National Developments in Information Systems and Services

Implications of Nationalism in the Development of the Scientific Information Infrastructure in North America in the Decades Leading Up to World War II

Bertrum H. MacDonald

Abstract

In the latter half of the nineteenth century American and Canadian scientists often voiced the view that science was universal. Their rhetoric implied that nationalism had no significant part in fostering scientific activity. While scientific endeavor could ignore national boundaries, the reality of developments in this period did not match the rhetoric completely. Expressions of universalism of science notwithstanding, nationalist attitudes are found when one looks closely at scientific work of Canadians and Americans from the 1850s into the early decades of the twentieth century. Evidence from the publication of scientific research and information dissemination systems in Canada and the United States demonstrates nationalist influences. Organizations, such as the Smithsonian Institution in the United States and the Royal Society of Canada and the National Research Council of Canada, were guided by nationalist perspectives when they created and established scientific information systems. In addition such journals as *American Geologist, Canadian Entomologist,* and the *Canadian Journal of Research* were characterized by nationalist outlooks. Although individual American and Canadian scientists could and did see science as being universal, at the collective, country level such determinants as nationalism had a clear and significant influence on the information infrastructures that developed in the nineteenth and twentieth centuries.

In the summer of 1857 the American Association for the Advancement of Science (AAAS) met in Montreal, the first time the association had ventured outside the United States for its annual conference since its formation nine years earlier. The meeting, "a highly successful one," according to one reporter, had led to "a virtual Scientific annexation of American to British American minds, in their action in the wide field of physical and natural science" ("Eleventh Meeting," 1857, p. 241). That the reporter held this perspective is not surprising given the rhetoric of leading scientists at the conference. In his opening address Alexis Caswell, vice president of AAAS, remarked:

> I think . . . that it is a matter of congratulation that we have met without the limits of the United States. . . . In the onward march of Science, it is one of the felicities of our time, that little account is taken of the boundaries that separate states and kingdoms. The discoverer of a new law or principle in nature, of a new process in the arts or a new instruction of research, of beneficial tendency, is speedily heralded over land and ocean; is welcomed as the benefactor of his race; and is immediately put into communication with the whole civilized world. (p. 242)

Caswell, a professor of mathematics and astronomy at Brown University who had lived briefly in Nova Scotia in 1827–28, was even more effusive in his remarks for he went on to say:

> We of the United States are here convened on British soil, little thinking that we have passed the boundary of protection of American law, or that amidst the generous hospitality of this enterprising commercial capital of a noble Province of Great Britain, we are aliens to the British constitution. We have left the American eagle, but we assure the gentlemen of Canada that we feel no danger of being harmed by the British lion. I have said that

> we are aliens to the British constitution; but that must of course be taken in the narrowest and most technical sense, for I am proud to say, on deliberate conviction, that nothing is alien to the British constitution that looks to the perfection of knowledge, to the furtherance of the arts or the amelioration of the condition of humanity. . . . There is something of special fitness in our assembling here at this time—at a moment when England and America are shaking hands with each other across the broad bosom of the Atlantic, when that electric chain which is to bind them in perpetual friendship, is being placed securely in the depths of the ocean far out of reach of any temporary storms which may impair its repose or lessen its efficiency. (p. 242)

Caswell's sentiments were echoed by John William Dawson, principal of McGill University and president of the Natural History Society of Montreal, which had invited the AAAS to that city:

> We believe that Science knows no political limits. The great physical laws of the Universe are the same in all lands. Geological structure and animal and vegetable life are everywhere framed on one uniform type. We cannot attempt to nationalize science without losing its greatest results. But we are connected with our American scientific friends by still closer ties. We are one with them in language, institutions and origin. ("Farther Gleanings," 1857, p. 356)

"The British people," in Dawson's view, were "as one in all parts of the world; . . . along with all the other peoples and races that have been united with it." Equally fervent as his American counterpart, Dawson remarked further:

> We love . . . to regard British America as an important connecting link between Britons of the old and the new world. Our country is rapidly rising to a position which may enable it to vie with the United States themselves; and retaining our connection with the maternal state, while we are united by the closest ties with our brethren of the South, we desire to cultivate that mutual good will which is so important to the welfare of the world. In what way can we better do this than through the amenities of science, and by inviting to mingle with us those minds that, more than any other, are building up the fabric of American greatness. (pp. 356–357)

Dawson's ambition did not rest with his desire to "mingle" American and British American minds, however. He looked forward to an early opportunity when Montreal, a British American city situated between Great Britain and the United States, could be the location where it would be possible to "unite" the AAAS, the British Association for the Advancement of Science, and many other scientific societies.

These statements, set in the middle of the Victorian period when the foundations of science were being set down in the United States and what would become Canada, reveal a view that science was universal, that nationalism had no significant part in fostering scientific work either generally or at more specific levels, such as the information systems that developed to promote scientific research. If the rhetoric were to be believed, it would be expected that scientists paid no heed to national borders when they published reports of their discoveries or sought and read the reports of scientific findings. Furthermore, the distribution methods that carried scientific publications could be expected to be unaffected by nationalist developments in both countries. But was this the case? Did national aspirations have no influence on the information infrastructure supporting the scientific enterprise that unfolded in Canada and the United States?

Caswell and Dawson notwithstanding, nationalist attitudes are found when one looks closely at the history of the publication and dissemination systems of scientific work in Canada and the United States. Even though numerous additional American and Canadian expressions of the belief that science is universal can be found in the decades following the Montreal meeting of AAAS (De Vecchi, 1984), leaders in the scientific communities on both sides of the border took steps to foster the development of communication systems that clearly had national significance. In the latter half of the nineteenth century political annexation of Canada by the United States was a real possibility. Recovering from the ravages of the Civil War, the United States was flexing its territorial muscle, and in 1867 the British North American colonies reacted in part by forming the new country of Canada as a means of preventing appropriation into the American state. During the 1880s and 1890s numerous Canadian scientists saw greater merit in an imperial British connection than in turning southward to increase ties with the United States (Daley & Dufour, 1981; Dawson, 1883; De Vecchi, 1984). Scientific institutions and communication systems developed within this political and social context, and in their work leaders in both countries saw national status and pride at stake. In effect, a disjuncture emerged between

the professed universalism of science and a desire for and efforts undertaken for national achievements. This juxtaposition of perspectives saw expression in the information infrastructure that developed.

