

## Networking Social Scholarship...Again

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### Article abstract

This paper proposes to answer several questions that arise from the actions of American scientists between 1840 and 1890. How did the broader organization of science in the late nineteenth century create a system of professional disciplines? Why did the American Association for the Advancement of Science (AAAS) form, and why did specialized societies like the American Chemical Society (ACS) later found an organization separate from the AAAS? Why did these professional societies create journals, and how did these journals help to communicate science? This paper combines both quantitative textual analysis and qualitative historical and sociological methods within the context of nineteenth-century American science. It is hoped that by broadening the methods used, and by better understanding the early deliberations of scientists before there was a formal scholarly communication system, it may be possible to contextualize current debates about the need for changes in the scholarly communication system.

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## RESEARCH ARTICLE

## Networking Social Scholarship...Again

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This paper proposes to answer several questions that arise from the actions of American scientists between 1840 and 1890. How did the broader organization of science in the late nineteenth century create a system of professional disciplines? Why did the American Association for the Advancement of Science (AAAS) form, and why did specialized societies like the American Chemical Society (ACS) later found an organization separate from the AAAS? Why did these professional societies create journals, and how did these journals help to communicate science? This paper combines both quantitative textual analysis and qualitative historical and sociological methods within the context of nineteenth-century American science. It is hoped that by broadening the methods used, and by better understanding the early deliberations of scientists before there was a formal scholarly communication system, it may be possible to contextualize current debates about the need for changes in the scholarly communication system.

**Keywords:** Scholarly communication; publishing; history of science

## Introduction

In the digital age, technological change and evolving scholarly practices have transformed the ways in which university faculty communicate their work. In the twenty-first century, the scholarly communication system is a complex social mechanism encompassing publishers, peer-reviewers, tenure committees, and many other actors. According to Christine Borgman (2000), the most essential element of the scholarly communication, or academic publishing, system is the journal article, which has remained 'remarkably stable and print publication continues unabated, despite the proliferation of digital media' (413). Journals have a long history dating perhaps as far back as the *Philosophical Transactions of the Royal Society* in 1665. The first American scientific journal, however, has a much shorter history. One could possibly date American scientific journals back as far as 1745 with the *Transactions of the American Philosophical Society*, a journal dedicated to all knowledge and founded by Benjamin Franklin in Philadelphia. Over time, however, Franklin's journal became rather localized and competed with other local scientific journals in cities such as New York and Boston. It was not until 70 years later, with the *American Journal of Science*, founded by Benjamin Silliman of Yale University in 1819, that the United States had a journal that was both consistently published and dedicated only to science. Simon Baatz (1991) argues that the *American Journal of Science* was the primary journal for science for most of the nineteenth century and brought together divergent metropolitan groups in cities like New York, Philadelphia, and Boston in ways that more localized journals, such as the *Transactions of the American Philosophical Society*, did not.

There was, however, another important element to the networking of scholarship beyond the journal in late nineteenth-century America: the professional association. Alexander Dallas Bache, one of the early founders of the American Association for the Advancement of Science (AAAS) and a collaborator with Benjamin Silliman, stated in the *Proceedings of the American Association for the Advancement of Science* that, 'While Science is without organization, it is without power: powerless against its enemies, open or secret; powerless in the hands of false or injudicious friends' (1852, lii–liii). Bache's statement was a call for scientists to begin to organize, and, partially because of Bache's efforts, scientists began to do just that over the course of the late nineteenth and early twentieth centuries; what they built transformed into a system of scholarly societies, universities, and other knowledge organizations. Therefore, by looking not only at journals and the

ways that they form in nineteenth-century America, but also at the formation of professional associations and the ways that such associations affected journals, one can begin to understand the complex network of scholarly communication, and perhaps think about ways that the current professional network may need to develop. For this paper, a multi-method approach is utilized to investigate the formation of scholarly communication in the United States circa 1840 to 1900, including both qualitative sociological-historical and quantitative computational-statistical approaches to exploring the topic, with the intent of better understanding how professional organizations and academic journals interact with each other.

To explore the evolution of journals during this period, topic modeling and other computational and statistical methods are used on scientific journals of the period, including the *American Journal of Science* and the *Journal of the American Chemical Society*, to see how some of the more prominent American scientific journals of the mid to late nineteenth century reflected the power dynamics within the nascent organization of science in the nineteenth-century United States. Overall, the goal of this paper is to demonstrate that combining quantitative topic modeling and qualitative historical analysis methods can provide a more nuanced understanding of the origins of the scholarly communication system. Combining these methods provides a unique approach that demonstrates how traditional historical methods and computational techniques can work together to inform understanding of complex social systems. The sub-discipline of scholarly communication within information science largely relies on quantitative analysis of citation patterns and relies on the sociological theories of scholars such as Robert Merton. This paper draws on a broader array of historical and sociological study and expands the conversation about how social forces shape journals at a time when scholarly communication in the United States was first beginning.

