits my research regardless of whether it is closed access or open access
    3. I publish in open access because my funding agency requires open publishing

4. I publish primarily in closed access because those are most highly valued by my department/university for tenure and promotion
5. My coauthor(s) primarily choose the journal we submit to
6. Other: _____ [Please specify]

14. Please explain your answer to question 13.

15. In what ways do you see this journal addressing the needs of researchers in the 21st century?

16. In your opinion, how has open access publishing changed the dissemination and use of research in biology?

17. Has publishing in open access had any influence on the way in which you write your original research articles? If yes, please explain how. If no, please explain why not.

Thank you for your time and for participating in my dissertation research.

Appendix B: Questionnaire for Editors

1. Name:

2. Field of research:

3. Country where you are primarily located:

4. What factors influenced your decision to serve as editor for [*PLOS Biology or BMC Biology*]? Select all that apply.
    1. I am an open access advocate
    2. The journal's reputation
    3. I have published in this journal before
    4. I am a member of the organization that publishes this journal
    5. I was elected Editor
    6. I have otherwise served the journal as a reviewer or in another role previously
    7. Other: _____ [Please specify.]

5. What role do you see this journal serving for the general research community of biology?

6. What do you think makes this journal distinct from others in the field of biology?

7. What do you think makes this journal distinct from closed-access journals in the field of biology?

8. In what ways do you see this journal addressing the needs of researchers in the 21st century?

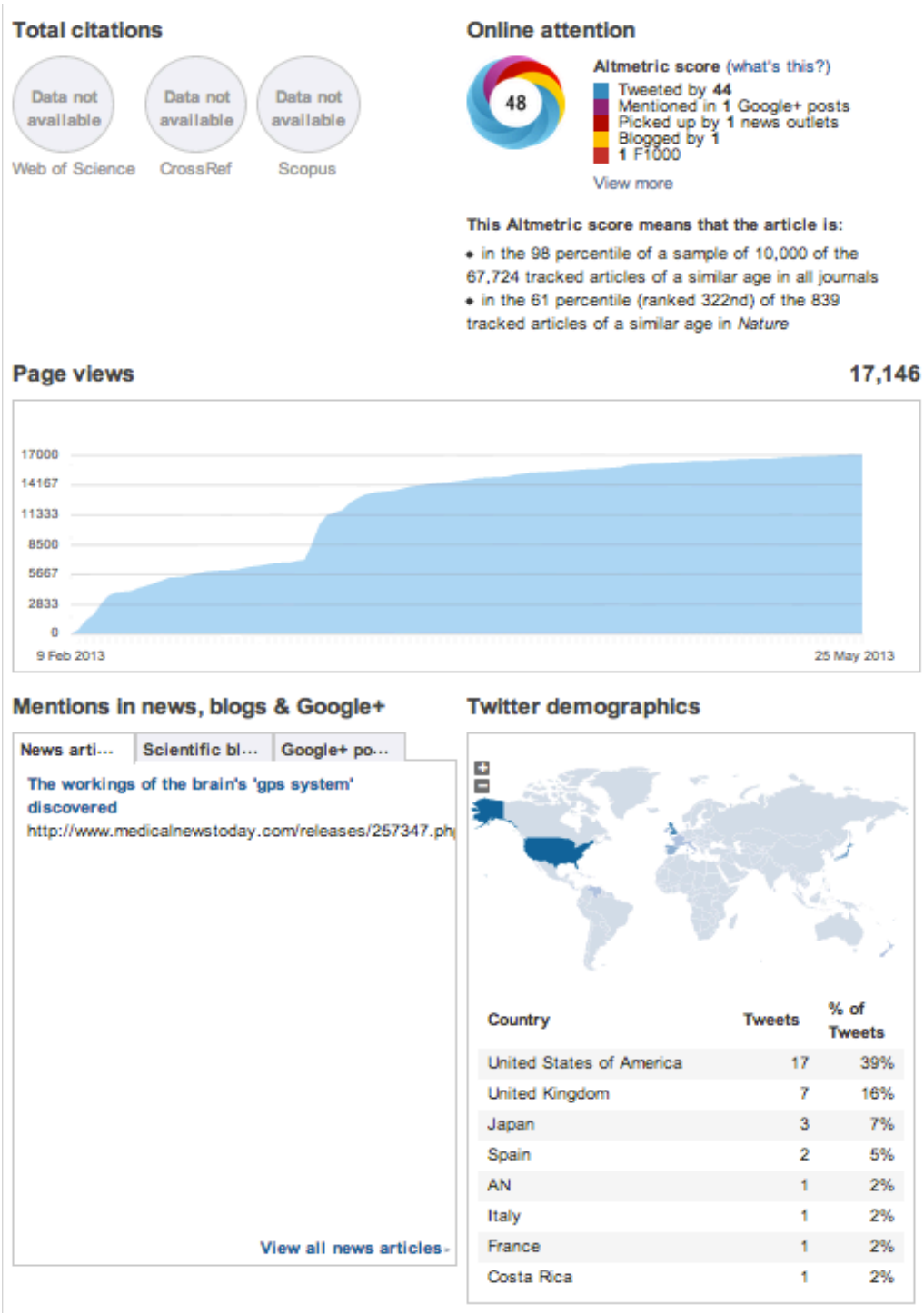
9. In your opinion, what are the most significant differences between print-based journal articles (ie. those you may have previously received via mail in paper-bound journal issues) and the kinds of articles you accept and publish now in this open access, online-only journal?

10. In your opinion, how has open access publishing changed the dissemination and use of research in biology?

11. What do you see as the biggest challenge for open access journals in the sciences and their editors moving forward?

Thank you for your time and for participating in my dissertation research.

Appendix C: *Nature*'s Use of Altmetrics



A sample Article Metrics graphic for a *Nature* scientific research article published March 14, 2013.