The Context

Science grew up in the nineteenth century, more so in North America than in western Europe. Robert Bruce, in his engaging book *The Launching of American Science, 1846–1876*, described the developments succinctly:

> In science as in other matters, the nineteenth century was a time for organizing. Until then, the scientific pursuit had for the most part been a small-scale, spare-time indulgence of individual curiosity. But science and technology had lately begun getting together to offer mankind a new range of possibilities for ease or adventure, pleasure or pain, increase or extinction. With such vistas opening, men began pursuing science more urgently, and the farther they pursued it, the more it ramified. The proliferation of its branches meant that individual scientists had to become more specialized. The growing complexity of science demanded formal scientific education and full-time professional work, not the casual, intermittent attention of self-taught amateurs. The spread of scientific investigation in so many directions called for the recruiting of scientists, the systematizing of communication among them, and the reliable evaluation of their work. And all this required money, even beyond the rising cost of more elaborate materials and apparatus. In short, the pursuit of science had to become a collective enterprise, like those in business. Modern science needed labor, capital, and management. (1987, pp. 3–4)

In the United States and Canada "science came to see itself, and society came to see it, as an established profession" (p. 4). In both countries scientific education grew apace with the rise of the modern university, at such institutions as McGill, the University of Toronto, Harvard University, and Yale University. And in both countries "government agencies became founts of employment and scientific leadership" (p. 4). The founding of the Geological Survey of Canada in 1842, for example, established a leading government agency for exploration and research that captured the attention of scientists on both sides of the border (Zaslow, 1975). Similarly, when the U.S. Geological Survey was created in 1879 (significant state surveys had operated for several decades prior to creation of the national agency), its research output was quickly recognized in Canada.

Science was popular in North America—witness the numerous scientific and literary societies that flourished in the Victorian period—and scientific endeavor, as Bruce described it, took solid root (Hewitt, 1990). By the beginning of the twentieth century science was big business no matter how you measured it (Jarrell, 1988, 1994). Not only was the scientific enterprise large; it was also very complex, involving individuals, professional associations, governments, educational institutions, and the private sector. Untangling individual factors from the complicated amalgam that makes up science in order to gain an understanding of the total activity is not at all easy. The growing body of historical studies of nineteenth- and twentieth-century science over the past several decades confirms the analytical complexity. Sorting out the implications of the communication aspects of science alone is a challenge (Edge, 1979).

We know that the quantity of scientific information increased substantially throughout the nineteenth century. Henry Menard in a volume titled *Science, Growth and Change* noted that in 1835, when nine American state geological surveys were active, there were 2,123 pages of geological literature. By 1879, when the U.S. Geological Survey was founded, about 93,000 pages of geological literature had been published by the American states (Menard, 1971). While this is only one subject (albeit one that received significant attention in both Canada and the United States), the quantity of geological literature illustrates why information systems developed to assist practitioners in keeping abreast of it all. Numerous local, regional, national, and international scientific associations were formed to facilitate the circulation of scientific information (Bates, 1945; Berger, 1983; Dupree, 1976; Kohlstedt, 1999; MacDonald, 1996; Oleson & Brown, 1976). From the 1850s onward many Canadian and American scientists attended conferences, such as the AAAS meeting in Montreal referred to earlier, where their papers were read and information exchanged—a practice that increased over the next century. Scientific societies not only held annual meetings but also published and exchanged journals with a "messianic attitude," to use Sarah Gibson's phrase (1982, p. 152).

Outside of meetings the expanding postal system expedited the interchange of information. Tens of thousands of letters circulated among scientists and the wider, interested community (Bork, 1999; Goldstein, 1994; Larson, 1993). These letters contained written responses to questions, as well as the exchange of many thousands

of copies of reprinted articles, which individuals and libraries collected. As the number of periodicals increased, so the number of reprints also grew by leaps and bounds.

Given the large number of interlocking factors affecting the development of the systems for the interchange of scientific information in late nineteenth- and early twentieth-century North America, a historian faces a challenge about how to reach an understanding of both the details and the broader patterns of communication activity. As R. MacLeod and R. Jarrell point out, "a comparison of even two national scientific enterprises demands of its student a wide-ranging familiarity with two cultures in all their ramifications" (1994, p. 1). Can one, for example, ascertain from the extensive interchange of scientific information that occurred whether national borders and different cultures influenced the evolving infrastructure? Over twenty years ago David Edge (1979) declared that quantitative measures of communication in science by themselves should not be the sole means of historical analysis. His appraisal focused on the large body of literature flowing from studies of the information output of late twentieth-century science. As he pointed out, it is more difficult to apply these techniques historically. Citation analysis, for example, which has found wide application in the very large twentieth-century citation databases, now accessible through the ISI Web of Knowledge, is not easily adapted to nineteenth-century studies since only very limited citation data sets exist for that period and the time and effort required to create such data sets are daunting. So researchers have found it necessary to rely on other methods and other sources of evidence to uncover development patterns. Besides examining nineteenth- and early twentieth-century scientific publications, for instance, historians have investigated correspondence records to discern characteristics of the networks of information exchange that often occurred (Duchesne, 1981; Goldstein, 1994; Shapin & Thackray, 1974; Sheets-Pyenson, 1982).[1]

Case Studies

Several cases illustrate how perspectives on universalism and nationalism were intertwined in North American scientific information systems in the latter half of the nineteenth and opening decades of the twentieth centuries. Canadians and Americans undertook meteorological and magnetic observation, exploration, and research on the geological and mineral resources of their territories and sought solutions to agricultural challenges. Governments on both sides of the border funded research in these areas, and as a result these fields of study were prominent in both countries well into the twentieth century.

American Cases

For a first case consider the relationship of Joseph Henry, America's "most eminent physical scientist," with the early directors of the Toronto Magnetic Observatory. As the first secretary of the Smithsonian Institution, established by the American government in 1846 from the bequest of the Englishman James Smithson to meet the terms of his will "for the increase and diffusion of knowledge among men," Henry played a pivotal role in shaping the American scientific enterprise (Moyer, 1997).