In the twenty-first century, the scholarly communication system comprises a complex community mechanism encompassing university faculty, scholarly societies, publishers, peer-reviewers, tenure committees, librarians, funding agencies, and many other actors. Advocates hoping to change the scholarly communication system and make knowledge more available must also understand how the journal article became so important and recognize the scientific power structures governing the production of journal articles. The nineteenth-century power structures which originated the current scholarly communication system had very different goals and a very different conception of how research should be shared. The current barriers to creating a more equitable system of scholarly communication have their origins in a nineteenth-century, industrially-oriented publishing organization. Repositioning the power of scholarly communication toward a more truly open-access system will require a more thorough understanding of its historical development and potential ways to overcome one hundred years of previous practice.

## **Literature Review**

Much of the earlier work on scholarly communication, including that of Borgman, focuses on the structure of scholarship as measured by scientometric analysis. Current scholarly communication research is largely based on the ideas of Robert Merton (1968), who concentrated on the values of twentieth-century science and on achieving status within scientific professions. Some scholars, such as Scott Frickel and Neil Gross (2005), have, however, criticized Merton's suppositions, saying, 'we find it difficult to believe that the quest for prestige and status is the sole motive shaping intellectual innovation' (211). In other words, Frickel and Gross argue that there may be other factors beyond prestige that influence the development of scientific and intellectual movements. In light of this criticism, it is important to ask whether there may be other frameworks that can help to understand the process of scholarly communication.

One way to address the criticism of Frickel and Gross—that could also supplement Merton's arguments about prestige and status—is to address the broader historical and sociological literature on professionalization and journals. Andrew Abbott (2005) discusses how professions are created when organizations, such as universities and scientific societies, operationalize workflows in order to meet common goals. According to Abbott, such operationalization processes create 'linked ecologies' that in turn form a 'hinge mechanism' that provides a way for both universities and professional societies to effectively interact with each other (2005, 255). For scholarly communication, one could argue that one of the hinge-mechanisms that has developed over time is the academic journal.

The question is how to investigate how social changes are reflected in journals over the period of 1840–1890, when scientific associations were first forming. Topic modeling and textual analysis methods are possible ways to investigate a large corpus of journals. Emily Marshall (2013) has utilized textual analysis methods, such as text mining and topic modeling, on research articles in twentieth-century British and French scientific journals to identify linguistic contexts of articles in relation to social institutions, such as government agencies and non-profit organizations. Though this paper is focused on American rather than

European academic journals, and on an earlier time period, Marshall's techniques for using topic modeling as a method for understanding disciplinary forms of writing will be particularly helpful in better determining and defining the genres of disciplinary writing within nineteenth-century American scientific documents.

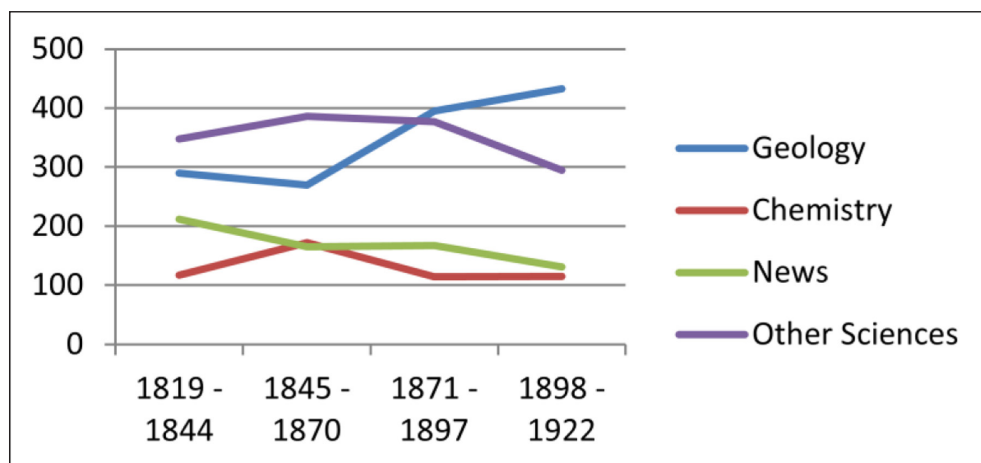
## Scholarly Journals

Since Borgman (2000) has identified journals as the primary method for social scholarship, looking at the *American Journal of Science*, one of the earliest and most consistently published scientific journals in the United States, can perhaps serve as a starting point. There are many ways one could attempt to understand the topics of conversation within the journals, but some preliminary textual analysis of the *American Journal of Science* using topic modelling from Mallet can serve as a preliminary basis for better interpreting the topics of research within early American journals. The topic models also illustrate some interesting trends.