Founded in 1839 as a result of the influence of the British Association for the Advancement of Science and the Royal Society of London, in its early years the Magnetic Observatory was staffed by British personnel whose superior knowledge of the physical sciences and of scientific equipment was acknowledged by American scientists. As G. A. Good (1986) has pointed out,

> American science was inferior to English science in many ways in the mid-19th century. This was certainly true of geomagnetics, as is indicated by the dependence of American scientists on the Toronto staff for information on the newest instruments and techniques for magnetic measurement. During the period of Imperial control, many Americans made the trip north seeking out the representatives of English science. (p. 39)

Joseph Henry was one of the American scientists who established both a professional and a personal relationship with the Toronto-based scientists, especially with J. H. Lefroy. Their friendship extended long after Lefroy left Toronto, as correspondence between the two, now in the Smithsonian Institution Archives, confirms. Henry and several American scientists looked north to Toronto for scientific information and advice, to the extent that Lefroy was sometimes surprised that he and his colleagues were more informed about the activities of individual

[1] The upsurge of interest in scientific correspondence led to the International Meeting on the History of Biology Correspondence and History of Biology (18th–20th Century), which was held at the Centre Alexandre Koyré, Muséum National d'Histoire Naturelle, Université de Paris, France, on 24–25 September 2003.

American scientists than Americans were about each other (Good, 1985, 1986).

Initially Henry's relationship with Lefroy centered on his need for information and knowledge that could only be supplied by British-educated scientists. Nonetheless, American scientists, Henry among them, also saw the need to foster national identity and pride. As Good suggests, "national jealousy in science was of course based in strongly-rooted tensions between England and the United States" (1986, p. 41). He notes, for example, that as early as 1839, Alexander Dallas Bache, superintendent of the U.S. Coast Survey and a close friend of Henry, "had a nationalistic side when he criticized J. W. Draper for his 'kink' of publishing his articles 'abroad' " (p. 41). Bache was acutely interested in obtaining credit for American science, and he emphasized this position in correspondence with William Bond of Cambridge, Massachusetts. "In a national point of view," he wrote in 1840, "it would be better that this [analysis of data of a magnetic storm] should be done between us than to reserve it for deductions on the other side of the Atlantic" (Bache to Bond, cited in Good, 1986, p. 41).

Joseph Henry held similar nationalist convictions. Even though he looked to the Canadian observatory and its British and Canadian staff for scientific knowledge and training in the use of equipment, his strong desire to promote the development of science in the United States characterized the information systems that he supported. On 23 December 1852 he spelled out his opinions in a letter to Thomas Corwin, secretary of the U.S. Treasury:

> The value of the rapid diffusion of a knowledge of the discoveries of different countries can scarcely be calculated. It often happens that several persons are engaged in the development of the same truth at the same time and it is therefore of the first importance that each should be informed of the discoveries of the other, and that the isolated knowledge of individuals and nations may be compounded into one system for the good of the whole. Nothing has tended more to retard original research in our own country than the difficulty which has heretofore existed in placing before the scientific world abroad the labors of our men of science. (cited in Rothenberg & Dorman, 1998, p. 418)

Henry felt that American science was not receiving appropriate international attention, and he also believed that American venues should be created and priority given to American authors. He made this point in a letter to Asa Gray, a notable American botanist at Harvard, on 10 January 1853. "I am somewhat perplexed with the proposition contained in your letter of the 6th inst," he wrote in response to Gray's question about publishing a French scientific manuscript, and he then elaborated:

> It is a fundamental maxim of this Institution to do nothing with its funds which can be equally well done by other means. Before the establishment of the Smithsonian Inst[itution], there was no adequate provision in the United States for the publication of original memoirs while in Europe it is supposed funds for this purpose are abundant. (Rothenberg & Dorman, 1998, p. 421)

While Henry was not opposed to publishing manuscripts received from across the Atlantic, he was quite concerned that a flood of foreign papers would overwhelm his intention to promote American science through the publication program that he initiated. In addition to the annual reports of the Smithsonian, which carried numerous scientific reports, he launched the *Smithsonian Contributions to Knowledge* in 1848 as a method to provide national, and possibly more important, international exposure for American scientific work. Of the several reasons that Henry set out for publishing the *Contributions to Knowledge*, the primary motivation was to act as "a powerful stimulus on the latent talent of our country." He intended to "encourage budding scientists and also make them known to their colleagues and others who would be further inspired by their success" (Gwinn, 1996, p. 203). Henry's objective was met on both counts. Throughout the nineteenth century the original memoirs and periodical reports published in the *Contributions to Knowledge* were largely American in authorship. Further, the *Contributions* quickly became a much sought-after Smithsonian publication by scientists inside and also outside of the United States.

Thus, although Henry welcomed and valued the interborder information exchange and transfer of knowledge that occurred through his contacts with Lefroy and Lefroy's colleagues, he strongly desired to establish a home-grown information infrastructure that would promote American science and place the United States prominently on science's world stage. With the resources of the Smithsonian Institution he took steps to achieve this objective. The publishing program he supported was influenced by nationalist views.

Another significant instance of scientific interchange occurred in the geological sciences. The establishment

of the Geological Survey of Canada in 1842 serves as a point to begin discussion of this case. William Logan, the first director, reported late in 1842 that he had begun his work by gathering public documents and other relevant information. He wrote:

> With a view to the formation of a systematic plan of operation, my efforts on my arrival here [i.e., the colony of Canada] were directed not so much to personal examination as to the collection of such information as might already exist in the country's public documents and reports, . . . I was enabled at the same time to form a collection of such maps of the country as were within the controul [sic] of the various departments of the Government, and to have them mounted and prepared for service in the field. . . . But among the documents which have come into my hands I have especially to express my obligation to His Excellency the Governor General for the published reports he has been instrumental in procuring for me on the Geology of the various States bordering on Canada. The value of these reports cannot be over-rated, as the study of them will tend to save a vast amount of labour and difficulty in the geological investigation of the Colony. ("Preliminary Report," 1845, pp. 10–11)

Although Logan soon began a prolific publication schedule for the Canadian Survey, his early interest in American scientific publications was by no means his last. He built a substantial private library (which eventually formed a core of volumes for the Survey Library), drawing on his frequent contacts with American geologists (MacDonald, 1990, chap. 5). Among several journals that regularly arrived in Logan's office was the *American Journal of Science,* a periodical that had wide influence in North America (Wilson, 1979). But the interest in geological publications was not unidirectional, as debates over geology soon developed among American and Canadian scientists. Some of these debates were intense, requiring the scientists to be fully aware of the work of others in both countries. Interpretations hinged on detailed knowledge of the discoveries and ideas of others (Eagan, 1986, 1987, 1989). Such knowledge was particularly important in paleontological studies where priority in naming fossil species fell to the first individual to describe specimens. For example, Elkanah Billings, paleontologist with the Canadian Geological Survey, and his American counterparts paid close attention to published reports that named fossil species.