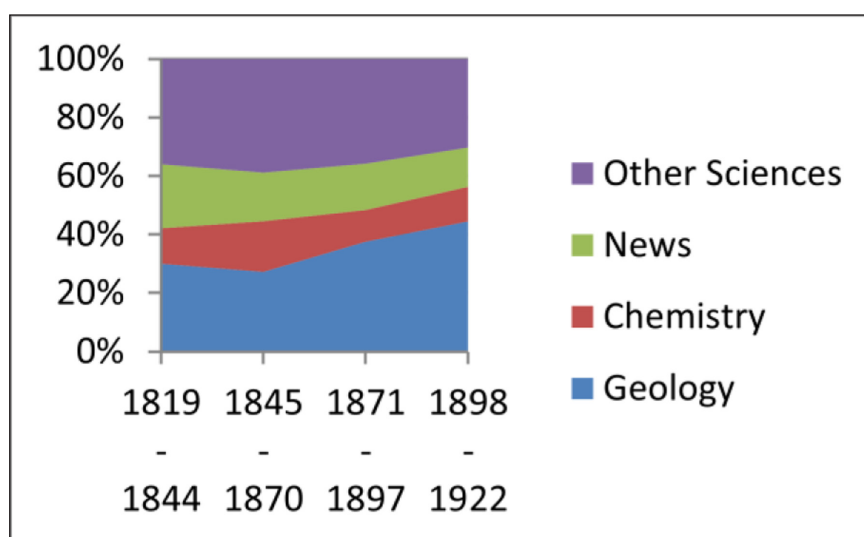
**Figure 1** (below) is a simple line graph showing the number of topics within categories of topical discussion. The graph shows that geology topics increase over time, whereas other topics generally decrease and, until about 1871, 'other sciences' include significantly more topics than geology. In 1871 'other sciences' topics decline precipitously, geological topics increase, and geology as a topic overtakes 'other sciences.' Since the *American Journal of Science* is currently a journal dedicated to geology, one would expect to see this trend. It is interesting to note, however, that this shift happens in the period from 1871 to 1897. The 1890s are a period when many other scientific professional societies are created, along with related scholarly journals. For instance, the *Journal of the American Chemical Society* was founded in 1879 and the *American Physical Review* (journal for the American Physical Society, the professional association for physicists) began in 1893. The trend line for chemistry topics also shows a decline during this period. The trends illustrated in **Figure 1** may be evidence of scientists leaving the more generalized *American Journal of Science* for more specialized journals when they are created. The decline of 'other sciences' does seem to happen during the same time period as the creation of journals in other, more specialized scientific disciplines.

**Figure 2** (above) shows much the same data as **Figure 1**; however, it represents the topics from this textual analysis as a percentage of the whole, rather than as raw numbers of topics in **Figure 1**, providing some nuance to the overall picture. Geology topics represent less than 30% of the entire number of topics in 1819, and that number gradually increases to nearly 40% in 1922. 'Other sciences' represent a high of nearly 49% in 1845 but decrease to a low of 30% in 1922. Thus, one can see that 'other sciences' are still an important component even as late as 1922. This could complicate the story about scientists departing to other journals. It is also possible that many scientists, despite the appearance of alternative journals, were still choosing to publish in the *American Journal of Science*.

This topic modeling begins to demonstrate that many of the power dynamics that can be seen within the larger social context of nineteenth-century American science were reflected in the prominent scientific journals of the time. By doing some textual analysis of topics in both the *American Journal of Science* and the *Journal of the American Chemical Society*, one can see some of the trends in what the leaders of both the AAAS and the ACS were discussing. Principally, through the topic models it is possible to see how the *American Journal of Science* evolves into a journal less focused on all sciences generally and into a journal dedicated to geology, with topics in 'other sciences' declining over time. One can also see that the *Journal of*



**Figure 1:** Trends in number of topics in the *American Journal of Science* 1819–1922.



**Figure 2:** Topics represented as a percentage of the whole in the *American Journal of Science* 1819–1922.

the *American Chemical Society* begins to discuss professional issues much more in the 1890s, which is when the organization was attempting to turn itself into a separate national entity distinct from the American Association for the Advancement of Science.

### ***American Journal of Science***

Benjamin Silliman (1818), in his very first preface to the *American Journal of Science*, stated that the journal 'will be a leading object to illustrate American Natural History, and especially our Mineralogy and Geology. The applications of these sciences are obviously as numerous as physical arts and physical wants; for not one of these arts or wants can be named which is not connected with them' (v). Silliman's goal appears to have been realized. When one looks at the number of topics about individual disciplines—that is, how many topics from the topic model are related to disciplines such as geology or chemistry—topics discussing geology are the most dominant topic over time, representing roughly 35% of topics between 1819 and 1922. Interestingly, however, the 'other sciences' are represented equally at 35%. Yet, none of the subtopics within 'other sciences' dominates. Astronomy, botany, engineering, medicine, meteorology, physics, and zoology each, individually, represent less than 10% of whole. In any given year, none of these topics represent more than 13% (with the exception of 1840, when physics represents 17.5% of all topics). Chemistry is one major exception. As a discipline, chemistry represents 13% of the total topics when averaged over this one hundred-year period, and, in individual years within this timeframe, it often represents 20%-25% of topics.

Simon Baatz (1991) has argued that news in the field was another important topic throughout this period; topic models also support this view. Topics related to news represent 17% of total topics when averaged over the period, and often represent 20% of topics for individual years. Every issue had a section called *Intelligence* that was dedicated to news from the field. Additionally, individual articles, particularly in the earlier years of the journal, would be dedicated to translating and commenting upon articles published abroad, and letters to the editor would discuss scientific endeavors both in the US and abroad. This distant reading of the actual articles within the *American Journal of Science* provides additional evidence to support the arguments that Baatz and others have made about the importance of the *American Journal of Science* as a source for news in the history of scientific communication within the US.

### ***Journal of the American Chemical Society***

Similarly, it is possible to see how scholarly communication trends changed within the American Chemical Society. Rather than examining the types of topics being discussed in chemistry, however, it is more relevant to examine how chemists in the *Journal of the American Chemical Society* were discussing topics of professionalization. Using Browne and Weeks' *History of the American Chemical Society* (1952), specifically their discussion of chemical topics discussed in the journal (discussed here as 'expected' topics), and comparing expected topics to the 'unexpected' topics that Browne and Weeks do not discuss, some interesting patterns emerge. The initial comparison between unexpected and expected topics shows that unexpected topics consistently made up a small number of topics in any given year (less than 20% of all



topics). Nonetheless, unexpected topics doubled during the tenure of one particular editor in the years 1890–1892, from 10% to 20% of topics, and that increase stayed consistent until the end of the dataset in 1922. This raises the question of whether this seemingly significant change in unexpected topics is suggesting an important variation in the content of the journal or whether it is simply an artifact of the LDA topic modeling.

To determine whether the change in topics during this period was indeed significant, a smaller dataset of keywords found in these topics was constructed to see if there was a significant difference in the word frequencies before 1890 and after 1892. To control for the vast increase in the size of the journal (especially at end of the dataset) the word frequencies were created for eleven-year periods pre-increase (1879–1890) and post-increase. (1891–1902). A dependent sample t-test showed that the mean word frequency pre-1892 was 501.9 with a standard deviation of 592.1, and the mean post-1892 was 1584.5 with a standard deviation of 1622.5. The t-critical value (73) for this test was 1.6 and the t-calculated was 7.6 with an effect size of 0.89. Therefore, the frequency of topic keywords is not simply an artifact of topic modeling; rather, there is a statistically significant difference in word frequency between the pre-increase and post-increase groups.

## Professional Associations

The question remains, however, of why these journals show these kinds of topic trends. The answer, in part, is that the *American Journal of Science* is reflecting trends within the overall professionalization of science in the United States during the nineteenth century. There was one particularly important issue within science at the time, originally discussed by Alexander Dallas Bache: power. By 1840 competition for power and the desire to ensure scientific credibility had become much-contested issues between the American Association for the Advancement of Science and other scientific groups that formed during the late nineteenth century. For the AAAS, the struggle was between several rival groups, all of which could lay claim to scientific knowledge. One of the most powerful of those groups was the nascent American Chemical Society. The question was whether power should remain centralized in an already existing group or whether it should shift to another set of individuals tied to the new professional society of the ACS. These competing groups were often comprised of individuals who belonged to multiple groups and who had very complicated opinions on what the future of science or chemistry should be. Nonetheless, these political divisions seem to replicate many of the characteristics of early American scientific professionalization.