Correspondence among geologists was extensive (Sheets-Pyenson, 1982). Extant records of numerous staff members of the Geological Survey of Canada and their American counterparts confirm wide networks of contacts, which were solidified through face-to-face meetings at conferences such as the AAAS meeting in Montreal in 1857 (the AAAS returned to Montreal for another annual conference in 1882). Beyond the circle of staff at the Canadian Survey headquarters in Montreal and Ottawa (the Survey was located in Montreal from 1842 until the early 1880s when it was transferred to Ottawa) other geological workers, such as John William Dawson at McGill University and George Frederic Matthew in Fredericton, were also prolific letter writers (Sheets-Pyenson, 1992; Miller & Buhay, 1990). They, similar to Robert Bell, a senior staff member and later acting director of the Canadian Survey, distributed their publications to geological scientists throughout the continent. Bell drew up several correspondence lists that itemize individuals receiving his publications, which today are in his papers held at the Library and Archives of Canada.

As the century progressed, the venues for reports of geological exploration and research increased, and the various geological surveys turned out many publications each year. But some geologists felt these were not sufficient, and new venues were sought. One was the *American Geologist*, which began publication in 1888. The editors of this new monthly periodical were motivated by what they claimed was a "lack of a distinctively geological journal in the United States, whose purpose should be to coordinate and express the results of [the] special labors on the general science of geology." They "lamented" what they saw as an "absence of a journal which [would] take cognizance of the various laboratories of the world, and of the publications that emanate from the various scientific centers" ("Introductory," 1888). The *American Geologist* soon became a "success" story, which continues to be published more than a century later as *Economic Geology*.

Given the network of American and Canadian geologists and the interchange of information across the border, was there a relationship between the network and the authorship or content of articles published by the journal? From the first ten volumes the following evidence emerges. A total of 332 papers was published, and of these 20 (6 percent) were written by Canadian scientists. Almost all of the remainder were written by Americans (93 percent). The content of the journal was decidedly American, but Canadian authors were not excluded.

The more international nature of the journal is seen in the reviews and in the list of new publications noted

in each issue. Canadian publications were often reviewed, several at some length, and the list of new publications frequently included Canadian titles. The lists confirm that Canadian societies and individuals were sending copies of their publications to the journal editors. New publications were listed in five categories: state and government reports, proceedings of scientific societies, papers in scientific journals, excerpts and individual publications, and foreign publications. American and Canadian publications were interfiled in the first four categories, reflecting the close association between the two countries. "Foreign" publications were those produced outside Canada and the United States (in a very few instances Canadian publications were included in the "foreign" category, but most publications listed in this category were published outside of North America). The interfiling of American and Canadian publications reveals that the editors saw no distinction between research conducted in the two countries. In the words of the American geologist, Persifor Fraser,

> Canada and the United States are bound together by many and strong bonds. They have had the same wilderness to reclaim; the same problem of the new western life to solve. Our borders separate no hostile people; but Canada's glories are ours, and ours are hers. Indeed some of the names which shed the greatest lustre on science, literature and art are those of Canadians. Is it not noticeable that the dictionary of the people of the United States, so fecund in expanding itself to meet the wants occasioned by new conditions of things, has but one adjective to specify the nationality of our own illustrious men, one which will apply equally to those in Canada,—*American.* (1884, p. xii)

Canadians as well as Americans endorsed the new *American Geologist* and the new society that grew up around it as support, even though Canadians sometimes resented the "cheerful, almost glib, appropriation of everything Canadian" (De Vecchi, 1984, p. 51). Evidence for the support is seen in the responses by Americans James D. Dana and A. Winchell and Canadians Robert Bell and John William Dawson to two surveys conducted by the Geological Society of America in 1882 and 1888 ("Pre-Natal History," 1890).

The journal, as the tally of articles shows, had a very strong American focus, however, and one Canadian scientist, John William Dawson, who had written to offer support, expressed a cautionary note. The Royal Society of Canada had just been established with a section dealing with geological sciences, and in Dawson's view the Canadian organization would "serve all the purpose to us [i.e., Canadians] of a Geological Society" ("Pre-Natal History," 1890, pp. 188–189).

During the years when the *American Geologist* was planned and launched, the Smithsonian Institution, headed by Joseph Henry and his successor, Stuart Baird (Rivinus & Youssef, 1992), was administering a massive information exchange program. Although such organizations as the American Philosophical Society and the American Academy of Sciences had initiated exchanges of scientific publications early in the nineteenth century, the creation of the Smithsonian Institution, with its mandate for "the increase and diffusion of knowledge among men," led to the establishment of an international exchange program that was unprecedented in scope. In late 1852 Joseph Henry advised Thomas Corwin that during the previous year 7,951 copies of American publications had been transferred to foreign institutions, and 5,293 copies of "foreign works" had been received, which, as he noted, could not have been procured "except at great cost" (Rothenberg & Dorman, 1998, p. 418).

Under the leadership of Henry and Baird the international exchange program flourished. As the century developed, the Smithsonian became the "principal facilitator between the United States and the rest of the world for exchanges of scientific, educational, and government publications among individual scientists, private societies, colleges and universities, and government bodies" (Gwinn, 1996, p. 15). Many Canadian institutions participated in the system, which lasted for nearly 150 years (Einhorn, 1972). The extent of the exchange system was substantial. "By 1870, the list of foreign exchange partners had grown to 1,985 organizations . . . [and] packages were sent to 26 countries around the world" (Gwinn, 1996, p. 268).