In part, the debate between the AAAS and the ACS was part of an already long history. The American Philosophical Society in Philadelphia—an organization with a scope broader than science alone, but still interested in scientific development—had existed since the 1740s, and, not to be outdone, Boston had a rival group to the American Philosophical Society, founded somewhat later: the American Academy of Arts and Sciences. In addition to these broader organizations, John Collins Warren of Boston attempted to establish the American Institution for the Cultivation of Science and John Poinsett tried to form the National Institute for the Promotion of Science around the same time. Warren (1859) believed that his society failed because ‘a jealousy was awakened lest the proposed association should interfere with the Philosophical Society’ (2). There was another reason. On August 9, 1838, Joseph Henry wrote to Alexander Dallas Bache on returning from the British Association for the Advancement of Science, complementing the control that aristocrats had over the proceedings because ‘otherwise *third* and *fourth* rate men would soon control the affair and render the whole abortive and ridiculous’ (italics are Henry’s). In this letter Henry also commented on the moves to create an association in the United States, stating, ‘a promiscuous assembly of those who call themselves men of science in this country would only end in our disgrace.’ Thus it seems, for Henry at least, the issue was not so much about creating an association for science but rather who controls the association.

The other failed attempt at a national association, the National Institute for the Promotion of Science, of which Bache was a corresponding member, was largely sponsored by the government and had little participation from non-government scientists. Therefore, those practitioners who were not a part of this group felt particularly left out and unwilling to lend their support. The Association of American Geologists and Naturalists (AAGN) was an organization that did, however, have a broad base of scientists. With nearly every state having a geological survey and many prominent scientists throughout the country involved with those surveys, the AAGN had many potential members. Additionally, members of the AAGN, such as Benjamin Silliman, Alexander Dallas Bache, and Joseph Henry, saw an opportunity to use the influence of Louis Agassiz, a well-known Swiss naturalist soon to be professor at Harvard. Along with Henry Rogers and Benjamin Pierce, Agassiz wrote the new constitution for the AAAS, and in 1847, at the AAGN meeting, it was Agassiz who gave a speech reported in the *Edinburgh New Philosophical Journal* (1848, n.p.) saying that ‘the men of science in this country have no cause to fear their European brethren. They have made more progress

in the same departments than the scientific men of Europe.' Agassiz then went on to give an account of national associations in Europe and 'it was then voted that the Association should be designated as the "American Association for the Promotion of Science"' (151).

One of the most noticeable features of the formation of both the AAAS and the ACS was the small number of people who engaged in the creation of the organization. In the case of the AAAS, the most central figure was Alexander Dallas Bache, the leader of a group he called the '*Lazzaroni*' (an Italian word referring to beggars' hospitals); in the case of the ACS, there was also a small number of people who facilitated the ultimate creation of a separate society, many of whom were also affiliated with the *Lazzaroni* in some way. Therefore, the professionalization of science in the United States was begun by a rather small and relatively elite group of people who, in some cases, had quite specific agendas. Alexander Dallas Bache (1806–1867) was a member of a very prominent Philadelphia family and had connections to political figures. Bache's great-grandfather was Benjamin Franklin; his grandfather was Alexander Dallas, Secretary of the Treasury, and his uncle George Dallas was Vice President of the United States. Bache was the director of the United States Coast Survey and also a professor of natural philosophy at the University of Pennsylvania. Bache's connections and influence within the scientific community were substantial. One of Bache's students, a member of the *Lazzaroni*, was John Fries Frazer, later Provost at the University of Pennsylvania. John Fries Frazer's son, Persifor, was also one of the influential figures in the foundation of the ACS. Bache also had frequent contact with Benjamin Silliman, the editor of the *American Journal of Science*, the most influential scientific journal in the United States at the time, and with Joseph Henry, a professor at Princeton University and the first Secretary of the Smithsonian Institution. Bache's connections spread even as far west as Indiana, where he asked a professor, Theophilus A. Wylie—Bache's student and a University of Pennsylvania classmate of John Fries Frazer, for help in obtaining the post as director for the US Coast Survey (Wylie 1843).

Joseph Henry, in a eulogy delivered for Bache (1872), said that Bache's 'marked characteristic was the control which he had acquired over his passions and feelings, and it was this which enabled him to suppress all tendency to self-indulgence to pursue with unremitting perseverance the course he had marked out' (4). Both Henry and Bache shared a desire for control: Henry (1843) once wrote to Bache that they ought to influence the *American Journal of Science* by creating 'a board of collaborators who should have the principle if not the entire control of different departments' (n.p.). As early as 1842, in the *Journal of the Franklin Institute*, however, Bache (1842) expressed a desire to create associations that would bring the benefits of science to the United States and that these associations would form 'a great system of public instruction worthy the patronage and support of a free and enlightened people' (394). In other words, Bache saw professional associations like the AAAS as part of a broader educational system for science in the United States.

The formation of the ACS similarly relied on the efforts of a small group of people. In 1874, a small group of chemists met to celebrate the centenary of Joseph Priestley's discovery of oxygen. Silliman, Draper, and many of the important figures in the early history of the ACS were present at this meeting. During this meeting Persifor Frazer proposed that a national chemical society be formed. J. Lawrence Smith opposed this idea and suggested creating a more permanent section within the AAAS because there simply were too few chemists, he believed, to form a national society, and the amount of money required to form a sustainable association was too great. Other figures present at this meeting included later presidents of the ACS and vice-presidents of the chemistry section of the AAAS.

In 1876, Charles Chandler, a professor of chemistry at Columbia University who was also present at the 1874 meeting, brought together a group of his fellow chemists to form a national chemical society called the American Chemical Society, drew up a constitution, and registered the organization in New York. Chandler and his fellow chemists also circulated a letter to other chemists throughout the country asking them to join the ACS and be a part of that national movement. George F. Barker, then vice-president of the chemistry section of the AAAS, noted this event in his speech recorded in the *Proceedings of the American Chemical Society* (1876):

Another event has taken place, which is of especial interest to the members of this subsection. I allude to the formation of the American Chemical Society. The movement originated in the city of New York and the preliminary meeting was held on the 6th of April last ... The most cordial relations exist between the society and this subsection. (86)

Though several chemists did join the ACS, it did not really become a national society until 1891, when the Chemical Society of Washington, the ACS, and the AAAS' section on chemistry, along with several smaller organizations, decided to merge.

Later, when there was a similar movement to create a chemical society separate from national organizations such as the AAAS, comparable trends occurred. There were some scattered groups relating to professional chemistry throughout the US, and a sampling of them can be found in an 1891 report in the *Journal of the American Chemical Society* summarizing a meeting held in Washington, DC, which included representatives from the Association of Official Agricultural Chemists, the Chemical Section of the Franklin Institute (Philadelphia), the Washington Chemical Society (Washington, DC), The Chemical Section of the Brooklyn Institute, the Louisiana Sugar Chemists' Association, the Chemical Society of the University of Michigan, the Cincinnati Chemical Society, and the Manufacturing Chemists' Association of the United States (1891, 194–195). There are few records, though, of these other groups being interested in any form of national professionalization effort, and in fact all of these groups were called together by the ACS itself, not through any local initiatives.

Much of the agitation for the creation of a national society for chemistry came from the most centralized group of chemists: the AAAS's chemistry section itself. Albert Prescott, a professor at the University of Michigan, president of the ACS (1886), and later president of the AAAS (1891), wrote a report published in the *Proceedings of AAAS* encouraging a national organization under the auspices of the AAAS:

To organize for further union, chemists must cherish the growing chemical aggregation in Section C [the AAAS's chemistry section], now of permanent standing and great social advantage, and an alliance with this Section, carefully framed for mutual benefit, must be fundamental in the new organization. (1889, 36)

The following year, Frank W. Clarke, chief chemist of the US Geological Survey, became the chair of that committee and reported on a circular sent to determine the feasibility of this plan. In Clarke's report in *AAAS Proceedings* (1890), he suggested holding a conference 'to decide how a national organization can best be brought about, and the long-desired union of all American chemists made a practical reality' (141).

There was a conference held in Philadelphia in 1890 (in conjunction with the ACS) and in Washington, DC in 1891 (in conjunction with the AAAS). The meeting in Washington, under the leadership of George Barker (president of the ACS in 1891 and formerly vice-president of the AAAS chemistry section in 1876), recommended, in the *Journal of the American Chemical Society* (1891), that 'the union, under the name and organization of the American Chemical Society of all the members of the different societies represented, and the reorganization of local chemical societies as local sections of the American Chemical Society' (191). That same year, Frank Clarke made a report in the *Proceedings of the AAAS* (1891):

[A] conference of representatives of ten organizations had been held. The representatives of the American Chemical Society had indicated a willingness to make the changes in their constitution necessary to adapt it to the requirements of American chemists in general, and a unanimous vote of all delegates present favored a union under the charter of that body. (179)

Another source of power particularly prevalent in American science was that of industry. The Preface to the first issue of the *Transactions of the American Philosophical Society*, published in 1769, states:

Knowledge is of little use when confined to mere speculation: But when speculative truths are reduced to practice ... are applied to the common purposes of life; and when by these agriculture is improved, trade enlarged, the arts of living made more easy and comfortable ... knowledge then becomes really useful. (i–ii)

Benjamin Silliman (1886) also praised J. Lawrence Smith, former president of the American Association for the Advancement of Science and the American Chemical Society, because he 'established a laboratory for the production of chemical reagents and of the rarer pharmaceutical preparations, in which enterprise he associated himself with Dr. E. R. Squibb, whose fame as a successful worker in pharmaceutical chemistry is well known' (235).