As important as the Smithsonian's international exchange program was to institutions outside the United States, N. E. Gwinn's analysis of the early decades of the program has situated it in the "growing cultural nationalism of the nineteenth century" (1996, p. 385). The exchange program, as she notes, demonstrated "that Americans were now able to engage in activities central to European scientific culture, and that they could produce their own publications and research, and that, in turn they could become less dependent on Europe." In effect, the information infrastructure that the Smithsonian established "fueled the notion of continual progress as an American ideal" and "helped create a separate American identity" (pp. 26, 385). In the 1840s Alexandre Vattemare, a French proponent of international

exchanges, had claimed in a petition to the U.S. Congress that "science overleaps the boundaries which political systems interpose between nations" (U.S. Congress, 1840, p. 1). While the Smithsonian's international exchange program aimed to overcome the barriers of national boundaries, the program itself "reflected the growth of American cultural and scientific nationalism," and because it did, it was supported by the American government and scientific organizations in the United States (Gwinn, 1996, p. 2).

Canadian Cases

In his opening address in 1882 as president of the new Royal Society of Canada, John William Dawson voiced a concern echoed by both Canadians and Americans when they felt they were distant from larger centers of activity:

> Means are lacking for the adequate publication of results. True we have the reports of the Geological Survey, and *Transactions* are published by some of the local societies, but the resources at the disposal of these bodies are altogether inadequate, and for anything extensive or costly we have to seek means of publication abroad; but this can be secured only under special circumstances; and while the public results of Canadian science become so widely scattered as to be accessible with difficulty, much that would be of scientific value fails of adequate publication, more especially in the matter of illustrations. Thus the Canadian naturalist is often obliged to be content with the publication of his work in an inferior style and poorly illustrated, so that it has an aspect of inferiority to work really no better, which in the United States or the mother country has the benefit of sumptuous publication and illustration. On this account he has often the added mortification of finding his work overlooked or neglected, and not infrequently while he is looking in vain for means of publication, that which he has attained by long and diligent labour is taken away from him by its previous issue abroad. In this way also it very often happens that collectors who have amassed important material of great scientific value are induced to place it in the hands of specialists in other countries, who have at their command means of publication not possessed by equally competent men here. The injury which Canadian science and the reputation of Canada sustain in this way is well known to many who are present and who have been personal sufferers. (1883, pp. viii–ix)

As well as making general observations, Dawson could speak from personal experience. Ignoring its own practice, the Royal Society of London declined to publish Dawson's 1870 Bakerian lecture, an experience that left him embittered (Sheets-Pyenson, 1991, 1996). Even so, his general views about publishing opportunities were shared by those in the 1882 audience in Ottawa. A few years earlier James Loudon had emphasized the importance of a nation having its own scientific periodicals in his presidential address to the Canadian Institute in Toronto (1877, p. 375). The Royal Society of Canada did begin a new journal, which for many years carried scientific papers. In contrast to the *American Geologist* discussed earlier, however, only Canadian authors could publish in the *Transactions.* So although there were extensive networks of Canadian and American geologists exchanging large numbers of letters and publications, such scientific periodicals as the *American Geologist* and the *Transactions of the Royal Society of Canada* were shaped more by national interests than by an integrated North American perspective.

If geological scientists took active advantage of the postal service to seek and offer information, agricultural scientists honed this technique to a fine art. Canadian data will illustrate the extent of their correspondence. In 1886 William Saunders was appointed the first director of the federal Department of Agriculture's Central Experimental Farm in Ottawa. The merits of establishing an experimental farm system (with branches located throughout the country), mirrored by similar research agencies in the United States, were quickly realized. Farmers and others flooded the Central Farm with requests for information. In 1889, for example, only three years after the farm opened, nearly 7,000 letters were received. Saunders and his staff responded by sending out 41,584 copies of reports and bulletins (Saunders, 1890). While he claimed this was a "formidable total of mail matter," a year later the incoming mail had jumped to 17,539 letters; the staff responded with 19,806 letters and also mailed out 218,129 copies of reports and bulletins. Three years after that, in 1893, the corresponding numbers were 23,571 letters received, 26,926 letters sent, and 227,899 copies of reports and bulletins mailed out. The steady stream of mailings did not let up. A decade later in 1903 the farm received 59,441 letters and mailed out 220,426 reports and 45,485 circular letters. Over the first decade and a half of the operation of the experimental farm system well over 2.25 million copies of publications were distributed across the country and abroad, truly a "formidable total of mail matter."

Much of this correspondence was directed toward

Canadians, farmers in particular. However, an examination of the records of the staff members of the central research station shows that they frequently corresponded with their counterparts in the United States. The records of American agricultural scientists of the period, such as Charles Valentine Riley, entomologist with the U.S. Department of Agriculture, confirm that the correspondence was two-way (Ho & Yuille, 1990). William Saunders maintained numerous contacts with scientific leaders throughout the United States, contacts he had built up over three decades prior to his appointment as director. He was a highly regarded horticulturist and entomologist whose *Insects Injurious to Fruits,* first published in 1883 by J. B. Lippincott and Company of Philadelphia, went through several editions ("Introductory," 1888). To prepare and keep this hefty volume up to date, Saunders maintained a lengthy line of correspondence with American scientists, including J. H. Comstock, L. O. Howard, Townsend Glover, C. V. Riley, William H. Ashmead, Matthew Cooke, S. V. Chapin, J. A. Litner, George H. Horn, E. T. Cresson, A. R. Grote, P. Uhler, and others (Saunders, 1883, pp. 5–9).

As Dominion Entomologist and Botanist, James Fletcher, another staff member of the experimental farm system (Estey, 1983), corresponded with an extensive list of scientists, government personnel, and farmers in Canada, the United States, and further afield. That correspondence often involved an exchange of publications. For over two decades a steady stream of letters flowed between Fletcher and his American counterparts in which they shared their knowledge of insect pests and diseases and recommended remedies for plant problems north and south of the border. In 1885–86, for example, Fletcher's correspondents included leading American scientists, such as J. H. Comstock at Cornell University; L. O. Howard at the Division of Entomology in Washington, D.C.; and C. V. Riley at the Department of Agriculture in Washington, D.C.