Contemporaries of Bache commented on how influential the period at the Franklin Institute was in his life. In two eulogies delivered on his death, Joseph Henry (1872), Secretary of the Smithsonian Institution, stated that 'the early period of his life, including that which preceded his first call to Philadelphia, was almost wholly devoted to the improvement of the mechanical, or the "doing" faculties of his mind' (18), and Benjamin Gould (1868), president of the AAAS, stated that 'the influence of the Franklin Institute, in



giving to Bache's first researches an especially practical character, is very noticeable at this period' (7). Bache (1842) also reflected, in the *Journal of the Franklin Institute* (1842), this emphasis on practical and applied knowledge: 'increased production, whether in agriculture or manufactures, is so obvious and powerful a source of prosperity to a country, that we naturally look with interest upon every circumstance which may affect it' (380). Thus, in the early period of Bache's life, he was very focused on application of knowledge, particularly as it is useful to industry in Philadelphia.

As Bache helped to establish the AAAS, his interest in practical knowledge continued. In his presidential address to the AAAS, published in the *Proceedings of the American Association for the Advancement of Science* (1852), Bache acknowledged that 'the calls for mechanical knowledge, and for the applications of physics, of mathematics, and of natural science, have, without a doubt, thrown us irresistibly into the career we are now following' (xlili). This emphasis on practical knowledge was not unique to Bache. Recall Benjamin Silliman's Preface to the *American Journal of Science* (1818), in which he stated that the journal 'will be a leading object to illustrate American Natural History, and especially our Mineralogy and Geology. The applications of these sciences are obviously as numerous as physical arts and physical wants; for not one of these arts or wants can be named which is not connected with them' (v). In other words, practical knowledge is not only important in the organization of science, such as in the AAAS, but in the diffusion of science within its journals.

The influence of industry continued to be present in proceedings of the AAAS and in the *Journal of the American Chemical Society*. In the *Proceedings of AAAS*, vice-president Harvey Wiley (1886) wrote, 'Men of affairs often criticise science because it is not practical ... I desire to say a few words respecting the economic aspects of Agricultural Chemistry' (125). His address then discussed the impact of chemistry on the farming industry. Two years later, the *Journal of the American Chemical Society* (1888) reported 'the outcome of the visit of the Society of Chemical Industry to the works of the above-mentioned company [Noble's Explosives Company]' (116), and the Journal often included entire sections dedicated to industrial chemistry. Clearly, therefore, many of the important figures within both the AAAS and the ACS were concerned with issues relating to industry.

Later leaders of the AAAS and the ACS also continued supporting practical knowledge and industry. J. Lawrence Smith, not only served as president of both the AAAS and the ACS, Smith was also the president of the Louisville Gas Works and various mineralogical exploratory companies that helped to discover mines in Turkey and the United States. According to Silliman (1886), Smith 'established a laboratory for the production of chemical reagents and of the rarer pharmaceutical preparations, in which enterprise he associated himself with Dr. E. R. Squibb, whose fame as a successful worker in pharmaceutical chemistry is well known' (235). Charles Chandler founded the New York section of the Society for Chemical Industry in 1896 and, because of his influence within the ACS, established links between the two organizations. Browne and Weeks (1952), in their history of the ACS, even suggest that the *Journal of the American Chemical Society* attempted to create a 'balanced presentation of every phase of chemical industry' (89) within the journal.

## Conclusion

With this historical analysis of scholarly communication, one can argue that the journal article is part of a larger social system, including professional societies and power structures, within the sciences. This social system has its origins, at least in the United States, in the nineteenth century. This paper is intended to accomplish several aims: first, to better understand how and why professional associations, universities, and journals intersected; second, to bring together both qualitative sociological-historical and quantitative computational-statistical methods to make a more nuanced argument about how journals interact with larger social forces within nineteenth-century American society; and finally, and perhaps most importantly, to provide a different framework for discussing modern issues about scholarly communication. Strivings for political influence and for power over the way in which the scientific profession is structured seem to echo Alexander Dallas Bache's belief that science needed to organize to have power and to protect itself from charlatans and the public, who did not have the ability to practice the field that he (and others) wished to foster in the United States. Furthermore, rather than have a broadly distributed and federated structure of science, the early leaders created a very aristocratic form of science that mimicked European scientific institutions, but in other ways attempted to safeguard pure science from the potential pitfalls of having members of the public dilute the truth. Finally, leaders of the ACS and AAAS tied the discoveries of their profession and the work of the universities that employed them to the United States' perceived need to meet the knowledge requirements of a rapidly developing industry.