Besides the publications he obtained through exchanges, Fletcher regularly read several scientific periodicals, including the *Canadian Entomologist* (begun in 1868), a journal that continues to be published. The early issues of the *Canadian Entomologist,* similar to many other journals of the period, were aimed at a readership of amateurs as well as experienced entomologists. Even so, the journal endeavored to inform readers about the latest developments in the field by including original reports along with reviews and news, as did the *American Geologist* referred to earlier. Both Canadians and Americans authored the papers, and reviews of American and Canadian publications appeared regularly in the journal. In the first volume, for example, the *Canadian Entomologist* drew readers' attention to the following American publications: *The American Entomologist;* papers by A. S. Packard in the *Proceedings of the Boston Natural History Society; The Maine Farmer; A Guide to the Study of Insects* by A. S. Packard (Salem, MA); *The Butterflies of North America* by W. H. Edwards (Philadelphia); *List of the Lepidoptera of North America* by A. R. Grote and C. T. Robinson (Philadelphia); *The American Naturalist; Catalogue of the Orthoptera of North America* by Samuel H. Scudder (Washington, D.C.); and the *First Annual Report on the Noxious, Beneficial and Other Insects of the State of Missouri* by Charles V. Riley.

In its objective to inform readers about relevant titles, no matter where they were published, the *Canadian Entomologist* was similar to other Canadian and American periodicals. The *Canadian Naturalist and Geologist,* published in Montreal (begun in 1856), for example, reviewed American and Canadian publications. As with the *American Geologist*, both Canadian and American authors contributed papers to the *Canadian Entomologist.* Nonetheless, the majority of contributors to the *Canadian Entomologist* were Canadian, and it presented a Canadian perspective well into the twentieth century. In a manner similar to the geologists of the period, entomologists also maintained wide circles of correspondence throughout North America. Even so, their entomological journals tended to take on national perspectives.

As the scientific enterprise increased in size and activity, Canadians expressed continuing concern about access to Canadian publication venues. When the National Research Council of Canada was founded in 1916, in response to the need for national coordination of the scientific war effort, it began to support financially the publication program of the Royal Society of Canada. But by the mid-1920s the *Transactions of the Royal Society of Canada,* with papers on an array of scientific topics, was declared inadequate for Canadian science. "We shall never get recognition scientifically until we have some scientific journals of our own," wrote H. M. Tory, National Research Council president, in 1925 (cited in Thistle, 1966, p. 173). Tory had reason to make such a claim. In his study of the development of physics and the rise of scientific research generally in Canada, Y. Gingras found that between 1900 and 1928 physicists at McGill University and the University of Toronto sent more than half their research papers to journals outside the country. McGill physicists "published 45 per cent of

their papers in England, 26 per cent in Canada, and 4 per cent in Germany" and their counterparts at the University of Toronto published "46 per cent . . . in Canada, 39 per cent in England, 10 per cent in the United States, and 2 per cent in Germany" (Gingras, 1991, p. 104). Without ignoring the merits of publishing outside the country, the Canadian scientific leaders argued that the *Canadian Journal of Research*, launched in 1929, was "largely due to the fact that there . . . [was] in Canada no national periodical devoted to research" ("Foreword," 1929, p. 3). In a very short period after it began publication, the *Canadian Journal of Research* received a wider distribution than the *Transactions of the Royal Society of Canada* and thus improved diffusion of the research of Canadian scientists (Gingras, 1991; Levere, 1996). The *Canadian Journal of Research* began a line of scientific journals that in the years after 1929 branched into a stable of National Research Council periodicals (Bishop, 1987; Gridgeman, 1979). Over fifty years later the rationale for launching the *Canadian Journal of Research* was reiterated by Claude T. Bishop, editor-in-chief of the council's journals. According to Bishop (1987), one of the reasons for publishing Canadian journals is "to maintain scientific self respect. While science *per se* is international, nationalism still exists and as long as . . . [Canada is] a separate country, . . . [Canadians] should not use the scientific literature without contributing to it" (p. 20).

All three Canadian journals (*Transactions of the Royal Society of Canada, Canadian Entomologist*, and the *Canadian Journal of Research*) were the result of dissatisfaction with placing Canadian research in scientific periodicals in the United States or Europe. Each was rooted in nationalist perspectives, even though with the exception of the *Transactions*, non-Canadians could and did publish in these journals. All the cases outlined here show that while Canadians and Americans continued to exchange information and publications freely in the spirit of scientific universalism, their journals could often be characterized from a nationalist outlook.

Conclusion

Science came of age in the United States and Canada during the latter part of the nineteenth and early decades of the twentieth centuries. Developments in the growth of science occurred earlier and proceeded more rapidly in the United States than in Canada, but in both countries the scientific community evolved from dependence on Europe to self-reliance. This status was achieved within similar but different social and political contexts, along with nationalist forces. While professing universalism in science, practitioners argued for and committed resources to develop national information infrastructures. Americans launched journals and dissemination systems to promote U.S.-based science, and Canadians pursued ventures on their side of the border that fostered Canadian science. That they should do so may have been a natural development. In "The Spread of Western Science," a now widely cited paper published in 1967, George Basalla outlined seven tasks that he claimed must be completed before "a colonial, dependent scientific culture is to be exchanged for an independent one." The creation of "channels . . . to facilitate formal national and international scientific communication" is one of the seven. This task, he argued, could be "accomplished by founding appropriate scientific journals and then gaining their widespread recognition" (Basalla, 1967, p. 618). What J. Todd described as Basalla's "neutral, linear, homogeneous path to scientific independence" could characterize the maturation of science, but the model has been questioned by Todd and by MacLeod for ignoring the political and ideological dimensions and lacking explanatory power (Todd, 1993, p. 37; MacLeod, 2000, p. 3). In Canada and the United States nationalism did play an important role in creating channels of communication; American and Canadian scientists were motivated by nationalist persuasion as they built scientific information infrastructures in their countries. Political and ideological dimensions were influential. As the two countries developed, scientists in both countries used expanding information infrastructures to advance national identities distinct from their largely British and European origin, even though in the closing decades of the nineteenth century Canadians saw themselves as a bridge between British and American science.

Interaction between Canadian and American scientists was extensive in the decades leading up to World War II. In meteorology and magnetism, geology, and agriculture the interchange of information was driven by commonality in the problems they encountered. It only made sense to pay attention to the discoveries of others working on similar questions. Networks of correspondence grew as the enterprise of science developed in both countries (see, for example, Duchesne, 1981; Waiser, 1982; Hull, 1991). Such transactions pointed to the universalism of science, which many scientists valued. But "annexation" of American and Canadian science did not occur, as the 1857 Montreal reporter suggested ("Eleventh Meeting," 1857). Nationalism

intervened and influenced the development of the scientific enterprise in general and the information infrastructure in particular.

It was not uncommon for scientists on both sides of the border to voice nationalistic views. The editors of the *American Geologist* made this clear when establishing their journal, and John William Dawson stressed this perspective in his statements about the need for a national journal in Canada. This attitude also found expression in the twentieth century. In the 1920s H. M. Tory, director of the National Research Council of Canada, believed that scientific journals garnered recognition and were "supposed to be the normal outcome of greater numbers of researchers and higher productivity" (Gingras, 1991, p. 103). Bishop (1987) echoed the same perspective seventy years later.

I. Inkster's statement—that the "transfer of knowledge . . . *between* industrial nations in the years prior to 1914 was facilitated by the prior or contemporaneous development of institutional structures which hastened the creation and diffusion of knowledge *within* nations"—rings true in the Canadian and American cases (1991, p. 90). Although individual American and Canadian scientists could and did see science as being universal, at the collective, country level determinants such as nationalism had a very clear and significant influence on the information infrastructures that developed.

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References

Basalla, G. (1967). The spread of western science. *Science, 156,* 611–622.

Bates, R. S. (1945). *Scientific societies in the United States*. New York: John Wiley & Sons.

Berger, C. (1983). *Science, God, and nature in Victorian Canada*. Toronto: University of Toronto Press.

Bishop, C. T. (1987). An overview of Canadian scientific journals. *Canadian Journal of Information Science, 12*(1), 20–34.

Bork, K. B. (1999). Correspondence as a window on the development of a discipline: Brogniart, Cleaveland, Silliman, and the maturation of mineralogy in the first decades of the nineteenth century. *Earth Sciences History, 18*(2), 198–245.

Bruce, R. V. (1987). *The launching of American science, 1846–1876.* New York: Alfred A. Knopf.

Daley, R., & Dufour, P. (1981, January). Creating a "northern Minerva": John William Dawson and the Royal Society of Canada. *HSTC Bulletin, 5*(1), 3–13.

Dawson, J. W. (1883). [Opening remarks, inaugural session 1882]. *Proceedings and Transactions of the Royal Society of Canada, 1,* vii–xi.

De Vecchi, V. (1984, June). The dawning of a national scientific community in Canada, 1878–1896. *Scientia Canadensis, 8*(1), 32–58.

Duchesne, R. (1981, May). Science et société coloniale: Les naturalistes du Canada française et leurs correspondants scientifiques (1860–1900) [Science and colonial society: Naturalists of French Canada and their scientific correspondents (1860–1900)]. *HSTC Bulletin, 5*(2), 99–139.

Dupree, A. H. (1976). The national pattern of American learned societies, 1769–1863. In A. Oleson (Ed.), *The pursuit of knowledge in the early American republic* (pp. 21–32). Baltimore: Johns Hopkins University Press.

Eagan, W. E. (1986). The multiple glaciation debate: The Canadian perspective, 1880–1900. *Earth Sciences History, 5*(2), 144–151.

Eagan, W. E. (1987). "I would have sworn my life on your interpretation": James Hall, Sir William Logan, and the "Quebec Group." *Earth Sciences History, 6*(1), 47–60.

Eagan, W. E. (1989). The debate over the Canadian Shield, 1880–1905. *Isis, 80,* 232–253.

Edge, D. (1979). Quantitative measures of communication in science: A critical review. *History of Science, 17*, 102–134.

Einhorn, N. R. (1972). Exchange of publications. In A. Kent, H. Lancour, & W. Z. Nasri (Eds.), *Encyclopedia of library and information science* (vol. 8, pp. 282–289). New York: Marcel Dekker.

Eleventh meeting of the American Association for the Advancement of Science. (1857, September). *Canadian Naturalist and Geologist, 2*(4), 241–299.

Estey, R. H. (1983). James Fletcher (1852–1908) and the genesis of plant pathology in Canada. *Canadian Journal of Plant Pathology, 5*, 120–124.

Farther [sic] gleanings from the meeting of the American Association in Montreal. (1857, November). *Canadian Naturalist and Geologist, 2*(5), 355–359.

Foreword. (1929). *Canadian Journal of Research, 1*(1), 3.

Fraser, P. (1884). The American Association. *Proceedings and Transactions of the Royal Society of Canada, 2,* xi–xiii.

Gibson, S. (1982). Scientific societies and exchange: A facet of the history of scientific communication. *Journal of Library History, 17*, 144–163.

Gingras, Y. (1991). *Physics and the rise of scientific research in Canada*. Montreal/Kingston: McGill-Queen's University Press.

Goldstein, D. (1994). "Yours for science:" The Smithsonian Institution's correspondents and the shape of scientific community in nineteenth-century America. *Isis, 85*, 573–599.

Good, G. A. (1985). Toronto Magnetic Observatory and international science ca. 1850. *Vistas in Astronomy, 28*, 387–390.

Good, G. A. (1986). Between two empires: The Toronto Magnetic Observatory and American science before confederation. *Scientia Canadensis, 10*(1), 34–52.

Gridgeman, T. T. (1979). A semicentennial: The NRCC research journals, 1929–1979. *Canadian Journal of Physics, 57*(7), iii–xvi.

Gwinn, N. E. (1996). *The origins and development of international publication exchange in nineteenth-century America*. Unpublished doctoral dissertation, George Washington University, Washington, D.C.

Hewitt, M. (1990). Science, popular culture, and the producer alliance in Saint John, N.B. In P. A. Bogaard (Ed.), *Profiles of science and society in the Maritimes prior to 1914* (pp. 243–275). Fredericton, Canada: Acadiensis Press and Centre for Canadian Studies, Mount Allison University.