What does this mean for science, both in the nineteenth century and today? At a time when science is again organizing to meet the perceived threats of enemies, it may be good to think about why the

modern system of scientific professions formed and how this formation affected academic journals. Fundamentally, science in the nineteenth century was built by a small number of people in order to meet the needs of a new industrial nation. Though that system certainly evolved over time, one might argue that some of the characteristics of nineteenth-century scientific professionalization still exist today. The question is whether science, its professions, and its universities need to reform to meet different needs in the twenty-first century.

Modern scholars who study the history of scholarly communication, such as Alex Csiszar (2015), a historian of the history of science, argue that 'We need richer, more nuanced ways of talking about the collective belief that take into account the complexity of scientific interactions and how those forms evolve along with regulatory frameworks used for evaluating scientific claims relevant to public policy' (165). In the nineteenth-century United States, scholarship was considered a professional activity tied to the market needs of a growing industrial economy. Marcel LaFollette (2009) has gone so far as to suggest that the market for academic publishing in the US was unique because the consumers and the producers were the same people. This phenomenon created an insularity that encouraged research communities to believe that they owned their content when in fact they did not. For scholars of the late nineteenth- and early twentieth-century US, 'open' access to knowledge meant only that professional scientists, who served as both producers and consumers of content, were able to read the scholarship within their fields. The question is, should scholarship remain the same in a changing social world?

Strangely enough, a voice from one hundred and seventy-five years ago, Alexander Dallas Bache, may provide some insights to that question. In a speech he published in the *Journal of the Franklin Institute* in 1842, Bache stated:

Voluntary associations for the improvement of agriculture, manufactures, and the arts, exist all over our country, not supported, it is true, by our great sovereign the people, but by a few, who are either immediately or remotely interested or who desire to advance the weal of their country. If the eyes of this most august sovereign might but be opened to the importance of fostering these institutions! (386)

Bache was criticizing the fact that small institutions spread around the United States were fostering science, and he was advocating for a national movement to support such institutions. Bache said that this support depended on the 'august sovereign,' or the American people. Americans' eyes must be opened to the possibility of science. For Bache and his supporters among the *Lazzaroni*, scientific societies like the AAAS were meant to centralize and nationalize scientific efforts in the United States. Additionally, such associations were meant to create an aristocracy of science that would exclude charlatans and others who might embarrass American scholars, who were interested in creating research comparable to what was being produced by their colleagues in Europe. One might suggest that Bache never truly opened the eyes of the people, as he alluded to in his speech, but simply substituted one small, spread-out group of people who promoted science with a different small group of nationally focused professionals. Perhaps the burden now falls upon these professionals to discover how to open the eyes of the same sovereign that today is questioning the very need for science.

At a time when librarians like Dave Ghamadi (2018) argue that 'academia has lurched from crisis to crisis in scholarly communication for too long' (2), when bibliometricians, such as Vincent Lavrivi re and others (2013), are noting inequality within scientific publishing, and when movements like #MeToo and #BlackLivesMatter are advocating to reform inequality within society as a whole, it is important to think about why the scholarly communication system is in crisis and why it is inequitable. Though this paper does not entirely answer the question of how scholarly publishing contributes to inequality, it does provide a part of the answer. In the nineteenth century, founders of science in the United States, such as Alexander Dallas Bache, never set out to create an equitable system. Quite the contrary: leaders of early American science sought to create an aristocracy that they controlled. It is therefore no wonder that the scholarly communication system, as it evolved, replicated unequal power structures and is now contributing to methodical bias against certain groups of scientists. Bibliometric analyses, such as topic modeling, can help to show how journals reflect underlying realities. Historical analyses can help to explain why such realities exist. This paper has begun to reveal the origins of such inequalities in the nineteenth century. By learning more about how the scholarly communication system evolved, and by demonstrating to practicing librarians and publishers the reasons for their unconscious sources of bias, one can only hope that more informed and more lasting solutions to the crisis in scholarly communication can be found.

## Competing Interests

The author has no competing interests to declare.

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