Ho, J. J., & Yuille, W. (1990). *The papers of Charles Valentine Riley: A register of his papers in the National Agricultural Library*. Beltsville, MA: National Agricultural Library.

Hull, J. P. (1991, Spring-Summer). Networks of knowledge: Two Canadian scientists and their transborder contacts. *Scientia Canadensis, 15*(1), 50–57.

Inkster, I. (1991). *Science and technology in history*. New Brunswick, NJ: Rutgers University Press.

Introductory. (1888, January). *American Geologist, 1*(1), 1.

Jarrell, R. (1988). Science and state in Ontario: The British connection or North American pattern. In R. Hall, W. Westfall, & L. S. MacDowell (Eds.), *Patterns of the past: Interpreting Ontario's history* (pp. 238–254). Toronto: Dundurn Press.

Jarrell, R. (1994). Measuring scientific activity in Canada and Australia before 1915: Exploring possibilities. *Scientia Canadensis, 17*(1-2), 27–52.

Kohlstedt, Sally G. (1999). *The establishment of science in America: 150 years of the American Association for the Advancement of Science.* New Brunswick, NJ: Rutgers University Press.

Larson, A. L. (1993). *Not since Noah: The English scientific zoologists and the craft of collecting, 1800–1840*. Unpublished doctoral dissertation, Princeton University.

Levere, T. H. (1996). The most select and the most democratic: A century of science in the Royal Society of Canada. *Scientia Canadensis, 20*, 3–91.

Loudon, J. (1877). The president's address. *Canadian Journal n.s., 94*, 365–380.

MacDonald, B. H. (1990). *"Public knowledge": The dissemination of scientific literature in Victorian Canada as illustrated from the geological and agricultural sciences.* Unpublished doctoral dissertation, University of Western Ontario, London, Canada.

MacDonald, B. H. (1996). In support of an "information system": The case of the library of the Natural History Society of Montreal. In P. F. McNally (Ed.), *Readings in Canadian library history 2* (pp. 217–240). Ottawa: Canadian Library Association.

MacLeod, R. (2000). Introduction. In R. MacLeod (Ed.), *Nature and empire: Science and the colonial experience. Osiris 2nd s., 15,* 1–13.

MacLeod, R., & Jarrell, R. (1994). Introduction. In R. MacLeod & R. Jarrell (Eds.), *Dominions apart: Reflections on the culture of science and technology in Canada and Australia, 1850–1945* (pp. 1–6). Toronto: Canadian Science and Technology Historical Association.

Menard, H. W. (1971). *Science, growth, and change.* Cambridge, MA: Harvard University Press.

Miller, R. F., & Buhay, D. N. (1990). *Life and letters of George Frederic Matthew: Geologist and palaeontologist. An annotated list of Matthew's geological correspondence in the New Brunswick Museum Library and Archives.* Fredericton, Canada: New Brunswick Museum.

Moyer, A. E. (1997). *Joseph Henry: The rise of an American scientist*. Washington, DC: Smithsonian Institution Press.

Oleson, A., & Brown, S. E. (Eds.). (1976). *The pursuit of knowledge and the early American republic: American scientific and learned societies from colonial times to the Civil War*. Baltimore: Johns Hopkins University Press.

Preliminary report addressed to Rawson W. Rawson, Esq. Civil Secretary to His Excellency the Governor General [dated Montreal, December 6, 1842]. (1845). In *Message from His Excellency the Governor General, with reports on a geological survey [for the year 1843] of the Province of Canada, presented to the House on 29th January 1845* (pp. 10–11). Montreal: Lovell and Gibson.

The pre-natal history of the Geological Society of America. (1890, September). *American Geologist, 6*(3), 181–194.

Rivinus, E. F., & Youseff, E. M. (1992). *Spencer Baird of the Smithsonian*. Washington, DC: Smithsonian Institution Press.

Rothenberg, M., & Dorman, K. W. (Eds.). (1998). *The papers of Joseph Henry. Volume 8: January 1850–December 1853, The Smithsonian years*. Washington, DC: Smithsonian Institution Press.

Saunders, W. (1883). *Insects injurious to fruits.* Philadelphia: J. B. Lippincott.

Saunders, W. (1890). Report. In *Experimental Farms reports . . . for 1889*. Ottawa: Brown Chamberlin, Queen's Printer (appendix to the Report of the Minister of Agriculture, Sessional Papers, no. 63, 1890).

Shapin, S., & Thackray, A. (1974.) Prosopography as a research tool in history of science: The British scientific community, 1700–1900. *History of Science, 12*, 1–28.

Sheets-Pyenson, S. (1982, December). Geological communication in the nineteenth century: The Ellen S. Woodward autograph collection at McGill University. *Bulletin of the British Museum of Natural History (History Series), 10*(6), 179–226.

Sheets-Pyenson, S. (1991). "Pearls before swine": Sir William Dawson's Bakerian lecture of 1870. *Notes and Records of the Royal Society, 45*(2), 177–191.

Sheets-Pyenson, S. (1992). *Index to the scientific correspondence of John William Dawson.* Stanford in the Vale: British Society for the History of Science (BSHS Monograph 7).

Sheets-Pyenson, S. (1996). *John William Dawson: Faith, hope, and science.* Montreal/Kingston: McGill-Queen's University Press.

Thistle, M. (1966). *The inner ring: The early history of the National Research Council of Canada*. Toronto: University of Toronto Press.

Todd, J. (1993). Science at the periphery: An interpretation of Australian scientific and technological dependency and development prior to 1914. *Annals of Science, 50*, 33–58.

U.S. Congress, House of Representatives. (1840). Memorial of Alexandre Vattemare. 26th Cong., 1st Sess., H. Doc. 50, 1.

Waiser, W. (1982, January). The Macoun-Merriam connection. *HSTC Bulletin, 6*(1), 3–9.

Wilson, L. G. (1979). *Benjamin Silliman and his circle: Studies on the influence of Benjamin Silliman on science in America. Prepared in honor of Elizabeth H. Thomson.* New York: Science History Publications.

Zaslow, M. (1975). *Reading the rocks: The story of the Geological Survey of Canada, 1842–1972.* Toronto: Macmillan Company of Canada.